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# DEVELOPMENT AND ASSESSMENT OF SOFTWARE FOR IMAGE ANALYSES OF COMPOSITE MATERIAL

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***Abstract.*** *In order to guarantee a correct utilization of a composite material, its component distribution must be as uniform as possible in the whole workpiece, since a correct distribution is strictly related to mechanical properties. The aim of this work is to present a qualitative and quantitative inspection of a composite material made of tungsten carbides in a Cu-Ni-Zn matrix by using a dedicated software developed in Matlab® for digital image processing of the composite surface. The images were taken under the same procedure of lens, position and illumination, in order to compare different workpieces from a calibrated image. The analysis starts transforming a digital image from the surface into a binary image (black and white). Onto this new image, extracting of pixel sets was performed and each set was statistically analyzed. At the end, a 3-D mapping is presented where the concentration of the components of the composite material is shown. Lack of components or non-uniform distribution of them will be pointed out by the software in the image as a rectangle area.*

***Keywords:*** *Image Processing, Composite Material, Tungsten Carbides.*

## 1. Introduction

The most diverse areas of the knowledge, specially engineering, require analyses of working material, which can be done qualitatively and/or quantitatively. By this approach plus the use of statistical procedures it is aimed to determine the material properties and intrinsic characteristics. It is common that some kinds of analyses cannot be performed by traditional as, for example, the manual measurement with an ordinary scale. This can be seen, for instance, in the medicine, where red-corpuscles are counted in determined blood volume and in the engineering, where the carbon percent is estimated in a steel sample (Gonzalez & Woods, 2000). Another example of particular application is the measurement of composite materials. These cited examples can be study by digital image processing. In the Figure 01, it can be observed a set of cells in which the image analysis process was performed in the field of biology and medicine.

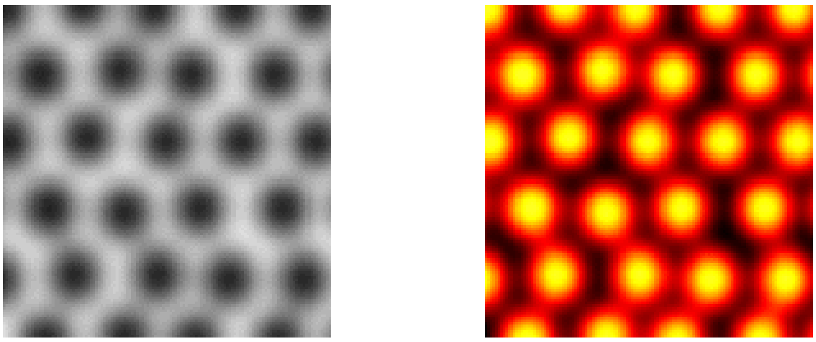

Figure 1. Example of image processing: left image represents cells in black and write format and right image is the same image but with color treatment (Albuquerque, 2004).

Regardless composite materials in engineering, the ones used in tools for abrasive machining are technological important. This composite material is made by brazing abrasive material (in this case, tungsten carbide) on a steel surface. The final tool quality is directly related with the deposition process of the abrasive material and in a final analysis it can be related to the tungsten carbide distribution. Thus, it is necessary to examine the surface and one approach can be the digital image processing. This option has the advantage of digital treatment on a computer that will result in a practice, reliable and non-time-consuming dataset. Another advantage of the process is the simple operation of the image analyzer, demanding, therefore, the minimum of qualification for the person who uses the software.

In this way it was developed a software with the function of performing surface analyses of composite material in order to characterize its manufacture and its use by using a sample from material, and only one simple digital picture. The use of this software replaces personal opinion from the operator whether the deposition was satisfactory or not. Therefore, in terms of practical aspects, standardization of the deposition procedures can be achieve and subjective interpretation of the final product quality is avoided.

The analysis of digital images has a great potential for surfaces qualification of composite materials, getting resulted fast and trustworthy. The objective of the work was the development of a processing routine in Matlab® to verify the homogeneity in a deposited surface of composite materials (tungsten carbide and Cu-Ni-Zn matrix deposited on steel plates). First there is a routine that transforms the digital picture into a binary image (black and white) for a posterior statistic analyses, getting as resulted a dataset related to the carbides distribution.

**2. Metodology**

The first step is the standardization of the type of picture to be taken off with regard to the camera position and the luminosity that falls on the material. The position of the light source must be in such way that the shade of one carbide does not exert influence in others, as shown the Figure 2. As consequence, the difference between the biggest and the smallest carbides does not have to be emphasizing. It means that if one carbide is much bigger than others, when the light rays reach it, a shadow will cover the other carbides and, therefore, a dark region in the image will be seen. In this case, the software scans this dark region as an absence of carbides and a fake result will be achieved.

