Development of the lower limb stump prosthetic sock

Cite as: AIP Conference Proceedings **2430**, 080001 (2022); https://doi.org/10.1063/5.0077279
Published Online: 24 January 2022

Aleksandr Charkovskij, Denis Bykouski and Dmitriy Samoilov

Development of the Lower Limb Stump Prosthetic Sock

Aleksandr Charkovskij [a)], Denis Bykouski [b)] and Dmitriy Samoilov [c)]

Vitebsk State Technological University, Faculty of Manufacturing Technology, Department of Technology of textyle materials, Moscow Av. 72, 210038 Vitebsk, Belarus

[a)] *Corresponding author: acharkovsky@mail.ru*
[b)] *Electronic mail: denisbykouskij@yandex.ru*
[c)] *Electronic mail: samoilov_dmitrii94@mail.ru*

Abstract. Prosthetics compensates for the negative effect of lower limbs amputation. The quality of the prosthesis depends on the quality of the prosthetic sock. The use of hybrid knitted fabrics, which combine the properties of several raw materials, makes it possible to create prosthetic socks with improved hygienic quality. Three variants of lower limb stump prosthetic sock samples of plush fabrics were produced on a Lonati DF 616 machine. The raw materials used in the samples were following: cotton yarn, polyester yarn, elastane yarn, polyamide yarn. Hygroscopicity and capillarity of the samples were researched. On the basis of the experimental data, it was recommended to produce the moisture-transferring layer of the prosthetic sock using polyester yarn. It was recommended to produce the moisture-absorbing layer of the prosthetic sock using cotton yarn. 3D model of the prosthetic sock knitted fabric was created and analyzed.

INTRODUCTION

Amputation of lower limbs significantly reduces the quality of life. Prosthetics compensates for the negative effect of amputation. The socket is one of the most important elements of a lower limb prosthesis. It joins the limb stump to the prosthesis. The prosthetic sock is used for contact between the limb stump and the socket. The quality of the prosthesis depends on the quality of the prosthetic sock. An example of the prosthetic sock is shown in the fig. 1.

The properties of the prosthetic sock depend on the stitch its fabric is knitted by [1]. Prosthetic socks is often produced of plush fabrics [2]. The structure of plush fabrics is shown in the fig. 2. The enlarged feet 1 form a pile surface on one side.

Plush fabrics are soft and thickened [3]. They are a good gasket between the limb stump and the prosthetic socket. The sides of plush fabric can be made of different yarns with various properties. The use of plush fabrics makes it possible to produce a prosthetic sock with predefined properties.

The pressure of the limb stump on the socket through the prosthetic sock should be uniform. Prosthetic sock material should have good hygienic quality. These characteristics depend on the raw material. Cotton yarn is often used to produce prosthetic socks. Cotton yarn has a high moisture absorption capacity, strength. The disadvantages of cotton yarn are its high crumple ability, high shrinkage when washing, low drying speed.

The use of hybrid knitted fabrics, which combine the properties of several raw materials, makes it possible to create products with improved hygienic quality [4-6]. This effect is due to the non-wetting of the knitted fabric in contact with the source of moisture. The use of antimicrobial polyester yarns produced by SvetlogorskKhimvolokno is effective and perspective. The products made of antimicrobial yarn are well compatible with skin, comfortable to wear and wash-resistant [7].

International Conference on Textile and Apparel Innovation (ICTAI 2021)
AIP Conf. Proc. 2430, 080001-1–080001-5; https://doi.org/10.1063/5.0077279
Published by AIP Publishing. 978-0-7354-4175-0/$30.00

