Product Development for Recycled Multifunctional Excursionist Winter Jacket

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1 Introduction

1.1 Title of Project

“Product Development for Recycled Multifunctional Winter Excursionist Jacket”

1.2 Background

A jacket is a short coat, worn by both men and women. The global winter wear market size was valued at USD 268.3 billion in 2018 and is estimated to expand at a CAGR of 4.3% over the forecast period. Dropping temperature below zero in many regions is attracting the demand for winter clothes to protect the body from frostbite. Moreover, several thin layers of clothing can be more effective at keeping you warm than one large, bulky layer, thereby increasing the volume sales of winter clothes. Changing fashion trends and frequent traveling by many people to cooler places for vacation and work purposes are also driving the global market over the forecast period. Rise in demand for winter wear products among consumers due to an increase in global warming conditions, thereby lowering the weather temperature across the regions. However, the growth in the distribution channels across the apparel sector has formulated the demand for the product. Rise in purchasing power of consumers, along with demand for the premium and branded products across different end users, drives the market. In outwear, coats and jackets accounted for the largest share of 52.5% in 2018. The segment is driven by rise in use of jackets for different purposes such as trekking, bike riding, armors, tours, and travels, thereby uplifting its sales in the market. Key manufacturers in the industry include Gap Inc.; VF Corporation; Columbia Sportswear Company; The North Face, Inc.; Patagonia, Inc.; Zara SA; Arc'teryx Equipment, Inc.; Recreational Equipment, Inc.; American multinational corporation Gap Inc.

1.3 Introduction

Brands strategy is gaining more popularity because they quickly adopt the latest trends through listening to the feedback from its consumers. Consumers are satisfied with the fact that they can wear clothes of the latest trend and at best comfort. Customers do not run into the same kind of clothing every time they enter a retail store and also look for an innovation or a functionality in the clothing they are willing to spend on. Brands that produce jackets with new functionalities and innovations are growing rapidly due to an increase in the interest among people who are into travelling and excursionists. Global clothing retailer claimed that it needs a minimum of two months to develop a jacket with some new innovation and functionality. More efforts are needed to develop outdoor jackets that can be used by everyone including older adults with functional limitations (Scootevest, 2001). The design will reduce the physical challenge of donning the jacket, reduce the restrictions on movement and safe ambulation, and reduce the likelihood of injury from a fall. The design will incorporate appropriate materials for weather conditions in cold regions of Europe and the United states with waterproof high-tech fabric and comfortable for users. These types of outfits are flexible and can be worn in extreme cold weather. The main purpose of outdoor and travel clothing is to protect from all types of weather and make travelers more comfortable. Such clothing is manufactured to provide added protection and insulation. They look stylish but protect the user from rain, wind and also offer warmth (Coolist, 2000).

Winter is the busiest time of year at ski resorts and some warm-weather locations, but for other popular destinations, winter is the off season. In many cities across the US and Europe, opting for a winter getaway means fewer crowds, more locals and a more authentic experience. Holiday celebrations and winter festivals are often located in picturesque ski towns surrounded by snowcapped mountains. Festivities will add both charm and entertainment options to already beautiful winter destinations.

1.4 Project Statement

There are many newly launched brands as well as already existing brands in the apparel industry. Competition is increasing day by day among brands and demand for activity specific clothing is increasing at a very fast rate. Today's customers have become more demanding about the latest trend & style specific to the activity they are performing. Inclination towards traveling as a hobby has increased compared to earlier times. Travel hobbyists take their passion very seriously and make sure to fully acquaint themselves. Customers (Excursionist) have a lot of options in terms of functionality because there are plenty of apparel brands in the market catering to such consumers, but only a few offer multiple functions in one product. The brands offering travel jackets are new to the market. Consumers are enthusiastic about adopting new product innovations but somewhat apprehensive about embracing new brands. "Innovating on established brands that are already trusted by consumers can be a powerful strategy," said Rob Wengel, senior vice president, Nielsen Innovation Analytics. To retain the existing customers and to attract new customers, brands should have the latest trend available with multiple functions. This project will discuss the different functions and offerings in the market and find the solution for winter travel excursionist jackets.

1.5 Need of the Project

New Times development is experiencing a new market emerging for travel specific green garments in western regions. Product-line expansion enables companies to take advantage of opportunities in different market sectors. Hence they are trying to expand their business like their competitors. The product that exists in the market has features but not in one single jacket.

1.6 Problem Formulation:

1.6.1 Initial Data

Innovation of an ideal excursionist jacket during the concept sample development stage to generate value for research & development in new ideas and incorporating recent technological advancement to open a new market for the brand.

1.6.2 Research Problem

New Times development is experiencing a new market emerging for travel specific green garments in western regions. Product-line expansion enables companies to take advantage of opportunities in different market sectors. Hence they are trying to expand their business like their competitors. The product that exists in the market has features but not in one single jacket.

1.6.3 Objectives

To identify the new potential design for a modular excursionist jacket that is suitable to be worn in extreme cold regions

2 Global socio-economic market trend analysis

In 2018, the winter wear market size globally was valued at USD 268.3 billion with an estimated compound annual growth rate of 4.3% by 2025. The main cause for rise in demand for good quality winter wear is global warming. Global warming is gradually lowering the weather temperature across the regions. Drop in temperature below zero in many regions is attracting the demand for winter clothes to protect the body from frostbite. Another reason driving the rise in demand is the changing fashion and travel trends. Due to the world being better connected as compared to the previous few decades, the frequency of people traveling to colder places for vacation and work purposes has increased tremendously. Rise in purchasing power of consumers, along with demand for the premium and branded products across different end users, is driving the market. Therefore, leading to the shift in consumer preferences from conventional towards newly arrived apparel, along with attraction towards light weighted winter wear products.

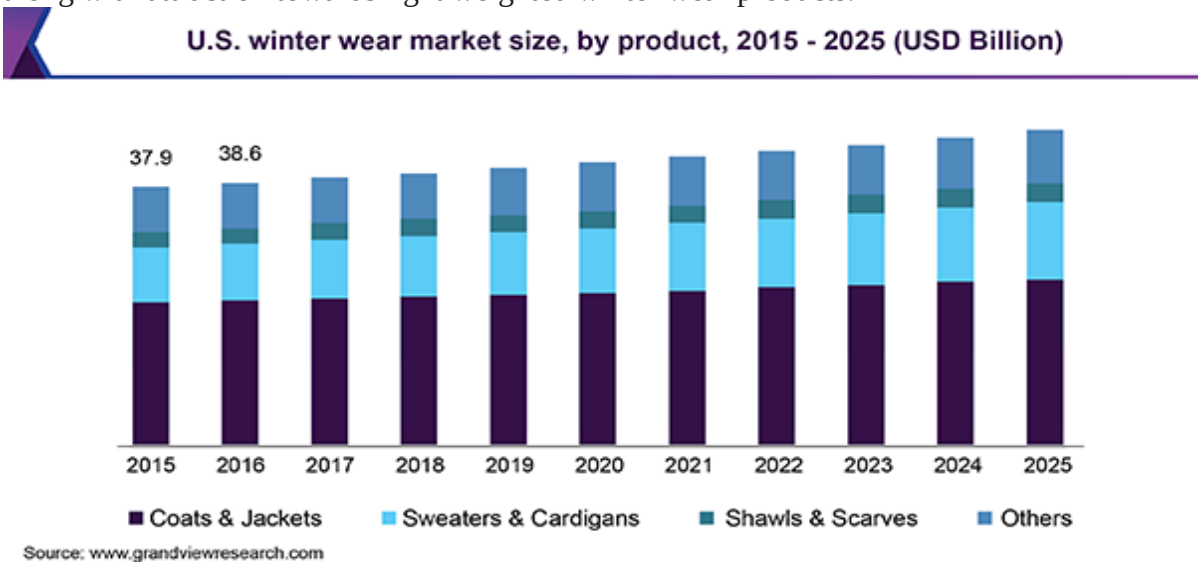


Figure 01- US winter wear market size, by product, 2015-2025

2.1 Product insights

Coats and jackets accounted for the largest share of 52.5% in winter wear in 2018. The segment is driven by rise in use of jackets for different purposes such as trekking, bike riding, armors, tours, and travels, thereby uplifting its sales in the market. However, the light and durable products available in the market has also been a key factor driving the demand in the market. The product is used as a fashionable clothing product with a high level of comfort. However, its use as a premium product with tough look and tear resistant property makes it more popular among the consumers.

2.2 End user insights

The men segment accounted for the largest share of 45.0% in the year 2018. The segment growth is attributed to trendy lifestyles and increasing penetration of men's winter wear products in

fashion apparel. Products such as jackets, hoodies and V neck and round neck cardigans are gradually gaining acceptance in the men's market. However, the growth is significantly fueled by the acceptance of the jacket products as casual and business attire by the men's category, thereby contributing to the growth of the market over the forecast period.
The women segment is expected to expand at the fastest CAGR of 4.8% over the forecast period. Penetration of different women wear products in the winter segment such as Jackets, sweaters, shawls, and scarves is driving the category. Moreover, acceptance of these products as a casual attire on festive occasions has contributed to the rise in demand for the product over the forecast period.

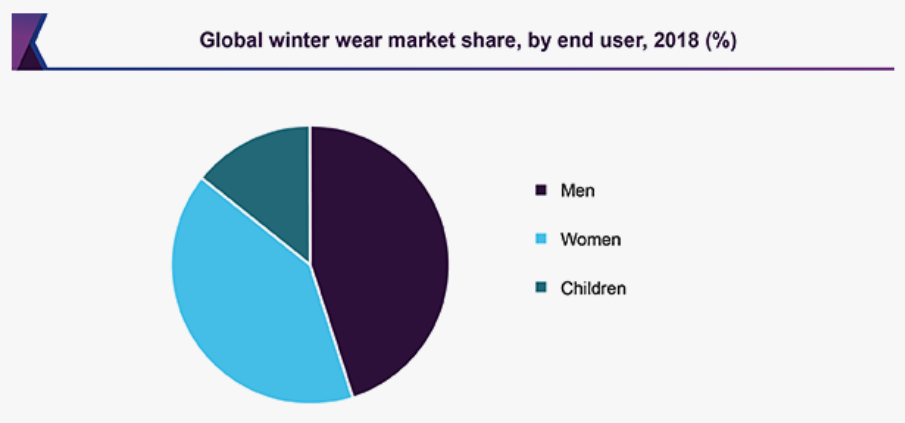


Figure 02- Global winter wear market share, by end users, 2018(%) Source:

2.3 Winter wear market share

Rising demand for winter wear products in developing countries such as China, India, and Japan leads to an increase in product innovations and developments, thereby fueling its demand in the market. Key manufacturers in the industry include Gap Inc.; VF Corporation; Columbia Sportswear Company; The North Face, Inc.; Patagonia, Inc.; Zara SA; Arc'teryx Equipment, Inc.; Recreational Equipment, Inc.; American Multinational Corporation Gap Inc.; and Crew Group, Inc.

2.4 Growth of Tour and Travel Industry

According to the World Travel and Tourism Council (WTTC), travel and tourism grew 3.9 percent in 2019, above global GDP growth of 3.2 percent. The travel and tourism industry generated 10.4 percent of all global economic activity last year. Over the last five years, it has been responsible for one in five of all new jobs created worldwide and has been the second-fastest growing sector in the world.
Also in the last year, travel and tourism increased its share of leisure spending to 78.5 percent, up from 77.5 percent in 2017. Spending from international tourists also increased to 28.8 percent in 2018, up from 27.3 percent in 2017 and 71.2 percent of spending comes from domestic tourists.

2.5 Types of travelers

There are three synonymous words: tourist, traveler and excursionist. In tourism literature, these terms are used every now and then that is why the distinction between them is necessary. For statistical measurement, it ought to be familiar with each term. Various surveys and researches need to have to clarify the distinction among them. The first definition about tourists (foreign) was drawn in 1937 by the league of nation's Committee of Statistical Experts; 'Any person visiting a country, other than in which he usually resides, for a period of at least twenty four hours.'; 'Persons travelling on holiday for a period of less than twenty four hours are treated as excursionists.' The definition of foreign tourist included persons travelling for pleasure or specific interests, meeting/representation, business and the people in sea cruises. Whereas it excluded the people seeking permanent work or residence, students and passengers passing through the country without stopping. Later the definition was adapted for domestic purposes also; a tourist is a person visiting a place for a period of at least twenty-four hours. In 1963, the United Nations Conference on Travel and Tourism (Rome) proposed the following definitions of visitor, tourists and excursionist:

- Visitor denotes a person visiting a country other than that in which he has his usual place of residence, for any reason other than following an occupation remunerated from within the country visited.
- Tourists are the visitors staying at least twenty four hours in the country visited and the purpose of whose journey can be classified under the headings: Leisure (recreation, holiday, health, study, religion and sports), Business, family, mission, meeting
- Excursionists are temporary visitors staying less than twenty four hours in the country visited (including travelers on cruise)

The definition was accepted by international travel statistics experts as it clearly distinguishes visitors, travelers and excursionists. In tourism literature, other terminologies used for tourists:

- Backpackers: independent and self-organized budget travelers
- Organize: tour activities are organized by tour company, higher spender
- Hedonists: travelers who seek only pleasure
- Volunteer: interested to work for community

2.6 Temperature zones in North America and Europe & Sustainable multifunctional winter excursionist jacket requirements

The temperature is frigid in much of Canada and the Midwestern and Eastern United States. Daily low-temperature records have dropped like snowflakes. New Year's polar plunges have been canceled due to the cold, and many people in the Southeast are in a battle to keep their pipes from freezing. In the Western U.S., Alaska, Europe, and Asia—not so much. December and January have been abnormally warm for most of the world. People in California have been worrying about wildfires in what should be the wet season, and Alaskans are ice skating in T-shirts.

From the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite, the temperature anomaly is mapped based on data. It shows land surface temperatures (LSTs) from December 26, 2017 to January 2, 2018, compared to the 2001–2010 average for the same eight-day period. Red colors depict areas that were hotter than average; blues were colder than average.

White pixels were normal, and gray pixels did not have enough data, most likely due to excessive cloud cover. Note that it depicts land surface temperatures, not air temperatures. Land surface temperatures reflect how hot the surface of the Earth would feel to the touch in a particular location. The map of North America underscores one of the realities of weather—when a cold snap hits one region, warmth often bakes another one. As the crest of a Rossby wave a ridge pushed unusually far toward Alaska in December, it dragged warm tropical air with it. In response, the other side of the wave—a trough—slid deep into the eastern United States, bringing pulses of dense, cold Arctic air south with it. The Rocky Mountains have boxed in much of the coldest, densest air, serving as a barrier between the cold and warm air masses.

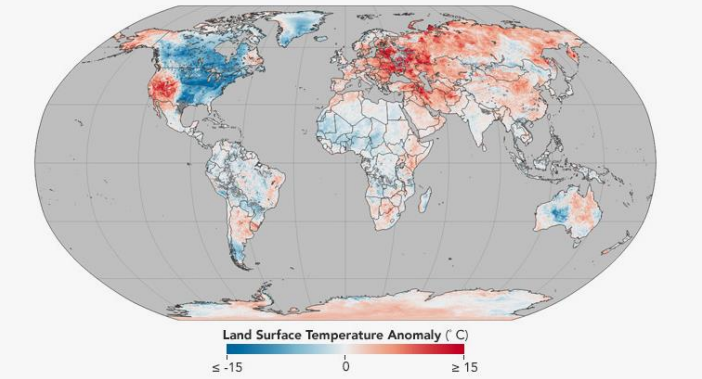


Figure 03 - Average land surface temperature anomaly

2.7 Excursionists of colder regions

During the coldest time of the year for many parts of the world, many people opt to wait until the temperatures begin rising again before going on their next vacations and many prefer to go for a vacation mainly in winters. Colder areas provide winter activities for people to partake in, such as outdoor ice skating. Such experiences are often unavailable in the summer, so it’s a treat to be able to take part in such opportunities by visiting these places in the winter.

2.8 Presence of various brands in the extreme winter jacket market

Scottevest is one of such jacket retailers who specialize in garments with conduit systems and specialized pockets and compartments for holding mobile phones, tablet computers and other portable electronic devices, and managing and controlling their wires. Scottevest coats and jackets are deliberately designed to circumnavigate baggage allowance weight and space restrictions by enabling wearers to stash the usual contents of their carry-on bag in up to 42 specially designed pockets. The designs are engineered to distribute the weight of the loaded pockets evenly across the garment, maintaining a slim, non-bulky silhouette. In addition to the jackets and outerwear, one signature design feature is incorporated channels for threading wires and flexes, inspired by an accident Jordan had after snagging the cable of his headphones on a door-handle while running through an airport.

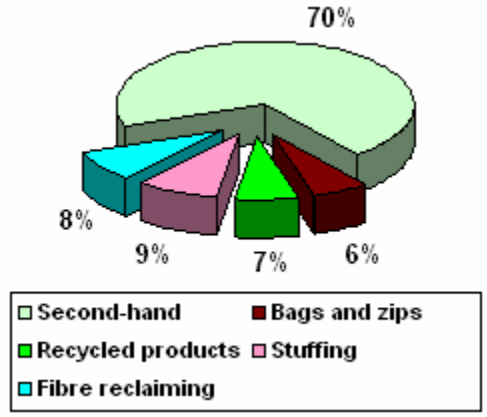
Other brands in the market providing similar jackets: Patagonia Nano Puff, Baubax Bomber, Arcteryx Beta AR, Arcteryx Cerium LT, Patagonia Nano Air, Arcteryx Macai Jacket, REI Magma down Jacket and Hardwear Ghost Whisperer Hooded Jacket.

2.9 Recycled textile

With more than 40% of the 6034 existing landfills due to close in less than five years, it is time to think of alternatives. Recycling of non-hazardous solid textile waste is a viable alternative. While recycling is not new to the textile industry, it is now a necessity brought on by increased fees at landfills and decreased availability of landfill space. Recycling is more than simply a trend or a new marketing campaign designed to make a profit as it is an economic necessity. However, the responsibilities of recycling cannot be shouldered by individual companies or industries. Recycling must be an integrated effort, a partnership among consumers, retailers, manufacturers, recyclers and the government.

The global demand for textile products is steadily increasing (The Fiber Year Consulting, 2015; Oerlikon, 2010), a trend likely to continue due population growth and economic development. Meanwhile, the textile industry is facing tremendous environmental and resource challenges. 63% of textile fibers are derived from petrochemicals (Lenzing, 2017) whose production and fate give rise to considerable carbon dioxide (CO2) emissions (Shen et al., 2010a). The remaining 37% is dominated by cotton (24%), a thirsty plant associated with water depletion – the desiccation of the Aral Sea being the most infamous example (Micklin, 2007) – and toxic pollution, due to intensive use of pesticides (FAO-ICAC, 2015). For most categories of environmental impacts, later stages in the textile production process give rise to even larger impacts (Roos et al., 2015a). Wet treatment

Figure 04 - Market for recycled goods



processes (dyeing, finishing, printing, etc.) are major sources of toxic emissions (Roos et al., 2015b), and spinning of yarns and weaving/knitting of fabrics most often rely on fossil energy use, causing emissions such as CO2 and particulates (Roos et al., 2015a). Allwood et al. (2006) suggest greenhouse emissions, water use, toxic chemicals and waste are the main environmental issues faced by the textile industry. Sandin et al. (2015) estimate that, for several environmental impact categories, the impact per garment use in a western country (in this case, Sweden) must be reduced by 30–100% by 2050 if the industry is to be considered sustainable with regard to the planetary boundaries outlined by Steffen et al. (2015). Roos et al. (2016) show that such a grand transition requires a combination of different measures for impact reduction, most likely including more reuse and recycling.

Textile reuse refers to various means for prolonging the practical service life of textile products by transferring them to new owners (Fortuna and Diyamandoglu, 2017), with or without prior modification (e.g. mending). This can for example be done through renting, trading, swapping, borrowing and inheriting, facilitated by, for example, second hand shops, flea markets, garage sales, online marketplaces, charities and clothing libraries. In the academic literature, various

forms of reuse have been conceptualized in terms such as collaborative consumption, product-service systems, commercial sharing systems and access-based consumption (Belk, 2014).
Textile recycling, on the other hand, most often refers to the reprocessing of pre- or post-consumer textile waste for use in new textile or non-textile products. In this paper, we adopt a more generous notion of textile recycling, also including the recycling of non-textile materials and products (such as polyethylene terephthalate (PET) bottles) into textile products.

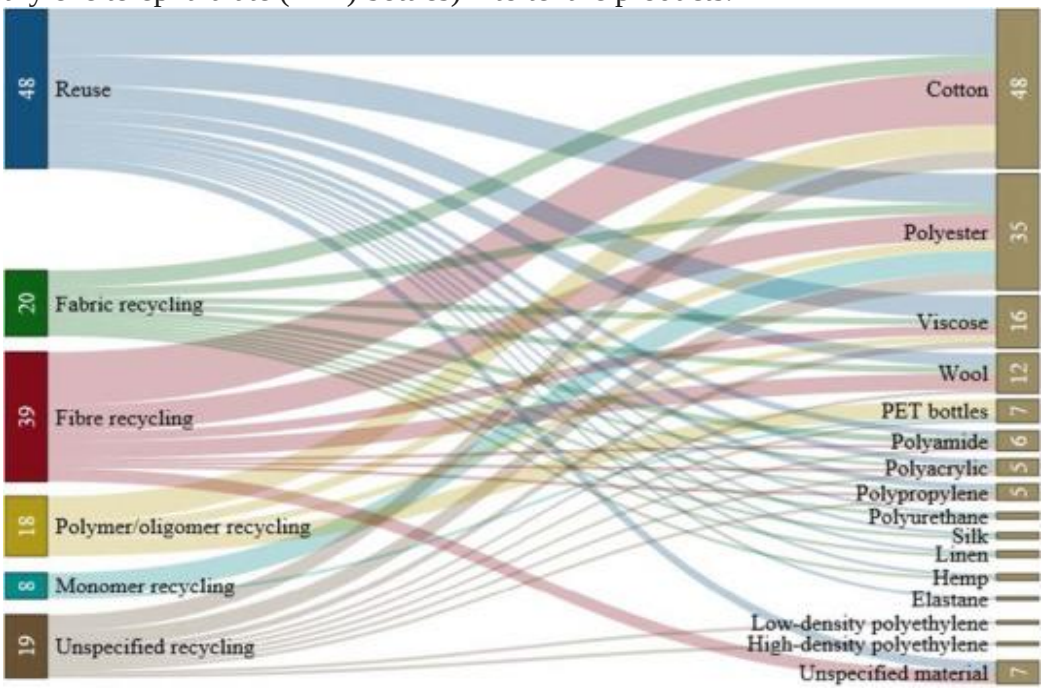


Figure 05 - Prevalence of studied combinations of reuse/recycling routes and studied materials . Numbers correspond to the number of cases examining reuse, or a specific recycling route, for a certain material. For example, there are only five publications of fabric recycling, but three of those cover fabric recycling of several materials, adding up to a total of 20 studied cases of fabric recycling

Textile recycling routes are typically classified as being either mechanical, chemical or, less frequently, thermal. This is in many cases a simplification of reality, as recycling routes often consist of a mix of mechanical, chemical and thermal processes. For example, chemical recycling most often refers to a recycling route in which the polymers are depolymerised (in the case of synthetic polymer fibers derived from petrochemicals, such as polyester) or dissolved (in the case of natural or synthetic cellulosic fibers, such as cotton and viscose). Having thus been disassembled to molecular levels, monomers or oligomers are depolymerized, and polymers respond into new fibers. However, prior to the depolymerisation or dissolution, the recycled material is most often mechanically pretreated. Moreover, thermal recycling often refers to the conversion of PET flakes, pellets or chips into fibers by melt extrusion – but the flakes, pellets and chips have been produced from PET waste by mechanical means, which is why this recycling route is sometimes referred to as mechanical recycling (Shen et al., 2010b). Furthermore, the term thermal recycling is easily confused with thermal recovery, which is when textile waste is incinerated to generate heat and/or electricity (Schmidt et al., 2016). To complicate things further, incineration with energy recovery is occasionally labeled as recycling, although the term recycling most often refers solely to material recycling. If the fabric of a product is recovered and reused in

new products, we refer to this as fabric recycling (sometimes this is referred to as material reuse (Zamani et al., 2015)). If the fabric is disassembled, but the original fibres are preserved, this is fibre recycling. If the fibres are disassembled, but the polymers or oligomers are preserved, this is polymer/oligomer recycling. And if the polymers/oligomers are dissembled, but the monomers are preserved, this is monomer recycling. Then there are various means of achieving these types of recycling routes, often by combining various mechanical, chemical and thermal processes. The above systematization of recycling routes resembles a systemization recently presented by the Ellen MacArthur Foundation (2017a).

Other classifications of recycling routes also deserve mentioning. For example, if the recycled material is of lower value (or quality) than the original product, this is termed downcycling. Today, existing textile recycling routes are in most cases down cycling. Clothing and home textiles are downcycled into, for example, industrial rags, low-grade blankets, insulation materials and upholstery (Schmidt et al., 2016). In contrast, if a product from recycled material is of higher value (or quality) than the original product, it is termed upcycling. As the length of the fibres and the constituent molecules are reduced by wear and laundry (Palme et al., 2014), fabric and fibre recycling typically yields materials of lower quality (if quality is defined in terms of fibre quality) than materials made from virgin fibres (unless mixed with yarn from virgin fibres). Thus fabric and fibre recycling are typically considered to be downcycling (at least in terms of fibre quality – in terms of other qualities of the end product, such as aesthetics, fit-for-purpose or material qualities defined by fabric construction rather than fibre quality, certain end products made from recycled fibres or fabrics may still be considered upcycled). In contrast, polymer, oligomer and monomer recycling typically yields fibres of similar quality to virgin fibres. It should be emphasised that just because fibre and fabric recycling are examples of downcycling (in terms of fibre quality), they are not necessarily less preferable from a waste hierarchy perspective compared to polymer, oligomer or monomer recycling. In contrast, a cascade approach could be optimal, in which the textile waste first enters fabric or fibre recycling, and once the fibre length has been reduced to a level at which the material is not fit for fabric or fibre recycling, it enters polymer, oligomer or monomer recycling.

Another classification for recycling routes is into closed- or open-loop recycling. Closed-loop recycling refers to when the material from a product is recycled and used in a (more or less) identical product, whereas open-loop recycling (also called cascade recycling) refers to processes in which the material from a product is recycled and used in another product (Ekvall and Finnveden, 2001; Klöpffer, 1996). A "product" can here refer to different levels of refinement, which means that a given recycling route may be referred to as either closed- or open-loop recycling, depending on context. For example, something that is a product in a business-to-business context (e.g. a fibre or a fabric) may not be in a retail or consumer context (where garments are key textile products). The latter viewpoint would imply that closed-loop recycling relies on, for example, a T-shirt being recycled into a T-shirt – or even a T-shirt of a certain size, colour and, perhaps most importantly, quality (e.g., fibre length) being recycled into a T-shirt of the same size, colour and quality. In contrast, a more lax definition of closed-loop recycling could, for example, be that a material category (such as packaging) is recycled into the same material category rather than another (such as textiles, as is the case in the aforementioned bottle-to-fibre recycling) (Östlund et al., 2015).

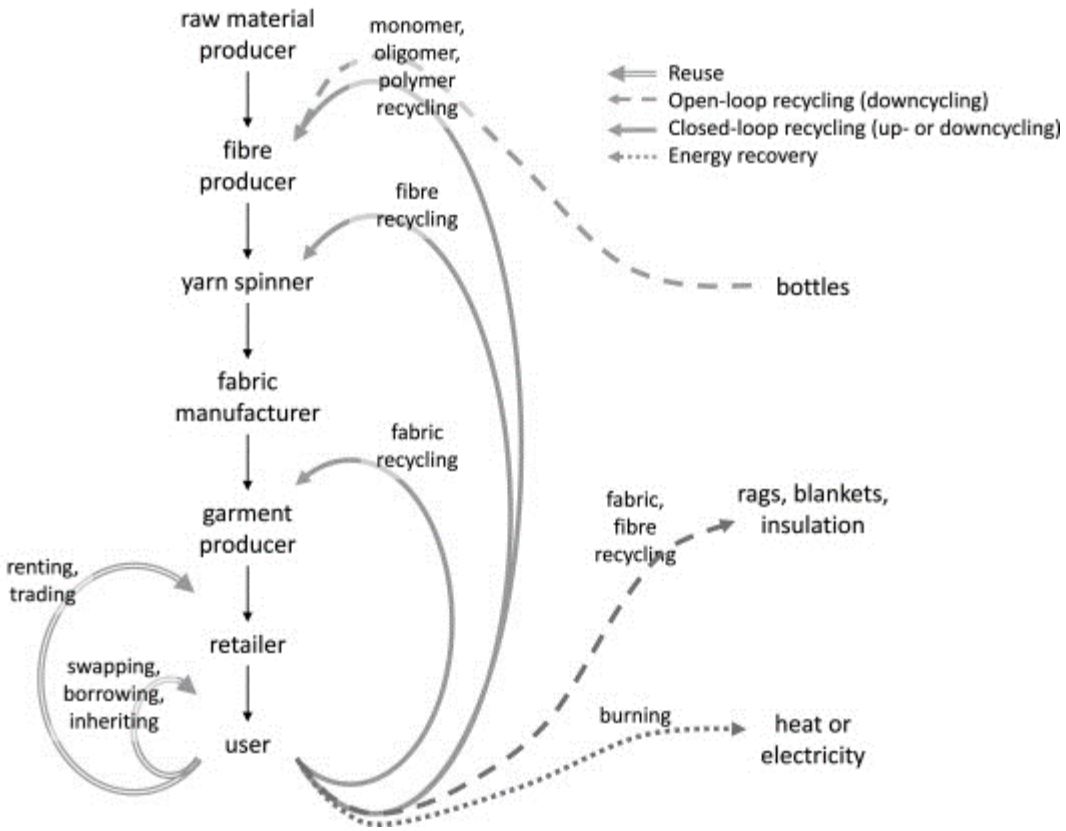


Figure. 06. A classification of textile reuse and recycling routes.

2.10 Recycling processes per fibre

Table 01: Description of the recycling process per fiber

Fibre	**Material input**	**Mechanical recycling process**	**Chemical recycling process**
Polyester	Polyethylene terephthalate (PET), approximately 95% of which comes from PET bottle recycling. Recycled polyester represents about 7% of all the virgin polyester production. (Textile Exchange Preferred Fibre Materials Market Report, 2017.)	Plastic PET containers are sorted by type and colour. The labels are then removed and the bottle is washed, crushed and chopped into flakes. The flakes are dried out and sent through a rotating screw, which heats the flakes to 220 degrees. It then enters a canal and emerges on the other side as fine long threads, which are then further processed into yarns	The material is first depolymerized to a base chemical molecule called monomer and then repolymerised with the help of chemical additives (typically methanolysis, glycolysis or hydrolysis) before being extruded into chips.

Nylon / Polyamide	As different types of nylon exist, the input has to be relatively homogenous waste material: e.g. nylon, old fishing nets, waste and scraps from virgin nylon production and textiles provided they are the same nylon type.(Textile Exchange Material Snapshot, http://textileexchange.org/downloads/material-snapshotrecycled-nylon-6/)	This is typically done with post-industrial nylon waste. The nylon is cleaned and then simply pelletized for further use.	A polymer is chemically de-polymerized and broken down into its monomer components. It is then re-polymerized to make a new yarn.
Cotton	The input material is any cotton garment.	Mechanical recycling of cotton is the most established recycling process, but still represents only a small percentage in volume. It consists of separating the waste by colour and then shredding it before it is re-spun into new yarns.	Chemical recycling of cotton is currently still at lab level but shows promising innovative development where for example the cotton is retrieved from post-consumer waste garments and dissolved to a molecular level. From there, it becomes a dissolving pulp to make viscose and lyocell products.
Wool	The input material is mainly pre-consumer wool waste.	Wool has been recycled commercially for at least 200 years. It consists in separating the waste by colour and then pulling the garment back into a fibrous state to make new products. (S. Russell, P. Swan, M. Trebowicz, and A. Ireland, "Review of Wool Recycling and Reuse," in Natural Fibres: Advances in Science and Technology Towards Industrial Applications, ed. R. Fangueiro and S. Rana (Dordrecht: Springer Netherlands, 2016), 415-428. doi:10.1007/978-94-017-7515-1_33.)	This process is not done today.

2.11 Ecological advantages of recycled fibers versus virgin fibers

Table 02: Comparison of the recycling process to virgin fibers

FIbre	Polyester	Nylon	Cotton	Wool
Land use	No land use as input material already exists.			
Water intensity	Both recycled and virgin polyester have a low water use so there is effectively no difference. (2 WRAP (2017) in personal correspondence with reference to the footprint calculator used for the Sustainable Clothing Action Plan http://www.wrap.org.uk/sustainable-textiles/scap)	Both recycled and virgin nylon have a low water use so there is effectively no difference.(WRAP (2017) in personal correspondence with reference to the footprint calculator used for the Sustainable Clothing Action Plan http://www.wrap.org.uk/sustainable-textiles/scap)	Low water use in the recycling process and low impact compared to growing cotton, which needs 2700 liters to make one cotton tee-shirt.	Low water use in the recycling process.
Chemistry	For mechanically recycled polyester, no chemistry is used other than detergents for cleaning the input material.	For mechanically recycled nylon, no chemistry is used. Chemically recycled nylon uses high temperature, high pressure and a common chemical for the process. (Aquafil (2017), in personal correspondence..)	Fewer chemicals are used than in conventional cotton as recycling does not include any farming operations.	Recycled wool requires fewer chemicals than conventional wool as neither farming nor scouring are required.
Energy	Recycled polyester uses 59% less energy than virgin polyester.	For example, the ECONYL (R) Chemically regenerated nylon uses 60% less energy than virgin nylon. (6 Aquafil (2017), based on Econyl's life cycle assessment.)	Energy requirements are almost 20% lower for recycled cotton than for conventional cotton	Energy requirement are lower for recycled wool.

CO2 emissions	Recycled polyester reduces emissions by 32% compared to virgin polyester. (7 WRAP (2017) in personal correspondence with reference to the footprint calculator used for the Sustainable Clothing Action Plan http://www.wrap.org.uk/sustainable-textiles/scap)	Recycled nylon reduces emissions by 26% compared to virgin nylon.(WRAP (2017) in personal correspondence with reference to the footprint calculator used for the Sustainable Clothing Action Plan http://www.wrap.org.uk/sustainable-textiles/scap)	By replacing the need for farming and avoiding the use of synthetic agrochemicals, emissions are minimized.	By replacing the need for farming and hence avoiding the emissions of methane during the animal's digestive process and the use of agrochemicals, emissions are minimized.

2.12 Benchmark for Fibers

The ecological advantages of recycled fibres versus virgin fibres differ per type of fibre but also within the same fibre depending on the origin and the recycling process. Quantitative data is not readily available and this lack remains an important point of discussion in the industry. More solid and scientific based data is needed to make informed decisions. Some organizations have set out to fill the gap. A Consortium led by Quantic is building up the World Apparel & Footwear Life Cycle Assessment Database, which is meant to provide specific data based on reliable life cycle assessments. The Higg Materials Sustainability Index (Higg MSI) is a material scoring tool from the Sustainable Apparel Coalition that measures the environmental performance of thousands of materials used in creating apparel, footwear and home textile products. MADE-BY, a not-for-profit organization specializing in sustainability in textiles, developed a benchmark in 2009 to compare the environmental impact of the most commonly used fibres in the garment industry. Although this benchmark has been criticized for being an oversimplification of a complex topic (e.g. the environmental impact of a fibre depends on so many parameters: country of origin, irrigation used, actual supply chain) leading to a biased classification, it has the merit of being open source and providing a first glimpse into the environmental impact of different fibres:

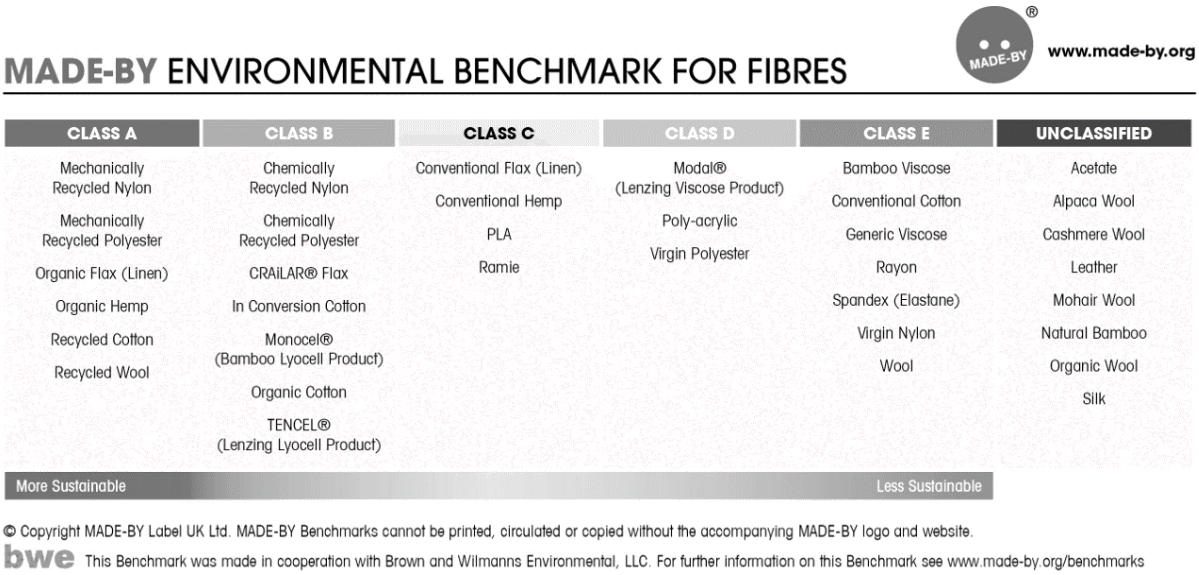


Figure 07- Made-By Environmental Benchmark for Fibers

2.13 Product Development

Table 03: Fibre Comparison for product development

Fibre	Currently available	Limitations
Recycled polyester	Most widely used fibre, with suppliers starting to offer some garments with recycled polyester. The quality is said to be the same, although more insight is needed as there is still a relatively low uptake in wear and, as a result, a lack of feedback.	The colour whiteness grade may not be as bright as For example the medical wear would expect it to be. For PPE, using recycled polyester in place of polyester could be possible in theory but it is hardly done as PPE wear is a combination of many different materials and largely constructed from chemicals.
Recycled nylon	Still very small scale in the industry in general and hardly mentioned in professional wear.	The market is limited to a few suppliers, which makes the access to this fibre more expensive.
Recycled wool	Not widely referred to.	Although it is an old recycling method, the market is very small and still needs to be built up.
Recycled cotton	It depends on the applicability. The market and large companies are working to find solutions, but the journey is a long one	Lower quality and performance can be an issue for apparel wear. However, these challenges can be overcome if recycled cotton is mixed with virgin fibre.

2.14 Upcycling and down cycling

With upcycling the recycled raw materials can be used again in equal or even higher value application level (product) than its original level (e.g. recycled PET yarn from plastic PET bottles). Downcycling means that the recycled materials are used on a lower quality level (e.g. isolation felt in the automotive from roughly unravelled textile waste). Reclaiming fibres avoids many of the polluting and energy intensive processes which are needed to make textiles from virgin materials. All recycled fibres score best of class on environmental performance (class A in the MADE-BY fibre benchmark). The Fiber Benchmark (MADE-BY) compares the environmental impact of the most commonly used fibers in the garment industry, supporting you to shift to more sustainable alternatives. Twenty-eight fibers are ranked on six parameters: greenhouse gas emissions, human toxicity and Eco toxicity (20% weight), energy, water and land use (13, 33% weight). The fibers are placed in Class A to Class E, fibers in 'Unclassified 'are not able to be ranked, yet.

2.15 Recycled cotton

Recycled cotton can be generally defined as converting cotton fabric into cotton fiber that can be reused in textile products. Recycled cotton is also commonly referred to as regenerated cotton, reclaimed cotton or shoddy. Recycled content includes recycled raw material, as well as used, reconditioned, and re-manufactured components. Textile recycling is generated from two primary sources:

1. Pre-consumer: includes scraps created by yarn and fabric by-products
2. Post-consumer: includes garments, upholstery, towels, household items to be repurposed

The largest volume of recycled cotton sources is produced through pre-consumer waste, such as cutting scraps. Post-consumer waste is more difficult to sort through due to various color shades, fabric blends, and it is generally a more labor-intensive process.

