Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Technology 2024

91613 Demonstrate understanding of material development

EXEMPLAR

Achievement

TOTAL 03

9163 Demonstrate understanding of material development

Introduction

For this investigation I have chosen to study the development of high-tech racing suits in swimming and how its properties have increased performance and decreased swimmers racing times by reducing drag. This is a context of interest as I am a competitive swimmer and therefore relate to the performance of these race-suits. Tech-suits are specialized garments designed to enhance an athlete's performance in competitive swimming. These suits are made from advanced materials that provide a high degree of compression, reduce drag, and improve buoyancy in the water[i]. Tech suits are made from a blend of fabrics like nylon, spandex and polyurethane, however in this report I will be focusing on the development of spandex and how it has been manipulated to optimize swimmer's performance. During this report I refer to the term's spandex, and elastane throughout and each term means the same thing.

History of tech-suits

The first big steps forward in the swimsuit technology came in the late 1950s, this is when industries began to use nylon in swimsuits to create tighter and smoother models. 1976 marked a time where compression suits began. They were worn tightly due to the texture of the fabric feeling like paper. In the 80s was added to the nylon fabric which remained until the 2000s. In the new millennium there was arguments that the suit should completely cover the legs, which was the first time there was a divide between swimsuits used in training and swimsuits used in competition. The advancements of swimming technology are due to the textiles, this is due to the goal of minimizing drag.

Development of a material to enhance a products performance

<u>What is spandex?</u>

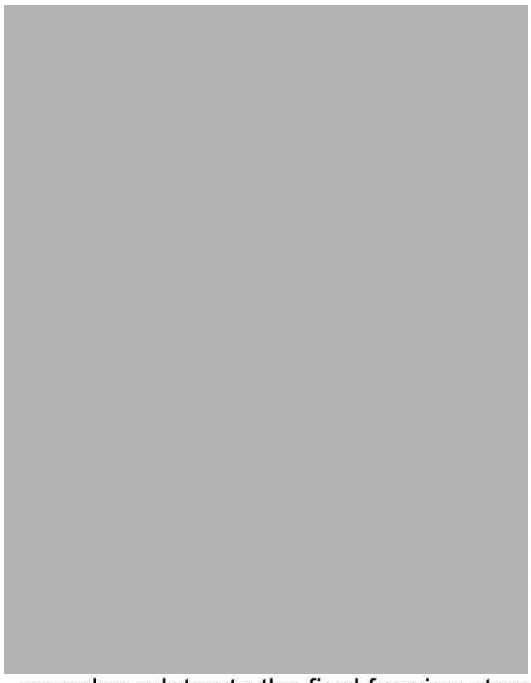
Spandex is a synthetic fabric it is known for its elasticity. Spandex fabric contains a minimum of 85% polyurethane and 15% other substances which can include nylon or polyester and can stretched to almost 500% of their normal size. The base material to make spandex is polyurethane, which was developed in 1937 by in Germany[ii]. At the end of World War II, a group of scientists transferred to which was the leader in synthetic textile development. In 1940 the first polyurethane elastomers were produced and were an alternative to rubber. In the 1959 a chemist [ii] while working at was working on developing a synthetic replacement for rubber. He invented a new polymer fabric with high elasticity, which they referred to as "spandex" and later sold under the brand name

Molecular structure of spandex

The diagram above is the chemical structure of spandex[iv]. It's molecular structure is made up of repeating units represented by the x and n in this structure. It is lightweight, smooth soft and durable, with better abilities than rubber.

How is spandex fabric manufactured?

Spandex can be manufactured in four different ways, however the most common and the one that I will be focusing on is the solution dry spinning. This method produces over 90% of the world's spandex fibers.



Dry-Spinning process:

The diagram to the right shows the process of dry spinning. The formation of long-chain polymers in spandex production involves a reaction between (-OH) groups on macro glycols and isocyanates, a process known as step-growth or addition polymerization. This reaction requires a catalyst, such as di-azobicylo octane, to initiate, while low molecular weight amines help regulate the fibers molecular weight. Spandex fibers are prone to damage from heat, light, atmospheric pollutants, and chlorine, stabilizers are incorporated to protect them. Antioxidants, including monomeric and polymeric hindered phenols which offer one level of protection. Anti-mildew agents are added to spandex used in swimwear, enhancing durability in damp environments[v]. The spinning method of spandex relates to the final forming structure of the fiber to prepare polymer from a prepolymer under the action of a chain extender[vi].

Describe why they are now well used fabrics

Spandex offers better quality compared to rubber, largely due to its construction from polymer strands which provide a unique elastic property. The stretchability of spandex is one of the best characteristics, allowing the fabric to return to its original shape after each stretch. Today, spandex is widely used in apparel because it provides a snug, comfortable fit while still allowing for freedom of movement. Spandex also offers comfort due to its ability to adapt to the body without sacrificing movement, hugging the body without it feeling restrictive[vii].

