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STUDY OF COMPOSITE MATERIALS FOR THE ENGINEERING USING WAVELET ANALYSIS AND IMAGE PROCESSING TECHNOLOGY

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ABSTRACT

Wavelet analysis and image processing technologies are important Tools for data analysis. We can apply these tools to the science of materials and polymers. This is important for the use of composite materials in engineering. We reviewed the methodology for wavelet analysis of image processing in the study of polymer compositions. We also use the contrasting procedure to improve the wavelet analysis. This allows you to improve the study of the properties of fiber as a reinforcing agent in polymer compositions for use in engineering. In this paper experiments had been held. The results presented here were found satisfactory and also are in good agreement with our earlier work and some other worker in the same field.

KEYWORDS: ***Wavelet Analysis, Composite Materials, Image Processing, Contrast Modification & Engineering.***

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Original Article

INTRODUCTION

Modern composite materials constitute a significant proportion of the engineered materials market, ranging from everyday products to sophisticated niche applications. Increasingly enabled, by the introduction of newer polymer resin matrix materials and high performance reinforcement fibers of glass, carbon and aramid, the penetration of these advanced materials has witnessed a steady expansion, in uses and volume. For certain applications, the use of composites, rather than metals has in fact resulted in savings of both cost and weight. Some examples are replacements for welded metallic parts, reinforcement, tubes, ducts, blade containment bands etc [1-6].

For example, in [3] the possibility of using of bamboo macro-, micro- and nano fibers as reinforcement in organic and inorganic matrices is considered. In [4], the possibility of using composite materials in sandwich panels with reinforcement ribs or webs for structural applications in engineering is considered. In [5] the possibility of using cellulosic fiber fabrics and their fabric reinforced polymer composites as reinforcement materials within and/or outside of construction materials (eg concrete) is explored. It is also shown that careful selection of reinforcement type enables finished product characteristics to be tailored to almost any specific engineering requirement. Therefore, the interest in polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research.

A special place among composite materials is occupied by natural fiber-reinforced polymer composite materials. Unlike conventional materials (e.g., steel), the properties of the natural fiber-reinforced polymer composite materials can be designed considering the structural aspects [7-11]. But, there are many factors that can change the properties of natural fibre reinforced polymer composites. Due to this, it is essential to illustrate and record the properties of these fibres, and investigate new source of applications of fibres in composites. In order to address these issues in detail, it is necessary to use the image processing procedure, for the investigation of the fiber. For this, it is important to have high-quality images composites, which are made under a microscope.

MATERIALS AND METHODS

Wavelet Analysis as a Tool for Study

One of the promising methods for image processing is, wavelet analysis. Wavelet analysis is a way of data mining, for extracting additional information about processes under study. Such information is extracted from the discontinuity points. Discontinuity point is a sharp intermittent transition, in some processes. In the image, the point of discontinuity is the brightness change. Analyzing the point discontinuity us to determine the presence of special characteristics of the analyzed image, as well as the point, where these characteristics may arise [12, 13].

Behind the formalization of the continuous wavelet transform, there's the use of two continuous and integrable along the whole axis t functions [12, 14]:

– wavelet – function $\phi(t)$ with zero integral value

$$\int_{-\infty}^{\infty} \phi(t)dt = 0 \qquad (1)$$

determining the details of the signal and generating extended fractions;

– scaling function $\varphi(t)$ with a unit value of integral

$$\int_{-\infty}^{\infty} \varphi(t)dt = 1 \qquad (2)$$

determining a rough approximation of signal and generating approximation coefficients.

Using formula (1) and formula (2), we investigate of the images by decomposing source data in a plurality of approximate and detailed coefficients. This decomposition is done, according to the rows and columns of the original image. We obtain the matrix of horizontal and vertical discontinuities of the original image. Then we combine the matrix of horizontal and matrix vertical discontinuities of the original image. So, we get a new image that has been transformed with wavelets. This allows us to do image segmentation, given the areas of interest.

But to ensure the reliability of the detection of discontinuities, it is necessary to carry out the procedure of enhancing the contrast of the image [14, 15].

Contrast Modification as an Addition for Wavelet Analysis

Contrast modification – one of the stages of preprocessing of microscopic images [15, 16]. Contrast is one of the main characteristics of the image; it is directly related to the brightness of pixels that are the sources of information about the objects in the image. Therefore, changing the contrast of the image allows improving both image perception accuracy, as well as the efficiency of its further processing, accuracy wavelet analysis. Modifying the contrast of the image makes some of its details more distinct. This emphasizes the points of discontinuity. Therefore, this is important for wavelet analysis.

By increasing the contrast of the image (pixels -individual image points), highlights become lighter and dark image regions become darker. When reducing image contrast, on the contrary, there is an expansion of the average gray-level range. Dark pixels become lighter, and light pixels become darker and partially transform into the midtones [17].