The same problem occurs if the light ray inclination has a small angle taking as reference the plate. In this case, the shadows from carbides are larger and interfere in other aside carbides. The best illumination method is achieved when the light ray inclination leads to carbide that has half side light and half side dark. This means that the shadow from the carbide does not interfere in another one, as seen in Figure 2.

The same comments are valid for the position of the camera, in such form that one carbide does not block the image of another one.

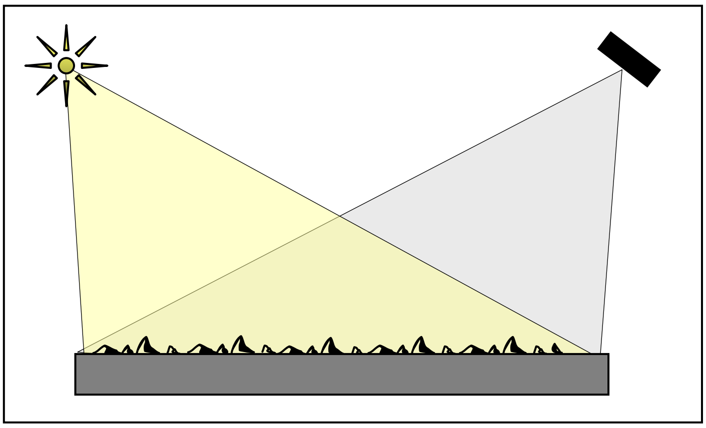

Figure 2. Methods of illumination.

The images captured by a digital camera (model MVC-FD75, 1.3 Mega Pixels, resolution 640x480, focal distance from 4.2 to 42mm) are transformed through the software in a matrix with the values of the colors in RGB format (red-green-blue channels) corresponding to each pixel ("picture element" or "pel") of the image (Matsumoto, 2001). An example of image in the RGB format is shown in Figure 3. The matrix acquired previously presents values that vary of 0 to 256 correspondents the RGB intensity of each pixel, through an already defined referential value in the software, these values are replaced by 0 (zero) or 1 (one) getting this way a binary matrix, that corresponds the image in black and white shown in the Figure 4.

This transformation from RGB format to binary one is accomplished by verifying cell by cell of the matrix regardless the intensity of each pixel, which varies from 0 to 1. If the cell is larger than a certain value (set by the user), this cell is changed by 1 (one). On the other hand, if it is lower, it is changed by 0 (zero). This approach allows making the preset of the binary matrix as a function of the more suitable intensity. The example of Figure 3 was used for illumination intensity of each pixel to be equal to 0.7 or 70%. Above this value, the pixel becomes 1 and below the value it becomes 0, what leads to the result presented in Figure 4.

Figure 3. Photograph of the sample.

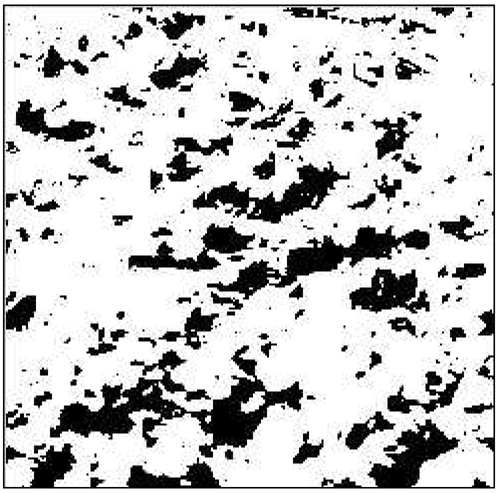

Figure 4. Binary image from the RGB one of Figure 3.

Completed the binary matrix, the software will pass to the statistical verification of a binary cells (sub-matrixes) group in which the group size is chosen previously in the beginning of the software (Figure 5). This verification is executed calculating the percentage of 0 (zeros) and 1 (ones) for each group, and the routine will run the entire matrix moving the groups until all matrix be completed. Each statistical result will have your won cell of another matrix in which will be called percentage (Esquef et al., 2004).

An example of this type of cited utilization can be seen in Figure 6 and 7. In these pictures a matrix size of 50 by 50 pixels were selected. This size was picked because it broaches the average carbide size of Figure 3. If the size of the carbide group is smaller, for instance, 5 pixels, it leads to a percentage matrix with poorer results and Figure 6 will turn almost blue. This happens because the binary matrix used in this analysis represents the white color rather than the black one, what brings difficult in the analysis. However, if the sample picture comes from smaller deposited carbide, the choosing of smaller groups is the most appropriated option and leads to better results. On the other hand, if the group size is larger than the carbide size, the sub-matrix will be composed by many pixels at once, and consequently, the precision of the analysis will be diminished, as well. In this case, the exact local where the poor carbide distribution is place won't be known. Thus, it is possible to state that the size group depends on the carbide size to be analysed.