How are tech suits formed using spandex? (Manipulation, Transformation, and formulation)

Swim suits have changed drastically over the years, especially in competitive swimming as they give athletes advantages. These suits are specifically important as they lead to faster time and improved performance. In the early days, racing suits were made out of materials such as wool, however, those materials were usually heavy. Throughout swim suits evolution they became much lighter and flexible designed to increase the swimmers speed while also reducing drag[viii].

The manipulation of spandex is often mixed with polyester or nylon as the blends of these with spandex enhance the durability and freedom of movement for the swimmer. A specific knit pattern is chosen for elasticity and breathability. The transformation is that heat is applied to set the spandex fabric which optimises its stretch and recovery features. This helps to maintain the shame under high-stress movements. Spandex fabrics are able to adapt well to typically bonded or glued rather than sewn to reduce bulk of the suit, increasing comfort while maintaining aerodynamics. Spandex blends are treated with polyurethane coting, which compliments the high durability, reducing the suits friction and adding water resistance. Spandex in the tech suits is essential for high performance and endurance during competitive racing.

How does the spandex enhance the performance of the product?

As spandex does not break down when exposed to body oils, water, sweat it makes it especially good to use in swimwear. Tech suits are designed to reduce drag through the compression of the suits on the swimmer's body, through reducing water resistance. Compression of the tech suits also help the swimmer's muscles work more efficiently[ix]. They are designed with spandex to conform to the body when you move to glide through the water more efficiently. After a swimming race you get a buildup of lactic acid in your muscles, the compression of the tech suit helps to prevent that buildup.

In the illustration to the right[x]you can see how when the swimmer is pulling the stroke forward the drag is pulling the swimmer back, which results in the resistance of their strokes. High performance swimmers goal is to decrease their times as much as possible, which is why they wear caps and tight fitting swimsuits.
According to a study done by Journal Of The American College Of Sports Medicine, the suits significantly improve swimming performance, showing that, on average performance swim suits improved by 3.2% as opposed to a regular training suit. As well as, showing that tech suits can reduce drag by 4.4% to 6.2%[xi].

The use of spandex fabric in high-performance tech suits, enhance the garments performance through the elasticity, durability and lightweight nature of the fabric. It

allows the suit to stretch offering freedom of movement without restricting the swimmer which therefore increases the buoyancy.

The tight fit provided by spandex minimises drag in the water, allowing swimmers to move more freely, while also offering a level of compression that reduces fatigue and supports muscles which is essential for having a good race by enhancing endurance. The stretchability of spandex allows for a full range of motion which is essential for swimmers to perform their strokes effectively and to the best of their ability. The snug fit of race suits helps to glide through the water, as buoyancy is an important factor to why suits make you go faster. Spandex fabric also dries quickly which is beneficial for competitive swimmers who need to change suits between events or sessions when at a swimming meet.

Technical performance specifications and the performance properties of the materials are used

Stretch and recovery: spandex offers a stretch up to a 500% to 700% times its size which means it can stretch significantly without losing its form, for the tech suits it allows it to fit tightly to the body while maintaining flexibility. Moisture management: With low moisture absorption, spandex remains lightweight even when wet. In tech suits, spandex is often blended with other fibres that allow sweat to evaporate quickly. Spandex provides compression, dependant on the suit design. This supports the muscles and enhance blood circulation, essential for endurance sports like swimming. Spandex blends also maintain durability and resist wear overtime[xii].

Specific enhancements of high performance tech suits with spandex

Durability, Speed enhancement, Strength

Spandex enhances high performance by providing durability, speed enhancement, and strength. Its resilience to wear, chlorine and UV exposure ensures longevity, essential for competitive swimmers wearing suits that need to retain elasticity. Spandex's elasticity creates a streamlined fit, reducing drag for faster movements through water. Spandex offers compression to stabilise swimmers to reduce fatigue and improve endurance. This tight fitting material to the body provides more durability allowing swimmers to take off seconds, if not less off their time which is a key goal in the spot.

Implications and impact of spandex

Product design, implementation/development of spandex in tech suits

Spandex has significantly influenced the development of high-performance tech suits, especially with innovations like the This suit, which combined microfibers of nylon and spandex, demonstrated how precisely engineered materials could enhance flexibility and performance. By reducing skin friction drag by 24%, the effectively used microfiber technology alongside spandex's elasticity to improve swimmer efficiency by up to 5%, according to
Over time, tech-suit design evolved from traditional sewn seams to fully bonded, full-body swimsuits.

