PROGNOSING DEVELOPMENT OF TEXTILE NANOTECHNOLOGIES

O. V. Yezhova

Department of Engineering Training Theory and Methodology, HSE
Central Ukrainian Volodymyr Vynnychenko State Pedagogical University
Shevchenka str. 1, Kropyvnytsky, Ukraine
oyezhova70@gmail.com

Abstract: *The article investigates current state and perspectives of developing sewing nanotechnologies in sewing cloths by analysing the peculiarities of textile nanotechnologies and the sphere of their application. Theoretical and information analysis of the patents of the database World Wide EPO according to the D01D and D06 classes has witnessed a considerable growth in the quantity of registered patented inventions both in the ways of chemical nanofibre production as well as applying nano-treatments for finishing textile fabrics. This fact gives us grounds to forecast a vivid growth of textile cloths production with the help of innovative nanotechnologies in the nearest 10-15 years. This growth will concern not only chemical fibre and thread production with the help of nanotechnologies, but it will also influence the methods of finishing in textile cloths by means of the latter ones.*

Keywords: *textile nanocloths, chemical nanofibre, nano-treatment, prognosis, patent.*

1 INTRODUCTION

Usage of science intensive technologies, namely nanotechnologies, has gained a considerable priority in textile material development.

There are several definitions of the notion «nanotechnology», but we will provide only those of the international standards and organizations.

Technical committee ISO/TK 229 provides the following definition to «nanotechnology» [1]:

1. Understanding and control of matter and processes at the nanoscale, typically, but not exclusively, below 100 nanometres in one or more dimensions where the onset of size-dependent phenomena usually enables novel applications,
2. Utilizing the properties of nanoscale materials that differ from the properties of individual atoms, molecules, and bulk matter, to create improved materials, devices, and systems that exploit these new properties.

According to the international standard [2], nanotechnology is a set of technological methods, applied while learning, projecting and producing materials, devices and systems, including purposeful control and management of constructing chemical composition and interrelation between certain elements of nanorange, out of which those systems consist.

Nanomaterials – are the materials that have such structural elements, geometrical sizes of which do not go beyond 100 nm at least in one direction and have new qualities, function and application characteristics.

Nanotechnologies are widely used in different spheres: i.e. building industry, medical technology, food production industry and colouring agents [3]. Being created in 1986, this technology is considered by some experts to be a new technological breakthrough. Jack Uldrich, one of the authors of the handbook in nanotechnologies, states that «nanotechnologies provide for quality improvement of everything produced with their help» [4]. In March 2012 he presupposed nanotechnology market has reached 2.6 billion dollars by 2015.

The aim of the article is to investigate current state and perspectives of developing sewing nanotechnologies in sewing materials by reaching the following objectives:

- analysis of the current state of art in nanotechnology use during sewing items production;
- prognosis of the nanotechnologies development in textile material production on the basis of theoretical and information patents' analysis.

2 QUALITIES OF SEWING NANOMATERIALS AND THEIR APPLICATION

Experts from the NanoPRO magazine introduce a list of advantages, inherent to nanotextile, that includes their resistance to dirt accumulation, ability of self-cleaning, antimicrobial qualities, and so-called «intelligent» perspectives, like implementation of sun batteries, sensor indicators, and means of protection

[5]. The spheres of their usage incorporate medical industry, protective ware and casual clothes of improved quality.

At the same time, there is not so much research on the risks of nanotechnologies to human health and ecology, underline Centres on disease monitoring and prevention. Another statement worthy of attention concerns introduction of highly-dispersive powders, nano-tubes and other nano-elements into the objects of immediate human use, which should not be only aimed at a desirable effect, but should observe security demands and be economically appropriate [6].

The leader in the sphere of invention nanotextile materials in the USA is believed to be Nano-Tex Company.

Due to newly invented technologies of this company, materials obtain such qualities as additional fabric strength, dirt resistance, one-way water permeability from the human body to the outer layer. More than 80 textile factories are using such innovative materials, which are being supplied to more than 100 clothes-wear manufacture brands [7].

Levi Strauss Company uses nanomaterials for gaining additional fabric elasticity, strength and some other qualities of their goods [3].

Such clothes-wear brands as Tommy Hilfiger and Brooks Brothers are producing dirt-resistant trousers, shirts and ties [3].

Production of protective clothes for the employees of nuclear power plants from the new polymer materials is one more aspect worthy of researching [8].

3 TEXTILE NANOMATERIALS PRODUCTION

While fabrics production nanotechnologies are applied in two directions:

1) in nanofibre production itself,
2) in finishing of traditional textile fibres and materials with the help of nanosubstances.

3.1 Nanofibre production

There are two ways nanofibres are being created:

1) by filling traditional polymers with nanoparticles of different substances;
2) by producing super-thing fibres (up to 100 nanometres in diameter).

Fibres filled with nanoparticles have been produced since 1990 [9]. Such fibres are characterized by a less shrinking ability, diminished inflammability and increased resistance to tear and wear. These characteristics can vary depending on the composition of nanoparticles used.