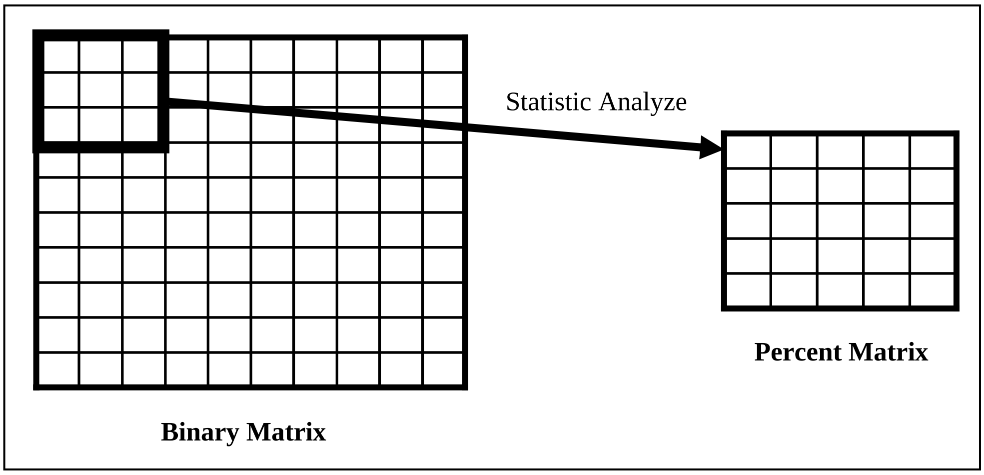


Figure 5. Sub-matrixes selection for statistical analyses of the binary matrix.

In order to promote a better visualization of the carbides distribution a 3D graph mesh is plotted, as can be seen in Figure 6, in which the color darkest indicates absence of carbide. In this way, if the graph present a dark portion isolated or distributed by the plate, it indicates that it has portion with bad distribution of the carbides, or in another situation, absent of carbides.

Another part of the routine will still verify the matrix percentage looking for places with low values of percentage, being this part called of 'SEEK', also getting these places coordinates that will be passed to the last routine part in which will show for who is using the software the place with bad distribution of carbides. This routine part is calling 'SHOW'. The results of all this analyze process can be seen by means of the Mesh graph 3D according to the Figure 6 and the Figure 7.

In Figures 7 and 6, the areas can be noticed where it has little carbides concentration and where has the biggest concentrations. In the right-upper side of these figures and in the central part of the left side they present a darker color, which the graduation to the side indicates few elements in that area. This can be established looking at Figure 3 that it is the original picture of the sample.

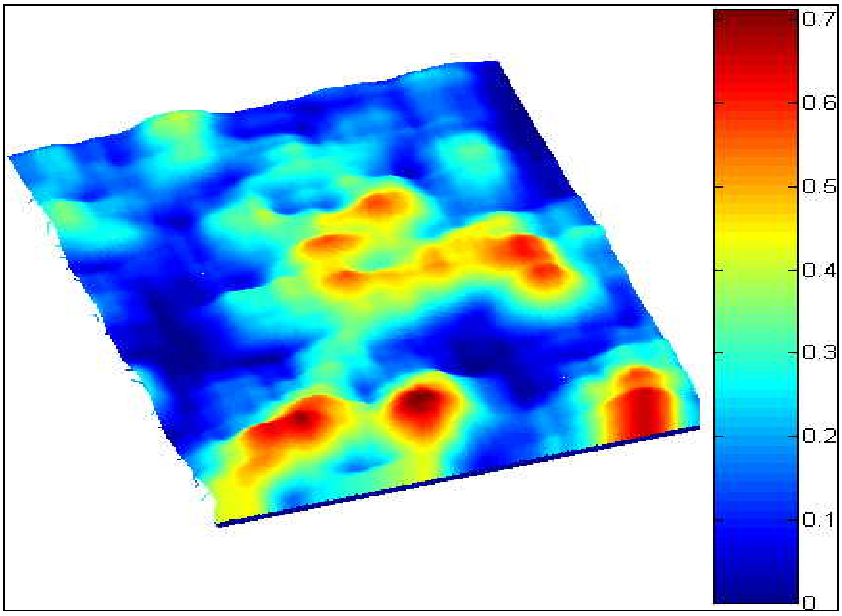


Figure 6. Percent graphic mesh of surface specimen.

