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A Study On Textile Industry's Visionary Technologies

S. Karthik[1] , R.M.Priya[2] , C.Dhanalakshmi[3] , P.Abarna[4]

[1] Assistant Professor, Department of Textile Technology, Jaya Engineering College, Chennai.
[2] Stduent of M.Tech Department of Textile Technology, Jaya Engineering College, Chennai
[3] Assistant Professor, Department of Textile Technology, Jaya Engineering College, Chennai.
[4] Assistant Professor, Department of Civil Engineering, Jaya Engineering College, Chennai.
texhod@jec.ac.in

Abstract
The cutting-edge 21st-century technologies, such as textronics, nanotechnology, and biotechnology, are discussed in the context of how they may be used in the textile business. These innovations, which are categorised as "foresight technologies," open up new avenues for the production of textiles, laying the groundwork for these goods' competitiveness on the global market in a variety of industries where they are used, such as the building, medical, and military sectors. The essential characteristics and illustrations of textiles and apparel made with cutting-edge technologies are discussed. Both the new opportunities associated with adopting these technologies into the textile sector and the restrictions associated with their dissemination received attention.

Keywords: foresight technology, global market, textronics, nanotechnology, biotechnology,

1. Introduction

New technologies are created in the twenty-first century as a result of the "rapid ageing technical solutions," with the aim of enhancing or demonstrating something that currently appears to be impractical. The foresight technologies of the twenty-first century are focused on achieving medium or long-term effects of economic development, including environmental protection. These technologies take into account industry and consumer needs from a multidimensional, horizontal perspective.

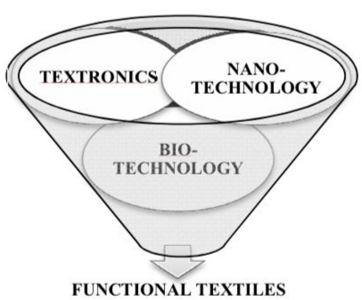
2. Literature review

The concept, which was first introduced in Japan in 1970 and afterwards spread to many other nations and Europe, includes the creation of foresight technology. This concept encompasses more than just a forecast of the future. It can be understood as a glimpse into the future with the potential to change how events turn out. In order to take the proper preemptive action in the sphere of science and technology, it is important to identify and evaluate future demands, opportunities, and dangers related to social and economic development.

The Government Ordinance of Government Minister of Science and Information No. 7/2004 of 3 March 2004 on establishment of the Steering Committee for the Pilot Foresight Project in the field of "Health and Life" was the first document providing the foundation for the idea of foresight development in Poland. The National Foresight Program "Poland 2020" was introduced by the Minister of Science and Higher Education in December 2006. Three study topics are covered by this programme: safety, information and communication technologies
sustainable development of Poland. In 2010, efforts inside the textile industry were also carried out as a part of this initiative. It was decided to launch the programme "Innovative Technologies for the Textile Industry. A Chance for Poland." Its goal is to create scenarios for the growth and of the textile industry taking into account the technologies, whose use in the manufacture of textile and apparel products forms the cornerstone of these goods' competitiveness on the global markets.

This article discusses the most recent technological advancements in the textile and apparel sectors, such as textronics, nanotechnology, and biotechnology (Fig. 1), which allow for the creation of functional textiles, or textiles with a high added value

Figure 1: The foresight technologies for textile and clothing industry.



3. Textronics and its influence on development of smart textiles

A contemporary technique known as textronics makes use of expertise in the fields of textiles, electronics, informatics, automation, and metrology. Its primary objective is to create systems that combine electronics with fibrous materials and include:

- Building specialised electrical devices using components and large-scale integrated circuits that are widely accessible and connected to textiles;

- developing novel fibre electronics in the form of integrated measuring systems with a sensor conditioner, power source, and telemetry transmitter housed in a single structure and tailored for attachment to fibrous constructions;
- Building elaborate control systems with multiple dimensions to enhance a man's sense of physiologic and aesthetic comfort;
- Finding sources of electricity that use fibres and fiber-based structures and are able to power textronics circuits.
- Investigating structural solutions for the production of special protective clothing, tailored to the use of textronics achievements.

E-textiles are the end result of textronics. They have the properties of a sensor that picks up on stimuli from the outside world, a processor that translates that information, and an executive device that can trigger a predetermined action. They're able to communicate, get information, and provide practical assistance, and they've shown that they can adapt to different settings. There are smart fabrics that are interactive and deserving of the name.

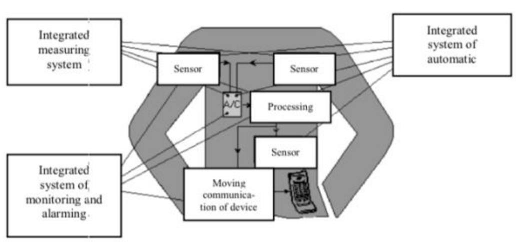


Figure 2: The scheme of textronics structure of clothes.