Cotton recycling prevents unneeded wastage and can be a more sustainable alternative to disposal. Recycled cotton can come from secondhand clothing or from textile waste or leftovers which are then spun into new yarns and fabrics. There are some notable limitations of recycled cotton, including separation of materials that are cotton/polyester mix.

Cotton can be recycled from pre-consumer (post-industrial) and post-consumer cotton waste. Pre-consumer waste comes from any excess material produced during the production of yarn, fabrics and textile products, e.g. selvage from weaving and fabric remnants from factory cutting rooms. Post-consumer waste comes from discarded textile products, e.g. used apparel and home textiles. During the recycling process, the cotton waste is first sorted by type and color and then processed through stripping machines that break the yarns and fabric into smaller pieces before pulling them apart into fiber. The mix is carded several times in order to clean and mix the fibers before they are spun into new yarns.

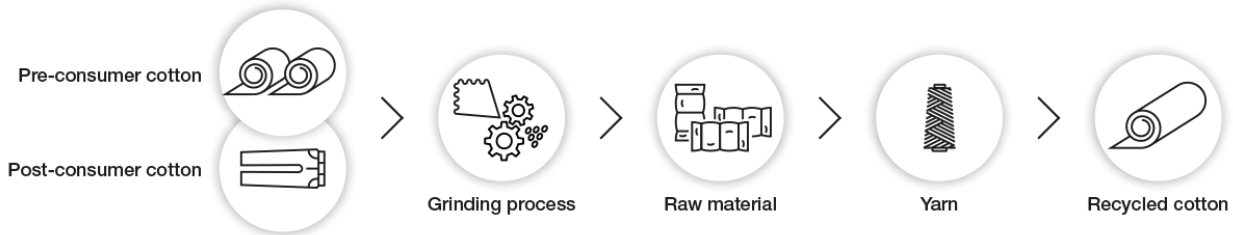


Figure 08: Recycling process for cotton garment

The resulting staple fiber is shorter than the original fiber length, meaning it is more difficult to spin. Recycled cotton is therefore often blended with virgin cotton fibers to improve yarn strengths. Commonly, not more than 30% recycled cotton content is used in the finished yarn or fabric.
Because waste cotton is often already dyed, re-dyeing may not be necessary. Cotton is an extremely resource-intense crop in terms of water, pesticides and insecticides. This means that using recycled cotton can lead to significant savings of natural resources and reduce pollution from agriculture. Recycling one tons of cotton can save 765 cubic meters (202,000 US gal) of water.
Recycled cotton is often combined with recycled plastic bottles to make clothing and textiles, creating sustainable, earth-conscious products. Recycled cotton can also be used in industrial settings as polishing and wipe cloths and can even be made into new, high-quality paper. When reduced to its fibrous state, cotton can be used for applications like seat stuffing or home and automotive insulation. It is also sold as recycled cotton yarn for consumers to create their own items. Additionally, cotton waste can be made into a stronger, more durable paper than traditional wood-pulp based paper, which may contain high concentration of acids. Cotton paper is often used for important documents and also for bank notes since it does not wear off as easily.

2.16 Mechanical Recycling

The general process of mechanical recycling of cotton for apparel applications involves the repining of waste fibres. Given that the mechanical process breaks the fibre, quality and strength are reduced and therefore, the recovered staple fibre must be blended with either virgin cotton fibres or other fibres to impart both increased strength, and to provide colour matching, thereby eliminating the need for re-dyeing. Other applications that utilize pre-consumer and post-consumer cotton as feedstock materials include a variety of nonwovens used for insulation, automotive felts, oil sorbent sheeting. The main challenge cited for widespread commercial adoption of closed-loop repining lies in facilitating logistical support to increase volume of material collected and processed.
The process flow diagram in figure below details the options for mechanical recycling of cotton to produce respond fibre for apparel, and blended materials for various applications.

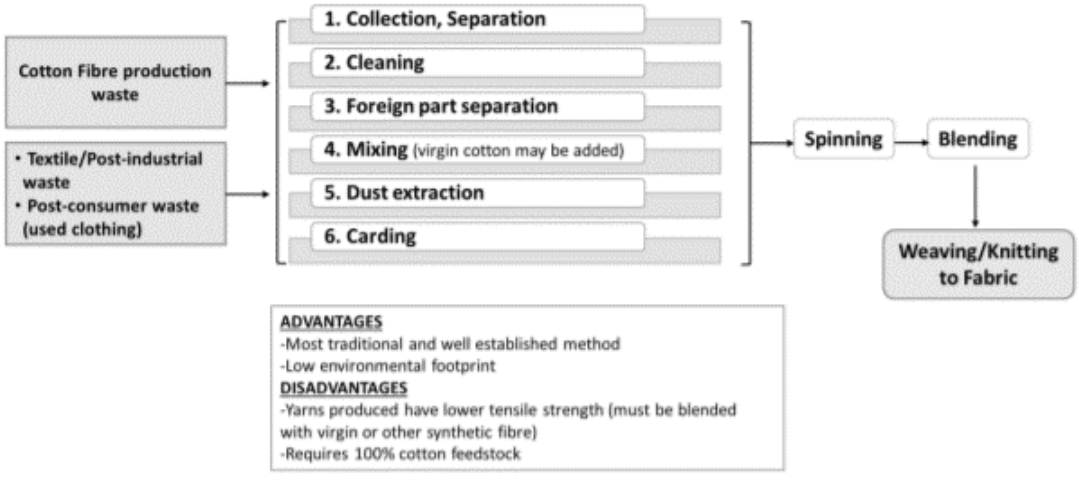


Figure 09: Overview of mechanical recycling process of cotton

2.17 Chemical Recycling

The chemical recycling process of cotton is based on the dissolution of cellulose. Two main routes which have been explored include: the DE polymerization of glucose monomers for use in other applications, or a polymer dissolution route where the separation and regeneration of cellulosic fibres occurs by use of solvents. The latter process may recover a chemically modified or pure cellulosic fibre product, which can also be incorporated as feedstock for regenerated/recycled man-made cellulosic fibres (MMCs). Chemical processes for recycling and regenerating MMCs would also reduce the burden of toxic chemicals, namely carbon disulfide used in conventional viscose production, and enable the production of fibres with equivalent virgin quality. The Local (NMMO) and Ionic Liquid processes are two main chemical recycling methods which have been explored and developed. Figure below summarizes the different chemical based processes for cotton fibre recycling.

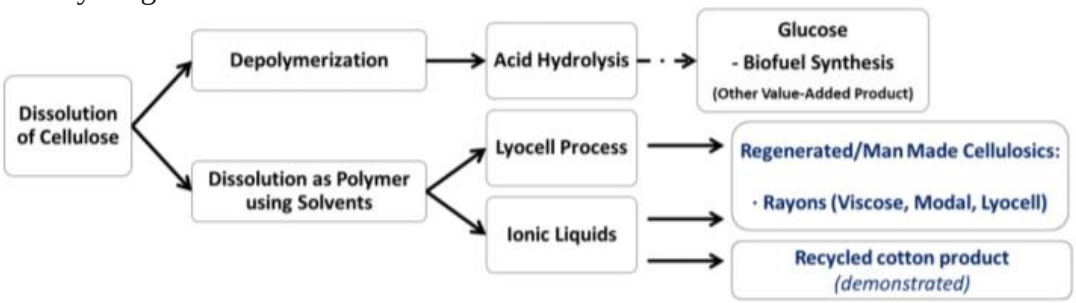


Figure 10: Overview of cotton chemical recovery processes

2.18 Benefits

- Recycled cotton can find new life in many different low grade products such as insulation, mop heads, rags, and stuffing.
- The process of recycling can divert many products from landfills. According to the Council for Textile Recycling, annual textile waste is estimated to equal 25 billion pounds.
- The amount of energy, water, and dye use is reduced from using a product that has already been processed. The savings are achieved through offsetting production of new materials. Since recycled cotton yarns most commonly are sourced from pre-consumer textile scraps that are sorted by color, the yarns are already dyed.
- The CO2 and fossil fuel emission savings can be partially offset from using existing materials. However, the collection, processing and shipping of cotton scraps or clothing can reduce or neutralize some of these savings.

2.19 Challenges

- Fibers will be shorter due to reprocessing, making weaker threads. Cotton must be blended with other fibers to be made into new yarn for strength and durability, and therefore cannot continuously be recycled.
- The content of recycled cotton will depend on end-use application. Any amount of recycled product will impact the yarn and fabric properties such as evenness, strength, and uniformity.

- Recycled yarn cost is generally higher than standard, virgin cotton yarn costs, and could possibly be cost-prohibitive.
- Testing instruments are made for ginned, virgin cotton. Sometimes, testing results can be skewed due to the difference in fiber packing and orientation.
- The risk of contamination by other fibers is much higher for recycled cotton. Stitching, sewing thread, small amounts of spandex should all be taken into account when establishing the recycled supply chain.

2.20 Recycled wool

Wool is a natural animal protein fibre that grows on sheep (other sources: goats, llamas etc.). The protein fibre is known as keratin. Wool exhibits many favorable properties in apparel, consumer products, as well as industrial textile applications. Wool has favorable thermal comfort properties, being breathable, warm, and moisture wicking. It is easily dyed and requires less washing than other fibres. The relatively long fibre length of wool makes it well suited for mechanical recycling. Wool accounts for up to 5% by weight of total clothing donated for recycling and reuse. Wool recycling has been practiced for over 200 years, with several options for its reuse, and is considered as one of the most reused fibres. The production stages from fibre to garment, along with recycling flows during process steps are outlined in Figure below:

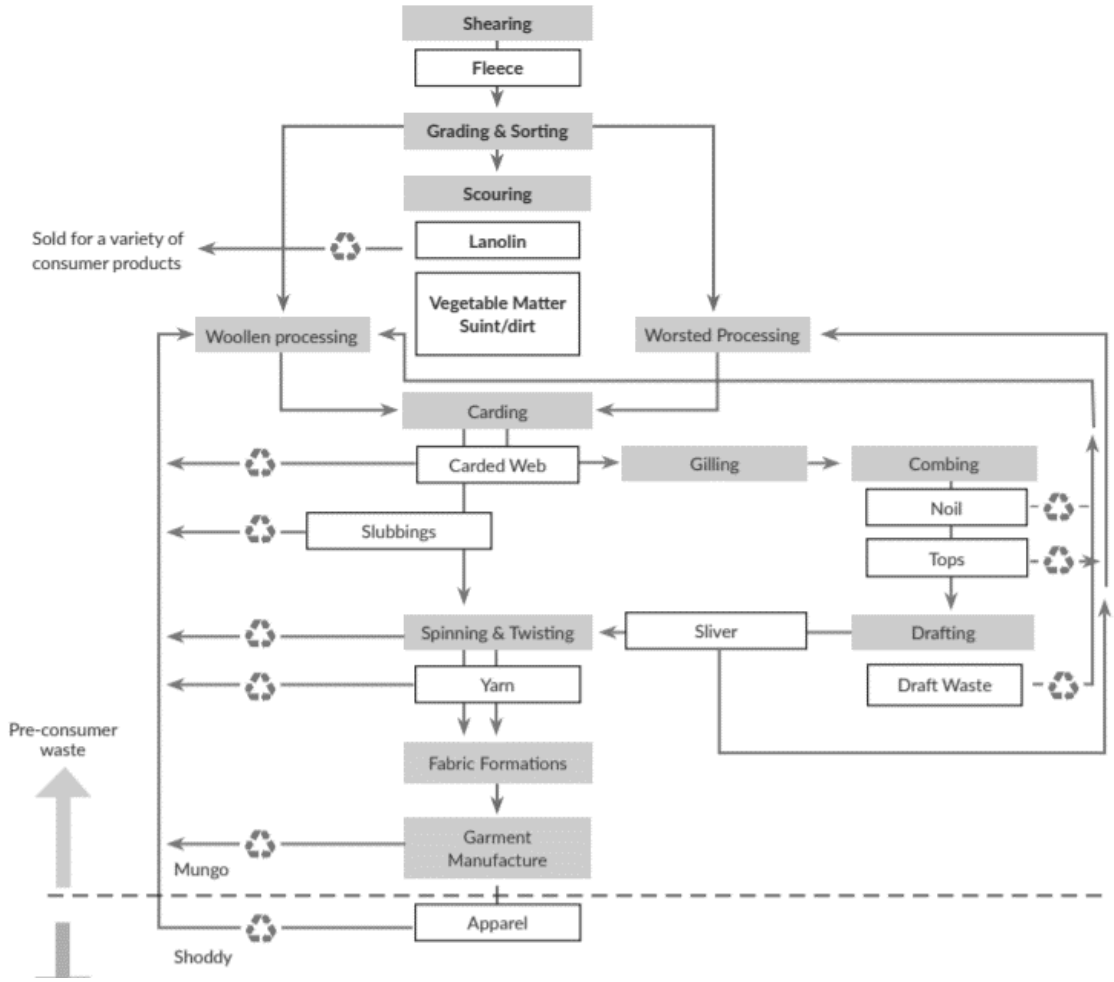


Figure 11: Overview of wool fibre processing steps with recycling flows of post-industrial and post-consumer waste

Wool textile waste is processed from both post-industrial (pre-consumer) and post-consumer materials. The textile waste recovered from manufacturing process (post-industrial) following closed-loop steps in which waste is continuously fed into different processing steps (Figure 20).109 Wool textile recycling is applied in commercially practiced open loop and closed loop mechanical processes. While chemical recycling of wool is not performed, there have been many research developments into recovery processes of keratin from pre- and post-consumer waste wool for other value-added applications.

2.21 Mechanical Recycling

Open Loop Recycling System (Pre-Consumer and Post-Consumer Waste): From this process, the recycled wool is mechanically pulled into their fibrous form and used as raw materials for new industrial products. Nonwoven fabrics are most commonly produced from this recovery system and used for the production of insulator pads for mattress or furniture, automotive felts and insulating materials, and oil sorbent sheeting. Nonwoven products are less sensitive to impacts on properties due to shorter fibre lengths, and the products derived from this system contribute to greater sustainability owing to a substantially longer second operational life. Figure below details basic steps in an open loop recycling system for wool, and examples of products and compositional requirements.

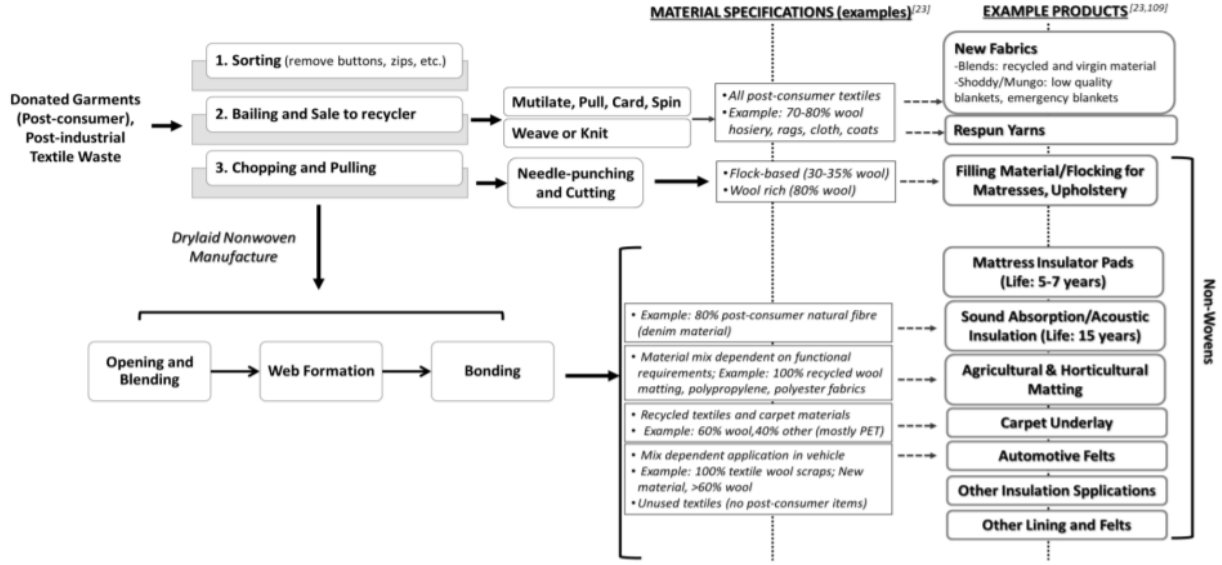


Figure 12: Open-loop recycling system for wool, with examples.

Closed Loop Recycling System (Post-Consumer Waste): During this process, garments are mechanically pulled into their raw fibre state (carding) and reused as raw material in the repining back to yarn by conventional processes. The yarn can be used to produce new high-value garments. With the impact of fibre breakage during mechanical recycling, the respond yarn will contain a blended proportion of virgin fibre, which can either be virgin wool, or synthetic fibre (reduce raw material costs in yarn manufacture). The sorting of wool by colour, may also be a means of eliminating the need for subsequent dyeing processes. Figure below summarizes the basic steps in the closed loop recycling for wool.

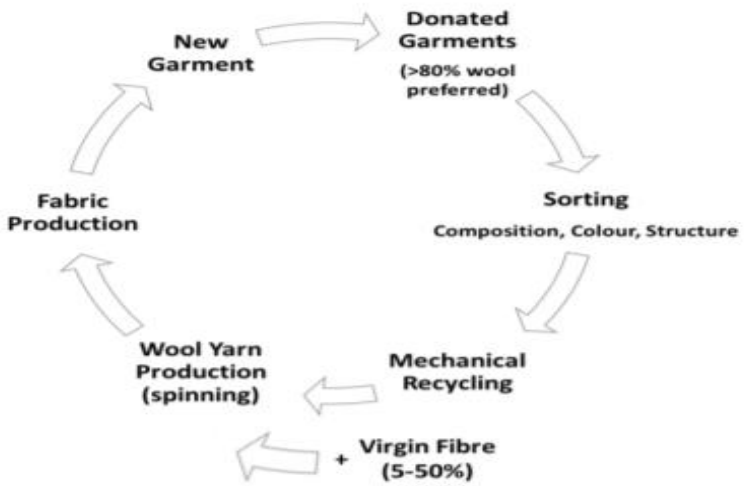


Figure 13: Basic steps in closed loop recycling of wool.

2.22 Recycled Nylon

Since Nylon is made of petroleum products it will not biodegrade. Nylon doesn't break down easily and accounts for about 10% of the debris in the ocean. According to the World Society for the Protection of Animals, more than 600,000 tons of fishing gear is dumped into oceans every year, including nylon nets. Fishermen often discard the nets because the alternative is much costlier – paying someone to dispose of them properly.

Nylon is a widely used synthetic polymer material for various applications and is also the generic term for polyamide-based materials. Nylon-6 and Nylon-6, 6 comprise approximately 85% of nylon material used. Main commercial applications for nylon include, fibre, packaging/films, carpet, and component parts most commonly found in the automotive industry. Nylon is characterized by its high strength, elasticity, wrinkle-resistance, and higher moisture regain than polyester. While nylon production holds a lower proportion than polyester in annual synthetic fibre production, it requires more energy to manufacture, and nearly three times as much as conventional cotton.55 Dyeing nylon is not suited to natural or low-impact chemical dyes, and is thereby another contributing factor to the environmental impact from its production process.56 Nylon derived micro plastic pollution in aquatic environments has been found to originate from nylon fishing nets (with total fishing net waste accounting for 10% of ocean waste), and synthetic textile fibres from laundering. 56 Nylon-6 is produced from the ring-opening polymerization of a single monomer, Ɛ-caprolactam –forming polycaprolactam (Figure 9). "6" denotes the 6 carbon atoms that comprise caprolactam.

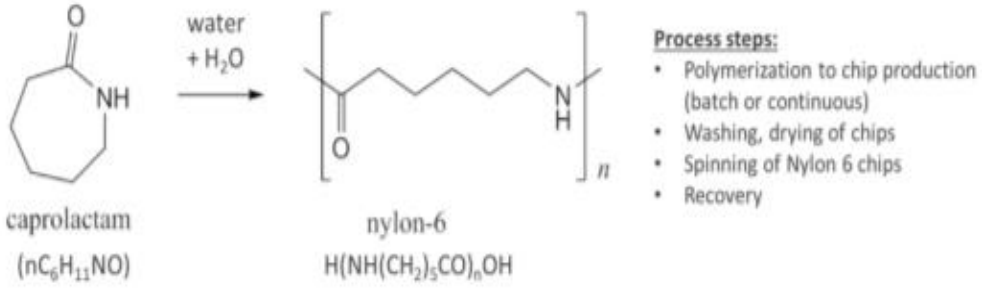


Figure 14: Polymerization of Nylon 6 (general process).

Nylon-6,6 is produced by combining two monomers – adipic acid (AA) and hexamethylenediamine (HMD) acid (or HMDA), with water, also known as a polycondensation reaction (Figure 10). “6, 6” denotes the 6 carbon atoms in each of the two monomers (AA and HMD) which comprise the polymer

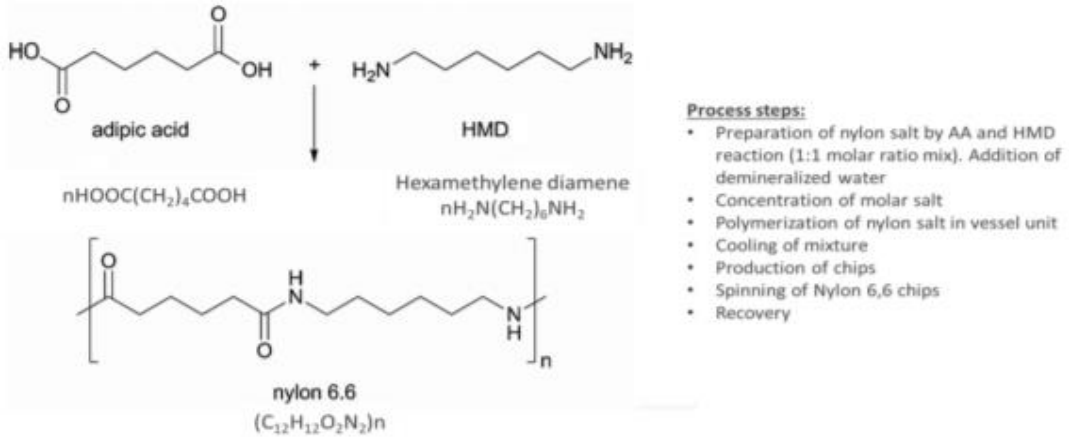


Figure 15: Polymerization of Nylon-6, 6 (general process).

Nylon-6 fibres exhibit high elasticity and lustre and are commonly used for carpet fabrics and rope. Nylon-6, 6 is characterized as being more wear resistant and durable than Nylon-6, with a slightly higher melting temperature.

2.22.1 Nylon Recovery and Recycling

The closed-loop recovery of Nylon-6 has been widely used in the carpet industry, through combining mechanical and chemical (depolymerization) processes. Chemical or monomer recovery systems are applied to volatilized caprolactam after spinning operations during Nylon-6 fibre formation. The depolymerization of Nylon-6,6 is more complicated, since it is composed of two different monomers and often requires a larger volume of reagents, which may be potentially more damaging, and produce more waste product. Chemical recycling of Nylon-6, 6 is not performed commercially, and monomer recovery systems are not feasible given that the processing of the compound does not yield large volumes of residual monomers. Nylon-6, 6 is commonly recycled mechanically from pre-consumer fibres.

2.22.2 Mechanical Recycling

The process for the mechanical recycling of nylon may involve the following steps:

- Cleaning process to remove impurities
- Shredding and grinding
- Melting into chips/pellets from which they can be used in new applications
- For fibre production: the recycled chips are melted and respun into filaments

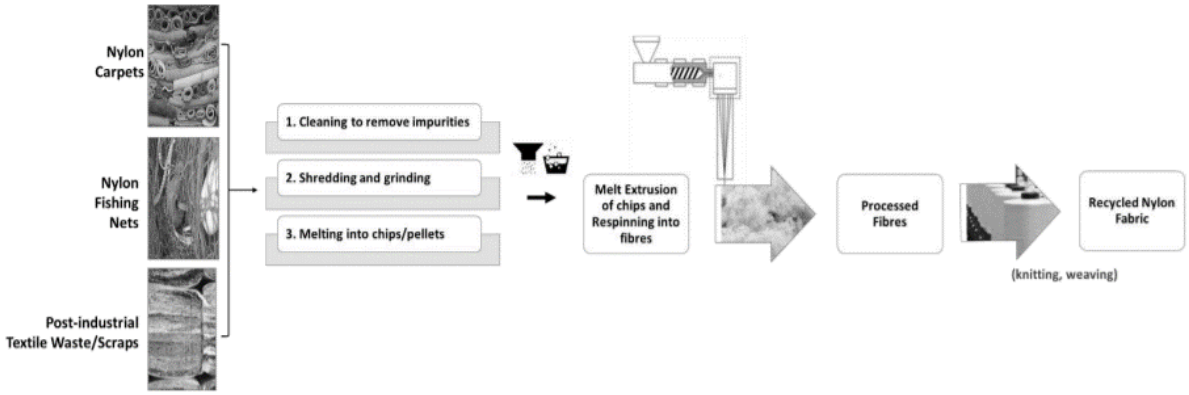


Figure 16: General route for mechanical recycling of nylon.

2.22.3 Chemical Recycling

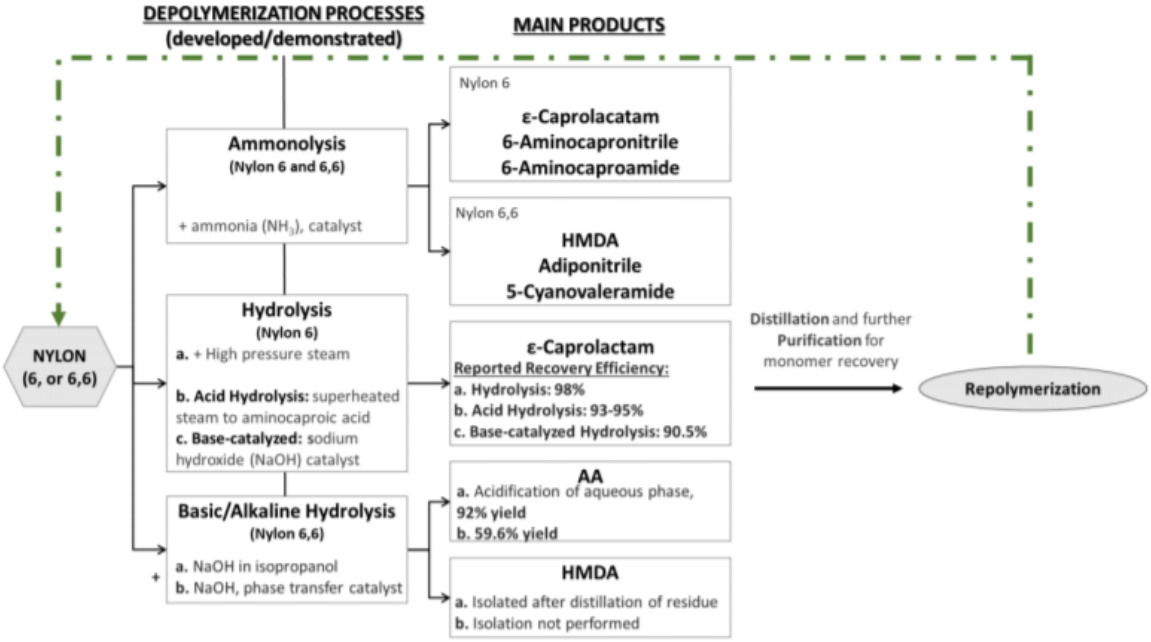


Figure 17: Overview of different approaches for chemical recycling of nylon.

Chemical recycling of nylons (6 and 6, 6) includes a depolymerization process followed by distillation to obtain and recover their monomeric constituents: caprolactam (for Nylon-6), and HMDA and adipic acid (for Nylon-6, 6). Various chemical processes have been demonstrated and developed, and are summarized in Figure 12. Barriers to their widespread adoption have included high costs, challenging materials issues, multiple processing steps requiring high operational knowledge, which are thought to pose difficulties for technology transfer.

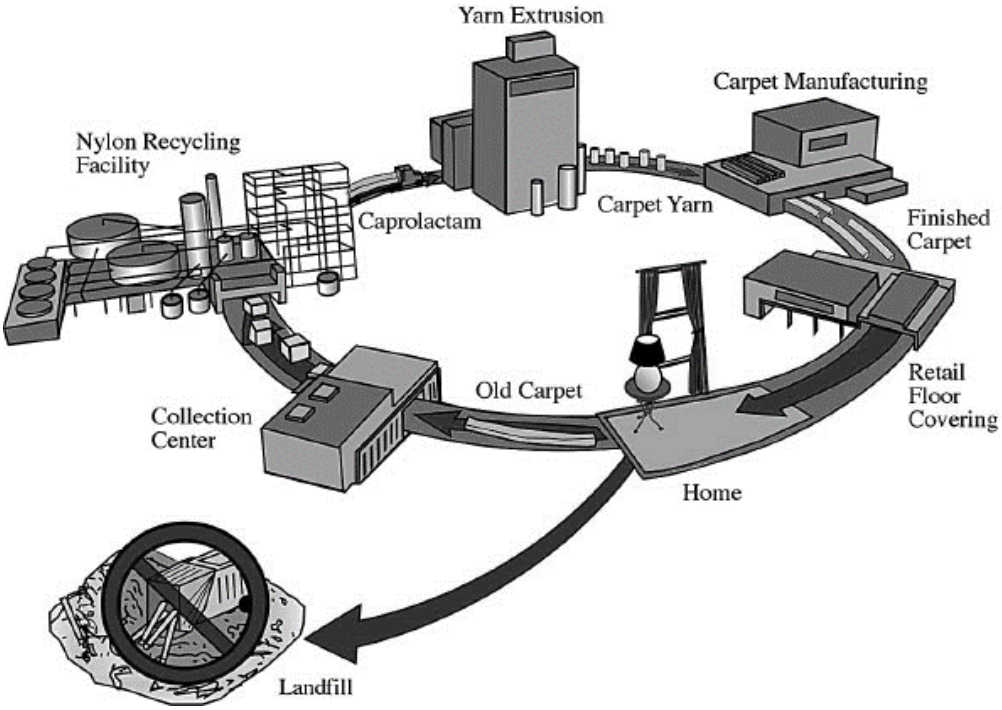


Figure 18: Overview of commercial nylon recycling loop

2.22.4 Importance of polyethylene terephthalate

PET has been traditionally employed in the production of textile fibers ever since the mid-1940s. The PET bottle was patented in 1973 by Nathaniel Wyeth and began to be used popularly for the production of disposable soft drink bottles in the 1980s. In 1987, more than 700 million pounds of PET were consumed in their production.

The overall world production of polyesters was 25–30 million tons in 2000, this value increased to 55 million tons in 2012 and mostly consisted of polyethylene terephthalate (PET). Polyester consumption has increased substantially in fibers and molding resins due to the strong demand for textile applications, as well as in food packaging and bottle markets for glass replacement.

Two PET grades now dominate the global market, i.e. fiber-grade PET and bottle-grade PET. These standard grades differ mainly in molecular weight or intrinsic viscosity (IV), respectively, optical appearance and the production recipes. The latter differ in the amount and type of co-monomers, stabilizers and metal catalysts, as well as colorants. Textile fiber-grade PET has a molecular weight of 15,000–20,000 g/mol, which refers to an intrinsic viscosity between 0.55 and 0.67 dL/g. PET fiber-grades for technical yarns such as tire cord have high molecular weights, with an intrinsic viscosity above 0.95 dL/g. Bottle-grade PET appears ‘glass-clear ’in the amorphous state. The average molecular weight ranges from 24,000 to 36,000 g/mol, which refers to an intrinsic viscosity between 0.75 and 1.00 dL/g. The standard bottle grade has an intrinsic viscosity of 0.80 dL/g. Other PET grades are manufactured for packaging films, as well as for the production of video and audio tapes. These PET types are often standard grades with an intrinsic viscosity of 0.64 dL/g. To reduce the sticking tendency of the final product, solid additives such as SiO2 or clay with specific particle sizes and particle-size distributions are incorporated.

2.23 Recycled polyester

Polyester is one of the engineering plastics which are frequently used. Polyethylene terephthalate, more commonly known as PET, is one of these polyesters, which is used for tape recorders and videos and is largely used in the packaging industry in different forms, also the great usage of PET is in the yarn industry. PET, as polyesters family, is a thermoplastic polymer with long branches of those which their wastes can be useable and bring economic benefits by using appropriate recycling methods

PET is semi-crystalline, thermoplastic polyester of characteristic high strength, transparency and safety. For the manufacture of PET the intermediates, pure terephthalic acid (TPA) and ethylene glycol (EG), are derived from crude oil. When heated together the first product is a monomer bis (2-hydroxyethyl) terephthalate (BHET) mixed with low molecular weight polymers (oligomers).

Recycling processes are the best way to economically reduce PET waste. On the other hand, as the price of virgin PET remains stable, new and cheaper technologies for recycling PET give a benefit to the PET recycling industry by providing industry with relatively cheaper PET. The first recycling effort of post-consumed PET bottles in the world was in 1977. The major factor affecting the suitability of post-consumed PET flakes for recycling is the level and nature of contaminants present in the flakes.

Like traditional polyester, recycled polyester is a man-made fabric produced from synthetic fibers. However, instead of utilizing new materials to craft the fabric (i.e. petroleum), recycled polyester makes use of existing plastic. Recycled polyester, also known as rPET, is obtained by melting down existing plastic and re-spinning it into new polyester fiber.

2.23.1 Classification of PET recycling

There are four distinct approaches to the recycling of post-consumer PET materials:

(1) Primary recycling involves the use of pre-consumer industrial scrap and salvage.

(2) Secondary recycling involves physical reprocessing, for example grinding, melting and reforming.

(3) Tertiary recycling involves subjecting waste PET to chemical treatment whereby its components are isolated and reprocessed for use in manufacture.

(4)Quaternary recycling in which the energy content of the plastics waste can be recovered by incineration

2.23.2 Primary recycling: pre-consumer industrial scrap and salvage

It is the recycling of clean, uncontaminated industrial scrap. The recycled scrap or waste is either mixed with virgin material to assure product quality or used as second grade material

2.23.3 Secondary recycling: physical reprocessing

It is the mechanical recycling of post-consumed PET, which passes through different steps such as contaminant removal, drying and melt reprocessing.

2.23.4 Tertiary recycling: chemical recycling

Chemical recycling involves the transformation of polymer chains. The polymer backbone under the recycling process is degraded into monomeric units (i.e. depolymerization), or randomly ruptured into larger chain fragments (i.e. random chain scission) with associated formation of gaseous products.
The chemical recycling is carried out either by (I) solvolysis or by (ii) pyrolysis, where solvolysis involves the degradation by solvents including water, and pyrolysis involves the degradation by heat in the absence of oxygen or air, or vacuum. Chemical recycling yields monomers, petroleum liquids and gases. Monomers are purified by distillation and drying, and used for manufacturing polymers.
Chemical recycling processes for PET were implemented nearly parallel to the manufacture of the polymer on a commercial scale

2.24 Manufacturing process

There are two ways to recycle PET: mechanically and chemically. Mechanical recycling is taking a plastic bottle, washing it, shredding it and then turning it back into a polyester chip, which then goes through the traditional fiber making process. Chemical recycling is taking a waste plastic product and returning it to its original monomers, which are indistinguishable from virgin polyester. Those can then go back into the regular polyester manufacturing system. Most rPET is obtained through mechanical recycling, as it is the cheapest of the two processes and requires no chemicals other than the detergents needed to clean the input materials through this process, the fibre can lose its strength and thus needs to be mixed with virgin fibre.
There are various new initiatives for improving and lowering the cost, spearheaded by companies such as Carbios, GR3N, Loop Industries, Resinate Materials Group and Worn Again. The challenge regarding upcycling is that upcycled products tend to be of lower quality and are generally only suitable for use in blends or coarse count applications.
Two of the main contributors to flake loss are bottle design and waste contamination. With regard to waste, encouraging practices that enable better recovery such as dual or multi stream recycling, can lead to higher quality of recyclable materials.

2.25 Mechanical Recycling

Mechanical recycling typically includes sorting, separation and removal of non-target materials or contaminants; reduction of size by crushing, grinding or shredding, or pulling fabric fibers apart for textiles; and then re-melting and extrusion into resin pellets. All thermoplastics, including PET,

can be re-melted to produce new plastics. As easy as that may sound, there are many challenges to mechanically recycling plastics into high quality materials capable of meeting the performance and cost expectations of higher value end products.

One of the reasons that recovered PET is often downcycled to lower value uses is because it is difficult and costly to recycle materials with lower intrinsic viscosity (IV) into applications that require higher IV values. The more complex a material's composition, the harder it is to mechanically recycle it back into materials of equal or higher value than the original material.

A good illustration of complexity is PET bottles versus PET textiles. The majority of bottles come in two primary colors, clear and green. In addition to the catalyst used to make the polymer, there may be a small number of additional additives used to alter material properties. Common contaminants for bottle and container recycling include opaque colors, barrier layers for added performance, metal closures, rings, pump springs, PVC shrink sleeves, and adhesives used on paper labels.

Textiles, on the other hand, are vastly more complex in their construction and coloration. Most textiles are a blend of fiber types (e.g., PET/cotton or PET/elastane), contain multiple dyestuffs and may also have additional polymers and chemicals used as backings or as surface treatments. Unlike PET bottles and other containers, post-consumer textiles come in many forms to serve many applications – clothing, shoes, carpet, residential and office furniture, and automobile interiors to name but a few. Mechanical recycling of pre-consumer PET textiles wastes for less demanding applications (what some call "downcycling") happens quite frequently.

Typical end uses are for "stuffing" or "filler" materials or nonwoven materials for furniture, mattresses, carpet pads, home or auto insulation, sound-deadening barriers and sediment erosion control to name a few. Certain pre-consumer wastes such as unused or damaged white ("greige") fiber and yarns are routinely folded back into primary production. With intention and considerable effort, some manufacturers are also collecting and recycling colored fabric waste from their operations back into first quality goods. However, due to the degradation of polymers and contamination that occurs over multiple use cycles, mechanical recycling eventually degrades the value of the PET and often prevents it from recirculating into higher value applications such as fiber-to-fiber recycling.

2.25.1 Process of Mechanical recycling of polyester

Step 1- Collection of plastic bottles and squeezing using rollers to squeeze out liquid
Step 2- Segregate clear bottles and colored bottles to allow white colour clothing to dye.
Step 3- Floating stickers are drainer using drainer from the liquid and sent to caustic soda bath
Step 4- Coloring material is added while shredding
Step 5- Sent to rotating drum for 10 hours and then dispensed to dry them out and mix colour
Step 5- Sent to rotating screws at temp 270 degree Celsius to dry them out
Step 6- It melts and forms filament threads
Step 7- the filaments are bonded together to make them stronger due to heating
Step 8- The fibres are torn again and again to add fluffiness
Step 9 - Carding the fibres that is brushing to align fibres
Step 10 - Spinning them to make threads cones
Step 11- Weaving or knitting to develop a fabric
Step 12- Finishing to give texture

2.26 Chemical recycling of polyester

In chemical recycling, the polymer is typically broken down to create monomers, oligomers, or other intermediates. The most common methods for chemical recycling of PET include glycolysis, methanolysis, hydrolysis and ammonolysis.Depending on which process and depolymerization agents are used, chemical recycling produces various end products.