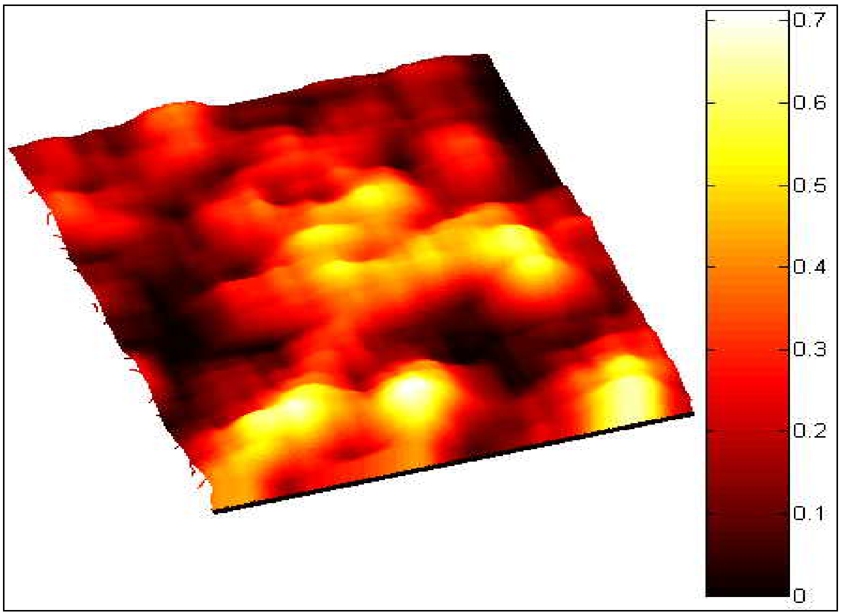


Figure 7. Another type de figure percent graphic of surface specimen.

A small summary showing how the routine is executed during the image analysis process can be observed by means of Figure 5 that emphasizes the execution sequence and the routine parts.

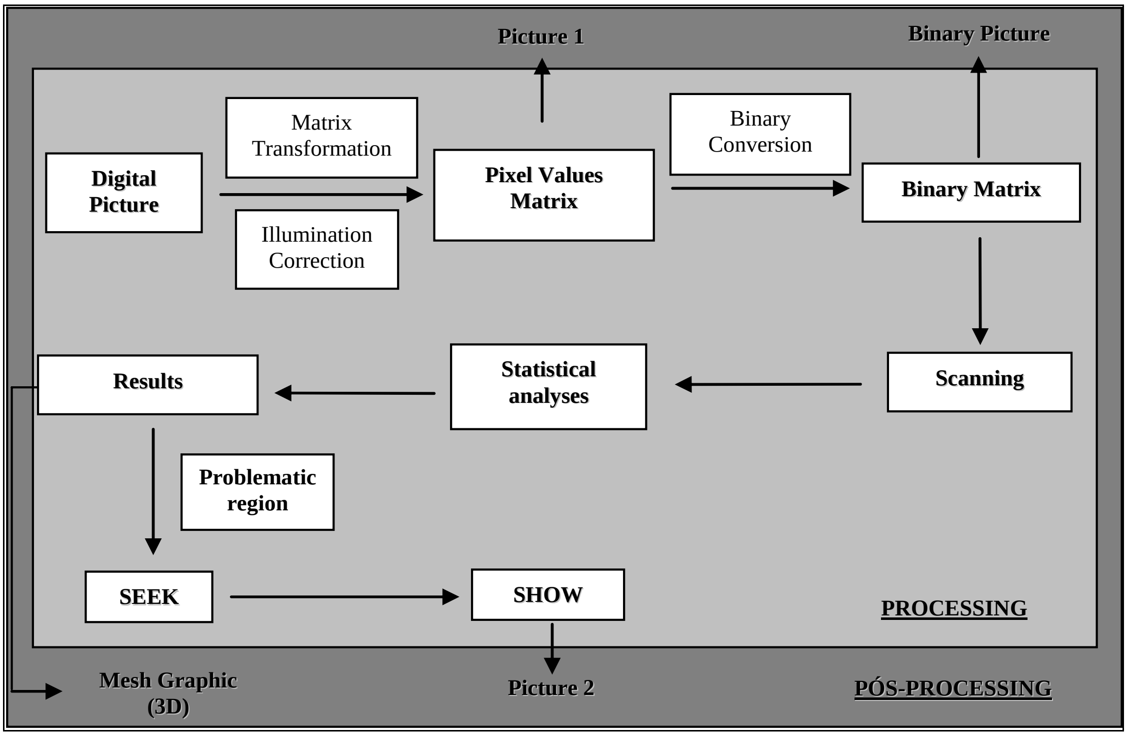


Figure 8. Flowchart of the developed software.

