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OPTIMIZATION OF CUTTING WEDGE GEOMETRY FOR A PLASTIC DISINTEGRATOR TOOL

CERNECKY, J[ozef] & BRODNIANSKA, Z[uzana]

Abstract: *The paper focuses on analysis of stress and deformation states during plastic dividing by a cutting wedge of a disintegrator. The acquired knowledge can be used to optimalize the geometry of cutting wedges for disintegration of plastic waste. To visualize and observe stress and deformation states in the area of a crack root during the entering of the cutting wedge, we used the method of holographic interferometry.*
Key words: *deformation, wedge, plastic, interferometry, crack.*

1. INTRODUCTION

In the paper we focus on the visualization of stress and deformation states during plastic dividing by a cutting wedge of a disintegrator tool by the method of holographic interferometry. Our aim is to achieve the distribution of stress in the area of disintegration of plastic. We are interested in the optimal geometry of a cutting wedge from the viewpoint of spending the least energy to disintegrate. One of the indicators is also stress and deformation states during entering of the cutting edge into plastic. The findings achieved from the interferometric measurements can serve to optimize geometry of a cutting wedge for a plastic disintegrator.

2. EXPERIMENT

To carry out an experimental research we used an experimental device illustrated in Fig.1. An important part of the equipment was a tool of disintegrator (4), whose cutting wedge entered the sample of plastic material (3). The force acting in the place of material dividing by a cutting wedge was derived via weights (2) fixed to an arm (1). The device allows variable setting of the strength of the acting force (Černecký & Pivarčiová, 2007).

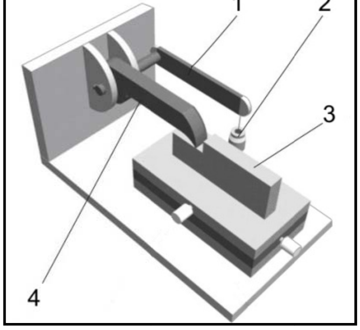


Fig. 1 Scheme of the experimental device
1 – arm, 2 – weights, 3 – sample plastic, 4 – tool of disintegrator

Deformations which occurred as an effect of entering the cutting wedge into the plastic (rubber sealing board of the NR/SBR type) in the initial stage corresponded to the case of one axis loaded by a pressure force (Guinea et. al., 2004).

To find out the stress and deformation states we used the method of holographic interferometry, which enables to visualize micro shifts in interaction of a tool's cutting wedge with the plastic (Jones & Wykes, 1989).

Formation of interference fringes which can be interpreted in a qualitative and quantitative way will be shown by the micro shifts. However, the qualitative analysis itself can provide us with understanding of stress and deformation states which appear during opening of a micro-crack (Sirohi, 1993).

The used method will picture not only spreading of the crack in the plastic, but also directions and amounts in loading of the tool. We used a singular solution in the following form during experimental determination of coefficients of stress intensity K_I:

$$\sigma_{xx} = \frac{K_I}{\sqrt{2\cdot\pi\cdot r}}\left(1-\sin\frac{\theta}{2}\sin\frac{3\cdot\theta}{2}\right)\cos\frac{\theta}{2} \qquad (1)$$

$$\sigma_{yy} = \frac{K_I}{\sqrt{2\cdot\pi\cdot r}}\left(1+\sin\frac{\theta}{2}\sin\frac{3\cdot\theta}{2}\right)\cos\frac{\theta}{2} \qquad (2)$$

$$\sigma_{xy} = \frac{K_I}{\sqrt{2\cdot\pi\cdot r}}\sin\frac{\theta}{2}\cos\frac{\theta}{2}\cos\frac{3\cdot\theta}{2} \qquad (3)$$

The coefficient of the tension intensity was determined from the equation:

$$K_I = \sigma\sqrt{a\cdot\pi} \qquad (4)$$

where r is distance of the isopach from the crack, a is dimension of the crack, θ is angle of the isopach depending on r, σ is total stress (loading), σ_{xx}, σ_{yy}, σ_{xy} are main stresses in the direction of the axis x, y, xy.

Considering that singular solutions take into account only the first member of a row their validity is limited to only very surrounding of the crack root (Balaš & Szabó, 1994).

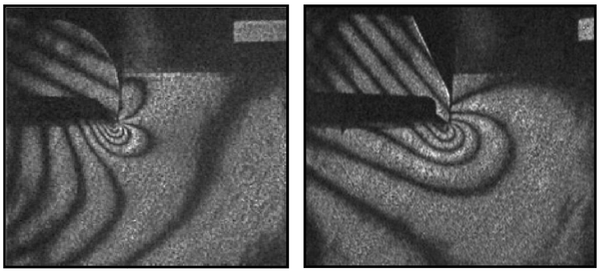
3. RESULTS AND DISCUSSION

In our paper we focused on the comparison and assessment of two geometries of a cutting wedge (CW) of a disintegrator. Cutting wedges A and B were loaded by the same weight of 50 g on an arm of 130 mm. Based on stress and deformation states in the material we searched for an optimal geometry of a cutting wedge of a disintegrator tool during dividing of plastic.