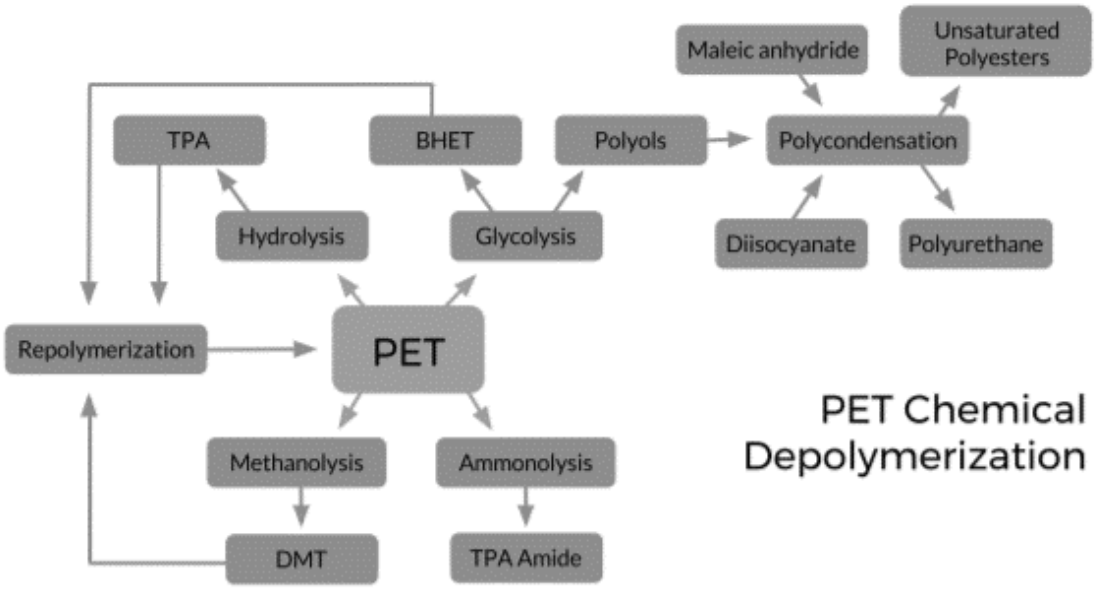
The most common end products are PET's monomers, purified terephthalic acid (PTA) and ethylene glycol (EG), the necessary building blocks to make new, virgin quality PET resin.

But chemical recycling is also used to separate PET from other materials and to remove colorants without actually depolymerizing it back to its monomers, or to create other end products that retain the material value of the polymer. For example, glycolysis will yield a mixture of polyols useful for the manufacture of polymers with properties quite distinct from PET, such as unsaturated polyesters, polyurethanes and poly-isocyanurates. Occasionally, the term "chemical recycling" is used to refer to processes that convert polymeric materials into fuels or syngas. The term may also be used to refer to incineration of polymeric materials for their energy value.

For many in the textile community, the ideal recycling system is one where reclaimed textiles are converted back into virgin quality yarns to make new textiles, also often referred to as "fiber-to-fiber" recycling. Chemical recycling is the only technology that can truly achieve this vision because it is able to remove all unwanted constituents – non-PET fibers, catalysts, surface treatments, backing materials, and other auxiliary chemicals used in textile production.

2.27 Chemical recycling VS mechanical recycling:

Meeting higher IV requirements of certain applications. It hits the "reset" button to start the cycle over, producing virgin quality recycled resins that can be solid-stated to meet the IV necessary for any specific end application. Another benefit of chemical recycling is that it is agnostic about the form or function the polymer serves. It does not matter if the polymer is in the form of a bottle, fleece jacket, compounding scrap, or an auto part. The process even allows for very high rates of contamination without negatively impacting the quality of the end product. However, the higher the contamination, the greater its impact on profitability and the number and types of by-products produced. Results from our study indicate that the purity level required for economic feasibility is 70% to 80% PET content by weight for the technologies we evaluated. Chemical recycling also allows for "upcycling" PET materials whose physical quality is so degraded or contaminated that mechanical recyclers are reluctant to process them, successfully diverting these materials from landfills.



SOURCE: AGUADO, JOSE AND DAVID P. SERRANO. *FEEDSTOCK RECYCLING OF PLASTIC WASTES.* 1999.

Figure 20: PET Chemical depolymerization

Solvolysis process is divided as follows: (1) Hydrolysis, (2) Aminolysis, (3) Ammonolysis (4) Methanolysis and (5) Glycolysis.

2.28 Open loop VS closed loop of recycled pet textile

Open- and ClosedLoop Recycling of PET Textile Waste the terms ``open- " and “closed-” loop recycling are frequently used to describe two different types of recycling in the circular economy. Their definition can vary, but most often they are used to describe the quality of end products made from recycled materials.

Open-loop recycling presumes that materials will be cascaded to lower value uses due to degradation in quality, whereas closed-loop recycling presumes to keep materials flowing within the same product value chain (e.g., bottle-to-bottle, fiber-to-fiber). However, in reality materials (virgin or recycled) flow to where there is greatest demand and economic value.

An open-loop model offers the best chance for building a scalable, efficient and sustainable infrastructure for recycling textiles (or any other material). Ideally, the entire materials economy would flow in an open loop where all materials have economic value defined by the end markets creating demand for their use. Two things are necessary to make an open loop system more efficient and effective:

1) “Reprogramming” cultural norms to see all materials as inherently valuable, leading to a societal commitment to build the infrastructure necessary to maximize the value of all materials flowing through the economy, and

2) Enabling materials to cascade “down” or “up” within an open system to uses that best fit their physical properties with the least amount of processing, making downcycling and upcycling irrelevant concepts. Innovations in recycling technologies can help move materials up or down the quality ladder to more efficiently respond to market demand.

Closed-loop recycling (i.e., materials being recycled back into the original products they served) is largely a reaction to a poorly designed open system. Most examples of successful closed loop recycling happen because one or more manufacturers make a concerted effort to intervene in existing markets or to to create

2.29 Need for recycled Polyester

Consumer awareness of the importance of environmental stewardship has led to increased demand for products manufactured with minimal impact on the world's wellbeing. And the demand for textiles that have a "green" pedigree has grown even in the face of economic hardships endured recently by many consumers. The environmental benefits gained from using recycled raw materials rather than virgin materials to make these products include conservation of natural resources as well as reduced energy consumption, carbon dioxide (CO'2) and other emissions, and waste going to landfills. Some of these products may command higher prices than their traditional counterparts, partly because the practice of recycling has not been fully adopted by consumers, so supply of recycled materials is limited. However, these products also tend to be made using cleaner, more efficient processes.

According to the report, the global polyester staple fiber market was valued at US$ 23,404.0 Mn in 2015 and is projected to reach US$ 42,415.1 Mn by 2024, expanding at a CAGR of 7.5% from 2016 to 2024. In terms of volume, the polyester staple fiber market is expected to reach 23,472.9 kilo tons by 2024, expanding at a CAGR of 4.0% between 2016 and 2024.

The global polyester staple fiber market is expected to reach $39.3 billion by 2025, according to a report from Research and Markets, with a compound annual growth rate (CAGR) of 6.3%. The rise in the global consumption of sustainable textiles has been a major factor driving market growth, the report noted.

Ralph Lauren is phasing out virgin polyester fiber, and it’s beginning with its signature polo shirt. Ralph Lauren says it will remove at least 170 million plastic bottles from landfills and oceans as part of a pledge to replace all virgin polyester fiber in its assortment with recycled alternatives by 2025.

Patagonia offered much more apparel made of recycled materials, including snowboard and ski pants and jackets in a street wear style. "Nothing changes quality-wise," said spokesperson Coley Glasgow. "Prices are a little higher [about 5 percent] but people are buying it."

Canada goose, which is expanding its U.S. business, introduced down-filled jackets made of CG-55 nylon, a fashion fabric; a Melton wool jacket and a Napa leather jacket with coyote-fur hood.

According to Sequel, eight million tons of garbage ends up in the world’s oceans and an estimated 75% of waste remains under the surface. The Spain-based company currently collects plastic from the bottom of the ocean, recycles plastic materials and develops them into an eco-friendly filament for fabrics. Seaqual’s project is strong due to its strong maritime network having more than 1,500 fishermen and 400 boats from the Spanish Mediterranean coast, helping the company collect plastic. Garbage collected from their nets is brought to different ports, where the waste (including plastic, glass and aluminum) is collected weekly and categorized for the proper recycling chain. PET plastic is then converted into flakes and an eco-friendly polymer. Once the 100% recycled polyester thread is created, it is used to create fabrics, which are transformed into garments.

Eco fibers are becoming the most popular type of fibers used in the clothing and apparel industry for properties similar to non-organic fibers. The two main functions performed by eco fibers in clothing are strength and comfort. Major fibers used in the clothing/textile application are organic cotton fibers, recycled fibers such as polyester, and regenerated fiber such as lyocell, viscose.

Among these, organic fibers are the most preferred fibers for clothing as they provide an optimum level of comfort and are best suited for maintaining a person's health and well-being. Variations of fibers are also implemented to provide strength and color consistency to the fabric manufactured such as recycled cotton fibers along with rPET, cotton fibers along with virgin acrylic fibers, and so on.

2.30 Standards for rPET

Quality testing for rPET fabric includes:

1. Intertek (a worldwide industry leader in third party quality testing)
2. OEKO-Tex® Standard 100
3. GRS (Global Recycled Standards)
4. BSCI (certifies social & ethical working conditions in our factories)

2.31 Organic Cotton Vs. rPET

Current worldwide demand for textile fibers is over 100 million tonnes per year and synthetic fabrics account for more than 50% of this consumption. Trying to replace synthetic fibers with cotton would have an immense environmental impact.

Natural fibers like cotton, when compared with synthetic fibers, present advantages in terms of waste production due to the biodegradability of both their discarded textiles and their micro-fibers. However, cotton has a very intensive resource consumption, mainly in terms of water and land degradation, due to the use of insecticides and herbicides. The cultivation and production of 1 kg of cotton requires in average 20,000 liters of water and some experts indicate that cotton is the largest user of water among all the agricultural commodities.

RPET fabric has a 50% lower carbon footprint than the organic cotton. Furthermore, compared to other synthetic fibres, RPET polyester fabric has almost a 90% lower carbon footprint than nylon, and 75% lower than polyester.

Table 04: Kg of carbon dioxide emissions per ton of spun fiber

rPET is also cited as producing far fewer emissions to the air than does the production of virgin polyester: again estimates vary, but Libolon's website introducing its new RePET yarn put the estimate at 54.6% fewer CO2 emissions. Apply that percentage to the data from the Stockholm Environment Institute[5], cited above:

KG of CO2 emissions per ton of spun fiber:

	crop cultivation	fiber production	TOTAL
polyester USA	0	9.52	9.52
cotton, conventional, USA	4.2	1.7	5.89
rPET			**5.19**
hemp, conventional	1.9	2.15	4.1
cotton, organic, India	2	1.8	3.75
cotton, organic, USA	0.9	1.45	2.35

The reason recycled polyester (often written rPET) is considered a green option in textiles today is twofold, and the argument goes like this:

1. The energy needed to make the rPET is less than what was needed to make the virgin polyester in the first place, so we save energy.
2. Keeping bottles and other plastics out of the landfills.

The water used in recycled polyester production is only a fraction of what is required in cotton growing. Water is not an input in the recycling process. It is mainly used to clean the shredded pieces of plastic and to remove the dirt and debris.

Recycled polyester is soft and durable. It is wrinkle – shrink – stain resistant. Its benefits include:

- Less soil, water and air contamination;
- Less dependence on oil used in the production of original polyester;
- Millions of plastic bottles saved from the landfill daily and less emissions from incinerators.

2.32 Legal Context: Textile waste and law

2.32.1 European Union:

At the time of writing, there is no specific waste stream for textiles in the EU legislation that is legally enforced [EU ENV]. There is however, a reference to textiles in the Waste Framework Directive [EU Lex, 2008], which is currently undergoing revision. This directive calls for the development of 'End of Waste 'specific criteria, also (but not only) for textiles. This development has not been undertaken yet [EC JRCCE]. As a consequence of the lack of EU wide applicable criteria for textiles, each individual member state's national rules apply. Therefore, once the currently ongoing revision of the Waste Framework Directive is concluded, it is most probable that the above outlined mandatory separate collection of textiles (required to be in place by 2025) will be addressed at the EU level. Until then, textile-based waste is considered 'general 'waste.

2.32.2 United Kingdom:

Duty of care provisions in section 34 of the environmental protection act [UK, 1990] stipulates that if any organization such as a charity, local authority or business passes second-hand clothing waste to a textile recycling merchant, they must ensure that that merchant has the legal authority to take the waste. In effect this means that the merchant is a member of the Textile Recycling Association, and holds compulsory employer's liability insurance. [Osborn, 2012]

2.32.3 France:

France is the only European member state that has implemented a legal framework related to 'End Producer Responsibility '(EPR) of textile producers [France CE], as well as regarding take back schemes of end-consumer products. [EcoTLC] lists all relevant legal provisions.

2.32.4 Italy:

Since the beginning of 2017, post-production and post-consumer textiles are considered 'special waste '('rifuti speciali'), and no longer 'urban waste 'as before. Any such material must now comply with the new legislative framework on traceability and management. The consequence is that transport and handling of such 'waste 'can only be done by companies with the required license, and that stringent documentation needs to be provided along the chain. [Altalex, 2017]

2.32.5 United States:

No specific regulation applies. Instead legal provisions are absorbed in the 'Resource Conservation and Recovery Act '[RCRA, 1976]. The act insists upon specific methods for the generation, storage, transport, treatment and disposal of hazardous waste produced during manufacturing of textiles and clothing. [Osborn, 2012]

2.32.6 China:

In summer 2017, the Chinese government decided to ban the imports of solid waste destined for recycling. The decision relates to 24 materials including plastic, paper and textiles, equivalent to 70% of all waste shipped to China. [GOSC, 2018; WTO, 2017]

2.33 Choose suppliers with a credible certificate

There are labels that certify the use of recycled fibres. Below is a selection:

1. GRS (Control Union Global Recycle Standard) is intended for companies that wish to make an independently verified claim as to the amount of recycled material they use in a specific (set of) products. The GRS has strict provision for how waste is handled during the production process. The standard includes environmental processing criteria in addition to raw material specifications. The website provides a list of GRS certified products, including fabrics (e.g. wool, polyester, cotton, denim, etc.), specifying the percentage of pre-consumer and post-consumer recycled content.
2. REMO is a global movement inspiring people to discover value in their once-loved garments and embrace sustainable fashion. REMO aims to close the loop and inject new

life into used fibers. REMO's track and trace system charts the journey of recycled fibres through the production chain. The system reveals exact information about an item's origin and past life, a precise percentage of its recycled content, and the resulting environmental savings on energy, water and CO2. The end result is a garment tag with a measurement of recycled content as well as a call to action to dive deeper into the garment's history.

3. Cradle to Cradle - Products with a Cradle to Cradle certificate have passed the assessment on product safety to humans and the environment, as well as its design for material reutilization like recycling or composting. Cradle to Cradle certification is four-tiered, consisting of Basic, Silver, Gold and Platinum levels to reflect continuing improvement. Certification is only available through the CCPII (Cradle to Cradle products) and companies wishing to apply have to sign a confidentiality agreement.
4. Recycled Claim Standard, The RCS is a chain of custody standard to track recycled raw materials through the supply chain. The standard was developed through work by the Materials Traceability Working Group, part of OIA's Sustainability Working Group. The RCS uses the chain of custody requirements of the CCS (Content Claim Standard provides companies with a tool to verify the content of specific input materials), and additional guidance for implementation of the standard may be found in the CCS Implementation Manual. The website also provides a list of suppliers.

2.34 Check suppliers policy and performance

Currently, claims on recycled fibers are becoming more and more common among suppliers in the textile supply chain. But in case there is no independent certification the claims of the supplier should be backed by reliable information. You can always consult a MODINT CR manager on their opinion. But, a supplier may also be able to show its actions on the recycling of textile and use of recycled fibers through its active involvement in one or more sustainability initiatives. Examples of relevant initiatives are:

1. SCAP: The Sustainable Clothing Action Plan was launched by the UK government at the London Fashion Week in February 2009. Over 300 organizations, from high-street retailers to designers and textile manufacturers joined the initiative. SCAP aims to raise awareness of the impacts of 'throw-away 'fashion and strives to maximize reuse, recycling and end-of-life management of garments. Traceability along the supply chain is addressed as an important aspect.
2. Texperium brings together sorters and reusers to create a refined supply chain. This makes sure the supply chain will be sustainable and offers new market chances. When participating in the projects of Texperium, participants are actively informed about new developments in the field of reusing and recycling. Texperium is an open innovation Centre provided with machinery for specialized tests.

2.35 Textile Finishes For travel jacket

Textile finishing decides the ultimate appearance and aesthetic properties of textile material. Additionally, it is liable to change various physical and chemical properties of textile materials per consumer needs. Textiles are made with a wide variety of fibre compositions, yarns and fabric structures. On such varied platforms, the finishers face a real challenge to impart desirable textile properties to a desirable extent. The extent of a textile's finish is measurable in some cases, while

in a large number of cases, the finish is related to sensory organs and is very much subjective. Finishes are mostly applied in mixtures and are difficult to identify and to standardize.
Textile finishing is conventionally carried out by a typical pad-dry-cure process using aqueous solutions of required chemicals. Removal of the water in the subsequent drying process consumes a significant amount of energy. With increasing energy costs, this is bound to contribute towards the overall cost of the product.
The application liquor transferred to the treated fabric after application by the padding technique exists in two forms. Firstly, there is liquor absorbed by the fibre, the amount of which depends upon the saturation moisture pickup of the component fibres. This is the amount of moisture the fabric will absorb when competently saturated without appearing to be wet.

2.35.1 Anti-Crease

The ability of a fabric to resist the formation of crease or wrinkle when slightly squeezed is termed as crease resistance. The ability of a fabric to recover to a definite degree is called crease recovery of the fabric.

2.35.1.1 Advantages

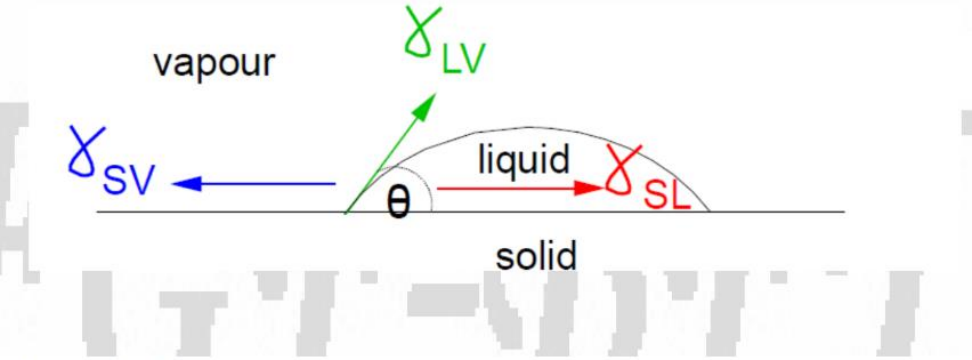
1. It improves the Crease Resistance and Crease Recovery property
2. It reduces the shrinkage of the fabric during laundering
3. It imparts a smooth and quick drying property
4. It improves Resilience, Handle and Draping quality
5. It improves the weight and Dimensional stability
6. It increases the strength of rayon in both wet and dry state
7. It gives resistance to degradation by light and laundering
8. It improves the fastness to Light and Washing of many dyestuffs
9. It prevents the Inter molecular slippage in the fiber core
10. It becomes partially waterproof and Rot proof

Synthetics like polyester, nylon, acrylic and olefin, have a natural resistance to wrinkles and a greater stability since they do not absorb water as efficiently.

2.35.2 Water Repellent Finish

Water Repellent- Permeable
Water Proof- Impermeable

2.35.2.1 Theory of Wetting



Where θ = the contact angle

γSV = the solid-vapour interfacial free energy

γLV = the liquid-vapour interfacial free energy (surface tension of the liquid)

γSL = the solid-liquid interfacial free energy

then γSV = γLV cos θ + γSL

Figure 21 : Water repellency process

Wetting is the ability of a liquid to maintain contact with a solid surface, resulting from intermolecular interactions when the two are brought together. The degree of wetting (wettability) is determined by a force balance between adhesive and cohesive forces.
Wetting deals with the three phases of materials: gas, liquid, and solid.
The contact angle (θ), as seen in Figure 1, is the angle at which the liquid–vapor interface meets the solid-liquid interface. The contact angle is determined by the balance between adhesive and cohesive forces. As the tendency of a drop to spread out over a flat, solid surface increases, the contact angle decreases. Thus, the contact angle provides an inverse measure of wettability

Table 05: Contact angle vs. degree of wetting

Contact angle	Degree of wetting	Interaction strength	
		Solid–liquid	Liquid–liquid
θ = 0	Perfect wetting	Strong	Weak
0 < θ < 90°	High wettability	Strong	Strong
		Weak	Weak
90° ≤ θ < 180°	Low wettability	Weak	Strong
θ = 180°	Non-wetting	Weak	Strong

A contact angle less than 90° (low contact angle) usually indicates that wetting of the surface is very favorable, and the fluid will spread over a large area of the surface. Contact angles greater than 90° (high contact angle) generally means that wetting of the surface is unfavorable, so the fluid will minimize contact with the surface and form a compact liquid droplet.

For water, a wet table surface may also be termed hydrophilic and a non wettable surface hydrophobic. Super hydrophobic surfaces have contact angles greater than 150°, showing almost no contact between the liquid drop and the surface. This is sometimes referred to as the "Lotus effect". The table describes varying contact angles and their corresponding solid/liquid and liquid/liquid interactions. Fornon-water liquids, the term lyophilic is used for low contact angle conditions and lyophobic is used when higher contact angles result. Similarly, the terms Omni phobic and omniphilic apply to both polar and apolar liquids.

2.35.2.2 Mechanism of water repellency

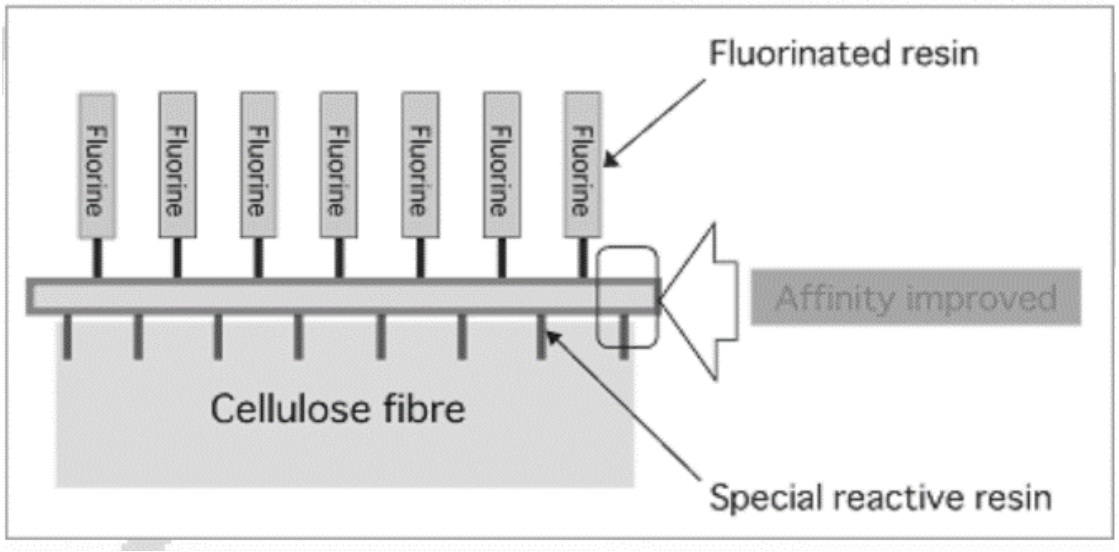


Figure 22: Water repellency process for cellulosic fibres

The repellency of a textile fabric depends upon the resistance to wetting and penetration by a liquid. For normal end uses of textile fabrics, water and oil are the most important interacting liquids. The resistance of a fabric to wetting is determined by the following parameters (Kissa, 1984; Zisman, 1964):

(1)The chemical nature of the fibre surfaces due to the presence of various polar or nonpolar groups).

(2)The geometry and roughness of the fibre surfaces (i.e., the presence of longitudinal striations, fissures, notches or scallops, etc.) and modified cross-sections that promote wicking.

(3)The nature of the capillary interfibre and interyarn spacing in the fabric.

Table 06: Surface free energy of different fabrics

Solid	Surface Free energy mN/m
Polyamide (Nylon 6.6)	46
Cotton	44
Polyester	43
PVC	39
Polyethylene	31
Polysiloxane, typical silicone oil	23-24
PTFE	18

For fabrics to be water repellent, the surface free energy of the fiber's surface must be lowered to about 24 to 30mN/m. Pure water has a surface tension of 72 mN/m so these values are sufficient for water repellency.

Table 07: Surface tension of different Chemicals

Surfactant (0.5% w/w)	Surface tension mN/m	Chemistry
A	29.3	fatty alcohol ethoxylate
B	32.5	phosphate ester
C	26.9	C9-C11 alcohol + 6 moles EO
D	27.6	C13 alcohol + 9 moles EO
E	27.9	C13-C15 alcohol + 7 moles EO
F	30.5	nonylphenol + 9 moles EO
G	29.6	nonylphenol + 8 moles EO

Repellent finishes achieve their properties by reducing the free energy at fiber surfaces. If the adhesive interactions between a fiber and a drop of liquid placed on the fiber are greater than the internal cohesive interaction within the liquid, the drop will spread. If the adhesive interactions between the fiber and the liquid are less than the internal cohesive interactions within the liquid, the drop will not spread. Surfaces that exhibit low interactions with liquids are referred to as low energy surfaces. Their critical surface energy or surface tension yC must be lower than the surface tension of the liquid yL(the internal cohesive interactions) that is repelled yL of water, at 73 mNm-1, is two to three times greater than yL of oils (20-35 mNm-1). Therefore, oil repellency finishes with fluorocarbons (yC = 10-20 mNm-1) always achieve water repellency but fluorine free products, for example silicones (yC=24-30mNm-1) will not repel oil. Low energy surfaces also provide a measure of dry soil repellency by preventing soil particles from strongly adhering to fiber surfaces. This low interaction allows the soil particles to be easily dislodged and removed by mechanical action.

2.35.3 Anti-microbial

Microbes are the tiniest creatures not seen by the naked eye. They include a variety of microorganisms like Bacteria, Fungi, Algae and viruses. Bacteria are unicellular organisms, which grow very rapidly under warmth and moisture. Further, sub divisions in the bacteria family are Gram positive (Staphylococcus aureus), Gram negative (E-Coli), spore bearing or non-spore bearing type.

Antimicrobials control, destroy or suppress the growth of microorganisms and their negative effects of odour, staining and deterioration.

The antimicrobial agents can be applied to the textile substrates by exhaust, pad-dry-cure, coating, spray and foam techniques. The substances can also be applied by directly adding into the fibre spinning dope. It is claimed that the commercial agents can be applied online during the dyeing and finishing operations. Various methods for improving the durability of the finish include:

1. Insolubilisation of the active substances in/on the fibre
2. Treating the fibre with resin, condensates or cross linking agents
3. Micro encapsulation of the antimicrobial agents with the fibre matrix
4. Coating the fibre surface
5. Chemical modification of the fibre by covalent bond formation

6. Use of graft polymers, homo polymers and/or co polymerization on to the fibre.

The methods of fabrication of antimicrobial textiles can be classified in two principal categories:

- Addition of an antimicrobial agent to the polymer before extrusion(fiber chemistry)
- Post – treatment of the fiber or the fabric during finishing stages.

Antimicrobials are defined as the agents that either kill microorganisms or simply inhibit their growth.

The degree of activity is denoted by:

- «-cidal»: agent that kill microorganisms
- «-static»: agents that inhibits microorganisms 'growth

2.35.3.1 Mechanism

Antimicrobial agents kill microorganisms or inhibit their growth by:

- Cell wall damage
- Inhibition of cell wall synthesis
- Alteration of cell wall permeability
- Inhibition of the synthesis of proteins and nucleic acids
- Inhibition of enzyme action

2.35.4 Fire retardant

2.35.4.1 Mechanism of Retarding Combustion

HEAT SINK

– Achieved by treating the material with heat-absorbing products, preventing its Concentration at a particular point.

• INCREASE IN IGNITION TEMPERATURE

– E.g. - Glass or semi-carbon fibres and aramid fibres are extremely stable and Heat-resistant.

• CHAR FORMATION

– Based on sulphur, phosphorus, or boron.

– Such flame-retardants decompose into sulphuric, phosphoric, and boric acids, which form stable non-volatile esters with hydroxyl groups on substrates such as cellulose and favor the formation of char.

• OXYGEN ARREST/ OXIDATION ARREST

– This principle is used in carbon dioxide and carbon tetrachloride fire extinguishers and is also the principle on which vapor-phase-active flame-retardants operate.

2.35.4.2 Types of Fire Retardants

On the above basis, flame-retardants may be classified into three major groups:

• Primary FR, based on phosphorus and halogens, frequently combined with other products; phosphorus by-products usually operate in the solid phase frequently with nitrogen showing synergistic effects

• halogenated products (chlorides, bromides), which are active in the gaseous phase and, in many cases, are applied together with antimony compounds in order to obtain synergistic effects;

• The compounds belonging to the third category, such as alumina hydrate or boron compounds, which provide endothermic reactions and act as helpers.

2.35.5 Stain Release finish

A stain is a discoloration that distinguishes itself from the material on which it is found. It can be unintentional, in the case of domestic stains on fabric, cloth, or other material, or it can be intentional.

2.35.5.1 Mechanism of Staining

- By mechanical adhesion of soil to the cloth - direct contact with a soiled surface or by rubbing of the garments against the skin or picking up dirt from liquors or from air; fabric construction facilitates such adhesion as the soil gets entrapped in inter fiber and inter yarn spaces or even into the capillary spaces of the fiber where it gets firmly deposited. Also soil which is oily in nature can diffuse into the fiber.
- By adhesion by electrical forces due to attraction of dust particles from air by electrically charged fiber surfaces.
- By redeposition of soil during washing -the redeposition on these fibers takes place because of their oleophilic nature. Also when a soiled fabric is allowed to lie unwashed for many days, the soil diffuses inside the fiber and it becomes difficult to remove it.

2.35.5.2 Factors affecting Staining

- Moisture Regain of Fibres
- Electrostatic Property of Fibres
- Fabric Construction
- Nature of Soil particle

2.35.5.3 Mechanism of Repellency

It forms a molecular barrier around the individual fibers to lower the critical surface tension (CST) so that the fabric does not attract stains or soil.

1. Liquids bead up and roll off the fabric.
2. Spills can be blotted up quickly with a clean, dry, absorbent cloth.
3. Provides unmatched resistance to oil- and water-based stains.

Release allows stains to be removed more easily during laundering than most common untreated fabrics.

4. Stains temporarily soak into the fabric.
5. Hydrophilic “water-loving” portion of finish draws in detergent and water.
6. Stains wash out more easily.

There are two types of soil release treatments available

1. Oleophobic treatments
2. Treatment with hydrophilic substances

Drying and curing fabric treated with finishes is a crucial final step in achieving optimal performance.

- It assures formation of invisible shields around each fiber.
- It ensures optimal durability and bonding between the finish and the fabric.
- The process removes any wetting agent used to apply the finish to the fabric.
- It also cures other components that may be in the pad bath, such as wrinkle-free derivatives.

Waterproofing of the fabrics may be divided into two large classes:

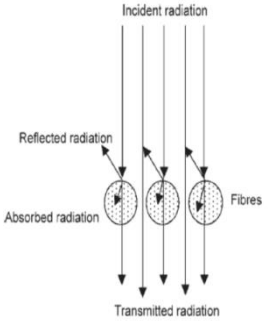
1. Processes in which interstices of the cloth as well as the, surface of the fibers, are covered with a film or skin so that the goods & not-only water shedding but impermeable to air and moisture.
2. Processes whereby the fibres are made water repellent through coating with hydrophobic substance or by a chemical reaction, but the fabric remains porous to air, i.e. "ventile.

Waterproof- Coating: Pitch, asphalt, waxes, Vulcanized rubber, Films of synthetic resin
Water Repellent: Metallic soaps, Silicones with Fluorocarbon, Waxy emulsion
Widely adopted method is Pad-Dry-Cure

2.35.6 UV Protection finish

Appropriate amount of sun bath promotes the circulation of blood, invigorates the metabolism and improves resistance to various pathogens.
But, penetration of UVR into the top layer of the skin leads to damage in the lower layer and produces premature ageing of skin and other effects including roughening, blotches, sagging, wrinkles, and basal cell cancer. Australia has high levels of solar UV radiation, mainly because of its geographical position; New Zealand, USA, Switzerland, Norway, Scotland, Britain and Scandinavian countries also have high melanoma rates.
The actual damage to human skin from UV radiation is a function of the wavelength of the incident radiation, most damage done by radiation less than 300 nm.

2.35.6.1 Mechanism of UV protection



When radiation strikes a fibre surface, it can be
•reflected,
•absorbed,
•transmitted
Through the fibre or pass between fibres
The relative amounts of radiation reflected, absorbed or transmitted depend on many factors, including the
1) Fibre type,
2) Fibre surface smoothness,
3) Fabric cover factor (the fraction of the
4) Surface area of the fabric covered by yarns) and
5) Presence or absence of fibre delustrants,
6) Dyes and UV absorbers.
The effect of fibre type on the SPF of undyed fabrics of similar construction is demonstrated
The SPF is the ratio of the potential erythema effect (skin reddening), to the actual erythema effect transmitted through the fabric by the radiation and can be calculated from spectroscopic measurements.
The larger the SPF, the more protective the fabric is to UV radiation. Typically, a fabric with an SPF of > 40 is considered to provide excellent protection against UV radiation

Table 08: Fabric SPFs

Fabric description	Approximate SPF
Cotton tricot	4
Wool tricot	45
Silk twill	7
Polyester tricot	26
Nylon/elastomer 80/20 tricot	12

Cotton and silk fibres offer little protection to UV radiation since the radiation can pass through without being markedly absorbed. Wool and polyester, on the other hand, have significant higher SPFs since these fibres will absorb UV radiation. Nylon falls in between these extremes. One factor influencing nylon and polyester absorbance is the presence of the delustrants TiO2, a material that strongly absorbs UV radiation

The requirements for a material to be effective as a UV protection finish include

• Efficient absorption of UV radiation at 300–320 nm,

• Quick transformation of the high UV energy into the vibration energy in the absorber molecules and then

• Into heat energy in the surroundings without photo degradation. Further requirements are

• Convenient application to textile fibres

• And lack of added colour for the treated fibre.

By careful choice of substituent, molecules can be formed that have

• The required absorbance of UV radiation,

• Lack of added colour

• And the necessary affinity to fibres

• And fastness.

• In most cases, the UV absorber is applied with the dyes during the dyeing process.

UV absorbers are organic or inorganic colorless compounds with very strong absorption in the UV range of 290 – 360nm.UV absorbers incorporated into the fibers, convert electronic excitation energy into thermal energy. They function as radical scavengers and oxygen scavengers.

The high energy short wave UV excites the UV absorber to a high energy absorbed, which may then be dissipated as longer wave radiation. Organic UV absorbers are mainly derivatives of o-hydroxyl benzophenones, o-hydroxy phenyl triazines, and o-hydroxy phenyl hydrazines

2.36 Down Jacket and their Aspects

Down consists of clusters of filaments growing and radiating from a central quill point. It has a three-dimensional structure, called loft, allowing it to have thousands of air pockets. Loft trap air, making down the light weight insulator for winter jackets. Down filling is highly resilient and is able to resist damage caused by compression. Following are various aspects of down filled jacket:

2.36.1 Filling Power

Fill power is the measurement of a down product's loft in relation to its insulating value. A higher filling power means more air can be trapped in a specific weight of down, thus creating greater

insulating properties. Fill power rating is usually measured by calculating how many cubic inches an ounce of down will cover. For example, a down rating of 500 means one ounce of down will cover 500 cubic inches.
Most common down products have a rating between 400 and 500, but the range can vary between 300 and 900+.

2.36.2 Weight

Weight is an important factor in most clothes purchasing decisions. It mostly depends on the purpose of use of the jacket. For example, for backpacking and outdoor travel, a lighter jacket will often be preferred with a higher fill power of up to 500.Higher filling powers can equate to lighter garments but there does need to be a trade-off between filling power and weight, which can depend upon the jacket's function.

2.36.3 Construction of down Jacket

Filling the down in a jacket can be done through two processes: Sewn-through Baffle and Box baffle. The most common method is sewn-through baffles, which involves stitching around each baffle's edge that goes right through the garment – from outer to inner layer. This method is easier to make and it keeps the down securely in place. It is therefore the most commonly used method but it does have one major drawback – the outer and inner layers will be drawn together by the stitching, reducing the loft amount and causing loss of warmth.
Box baffle is more difficult to construct as it allows each baffle to have its own three-dimensional rectangle. It involves filling in the down after creating pockets on each part of the jacket and then sewing it together. This reduces pinching at seams and therefore allows maximum possible loft, giving better insulation.

2.36.4 Dwr treatment of down

The principle downside of down is that it tends to stick together and lose loft when made wet. When this happens, it will lose its insulation properties. The traditional response to this has been to seal it within a fabric membrane but this means losing the advantage of down's natural breathability. DWR treatments allow the down to resist light moisture. These durable water repellents (DWR) work at a microscopic level. They do not, however, resist submersion or a heavy downpour.

2.36.5 Synthetic insulation

Simulated down has the benefit of maintaining its properties when wet, will dry quickly, and it is generally more moderately priced. There are currently many innovations in synthetic insulation, including a newly developed microfiber material that closely mimics the look and feel of natural down but, when wet, has double the loft of natural down. It is lightweight and also highly breathable.

2.36.6 Shell and lining material

The shell and lining has a profound effect on durability, weight, warmth, and water resistance. For an outdoor jacket, it is important to have a breathable shell fabric that will allow perspiration. If this is neglected, moisture will be trapped inside the jacket, dampening the down. Nylon and polyester are commonly used for outer layers, since they are durable and can withstand harsh conditions with an ability to prevent down leakages.

2.36.7 Filling types

Winter sports encompasses many different disciplines, but the ascent of mountains inevitably entails colder conditions – the Earth's dry lapse rate is 9.8 °K km-1 (McElroy 2002), meaning that if it is 10 °C at sea level it may be approximately 0 °C at 1000 m and -10 °C at 2000 m. Some routes or mountains cannot be climbed in summer time due to dangers of rock-fall (snow and ice can hold loose rocks in place), or the route may be a 'winter-only route', and so scaling mountains when it is cold is sometimes necessary. However, cold is not the only concern, as excursionists encounter great extremes in temperature. A typical summer ascent in the European Alps may begin with an approach, carrying all one's equipment, in temperatures of 30 °C. The temperature at night may drop below -10 °C, demanding an extremely insulated sleeping bag and warm clothing for any climbing in the early morning. In the greater mountain ranges (Himalayas, Karakorum, Andes), similar temperature fluctuations may be encountered, though the minimum temperatures may fall as low as -50 °C. In maritime climates such as in the UK, the air temperature may not often fall as low as this, though the perceived cold can be severe because of the humid air, high wind speeds, and rapidly changing weather.

When assessed according to the three important criteria for an insulating material discussed in section 1.2.2 – warmth-to-weight ratio; compressibility and recovery from compression; and water-resistance – down fares very well. Indeed, down is regarded very highly by mountaineers (and is thought by some academics to be superior to all other insulations (Kasturiya et al. 1999)) because of its excellent compressibility (Gao et al. 2010) and compression recovery (Martin 1987), and virtually-unparalleled warmth-to-weight ratio (Gao, Yu & Pan 2007b). Eider down, in particular, has a near-legendary warmth and it has been suggested (Todd 1996) that eider down is the most thermally-insulating of all natural materials. Down also benefits from extremely high durability, excellent touch comfort, and a strong track record. It has remained the choice for many mountaineers in cold conditions, both as filling for their sleeping bags and in their warmest garments for 50 years, and is synonymous with ascents of very high mountains such as Mount Everest. When compared to traditional insulations such as wool or animal furs, down's greatest asset is its warmth-to-weight ratio (Havenith 2010) and when compared to modern synthetic insulations this property remains unsurpassed (Gao, Yu & Pan 2007b; Kaufman et al. 1982; Farnworth & Osczevski 1985). For example, a down jacket of equal warmth to a synthetic jacket would be approximately half of its mass (Morrissey & Rossi 2013).