**3. Results**

As a practical observation and study of the developed software, Figure 9 brings an example of a problematic sample. Tungsten carbide in a Cu-Ni-Zn matrix was deposited on a steel plate as shown in Figure 9a (image of the deposit to be analyzed). The binary image from the original one is shown in Figure 9b. The scan matrix is then used on the binary image and after statistical analyses the percentage matrix is plotted in Figure 9c. After this percentage matrix is plotted the software runs the 'SEEK' routine and the lowest percentage of carbide region is found. The coordinate of this region is obtained and is presented by 'SHOW' routine, which graphically presents the problematic region in Figure 9d.

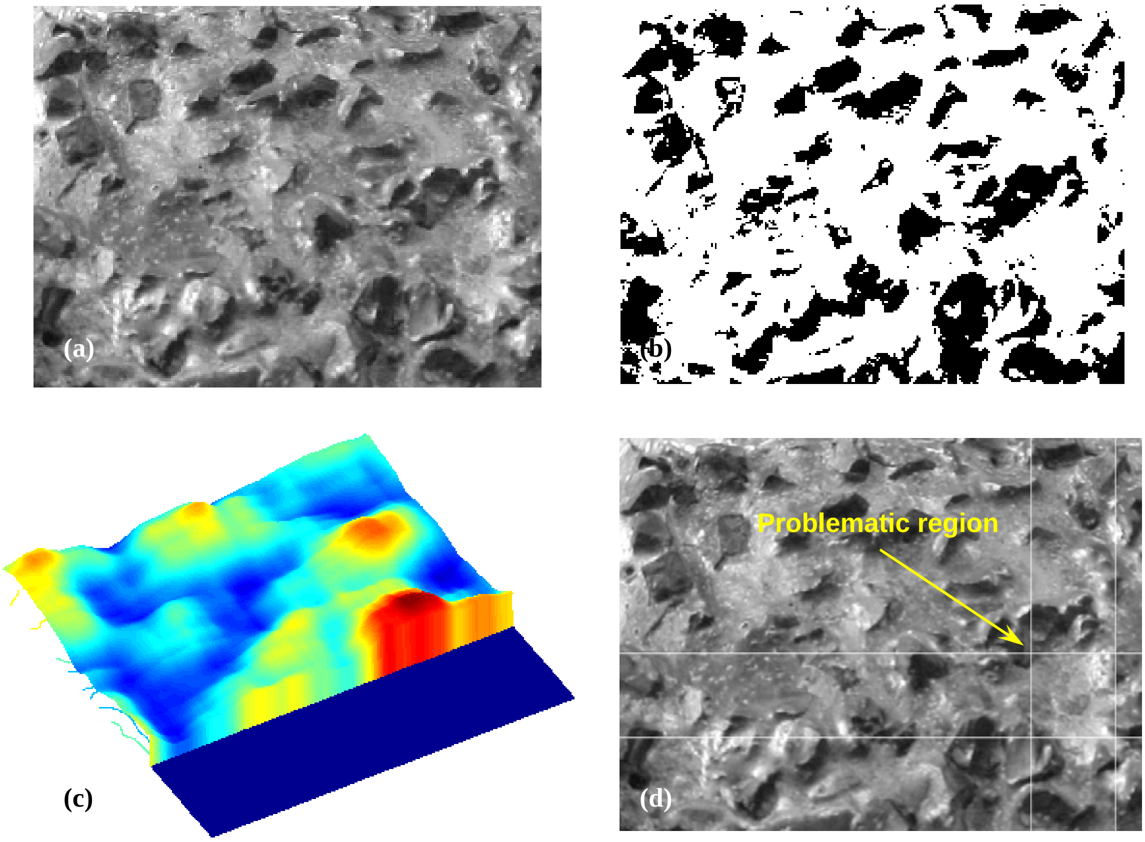


Figure 9. Example of locating a problematic region with the lack of tungsten carbide: (a) original image; (b) binary image; (c) pergentage matrix and (d) problematic region.

## 3. Conclusion

It is possible to conclude that the developed process of digital image analysis for composites materials comes as a handle application in order to characterize these materials. In this type of qualification the results are quickly and trustworthy obtained, what underlines the importance the developed software for easy and safe operation.

## 4. Acknowledges

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