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A NEW ALGORITHM FOR TESTING THE PROPERTIES OF NONWOVEN FABRICS

The new algorithm to study the properties of nonwoven fabrics is presented in the paper. The algorithm consists in image processing of the image of the highlighted nonwoven fabric. From the image there are selected the bright areas, which means sparse distributions of the fibers. Because nonwoven fabrics are used, among others, as medical and filtration materials their structure has significant impact on their ownership. The software task is primarily determine the porosity of the material.

Keywords: algorithm, nonwoven fabrics, porosity

INTRODUCTION

Polymer-laid nonwoven fabric formation in melt-blowing process [1] creates huge technological problems. The structure of fabric, its properties and characteristics are influenced by such parameters as the moisture of the polymer, the temperature of formation at the separate zones of installation, the output and temperature of the air blowing out the melt, the take-up velocity of the nonwoven, the distance of the condenser from the spinning nozzle, and the thickness of the fibers received [2]. The quality of non-woven fabrics is very important due to the applications in many areas such as for example engineering, medicine. Nonwoven with incorporated in its structure Triclosan, encapsulated in biodegradable polylactide, was studied for influence on the microbiological effect [3]. Nonwoven fabrics have been studied as a means of anti-allergenic protection against saprophytes [4]. Chitin nonwoven fabrics have been applied as clinical wound dressing [5]. Nonwoven garment was tested as a means of reducing bacteria in the operation room [6]. Biomodification of nonwoven polyester fabrics have been used in serum free cultivation of tissue cells [7]. Nonwoven fabrics have been used to improve of the electrolyte in the Li-ion battery technology [8]. This kind of materials are

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applicable in for example water filtration [9]. The influence of the technological parameters of the padding process was under investigation for the filtration properties of polyester nonwoven fabrics [10]. To study the properties of non-woven fabrics are also used numerical methods. Numerical simulations on nonwoven-fibrous were performed to determine material design space for energy storage device separators [11]. Finite element method analyses have been applied to simulate behavior of the nonwoven fabrics [12-14]. The system for detect fabric weave patterns with help of computer image processing and analysis has been developed [15]. A novel approach to assessing textile porosity by the application of the image analysis techniques has been presented in [16]. R.H. Gong and A. Newton [17] have been described image-processing technique for measuring the fiber orientation distribution in nonwoven fabrics. E. Ghassemieh, M. Acar, and H.K. Versteeg [18] developed the image analysis techniques for study microstructural changes in non-woven fabrics. B. Pourdeyhimi, R. Dent, and H. Davis [19] presented the development of of an image analysis technique using the Fourier transform of the image to evaluate orientation in a fibrous assembly. The aim of this paper is to designate the diaphanous areas in nonwoven fabrics and their selected statistical parameters by means of numerical methods.

1. NUMERICAL ALGORITHM

The analyzed image is showed on Fig. 1. It shows the highlighted image of polymer-laid nonwoven fabric. It can be seen the brighter areas to be analyzed. The study of such images must consist of several stages. The first one should rely on image processing. The algorithm provides as first to convert a color image to image with levels of gray.

There are many methods of such transformations. One of them is to present only one color component of the color image. Because the human eye is most sensitive to green color and the least on the blue color, so the method described by Eq. (1) has been chosen in this paper.

$$R_{gr} = G_{gr} = B_{gr} = 0.2126 \cdot R_{col} + 0.7152 \cdot G_{col} + 0.0722 \cdot B_{col} \quad (1)$$

where R_{gr}, G_{gr}, B_{gr} denotes the base colors, red, green, and blue of image with levels of gray, R_{col}, G_{colr}, B_{gr} denotes the basic colors of color image.

The converted image scaled in 256 levels of gray is presented on Fig. 2. Because the analysis of the bright area is needed, so it should be extracted from the image. It can be done by converting the image in gray levels into the image of two-color. It should be selected the limit below which the gray levels convert into black color, and above which the gray levels convert into white color. If this limit is chosen at the level of 200, then we get a picture with white spots of different sizes, as it is shown in Fig. 3.