The insulation effect of clothes can be measured in the unit "I_{cl}, Clo" - where
1 Clo = 0.155 m^2K/W

- Clo = 0 - corresponds to a naked person
- Clo = 1 - corresponds to the insulating value of clothing needed to maintain a person in comfort sitting at rest in a room at 21 °C (70 °F) with air movement of 0.1 m/s and humidity less than 50% - typically a person wearing a business suit

Table 09: CLo level of different clothing

Clothing		Insulation	
		I_{cl} Clo	m^2K/W
Jacket	Vest	0.13	0.020
	Light summer jacket	0.25	0.039
	Smock	0.30	0.047
	Jacket	0.35	0.054
Coats and over-jackets and over-trousers	Overalls multi-component	0.52	0.081
	Down jacket	0.55	0.085
	Coat	0.60	0.093
	Parka	0.70	0.109

Winter clothes have an average clo value of 1. So, 1 clo is the amount of clothes that are required for a person to stay comfortable at 21 degrees °C (70 °F), with humidity at less than 50% and a wind velocity of 0.9 km/h.
Clo 0 is equivalent to a naked person, and for example, Eskimo clothes (fur pants, fur coats, etc.) have a clo value of 4.
Frequently-used alternatives to down are nonwoven synthetic insulations, such as Primaloft (Donovan 1986), Thinsulate (3M 2012) and Polarguard (Harding 1979; Frankosky 1983). These fabrics are available in different basal weights and thicknesses and, when compared to down, perform very well when wet, losing little thermal resistance. However their dry warmth to weight ratio is inferior to down's and their performance diminishes with repeated compression (REI 2014). Synthetic insulations are usually cheaper than down, which is too expensive for some consumers (Farnworth & Osczevski 1985), though down's excellent lifespan offsets this over time.

1. Primaloft- There are 3 different categories of Primaloft insulation, and all of them have several subcategories. These are Primaloft Gold Insulation, Primaloft Silver Insulation and Primaloft Black Insulation. A common characteristic that all of these types share is that they are incredibly lightweight. They are all also very packable, which makes products with Primaloft insulation easy to store even in small places. It also makes them very suitable for layering.
   Primaloft Gold insulation has a clo value of 0.92, which will provide the same amount of warmth as 500 or 550 fill-power down would. Primaloft Silver insulation has a clo value of 0.79 and 0.65 for Primaloft black.
2. Thinsulate- The microfibers in Thinsulate trap air molecules between the person and the outside world — the more air it traps, the warmer the person stays. This science explains

why winter coats are typically bulky. But Thinsulate fibers are finer than those used in other synthetic and natural insulation materials, so they trap more air in less space, making it a more efficient insulator.

3. Polarguard-It is a Continuous Filament Polyester Insulation.

Table 10: Comparison of Basic Insulation available in market

Factor	Polarguard	Primaloft PL1	500-600 Fill Down	>800 Fill Down
Purchase Cost	<$80 (low cost) $120-180 (high quality)	$140-200	$140-200	>$250
Long Term Durability	4-7 years	3-6 years	10-15+ years	10-15+ years
~Comparative Stuff Size	2.2x	1.8x	1.4x	1x
Typical "30F" weight	2.7-3.5lb	3lb	2.2lb	1-1.5lb
Warm When Wet	Fair+ (dries faster)	Fair (absorbs less)	Poor	Poor

4. Sustans (Sorona) - DuPont Company recently introduced a new polymer platform, Sorona®, based on 1, 3-propanediol. Sorona polymer can be shaped into fibers and other articles to offer a unique combination of softness, comfort-stretch and recovery, dye ability, and stain resistance. Sorona imparts distinctive characteristics to fabrics and a vast array of other applications such as upholstery and specialty resins. The breakthrough technology behind Sorona polymer enables manufacturers of apparel, upholstery, specialty resins, and other materials to use their existing assets to make new, higher-value products to meet customer needs.
5. Milkweed - Milkweed is a native plant that grows in abundance in North America, predominantly east of the Rocky Mountains. Its distinctive seed pods in the wind during the fall, distinguished by the wispy white filaments. While 100 percent milkweed performed well behind down and traditional synthetics on hand, stiffness, compressibility, the ability to retain loft and outright insulation, a mixture of milkweed with either

synthetics or down feathers performed at or near the top in every test. After wearing it in temperatures as low as -22 °F

6. DuPont™ Comfort ax™ Fiberfill- The Comformax™ Premium provides excellent wind resistance yet still maintains high air permeability. The ultimate wind barrier should stop wind, and at the same time it should permit heat and perspiration to escape to help regulate the body's temperature. Comformax™ Premium does this much better than film laminates. The nonwoven membrane is produced by entangling micro fibers with high pressure, reducing the holes between them to provide microscopic pores, so that it achieves the optimum balance between wind resistance and air permeability. This true open-pore structure allows perspiration vapor to pass through quickly without moisture condensation. The nonwoven membrane of Comformax™ Premium does not get stiff or noisy in the cold weather.
7. Solarball- It's a 100% recycled polyester fibre that retains heat to keep you cozy all winter. And because the filling is recycled, the jacket itself needed less resources to produce it.
8. ThermoBall Eco- ThermoBall Eco, featuring eco-friendly fabric made from upcycled plastic bottles. It's also filled with Prim loft's vegan down alternative made from at least five plastic bottles diverted from the landfill. According to The North Face, its ThermoBall line traps heat within small air pockets, mimicking down feathers. An independent study conducted by Kansas State University revealed that the warmth provided by the insulation is equivalent to 600-fill goose down.

Down insulates by trapping air and is prized for being light, easy to compress, long-lasting and breathable. It's the insulation of choice in cold, dry conditions, or whenever reducing weight and saving space are top priorities. Fill power is the term used to measure down's ability to loft, and thus trap heat. It is calculated by how many cubic inches one ounce of down can fill in a testing device. For example, 600-fill-power down means that one ounce of that down fills 600 cubic inches of space. Premium goose down can reach 900 fill-power, and potentially even higher. Duck down can achieve fill-power ratings no higher than 750 or 800.

The advantage of higher-fill-power down is that sleeping bags and jackets require less down to fill space and achieve a certain temperature rating. Less down equals a lighter product. So a sleeping bag rated +20°F with 700-fill-power down will be lighter than a +20°F bag using 600-fill-power down (assuming the fabrics and other features are comparable in weight).

2.37 Sustans

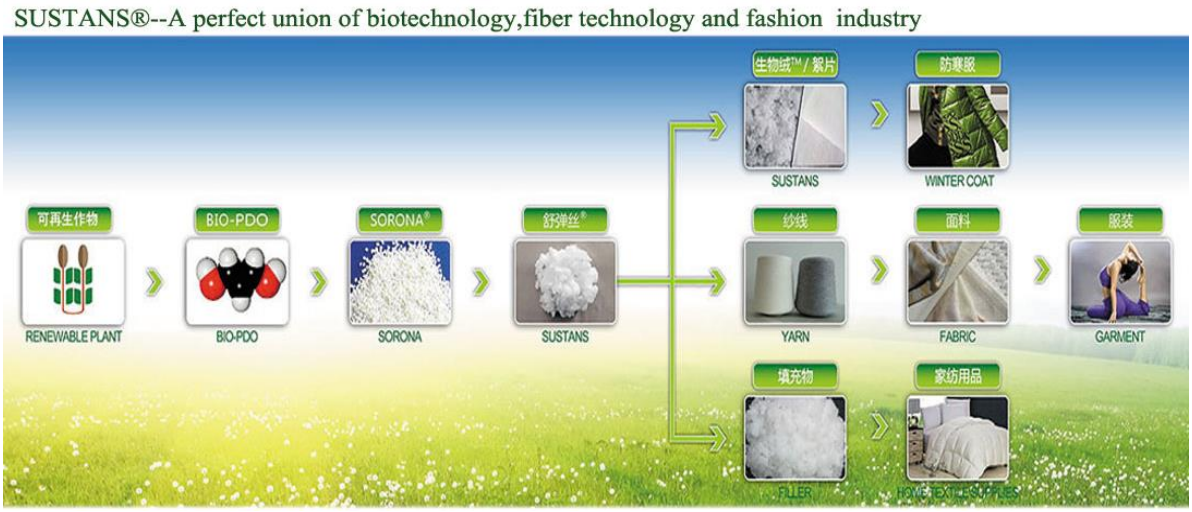
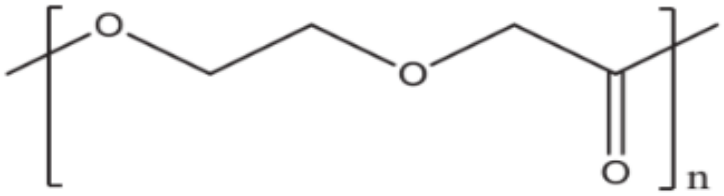


Figure 23: Sustans Commercial manufacturing process

Bio-PDO(Bio-Polydioxanone) or, to give it its commercial name, Susterra propanediol produced by DuPont Tate & Lyle Bio Products, which is used as a basis for a number of environmentally friendly materials.

Bio based poly(ether-esters) are thermoplastics elastomers prepared by two stage melt transesterification process from readily available starting materials such as alkylene terephthalate, an alkane diol and a poly (alkylene glycol ether) derived from renewable resources.

Polydioxanone are colourless, crystalline, biodegradable synthetic polymers of multiple repeating ether-ester units.



Scheme 1.30 Polydioxanone.

Figure 24: Chemical Structure of Sustans

The variety of corn involved is known as yellow dent and has a high starch content. After harvesting and drying, using a wet milling process, the corn is separated into its four basic components: starch, germ, fibre and protein. The nutrient rich components are used for animal feed while glucose is derived from the remaining starch fraction and is the raw material used for making 1.3- propanediol. The process starts off with a culture of a special microorganism in a small flask with the glucose. As it grows, it is transferred to a seed fermenter. Fermentation takes place under exact temperature conditions and involves a patented process where the microorganism functions as a biocatalyst, converting glucose into biobased 1.3-propaneidol.

The resulting product is filtered to remove deactivated microorganisms, unfermented glucose and excess water. After separation, it is then passed through a bed of charged resin that attracts and removes any residual salts. The product is then steam distilled to a highly-purified state, removing any trace impurities. The resulting material, highly purified bio-based 1.3- propanediol, is checked against product specifications before using in a variety of high-performance applications. This

includes customers such as DuPont which makes Sorona fibres, personal care and cosmetic customers who make skin-friendly humectants and industrial customers who use Bio-PDO as the building block for a variety of high performance biobased polyurethanes.

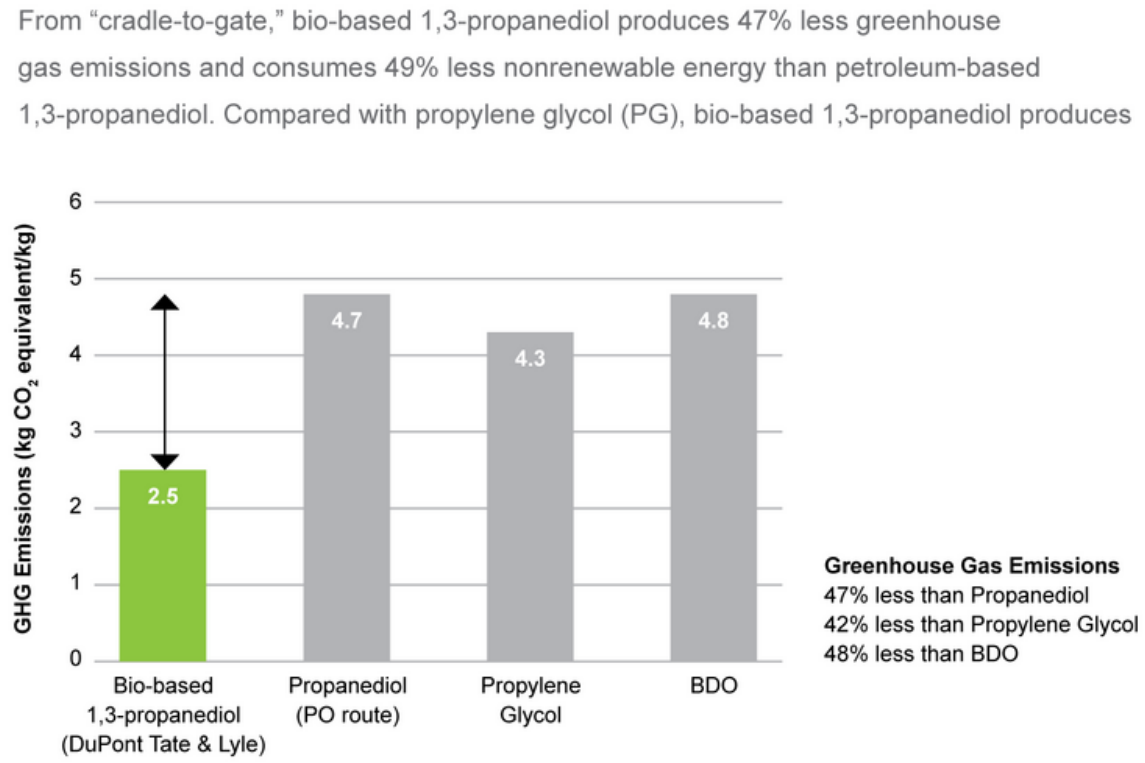


Figure 25: GHG Emissions from different filler used

The building block is not only plant-based but is also sustainably produced. It has published a cradle to gate life cycle analysis (Tables 1 and 2) showing that it produces 47% less greenhouse gas emissions and consumes 49% less renewable energy than petroleum-based 1.3-propanediol. Compared with propylene glycol (PG), the reductions are 42% and 41%, and compared to butanediol (BDO), 48% and 46% respectively. At full capacity (scheduled for mid-2019) the process will achieve a greenhouse gas emission reduction equivalent to taking 40,000 passenger cars off the road for one year. As regards non-renewable energy it will save enough energy to power one million 100W incandescent light bulbs for one year. As Susterra propanediol is a building block for bio-based polyurethane chemistry, any footwear material or component that is currently made using polyurethane-based on traditional petroleum routes can now be biobased.

42% less greenhouse gas emissions and uses 41% less nonrenewable energy from cradle-to-gate. Compared with butanediol (BDO), bio-based 1,3-propanediol produces 48% less greenhouse gas emissions and uses 46% less nonrenewable energy from cradle-to-gate.

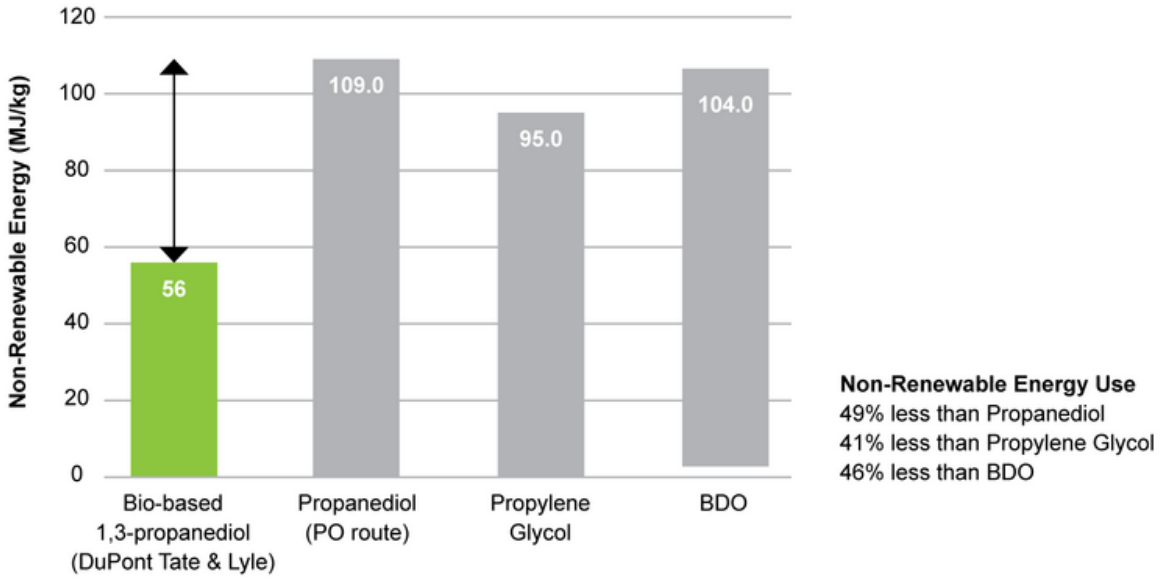


Figure 26: Non-Renewable Energy produced from different filler

Bioseparation of 1,3-propanediol is a biochemical process for production of 1,3-propanediol (PDO). PDO is an organic compound with many commercial applications. Conventionally, PDO is produced from crude oil products such as propylene or ethylene oxide. In recent years, however, companies such as DuPont are investing in the biological production of PDO using renewable feedstocks such as corn.

2.37.1 History

In May 2004, DuPont and Tate & Lyle announced that they would start up a joint venture to build a facility that produces polymers from renewable feedstock instead of petrochemicals.In particular, their goal was to design a fermentation system that converts corn sugar into PDO (propanediol manufactured in this way is referred to in the media as "BioPDO"). They argue that using such a bioprocess is more energy efficient than conventional petrochemical processes (conversion of propylene into propanediol) because the bioprocess has four advantages over the conventional process: smaller environmental footprint, lower operating costs, smaller capital investment, and greater sustainability due to use of renewable corn feedstock.

2.37.2 Process

BioPDO can be made by the bacterial fermentation of glycerol. However, DuPont has managed to engineer a strain of Escherichia coli (E. coli), a common bacterium, to allow industrial-scale production of 1,3-propanediol by fermentation of glucose. After the E. coli produce sufficient BioPDO product, DuPont uses a method to separate the BioPDO from the cellular broth that comes out of the bioreactor consisting of four steps: microfiltration and ultrafiltration, ion exchange, flash evaporation, and distillation.

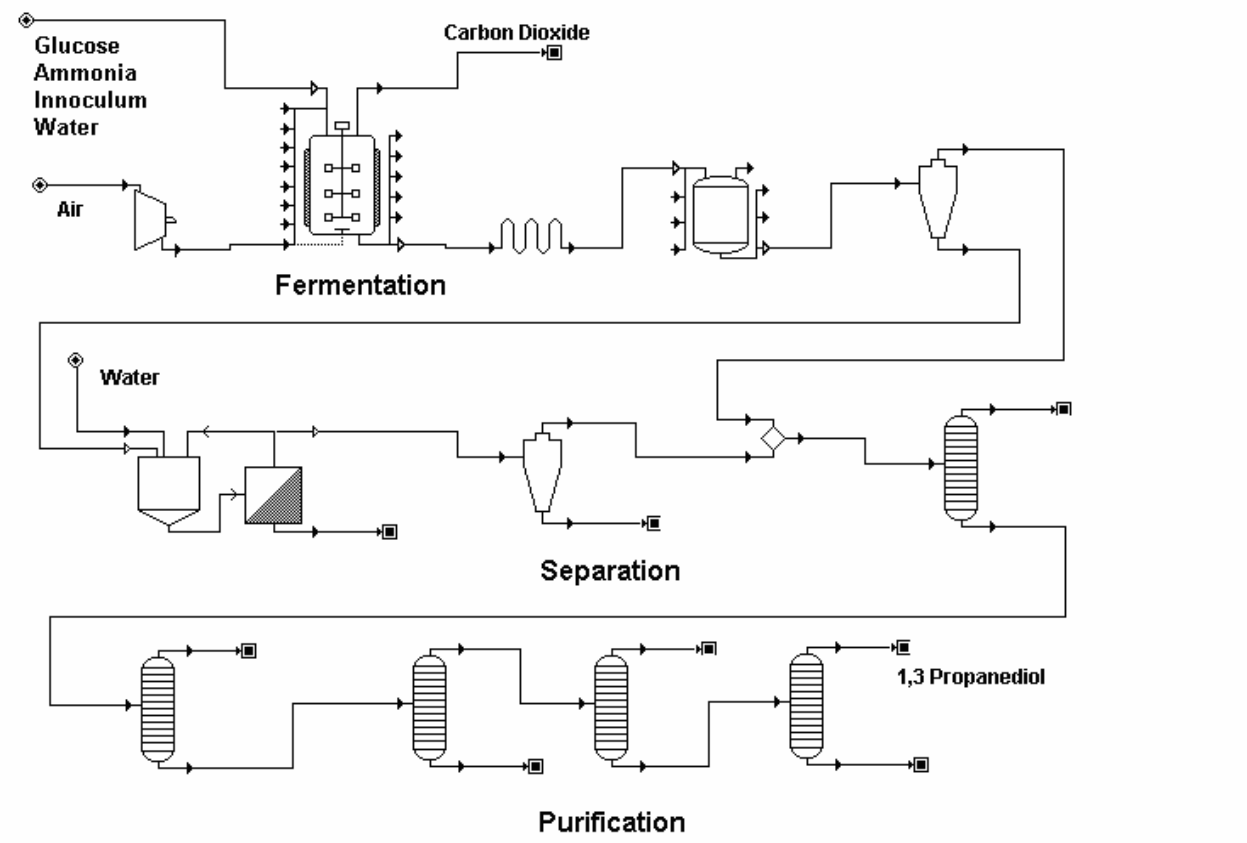


Figure 27 : Bio-PDO Manufacturing process

2.37.3 Filtration

The first of the two filtration steps, microfiltration, is used to remove the cells from the reactor broth. Ceramic filters are used because, although expensive, they can last for five to ten years. High temperatures have been found to increase the flux of liquid across the microfiltration membrane, so a minimum temperature of 165 °F (74 °C) is specified. A series of three ultrafiltration membranes are used to filter out proteins with a molecular weight of 5,000 Daltons and higher. The feed pressure to the microfiltration membrane is typically 65 psia with a transmembrane pressure drop of 40 psia. The feed pressure to each ultrafiltration membrane is 60 psia. Using these feed pressures and temperatures, typical transmembrane liquid fluxes are 108 LMH (liters per hour per square meter) for the microfiltration membrane, and 26 LMH for the ultrafiltration membrane.

2.37.4 Ion exchange

The next step of the scheme, ion exchange, removes impurities that cause the downstream polymer product to turn yellow. Four ion exchange columns in series are used to remove these impurities, and they are arranged in the following order:

1. Strong acid cation exchanger
2. Strong base anion exchanger
3. Strong acid cation exchanger

4. Strong base anion exchanger

The first cationic exchanger replaces the divalent cations in solution with hydrogen ions. The first anionic exchanger replaces the anions in solution with hydroxide ions.The second cationic and anionic exchangers further reduce ion levels in solution. Note that hydrogen ions (H^+ spontaneously react with hydroxide ions (OH^-) to form water (H_2O):

$$H^+ + OH^- \rightarrow H_2O$$

2.37.5 Flash evaporation

After the ion exchange step, excess water is produced from the hydrogen and hydroxide ions, and that can dilute the product to less than 10% concentration by weight·By sending the dilute solution to an evaporation system under vacuum, water will flash out of the solution into low-pressure steam, leaving a propanediol solution with up to 80% propanediol by weight.The low-pressure steam is then compressed to a higher pressure and temperature, and afterward directed to the outer casing of the flash evaporation unit to heat the system.

2.37.6 Distillation

The final step of the scheme, distillation, comprises two distillation columns, and optionally four distillation columns. The three main types of chemicals in the fluid at this stage of the separation are water, BioPDO, and impurities such as glycerol, sugars, and proteins. Of the three chemicals water has the lowest boiling point , so it is removed as distillate in the first column. The bottoms of the first column are then sent to a second column, where BioPDO is removed as distillate because of its lower boiling point. Both columns operate under low pressure (55 mm Hg in the first column; 20 mm Hg in the second column) to lower the boiling points of the distillate and bottoms streams, thereby using a lower pressure steam than that for atmospheric columns.At this point, the BioPDO stream has 99% purity. If the BioPDO is to be used for polymer production, however, then greater purity is required.To achieve greater purity, the BioPDO distillate of the second column is sent to a hydrogenation reactor to convert the remaining polymer-coloring impurities into non-coloring chemicals. The effluent of the reactor is then sent to a second set of two distillation columns that operate the same way as the first set of columns. The BioPDO distillate of the fourth distillation column has a purity of 99.97%, which is able to meet polymer- and fiber-grade standards.

2.37.7 Energy efficiency of process

According to DuPont, the BioPDO process uses 40% less energy than conventional processes. DuPont also claims that the bioprocess reduces greenhouse gas emissions by 20%, and that the production of one hundred million pounds of BioPDO annually "saves the energy equivalent of fifteen million gallons of gasoline per year".Because of DuPont and Tate & Lyle's success in developing a renewable BioPDO process, the American Chemical Society awarded the BioPDO research teams the "2007 Heroes of Chemistry" award.

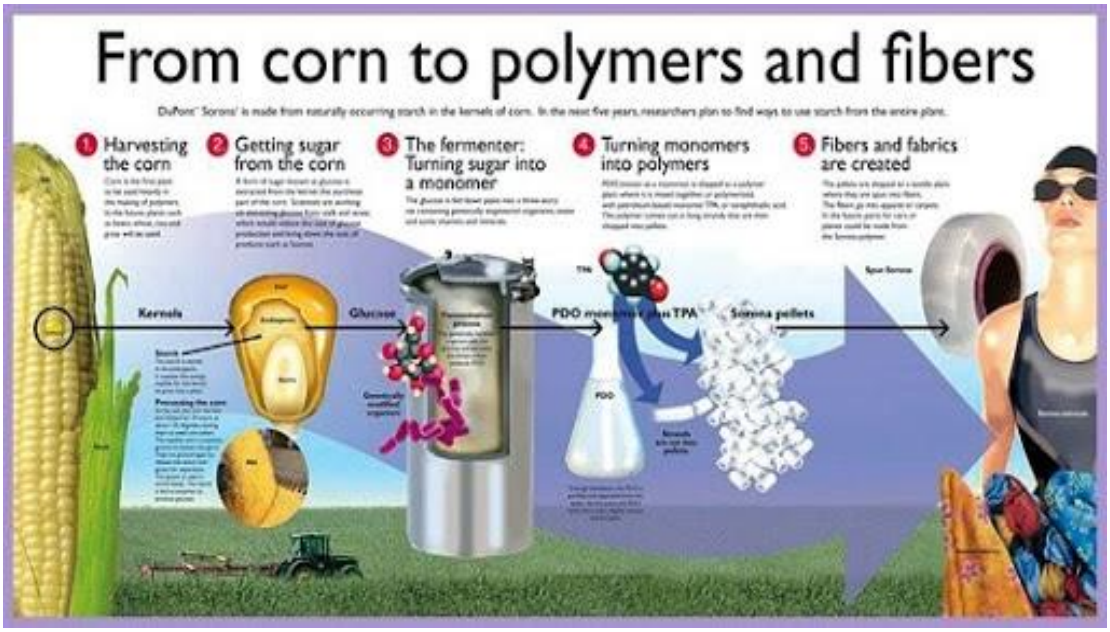


Figure 28: Bio-PDO Manufacturing process from corn

2.38 Types of Fits in Jacket

Fitting refers to how well a garment confirms to the three dimensional human body figure. In the apparel industry, every brand has its own definition of different types of fit. The terminology changes from brand to brand but the shape of the garments are somewhat similar. Following are few types of fits in jacket:

2.38.1 Slim fit

- Outerwear is much more streamlined, promoting a wide range of motion (suitable for touring or pole-whacking).
- Jackets fit much closer to the body (sometimes limiting the layers) and have a more tailored or fitted profile, often with a waist-length cut.

This tighter fit, sometimes referred to as "alpinist," has a more minimalist look and feel that's grown more and more popular in the techy or fashion forward circles of our sports.

2.38.2 Regular fit

A regular fit, is a product having a fit that's not too tight, not too baggy, but right in the middle. Outerwear will have plenty of room for layering but won't look like a yeti when not wearing many layers underneath.

- Jackets will typically have a standard length that doesn't pull up past the waistline when arms are raised, with sleeves that stay extended to the wrists when the arm is bent, but won't go too far past hands when arms are straight.

2.38.3 Loose fit

Outerwear with a baggier fit is designed to have more coverage all around, while maximizing room for layers underneath. With a baggier fit, one can expect:

- Outerwear will have extra room all over with enough coverage. Jackets will have more room throughout the body and sleeves, and tend to be longer when compared to a regular or traditional fit.
- This style has become popular among park skiers and snowboarders who want a baggy look more than they care about the actual fit. Brands are now designing lines just for them. Also, brands that were known as more traditional in the past, now make fits that appeal to a newer generation seeking a more progressive fit.

2.39 Backpack

A backpack is a large bag used to carry things on your back, used especially by people who go camping or walking

2.39.1 Types of Backpacks

There is an extensive array of backpacks in the market to suit specific needs. From 10 liters all the way to over a hundred liters, backpacks come in different sizes and styles for both indoor and outdoor use. The kind of backpack needed to commute to work while safely storing your laptop will be vastly different from the backpack one will use when one goes on a camping excursion which lasts several days. For this reason, there is no such way of knowing how many liters a regular backpack is.

2.39.2 Daypacks

Daypacks are backpacks that are designed for excursions that are only a day long. These are meant to carry things that are needed for a few hours or up to 12 hours. Daypacks are usually between 8 to 30 liters in volume. Small daypacks, such as those that are less than 10 liters, are ideal for day hikes or even or exploring an attraction in the city for a day. It is used to carry snacks and refreshments, a towel or a change of clothes, and perhaps a lightweight jacket. Generally, any backpack under 30 liters is suitable for use as a daypack.

2.39.3 Weekend backpack

Weekend backpacks are suitable for quick getaways lasting 2-3 days. A good weekend backpack is around 40 liters in volume, and is typically used to carry enough clothing for your trip as well as a few other necessities. Additionally, a weekend backpack should have enough space to bring all the clothes needed for up to three days without needing to have clothes laundered.

2.39.4 Multi-day backpacks

Multi-day backpacks are used for longer trips that span several days; it could be used for trekking and hiking, as well as backpacking trips abroad. They come in 50 to 90 liters in size, and in the larger range can accommodate sleeping bags and a tent. For a 5-night trip or more, a backpack that

can accommodate 70 to 90 liters is suitable for a 3-5-night trip, 50-65 liters suffices; and for 2 nights, 35-50 liters.

2.39.5 School backpacks

School backpacks are used by kids, high school students, and college students to carry a heavy load. These are usually 6 up to 20 liters in size. They are spacious and roomy; it is designed to carry several books, notebooks, and a small laptop or tablet. The same size of backpacks that are used for school can alternatively be used for sports as well. For example, the popular Jan sport brand is well-known for their versatile line of school backpacks. Deciding on how many liters a school backpack is should depend on the weight and quantity of things.

2.39.6 Laptop backpacks

Students and professionals alike rely on various types of laptop backpacks. The laptop backpack will depend entirely on the size of laptop. Common laptop backpacks are designed to cater to 13 inch, 15 inch, and 17 inch laptops.

2.39.7 Tactical military backpacks

Used by soldiers for heavy-duty, tactical military backpacks are distinct because of the kind of material it's made with. These are designed to resist water tearing, and are durable enough to survive even in the most rugged environments. Tactical military backpacks are also excellent choices for outdoor adventures and traveling because they are robust. They come in 25-50 liter sizes.

2.39.8 Drawstring backpack

For a lightweight backpack, a drawstring backpack is one of the best options out there. The material is typically made from fabric, and these are excellent choices for carrying an extra pair of shoes, or your gym clothes and a towel. Drawstring backpacks make great extra backpack storage to your regular backpack or can also be used as a lightweight carry all.

2.39.9 Carry on backpacks

Carry-on backpacks come in varying sizes to meet the general 45-linear-inch requirements of most airlines.

2.39.10 Hydration backpacks

Used by cyclers, runners, and hikers, hydration backpacks are an efficient solution for recreational needs. These are made with an ergonomic design that places comfort above all, and security for your belongings. The most distinct feature of a hydration backpack is its hydration bladder compartment which is used to store water. Water reservoirs can range from 0.5 liters (1.10 pounds) to as much as 3 liters (6.61 pounds). On the other hand, gear capacities for hydration packs range from under 5 liters to as much as 50 liters.

2.40 Suitcase backpack

A popular choice among frequent business travelers, suitcase backpacks are compact and easily fit within the aircraft overhead bin. These are designed to be easy to travel with, sometimes have rollers or wheels, and are made with flyers who often go on many domestic or short flights. Depending on the size, suitcase backpacks can fit a laptop and some clothes, or more items. The most common styles in the market range from 25-40 liters.

2.41 Duffel bag backpack

This model combines the best of both worlds: duffel bags and backpacks. These are made for the gym and travelling, since they're portable and big enough to carry your clothes, shoes, and toiletries while adding the ease provided by backpack straps. Additionally, duffel bag backpacks also have a very distinct design that stand out from other backpacks in the market. These hybrid backpacks can also double as weekend and multi-day bags, and can usually hold from 20 to over 100 liters.

2.42 Compression backpacks

Also known as a compression sack, as its name implies these bags can be compressed so that you get as much storage efficiency as possible. It makes a great additional backpack or carry all, and helps ensure that you make use of all the space possible when traveling. Compression backpacks are also ideal for travelers who want a compact and light bag without sacrificing storage space, which gives you a much more comfortable adventure. Compression backpacks range from 15 to 50 liters.

2.43 Female-specific backpacks

While women can wear unisex or an appropriate men's backpack, there are some models in the market that are designed to fit women more comfortably. Female-specific backpacks are usually designed with a curved waist belt, shorter torso length, and narrower shoulder width; features that are more mindful of the differences in a woman's body, which typically won't be in a man's hiking backpack.

2.44 External attachments

External attachments available for water bottles, rain gear, bulky sleeping pads, and snowshoes which can be stuffed into your backpack's exterior pockets. Alternatively, some external attachments can also be attached to the bottom, back, or side of your backpack so that one can use the same bag for longer trips

2.45 Backpack Sizes

- **0-10 Liters**

It is the smallest size category available for backpacks. Most of the hydration packs, trail running packs, and lumbar packs fall in this volume category. It's minimalism at its best, and designed to

truly only carry the essentials such as a hydration reservoir, a lightweight rain cover, and a few snacks.

- **10-20 Liters**

This backpack capacity is for adventures requiring one to travel quickly for no more than a day. These include day commuting to work or day hikes, where all one will need food and drink for the day, light insulation layers, a headlamp, two liters of water, a headlamp, and a space blanket.

- **20-30 Liters**

Most of the daypacks fall under this category. These are made to include the essentials such as food for the day, light insulation layers (puffy or fleece jacket), rain shell, a headlamp, a small first aid kit, and a space blanket.

- **30-40 Liters**

This is the category where most weekend and overnight backpacks fall under. If one does go hiking, backpacks of this capacity would be suitable. Backpacks that are 30-40 liters in size are usually designed with additional pockets and compartments found on its exterior and hip belts for storing headlamps, snacks, and knives.

- **40-50 Liters**

Ideal for multi-day trips, a 40 - 50-liter backpack is suitable for carrying everything needed including a small pot for cooking, food back for carrying up to 6 days 'worth of food, camp fuel and stove, change of clothes, a water filter, and a down sleeping back.

- **50-60 Liters**

These backpacks are an upgrade of the 40 - 50-liter capacity, allowing you to carry everything in the previous category with additional breathing room for bigger sleeping pads and a tent.
However, many overnight and weekender backpacks are also made in this size range to cater to the essential three things you'll need on an overnight hiking trip: shelter, sleeping bag, and pad which, while needed, are usually bulky. Backpacks this size can hold more extra clothing, a pillow, larger sleeping pad, and a tent good for 2-3 persons, camping shoes, and a synthetic sleeping bag.

- **60-70 Liters**

These size backpacks are also used for multi-day backpacking trips which would fit all the conventional equipment and items needed in the previous category, but these will also have additional space for non-essentials. Many hikers prefer using this capacity for a backpack because it allows one to take more such as a larger first-aid kit, food for as much as 10 days, and extra cookware such as an extra pot or a frying pan.

- **70-80 Liters**

Backpacks of this size can carry supplies for other people, such as kids or other hiking companions. The only limit to packs this size is the weight you can carry on the back. A 70-80 liter backpack is also essential for going on high-altitude climbs. It allows to pack everything on the previous categories plus a tent good for four, highly-insulated and cushioned sleeping pad, and a down or synthetic sleeping bag.

2.46 Requirements for a Excursionist

An excursionist carries various things for a short trip to a colder region. An excursionist needs to consider the climatic condition for travel as well as carry multiple items for a shorter visit. For instance , Glove to keep hands warm, Eye mask and neck pillow for a short nap, Water bottle to go, Sanitizer to keep surfaces cleaner, Earplug for entertainment, Secret pocket to save money from theft, Sunglass for protection of cornea from sun, Cards for payments, Pen for various forms

to be filled during travel, Passport and travel document, Torch and whistle for safety, Camera to capture moments, Flip flops in case of rain, Towel for freshening up, Waterproof bag for wet clothes, Microfiber fabric for sunglasses, RFID proof card pocket and keys.

2.46.1 Testing

The process to determine the properties of different kinds of substances is called testing. Testing is an important segment of the textile industry; it helps to find suitable fabric for suitable purpose. Fibre identification is done in three ways: Microscopic examination of the longitudinal and cross sections of the fibre, Burning test in a flame, Solubility tests in chemical reagents.

2.46.2 Microscopic test

The microscopic test reveals the macroscopic features of the fibre. When observed along the length (longitudinal section), the surface features are revealed. When a fibre is cut in the perpendicular direction and a thin cross section examined on the microscope, the shape of the cross-section and the macroscopic features in the cross-section can help identify some fibres.

An optical microscope with a magnification of at least 100 is generally used. A projection microscope is however preferred since it gives an enlarged view on the screen, which can be traced on a tracing paper. If the microscopes are of the polarizing type, the contrast is sharper and more information can be collected. Thus polarizing projection microscopes allow greater amount of detail and are therefore generally used. To examine the fibre in the longitudinal direction, a few fibres (or a few short lengths of cut filaments) are straightened and parallelized and placed on a glass slide. They may be secured with the help of cello tape on both ends. To reduce scattering of light, the fibre is immersed in a drop of inert liquid having a refractive index close to the refractive Index of the fibre and covered with a cover glass.

The sample is then mounted on the microscope stage and its focused image observed on the screen. The longitudinal texture may then be traced on tracing paper. The cross-section can be made as follows: A bundle of straight and parallel fibres is embedded in a cork with the help of a needle in which the yarn or filaments are threaded. A thin section of the cork is then carefully cut using a new blade and this thin section is then placed on a glass slide and secured with cello tape.

The assembly is mounted on a microscope. The cross sectional view, when combined with the corresponding longitudinal view, may then assist in identifying the fibre.

2.46.3 Burning test

The fibres being chemically different, they show different burning characteristics which can be used to identify them.

1. Acrylic- Acrylics burn readily due to the fibre content and the lofty, air filled pockets. A match dropped on an acrylic blanket can ignite the fabric which will burn rapidly unless extinguished. The ash is hard. The smell is acrid or harsh.
2. Nylon-Nylon melts and then burns rapidly if the flame remains on the melted fibre. If kept on the flame, it smells like burning plastic.
3. Polyester- Polyester melts and burns at the same time, the melting, burning ash can bond quickly to any surface it drips on including skin. The smoke from polyester is black with a sweetish smell. The extinguished ash is hard.

4. Cotton- When ignited it burns with a steady flame and smells like burning leaves. The ash left is easily crumbled. Small samples of burning cotton can be blown out like a candle would.
5. Wool- It is also a protein fibre but is harder to ignite than silk as the individual hair fibres are shorter than silk and the weave of the fabrics is generally looser than with silk.

2.46.4 Solubility test

The solubility of fibres in some specific chemical reagents (acid, alkali, bleaching agent, solvent) provides a definite means of identification, if not for a specific fibre, then for a generic group. When combined with the results of microscopic and burning tests, the results of solubility tests make it possible to identify the fibres in most cases.

2.46.5 Tensile strength test

Tensile testing is the most commonly applied test method for analyzing the mechanical properties of fabric materials. Although the direction of applied force is always in tension, there are a variety of tensile test methods available for capturing the most relevant data for final product usage. A grab test is a tensile test in which the center part of the specimen width is gripped in the tensile grip jaws. Due to the way the sample is gripped, edge effects, which may cause inaccurate data for fabrics, are eliminated. Similar to the strip test method, tensile force is applied to the fabric specimen until rupture and maximum force is recorded. Fabric specimens most often tested using the grab method are woven and non-woven textile fabrics.
Testing standards outlining grab test instructions include:

- ASTM D751 – Standard Test Methods for Coated Fabrics (Breaking Strength, Procedure A)
- ASTM D1683 for woven apparel fabric seams
- ASTM D2208 for soft, boarded, seeded, or embossed leather
- ASTM D5034 – Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)
- ISO 13934-2

2.46.6 Seam strength test

Seam strength is the strength of the connecting seams constituting the fabric. The grab test method and the strip test method can be used to measure the seam strength of fabric specimens. ASTM D4884 is the test method recommended for measuring the seam strength of geotextiles. ASTM D751 includes specific sections on seam strength testing and adhesion coating testing.