Textronics products are widely used. Most of them are associated with sport and recreation clothes, as carriers of miniaturized electronic devices created by renowned fashion companies cooperating with the companies producing electronic devices. One of the first products of this cooperation was, introduced in 2000 by Levi's and Philips companies, jeans jacket that integrated a mobile phone, mp3 player, headphones and microphone. Electronic devices were placed in special pockets and were connected by wireless technology. Before every washing, the system have to be completely dismantled, which was not comfortable. The product cost 800 pounds and has not made a success. However, it initiated the development of smart technology and it is considered as the forerunner of textronics products of common use.

Textronics also applies in other areas. By using of suitable sensors that enable to receive variety of external impulses, smart textronics products can perform the monitoring function used in the emergency services, military, police, and also in medicine. Modern intelligent systems enable to measure such parameters as: internal and external temperature, pulse, breathing rate, blood pressure, skin moisture and the presence of harmful gases and liquids in the environment. Such clothing can provide active or passive protection, detect danger, initiate alarm or warning systems, thus can significantly improve communications and automate the work of rescue units.

4. Nanotechnology and Nanotextiles

The manufacturing of nanofibers, the alteration of conventional fibre via the use of nanocomponents, and the change of materials' surface during finishing processes are where nanotechnology is most prominent in the textile sector.

Nanofibers have a diameter of less than or equal to 100 nm, making them extremely thin fibres that are roughly a thousand times thinner than a human hair. The polymers used to make them can be either natural or synthetic. Polymers such as cellulose, protein, polyamide, acrylic, polyvinyl chloride, carbon, ceramic, polypyrrole, and polyaniline are among the most well-known. To improve surface area and introduce new mechanical properties to materials at the nanoscale are the main goals of nanofiber research. Generally speaking, a material's mechanical properties improve dramatically as its fibre diameter decreases. In a similar vein, nanofibers have a much larger surface area than micron- and macro-scale fibres. Nanofibers' peculiar features are influenced by their physical qualities and the variety of raw materials employed, which in turn has significant consequences for a wide range of applications (Fig. 3). (Fig. 4).

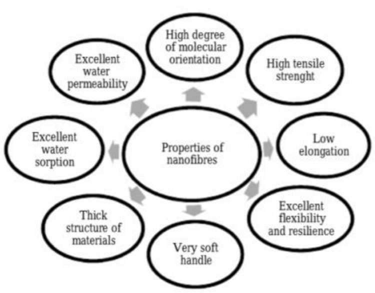


Figure 3: Properties of nanofibres

The use of nanofibers in textile production is on the rise. Their presence renders clothing more ethereal and lightweight, yet their thick structure confers waterproofing and breathability. The military and law enforcement have found military applications for nanofibers. Bulletproof vests can be made from carbon nanofibers or a blend of cotton and boron carbide nanofibers (B4C). These materials are similar to the once-popular Kevlar in

terms of their protective qualities, but they are more comfortable to wear and offer enhanced mobility because of their reduced weight and improved pliability. Possible explanations for this fat-burning capacity include wearing underwear made from polyester nanofibers. The nanofibers used to make the underwear offer greater resistance and create more friction than conventional fibre, both of which help the body burn more calories.
They create the nanofibers to use as a filtering medium. Their ultra-compact design allows them to pick up even the tiniest contaminant, on the nanometer scale. Filters made from these materials are used in vehicles and factories to do things like clean water, clean up oil spills, and separate very dangerous compounds.

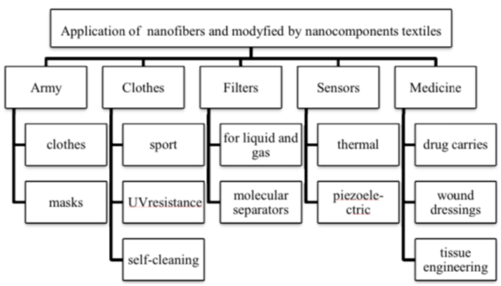


Figure 4: Application of nanotechnology in the textile industry.
Nanocomponents consist primarily of phyllosilicates (montmorillonite MMT), silica, fullerenes and carbon nanotubes (CNT), chalk, graphite, carbon black, metals and their compounds. Adding a negligible amount (3%) of nanocomponents dramatically alters the alteration of chosen characteristics of fibres (Table 1), but does not significantly lower the strength parameters.
Table 1. The types of nanocomponents and their influence on fibre's properties.