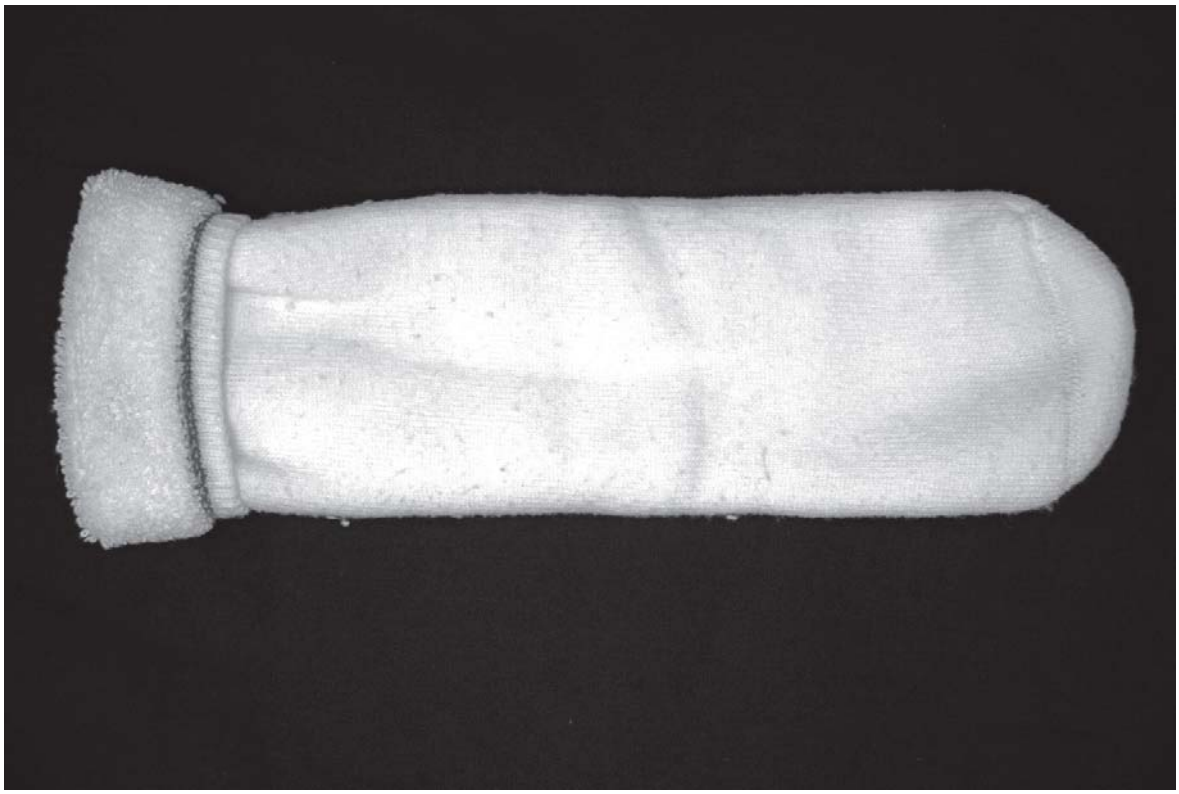

FIGURE 1. Lower limb stump prosthetic sock

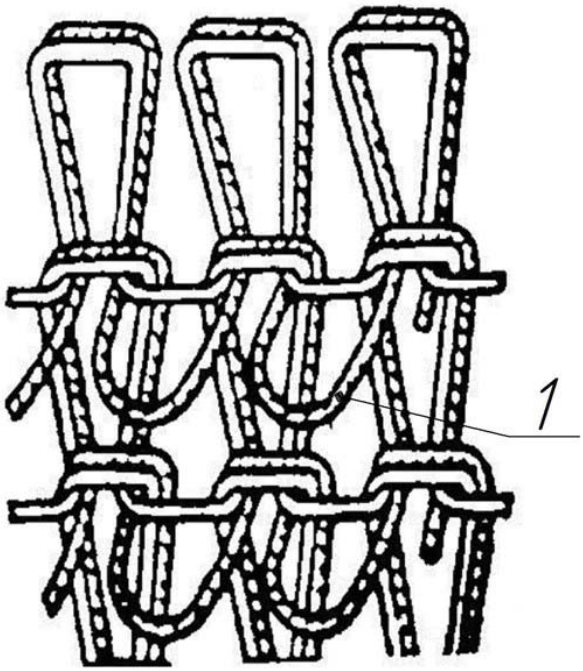

FIGURE 2. Plush fabric

MATERIALS AND METHODS

Hygroscopicity [8, 10] and capillarity [9, 10] are important physical and mechanical properties of textile materials because these materials have to provide comfort in contact with the human body. Three variants of lower limb stump prosthetic sock samples of plush fabrics were produced on a Lonati DF 616 machine. The raw materials used in the samples were following: cotton yarn, polyester yarn, elastane yarn, polyamide yarn.

First variant raw materials:

– ground yarn – cotton yarn with a linear density 20 tex;

– plush yarn – polyester yarn with a linear density 7,8x2 tex.

Second variant raw materials:

– ground yarns – elastane yarn with a linear density 2,2 tex and polyamide yarn with a linear density 4,4 tex;

– plush yarn – polyester yarn with a linear density 7,8x2 tex.

The third variant raw materials:

– ground yarns – elastane yarn with a linear density 2,2 tex and polyamide yarn with a linear density 4,4 tex;

– plush yarn – cotton yarn with a linear density 20 tex.

Hygroscopicity and capillarity of the samples were researched.