2.46.7 Air permeability

Air permeability can be measured by using distinct test protocols, for example, ASTM D 737 and ISO 9237. According to these test methods, the airflow through a given area of fabric is measured at a constant pressure drop across the fabric. The fabric is clamped over the air inlet, and the air is drawn through this fabric sample by means of a suction pump. The rate of air flow at this point is

measured using a flow meter. The value of permeability may differ considerably across the entire area of the fabric due to irregularities in the yarn.
The permeability findings are not influenced by fabric orientation because the measured area is always circular. The test conditions for the measurement of air permeability are the clamping area of the sample (cm^2) and the pressure difference (Pa). According to the ASTM standard, the recommended test area is 38.3 cm^2, while alternate areas are 5 and 100 cm^2. The air is drawn perpendicularly through the fabric and the airflow rate is adjusted to provide a pressure difference of between 100 and 2500 Pa between the two fabric surfaces (minimum pressure drop of 125 Pa). The pressure drop is 100 Pa for apparel and 200 Pa for industrial fabrics. The air permeability in mm/s can be calculated as

$$\text{Air permeability, } R = \frac{Qv}{A} \times 167$$

Where, Qv is the flow rate of air in "dm^3 per min" or "liters per min"
A is the fabric area in cm^2

2.46.8 Moisture wicking

Wetting and wicking are important phenomena in the processing applications of fibrous materials. Various aspects of liquid- fibre interactions such as wetting, transport and retention have received much attention both in terms of fundamental research and for product and process development. Wetting is the displacement of a fiber-air interface with a fiber-liquid interface. 'Drying 'has been defined as the removal of volatile substances by heated air from a moist object. During drying of moist objects simultaneous heat and moisture transfer occurs both inside the solid and in the boundary of the drying agent. The absorption and spreading of water is affected by their fiber properties, yarn properties, fabric structure and any mechanical or chemical treatments applied on the fabric.

1. Volumetric method: The main principle of this volumetric method deals with the measure of difference in absorbency of the liquid by the fabric over a period of time. The Siphon test method, Vertical-wicking experiment, Densitometer apparatus, Gravimetric Absorption Testing System and dynamic water absorption measurement falls under this classification.
2. Observation method: A drop of liquid was delivered from a fixed height onto the test fabric. The wicking of the fabric is measured by tracing its outer boundary by direct observations. No specific equipment is required and it offers the opportunity to make measurements for a minimal financial outlay and takes little time, but this is at the cost of accuracy; the determination of the end-point by observation is prone to subjective variations. The optical test methods are Areal wicking 'spot 'test, Longitudinal wicking 'strip 'test (AATCC 197), Horizontal-wicking test, Radial wicking (ring test), Sink test.
3. Optical method: The experimental setup and procedure of the Contact angle measurement, automatic longitudinal wicking test method, Horizontal-wicking test, Dynamic water absorption tester for terry fabrics, embedded-image processing method are the following optical evaluation method. Numerous wicking tests have been developed based on image-

analysis techniques which can record the time-dependent wicking curve with the help of a charge-coupled device (CCD) camera.

4. Spectroscopic method: The determination of mass of water absorbed by fabrics is a measure of the differences in depth of colour between the dry and wet states of the fabrics using a spectrophotometer. Transfer-wicking test by X-ray micro tomography, transfer-wicking set-up, Trans planar water transport are examples of spectroscopic methods.
5. Electrical method: Electrical techniques are suitable for the investigation of a range of fabric properties providing data that are not so easily accessed by other means. It can be used to measure the horizontal and vertical wicking rate of fabrics by electrical resistance. Horizontal-wicking testing by electrical resistance, Moisture Management Tester (MMT), Longitudinal wicking 'strip 'test by capacitance, Vertical-wicking testing by electrical resistivity, Sweat transfer tester are working under the electrical principle.
6. Pressure based method: The fabrics which do not saturate immediately (fabrics with relatively poor absorbency and/or thick fabrics), whereas hydrophilic fabric and multiple layers of fabric can be tested by pressure based method]. A pressure sensor was attached to detect the reduction in pressure of the water column due to water absorption in fabric and the small change of-pressure signal was magnified by an amplifier measured based on time. A special feature of this method is that multilayer fabrics can be tested but it is difficult to ensure repeatability.
7. Magnetic resonance method: Nuclear magnetic resonance (NMR) is a physical characterization technique which enables observation of the absorption spectrum of an electromagnetic field by nuclei. The absorbed electromagnetic field gives a specific signature for each particular atom; therefore, the atom can be characterized and the electromagnetic intensity represents the amount of material presented. NMR has also been used for imaging fluid distribution and movement in textiles.
8. Temperature detection method: This technique makes use of the latent heat of evaporation of water from a damp fabric. The temperature of a wet fabric decreases when evaporation takes place. During the evaporation period, the water within the fabric absorbs energy from the surroundings, thus causing a drop in temperature and enabling the presence of water to be detected. Areal wicking 'spot 'test by temperature detection, In-plane wicking test by temperature detection are working under this principle.

Tests for absorption/distribution of liquid moisture:

- BPI 1.2.1 Liquid sweat transport and liquid sweat buffering
- AATCC 79 Absorbency of textiles
- AATCC 197 Vertical wicking of textiles
- AATCC 198 Horizontal wicking of textiles
- AATCC 195 Liquid moisture management properties of textile fabrics

2.47 Drying/evaporation Test

- AATCC 199 Drying rate of textiles: Moisture analyzer method
- AATCC 200 Drying rate of textiles at their absorbent capacity: air flow method
- AATCC 201 Drying rate of fabric: Heated plate method

The textile sample is moistened and then dried at a given temperature until it reaches the drying end point. The end point of drying is the state where the weight of the fabric is about 4% higher

than its weight in the dried state. Time needed for reaching this state is called the drying time. When the sample is moistened, it is immersed in deionized water for 1 min. Then, the sample is suspended vertically for 5 min and left freely to dry. After then, the sample is again weighed. The method can be used only for materials that can be labelled as absorbable. The instrument moisture analyzer is used for realization of the test. The instrument does not allow the real conditions to be simulated, it means, the presence of the air flow and heating, which helps to speed up drying, and it corresponds to better usage of functional textiles on the body of the wearer.
Another method called BPI is described in the standard TNI CEN/TR 16422: Buffering capacity of liquid sweat and sweat transport – transfer of liquid sweat and balancing of liquid sweat. The equipment for measurement of evaporation and thermal resistance, the so-called small skin model, is used in the method. During the measurement, both the air flow and the heating of the material during the drying process simulating the drying effect on the wearer's skin are applied. The testing is carried out using the device described in ISO 11092. The principle is based on the heated plate simulating the effect of sweating. The temperature of the plate is set at 35°C, and relative humidity of the ambient air is set at 40%. The advantage of the method lies in its speed and not too big ambitiousness. However, it has no explanatory power concerning the course of drying and determination of the time, when the fabric is fully dry.

2.48 Water repellency Test

There are three main types of test methods available for assessing the water repellency of the specimen, which should be suitably preconditioned prior to testing under standardized conditions: Class I spray tests for assessing rain impact, Class II hydrostatic pressure tests, which measure water penetration, and Class III sorption of water due to immersion of specimen in water

1. Spray tests to simulate exposure to rain: In the AATCC Test Method 22, Water-Repellency: Spray Test, water is showered on the fabric specimen, which has been preconditioned for 4 h prior to testing, producing a wetted pattern. A rating will be given by comparison of the wetted pattern to standard chart pictures.
2. The AATCC Test Method 35, Water Resistance: Rain Test assesses fabric performance when it is sprayed with rain water as well as the pressure due to the rain's impact. This test is applicable to all types of fabrics whether treated with a water repellent chemical or not. The fabric performance is assessed by various parameters by determining the maximum pressure where no penetration is observed, the effect of a change in pressure on fabric penetration, and the least pressure required for penetration of 5 g of water onto the tested specimen.
3. Other standard test methods are ISO 9865, Textiles, Assessing the Repellency of Water by Bondsman Shower Test and BS EN 29865; both determine the repellency of fabrics that are permeable to air. Water is filtered and deionized, which is then passed through jets of specific dimensions and sprayed onto the fabric surface. Four test specimens will be kept at a specific angle to the cups and are simultaneously exposed to a heavy rain shower of controlled intensity while the under-surface of each specimen is subjected to a rubbing action. Water that is passed through the fabric will be collected in the cup and later its volume will be measured. In addition, the amount of water that is retained by the test specimen will be measured by comparison of the weight of the fabric before and after the testing.
4. Hydrostatic pressure tests: For many high-performance fabrics that are rendered waterproof, a hydrostatic pressure test may be conducted in one of two ways:

a. By applying a gradual hydrostatic pressure on the fabric and assessing the minimum pressure necessary for penetration.
b. By subjecting the fabric to a constant hydrostatic pressure for a lengthy time duration and assessing any penetration

5. The AATCC Test Method 70, Water-Repellency: Tumble Jar Dynamic Absorption Test assesses the absorption of water into the specimen under conditions similar to actual use. Preconditioned and pre-weighed samples are kept in water for a specific time; extra water is eliminated by the wringer method and the sample is weighed again. The percentage weight increase of the specimen will reflect the sample's absorption.

2.49 Thermal insulation Test

The sense of cold develops due to the increase in heat loss from a human body. Excessive cold can be a health hazard, since excessive heat loss from the body may result in hypothermia/frostbite. Decreased body temperature due to heat loss also affects the physical, manual and perceptive performance of individuals. Therefore, protective measures are taken through clothing that controls and regulates heat loss. Clothing is a protective means for thermal insulation. Clothing and garments used in cold climates should have sufficient insulation to maintain the thermal balance of the body. The required clothing insulation (IREQ) is calculated on the basis of the hypothesis concerning the heat flow by conduction, convection, radiation and evaporation. Thermal insulation varies with fabrics/clothing and is tested with new ensembles and garments.

IREQ represents the resulting clothing insulation required in a cold environment to maintain the body in a state of thermal equilibrium at an acceptable level of body and skin temperatures. IREQ measures the cold stress, combining the effects of air temperature, mean radiant temperature, relative humidity, and air velocity for a defined level of metabolic rate. It analyzes the effects of the cold environment and the metabolic rate on the human body. It also deals with the requirement of particular clothing insulation and the subsequent selection of clothing to be used under actual conditions. It evaluates the change in heat balance parameters to provide a suitable design and plan for work time and work regimes under cold conditions. IREQ is calculated by the analysis of a human body's heat exchange with the environment.

The mathematical expression of IREQ is the general heat balance equation, as shown in Equation

$$M\text{-}W = E_{res}C + res E + K + R + C + S +$$

where M is metabolic rate, W is effective mechanical power, E res is respiratory evaporative heat loss, C res is respiratory convective heat loss, E is evaporative heat exchange, K is conductive heat exchange, R is radioactive heat exchange, C is convective heat exchange, and S is body heat storage rate.

The left side of the equation indicates the internal heat production of the body, balanced by the right side, which denotes the sum of heat exchanges in the respiratory tract, heat transfers on the skin and heat storage accumulation in the body. Heat loss from the human body through clothing takes place by four modes of heat transfer: conduction, convection, radiation and evaporated sweat. Heat exchange depends on the thermal insulation of the clothing ensemble and the skin-to-clothing surface temperature gradient. Dry heat flow to the clothing surface is equivalent to the heat transfer between the clothing surface and the environment. Therefore, heat exchange through clothing is determined by the resultant thermal insulation of clothing. It is given in Equation

$$T)Sk\text{-}TcI\ /(clr = R + C = M - W - E_{res}C + res - E - S$$

where Tsk is mean skin temperature, Tc is clothing surface temperature, Icl,r is resultant clothing insulation, and IREQ is required clothing insulation. IREQ is expressed in $m2\ K\ W{-}1$. It is also expressed in Clo, where 1 Clo = 0.155 $m2\ K\ W{-}1$. From Equations (1) and (2), the required clothing insulation, IREQ, is calculated on the basis of the hypothesis concerning heat flow by conduction, as shown in Equation (3).

IREQ= (TSk-TC(R+C) /(

The values of R and C depend on metabolism rate and can be determined using Equation (1). It is to be noted that human beings 'metabolism rates vary (50 - 400 $Wm{-}2$)

Manikin methods:

- ISO 9920 Ergonomics of the thermal environment – Estimation of thermal insulation and water vapour resistance of a clothing ensemble
- ISO 15831 Clothing physiological effects – Measurement of thermal insulation by means of a thermal manikin
- ASTM F1291 Standard test method for measuring the thermal insulation of clothing using a heated manikin
- ASTM F2732 Standard practice for determining the temperature ratings for cold weather protective clothing

2.50 Pilling test

Pilling is a condition that arises in wear due to the formation of entangled fibre, pills, clinging to the fabric surface giving it an unsightly appearance. Pills are formed by a rubbing action on loose fibres which are present on the fabric surface. It's often caused by friction, either from rough washing cycles or abrasive detergents. Fabric pilling, which will affect the appearance of fabrics and reduce the use performance of fabrics. But it doesn't affect the durability or functionality of the fabric. Fibers such as wool, cotton, polyester, nylon and acrylic have a tendency to pill the most, but wool pilling diminishes over time. Whereas pilling of synthetic textiles is a more serious problem, because the stronger fibers hold on to the pills preventing them from falling off.

To avoid pilling generally the singeing process is done to the loose fibers protruding on the surface of the textile, and spinning the yarn with a high number of twists per inch. Some fabrics are chemically treated during the manufacturing process in order to reduce their propensity to pill. Polymeric coatings are sometimes applied to bind fibers into the fabric surface and prevent initial fuzz from forming.Pilling test by martindale abrasion tester: The specimens are mounted on large (bottom) and small (top) specimen holders. Then rubbed against each other (source sample).If the degree of pilling is different on the upper and lower holder, the upper specimen is assessed. The number and timing of the cycles depend on the type of fabric tested and would be laid down in the relevant specification.

2.51 Color fastness Test

Color fastness is a term used in the textile industry to describe the resistance of a fabric against color fading or color transfer. There are different types of colour fastness: to Washing, to Light, to Crocking/Rubbing, to Perspiration, and to detergent washing test

1. Color Fastness to Washing: A textile item must withstand repeated washing throughout its lifecycle without losing its color properties or staining other articles it's washed with. Detergent washing testing determines the resistance of textile colors to domestic or

commercial laundering procedures. The two main standards for detergent washing are ISO 105 C06 and AATCC 61. Aim for a color change rating of 4 and a color staining rating of 3 to 5 for detergent washing.

2. Color fastness to crocking test (wet and dry rubbing): Crocking refers to transfer of a colorant through rubbing. Crocking test determines the resistance of textile colors to rubbing off and staining other materials. A fabric with poor color fastness could rub colorants off on consumers, furniture, other textiles or miscellaneous items.
   The ISO 105 X12 and AATCC 8 test methods both use a machine known as a "crock meter" to rub the fabric. The crock meter has a rubbing finger which the lab technician rubs across the fabric by turning a mechanical lever. The crock meter applies a stronger force for a longer period than an inspector can manually apply when performing inspection at the supplier's facility. The rubbing fingers vary in size for pile fabrics and other textiles. The rubbing direction can also vary based on the type and design of the fabric. But the crock meter typically rubs the fabric in the warp and weft directions separately.
   The staining of the rubbing cloth is then assessed using the Grey Scale for Staining. Many textile importers will accept a grade 4 rating for dry rubbing and grade 3 rating for wet. Color fastness to wet rubbing is typically lower than for dry rubbing for most fabrics. ISO 105 X12 and AATCC 8 vary mostly in the amount of water used to wet the cloth rubbed on the test specimen.
3. Color fastness to light test: The color fastness to light test determines the effect of natural sunlight on textile colors. All textile colorants are susceptible to some fading in sunlight, as colorants by nature absorb certain wavelengths. Color fastness to light testing might be particularly important to importers of clothing worn predominately outdoors. But even retail display lighting can cause fading. ISO 105 B02 and AATCC 16 are the most common international standards for color fastness to light. Both standards test fabrics under a Xenon Arc lamp that closely resembles natural sunlight, but the standards vary significantly in their assessment methods.
   a. ISO 105 B02: ISO 105 B02 has four different exposure cycles with different humidity and temperature levels, including A1, A2, A3 and B. Many importers use A2 because it mimics extreme low humidity conditions. ISO 105 B02 varies from AATCC 16 in that a blue wool reference material with a known reaction to light is simultaneously exposed to light during the test. The fading of the test sample is then rated in comparison to the fading of the blue wool reference. The Blue Wool Scale ranges from 1 (very low color fastness to light) to 8 (very high color fastness to light). In ISO 105 B02 A2, the lamp can also have either a black panel (uninsulated) or black standard (insulated) sensor to control the temperature.
   b. AATCC 16: AATCC 16 includes five different testing options. Option 3 is the most commonly used because it simulates extreme low humidity conditions and is most equivalent to the ISO 105 BO2 A2 cycle. The Option 3 procedure subjects the fabric to continuous light, while some other AATCC 16 options subject the fabric to alternating light and dark conditions. Option 3 uses a Xenon lamp with a black panel sensor, while Option 4 and 5 use black standard sensors. AATCC 16 differs from ISO 105 B02 in that light exposure in the former case is measured using a specialized unit of irradiance known as AATCC Fading Unit (AFU). The color change of the fabric is measured using the Grey Scale for Color Change, as in other

AATCC color fastness test standards. Importers will typically accept a grade 4 rating for this test.

4. Color fastness to perspiration test: The color fastness to perspiration test determines the resistance of textile colors to human perspiration. Fabric dyes and human perspiration can often react and cause color fading in clothing items. A color fastness test for perspiration is particularly relevant for sports apparel and swimwear, which will most likely be exposed to heavy perspiration during use. ISO 105 E04 and AATCC 15 are the two main standards for perspiration testing. For this test, the lab attaches a strip of multitier fabric to the test specimen to measure staining. This multitier fabric has swatches of different kinds of fibers, such as nylon, cotton, acetate, polyester, wool and acrylic fabrics. The lab then compares the staining of the multitier fabric to the Grey Scale for Staining, with a desired grade 3 rating. The lab compares the color of the test specimen with the Grey Scale for Color Change, with a desired grade 4 rating.
    a. ISO 105 E04: During this test, the lab soaks the fabric in a simulated perspiration solution for 30 minutes under a fixed pressure and then dries it slowly at an elevated temperature. ISO 105 E04 tests for color fastness to both acidic and alkaline perspiration. Human sweat is typically acidic, though it can become alkaline in higher temperatures or when bacteria are present.
    b. AATCC 15: AATCC 15 only tests color fastness to acidic perspiration. The AATCC previously included alkaline test methods in the standard but removed it in 1974, as they didn't believe it reflected normal end usagethe drying time, pressure and temperature also vary between ISO 105 E04 and AATCC 15. AATCC 15 requires the fabric to be heated for longer at a slightly higher temperature than ISO 105 E04.
5. Color fastness to water test: Color fastness to water determines the resistance of textile colors to immersion in water. You might think this test sounds like the washing test. But color fastness to water testing is specifically used to measure the migration of color to another fabric when wet and in close contact. The washing test also typically uses a basic PH solution due to the addition of detergent, while this test is conducted at neutral PH levels.ISO 105 E01 and AATCC 107 are the most common standards for color fastness tests to water. The standards are technically equivalent, but the testing methods vary slightly between them.
    a. ISO 105 E01 and AATCC 107: For this test, the lab technician attaches a strip of multitier fabric specimen to measure staining, as with the perspiration test. The test specimen and multitier fabric are immersed together in water under specific conditions of temperature and time. After soaking, the fabric is then placed between glass or plastic plates and dried under specified time, pressure and temperature conditions. Themultitier fabric is then compared to the Grey Scale for Staining and the test specimen is compared to the Grayscale for Color Change. Many importers will accept a grade 3 rating for staining and a grade 4 for color change.

       ISO 105 E01 and AATCC 107 vary most in the heating time of the test specimen after immersion. AATCC 107 requires the specimen to be heated for longer than ISO 105 E01.

2.52 Comfort standards

Thermal comfort is that condition of mind that expresses satisfaction with the thermal environment.International standards have been established with the purpose of "specifying the combinations of indoor thermal environmental factors that will produce thermal environmental conditions acceptable to a majority of the occupants within the space."

2.52.1 Primary Factors:

Six primary factors must be addressed when defining conditions for thermal comfort. A number of other, secondary factors affect comfort in some circumstances. The six primary factors are as follows:

1. Metabolic rate
2. Clothing insulation
3. Air temperature
4. Radiant temperature
5. Air speed
6. Humidity

The first two factors are characteristics of the occupants, and the remaining four factors are conditions of the thermal environment.

2.52.2 Individual factors:

- Activity (met)
- Clothing insulation (clo unit)

There are leading standards developed for thermal comfort including:

- ASHRAE-55
- ISO 7730

According to the standards listed above, occupant thermal comfort can be predicted based on air temperature, thermal radiation, humidity, air speed, as well as personal factors such as physical activity and the degree of clothing insulation.
Numerical simulation helps predict those conditions already in the early stage of conceptualization. Timescale provides thermal comfort parameter outputs in the form of Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) fields as developed by P.O. Finger, following the static model for thermal comfort

2.52.2.1 Clothing Coefficient (clo)

- Definition: A unit used to express the thermal insulation provided by garments and clothing ensembles.
- 1 clo = 0.155 $m^2 \cdot °C/W$ (0.88 $ft^2 \cdot h \cdot °F/Btu$)
- Clothing insulation (clo unit) Research on clothing insulation originally conducted for military purposes. 1 clo = 0.16 Cm2/w (1 m2 = 11 ft2). The clo is a measure of thermal resistance and includes the insulation provided by any layer of trapped air between skin and clothing and insulation value of clothing itself. 1 clo unit will maintain a sedentary man at 1 met indefinitely comfortable in an environment of 21oC (69.8oF), 50% RH, and .01 m/s (20 ft. /min) air movement. Assuming no

wind penetration and no body movements to pump air around, clothing insulation = 0.15 x weight of clothes in lbs. (i.e., 0.15 clo per lb. of clothes). So 10 lbs. clothes = 1.5 clo.
Tog = European unit of thermal insulation
1 tog = 0.645 clo.

- Recommendation: Use 0.5 clo for summer clothing and 1 clo for winter clothing levels.

Table 11 : Clo units required for different purpose By ASHRAE Standards

S.No	Clothing ensemble	Clo units
1	Nude	0
2	Shorts	0.1
3	Light dress, pantyhose, bra and panties	0.3
4	Shorts, short sleeved shirts, sandals	0.4
5	Blouse, slacks dress, pantyhose, bra and panties, shoes	0.5
6	Long lightweight trousers, short sleeved shirts, socks, shoes	0.5
7	Sweater, skirt, blouse slip, pantyhose, bra and panties, shoes	1.0
8	Business suit with usual undergarments and footwear	1.0
9	1 Clo plus light overcoat	1.5
10	1 Clo plus substantial overcoat	2.0
11	Long underwear, flannel shirt, sweater, heavy trousers, heavy coat, woolen socks and boots	3.0 - 3.5
12	Specialized polar or alpine ensemble	4.0 - 4.5

- 1 clo is the insulating value of a normal business suit, with cotton underwear. Shorts with short-sleeved shirts would be about 0.25 clo, heavy winter suits with overcoats around 2 clo and the heaviest arctic clothing 4.5 clo. Table above gives the clo-values of various pieces of garments. The total clo value of an ensemble is 0.82 times the sum of individual items

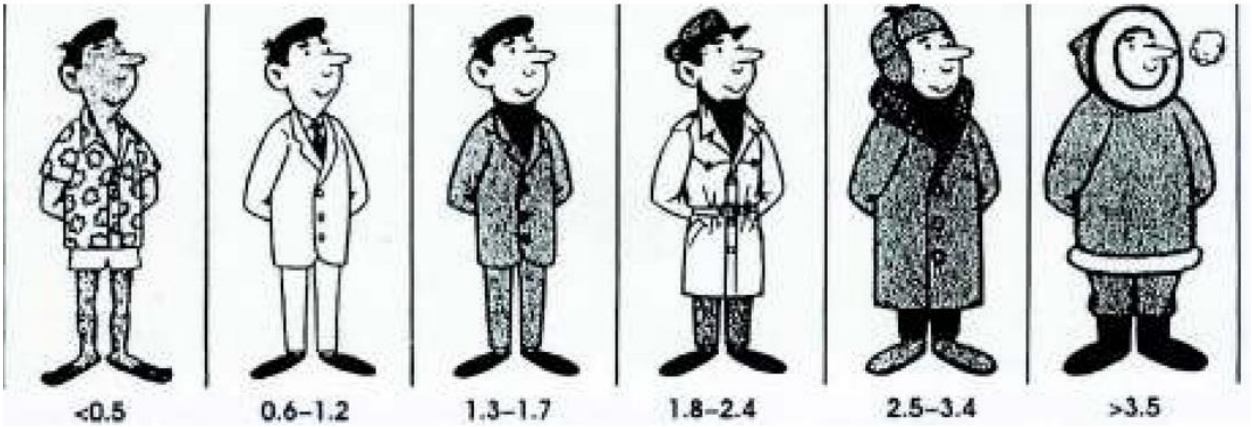
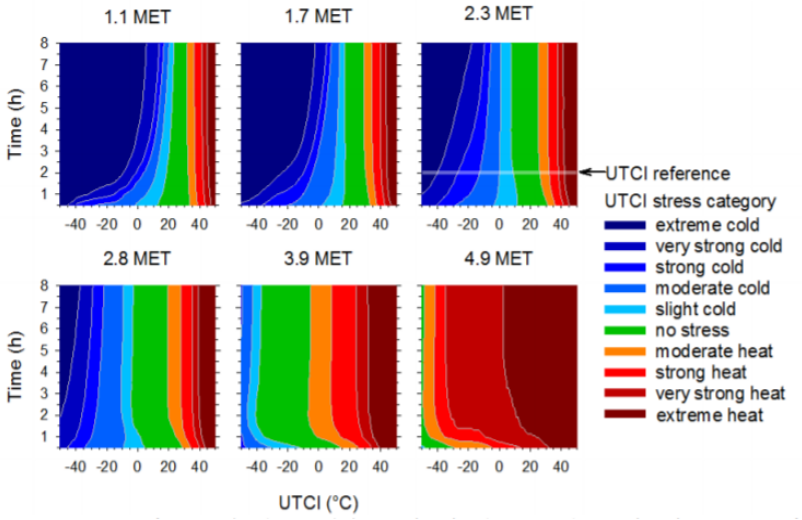


Figure 29 : Insulation of clothing in clo units (Auliciems A. et al, 2007, p.9)

2.52.2.2 Metabolic rate (met)

- Definition: The rate of transformation of chemical energy into heat and mechanical work by metabolic activities within an organism.
- 1 met = 58.2 W/m² (18.4 Btu/h·ft²)
- Recommendation: Use 1 met for passively sitting occupants (e.g. theater audience), 1.5 met for actively sitting occupants (e.g. office work)
- S = M -W -E -(R + C) where
  S = rate of heat storage of human body, M = metabolic rate, W = mechanical work done by human body, E = rate of total evaporation loss; R + C = dry heat exchange through radiation & convection

Figure 30 : Metabolic rate and scale of activity level variation



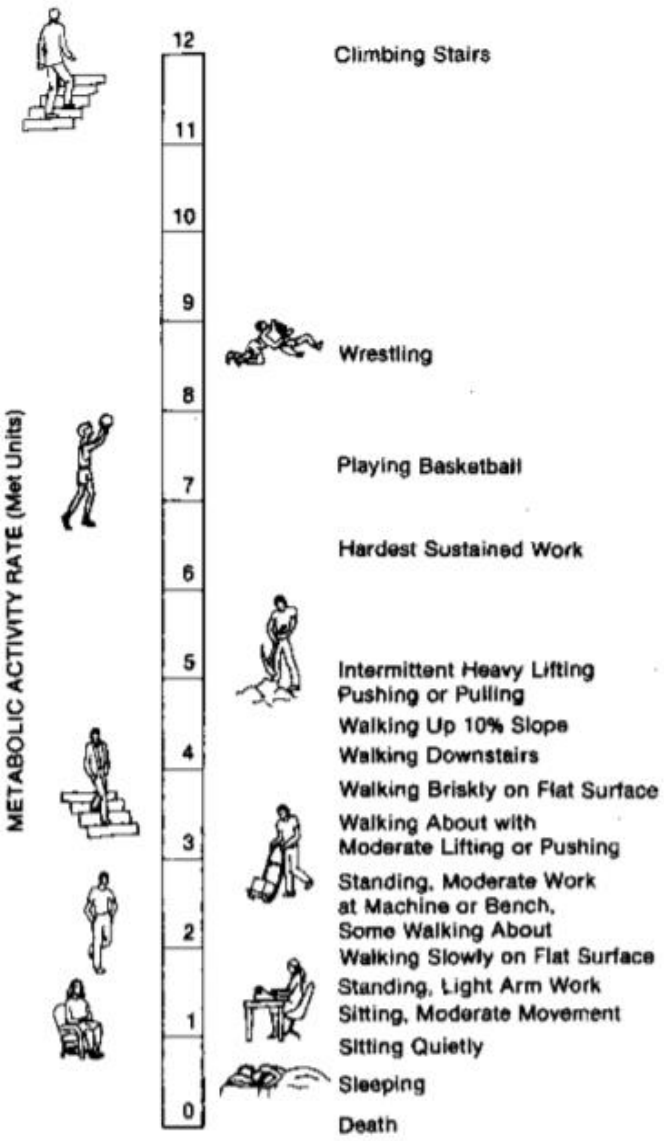


FIGURE 1.6. Scale of activity level variations (in met units).

Figure 31: MET units for different activities

2.53 Trim Analysis

2.53.1 Zippers

A zipper, zip, or zip is a fastening device. It is a commonly used device for binding the edges of an opening of fabric or other flexible material, as on a garment or a bag.

2.53.2 Aspects of zipper:

1. Zipper Size (The width between these two edges in millimeters is the zipper size. In the picture below I have two different metal zippers in different sizes)
2. Weight
3. Length

2.53.3 Structure of a Zipper

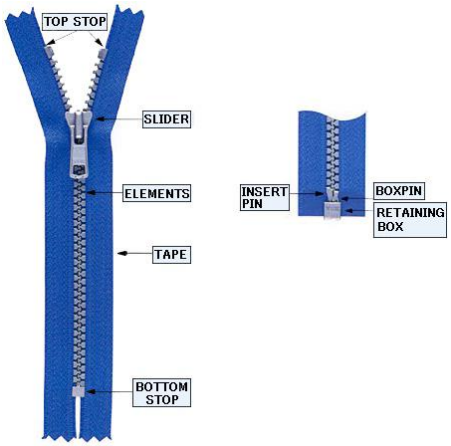


Figure 33 : Structure of zipper

1. Slider: The slider joins or separates the elements when the zipper is opened or closed. Various types of sliders are available depending on use.
2. Elements: The teeth, also known as elements, are the parts on each side of a zipper that mesh, or engage, with each other when passed through the slider. When the left and the right side teeth are engaged they are called chains.
3. Tape: The tape is manufactured exclusively for zippers. It is usually made of polyester, but depending on use, synthetic fiber tape, vinyl tape and cotton tape are also available.

Table 12 : Types of zipper functions

2.53.4 Types of Function

Closed-end (C)	Open-end [Separator] (O)	Two-way separator (M)	Zipper with double sliders(C)	Zipper with double sliders(CX)

Table 13 : Standard slider functions

2.53.5 Standard Slider Functions

Non-Lock slider (DF)	**Automatic slider (DA)**	**Semi-automatic slider (DS)**	**Jeans slider (GS)**
			
The pull-tab does not lock at any position on the body. No locking mechanism.	The lock automatically locks when no force is placed on the tab-pull.	When the pull-tab is lowered, it locks. When the pull-tab is raised, it unlocks.	Jeans Semi-automatic slider
Pin lock slider (DP)	**Reversible slider (DUA)**	**Plastic slider (TA)**	**Plastic slider (TF)**

			
Pins on the pull-tab work on the elements and lock.	The pull moves along a rotating rail. The zipper opens and closes from either the front or back.(Automatic)	Locks are made of metal. (Automatic)	(Non-Lock)

Key lock slider	**Double pull**
	
Can be locked with a key.	Opens and closes from either front or back. (Non-Lock, Automatic)

2.53.6 Market availability:

a. Vision Aquaguard:YKK's water repellent zipper type for the AquaGuard® series, is a polyurethane laminated tape on a VISLON zipper. The new element design provides enhanced water resistance. This zipper is water repellent, not waterproof/watertight.

Table 14 : Types of water repellent zippers

				
T8 Shiny Transparent film	**T9** Matte Colored film	**T9** Shiny Film (Black/White)	**T10** Matte Transparent	**T810/T108** Shiny and Matte film

b. Aquaguard coil: It is created by laminating PU on the backside of a coil zipper. There are three types of film variations: shiny transparent film ,matte transparent film and matte colored film with a high quality appearance.

Table 15 : Appearances of water repellent zippers

		
T8 Shiny Transparent film	**T9 Matte** Colored film	**T10 Matte** Transparent film

c. Aquaseal: It is made for active marine sportswear. It is made from a high quality plastic. It doesn't allow water to penetrate through the teeth of the zipper.

d. YKK Natulon recycled zippers

   i. Chemically recycled zippers: This zipper is designed for customers who wish to market their finished product as recyclable.The zipper is made from recycled material using a chemical process that facilitates further recycling.

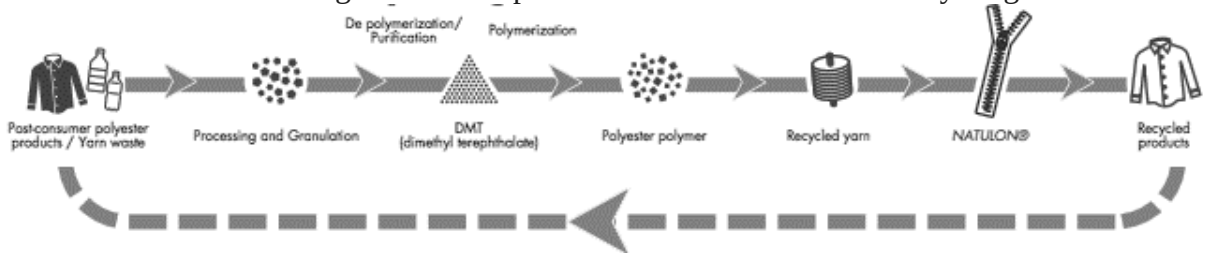


Figure 33 : Chemical process of recycling of zippers

Table 16 : Recycled material ratio for chemical process of recycling of zippers

	Element	Tape	Recycled material ratio (Uncut Zipper Roll)*
Coil	Recycled PET	Recycled PET	>86%
VISLON®	Recycled PBT	Recycled PET	>91%
VISLON®	POM	Recycled PET	>38%
Metal	Brass	Recycled PET	>22%

*by weight

ii. Mechanically recycled zippers: The resource saving fastening product made from recycled materials for customers who want to increase the recycled content of their products

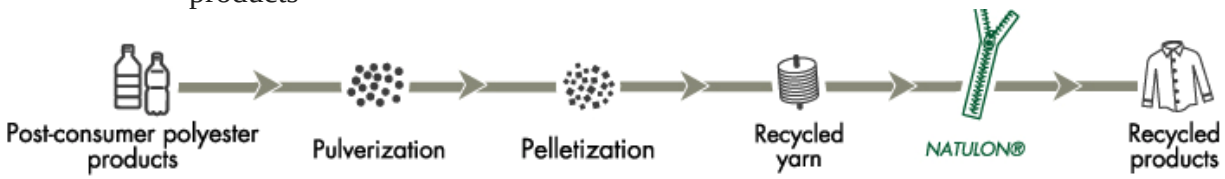


Figure 34 : Mechanical process of recycling of zippers

Table 17 : Recycled material ratio for mechanical process of recycling of zippers

	Element	Tape	Recycled material ratio (Uncut Zipper Roll)*
Coil	Recycled PET	Recycled PET	>86%
Coil	PET	Recycled PET	>42%
RC	PET	Recycled PET	>42%
VISLON®	POM	Recycled PET	>37%
Metal	Brass	Recycled PET	>16%
YZiP®	Brass	Recycled PET	>19%

*by weight

Note: PBT=PolyButyleneTerephthalate PET=PolyethyleneTerephthalate POM=PolyOxyMethylene(Polyacetal)

Ideal earth zippers

innovative and functional line of zippers for this market—AquaTek (water repellent), Delrin AX, Delrin CX, Delrin WF, IDEAL Earth Collection, MagZip, and Reflective products were all designed for maximum performance in the most extreme conditions on the planet.

e. AquaTek

These zippers use coated tapes making them awesome for outerwear like rain coats and board jackets, as well as technical outerwear.

- Water-resistant, resists the penetration of water on impact
- for outerwear like raincoats and board jackets
- Great for technical outerwear

f. Hydropel

Water-resistant, wind-resistant, anti-wicking, breathable, soft, super lightweight, available in Matte and High Gloss finish, over 600 colors, and resist water on impact as determined by the AATCC 35 Rain Test.

i. Water Resistant: Resists Penetration of water on impact; as determined by AATCC 35-2000
ii. Wind Resistant: Tape is tightly woven to effectively block wind
iii. Anti-Wicking: Each yarn is chemically treated so it doesn't absorb moisture keeping the zipper dry inside & out
iv. Breathable: 100% breathable through micropores in the woven tape allowing moisture to escape and ensuring dryness and comfort

g. Sustainable zippers

Ideal Earth zippers are made using repreve polyester, utilizing special processes that convert recycled water bottles into zippers.

Figure 35 : Repreve polyester recycling for zippers

2.54 Recycled buttons and snaps

There are various processes to obtain recycled buttons and snaps. For instance, used oils are recycled into hydraulic fluids, electronic waste is recycled for glass and heavy metal reclamation, waste paints and lacquers are recycled and mixed as high BTU content primary fuels for cement kilns, waste solvents are recovered on-site with a solvent recovery unit and used for paint clean up, plastic drums and containers are recycled for plastics re-manufacturing, cardboard and white paper are recycled for cardboard and paper remanufacturing, aluminum cans are collected and recycled for aluminum remanufacturing, and all scrap metals (copper, brass, steel, etc.) are collected and sold back to our various suppliers for metals re-manufacturing.

2.55 Customer Satisfaction (ACSI)

The customer satisfaction (ACSI) index score is calculated as a weighted average of three survey questions that measure different facets of satisfaction with a product or service. ACSI researchers use proprietary software technology to estimate the weighting for each question.

The heart of the American Customer Satisfaction Index is a set of three questions that assess satisfaction, each on a different 10-point scale:

Some organizations normalize and average the three ratings, like this:
(Satisfaction + Expectancy + Performance - 3) / 27 * 100
ASCI scores of retailers:

Table 18 : ASCI scores of retailers

Apparel	76
Levi Strauss	78
Nine West	77
VF	76
Hanesbrands	74
All Others	72

Aside from Unilever, Nike and Adidas are the only nondurable manufacturers to hold customer satisfaction steady this year. Nike scores 78, while Adidas remains stable at 77. But the two largest athletic shoe companies are slightly behind the "all others" category (79), which includes Under Armour and Skechers. A decline for the smaller manufacturers pulls down the industry's customer satisfaction by 2.5 percent to 78.

The apparel industry registers an ACSI score of 76, following a slip of 2.6 percent. Levi Strauss regains its perch at the top of the category with a score of 78. Nine West Holdings, which includes Jones New York brands, is next at 77. VF, which owns a range of brands such as Wrangler, JanSport and The North Face, comes in at the industry average (76), while Hanesbrands scores 74. The category of all smaller companies brings up the tail at 72, the lowest customer satisfaction level in apparel.

Figure 36 : ASCI Model

The survey and modeling methodology quantifies the strength of the effect of the index on the left to the one to which the arrow points on the right. These arrows represent "impacts." The ACSI model is self-weighting to maximize the explanation of customer satisfaction (ACSI) on customer loyalty. Looking at the indexes and impacts, users can determine which drivers of satisfaction, if improved, would have the most effect on customer loyalty.