This transition involved fusing overlapping fabric layers rather than sewing them, a method that further reduced drag by up to 6%. This bonding technique also added targeted compression zones to the fabric, supporting muscle groups and boosting performance. Today's tech suits build upon these innovations, offering athletes improved hydrodynamics and support.

In the evolution of tech suits, spandex has contributed to not only to flexibility but also to key design advancements, as manufacturers recognised the need for targeted compression zones within the suits. By incorporating strategic layering and support for specific muscle groups, these innovations have enhances bot endurance and performance benefiting athletes in both long-distance and sprint races.

Another aspect to the [redacted] is its panels and core stabilizers. In tradition racing swimsuits there is typically only one single layer that minimises drag. To solve this problem of only one material meaning it tended to become to tight [redacted] utilised composite layers with different elastic and properties. The [redacted] was introduced in the 2008 Beijing Olympics, where 94% of the world's record-setting races were won by swimmers wearing that suit. Its exceptional performance of reducing drag led FINA had to ban it from future competitions, with many arguing that it undermined the athletes diminished the natural ability[xiii].

Ongoing maintenance and end of life disposal of spandex in tech suits

To ensure the longevity and performance of spandex fabric and high performance tech suits, proper care and maintenance is essential. Checking the label before washing the garment will give you specific guidelines on how to take care of the fabric. It is crucial for spandex to be washed in cold water. Race suits have specific tech-suit wash to prevent damage to the fibres as high heat from dryers can break those spandex fibres down, leading to the loss of elasticity and compression fit[xiv]. If you do not rinse suits after swimming in chlorine or saltwater to residues that can break down exposure can lead to fading and degradation of the spandex material.

The Leicester City and recovery properties bandings allowed takes its title against somebody, reducing drag and improving hydro networks. This directly enhances athletes performance in swimming through spandex is flexibility which allows a full range of motion. When properly maintained the impact of spandex enhances the durability of suits, offering athletes long lasting performance.

Spandex is not particularly a very sustainable material which is due to its non-biodegradable nature and an intensive and high polluting production process. Reuse: Tech suits require elasticity for performance, but manufacturers can choose alternative materials which will lower the environmental impact. Reduce: By blending fabrics that combine a lower amount of spandex with recycled polyester or nylon, manufacturers can achieve this long lasting environmental impact. Manufacturing durable, long-lasting suits reduces the need for a frequent replacement which minimises waste. Recycle: spandex is difficult to recycle due to its composition. Some companies are developing chemically recyclable synthetic fibres which help with recycling initiatives to reduce the impact it has on sustainability. Repair: It is a good idea to encourage athletes to repair their suits instead of buying new ones can

help to reduce the waste, by mending semes or patching up small tears. Rethink: this industry is constantly shifting towards bio degradable spandex options which degrade more easily at the end of their life cycle. The 6 R's can be applied to high performance tech suits to emphasise the importance of sustainability. Recycling spandex allows there to be not just one use of the material, although at some point the fibre will not be usable meaning it will be placed in a landfill.

Explain the concepts and processes employed in the development of the material

Production costs

In developing spandex, several key concepts and processes drive both material quality and production costs. Spandex is primarily valued for its elasticity and comfort, which make it essential for applications like athletic wear and swimwear. Production involves blending macro-glycol materials, such as polyester, polyether, polycarbonate, or polycaprolactone, creating a fibre with high stretchability. The dry spinning method is the most common and cost-effective process, accounting for over 90% of spandex production worldwide. However, the production costs are substantial, with an estimated cost of $2,249.00 USD per ton due to the high price of raw materials, specialized labour, and advanced technology requirements. This investment in quality and efficiency is critical to producing a durable, flexible material suitable for high-performance garments[xv].

Conclusion

In conclusion, the development of spandex in high-performance tech suits has been impacted through the development of the fabric, enhancing the flexibility, durability and compression. Spandex's unique properties such as stretch, recovery, resistance to wear, enables tech suits to conform the body, reduce drag, and support muscle efficiency, this all ultimately boots the swimmers speed and endurance at high level competitions. Innovations like the [redacted] pushed the boundaries of swimwear technology minimized resistance and increased hydrodynamics.

While spandex has revolutionized tech suits, it also prevents environmental change due to its non-biodegradable nature and production impacts. However, through the application of the 6R's of sustainability can reduce waste and improve the environmental footprint of each tech suit without compromising their competitive advantages.

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Achievement

Subject: Technology

Standard: 91613

Total score: 03

Q	Grade score	Marker commentary
One	A3	The candidate refers to a product and how the material enhances its performance. This is done, through an understanding of development, enhancements, manufacture, disposal, and lifecycle.