RESULTS AND DISCUSSION

Figure 3 shows the dependence of hygroscopicity on time. Figure 4 shows the dependence of capillarity on time. Capillarity values of the all samples are high. They reaches its maximum value during approximately the same period of time (45-50 minutes). Hygroscopicity value of the sample No.3 is significantly higher than its value of the samples No.1 and No.2.

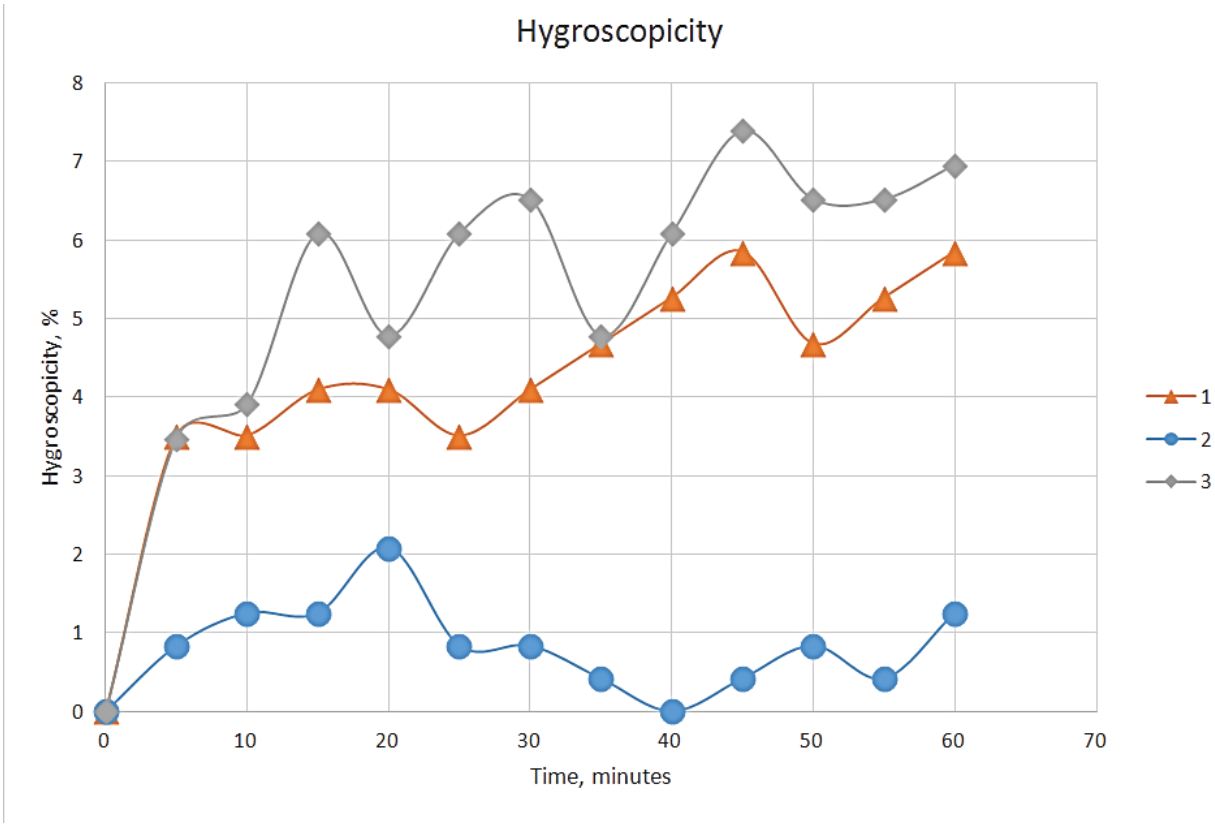

FIGURE 3. Dependence of hygroscopicity on time.