2.56 Product portfolio of Ralph Lauren

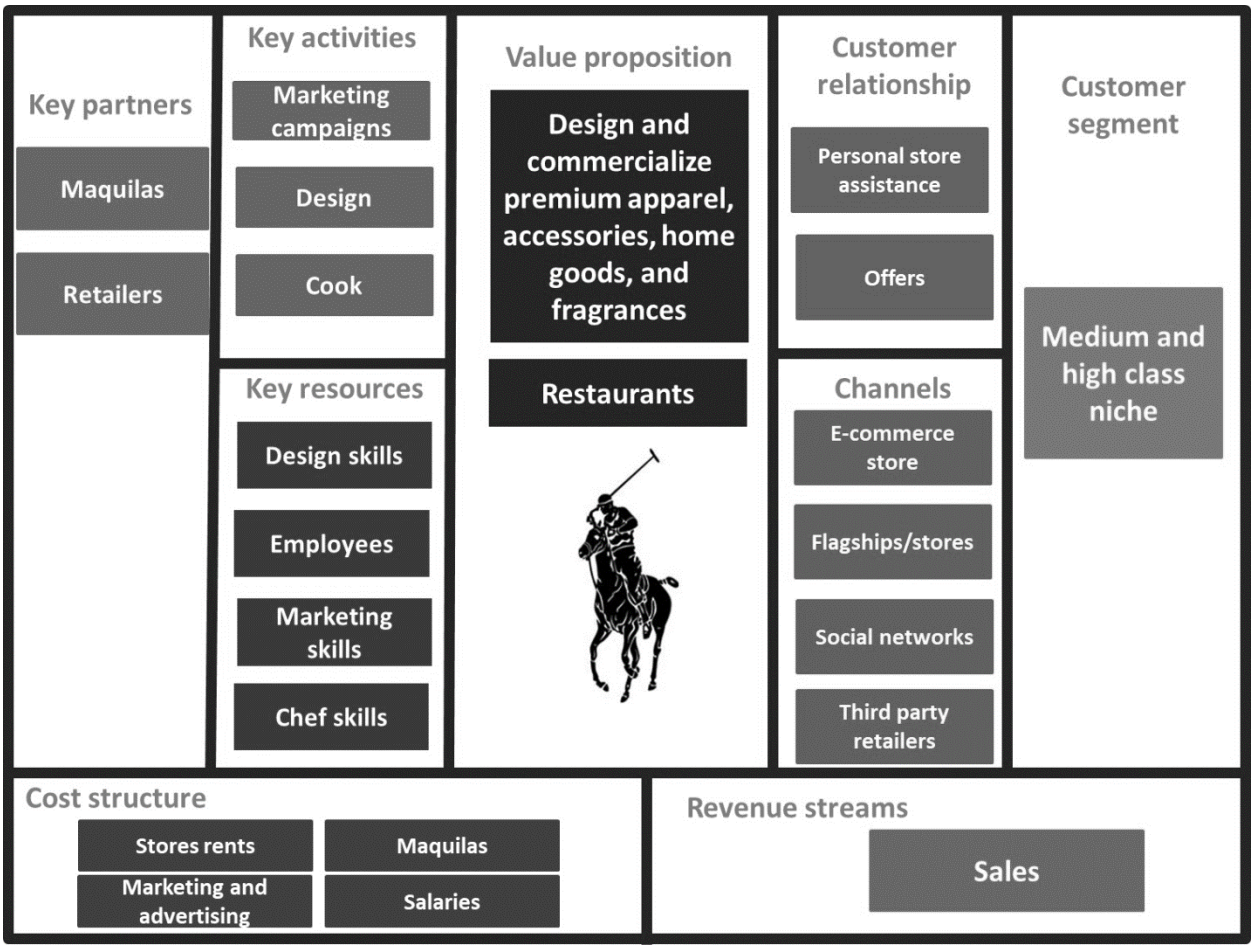


Figure 37: Business model for Ralph Lauren

2.56.1 Customer segment:

The segmentation is directed to customers with medium or high income. The products are expensive.

2.56.2 Value proposition:

design and commercialization of premium clothes, accessories, fragrances and home goods. All of them are exclusively designed by the brand and they are considered premium and unique. A second proposition is the restaurants.

2.56.3 Channels:

The different channels that Ralph Lauren uses are listed below:

- E-commerce store: Ralph Lauren has its own shop online
- Flagships or stores: Ralph Lauren has its own "mainly" stores, Flagships, in important cities and streets but also it has other shops located in shopping centers.
- Social networks: It has presence in the most important social networks, Facebook, Twitter, Instagram, and YouTube. In these platforms the firm shares its products and curiosities of the company such as interviews, events, etc.
- Third party retailers: many small and big retailers around the world commercialize Ralph Products, such as Sears, Liverpool, El Corte Inglés, etc.

2.56.4 Customer relationship:

It creates relationships through personal assistance for the customers that go to buy into the stores or eat in the restaurant. Another method is the offers the brand has in the reverse of the ticket one someone buys something or coupons.

2.56.5 Revenue streams:

The main revenue stream is sales of products and food.

2.56.6 Key resources:

- Design skill: designs of products are unique and exclusive, for this reason is mandatory to have skilled designers.
- Employees: It needs people to take care of stores and restaurants. The stores and people play an important role in customer experience, for this is necessary to have employees committed to the brand.
- Marketing skills: advertising and marketing campaigns also play an important role. The campaigns should be very effective to give the message of exclusivity and luxury. For this reason it is necessary to have skilled marketing workers.
- Chef skills: for the restaurants is necessary to have skilled chefs.

2.56.7 Key activities:

- Marketing campaigns, the
- Design of the products
- Cook food

2.56.8 Key partnerships:

- The brand designs the products but a third party, maquila, is in charge to produce them. Maquila should be a trustful partner to fulfill with the exclusive designs.
- Retailers or departmental stores are important because they can reach more customers.

2.56.9 Cost structure:

- Rent of the stores, flagships and restaurants. Fulfill with the space where these are located.
- Maquilas: manufacturers of the products
- Marketing and advertising: the cost incurred in the marketing projects
- Salaries

2.57 Ralph Lauren brand architecture

Ralph Lauren always had a long-term vision in shaping its product portfolio. It has always been important for the brand to link its different apparel and accessories lines under a single cohesive identity. The brand is currently going through a difficult time with decline in revenues and the need for optimisation of its operations. It has now become even more important for the brand to ensure that its product portfolio works together and portrays a consistent and credible image for the brand. It is also exploring opportunities to broaden its product lines and also venture beyond fashion. Regardless of the outcome of these initiatives, it is important for Ralph Lauren to ensure that the expanded product portfolio still has a strong link with the iconic parent brand.

Ralph Lauren has always enjoyed success due to positive consumer perceptions of its classic designs, high quality and premium image. It has followed an expansion strategy using the same core credentials into other fashion segments. The Ralph Lauren brand architecture has always been a topic for branding discussions as the architecture is constantly optimized to maximise the Ralph Lauren brand equity. Because of this executives do not hesitate to kill sub-brands that do not perform well – some examples of sub-brands that have left the portfolio are Ralph Lauren Black Label, Ralph Lauren Blue Label and Ralph Lauren Rugby. As of February 2017, the Ralph Lauren brand portfolio comprises 17 fashion brands, each differentiated by a different line of apparel with specific targeting towards different marketing and consumer segments.

The brand architecture falls somewhere in-between a ‘branded house ’and ‘house of brands’. In reality both Ralph Lauren and Polo have masterbrand status and are used to endorse specific sub-brands. The Ralph Lauren masterbrand has a broader equity compared to that of Polo, which is more used for endorsement of Polo-specific apparel lines. Brands that are part of the portfolio from acquisitions are allowed to operate without any form of endorsement. The current portfolio stands as below and ensures that the Ralph Lauren masterbrand has its influence throughout the portfolio:

2.57.1 Polo Ralph Lauren:

This is Ralph Lauren's first complete line of men's Polo shirts, sportswear and tailored clothing. Launched in 1968, it is the oldest brand in the portfolio and continues to be top-of-mind in the men's luxury casual and sportswear markets. It now offers accessories including eyewear, handbags, hats, scarves, gloves, belts and small leather goods as well.

2.57.2 Ralph Lauren Collection:

The Ralph Lauren Collection is Ralph Lauren's highest end brand launched in 1971. Timeless and sophisticated, it is a line of women's clothing that ranges from handmade evening gowns and tailored blazers to luxury sportswear. With its high price point, it targets the fashion-conscious and refined lady.

2.57.3 Polo Golf:

Launched in 1987, Polo Golf combines Ralph Lauren's love for sport and a luxury lifestyle. It offers state-of-the-art golf apparel including custom-fit mesh polo shirts, stretch shorts and that aims to enhance a golfer's swing.

2.57.4 Polo Sport:

Launched in 1992, this is Ralph Lauren's line of high-performance active wear, targeted at athletes and fitness junkies. This brand showcases Ralph Lauren's dedication to innovation. In 2014, it ventured into smart wearables and showed the world its first PoloTech™ shirt – a men's shirt with cutting-edge silver fibers woven directly into the shirt and a small sensor-filled black box attached near the ribcage to collect real-time biometric stats like steps taken and heart rate.

2.57.5 Double RL (RRL):

This brand was named after Ralph Lauren and his wife Ricky's ranch in Colorado (hence the "double R"). It was launched in 1993 and offers rustic-styled apparel inspired by the independent, hardworking spirit of the West – including denim, military-grade chinos, sweaters, flannels, vintage accessories and leather goods.

2.57.6 Ralph Lauren Purple Label:

This is the upscale couture line of Ralph Lauren that was launched in 1994. It offers refined and custom-made tailoring for men's tuxedos, suits, and sportswear, including Polo shirts made from luxury two-ply long-staple cotton.

2.57.7 Lauren by Ralph Lauren:

This was Ralph Lauren's line of women's clothing priced at a more accessible point, aimed at the modern, everyday lady. It was launched in 1996 and offers a large range of apparel, bags and accessories, from sophisticated work dresses to swimwear to sleepwear.

2.57.8 Ralph Lauren Golf, RLX and RLX Golf:

These collections were launched in 1998 and offers ultra-modern, graphic, performance-driven golf apparel, including progressive fits to sophisticated styles to technologically advanced fabrics. It is targeted at younger golfers who want to look trendy. Ralph Lauren Golf offers golf apparel for ladies while RLX Golf offers golf apparel for men. RLX offers clothing and outerwear built for general outdoor sports such as tennis, golf, skiing, sailing and hiking.

2.57.9 Club Monaco:

This Canadian-based specialty retailer which sells designer lookalike casual apparel for both men and women was acquired by Ralph Lauren in 1999. This was a growth strategy that aimed to provide a venue of choice for youth aged 15 – 25 who aspired towards well-fitted, fine clothing with modern, urban sophistication.

2.57.10 Pink Pony:

Established in 2000, the Pink Pony campaign is a global initiative that was set up to show support towards cancer victims. A proportion of Pink Pony product sales goes towards the Pink Pony Fund and other large cancer charities across the world. The Pink Pony brand comprises women's sportswear and shoes crafted in luxurious fabrics, all of which feature the pink Polo player logo, demonstrating the company's commitment towards the battle against cancer.

2.57.11 Polo Ralph Lauren Children:

This collection is designed to reflect the timeless heritage and modern spirit of Ralph Lauren's men and women collections. It is subdivided into Boys (sizes 2-7 and 8-20), Girls (2-6X and 7-16), Big Kid, Little Kid and Baby (Boy and Girl). It offers a variety of clothing from t-shirts and dresses to overalls and loafers.

2.57.12 American Living:

Launched in 2008, American Living was bought over by Ralph Lauren. The brand is available at department stores Macy's, Belk and JCPenney and offers classic, all-American collections including men's, women's and children's apparel, and home goods. The brand's pricing is aspirational yet accessible.

2.57.13 Ralph Lauren Watches and Fine Jewelry:

Launched in 2009, the Ralph Lauren Watch & Jewelry Co. introduced a premium collection of timepieces that are inspired by the image of prestige and sophistication that the Ralph Lauren brand has evolved to represent. This sub-brand has now expanded to include collections inspired by luxury lifestyles – including the Stirrup Collection inspired by the equestrian lifestyle, and the Automotive Collection inspired by Ralph Lauren's passion for classic car designs.

2.57.14 Denim & Supply Ralph Lauren:

As its name suggests, this sub-brand that was launched in 2011 offers mainly denim-based and casual apparel, including loose sweaters and plaid. It was born in Brooklyn, New York, and is inspired by the style of artists, painters, musicians and poets who inhabited there. With its lower price point and accessibility, it targets the younger crowd who is less interested in luxury and refinement.

2.57.15 Chaps:

This brand is similar to the Lauren by Ralph Lauren brand, and offers casual sportswear and dresses at a slightly lower price point. It draws on authentic inspirations, from nautical styles to American vogue, and offers apparel for men, women and children as well as home accessories.

2.58 The Ralph Lauren brand portfolio: Extending outside fashion

The above sub-brands allow Ralph Lauren to operate in many segments of the fashion apparel market and capture value in ways that do not cannibalize the other brands in the portfolio. Leveraging its strong brand equity in the fashion apparel market, Ralph Lauren has also extended the brand to watches and fine jewellery, categories that are natural extensions of fashion and luxury. However the brand has also extended into other product categories such as:

2.58.1 Ralph Lauren Home:

This home furnishing and accessories brand reflects the style and craftsmanship aligned with Ralph Lauren's brand image. It offers furniture, bed and bath linens, china, crystal, silver, decorative accessories, gifts, lighting, fabric, wall and floor covering, and photography artwork.

2.58.2 Ralph Lauren Pet:

Extending Ralph Lauren's style into pet collectibles, this brand offers dog vests, sweaters, hoodies, parkas, coats and leashes, all with the signature embroidered Pony logo, for discerning pet owners.

2.58.3 Ralph Lauren Fragrance:

The Ralph Lauren Corporation launched its first fragrances in 1978 – Lauren for women and Polo for men. Today, it has expanded into a variety of 10 fragrances for men, 9 fragrances for women and 3 unisex fragrances.

2.58.4 Ralph Lauren Restaurants:

To date, Ralph Lauren owns three restaurants and a café – the RL Restaurant, Ralph's Coffee and the Polo Bar. The RL Restaurant was opened in 1999 just across from the world's largest Polo store, the Chicago Flagship on Michigan Avenue, and represents the setting of foot by Ralph Lauren into the restaurant industry. Just like how its fashion brands are strongly inspired by Americana, the food is inspired by American classics and modern city-club cuisine – think seafood, steaks, chops, sandwiches and salads. First-time diners can also expect to be treated as a

member in its unique club atmosphere, reflecting the brand's impeccable attention to service. In 2010, it opened Ralph's in Paris, offering all-American experience to lovers of American food in Paris. The menu even offers beef from Ralph Lauren's Double RL ranch in Colorado. In 2014, it opened its first coffee shop on the second floor of the Polo Ralph Lauren flagship store in Manhattan. In 2015, it opened The Polo Bar in the heart of New York, offering a more casual yet refined setting for food and drink. Food is inspired by Ralph Lauren's personal favourites, and waiters are decked in custom Ralph Lauren grey flannel trousers, leather wingtips and silk repp ties. The RL Restaurants are indeed a great way to present another channel for consumers to experience the Ralph Lauren brand, rather than just its fashion and home products.

Through extending into multiple product categories, Ralph Lauren has been able to leverage its brand equity to have a presence in these lucrative sectors. It is truly a success story of classic brand management – appealing to a broad category of discerning, fashion conscious consumers through holistic brand equity encompassing multiple categories combined with a high-quality product experience.

1. Process Flow

The Project was broadly divided into three phases: -
Phase 1 – Understanding winter wear excursionist market and its products
Phase 2 – Identifying the customer requirements for excursionist market
Phase 3 – Analyzing and developing the garments

1. Literature Review(Gap Analysis)
    a. New emerging market survey
    b. Fashion blogger and instagram analysis
    c. Analysis of excursion as a hobby
    d. Understanding requirements of excursionist while travelling
    e. Brand feedback
2. Primary Data analysis
    a. Market survey- competitors data collection (specs)
        i. Price
        ii. Features
        iii. Fabric
        iv. Technologies

Information Collected from competitor survey?

3. Who are top competitors and benchmarkers among their competitors?
4. On what basis will I be able to compete?

5. What is the range of products they offer?
6. What are the pricing structure?
7. Do they satisfy their customers?
    a. Customer survey-
        i. Their requirements of performance and features
        ii. Brand impact (awareness of existing brands and the product they offer)
        iii. Concept test (likelihood of purchasing the product)
        iv. Fit analysis (problems faced in fit of the garment and comfort level)

Research Design

I. Type of Research Design

Exploratory research design was used for the project. The main purpose for using the exploratory research was to explore the requirements of the consumers. Besides this, another objective was to understand the brand ratings in minds of the consumers

II. Scale selection for questionnaire

The scale selected for the questionnaire would be Likert scale. This scale is selected for the questions which involves understanding of the parameters and requirements of the consumers

III. Questionnaire

Design Questionnaire includes both open and closed ended questions. Open ended questions are kept for recording the free responses for understanding the requirements and problems of the consumers. Closed ended questions are kept for recording the price ranges, and knowing the buying behavior of the consumers.

IV. Sampling Design

a. Target Population

The target population for the research project would be defined as:

Element: Working People/ Students (21- 50 years)

Sampling Unit: College Exchange student, winter excursionist, Majorly Online (cold regions), buyers from western region

Extent: USA, Canada, Europe, UK, Himalayan region

Time Period of the survey: 1 month

b. Sampling Technique

The Sampling without replacement technique with probability judgment sampling is used for the survey. The reason for using this technique is used because the sample element can be repeated and a judgment selection of the customers has to be done.

c. Sample Size

The Sample size selected for the research would be 200 customers falling in the age group between 21 years to 50 years.

3 Market Analysis

The extreme winter multi-functional jacket market is niche. It is a small market segment, as a result limiting the range of direct competitors but expanding the range of indirect competitors. The designs incorporating all the features present in the market are narrow. Hence a study of the direct and indirect competitor's jacket features, fit type and pricing is done to integrate as many features as possible in design with competitive pricing and most preferred fit. The target group/ consumers and stakeholders views and preferences are also taken into account through surveys to understand the market trend, understand what's really important to them, and prioritize the right features.

3.1 Identification of the Direct & indirect competitive brands and their fits

The benchmarking process of this jacket is done on the basis of two sub categories. First, the competitive are the inspirational brands having a similar product category; the enhancement of a jacket of any brand towards a jacket with better brand value can only be obtained by keeping a vision to broaden the circles of the kinds of jackets being offered. So, this allows the brands which the brand and the jacket range must look closely on to beat the relevant competition in the market and enhance its brand value in terms of collection offered, price points, fabric, etc. Second, is to look at the bigger and successful brands which have been the market leaders in terms of the multifunctional and winter jackets. They might also be an inspiration to a wide number of collections, products, the overall range or the most basic fit of the jackets.

For the benchmarking process, all the brands which cater to the men's wear winter and multifunctional jacket category are listed and analyzed. The brands which have the same price range and the target the customers of the same age group are selected. They are the Competitor brands and the other brands that are chosen, which lie in the lower price grid are the indirect competitor's brands.

The next step is to select the feasible factors with the help of the product team on the basis of which competition mapping is done.

The factors for completion mapping are:

- Fit
- Fabric
- Price Point
- Color
- Fashion Quotient
- Trims (Visual Assessment)

3.2 Benchmarking market survey (Secondary Data)

Market survey of 51 respondents from various region including India, Europe and North America was conducted. This questionnaire had general questions related to preference of consumers on jackets available in the market.

3.2.1 Competitors

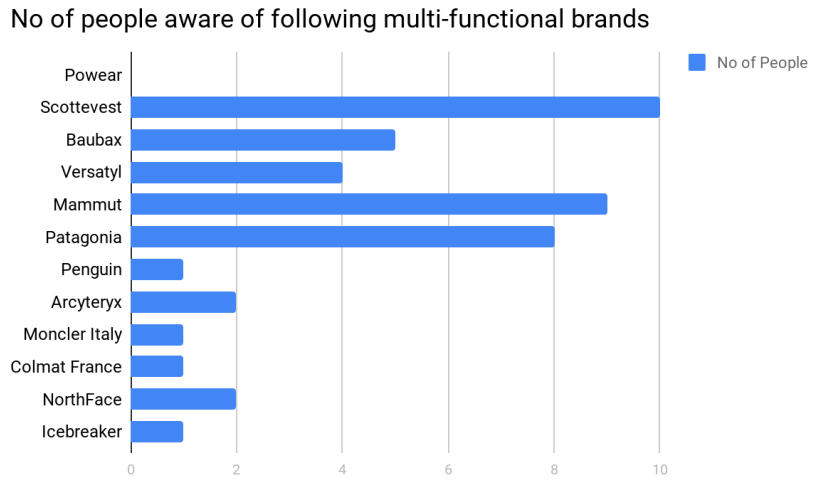


Figure 38 : Competitor brands for the jacket

Scott vest, Baubax 2.0, Versatyl, Mammut, Penguin, Arcteryx are indirect competitors and Patagonia, North Face, Moncler, Colmat, Mammut are direct competitors. While 37.3% aren't aware of any specific brand with multi functionality options.

3.2.2 Competitors for extreme winter

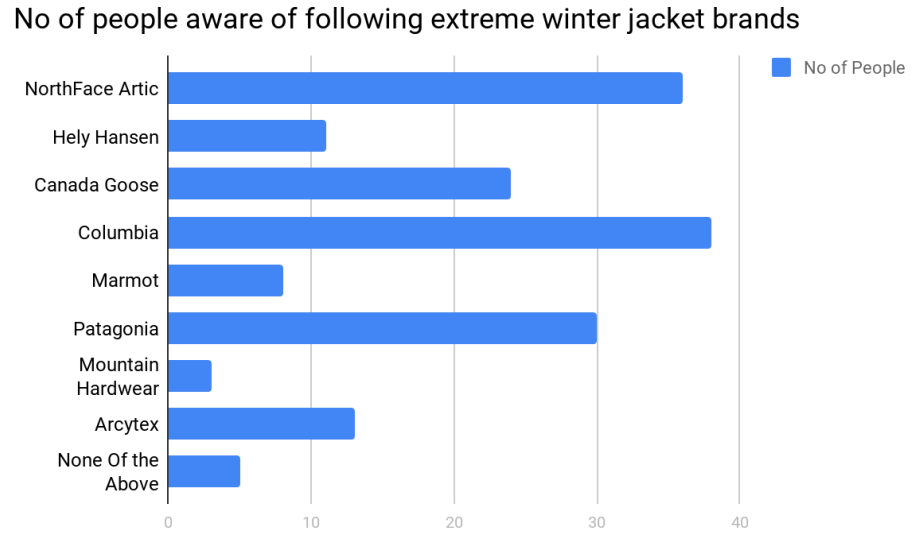


Figure 39 : Competitor brands for extreme winter jacket

North Face Artic, Heely hansen , Canada goose , Columbia , Marmot , Patagonia, Mountain Hardwear, Arcteryx are few known brands among consumers in European and American market.

3.2.3 FIT Preference

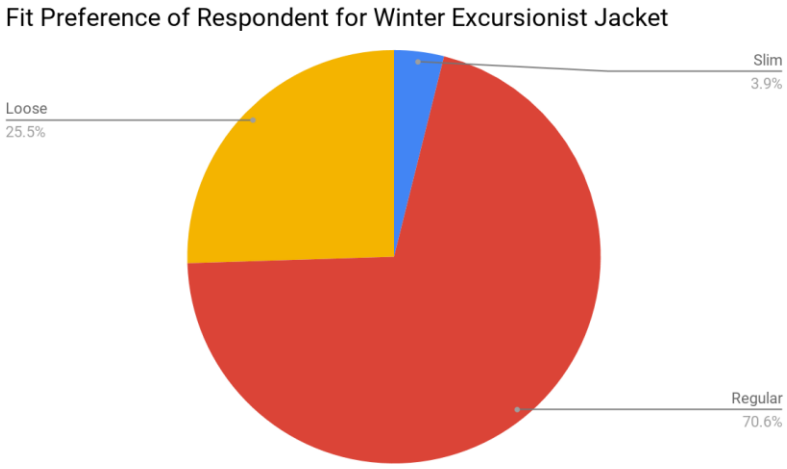


Figure 40 : Fit preference

Fit preference of respondents for winter excursionist jacket is mostly regular fit because of comfort and freedom of movement. Mostly people prefer regular fit over slim and loose.

3.2.4 Extreme winter preference

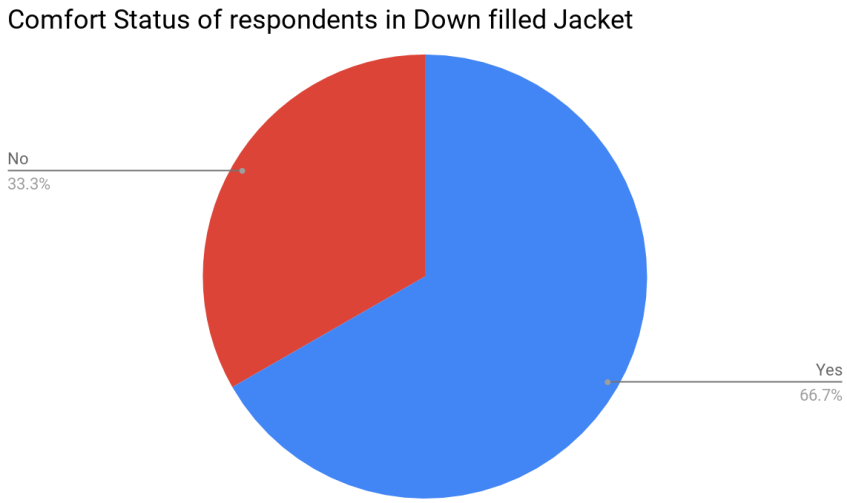


Figure 41 : Extreme winter preference

66.7% respondents feel comfortable in down jacket as compared to other jackets.

3.2.5 Cold excursionist market

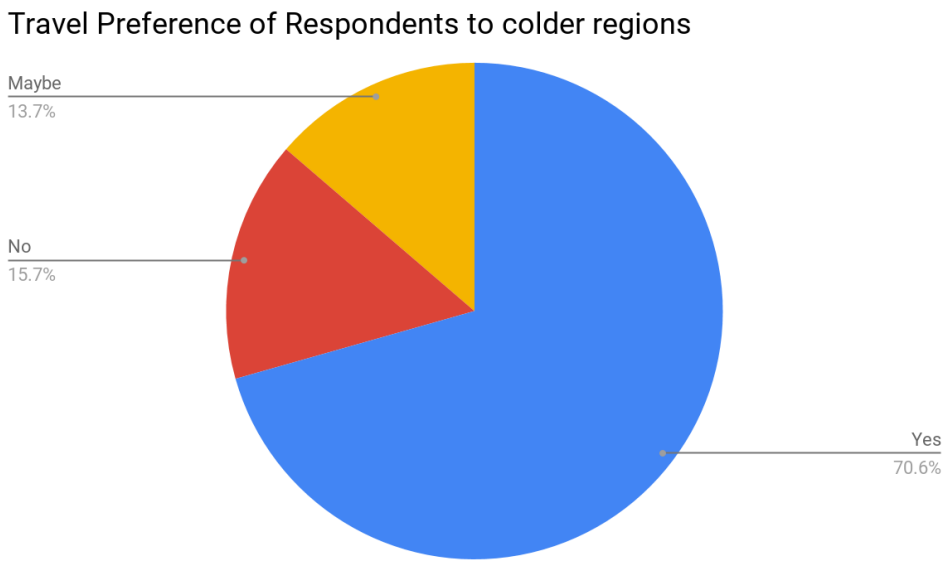


Figure 42 : Cold excursionist market

70.6% of respondents like excursions to winter places while 13.7% likes it partially.

3.2.6 Awareness of the specialty

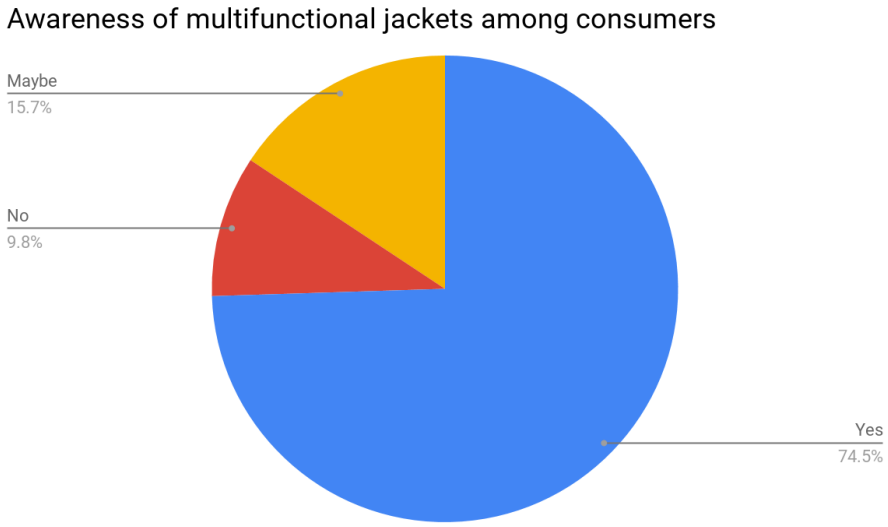


Figure 43 : Awareness of multifunctional jackets

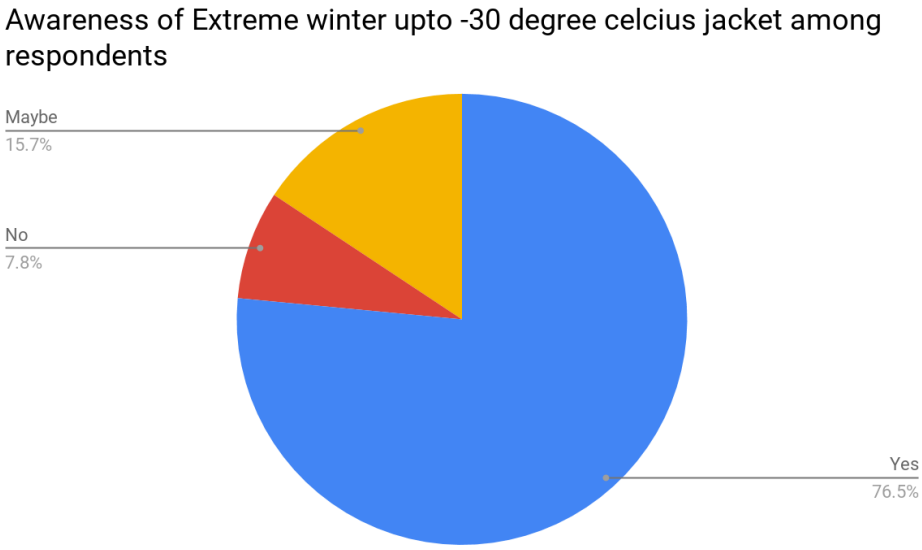


Figure 44 : Awareness of extreme winter jackets

84.5% respondents are aware of multifunctional jackets while 15.7% have heard about multifunctional jackets. While 76.5% respondents are aware about extreme winter jackets while 15.7% have heard about extreme winter jacket.

3.2.7 Consumer Comfort preference

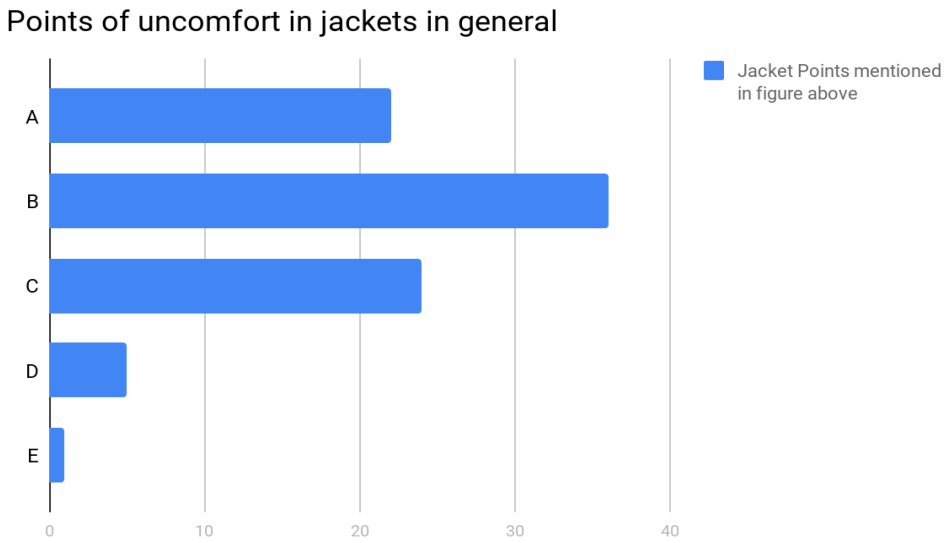


Figure 45 & 46 : Points of discomfort in jackets

Mostly respondents feel uncomfortable in underarm fitting of the jacket while neck and biceps are equally uncomfortable to consumers.

3.2.8 Feature Feasibility

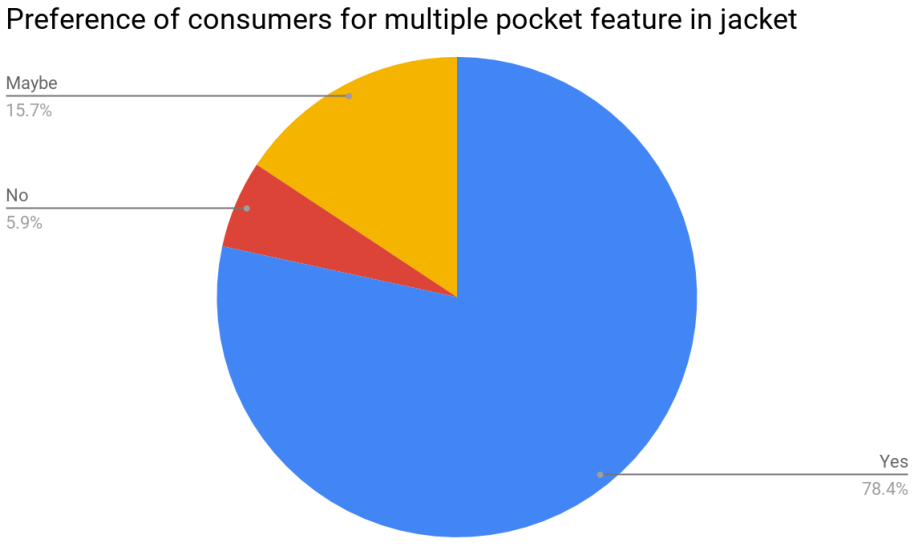


Figure 47 : Preference of consumers for multiple pockets feature in jacket

78.4% respondents prefer multiple pockets in jacket for multiple uses.

3.3 Competitors Analysis

1. Direct

Recent winter collection of following brands were analyzed to understand the current technologies and trends for jackets:

Table 19: Direct competitors

S.No	Brand	Price(in USD)	Material	Fit	Length	Notes
1	Tommy Hilfiger	500- 800	Nylon , Polyester , Organic Cotton,	Regular, Loose	Short Length	• Water Repellent Zipper
2	Michael Kors	600-1000	Nylon- Elastane, Poly-Nylon, Polyester, Nylon	Regular	Short Length	• 2 jackets in one • Water repellent Fabric
3	Calvin Klein	250-500	Poly-Viscose-Elastane, Nylon	Regular, Loose	Short and Mid length	• Darts on down fill jacket for fitting • warm at -8 degrees
4	Hugo Boss	800-1200	Polyamide, Polyester, Viscose, Nylon	Loose/relaxed fit, Regular fit, slim fit	Short and Mid length	• Collection name:Travel with BOSS • WR finish • Filling: 80% Polyester (recycled)
5	Lacoste	250-500	Polyester, Polyamide, Poly-Elastane, Fleece, Nylon	Regular, loose , slim	Short length	• Filling: Down (90%), Feather (10%) • Reflective bands
6	Banana Republic	180-300	Polyester, linen-cotton, twill cotton	Regular and loose	Short and Mid length	• WR Coating • Shirttail hem
7	Mackage	800-1100	Polyamide, Polyester,Nylon, Leather, wool acrylic	Regular, Slim, Loose	Short mid and long	• Duck Down • WR • Insulated pocket(polar fleece pockets) • Nano Down • Storm Visor • Removable Hood

2. Indirect

Table 20: Indirect competitors

S.No	Brand	Price(in USD)	Material	Fit	Length	Fill Power	Weight(in gram)	Temp zone (in C)	Notes
1	North Face Arctic	200-600	Cotton-NylonPolyester rPET Nylon rNylon rPET Taffeta Poly Mesh Nylon-Elastane	Regular Loose	Short Mid Long	550 - 950	390-1500	15 to -30	• Darting at front and back waist for a better fit • handwarmer pockets • Raglan sleeves for extra mobility • DWR(Durable Water Repellent) • Adjustable Velcro® cuff tabs • polyurethane (PU) coating • ThermoBall(Primaloft)
2	Canada goose	600-1700	Wool, Nylon, Polyester	Regular, Slim	Hip, Knee, Mid thigh	625-750	600-2000	5 to -40	• WR • 3 M Reflective tape • Arctic Teche
3	Columbia	100-400	Nylon, Polyester, Neoprene elastane	Regular, slim	Hip Knee	550-700	Not mentioned	20 to -40	• Omni Heat Reflector • Thermarator™ Insulation • Removable, adjustable, helmet-compatible storm hood • 2-way underarm venting • Interior security pocket • Media and goggle pocket • Zippered hand pockets • Ski pass pocket • Interior security pocket

									• 360° reflective • Adjustable cuffs • Zippered hand and chest pockets • Interior security pocket • Media and goggle pocket • Zippered hand pockets
4	Marmot	300-425	Polyester Acrylic Nylon rNylon	Regular Athletic	Mid Short	700-800	440-1023	20 to -15	• Environmentally sustainable PFC-free DWR • Water-resistant hand pockets • Micro Fleece Lined Zip Handwarmer Pocket • Inside Zip Pocket • Interior Drop Pocket • PitZips • Thinsulate • PFC-free water-repellent • Waterproof zippered chest pockets; Zippered sleeve pass pocket and hand pockets • Interior Zippered Pocket • 4-way water-resistant center front zipper; 4-way rainbow seat zipper with stay-open hook • Dual internal mesh 1-liter water bottle pockets; Zippered hand and thigh pockets • Power Down with Down Defender • PrimaLoft® Black Insulation Eco

5	Patagonia	350-500	Polyester Nylon rPet rNylon rDown polyester taffeta Polyester fleece	Regular	Short Mid	600-700	400-1307	20 to -30	• Two high handwarmer pockets with watertight zippers • stay clear of a harness or pack waist belt; • one exterior welted, left-chest pocket with DWR treated zipper • interior stretch catch-all pocket • PlumaFill • Media-Compatible Interior Pocket • zippered pocket at the collar • Removable Hood
6	Mountain Hardwear	400-800	Nylon Polyester Wool	Standard, slim	Hip, knee	800-900	Not Mentioned	Not Mentioned	• Zippered chest pocket, flap chest pocket and two zippered hand pockets • Zippered arm pocket for ski pass • Oversized zippered chest pockets for gloves, skins or radios • Small front zip pocket for essentials • Integrated RECCO® avalanche rescue reflector • 8-12 pockets
7	Arctery x	350-850	Nylon Polyester	Trim , relaxed FIt	Hip	Not mentioned	480-900	Not mentioned	• WaterTight™ Vislon zipper • Insulated hand pockets • two internal mesh pocket • Tall collar • DWR • Insulated hood

									• Chest pocket with zip • Two insulated hand pockets with zippers • GORE-TEX • 55% post consumer recycled content, wrapped in a 100% recycled polyester shell and lining • Helmet compatible StormHood • Laminated die-cut Velcro® cuff adjusters • Alpinist Mountain Standards Award • Urban Climber Magazine's Staff Pick
8	Helly Hansen	200-400	Polyester				700-1195		• Lifaloft insulator • Fusion modular system jacket to pant • Dual hand warmer pockets, two water secure chest pockets and one chest Life Pocket • Internal pockets for goggles and electronics • Ski-pass pocket • Adjustable hood • Single Storm flap front opening • Solas reflective • One hand adjustable hem • Articulated sleeves • Kill cord D-ring • Hanger loop • wrist gaiters with thumb hole • Goggle shammy

									• Fusion modular system jacket to pant • Dual hand warmer pockets and one chest pocket with goggle shammy • YKK® Aqua guard™ water resistant zippers • Hi vis hood brim • 2 bellow pockets, 1 chest pocket, 2 vent pockets and 1 beacon pocket • backpack specific pocket placement • Back right pocket with velcro closure. • Down insulated