Properties	Nanocomponent
Electroconductivity, antistatic properties	Carbon black, copper, polypirol, polyanilina
Durability	Al_2O_3, CNT, SiO_2, ZnO
Antibacterial properties	Ag, chitosan, SiO_2 , TiO_2, ZnO
Self-cleaning, hydrophobic properties	CNT, fluoroakryl, SiO_2, TiO_2,
Stain resistance,	Carbon black, SiO_2
UV resistance	TiO_2, ZnO
Fire Resistance	CNT, montmorillonite,
Thermal conductivity	CNT

According to Table 1, silver, which has an antibacterial effect, is the most widely utilised nano-component in the textile sector. Bacteriostatic fabric for medical purposes, made by Andrychowskie Zakady Przemysu Bawenianego Andropol S.A., is an example of its use in textiles, where it serves as a tool of the competitiveness of Polish firms. After 50 washes, this cloth supposedly proves to be bactericidal, meaning that it can reduce the spread of bacteria and germs in healthcare settings

It's important to highlight several restrictions of use when considering the widespread adoption of nanotechnology in the textile and garment industries. Their potential hazards to people and the environment are the biggest issue. Because nanocomponents are so much smaller than individual cells, they pose a risk if they find their way into living organisms' tissues. They also pose a risk if they find their way into the environment, as can happen during washing and cleaning. When considering the effects of nanotechnology on living organisms and the environment, nanofibers, which are a type of solid nano-structured material, raise significantly less concern.

5. Biotechnology and its importance in the realization of Cleaner Production in the textile industry

Biotechnology is an interdisciplinary field that uses living cells, their components, and molecular analogues to acquire new materials and products. This field integrates the sciences of biochemistry, genetics, microbiology, and engineering. On page 28 of the book "15: Biotechnology in the Textile and Apparel Business," we learn that "[t]he textile and clothing industry is focused on:

- synthetic textiles with surface modifications made from novel ingredients like biopolymers and biomasses.
- Best Available Techniques (BAT) in biotechnology are designed to replace environmentally and human health hazardous chemical textile treatment procedures.
- Enzyme system development and extension of applications in surface treatment for functionalization of textile substrates, which is the useful key to achieving the added value of a product and a new quality area of use of a product.

Implementing the concept of Cleaner Production requires significant research in the field of textile engineering, specifically into the replacement of hazardous, less efficient, and environmentally harmful chemical processes with safe biochemical processes that affect the properties of fibres and textiles. Wool degreasing, synthetic fibre modification, yarn polishing, textile greasing, and even the stone-wash process now all make use of enzyme biocatalysis. Changes in friction and adhesive properties, crucial for the fibres' aesthetic, processing, and utility properties, can be obtained through enzymatic modification of the chemical or physical structures, consisting of changes in fibre surface micro-topography, and changes in molecular structure, resulted from the degradation of the molecular surface layers of amorphous material.

Biomaterials are another example of how biotechnology is being used to its full potential in the textile business. They are made from renewable resources, but some of them are also made from modified fibres that, thanks to various treatments often applied during the finishing process, naturally include antibacterial and antifungal qualities. Materials created from fibres of poly(ethylene oxide) - a biocompatible polymer - in which bacterial cells were closed during the electrospinning process, ensuring that around 97 percent of the microbes survive, are an example of the most recent interesting success in this area. This

material, which contains living bacterial cells trapped within the fibres, can be utilised in biological filters to eliminate chemical contamination of water, or in self-cleaning clothing that doesn't smell bad even after being saturated in perspiration.
The use of biotechnology in the textile industry has a significant impact on environmental protection beyond the qualitative impacts connected to enhancing the qualities of textile fibres. It's a helpful resource for spreading the message of Cleaner Production in the apparel sector.

6. Conclusion

To thrive in today's era of globalisation and intense market competition, the textile and apparel industries must fully embrace the fruits of modern technology. Industries that provide functional textiles and clothes for a variety of uses have a lot of room to grow thanks to the possibilities presented by textronics, nanotechnology, and biotechnology.

As a result of the incorporation of cutting-edge technological advancements, textiles today possess attributes that either allow them to perform functions that were previously impossible or enable the combination of functions that were before incompatible. They actively assist thermo regulatory processes and enhance comfort, and are characterised by very good biophysical qualities required for individual layers of clothing. They also serve other purposes, such as providing information or shielding the wearer from harm (such as ultraviolet (UV) rays, bacteria, insects, heat, or gunshots).

Reducing energy use, water use, and wastewater production, as well as minimising or eliminating the use of harmful chemical agents, are all examples of how modern technology has helped lessen environmental dangers, while also allowing for the development of humanoecological properties in manufactured goods. However, since their long-term consequences on people and the planet are still a mystery, their use is not without potential danger. It's also worth noting that, as of right now, these technologies are still viewed as extremely costly and time-consuming endeavours that necessitate well-equipped labs and technical workshops.

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