Data for Analysis

For analysis, we use images that are obtained by means of scanning electron microscopy (Figure 1).

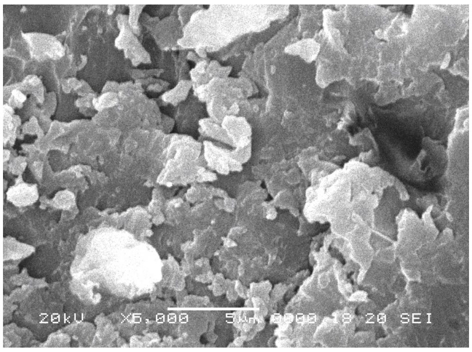


Figure 1: Image of Polymer Composite

We see that, that clusters micro-grains of composite sample is the inhomogeneous and deformed at microscopic level and therefore can be, for example, the reason for resistive ac conduction. Bright areas observed in the SEM (electron microscopy) micrograph are due to the strong reflections from aluminum nitrate particles embedded in the host matrix.

Therefore, important highlight these plots and assess their area. For this we use wavelet analysis and image processing technology.

RESULTS AND DISCUSSIONS

To study the image of composite materials, we also use the noise removal procedure. Noise - fine grains in the image. This noise will affect the results of the processing. Then the general analysis procedure is shown in Figure 2.

To remove noise we use the median filter. This is the most common method of removing noise. This method gives good results [15]. Then, after removing the noise, we apply the procedure for changing the contrast of the image. The following methods can be used to change the contrast of the image: histogram equalization of brightness values (luminance), non-linear stretching of dynamic range of brightness values, vasks filtering, fuzzy masking [18, 19]. We use the method of histogram equalization. This is a simple and quality method for changing the contrast of an image.

The results of application of median filtering and contrasting procedures can be clearly seen on Figure 3, which shows the histogram of the original image (Figure 3a), image after filtering (Figure 3b), image after filtering and contrasting (Figure 3c).

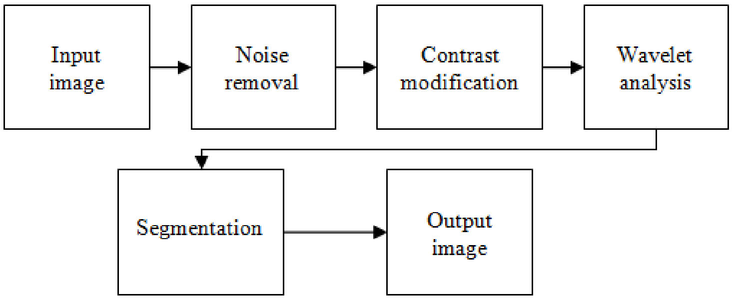
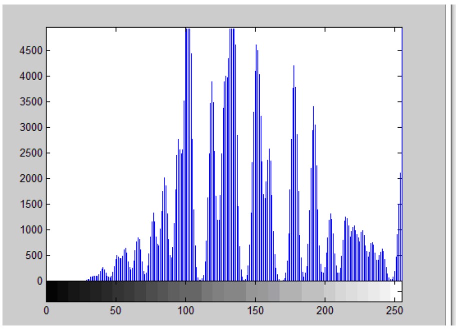
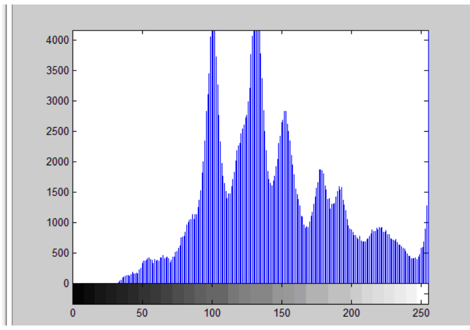


Figure 2: Sequence of Analysis of Composite Materials using wavelet Analysis and Image Processing Technology

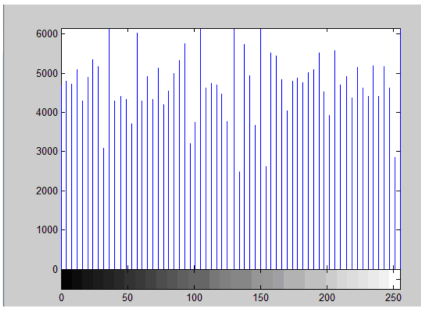
Now we will do the wavelet transform. For this, we use the general algorithm of wavelet analysis for the image analyzing [14, 17, 19]. This algorithm is described in the section – Wavelet analysis as a tool for study.