Table 21: Indirect competitors

S.No	Brand	Price(in USD)	Material	Fit	Length	Fill Power	Weight (grams)	Temp zone (in C)	Notes
1	Baubax	198	100% polyester	regular	hip	-	900g to 1 kg	22 - 7	• Water repellent • Passport pocket • Pen pocket • Zipper pen / stylus • Phone and power bank pocket • ipad pocket • Cupholder • Blanket pocket • Built in eye mask
2	scottevest	175 - 250	100% polyester	regular	hip	-	550 to 800g	15 - 5	• Sunglass pocket • Camera pocket • Pen pockets • Phone and ipad pocket

									• Water bottle pocket • Key holder • Wallet pocket • Hand warmer pockets • Travel document pockets • Water repellent fabric
3	Powear IN2.0	425-500	Nylon, Cotton	Regular	Hip Knee	-	Not mentioned	-	• Passport pocket and Metro card pocket • Can be converted into a sling bag • RFID pocket • Headphone port • Waterproof trims • ipad pocket
4	Versatyl	50 - 60	100 %Polyester	Slim fit	Hip	-	179g	10 to 15	• Two napoleon chest pockets for IDs/Cards/Passport, • One Upper Arm pocket for keys/ change/ essentials, • Two Forearm pockets for keys/change/ essentials • Two hand warming pockets, Earphone loops, Pen holder pocket, Mini torch or bottle holder • Phone pocket, Portable charger pouch, Compact camera pouch, Tablet or Document slider • Jacket is water resistant and wrinkle free

3.4 Consumer Survey - Kano Model

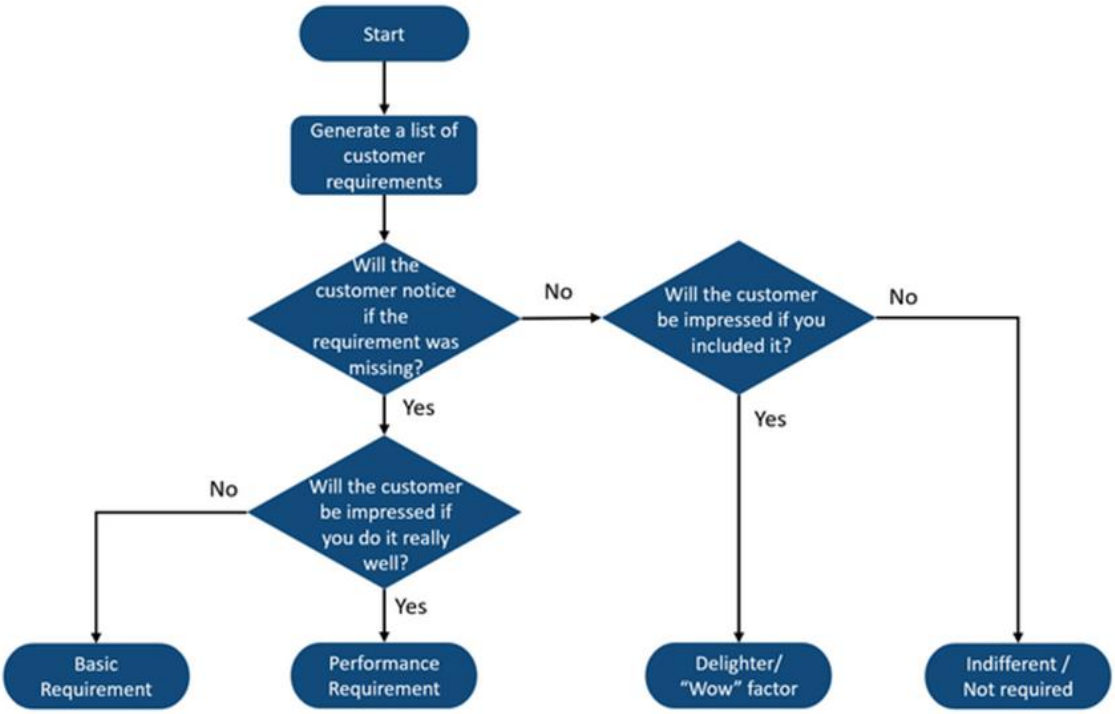


Figure 48 : Kano model

3.4.1 Possible features mentioned online suggested for excursionist to carry on their travel are listed:

A. Cold temperature withstand
B. Comfort level
C. Fitting
D. Aesthetics
E. Green
F. Detachable Length
G. Ease to use keys slot
H. Hand warmer pocket
I. Glove pocket
J. Eye mask
K. Neck pillow
L. Water bottle storage
M. Sanitizer pocket
N. Earplug slot
O. Water proofing feature
P. Microfibre fabric for sunglasses
Q. Rfid proof card pocket
R. Elastic loop for keys
S. Secret pocket
T. Detachable bag

U. Hidden eyemask pillow
V. Sunglass pocket
W. Card slot
X. Pen pocket
Y. passport pocket
Z. Torch
AA. Whistle provision
BB. Camera
CC. Flip flop compartment
DD. Towel

3.4.2 Possibility of consumers noticing the features:

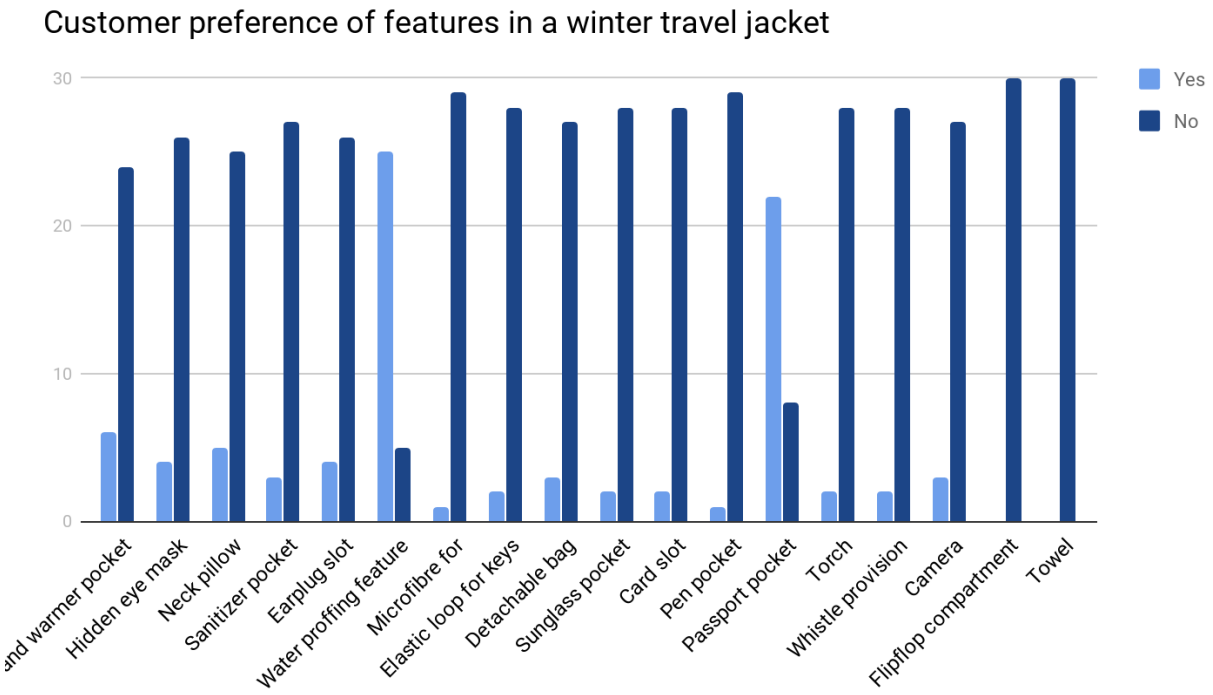


Figure 49 : Customer preference of features in a winter jacket

3.4.3 Possibility of consumers being impressed if they were included:

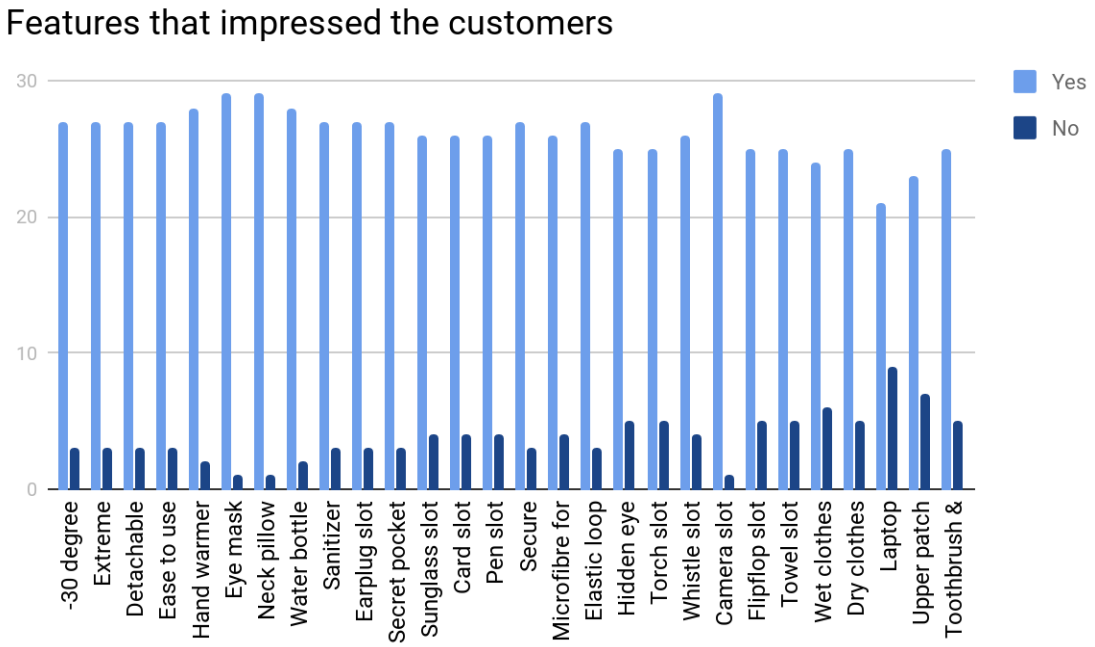


Figure 50 : Features that impressed the customers

3.4.4 Classifying the features into basic, performance, delight and not required features

BB. Wow Factor

1. -30 c
2. Extreme weather
3. Downproof
4. Detachable Length
5. Hand warmer
6. Card slot
7. Secure sunglasses
8. Microfibre fabric for sunglasses
9. Rfid proof card
10. Detachable bag
11. Hidden eye mask pillow
12. Torch
13. Whistle
14. Camera
15. Flip flop
16. Towel
17. Wet clothes
18. Dry clothes
19. Secret pocket
20. Ease to use keys
21. Green sustainable
22. Eye mask

23. Neck pillow
24. Earplug slot
25. Sunglass
26. Pen
27. Water bottle storage
28. Sanitizer pocket

FF. Performance feature

1. Comfort
2. Water proofing
3. Fit
4. Aesthetics

GG. Basic Requirement

1. Glove pocket
2. Passport ticket

HH. Not Required featured

1. Laptop pocket
2. Upper patch pocket
3. Toothbrush and toothpaste
4. Body wash

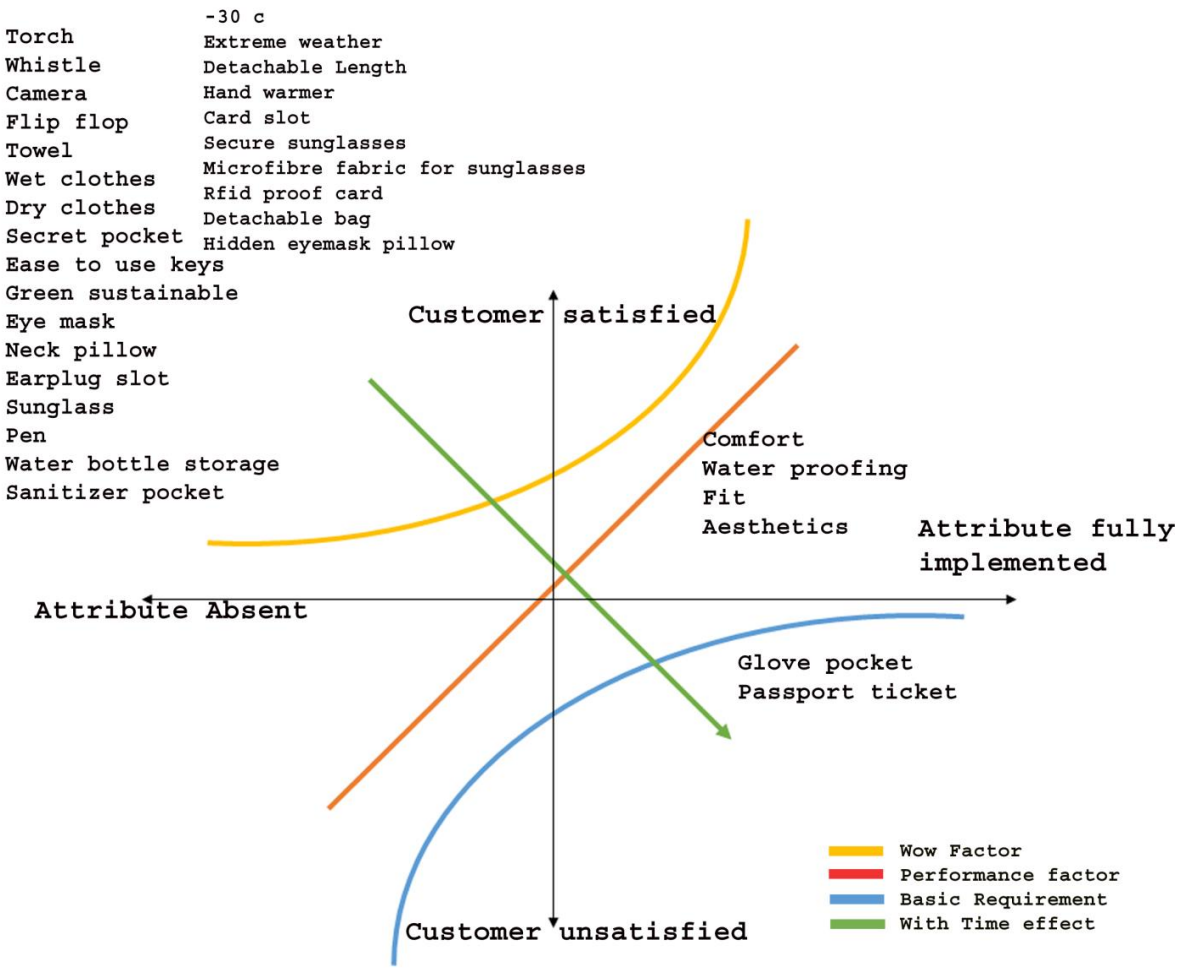


Figure 51 : Customer satisfaction curve

4 Concept Generation

For travelers craving adventure, wintertime in the countries like the US and Canada, Sky Gazing in Northwestern Canada, Wolf-Watching in Yellowstone, Heli-Skiing in Southwestern Colorado, Ice Fishing at The Ranch at Rock Creek, Dogsledding Near Anchorage, Alaska and Frozen Vineyards in Quebec the most popular destinations to experience. But before the travellers plan out their trip, they decide their essentials, in which comes the primary essential, their outfit during their trip. The outfit they are going to wear should be comfortable, warm, accommodate essentials and should also support the activities they will be participating in. As there is a limitation in availability of such a product in the existing market the idea of developing a "Multifunctional winter excursionist jacket" occurs.

This jacket can be worn in extreme winters having temperature up to -30 ℃and is made of completely synthetic and recycled materials to develop a product that is animal cruelty free and also supports the environment.

4.1 Pestle Analysis

4.1.1 Political Factors

The government has the ability to encourage companies to buy fabrics locally, especially if the taxation on imports from other countries increases. But due to the availability of certain materials, they are being sourced abroad legally. Additionally, certain groups like PETA boycott against companies who use real animal furs and skins. For this jacket, the raw materials are being sourced from China due to the limitations in the availability of materials within India. The product is in accordance with PETA and use of vegan material.

4.1.2 Economic Factors

The economy is still recovering from the impact of the recession, but more people are finding extra money to put towards fashion and accessories and also in tourism.There is an expansion of brands marketing seasonal clothing or activity related clothing like winter wear and mountaineering jackets and the brands have found their market, which is majorly parts of the United States, Canada and Europe which is the market for the new product development as well. They are countries with a good employment rate, population growth, extreme winter climates, popular holiday destinations and people who spend on tourism and apparel.

4.1.3 Social Factors

For job interviews, people normally wear formal attire. An office worker typically wears semi-casual attire. And retail workers are often confined to a dress code or uniform. People decide to wear attire depending on the occasion and that's set by pre-defined customs in a country. So, the kind of work, purpose, demographics play a major role in people's lives when they have to decide what to wear. The multifunctionality pockets of the jacket allows the user to carry utilities without a need to carry a backpack. Hence, people travelling to cold regions would prefer wearing a multifunctional jacket for winters.

4.1.4 Technological Factors

Online shopping is a dream for so many people. Instead of visiting busy shops and manually looking for clothes you might like, you can surf through an online category, pick the desired size, and have it delivered in days. Though the jacket will be launched in a limited market, customers belonging to different regions can also buy this jacket through an online medium when they have a requirement for it.

4.1.5 Legal Factors

The fashion industry follows similar legal rules and regulations like any other business. To stay legal, they follow tax restrictions, export restrictions, and inflation costs. They must also maintain workers rights. The product and the way it is being produced will not be violating any law.

4.1.6 Environmental Factors

Considering the environmental factors, the product is made of 100% recycled polyester fabric which is recycled from the PET bottles and since it's a jacket for extreme winters, the jacket contains synthetic down material which is again made of recycled polyester instead of using duck or goose down. The trims used will also be recycled trims like the recycled zippers and the packaging material used will also be recycled plastic bags. Hence, the product is helping in reducing the landfills of plastics.

4.2 SWOT Analysis

Table 22 : SWOT analysis

Strengths	Weaknesses	Opportunities	Threats

• Unique product having both features of winter and travel jackets • Compatible for extreme winters upto -30℃ • Ample amount of storage and many features • Comfortable fit • Made of recycled polyester from PET • Animal cruelty free product since duck / goose down is replaced by synthetic down	• Not multi seasonal • Limited market • Affordability of the jacket	• New market opportunity - the United states, Canada and Europe • Online sales of the jacket can capture the market all over the world for those in need of a product like this though launched in just a few countries.	• Existing brands like Baubax, versatyl, canada goose, columbia producing travel and winter jackets

4.3 Design Brief

4.3.1 Findings of Survey

The major findings of the survey are: -

1. There are multiple brands offering modular jackets but limited brands are offering it for winter collection. The brands which are offering it for winter excursionists don't offer much multi functionality pockets.
2. Hand warmer pockets have been seen as a basic necessity in the majority of the winter excursionist jackets.
3. Features like -30 ℃, Extreme weather, Downproof, Detachable Length, Hand warmer, Card slot, Secure sunglasses, Microfibre fabric for sunglasses, Rfid proof card slot, Detachable bag, Hidden eye mask pillow, Torch, Whistle, Camera, Flip flop, Towel, Wet clothes, Dry clothes, Secret pocket, Ease to use keys, Green sustainable, Eye mask, Neck pillow, Earplug slot, Sunglass slot, Pen slot, Water bottle storage and Sanitizer pocket are most common features preferred by consumers.
4. The fabrics used are majorly polyester, nylon and acetate.
5. Fill power used are majorly ranging from 600 to 900.
6. Jackets can go as low as -35 degree celsius and weight ranges from 400 grams to 2 kgs if clo level is correct.

7. Length preferred are mostly hip and knee length.
8. Cuff adjuster helps to tighten the wrist.
9. Goggle pockets and electronic pockets are one of the common features with DWR finish shells.
10. There are comfort issues in the underarm area faced by major consumers of jackets.
11. Consumers prefer regular fit more than other fits due to comfort parameters.

4.3.2 Final Design Brief

The design brief that was decided contained following objectives: -

1. The limitation in the availability of multifunctional jackets for extreme winters has generated this idea of providing a jacket that can be worn in extreme winters that is upto -30 ℃ and has multiple compartments and pockets that fulfills the requirements of an excursionist.
2. The jacket will be made of recycled polyester fabric that has water repellent finish and downproofing since the jacket type is a down jacket that will have recycled synthetic down used as the filling to provide the person wearing the jacket enough warmth to travel in extreme winter weather upto -30 ℃. The trims like zippers that are to be used in the jacket are also recycled and water proof.
3. The jacket consists of multiple functions like detachable length for comfort and extra storage, hand warmer pockets to keep the hands warm, credit card slot that is RFID proof, secure sunglass slot with microfibre fabric, detachable bag attached to the the jacket for extra storage, detachable hood with a hidden eye mask and an inflatable neck pillow, torch compartment, whistle, camera compartment, flip flop compartment, towel compartment, wet and clothes compartment, secret pocket, ease to use keys loop, earplug slot, pen slot, passport pocket, water bottle storage , a sanitizer pocket, a phone pocket with connecting power bank slot with DWR (durable water repellent) finish.
4. Regular fit is preferred by most of the consumers for its not very sleek or a very baggy look. Customers find regular fit more comfortable and appealing when it comes to winter jackets. But then, the users do face discomfort while using down jackets. So, this jacket to be developed will have darting at front and back waist for a better fit and raglan sleeves for extra mobility and adjustable velcro cuff tabs.

4.4 Creation and Development of Garments

Garment Sketch

Front

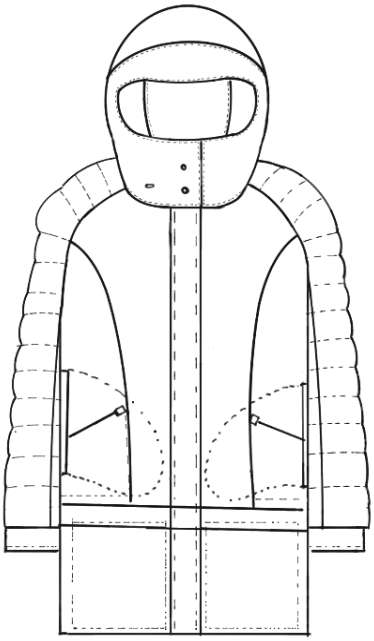
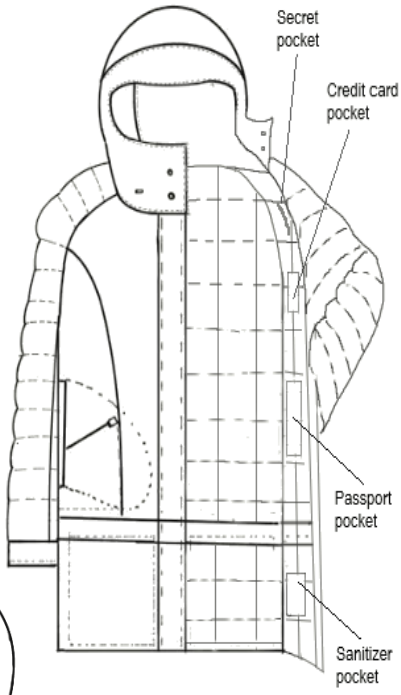


Figure 52 : Garment sketch front



Back

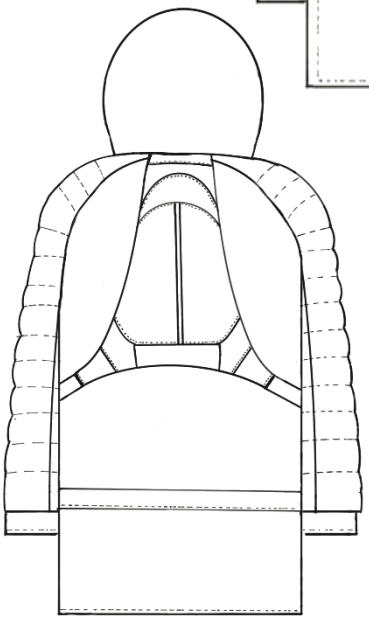


Figure 53 : Garment sketch back

Backpack and Hood

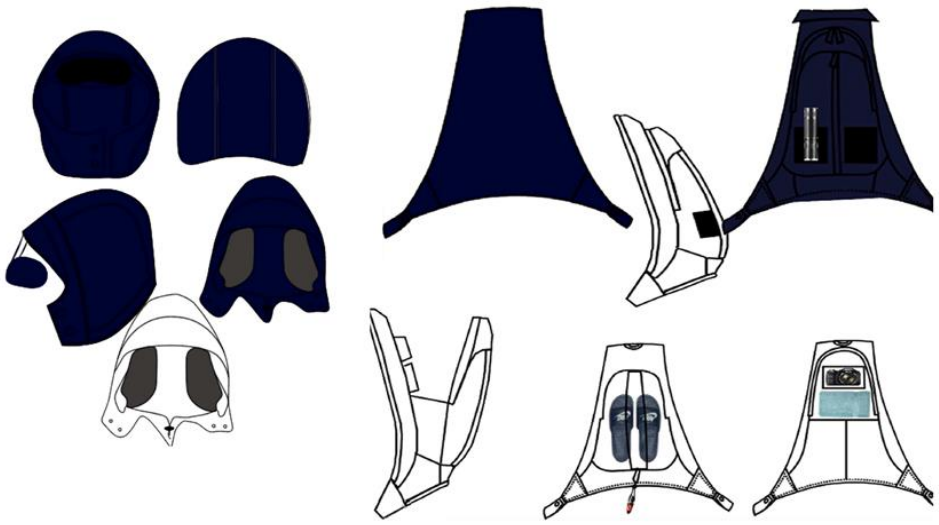


Figure 54 : Sketch of backpack and hood

4.5 3D Prototyping

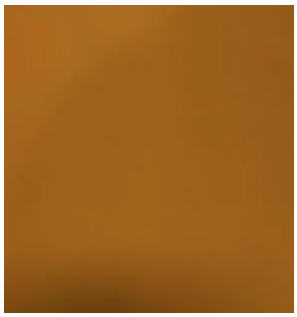
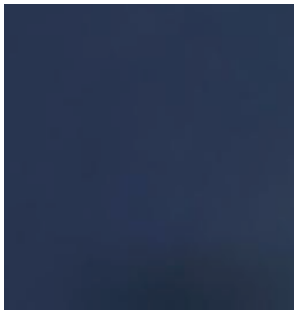
Figure 55 : 3D Prototyping back and front

4.6 Fabric selection

Table 23 : List of suitable fabrics

S.No	Fabric	Composition	Gsm	count	Finish

1		100 % Polyester (twill)	110	50 d x 50 d / 32 ot	Water repellency + lamination (down proof)
2		100% Nylon	100	70 d x 160 d / 23 ot	Piece dyed, Water repellency
3		100% Nylon	110	70 d x 320 d / 84 x 48	Piece dyed, Water repellency
4		100% Nylon	39	20 d x 20 d / 206 x 204	Piece dyed, Water repellency, Anti UV UPF 40+
5		100% Polyester (twill)	90	50 d x 50 d / 32 ot	Water repellency + CIRE (down proof)

6		100% Polyester	70	50 d x 50 d / 32 ot	Water repellency + CIRE (down proof)
7		100% Polyester	69	30 d x 30 d / 400 t	Water repellency + lamination (down proof)
8		100% Polyester	85	50 d x 50 d / 32 ot	Water repellency + lamination (down proof)

4.6.1 Fabric testing

Table 24 : Tests carried out for the suitable fabrics

SNO.	BASIS OF COMPARISON	1	2	3	4	5	6	7	8
1.	Fibre Identification	100% Polyester	100% Nylon	100% Nylon	100% Nylon	100% Polyester	100% Polyester	100% Polyester	100% Polyester
2.	Yarn Count(Along Warp)	88	90	93	58	72	65	66	72
	Yarn Count(Along Weft)	96	94	102	61	80	78	74	78
3.	Gsm Of Fabric	110	100	110	39	90	70	69	85
4. A)	Epi (Through Counting Glass)	94	88	96	58	77	65	66	72

	Ppi (Through Counting Glass)	99	94	108	60	84	78	79	78
4. B)	**Epi (Through Unravelling Method)**	88	90	93	58	72	65	66	72
	Ppi (Through Unravelling Method)	96	94	102	61	80	78	74	78
5.	**Weave Analysis**	twill	twill	twill	twill	twill	twill	twill	twill
6.	**Tensile Strength (Warp Wise)**	46.1	64.7	63.4	37.2	43.4	41.8	41.4	42.9
	Tensile Strength (Weft Wise)	45.2	64.2	63.0	34.8	40.8	37.8	37.4	41.1
7.	**Seam Slippage**	30.7	49.3	48.9	22.7	27.3	25.5	24.3	27.8
8.	**Dry Crocking Test**	4	4	4	4	4	4	4	4
	Wet Crocking Test	4	4	4	3	3	4	3	3
9.	**Abrasion Test (Difference In Weight)**								
10.	**Moisture Wicking**								

4.6.2 Filling Test Reports

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委托单位	上海硕特无纺布有限公司 地址：上海市金山区枫泾镇亭枫公路8399号				
客户认定信息	SOFEELATE舒天特DP梳绒棉-1 300cm×150cm 商标：SOFEELATE 颜色：白 纤维成分：聚酯 单位质量：180g/m² 生产单位：上海硕特无纺布有限公司 ----------				
检验性质	委托检测	样品受理/测试开始日期	2015-06-26 16:59	报告签发日期	2015-07-01
检验依据	---				
综合检验结论	—				
检验结果					
备注					

检验专用章

检测报告附页 (电子版)

No:150184261

检验项目 (计量单位) [样品识别]	测试方法	标准值及允差	测试结果	判定	备注
●保温率	GB/T 11048-1989 方法A 平板式	-------	保温率 86.73% 克罗值 3.810clo	---	
●平方米质量 (g/m^2)	GB/T 24218.1-2009	-------	185.10	---	

备注	(本栏空白)

4.6.2.1 Summary of the filling test

According to the report, the sample has thermal insulation or warmth retention property 3.810 clo and water vapour resistance 86.73%, done by sweating guarded-hotplate test. The sample has mass per unit area 185.10.

According to ASHRAE Standards, for a met level of 2.8 (walking) and for winter wear purpose below -20 degrees a clo of range 3-4 clo is needed. Hence filling is suitable for a jacket to be worn in extreme winters.

Figure 56 : Filling material

5.10 Trim Selection

Table 25 : Trims selection and details

S.No	Trim Type	Image	Material	Brand	Remarks
1.	Coil zipper		Nylon	YKK	Not water resistant
2.	Fastening buckles		Polyacetal	YKK	waterproof
3.	Velcro tape		Nylon	Velcro	Water resistant

4.	Coil zippers		Nylon	YKK	Not water resistant
5.	Tape snap		Nylon	YKK	Water resistant

4.7 Prototype Modifications

Figure 57 : Prototype

Figure 58 : Comments on prototype

Figure 59 : Prototype fitting on body form

4.7.1 Garment Features

Table 26 : Garment features

Weight	1.5 Kg
Breathability rating	20,000 g / m2

Waterproof rating	20,000 mm
Durability	5 - 7 years

4.7.2 Stakeholder Survey

The product is worn for a few hours by 30 stakeholders of the company and the product is rated as per the use in order to understand the success of the prototype in the actual environment. Following is the data collected:

Q1 - How would you feel if you could no longer use our jacket in winters?

Table 27 : Stakeholders responses percentage and count

#	Answer	%	Count
1	Extremely unhappy	16.67%	5
2	Moderately unhappy	16.67%	5
3	Slightly unhappy	43.33%	13
4	Neither happy nor unhappy	23.33%	7
5	Slightly happy	0.00%	0
6	Moderately happy	0.00%	0
7	Extremely happy	0.00%	0
	Total	100%	30

Table 28 : Stakeholder survey variables

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	How would you feel if you could no longer use our jacket in winters?	1.00	4.00	2.73	1.00	1.00	30

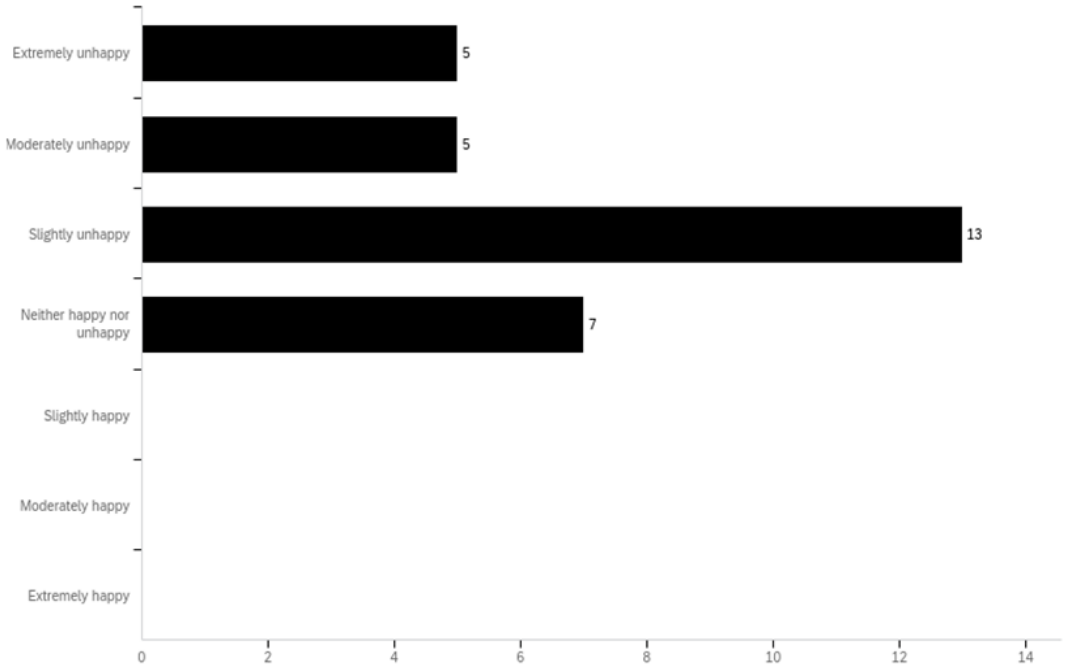


Figure 60 : Graphical representation of stakeholder's responses

Q2 - How easy or difficult is it to use our jacket?

Table 29 : Stakeholder survey variable

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	How easy or difficult is it to use our jacket?	1.00	4.00	1.77	0.76	0.58	30

Table 30 : Stakeholders responses percentage and count

#	Answer	%	Count
1	Extremely easy	40.00%	12
2	Moderately easy	46.67%	14
3	Slightly easy	10.00%	3
4	Neither easy nor difficult	3.33%	1
5	Slightly difficult	0.00%	0
6	Moderately difficult	0.00%	0
7	Extremely difficult	0.00%	0
	Total	100%	30

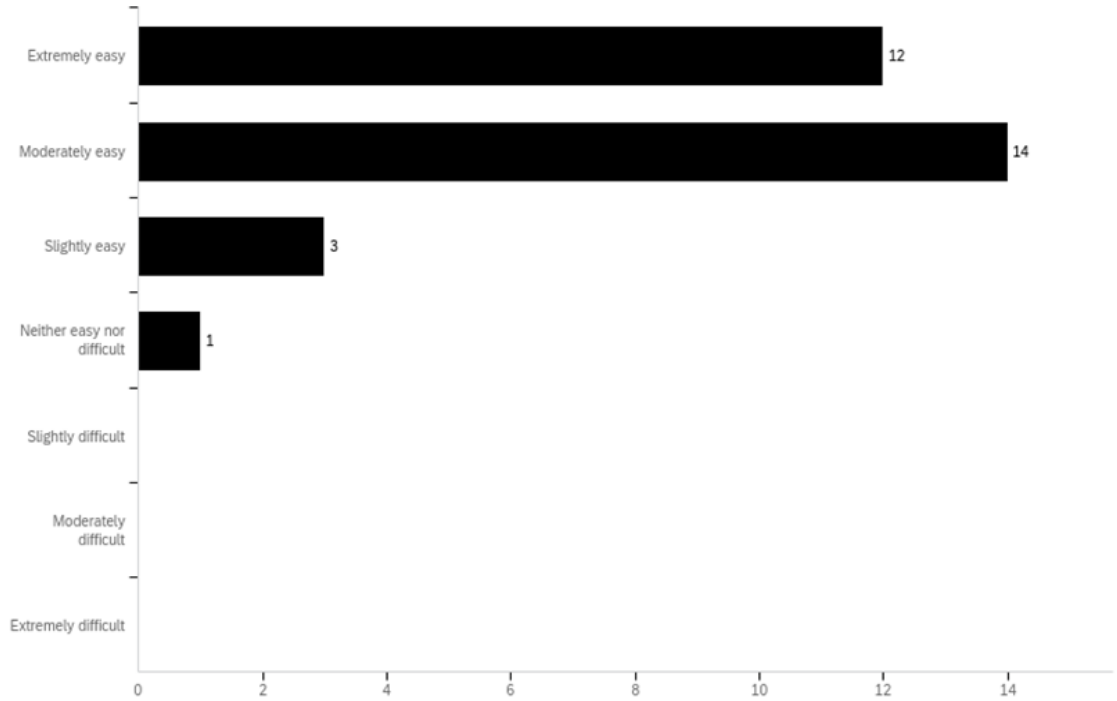


Figure 61 : Graphical representation of stakeholder's responses

Q3 - How well does our jacket help you complete the task you are trying to do?

Table 31 : Stakeholder survey variables

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	How well does our jacket help you complete the task you are trying to do?	1.00	3.00	1.47	0.56	0.32	30

Table 32 : Stakeholders responses percentage and count

#	Answer	%	Count
1	Extremely well	56.67%	17
2	Very well	40.00%	12
3	Moderately well	3.33%	1
4	Slightly well	0.00%	0
5	Not well at all	0.00%	0
	Total	100%	30

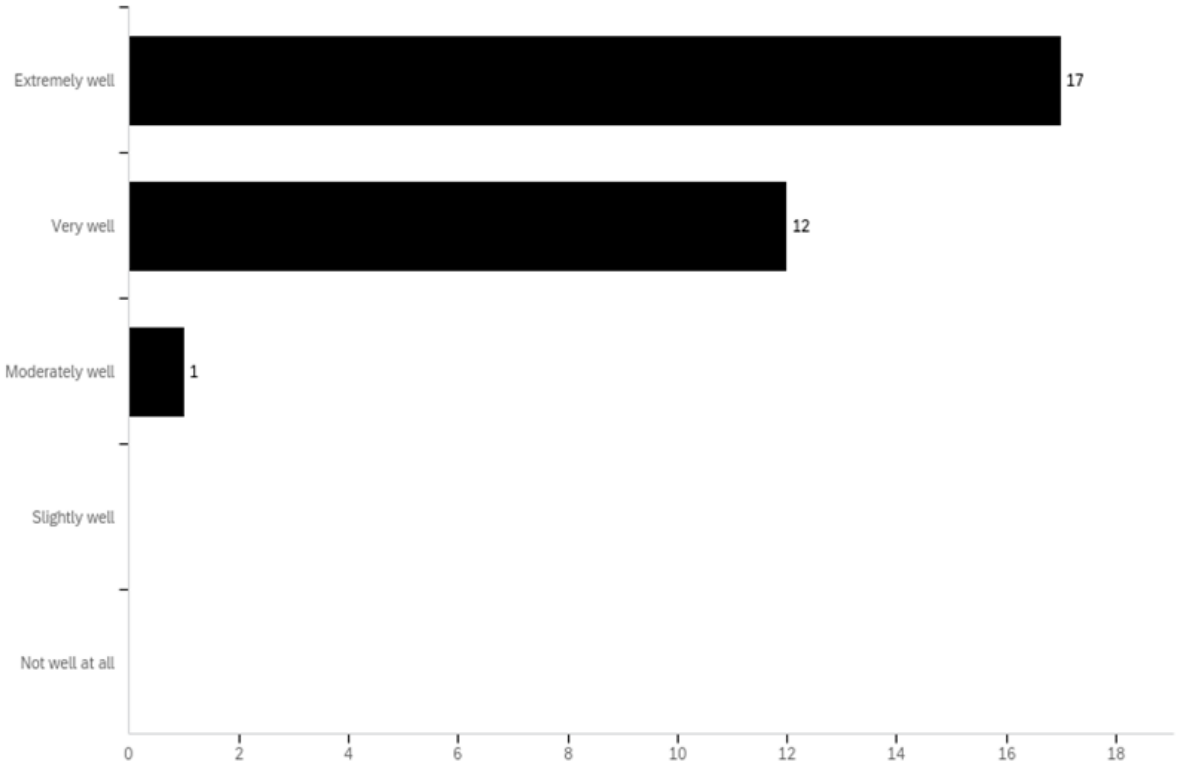


Figure 62 : Graphical representation of stakeholder's responses

Q4 - How unique is our jacket?