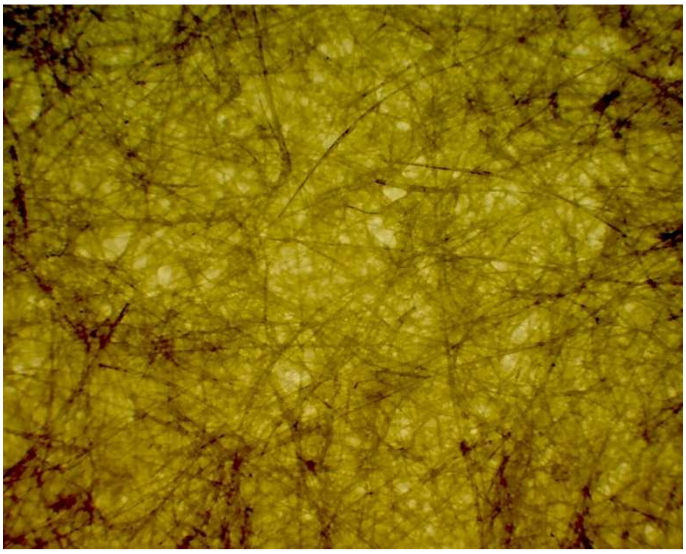

Fig. 1. The image of highlighted nonwoven fabric

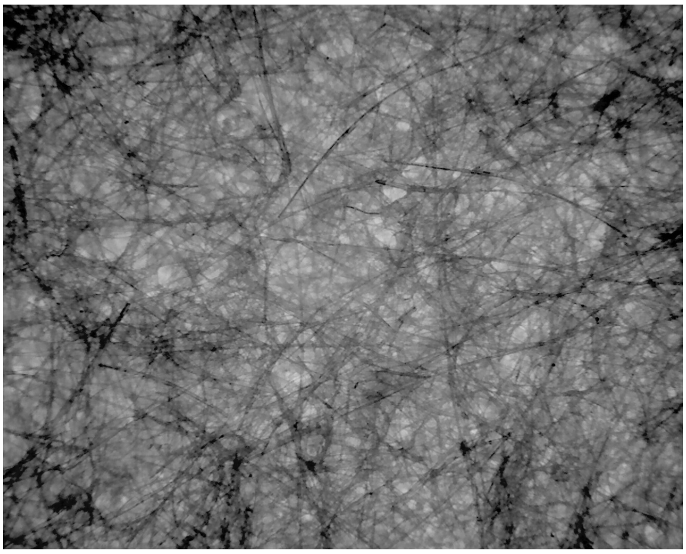

Fig. 2. Image from fig. 1 with color converted into the gray levels

The second part of algorithm is based on processing of white stains. The need is to locate any stain from a separate and process it. This is done by applying the so-called algorithm of mooving pixel. It is searching the first pixel lying on the edge of the stain. Then pixel goes around the edge of the stain and marks its inside. The number of pixels for each stain is counted at the same time. The process is shown in Fig. 4, where an edge is marked with blue color and the inside with yellow color. If Figure 4 will be magnify, it can be seen the green pixels in the stains. They mean geometric centers of the stains.

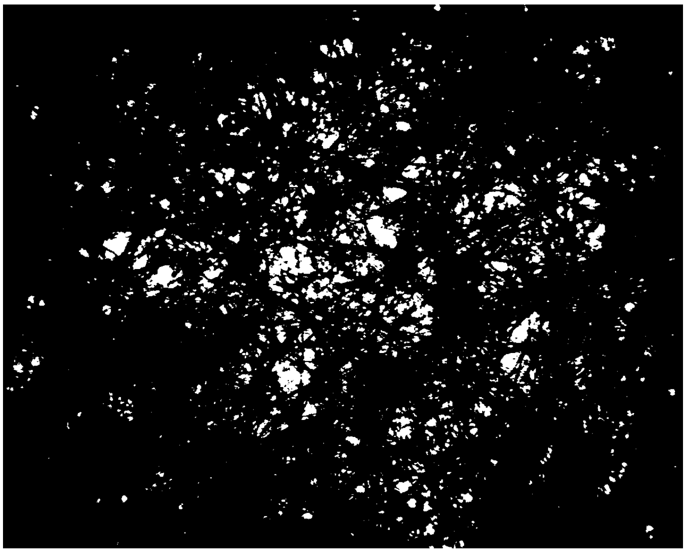

Fig. 3. Image from Fig. 2 converted into the image of black-white color

(a) (b)

Fig. 4. Image consists with several stains: a) before processing, b) after processing

The picture on Fig. 5 presents the image from Fig. 3 after processing. The software includes also the algorithms for calculating such quantities as the number of stains, the size of each stain, the coordinates of geometrical centers of the stains, etc.