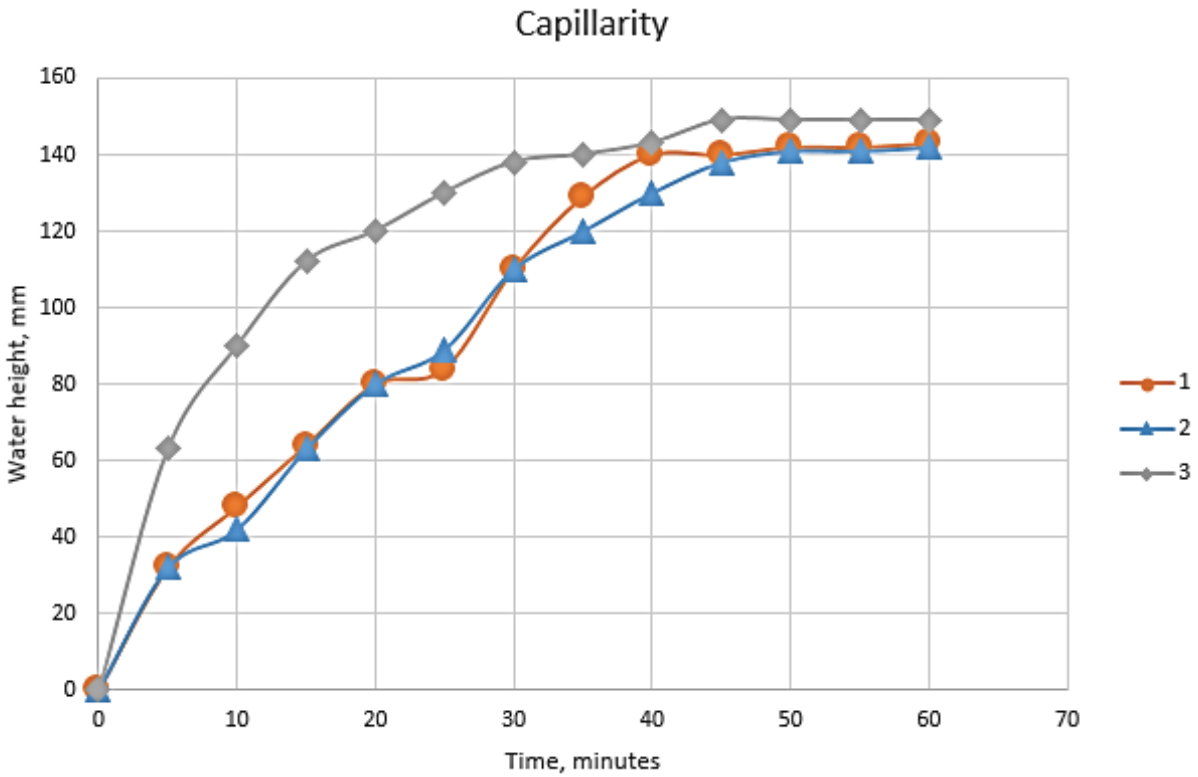

FIGURE 4. Dependence of capillarity on time.

Polyester yarns has high capillarity (143 mm) and low hygroscopicity (1%). Thus, it can be used as the raw material of the moisture-transferring layer of the prosthetic sock (e.g. Quick Dry yarns produced by «SvetlogorskKhimvolokno» company). Due to its low hygroscopicity, the moisture-transferring layer will provide the dry effect of the prosthetic sock. Cotton yarn has high moisture absorption capacity. Thus, the moisture-absorbing layer can be produced of cotton yarn.

3D modeling of the knit allows to visualize its structure and looks, estimate its physical properties and other characteristics [4]. As part of this work, a 3D model of a prosthetic sock hybrid two-layer plush knitted fabric was created. The fabric was matched the previously described requirements. Computer-aided design system "KOMPAS-3D" developed by "ASCON" company was used to create the model. Figure 5 shows the 3D model of the fabric. Figure 5a shows the front view of the model, figure 5b shows its side view.

The ground moisture-absorbing layer 1 is made of cotton yarns with a linear density 20 tex. The plush moisture-transferring layer 2 is made of polyester yarns with a linear density 7.8x2 tex. The enlarged feet 3 of the plush layer form a pile surface. Thus, the polyester yarns are on the face side of the fabric and on the backing side too. The prosthetic sock contacts the limb stump skin with its pile surface made of polyester yarns. In accordance with the 3D model structure, the pile surface transfers moisture to the inner moisture-absorbing layer 1 due to the high capillarity of the polyester filaments and their low hygroscopicity. The inner layer holds the moisture transferred from the surface of the limb stump.

CONCLUSION

Thus, the following are recommended:

– combining different types of raw materials is advisable for making a hybrid prosthetic sock with increased comfort;