Table 33 : Stakeholder survey variables

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	How unique is our jacket?	1.00	4.00	1.83	0.82	0.67	30

Table 34 : Stakeholders responses percentage and count

#	Answer	%	Count
1	Extremely unique	40.00%	12
2	Very unique	40.00%	12
3	Moderately unique	16.67%	5
4	Slightly unique	3.33%	1
5	Not unique at all	0.00%	0
	Total	100%	30

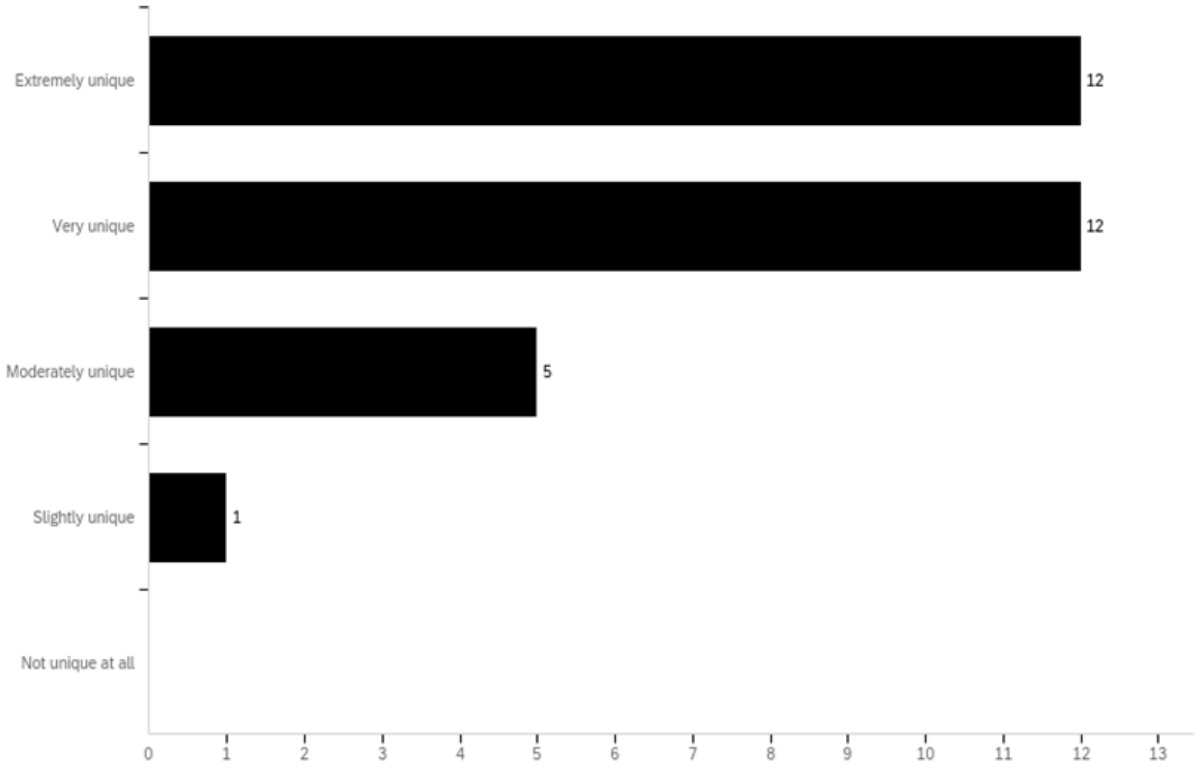


Figure 63 : Graphical representation of stakeholder's responses

Q5 - How much do you agree with this statement: our jacket is worth the cost?

Table 35 : Stakeholder survey variables

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	How much do you agree with this statement: our jacket is worth the cost?	1.00	3.00	1.80	0.79	0.63	30

Table 36 : Stakeholders responses percentage and count

#	Answer	%	Count
1	Strongly agree	43.33%	13
2	Somewhat agree	33.33%	10
3	Neither agree nor disagree	23.33%	7
4	Somewhat disagree	0.00%	0
5	Strongly disagree	0.00%	0
	Total	100%	30

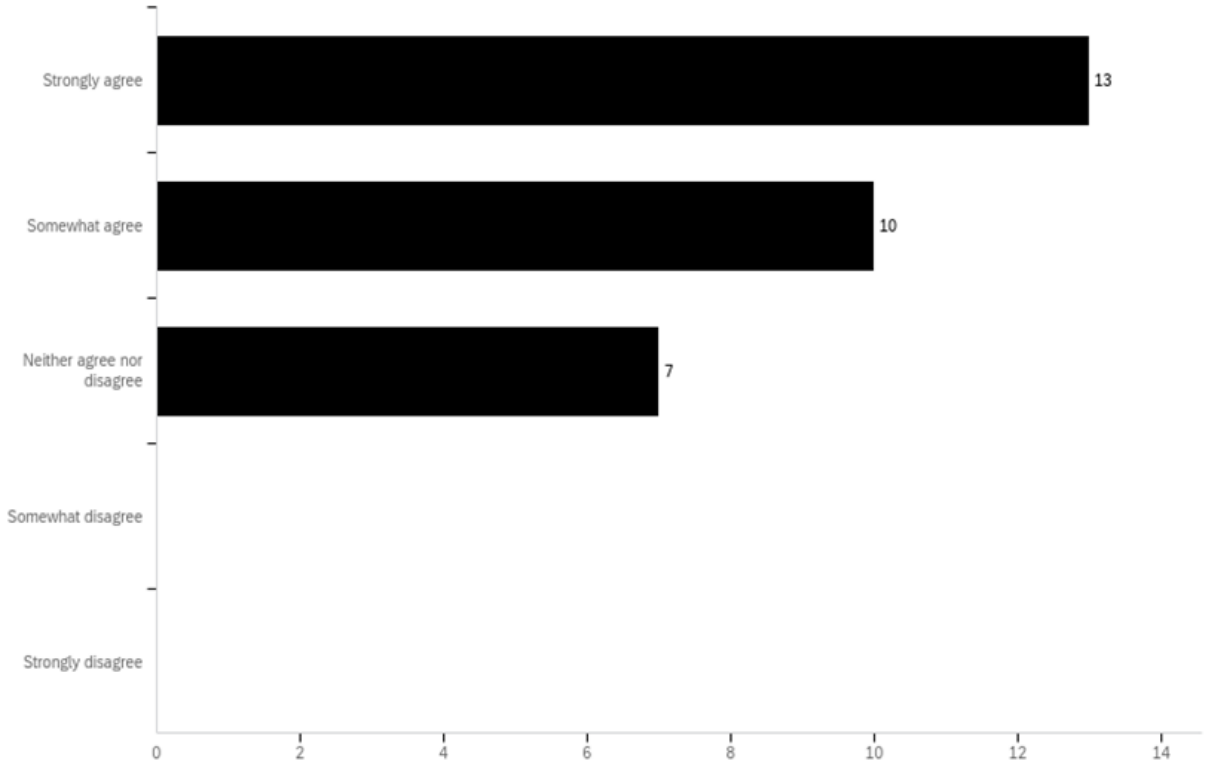


Figure 64 : Graphical representation of stakeholder's responses

Q6 - What would you change or improve about our jacket?

What would you change or improve about our jacket?

Table 37 : Options for improvement in the jacket

It consists of all the features important to the travelers but it can have additional reflective fabric tape to widen its feature and use.
More excursionist based pantone combination can be used for final collection
Cost factor can be reduced further by using cheaper filling type.
The design is nice and unique. It can incorporate more aesthetic features and color combination.
Add more detachable components for multiple occasion wear
Add side seam zipper
Nothing as such

Q7 - How is your ongoing experience with our jacket?

Table 38 : Stakeholder survey variables

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Satisfaction (0 means extremely dissatisfied and 10 means extremely satisfied)	7.00	10.00	8.90	0.79	0.62	30
3	Performance(0 means falls short of performance and 10 means meets the performance required)	8.00	10.00	8.97	0.75	0.57	30
2	Expectations (0 means falls short of expectations and 10 means exceeds the expectations)	8.00	10.00	9.03	0.91	0.83	30

Figure 65 : ASCI score

4.8 ASCI Score

The heart of the American Customer Satisfaction Index is a set of three questions that assess satisfaction, each on a different 10-point scale:

Figure 66 : ASCI score

ASCI Score= (Satisfaction + Expectancy + Performance - 3) / 27 * 100

Hence ASCI Score for our product = (8.9+9.03+8.97 - 3)/27 * 100 = 88.30%*

(* ASCI here is done for sample size of 30, the number might be smaller for higher confidence level)

4.9 Key Measurements taken from competitors for reference

Table 39 : Point of measurements

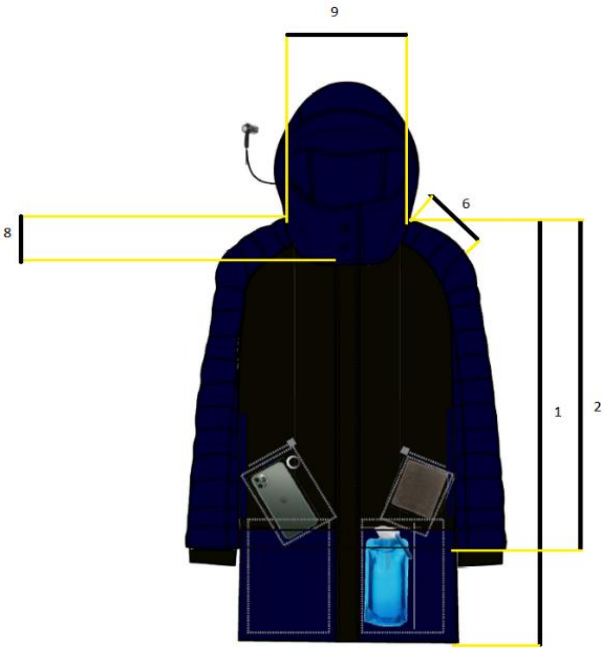
POM	S. No.	Point of Measurement	Tol(+)	Tol(-)	Req Meas
1	1	Front body length from HPS	3/8	3/8	40
2	2	Front body length from hps till detachable zipper	3/8	3/8	30
3	3	Center back length From CBN	3/8	3/8	41
4	4	Center back length From CBN till detachable zipper	3/8	3/8	31
5	5	Detachable zipper flap width	1/4	1/4	2 1/2
6	6	Shoulder slope	1/8	1/8	2 1/2
7	7	Shoulder seam forward	1/8	1/8	7/8
8	8	Front neck drop	1/8	1/8	4
9	9	Neck width	1/8	1/8	6 1/2
10	10	Back neck drop			5/8
11	11	Shoulder width	1/2	1/2	19 1/4
12	12	Across front 7 " below HPS	1/2	1/2	16 1/2
13	13	Across Back 7" below HPS	1/2	1/2	18 3/4
14	14	Chest circumference 1" below armhole	3/4	3/4	46
15	15	Bottom Opening Circumference	3/4	3/4	46
		Sleeve			
16	16	Cap Height	1/4	1/4	4 3/4

17	17	Sleeve length from Center Back Neck	1/2	1/2	35
18	18	Buceo 1" below Armhole	1/4	1/4	18 3/8
19	19	cuff opening relaxed	1/4	1/4	8 1/4
		Placket			
20	20	Placket CF	1/8	1/8	2 1/2
21	21	1st snap below neck seam	1/4	1/4	1
22	22	Last snap placement above bottom edge	1/4	1/4	1
		Shell Pocket front			
		Front patch pocket(on detachable length)			
24	24	Width	1/4	1/4	3 1/2
25	25	Height	1/4	1/4	8
26	26	Placement from detachable zipper to pocket top edge	1/4	1/4	1/2
		Front slant pocket			
27	27	Width	1/4	1/4	6
28	28	Slope drop	1/4	1/4	1 1/2
29	29	Placement from CF edge to zipper edge	1/4	1/4	15
		Front slant pocket			
30	30	Width	1/4	1/4	6
31	31	Height	1/4	1/4	6 3/8
32	32	Placement from zipper to pocket edge	1/4	1/4	1/2
33	33	Slope drop	1/4	1/4	1 1/2
		Inseam side slit pocket			
34	34	Width(pocket bag)	1/4	1/4	9
35	35	Height(pocket bag)	1/4	1/4	9
36	36	Placement from CF edge to pocket edge	1/4	1/4	18
37	37	Pocket opening length	1/4	1/4	6
38	38	Pocket Placket width	1/4	1/4	5/8
39	39	Width	1/4	1/4	3 1/2
40	40	Height	1/4	1/4	7
41	41	Placement from zipper to pocket top edge	1/4	1/4	15

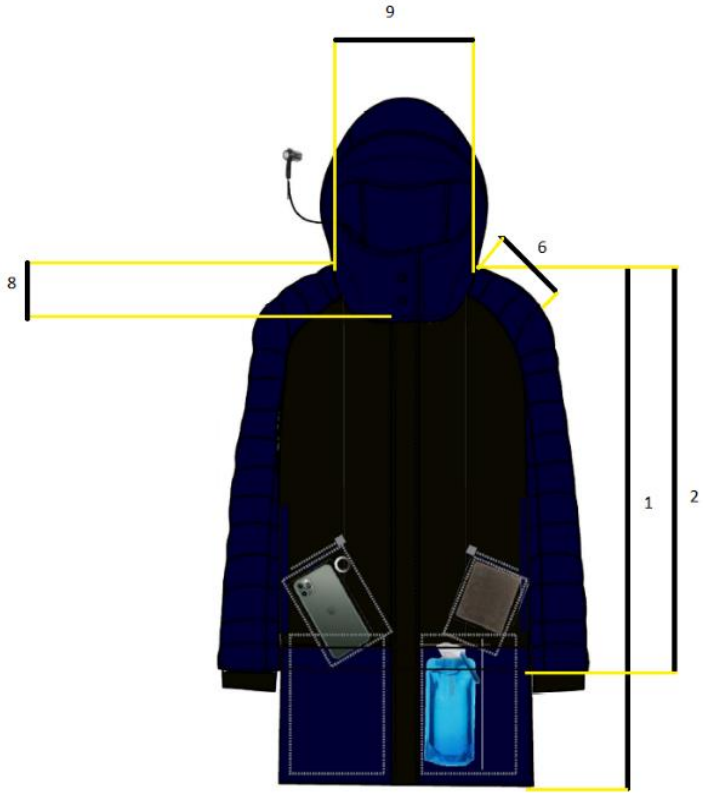
		Looper			
42	42	placement from pocket top	1/4	1/4	
		Top Big pocket			
43	43	Width	1/4	1/4	3 1/2
44	44	Height	1/4	1/4	6
45	45	Placement from Jacket Bottom to pocket edge	1/4	1/4	6
		Top Small pockets			
46	46	Width	1/4	1/4	1/2
47	47	Height	1/4	1/4	6
48	48	Placement from CF edge to pocket edge	1/4	1/4	6
		Earplug			
49	49	Earplug Loop hole	1/4	1/4	1/2
		Lining Pocket right			
		Hidden zipper (between lining and shell fabric)			
50	50	Length	1/4	1/4	6
51	51	Placement from zipper to pocket bottom edge	1/4	1/4	3 1/2
		Top pocket 1			
52	52	Width	1/4	1/4	4
53	53	Height	1/4	1/4	3 1/2
54	54	Placement from CF edge to pocket edge	1/4	1/4	6
55	55	Placement from collar to pocket edge	1/4	1/4	2 1/2
		Top pocket 2			
56	56	Width	1/4	1/4	3
57	57	Height	1/4	1/4	9
58	58	Placement from CF edge to pocket edge	1/4	1/4	15
	59	Pocket patch width	1/4	1/4	4
59	60	Pocket patch length	1/4	1/4	5
		Top pocket 3(on the detachable length)			
60	61	Width	1/4	1/4	4
61	62	Height	1/4	1/4	5 1/2

62	63	Placement from zipper to pocket edge	1/4	1/4	1/2
63	64	Placement from CF to pocket edge	1/4	1/4	3
		Key Looper(on the detachable length)			
64	65	Width	1/4	1/4	1/2
65	66	Length total	1/4	1/4	6
		Detachable hood			
66	67	Hood height at HPS	1/4	1/4	13 7/8
67	68	Hood width at 6" below top	1/4	1/4	10 5/8
68	69	1st snap button on hood	0	0	1/2
69	70	X snap button on hood	0	0	1/2
70	71	Collar - extended	1/4	1/4	3 1/2
71	72	Detachable zipper length	1/4	1/4	
87	73	Eye mask length	1/4	1/4	6
88	74	Eye mask width	1/8	1/8	3
89	75	Neck pillow length upto CB	1/4	1/4	12
90	76	Neck pillow width	1/8	1/8	3
		Backpack			
72	77	Backpack height	1/4	1/4	18 1/2
73	78	Backpack curve length	1/4	1/4	19
74	79	Backpack top width	1/4	1/4	8
75	80	Backpack bottom width	1/4	1/4	17 1/2
76	81	width between zipper 1 & 2	1/4	1/4	3 1/2
77	82	width between zipper 2 & 3	1/4	1/4	3 1/2
78	83	length of zipper 3	0	0	10
79	84	Bottom connecting flap width	1/4	1/4	3
80	85	Backpack width in middle	1/4	1/4	12
81	86	1st snap button from neckline	0	0	1
82	87	X snap button from bottom hem	0	0	1
83	88	Distance between snap buttons	0	0	6
84	89	Mesh pocket height	0	0	3 1/2

85	90	Mesh pocket width	0	0	2 1/2
		Puffer			
86	91	Puffer/ filling segment width	0	0	3 1/2



Figures 67 : Point of measurements



Figures 68 : Point of measurements

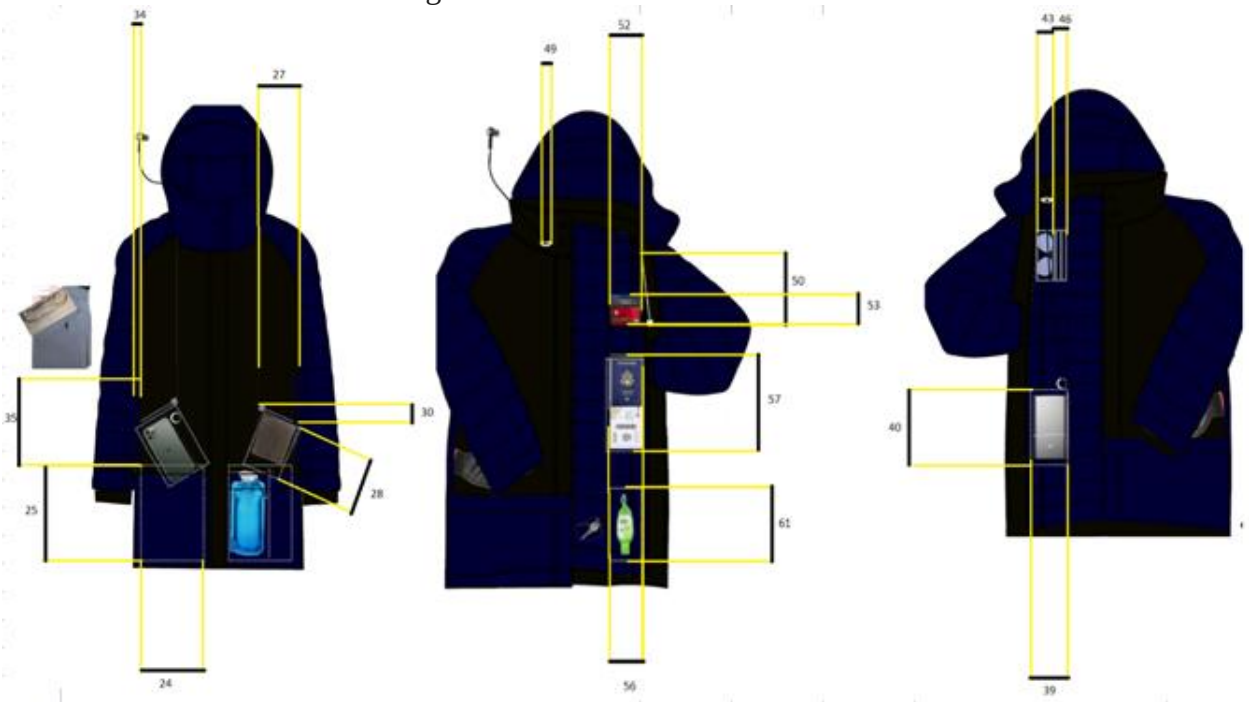


Figure 69 : Point of measurements

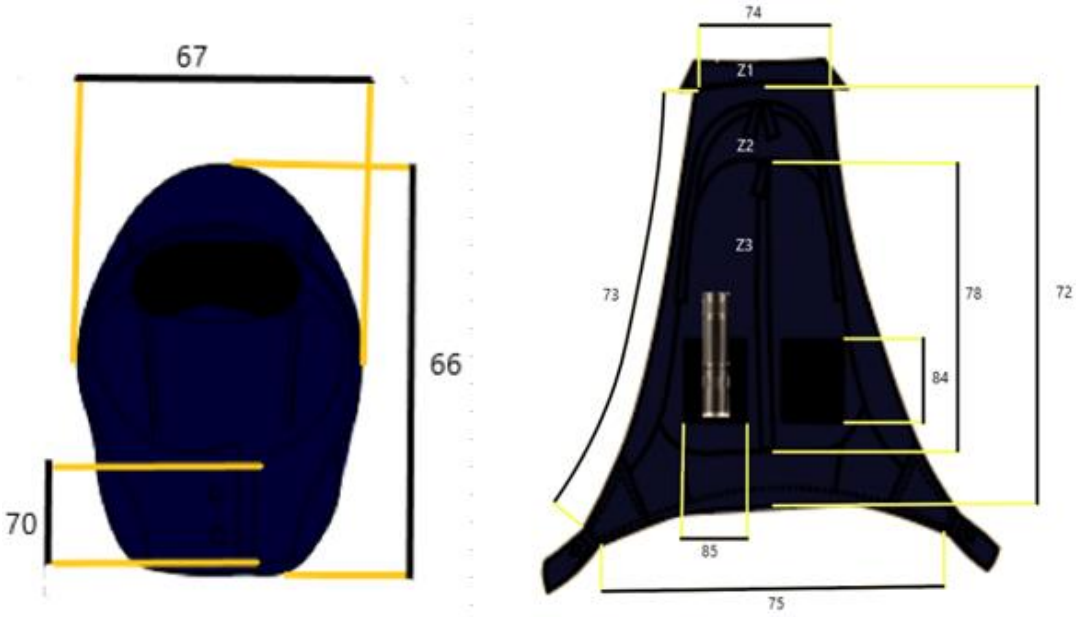


Figure 70 : Point of measurements

4.10 Marker Plan and Operation Bulletin

Figure 71 : Marker plan

Table 40 : Operation bulletin

Seq No.	MACHINE	Resource	SMV
1	MARKING	WELT POCKET MARK	0.3
2	FUSING	WELT POCKET FUS	0.2
3	SINGLE NEEDLE LOCKSTITCH MACHINE	WELT POCKET STITCH	0.3
4	SINGLE NEEDLE LOCKSTITCH MACHINE	BOTTOM WELT EDGE STITCH	0.3
5	SINGLE NEEDLE LOCKSTITCH MACHINE	WELT FUSING STITCH EDGE	0.3
6	SINGLE NEEDLE LOCKSTITCH MACHINE	WELT TOP STITCH AT EDGE	0.4
7	SINGLE NEEDLE LOCKSTITCH MACHINE	FRONT BODY SIDE POCKET	0.5
8	SINGLE NEEDLE LOCKSTITCH MACHINE	SIDE FUSING	0.3
9	SINGLE NEEDLE LOCKSTITCH MACHINE	SIDE POCKET POINTED	0.35
10	SINGLE NEEDLE LOCKSTITCH MACHINE	SIDE POCKET BAG STITCH	0.4
11	SINGLE NEEDLE LOCKSTITCH MACHINE	FRONT BODY BOTTOM	
12	SINGLE NEEDLE LOCKSTITCH MACHINE	POCKET IRON	0.25
13	SINGLE NEEDLE LOCKSTITCH MACHINE	POCKET HEM	0.3
14	SINGLE NEEDLE LOCKSTITCH MACHINE	POCKET MARKING	0.3
15	SINGLE NEEDLE LOCKSTITCH MACHINE	POCKET STITCHING EDGE	0.4
16	SINGLE NEEDLE LOCKSTITCH MACHINE	SLEEVE BODY	
17	SINGLE NEEDLE LOCKSTITCH MACHINE	FAULTY STITCH	
18	SINGLE NEEDLE LOCKSTITCH MACHINE	FRONT AND BACK ASSEMBLY	
19	SINGLE NEEDLE LOCKSTITCH MACHINE	FRONT BACK SETTING	
20	SINGLE NEEDLE LOCKSTITCH MACHINE	FRONT BACK ATTACHMENT	
21	SINGLE NEEDLE LOCKSTITCH MACHINE	SIDE SEAM ATTACHMENT	
22	SINGLE NEEDLE LOCKSTITCH MACHINE	SLEEVE ATTACHMENT	1
23		ASSEMBLY	
24	HELPER	FRONT BACK SETTING	1
25	HELPER	FRONT BACK ATTACHING	1

26	HELPER	SLEEVE ATTACHING	1
27	SINGLE NEEDLE LOCKSTITCH MACHINE	SIDE SEAM ATTACHING	1
28	SINGLE NEEDLE LOCKSTITCH MACHINE	LINNING	
29	SINGLE NEEDLE LOCKSTITCH MACHINE	CULTING	
30	SINGLE NEEDLE LOCKSTITCH MACHINE	FRONT PANNEL ATTACHING	1.5
31	SINGLE NEEDLE LOCKSTITCH MACHINE	POCKET IRON	1.5
32	SINGLE NEEDLE LOCKSTITCH MACHINE	POCKET HEM	1.5
33	SINGLE NEEDLE LOCKSTITCH MACHINE	POCKET MARKING	1
34	SINGLE NEEDLE LOCKSTITCH MACHINE	POCKET ATTACHING	1
35	SINGLE NEEDLE LOCKSTITCH MACHINE	BOTTOM DOOR	0.5
36	SINGLE NEEDLE LOCKSTITCH MACHINE	BOTTOM ZIP ATTACHING	0.5
37	SINGLE NEEDLE LOCKSTITCH MACHINE	BUTTON ATTACHING	0.5
38	SINGLE NEEDLE LOCKSTITCH MACHINE	BUTTON FINISHING	0.4
39	SINGLE NEEDLE LOCKSTITCH MACHINE	COLLAR FUS	
40	SINGLE NEEDLE LOCKSTITCH MACHINE	COLLAR MARK	1
41	SINGLE NEEDLE LOCKSTITCH MACHINE	COLLAR READY	1
42	SINGLE NEEDLE LOCKSTITCH MACHINE	COLLAR TURNING	1
43	SINGLE NEEDLE LOCKSTITCH MACHINE	COLLAR POINTING	1
44	SINGLE NEEDLE LOCKSTITCH MACHINE	HOOD	
45	SINGLE NEEDLE LOCKSTITCH MACHINE	HOOD ATTACHING TOP	1
46	SINGLE NEEDLE LOCKSTITCH MACHINE	HOOD ATTACHING INSIDE	1
47	SINGLE NEEDLE LOCKSTITCH MACHINE	HOOD PATCH ATTACHING	1
48	SINGLE NEEDLE LOCKSTITCH MACHINE	HOOD EDGE STITCHING	1
	SINGLE NEEDLE LOCKSTITCH MACHINE		
49	SINGLE NEEDLE LOCKSTITCH MACHINE	BAG	
50	SINGLE NEEDLE LOCKSTITCH MACHINE	ZIP ATTACHING	1
51	SINGLE NEEDLE LOCKSTITCH MACHINE	ZIP CLOSING	1
52	SINGLE NEEDLE LOCKSTITCH MACHINE	PANEL ATTACHING	1

53	SINGLE NEEDLE LOCKSTITCH MACHINE	OTHER PANELL ATTACHIN G	1
54	SINGLE NEEDLE LOCKSTITCH MACHINE	ZIP ATTACHING	1
55	SINGLE NEEDLE LOCKSTITCH MACHINE	ZIP FIXING	1
56	SINGLE NEEDLE LOCKSTITCH MACHINE	BAG BUCKELS ATTACHING	1
57	SINGLE NEEDLE LOCKSTITCH MACHINE	BUCKELS READY	1
58	SINGLE NEEDLE LOCKSTITCH MACHINE	BACK FINISHING	1
59	SINGLE NEEDLE LOCKSTITCH MACHINE	COLLAR ATTACHING	1
60	SINGLE NEEDLE LOCKSTITCH MACHINE	COLLAR FINISHING	1
61	SINGLE NEEDLE LOCKSTITCH MACHINE	FRONT POINTED	

4.11 Product care and labelling

Storage

Most insulated garments except down items do not require special care before and during storage. A bonus for down items is that they can be rolled or packed in a very small space, which is convenient for backpacking and traveling. When unrolled and briskly shaken, down will spring back to its original loft. However, for regular storage purposes, down garments should not be stored like that. Hang garments on broad wooden hangers and protect them with dust covers. At least once a year, hang down garments outside to air and restore its loft. Other down items should be loosely folded and completely dry then placed in a covered container and stored in a dry place.

Care

Permanent care labels should be in all insulated garments. Frequently, care labels in down items state dry clean or hand wash. Actually, if proper procedures are followed, washing will produce excellent results. But, a down garment can be satisfactorily dry cleaned. It is essential that a dry-cleaned down jacket be properly aired because dry-cleaning solvent fumes have caused serious illnesses and deaths. It is strongly recommended not to dry-clean down items at home. A down jacket represents a fairly large investment and if properly cared for should last a number of years. Periodically these garments need to be cleaned because heavily soiled garments tend to become compact and are not as warm as clean garments. Frequently, consumers complain that once a garment is cleaned it is not as warm as it was originally. The following procedures should produce a clean jacket which retains its loft and provides maximum warmth.

1. Close all fasteners particularly Velcro tape before washing to prevent snagging the jacket fabric.
2. Pretreat any heavily soiled areas or spots with a mild, liquid hand dishwashing detergent (Ivory, Joy).
3. Soak garment in a solution of warm soft water and mild detergent such as Ivory Snow, Woolite or other products designed for down in a large tub. Regular phosphate detergents have a tendency to dry the natural oils down; avoid products containing enzymes or bleaches.
4. Sponge the shell of the garment, rubbing stubborn spots with detergent. As the garment shell is very tightly woven and water repellent , sufficient time is necessary for the detergent solution to

penetrate and clean the down . Let the garment soak for an hour or two depending upon the amount of dirt.
5. Press the soapy water out of the garment by gently pressing with both hands. Avoid wringing or lifting the garment when it is full of water. Wet down is extremely heavy; if unsupported the weight of the water may rip the quilting or stitches.
6. Rinse garment by pressing water through the fabric with fingers spread apart-until the rinse water is perfectly clean . Traces of soap left in the jacket will cause the down to mat.
7. Pick up the article and gently transfer it to the washing machine. Thoroughly balance the garment in the machine and put through the spin dry cycle or allow to drip dry by draping it over two lines.
8 . Place the garment in a clothes dryer, add a pair of clean, rubber-soled tennis shoes with laces removed and a few towels. Set the dryer on the lowest heat possible. The shoes will help break up the down clumps, and help regain the loft .
9. Tumble dry for about 15 minutes, check to note the drying progress. Nylon or polyester jackets will dry more rapidly than cotton/polyester fabrics. Return the jacket to the dryer until it feels dry. If it is not as fluffy as preferred, tumble it on air-fluff for a short period of time. Be sure there is no moisture left, because down can mildew.
10. Or dry the garment outside, spreading it across two lines to avoid a stress point. If possible dry in warm, dry weather. It may take several days to dry depending upon the weather.

Care labelling

American care labelling system has been followed

- Machine wash cold separately
- Gentle cycle
- Only non chlorine bleach when needed
- Tumble dry low, dry flat
- Do not iron

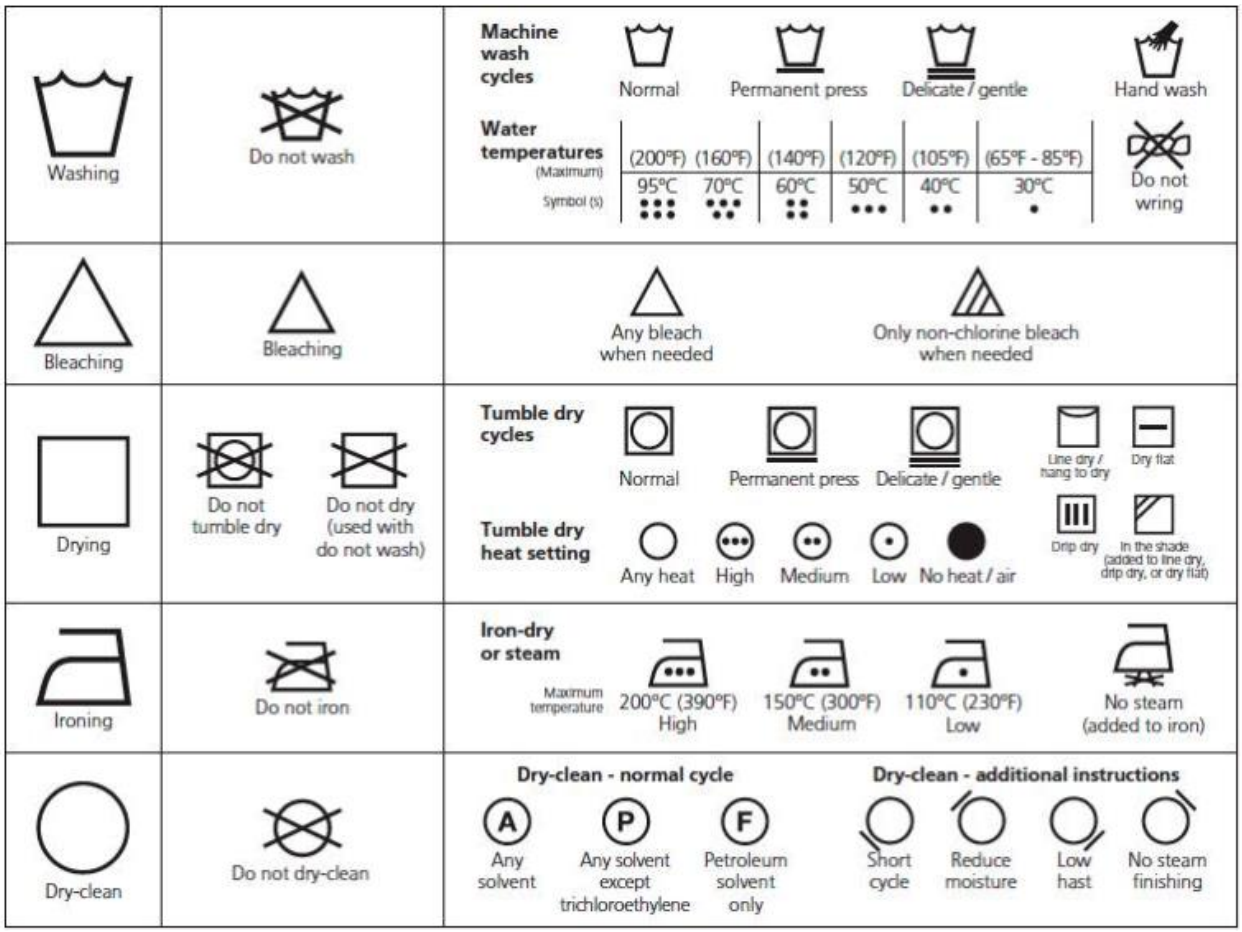


Figure 72 : Wash care symbols

4.12 Costing of the Product

CMT (Cut Make Trim) costing refers to a price component in the cost breakdown of a garment manufacturing price. International commercial contract between two organizations is the FOB (Freight on Board) Costing which is the cost of delivering the goods to the nearest port.

Table 41 : Costing sheet for the jacket

		COSTING SHEET			**S-XL**				
NO.	**ITEM**		**Width**	**Unit**	**CONS. NET**	**WAST. %**	**Final CONS.**	**PRICE USD**	**COST USD**
A	**MATERIAL**								
1	Shell Fabric + Piping	100% polyester , micro fiber, 100-110 gsm	57/58"	yds	3.750	3%	3.86	$0.800	$3.09

2	lining	100% polyester taffeta 230T	57/58"	yds	3.300	3%	3.40	$0.650	$2.21
3	crush fiber /ball padding	550 gm		kg	0.550	3%	0.57	$2.700	$1.53
4	Padding for hood	100 gram			0.200	3%	0.21	$0.700	$0.14
5	Tricot				0.000	3%	0.00		
B	**TRIMS**								
6	zipper 1	Vislon -8 (center front)		pc	1.000	3%	1.03	$0.350	$0.36
7	zipper 2	Nylon-5 (for detach body)		pc	1.000	3%	1.03	$0.250	$0.26
8	zipper 3	nylon -8 for bag compartment		pc	2.000	3%	2.06	$0.300	$0.62
9	zipper 4	Nylon -5 detachable bag to jkt		pc	1.000	3%	1.03	$0.200	$0.21
10	zipper 5	nylon-3 detachable Rfid + coin pkt		pc	2.000	3%	2.06	$0.100	$0.21
11	snap button metal 1	detachable hood at neck		pc	6.000	3%	6.18	$0.040	$0.247
12	snap button metal 2	hood front fastening		pc	2.000	3%	2.06	$0.040	$0.082
13	snap button metal 3	for bag fastening		pc	2.000	3%	2.06	$0.060	$0.124
14	Twill tape	for bag handle + fastening		yds	1.000	3%	1.03	$0.400	$0.412
15	Velcro	at cuffs		yds	2.000	3%	2.06	$0.030	$0.062
16	Inside brand label			pc	1.000	3%	1.03	$0.008	$0.008
17	Care label			pc	1.000	3%	1.03	$0.006	$0.006
18	Hangtags			pc	1.000	3%	1.03	$0.060	$0.062
19	Price tag			pc	1.000	3%	1.03	$0.000	$0.000
20	Poly& carton stickers			pc	1.000	3%	1.03	$0.010	$0.010
21	Strings			pc	1.000	3%	1.03	$0.060	$0.062
22	Silica gel			pc	1.000	3%	1.03	$0.020	$0.021

23	Gum tape & others			pc	1.000	3%	1.03	$0.050	$0.052
24	Fusing and others			yds	2.000	3%	2.06	$0.030	$0.062
25	Cartons								$ 0.20
26	Poly bag								$ 0.10
27	Sewing threads								$ 0.20
C	**TOTAL MATERIAL COST**								**$10.33**
D	**Comm. & L/C Charges**	3% On Materials							**$ 0.31**
E	**CM**								**$ 16.00**
F	**Gross Margin**	5% On FOB							**$ 1.33**
	TOTAL FOB								**$27.97**

5 LIMITATIONS AND SCOPE FOR FURTHER STUDY

5.1 Limitations

i) Due to the global pandemic of Covid - 19 this year, the manufacturing units and logistics services were not functioning during the lockdown from the month of March, 2020 onwards until the month of May, 2020. Therefore, sourcing of raw materials and trims for the final product, the testing process and the garment construction could not be completed due to the unavailability of the resources during the lockdown.

5.2 Future scope

i) The jackets will be primarily developed to be sold in the American and European markets, but winter excursionists are around the world. Therefore, when the jacket gains its popularity, it is expected to be sold globally.
ii) Brands that have multifunctional jackets as their product line can introduce a new product range for winters or extreme winters.

5.3 CONCLUSION

Newtimes group aims to bring inspiration and innovation to every new product that is being developed. As a high profile, Newtimes group continually strives to keep itself at the forefront of product innovation and design. The idea to develop a recycled multifunctional winter excursionist jacket is unique and it will enable the company to launch a new product line and capture a new market. As the Newtimes group works with the brand Ralph Lauren and the brand is known to have high sophistication and technicalities in its products, the proposed jacket design will be produced as a part of the Newtimes group's developments for winter season collection for Ralph Lauren.
The process of designing a new jacket or developing begins by identifying the opportunities available in the market. It includes screening of the ideas, evaluation of the available pool of ideas, developing the product, and commercializing the product.
Once the company has commercialized the product, a marketing strategy must be designed to promote the new jacket in order to increase awareness among the customers. However, the jacket consists of multiple features which when included in the product promotion strategy will help in capturing more customers worldwide.

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