Carbon nanotubes are being widely used nowadays. Fibres with nanotubes woven are 6 times stronger and 100 times lighter than steel. Additionally, they may acquire capability to electrical conduction and resistance to chemical reagents. The sphere of such materials usage encompasses production of special protective clothes against electromagnetic radiation, explosions and chemical substances.

Filling chemical fibres with alumina nanoparticles increases their heat and electrical conduction, their chemical activity and strength, protection against UV-radiation and fire. Such fibres are used for protective clothes production, e.g. helmets. Syntactical fibres, filled with nanoparticles of metal oxides such as TiO_2, Al_2O_3, ZnO, MgO, obtain as a result abilities of photocatalyst function, UV-protection, anti-microbe characteristics, electrical conduction and dirt resistance.

Superslim fibres (100 nanometers in diameter) owning to their high quantity of surface area obtain increased capability of absorption.

Research conducted in England, France, USA and Israel is focused on creation of protein fibres, restructuring spider's web (up to 100 nanometers in diameter). These light, flexible and strong fibres will be used in future for production of body armour, surgical instruments, fishing rods etc.

3.2 Use of nanosubstances in finishing of textile fibres

During the finishing nanoparticles are applied in a form of nanoemulsion or nanodispersion. This makes possible to provide fabrics with water- and oil-resistance, low inflammability, dirt resistance, softness, antistatic and antimicrobial effects, thermo and shape stability, etc.

First nanomaterials for fibre evaporation, containing silver particles, were produced and released to the market by Du Pont firm [9]. Now much cheaper means of finishing are being used for these purposes.

For example, Teflon finishing guarantees water-, oil- and dirt resistant effects. At the same time, nanoparticles do not constitute a barrier for pores of the material and it breathes well [10]. These fabrics are widely used in interior textile production of furniture upholstery, curtains, tablecloths etc.

Due to the application of nanoemulsions, new cotton textile materials have been created with the right side being water-, oil- and dirt resistant, and with the reverse side staying hydrophilic, i.e. capable to absorb water. Such materials are used for producing military, sports and manufacturing clothes.

The following article [11] describes the technology for manufacturing of planar textile fabrics bonded by the perpendicular lying of polymer melt, where threads with nano-coating are probably to be used in manufacturing process.

The article [12] aims to introduce and compare spinning methods which are used to create nanofibers and nanofibrous materials.

Thorough analysis of the perspective directions in textile material development for sewing industry allowed us to formulate a working hypothesis: in 10-15 years' period of time fibre materials, made with the help of nano-technologies will be in prevailing use in future sewing industry.

4 METHODOLOGY OF TEXTILE DEVELOPMENT PROGNOSIS

As it has been mentioned [13, p.30] all prognostic methods can be divided into:

1) general scientific (or logical means);
2) inter-scientific;
3) purely scientific.

This research applies hereby inter-scientific method of extrapolation. This method is based on the assumption that, some defined tendency either in the past or in present will be true in future as well, as long as the causing factors do not change.

Analysis of patent information represents here one of the kinds of scientific and technical development prognosis with the help of extrapolation method. In the second half of the XX century a technical invention, described in the patent form was believed to be introduced into serial industrial production within 10-16 years [13, p. 56]. Anyhow there is no verified scientific data proving this time frame today in the world of highly technologically developed economy. But there is a world tendency for the time frame between invention and implementation into practice to be shortened.

In accordance with the method of technical progress prognosis on the basis of theoretical and information patents' analysis by V.A. Lisichkin [13, p. 72], last 6-year period, named as ground time for prognosis, is considered. The first year of the period is believed to be crucial for defining a starting point. The number of patents issued that year is taken as a basic starting quantity and then compared with the quantity of the patents in the following years. Depending on the decrease or increase in the patent quantity, conclusion about positive or negative perspectives of the technological branch development is formulated. Namely this method, with time-frame modification to 10 years, has been chosen in this research for prognosis of innovative development in sewing industry [14].

5 RESULTS AND DISCUSSION

In order to prove our working hypothesis in the part of chemical nano-fibre production we have conducted patent search according to the following initial conditions:

- class D01 «Natural or artificial threads or fibres, spinning»; sub-class D01D «Mechanical methods or apparatus in the manufacture of artificial filaments, threads, fibers, bristles or ribbons» [15];
- «nano» as a key word in the title or in the abstract.

Approximately 1753 results found in the Worldwide database for: «nano» in the title or abstract and D01D as the IPC classification. Previous search resulted in the quantity of 1753 patents in general. From 2007 till 2016, 1662 patents have been registered, giving us grounds to consider this decade to be an active development period of this branch in material production. Analysis of the patents' distribution according to the years has shown a sweeping growth (by 3.3 times) in the quantity of patented inventions from 2007 till 2016, – from 66 to 220, and a slight decline in quantity from 2013 to 2014, compared with the year of 2012 (correspondently 193, 180 and 220 patents) (Figure 1). As a result, our hypothesis, about positive perspectives for developing innovations in the sphere of chemical fibres and threads with the help of nano-technologies, has proved to be true, forecasting considerable growth of this branch in future.