In the paper we focused only on initial state of entering of the cutting edge into plastic. To find out this we used the method of holographic interferometry which enables to visualize shifts in the material even for very small loadings.

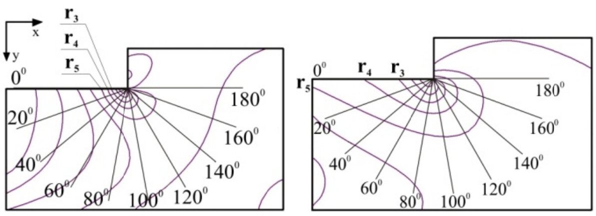
Fig. 2 shows interferograms of cutting wedges A, B obtained by the double-exposure method, while the first one was formed by superposition of the object wave and the reference wave before deformation of the object and the second exposure after the deformation of the object.

This method gave us a double-exposure holographic interferogram which presents the state of object at the moment of the second exposure. It is possible to observe changes in the number of interference fringes (isopaches) with the changes of loading. With a bigger change of loading we can observe higher density of fringes. To analyze stress and deformation states CW A we chose isopaches with the initial distance (at 0˚) r_3 = 3,1 mm, r_4 = 4,1 mm and r_5 = 5,5 mm (Fig. 3a).



a) b)

Fig. 2 Picture of a holographic interferogram of a) cutting wedge A, b) cutting wedge B



a) b)

Fig. 3 Character of the isopach field surrounding the crack root of a) cutting wedge of A, b) cutting wedge of B

Cutting wedge B has a different geometry than a cutting wedge A which is manifested in the shape and density of interference fringes and so that enabled us to determine which geometry of a cutting tool is better.

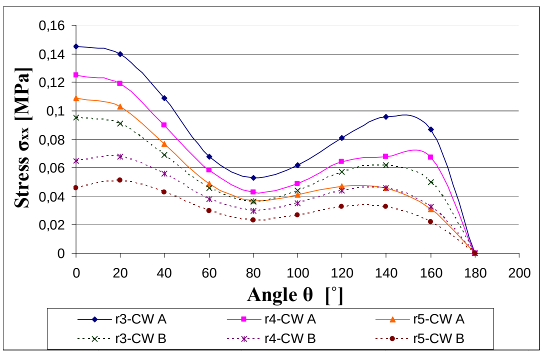


Fig. 4 Graphic development of stress σ_{xx} with a singular solution for the distance r_3, r_4, r_5 from the crack

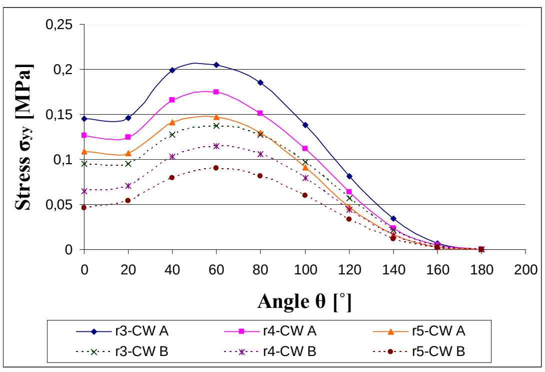


Fig. 5 Graphic development of stress σ_{yy} with a singular solution for the distance r_3, r_4, r_5 from the crack

To analyze stress and deformation states of CW B we chose isopaches with the initial distance (at 0˚) r_3 = 6,7 mm, r_4 = 14,3 mm, r_5 = 28,16 mm (Fig. 3b). The value of stress σ_{xx}, σ_{yy} for the distances r_3, r_4, r_5 was calculated according to the equations (1), (2). Similarly, we can calculate the value of stress σ_{xy} according to the relation (3). To be able to find out the values of stress it was necessary to calculate the coefficients of the tension intensity K_I according to the relation (4).

Graphic development of stress σ_{xx} for CW A and CW B is pictured in Fig. 4 and graphic development of stress σ_{yy} for CW A and CW B is obvious from Fig. 5.

The findings suggest that the stress σ_{xx} and σ_{yy} is for CW B lower than for CW A, so it can be established that geometry of CW A is better.

4. CONCLUSION

In our paper we used the method of holographic interferometry (microscopic method) to determine stress and deformation states. Based on the stress and deformation states in plastic we compared the optimal geometry of a cutting wedge during dividing of plastic.

We obtained the distribution of stresses in the zone of dividing from interferometric measurements. The stress field in the area of interaction of cutting wedge and plastic consisted of the stress field of the plastic and the stress field of the tool, which is proved by the shapes of interference fringes on both bodies.

The stress values were determined by singular solutions. The cutting wedge A had higher values of stresses σ_{xx}, σ_{yy} at the same loading than the cutting wedge B in the area of crack root, which is evident from the Fig. 4, 5. It was possible to observe changes in the number of interference fringes with the changes of loading. The higher loading was, the higher density of fringes was produced.

We also focused on a qualitative analysis of interferogram pictures based on which we can observe spreading of the crack in plastic as well as directions and values of loadings in the tool. The used double-exposure method enables us gradually record changes which are constantly increasing in one direction so that the following referential states are gradually recorded as the states of former changes.

5. ACKNOWLEDGEMENTS

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