Pregledni naučni rad

MEDICAL TEXTILES, POSSIBILITES AND CHALENGES

Silvana Zhezhova, Sanja Risteski, Sonja Jordeva, Vineta Srebrenkoska
University „Goce Delchev“, Shtip, Faculty of Technology, North Macedonia

Abstract: *The medical textiles segment is the fastest growing sector of the technical textile sector. Textile structures used in this field include yarns, woven , knitted, non - woven textile materials, textile composite, designed to meet specific requirements of surgery, postoperative treatment and treatment of wounds and burns under sterile conditions. Although textile materials are widely accepted for medical and surgical applications, new areas of application are constantly emerging. Given the uncertainties of covid 19, the pandemic directly and indirectly affects the medical textile market. The forecasts are that in the following period the consumption of medical textiles will continue to grow. This paper presents the possibilities and challenges for fibrous structures in the field of medical and healthcare.*

Key words: *medical textile market, fibrous structure, non-implantable materials, implantable materials, healthcare and hygiene products*

Introduction

Historically, the development of society has been closely linked to the development of textiles and their use. Textiles are used in various segments of our lives, such as: clothing industry, interior design, construction industry, aerospace industry, medicine etc. Every segment of our everyday life, is directly or indirectly influenced by textile.

According to the application, textiles are generally classified as textiles for textile and technical purpose.The term textile refers to the centuries-old use of textiles to meet some basic human needs such as: clothing, arranging the living space, hygiene and a number of other needs related to everyday life [Horrocks and Anand, 2000; Senthil Kumar, 2016].

In recent years, the meaning of the term textile has expanded and it is necessary to emphasize that the various textile materials are becoming more important for application in technology, industry, construction and architecture, agriculture and medicine. In this way, textiles become important materials for various non-textile purposes. This term actually refers to the application of textiles for various purposes as a substitute for traditionally used materials (e.g. metals, alloys, ceramics, etc.).

The term technical textiles refers to all types of linear, two-dimensional and three-dimensional products that are used in various industries primarily for their performance or functional characteristics, not for their aesthetic and decorative properties. This means that technical textile is designed to have huge spectrum of certain properties, making them suitable for application in different industries. According to the application and end-user industry, technical textiles are classified

into twelve categories: agro textiles (agrotech), construction textiles (buildtech), clothing textiles (clothtech), geo-textiles (geotech), domestic textiles (hometech), industrial textiles (indutech), medical textiles (meditech), textiles used in transport (mobiltech), packaging textiles (packtech), protective textiles (protech), sports textiles (sportech) and environmentally-friendly textiles (oekotech) [Rasheed, 2020].

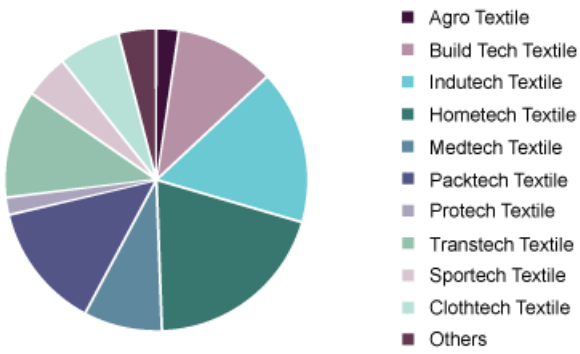

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Figure 1. Global technical textile market share, by end use, 2019 (%) [Medical Textiles Market Size, Share & Trends Analysis Report By Product (Non-woven, Woven), By Application (Healthcare & Hygiene Products, Implantable Goods), By Region, And Segment Forecasts (MTMSPARSF), 2021 - 2028]

On Figure 1 is given global technical textile market share, by end use for 2019 year. In terms of revenue in 2019, domestic textiles (hometech) segment had the highest market share of 19.8% and is projected to witness a CAGR of 5.2% from 2020 to 2027 [MTMSPARSF, 2021 - 2028].