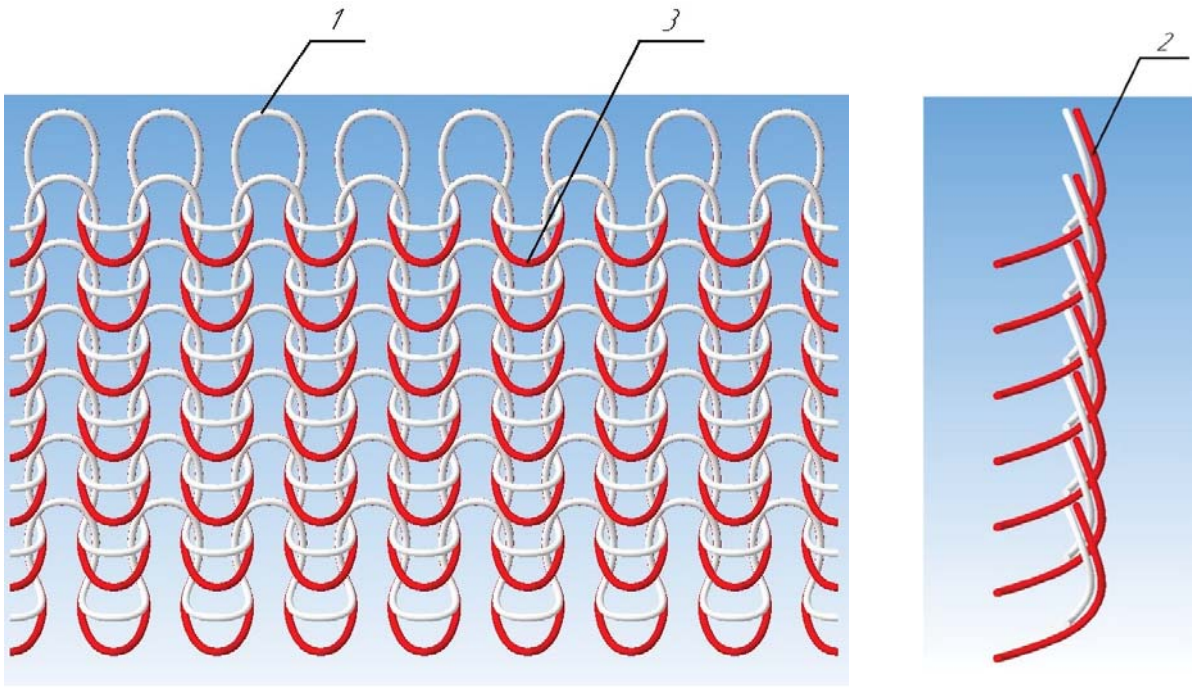

FIGURE 5. 3D model of the prosthetic sock hybrid two layer plush knitted fabric with moisture-transferring layer of polyester yarns and moisture-absorbing layer of cotton yarns.

– the use of polyester yarns with high capillarity and low hygroscopicity is reasonable for creating a prosthetic sock moisture-transferring layer in contact with lower limb stump surface;

– the use of cotton yarns with high hygroscopicity is advisable for creating a prosthetic sock moisture-absorbing layer holds the moisture transferred from the surface of the limb stump;

A 3D model of the prosthetic sock hybrid two layer plush knitted fabric with moisture-transferring layer of polyester yarns and moisture-absorbing layer of cotton yarns was created. The model visualizes knitted loop structure of the fabric. Analysis of the structure confirms our recommendations.

REFERENCES

1. P. Komárková, V. Glombíková and A. Havelka, «Proceedings of 17th World Textile Conference AUTEX 2017- Textiles - Shaping the Future» in *IOP Conf. Ser.: Mater. Sci. Eng., Corfu* **254,** pp. 182004 (2017).
2. N. Savostitskiy and E. Amirova, *Material Science of Clothing Production* (Publishing House Academia, Moscow, Russia, 2000), pp. 124.
3. L. Kudryavin and I. Shalov, *Fundamentals of knitting technology* (Legprombytizdat, Moscow, Russia, 1991), pp. 330.
4. A. Kuznetsov, A. Charkovskij, V. Goncharov, and V. Beresnev, *Bulletin of Vitebsk State Technological University* **1(36)**, pp. 54 (2019).
5. N. Kolesnikov, *Izvestia of Higher Educational Institutions, Series " Technology of The Textile Industry* **1(337),** pp. 15 (2012).
6. A. Charkovskij, V. Beresnev and D. Bykouski, *Bulletin of Vitebsk State Technological University* **1(38)**, pp. 134 (2020).
7. B. Büyükakıncı and S. Döşler, *Bulletin of Biotechnology* **1(2)** (2020).
8. L. Zhou, *Advanced Materials Research* **332-334**, pp. 731 (2011).
9. M.G. Çil, U.B. Nergis and C. Candan, *Textile Research Journal* **79**, pp. 917 (2009).
10. S. Kataeva, L. Nemirova, S. Tashpulatov, U. Muminova and R. Zhilisbaeva, *Izvestia of Higher Educational Institutions, Series " Technology of The Textile Industry* **5(383)**, pp. 154 (2019).