



UNION OF ENGINEERS AND TEXTILE
TECHNICIANS OF SERBIA

EDITOR:
SNEŽANA UROŠEVIĆ

VI INTERNATIONAL SCIENTIFIC CONFERENCE
CONTEMPORARY TRENDS AND INNOVATIONS
IN THE TEXTILE INDUSTRY

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VI MEĐUNARODNA NAUČNA KONFERENCIJA
**SAVREMENI TRENDOVI I
INOVACIJE U TEKSTILNOJ
INDUSTRIJI**

PROCEEDINGS

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Prof. dr SNEŽANA UROŠEVIĆ

PROCEEDINGS

Belgrade, 14-15th September, 2023
Union of Engineers and Technicians of Serbia
Dom inženjera „Nikola Tesla“



UNION OF ENGINEERS AND TEXTILE TECHNICIANS OF SERBIA

AND

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FACULTY OF TECHNOLOGY AND METALLURGY IN BELGRADE
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Emilija Toshikj, Igor Jordanov

**CHITOSAN-BASED DIFFERENTLY OXIDIZED COTTON YARNS ANALYZED
BY FTIR-ATR** 108

**Koviljka Asanovic, Nadiia Bukhonka, Tatjana Mihailovic, Isidora Cvijetic, Mirjana
Reljic, Mirjana Kostic**

**INFLUENCE OF PILLING ON THE STRUCTURAL CHARACTERISTICS OF
FLAX PLAIN WEFT-KNITTED FABRICS** 115

**Jovana Stepanović, Tatjana Šarac, Nataša Stamenković, Nenad Ćirković, Dušan
Trajković, Jovan Stepanović**

**THE INFLUENCE OF TENSILE FORCE ON THE MORPHOLOGICAL
CHARACTERISTICS OF TEXTURED POLYESTER MULTIFILAMENT
YARNS** 125

Hülya Kesici Güler, Funda Cengiz Çallioğlu

PCL BASED NANOFIBROUS WOUND DRESSING DESIGN 130

Mokina Anna Y, Ulme Andra

MODERN ECOTEXTILE IN FASHION AND INTERIOR 138

Damjana Celcar, Tanja Pilar

ACOUSTIC TEXTILES FOR INTERIOR 146

Liudmyla Melnyk, Olena Kyzymchuk

**PROSPECTS OF FUNCTIONAL TEXTILE PRODUCTS FOR REHABILITATION
AFTER LIMB AMPUTATION** 156

Lazaros Firtikiadis, Prodromos Minaoglou, Nikolaos Efkolidis, Panagiotis Kyratsis
**SLIPPER-SOLE COMPUTATIONAL DESIGN: A CUSTOMER-BASED
APPROACH** 162

Nikola Hanković, Dragan Živanić, Mirko Katona

ANALYSIS OF THE CONVEYOR BELT TENSILE PROPERTIES 173

**Marija Stoicovska, Frosina Vielickova, Sara Srebrenkoska, Svetlana Risteska, Sanja
Risteski, Vineta Srebrenkoska**

**UTILIZING VACUUM BAGGING PROCESS TO PREPARE CARBON/EPOXY
COMPOSITE LAMINATES** 181

**Teodora Gvoka, Gojko Vladić, Nemanja Kašiković, Katarina Maričić, Gordana
Bošnjaković, Savka Adamović**

**THE UTILIZATION OF WASTE TEXTILE MATERIALS IN THE PACKAGING
PRODUCTION** 186



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PROSPECTS OF FUNCTIONAL TEXTILE PRODUCTS FOR REHABILITATION AFTER LIMB AMPUTATION

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ABSTRACT: Today there is a wide range of reasons for a limb amputation: traffic accidents, industrial and home injuries, congenital anomalies and malignant tumors, burns, diabetes, etc. During the war, the number of cases increases rapidly because of gunshot wounds, as a result of which a limb amputation is the only decision to save the patient's life and prevent further development of the disease. Prosthetic technologies allow amputees to continue their lifestyle and maintain social status despite the loss of a limb. However, between amputation and prosthetics, there is a rehabilitation process sometimes prolonged. Swelling is an urgent problem during this period. Compression therapy with an elastic bandage, which creates pressure on the stump is the method for its prevention. It is very important to do it correctly, because a loose bandage will not prevent or eliminate swelling, tight one can damage the tissues of the stump, injure, disrupt blood circulation. Additionally, the pressure created on the stump should be gradient: the highest at the bottom of the limb with decreasing to the top. The main purpose of this work is an analysis of the assortment of rehabilitation products with a textile base used after limb amputation, and their design features, as well as the conformity of the products` dimensional features to the shapes and sizes of standard limbs, considering the amputation site. It is the basis for future development of compression covers with improved functionality and comfort for the individual needs of each patient.

Keywords: compression cover, rehabilitation products, limb amputation.