The medical textile segment is considered to be the fastest growing sector of the technical textile sector. Textile structures used in this field include yarns, woven, knitted, non - woven textile materials, textile composite, designed to meet specific requirements of surgery, postoperative treatment and treatment of wounds and burns under sterile conditions.The number of applications is large and varied, from simple surgical sutures to complex composite structures for bone and tissue replacement, protective materials used in operating rooms and in the process of postoperative wound treatment, hygiene materials, etc. Rising birth rate, growing aging population, increasing awareness regarding better healthcare services and efficient medical treatments in the developing economies is expected to grow the demand for medical textile products.

The healthcare and medical sectors offer the greatest opportunities for the development of various sophisticated textile structures for different types of medical applications and represent one of the most important areas for stimulating production of technical textiles. Depending on their purpose, these textiles are designed to have improved absorption, flexibility, durability, lightness, resistance, softness,

biodegradability, amongst other characteristics [Rohani and Nouri, 2020; Medical Textiles, 2022].

The uniqueness and challenge in the field of medical textiles lies in the need to understand and apply the principles of textile science and technology to provide optimal solutions to a number of medical and healthcare problems. This primarily requires a multidisciplinary approach because it is not enough for the technologist to have knowledge only in the field of textile science and technology, but it is necessary to have appropriate knowledge in the field in which the textile will be used. So, it is necessary to establish communication between the manufacturer and the needs of the end user.

1. Fibrous structure used in medical textile

In general, all types of textile fibers can be used to produce medical textile. Natural fibers such as cotton and silk are the most used types of fibers in medicine, but regenerated cellulose fibers (viscose, lyocell) are also widely used for production of non-implantable materials and for health care/hygiene products.

Wide range of products for specific applications use the unique properties of synthetic fibers such as polyester, polyamide, polypropylene and polyethylene and high-performance fiber (aramid, carbon, glass etc.) All fibers used in this product must be non-allergenic, non-toxic, non-carcinogenic and must be able to be sterilized without imparting any change in their physical or chemical characteristics [Medical Textiles: Healthcare And Hygiene Products, 2022].
With use of adequate spinning processes textile fibers are converted into yarns (staple yarns, ply yarn, filament yarns) with improve strength, abrasion resistance and handling. There are many types of technical filament yarns (aramid, glass, carbon, high density polyethylene and other) used in various applications. The technical yarns must meet the specific functional requirements of the intended end-use (high strength, high modulus, or both). With selection of suitable textile fibers and special spinning techniques various technical yarns can be produce.

With applications of different textile process (weaving, knitting and braiding) technical yarns are converted in textile structures. Two-dimensional woven fabrics are most used, but also three-dimensional woven textile structures are being developed and produced. With selection of type of yarn for warp and weft (raw material, structure of the yarns, linear density, direction of twist and twist factors), number of weft and warp yarns per centimeter, type of weave (plain, twill, satins, lenos) various types of woven structure can be produce with different properties in term of strength, thickness, density, extensibility, porosity, and durability. Woven fabrics typically find their applications in hospital and surgical hosiery, different types of bandages, plasters, wound contact layer, cardiovascular implants, artificial tendons, etc.

There are two types of knitted fabrics, warp and weft knitted structure. The main advantage of knitted fabrics is their flexibility, and their disadvantage is the high porosity. Knitted textile materials are generally used for cardiovascular implants and

other applications used in surgical mesh, hernia repair, reconstructive and cosmetic surgery etc. [Qin, 2016; Sharma and Popli, 2018].

Braided structures (ropes, shoelaces, and cables) are produced using old textile manufacturing technology known as braiding. These structures can fulfill the explicit demands imposed by the medical sector and can be designed with or without a core. Braided structures are usually used for production of biodegradable and non-biodegradable surgical sutures, artificial ligament, artificial tendon, etc. [Rana and Fangueiro, 2015].

