USE OF STATISTICAL APPROACH FOR DEFECTOSCOPY OF VISUALIZED TRANSPARENT POLYMERIC FOILS

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The contribution treats the topic of acquiring information on the properties of optically transparent materials by the Schlieren optical visualization method applied under laboratory conditions, and on processing the experimentally gained information. Experimental results obtained on different types of polymeric foil serve as an evidence of applicability of this method in the defectoscopy of transparent polymeric foils using statistical characteristics.

1. Introduction

Optical visualization methods use changes in the absorption of photons during their transmission through mechanically loaded regions of transparent polymeric foils [1],[2]. Schlieren system serves to measure the amount of light deflection generated by a transparent optical phase object. Optical disturbance in the test object will produce variations of the recorded light intensity which are a measure of the deflection experienced by the light in the test object. Obtained results can be processed using methods of image processing [4].

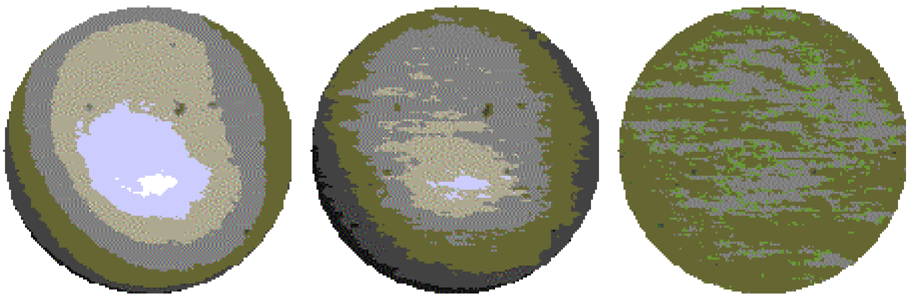
2. Image properties

It is necessary to correct influence of light source inhomogeneity , influence of the optical string and of the sensing device for evaluation of images gained by the optical visualization of polymeric foils. One of the possibilities is to use reference image picked up without presence of tested object to be studied. The reference image can be taken as an image of errors of the whole optical system on the assumption that we have used a virtual light source. Then the corrected image of the tested foil can be obtained by the formula

$$g(i,j) = \frac{c}{f_C(i,j)}.f(i,j), \qquad (1)$$

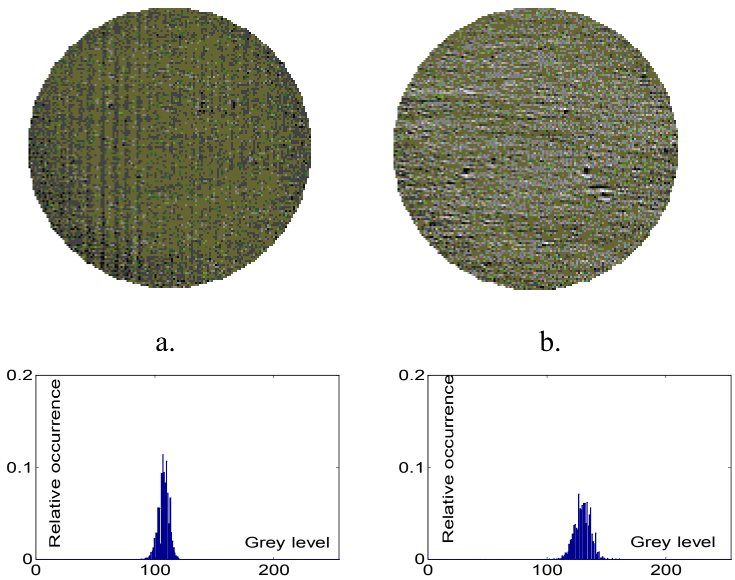
where f(i,j) are values of brightness of tested foil (fig.1.b), $f_c(i,j)$ are values of reference image brightness in the same point (fig. 1.a), c is a suitable chosen constant and g(i,j) is the grey level of resulting image (fig.1.c).

In an ideal image of visualized foils the changes of brightness reflect changes of refractive index of transparent foil. The refractive index depends on the density of material through which light beams traverse. In figure 2. the sharpened corrected images of two different foils (a. AG36 and b. AC700) are displayed. From images it is seen, that different foils have different characteristic features, that are well observed, images of different foils can be distinguished and on the contrary images of different samples show some similarity. Features show some regularity of stochastic character. One of the possibility how to describe character of foils images is to use the statistical characteristics. In figures 2.c and 2.d are histograms of relative occurrences of grey levels.



a. b. c.

Fig.1. Examples of images : a/ image without tested foil, b/ with tested foil , c/ image of the same foil after correction



c. d.

Fig.2 Modified images of foils AG36 and AC700 and their histograms

It can be seen, that there are differences among histograms in regard to the position and the shape. The attributes of histograms can be numerically characterized using moments of distribution as the mean value of grey level is

$$m = \sum_{i=1}^{L} x_1 p(x_i) \qquad (2)$$

a centred moments of the distribution of the k-th order

$$\mu_k(x) = \sum_{i=1}^{L} (x_i - m)^k . p(x_i) , \qquad (3)$$

and normalized moments of the distribution of the k-th order

$$\mu_{kN}(x) = \frac{\mu_k(x)}{[\mu_2(x)]^{\frac{k}{2}}} \qquad (4)$$

for k> 2, where x_i is the value of i-th grey level, $p(x_i)$ is the relative occurrence of this grey level, which can be taken as the probability of occurrence of grey level, and L is the number of grey levels in the image. There are some other statistical characteristics describing images [5] or methods based on the grey level co-occurrence matrix [3].