PERSPEKTIVE FUNKCIONALNIH TEKSTILNIH PROIZVODA ZA REHABILITACIJU NAKON AMPUTACIJE UDOVA

APSTRAKT: Danas postoji veliki broj razloga za amputaciju ekstremiteta: saobraćajne nezgode, industrijske i kućne povrede, urođene anomalije i maligni tumori, opekotine, dijabetes i dr. usled čega je amputacija ekstremiteta jedina odluka za spasavanje života pacijenta i sprečavanje daljeg razvoja bolesti. Protetske tehnologije omogućavaju osobama sa amputacijom da nastave sa životnim stilom i zadrže društveni status uprkos gubitku ekstremiteta. Međutim, između amputacije i protetike postoji proces rehabilitacije koji se ponekad produžava. Otok je hitan problem u ovom periodu. Metoda njegove prevencije je kompresiona terapija elastičnim zavojem, koji stvara



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pritisak na panj. Veoma je važno da se to uradi ispravno, jer labav zavoj neće sprečiti ili ukloniti otok, zategnut može oštetiti tkiva panja, povrediti, poremetiti cirkulaciju krvi. Pored toga, pritisak koji se stvara na panju treba da bude gradijentan: najveći na dnu ekstremiteta sa smanjenjem do vrha. Osnovna svrha ovog rada je analiza asortimana proizvoda za rehabilitaciju sa tekstilnom podlogom koji se koriste nakon amputacije ekstremiteta i njihovih dizajnerskih karakteristika, kao i usaglašenosti dimenzionalnih karakteristika proizvoda sa oblicima i veličinama standardnih ekstremiteta, s obzirom na mesto amputacije. To je osnova za budući razvoj kompresionih navlaka sa poboljšanom funkcionalnošću i udobnošću za individualne potrebe svakog pacijenta.

Ključne reči: kompresijski poklopac, proizvodi za rehabilitaciju, amputacija ekstremiteta.

1. INTRODUCTION

Limb amputation is one of the oldest surgeries, which is performed only in case of failure of conservative methods of treatment. The main indication for amputation is a direct threat to the patient's life, in particular gangrene of any cause, wound infection, limb trauma as well as gunshot wounds. That is why today during the Russian invasion it is performed regularly in Ukraine hospitals. Young people are the majority of patients. The problem of prosthetics for young and active people is more relevant now than ever. The main goal of prosthetics is to restore a person's mobility, professional and social activity.

The success of prosthetics mainly depends on the effectiveness of the rehabilitation period, and there are greater chances of success if the earlier rehabilitation has begun [1]. The scar healing and preparation of the stump for prosthetics are the main tasks for this period. The patient has to start physical therapy timely to avoid such complications as pathological scars, residual pain in the limbs, phantom sensations, edema, etc. After the surgery, the patient is recommended to perform active and passive exercises with resistance, to form the stump and, firstly, to reduce postoperative swelling. Compression is used to eliminate edema, and the created pressure must be gradient: the greatest is at the bottom of the limb with a decrease to the top. The compression improves blood circulation, reduces pain and swelling, helps in the treatment of phantom pain, shapes the stump before wearing the prosthesis, [2]. Later it will shorten the adaptation period of the stump to the prosthesis.

Achieving the desired effect from compression depends on the characteristics of the used materials and the created pressure since the movement of soft tissues and the reduction of the size of the covered area occur. Generally, the pressure created by the compression product depends on both the material's properties (elasticity, rigidity, and elongation) and the body shape namely the curvature radius of the surface with which the product is contacted. Thus, the required result of compression is a consequence of the correct choice of material depending on the purpose of the product and the conformity of the products' dimensional features to the shapes and sizes of limbs and stumps..

The main purpose of this work is an analysis of the assortment of rehabilitation products with a textile base used after limb amputation, and their design features.

2. RANGE OF TEXTILE PRODUCTS FOR REHABILITATION

Various compression techniques can be used after amputation: bandaging the stump and wearing silicone liners or unique covers. The type of compression means is prescribed by a surgeon or an attending physician. In order to assess blood circulation and sensitivity of the stump these means are taken off from time to time. In addition, it is necessary to regularly measure the stump volume to understand the rate of swelling reduction.

The simplest way for compression therapy is elastic bandage [3]. The study of the structure and properties of elastic bandages available on the Ukrainian market showed that all bandages are warp-knitted with longitudinal elastomer threads [4]. The elastic component of full deformation for all tested bandages exceeds 0.95. However, the application of elastic bandages requires special skills and practical experience and must first be applied by a highly qualified medician. Improper bandaging will be at best useless or can even injure the patient. In addition, in order to carry out hygienic procedures and medical control it is necessary to bandage the stump 2-3 times a day and even more often in a warm period. The multilayer bandage overlapping the previous layer (Figure 1) is usually used for stump formation so the permeability and breathability are reduced.



Figure 1: Multilayers bandaging

The silicone liner is an alternative to bandages for compression therapy after limb amputation. However, they are not as individual and available only in certain sizes, so a different size liner must be used when stump swelling is reduced. On the other side, ensuring the tightness of the connection or even pressure is the main task when using liners. It is important that there is no air between the liner and the limb but in this case, patients may experience increased sweating of the stump inside the liner. This can cause irritation of the skin of the stump.