Non-woven textile materials play a significant role in the medical sector because they offer numerous advantages (short production cycles, higher flexibility and versatility and lower production costs) compared with woven and knitted fabrics. The properties of nonwoven materials depend on the characteristics of the constituent polymer or fiber and on the bonding process. There are numerous medical uses for nonwoven materials: filtration materials, surgical drapes, pads, dressings, surgical gowns, masks and other wearable products, implantable textiles such as tissue scaffolds for rebuilding internal organs, etc. [Urosevich, 2011; Bartels, 2011].

Textile composites are composite materials reinforced with textile. Textile reinforced composites are important materials due to certain advantages, their strength (provided by the textile structure) and the unity and ability to transfer strains (provided by the polymer matrix) [Zhezhova et al., 2017]. They are widely used in many different applications in the medical industry where they are increasingly replacing metals and glass (medical equipment, implants, artificial limbs, to reinforced or replaced natural tissues, bone plate, suture materials for repair of broken bones and for diagnostics). The main reason for this is the amazing versatility of polymers and fibers which enables the design and manufacture of a various composite to meet very different application requirements.

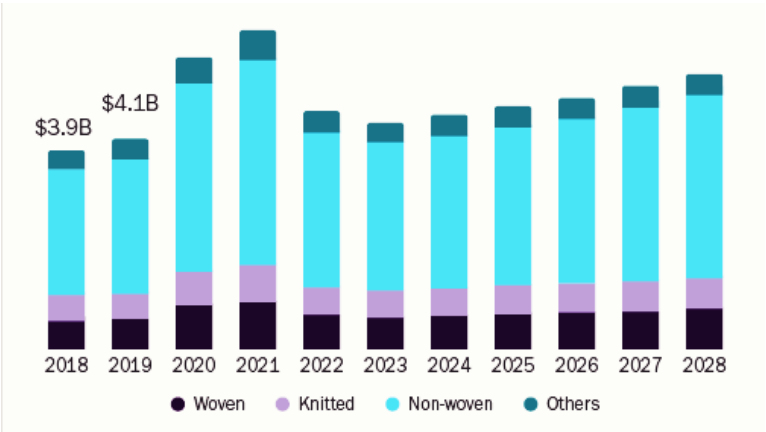

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Figure 2. U.S. medical textile market size, by product, 2018-2028 (USD billion) [MTMSPARSF, 2021 - 2028]

On Figure 2 is presented U.S. medical textile market size, by product, 2018-2028 (billion USD). Analyzes show that nonwovens accounted for 65 % of the global medical textile market in 2020 and is expected to grow during the forecast period (2018-2028), due to the low production cost and increased consumption of the healthcare and hygiene products. The crises caused by COVID-19 virus in 2020 has exponentially increased the demand for medical textiles, especially nonwoven fabrics, which are used to produce personal protective equipment (PPE), such as face masks, gowns and other products [MTMSPARSF, 2021 - 2028].

The second largest segment is woven fabrics, but it is expected the demand for knitted fabrics to grow at a revenue based CAGR of 3.4%. This is due to the rising demand to produce artificial blood vessels, cell scaffolds, hernia patches, and tissue re-engineering applications owing to their better porosity and structural efficiency compared to woven fabrics [MTMSPARSF, 2021 - 2028].

2. Types of medical textiles

The textile used for medical and surgical purposes can be classified as follows (Figure 3) [Azam and Shavandi, 2016; Parveen Banu et al., 2014; Textile materials in implantable medical surgeries (TMIIMS), 2021]:

- Non - implantable materials (Wound dressing, bandages, plasters, gauzes etc.)
- Implantable materials (surgical sutures, vascular grafts artificial ligaments, artificial joints, etc.)
- Extra-corporeal devices (artificial kidney, artificial liver and artificial lung)
- Healthcare/hygiene products (surgical clothing, bedding, covers, clothes, wipes, etc.)