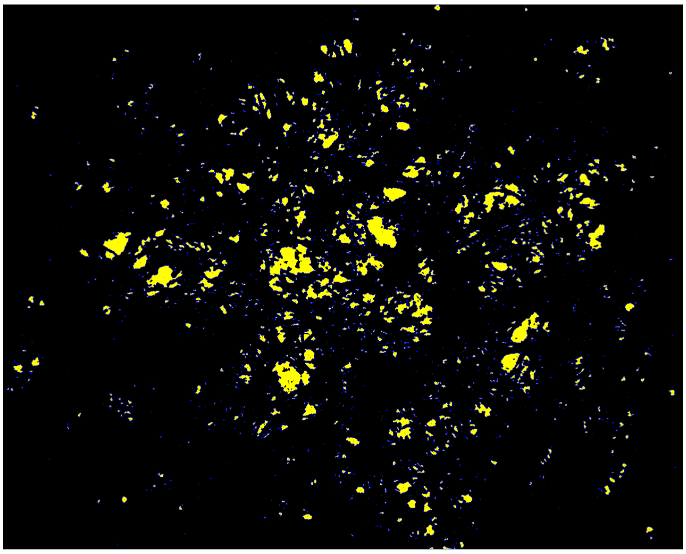

Fig. 5. Image from Fig. 3 after processing procedure

2. NUMERICAL RESULTS

This section shows selected numerical results obtained from the software based on the described algorithm. Table 1 presents selected parameters of the greatest 10 bright areas on the nonwoven fabrics from Fig. 1. The pixel coordinate 0, 0 lies in the upper left corner of the nonwoven fabric. Knowing the real size of nonwoven fabric, it is easy to find the position and the size of the stains.

Table 1. Selected results obtained for 10 greatest stains on the nonwoven fabric

The order down the size of the stains	**Pixel x – coordinate of the geometrical center**	**Pixel y – coordinate of the geometrical center**	**The size of the stain**
1	544	483	2932
2	541	700	2243
3	714	427	2136
4	303	514	1607
5	780	574	1527
6	983	611	1430
7	217	448	1301
8	689	489	952
9	995	672	923
10	1117	438	908

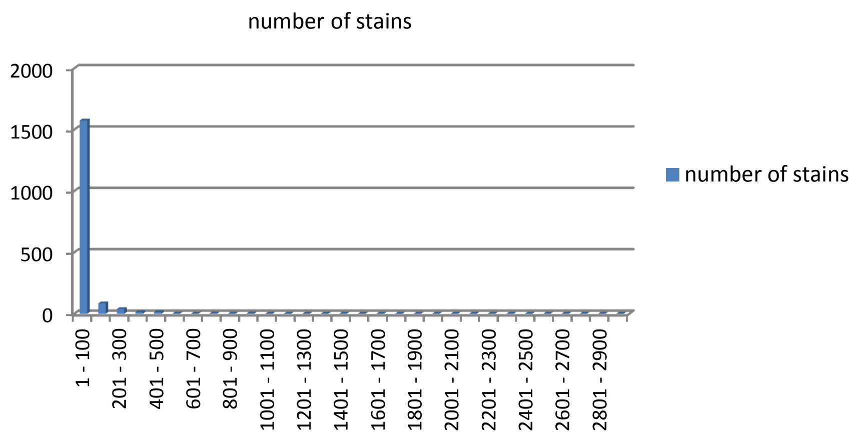

Fig. 6. Distribution of the stains according to their size

Figure 6 shows histogram of the distribution of the amount of stains, depending on their size. Because the number of all stains is 1743, and their size varies from 1 to 2932 pixels, there are selected on the horizontal axis the size ranges of these stains (in this case every 100 pixels). It can be seen from Fig. 6 that the most of the stains are the smallest, but there are also larger pieces.

3. CONCLUSIONS

The numerical algorithm for testing the degree of porosity of the nonwoven fabrics is presented in the paper. Because the nonwoven fabrics are used in many areas of technology and medicine, the algorithm is a good tool for testing the quality of these materials. The software extracts the unevenness of the distribution of the fibers in nonwoven fabrics and thus can be used to specify their spatial structure.

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NOWY ALGORYTM DO BADANIA WŁAŚCIWOŚCI WŁÓKNIN

Przedstawiono nowy algorytm do badania porowatości włóknin. Algorytm zawiera przetwarzanie obrazu podświetlanej włókniny. Na obrazie są zaznaczone jasne obszary, co oznacza rozrzedzoną dystrybucję włókien. Ponieważ włókniny są używane między innymi jako materiały medyczne i filtracyjne, ich struktura ma znaczący wpływ na ich właściwości fizyczne. Zadaniem oprogramowania jest przede wszystkim określenie porowatości materiału.

Słowa kluczowe: porowatość, włóknina, algorytm

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