3. Defectoscopy

The main problem of defectoscopy is to detect, or to localize areas in the tested object , in our case in the polymeric foils or in the images of foils, which correspond to disturbances or inhomogeneities that are present in the tested material. Images of the foils without defects are characterized by the regularity of stochastic character of the structure. In the case of images with defects the damaged areas will be characterized by the different structure. One of the possibilities of detection of defects is the visual comparison of images of foils with and without defect to which papers [1] and [3] paid attention. In order to increase effectiveness of comparison it is possible to use other tools of image processing as are sharpening or equalization of histogram.

These structures can be described by the numerical characteristics calculated from the histogram of grey level occurrence . From the tested characteristics the best results have been achieved using the even order centred moments of distribution . To verify the possibilities of inhomogeneities we detected foils images of 16 foil samples from which 6 had defects Statistical characteristics calculated for the whole foil image and for their four parts created by division of foil image into four parts have been compared. .For illustration there is the graph in fig. 3 that demonstrates values of the normalized moment of 6^{th} order for all tested foils and for their parts. It can be seen, that spread of the values of calculated moment for individual images and for their parts depends on the homogeneity of foils images. Maximum spread of values has been observed for foil KX30D (in fig. 4 parts of foil image are ordered according to the growing values of normalized moment (4). In fig. 5 are parts of foil KX40D. ordered in the same way as in fig.4.

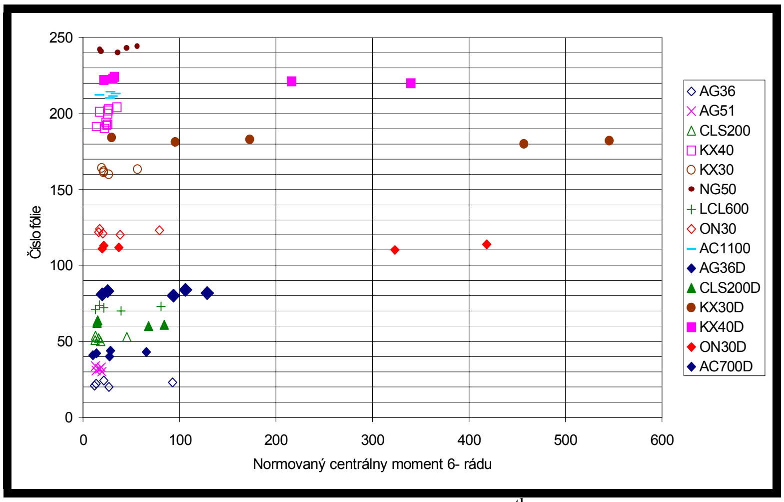


Fig. 3 Clustering of foils patterns in dependence on the 6^{th} order normalized centered moment

The experiments showed that detection of anomalous parts of foil part using normalized centered moments of even order is suitable for larger defects(comparable with dimension of image). For smaller anomalies it is suitable to use centered moments according to the formula (3).

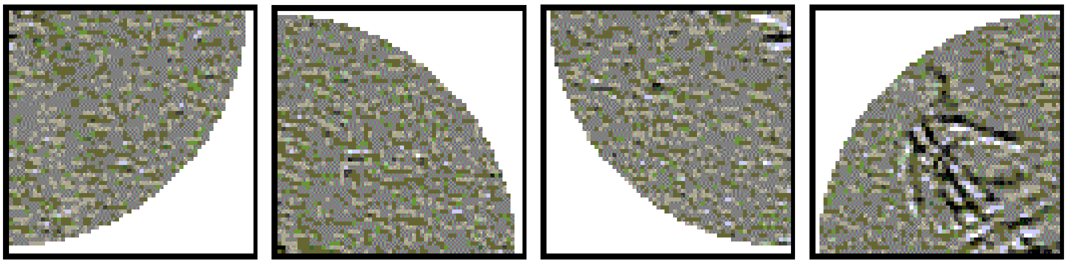


Fig.4 Images of parts of foil KX30D ordered according to the growing value of centered moment of 6th order

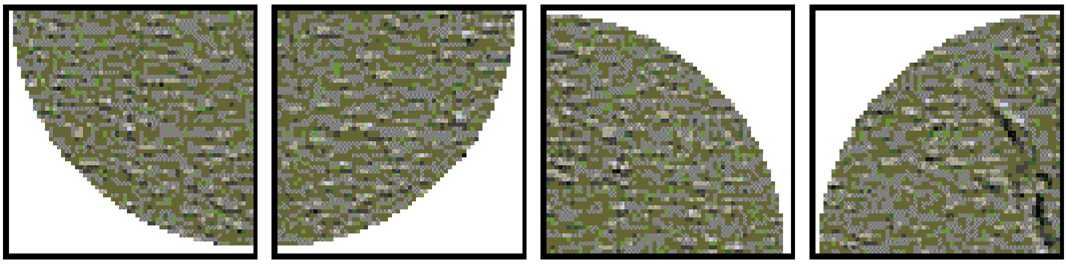


Fig. 5 Images of parts of foil KX40D ordered according to the growing values of centered moment of 6th order

From fig. 3 one can see, that for detection of more extensive defects it is possible to compare statistical characteristics calculated from the whole image.obrazku 4. What is especially marked while comparing values for foils KX30,KX40 a ON30 (e.g. foils without defects) with the images of corresponding foils with defects (KX30D,KX40D a ON30D). The values of observing statistics for the whole foils are for KX40D maximum , next are foils KX30D and ON30D In all mentioned cases their values considerably distinguish from values calculated for the foils without defects or for their parts.

4. Conclusion

Presented results show that it is possible to use Schlieren visualization method for the polymeric foils defectoscopy. One of the possibilities is use of statistical characteristics calculated from the pre-processed image. Schlieren metods completed by other characteristics calculated form the preprocessed foils images has found its application in the field of identification or classification of polymeric foils as well [5].

References

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