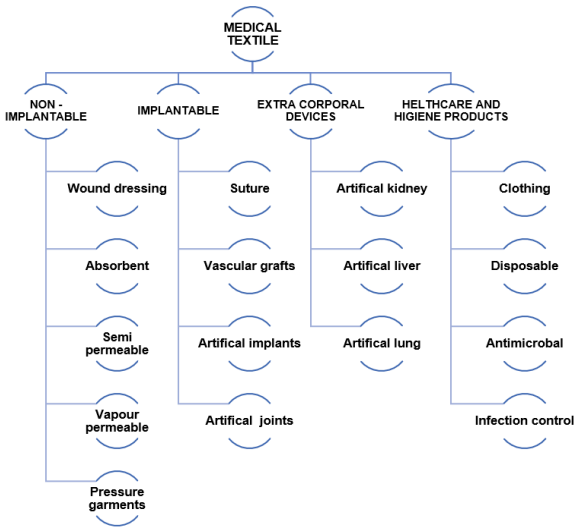

Figure 3. Classification of medical textile by application [Azam and Shavandi, 2016; Parveen Banu et al., 2014; [TMIIMS, 2021]

Non-implantable materials are used outside the human body, they are never implanted within the body. Wound dressing and bandage are the most used non-implantable material. Different kind of textile fibers can be used for production of these materials: cotton, silk, viscose, lyocell, collagen, polyester, polyamide, polypropylene etc. [Parveen Banu et al., 2014].

Implantable materials are the textile structures that can be used inside the human body for various purposes, such as wound closure (surgical sutures) or replacement surgery (artificial ligaments, soft tissue implants, cardiovascular implants). Biocompatibility is one of the most important factors for these kinds of materials. Also, these materials should be biodegradable and non-toxic [TMIIMS, 2021].

Extra corporal devices are artificial organ that are used to replace or to support the function of vital organs (kidney, liver, lung etc.). These devices are used for blood purification such as hemodialysis, hemofiltration, plasma-exchange and hemadsorption.

Health and hygiene products are used for treatment and care purposes. The range of products available for healthcare and hygiene is numerous, and they are typically used for external application, protection and safety of the medical staff and patients. They are designed to either be washable or disposable. Healthcare and hygiene products include hospital gowns and uniforms, clothing and wipes, surgical hosiery, masks, caps, hospital bed products etc.

In terms of application (Figure 4), the healthcare and hygiene products segment led the market and accounted for over 45.0% share of the global revenue in 2020. While in 2018, implanted products had the largest share (33.20%) in global revenue [MTMSPARSF, 2021-2028]. This is partly due to the pandemic caused by the covid 19 virus. Pandemic contributed to a significant increase in the consumption of hygiene products, such as masks for personal protection, but also for general hygiene products for the treatment of covid infected patients [MTMSPARSF, 2021-2028]. The forecasts are that this sector will continue to grow in the years to come.

The non-implantable goods segment is expected to register a revenue based CAGR of 4.4% over the forecast period. The increase in the number of surgeries globally is expected to increase the consumption of non-implantable products as they protect wounds from the external environment.

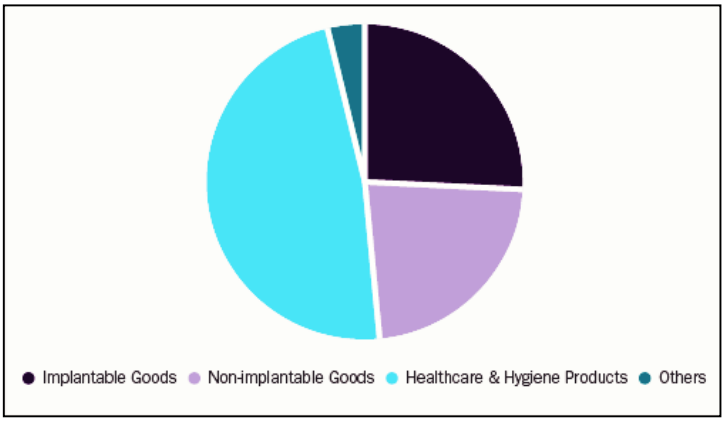

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Figure 4. Global medical textiles market share, by application, 2020 (%) [MTMSPARSF, 2021-2028]