a) Original Image



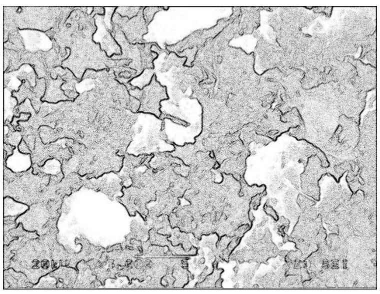
b) Image After Filtering



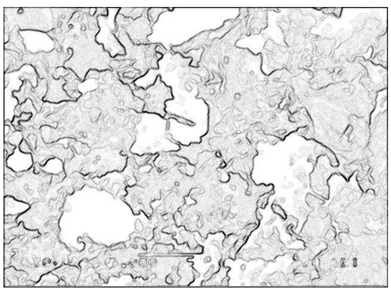
c) Image after Filtering and Contrasting

Figure 3: Histogram of Images that are Explored

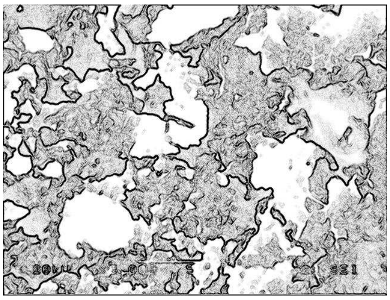
Figure 4 shows the results of wavelet analysis, for different images: original image (Figure 4a), image after filtering (Figure 4b), image after filtering and contrasting (Figure 4c).



a) Original Image



b) Image after Filtering



c) Image after Filtering and Contrasting

Figure 4: Results of wavelet Analysis

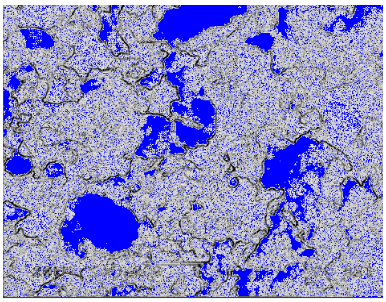
In Figure 4c, the areas of interest are distinguished more clearly, than in Figure 4a and Figure 4b.

Now, we will do the segmentation of the images in Figure 4. This will show us the difference between the results of processing the original image. For segmentation, we use a difference in shades between individual areas of interest. We can say that this color segmentation, where instead of the color values we use the value of shades [18].

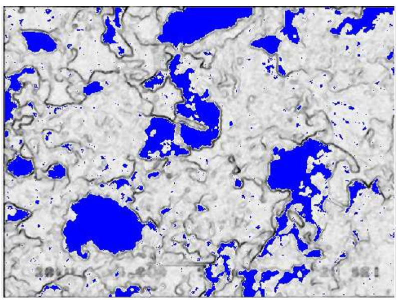
In Figure 5, it shows the results of segmentation for different images: original image (Figure 5a), image after filtering (Figure 5b), image after filtering and contrasting (Figure 5c). Areas of interest are highlighted in blue.

We can see a different selection of areas of interest. At the same time, the total area of areas of interest is equal to 18% of the total area of the image (it was determined by experts).

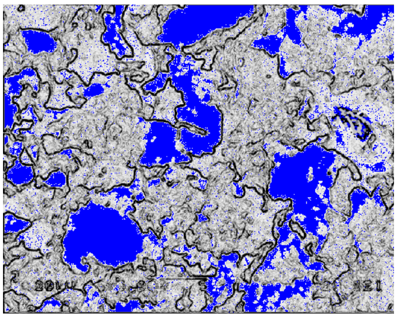
After processing the original image (Figure 4a), we segmented 37% of the image area, which is identified as an area of interest (Figure 5a). We see a lot of false points. After processing the image in Figure 4b we segmented 14% of the area of the image, which is identified as an area of interest (Figure 5b). We see that some points are not segmented. After processing the image in Figure 4c we segmented 19% of the area of the image, which is identified as an area of interest (Figure 5c). We got the most accurate segmentation. But we also have an error of 1%. This is a mistake due to the fact that it is difficult to identify all points of interest on the source image. But wavelet transformation and image processing technology allow more precise determination of points of interest.



a) Original Image



b) Image after Filtering



c) Image after Filtering and Contrasting

Figure 5: Results of Segmentation

CONCLUSIONS

We examined the possibility of using wavelet analysis and image processing technology, for the study of composite materials, which are used in the engineering. We showed a sequence of analysis of images of composite materials, which gives a good result. This is done by allocating specific features on the image of the polymer composites with a special emphasis on the impact of scale values. It is also important to use a contrasting procedure before performing wavelet analysis.

We have shown that using wavelet analysis and image processing technology allows you to select the areas that are being analyzed. This selection is the accurate. This allows for someone to better perceive the differences between uneven and cracked surface in polymer compositions. This is important for the use of composite material in engineering.

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