A compression cover is another mean recommended for creating pressure on the stump. Its put-on and take-off are much easier than bandaging. The patient can do it by himself at home. In general, such cover is more reliable. It fixes and evenly compresses the soft

tissues of the stump, preventing unwanted fluid accumulation. Uniformity of pressure is the most important advantage over bandages. The textile material of the cover, unlike many layers of a bandage or a silicone product, has good air permeability, so it is more comfortable. Moreover, it is recommended to be used not only after amputation but as well after removing the prosthesis in order to improve blood supply and prevent swelling.

There are a number of Prosthetic Brands on the market that represent means for the rehabilitation period after limb amputation. Among them are the followings: Amputee Essentials, Knite-Rite, Ottobock, Alps, Silipos, Syncor, Engineered Silicone Products, etc. The range of products includes both closed-circuit covers (socks) (Figure 2) and prosthetic sleeves (Figure 3). The sock provides pressure on the stump and is used during the rehabilitation period before prosthetics. The prosthetic sleeve is used during the period of the prosthesis wearing. It should be noted that these means, like the prostheses themselves, have their own characteristics according to the patient's activity, namely sports, daily routines, etc.



Figure 2: Knit-Rite Soft Sock Error!
Reference source not found.



Figure 3: Knit-Rite Tubular Elastic Shrinker

The knitting technology allows the creation of a completely seamless product. The improved control of the loop length and the elastomeric thread's tension leads to the creation of gradient pressure. The advanced threads, for example with additional antibacterial properties, can also be used to improve product performance. Prosthetic socks of different thicknesses (light, three- and five-layer) allow adjusting the fit of the prosthesis when the volume of the stump is changed. Wearing a prosthesis with a thin layer of sock creates a temporary leg length discrepancy that can be corrected by a thicker layer. The use of special fibers leads to moisture control as well.

The choice of textiles used for the cover manufacture is fundamental to ensure the product's functionality, maximum comfort, and safety [6]. For example, the ALPS South [7] uses a few types of knitted materials with different characteristics and functions to provide specific benefits for each prosthetic leg user depending on individual lifestyle and clinical conditions. The first material's type has stretchability in both directions (coursewise and walewise), which makes it well adapted to the shape of the remaining

limb during movement and provides maximum comfort. The others have reduced by 80-90% walewise elasticity providing greater control and stability of the prosthesis for active patients.

It's clear there isn't big diversity in product types for rehabilitation after limb amputees. On the other side, the compression product must exactly fit a limb at the amputation site which is difficult to achieve within the available pre-sized products. Today with rapidly growing amputation cases in Ukraine, it is important to create rehabilitation products with both high therapeutic effects and improved comfort. The shortened time from design to production is a topical issue as well.

3. FUTURE DEVELOPMENT

The creation and development the therapeutic and preventive products that contribute to the rehabilitation process after limb amputation is not a new problem and is being actively developed by scientists. But they are most concentrated on medical aspect [8]. However, the creation and development of a product that clearly corresponds to the patient's stump is an important task for textile engineering.

The degree of pressure produced by a compression garment is determined by a complex interrelation between clothes and body. From the clothing point of view the principle factors are: the design and fit of the garment, structure and physical properties of its materials. As for the body they are: the size and shape of the body's part to which it is applied and the nature of the activity undertaken [9]. 3D/4D body scanning technology has added value to both medical and clothing industry due to several advantages offered by this technology [10]. On the other side, FEM-simulations have great potential in 3D-knitted fabrics modeling and the shape-fidelity prediction [11].

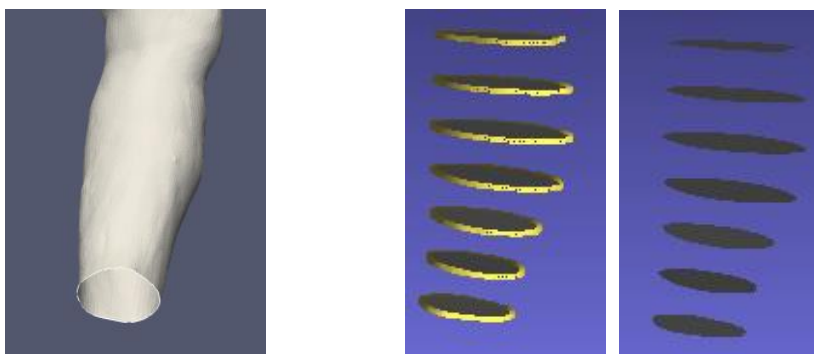


Figure 4: Data for future work: a. avatar; b. slices at differen cites

Our target is to develop an algorithm for converting the stump avatar into a technological map for the knitting machine based on the limbs scan and the capabilities of software resources (Figure 4). It will be a basis for manufacturing advanced rehabilitation products with an accent on individual patient needs.



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