The global medical textiles market size was valued at USD 24.70 billion in 2020 and is expected to grow at an annual growth rate (CAGR) of 4.5% from 2021 to 2028. The global medical textile market has been segmented into Europe (Germany, UK, France), North America, South America, Asia Pacific (China, Taiwan, South Korea, India, Japan, and Indonesia), and the Middle East and Africa. Asia Pacific dominated the market and accounted for over 30.0% share of the overall revenue in 2020, because of many companies for production of nonwoven textile materials. Europe is expected to exhibit a revenue based CAGR of 4.2% from 2021 to 2028. This is due to the increase in healthcare costs in 2020 in several countries (Germany, \UK, Spain, France, Italy and Russia), [MTMSPARSF, 2021-2028].

Conclusion

The healthcare and medical sectors offer the greatest opportunities for the development of various sophisticated textile structures for different types of medical applications and represent one of the most important areas for stimulating production of technical textiles. The global medical textiles market size was valued at USD 24.70 billion in 2020 and is expected and is expected to grow at an annual growth rate (CAGR) of 4.5% from 2021 to 2028. The healthcare and hygiene products segment dominated the market in 2020 and accounted for over 45.0% share of the global revenue. The forecasts are that this sector will continue to grow in the years to come.

The crises caused by COVID-19 virus in 2020 has exponentially increased the demand for medical textiles, especially nonwoven fabrics, which are used to produce personal protective equipment (PPE). The nonwovens accounted for 65 % of the global medical textile market in 2020 and is expected to grow during the forecast period (2018-2028), due to the low production cost and increased consumption of the healthcare and hygiene products.

The demand for medical textile products is expected to grow on account of the increasing awareness regarding better healthcare services and efficient medical treatments. Other factors contributing to the market growth include reduced healthcare costs, product innovations, the rising awareness about the benefits of medical textiles growing concern for patient protection, an escalating aging populations and regulations for healthcare and patient safety. Furthermore, increasing demand for nanofibers, which are manufactured using biocompatible and biodegradable materials by electrospinning technology, is also positively impacting the market as they extensively aid in tissue engineering, drug delivery and wound healing.

Continuous innovation in the field of medical science and textile technology, as well as interdisciplinary collaboration between scientists in the field of polymer materials, textiles, and medicine, are expected to contribute to the growing market for medical textiles.

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MEDICINSKI TEKSTIL, MOGUĆNOSTI I IZAZOVI

Silvana Zhezhova, Sanja Risteski, Sonja Jordeva, Vineta Srebrenkoska
Univerzitet „Goce Delčev", Štip, Tehnološki fakultet, Sjeverna Makedonija

***Sažetak**: Proizvodnja medicinskog tekstila je najbrže rastući sektor tehničkog tekstila. Tekstilne strukture koje se koriste u ovoj oblasti obuhvataju pređe, tkane, pletene, netkane tekstilne materijale, tekstilne kompozite, dizajnirane da zadovolje specifične zahtjeve hirurgije, postoperativnog liječenja i previjanja rana i opekotina u sterilnim uslovima. Iako su tekstilni materijali široko prihvaćeni za medicinsku i hirurška primjenu, stalno se pojavljuju nova područja primjene. S obzirom na veliku neizvjesnost u vezi sa Covid-19, pandemija direktno i indirektno utiče na tržište medicinskog tekstila. Prema prognozama u narednom periodu potrošnja medicinskog tekstila će nastaviti da raste. Ovaj rad prikazuje mogućnosti i izazove za primjenu fibrozne strukture u oblasti medicine i zdravstva.*

***Ključne riječi:** tržište medicinskog tekstila, vlaknasta struktura, neimplantabilni materijali, implantabilni materijali, proizvodi za zdravstvenu njegu i higijenu*

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