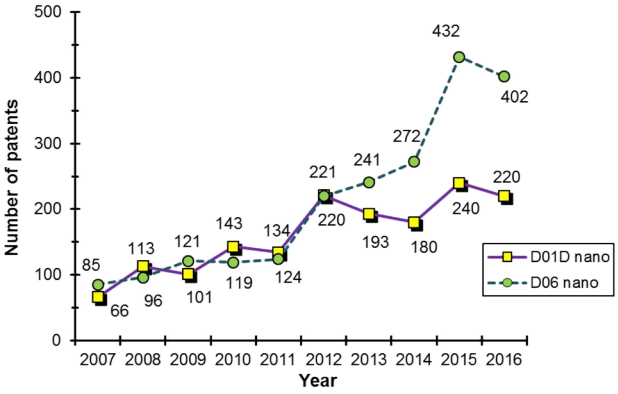

Figure 1 Quantity of patents on the ways of producing chemical nano-fibres and finishing of textile materials with nano-treatment (according to the database World Wide EPO retrieved on 24.04.2017)

In order to check our working hypothesis in the part of finishing textile materials with the help of nano-technologies, we have conducted patent search according to the class D06 «Treatment of textiles or the like, laundering, flexible materials not otherwise provided for» with a key word «nano» in the title or abstract.

Previous search resulted in the following: approximately 2367 results found in the Worldwide database [15] for «nano» in the title or abstract and D06 as the IPC classification. From the year 2007 till the year 2016, the quantity of registered patents constituted 2178, signalling vivid growth of this branch in material production for the last decade namely. Distribution year per year analysis suggested swift (by 4.7 times) increase in the quantity of patented inventions from the year of 2007 to the year of 2016 – from 88 to 402 inventions correspondently (Figure 1). As a result, our hypothesis, about positive perspectives

in development of textile finishing methods with the use of nano-technologies, has turned out to be true, providing expectations for considerable growth of innovations in this direction.

6 CONCLUSIONS

Having conducted theoretical and information patent analysis, a sweeping growth in the quantity of registered patents concerning innovative ways of chemical nano-fibre production and finishing textile materials with the help of nano-treatments has been defined. This fact allows us to presuppose a considerable growth of innovations in the sphere of textile nano-materials in the nearest 10-15 years. This growth will concern not only chemical fibre and thread production with the help of nanotechnologies, but it will also influence the methods of finishing textile fabrics with the help of nanotechnologies.

7 REFERENCES

1. ISO/TC 229 Nanotechnologies, available from http://www.iso.org/iso/iso_technical_committee?commid=381983, (accessed 24.04.2017)
2. Nanotechnologies, Part 1. Key terms and definitions: GOST ISO/TS 80004-1-2014, Moskow: Standartinform, 2015 (in Russ)
3. Gustke C.: Nanotechnology Now an Unseen Success, May 2012, available from http://www.cnbc.com/ (accessed 24.04.2017)
4. Uldrich J.: The Next Big Thing is Really Small: How Nanotechnology Will Change the Future of Your Business Crown Business, 2003, p. 208
5. Nanotechnology Benefits, 2013/nanopro, Available from: http://www.nanopro.biz/ (accessed 01.04.2017)
6. Nikiforov Yu: Textile industry will make nanotechnology closer to people, Russian electronic nanojournal 2010, available from http://nanorf.ru (accessed 24.03.2017), (in Russ)
7. Nano-Tex announces new way of providing moisture management, March 2012, available from http://www.sportstextiles.com/ (accessed 01.04.2017)
8. Tretiakova L.D., Ostapenko N.V., Kolosnichenko M.V., Pashkevich K.L., Avramenko T.V.: Designing of Rational Structure of Range of Insulating Protective Clothing on the Basis of the Principles of Transformation, Vlakna a Textil 23(4), 2016, pp. 27-35
9. Nanotechnology in the textile industry, Research centre for light industry 2013, available from http://cnilegprom.by/ (accessed 24.04.2017), (in Russ)
10. Teflon® fabric protector meets interior exceiience, DuPont, News from DuPont Home Textiles Division 2012, available from http://www2.dupont.com/ (accessed 24.04.2017)
11. Sirkova B., Ježik K., Sanetrnik F.: Manufacturing of planar textile fabric structures bonded by perpendicular laying of polymer melt, Vlakna a Textil 22(1), 2015, pp. 17-20
12. Blažková L., Hlavatá J., Horáková J., Kalous T., Novák P., Pelcl M., Strnadová K., Šaman A., Chvojka J.: Comparison of the well-known spinning and electrospinning methods for polyvinyl alcohol, Vlakna a Textil 23(1), 2017, pp. 57-63
13. Gvishiani D.M., Lisichkin V.A.: Prognostics, Moskow: Znanie, 1968. p. 92, (in Russ)
14. Yezhova O.: Projections of innovative educational contents when training specialists in the sewing industry, St. Petersburg State Polytechnical University Journal. Humanities and Social Sciences 4, 2014, pp. 197-204, (in Russ)
15. European patent office, available from http://ep.espacenet.com (accessed 24.04.2017)