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Determining the diamond lapping films' ability to micro-finishing

Określanie zdolności diamentowych folii ściernych do mikrowygładzania

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In order to determine the micro-finishing abilities of diamond abrasive films, surface topography was analyzed using confocal microscopy OLS 4000 Olympus. In the analysis of stereometric features of the abrasive surface, it was considered that during the micro-finishing process the abrasive surface is pressed against the workpiece. The procedure for determining the changes in topography of the film surface in the treatment area was developed as a result of elastic deformations of the film carrier, the grain binding binder and the pressure roller. New parameters for the activity of abrasive grains were developed and the values of grain hollows, depending on the pressure value in the machining zone and the nominal size of the grain (3, 9, 15, 30 μm) were determined.

KEYWORDS: diamond abrasive film, micro-smoothing, precision machining, finishing ability

Precision machining is carried out using the highest quality abrasive tools [11]. In abrasive foils for smoothing, abrasive grains are fixed on a flexible carrier in the resin bond layer [4]. In the machining zone, when the film is elastically pressed against the surface of the object by means of a roller, abrasive grains penetrate into the material being processed [6] and move relative to each other - mainly in the normal direction to the surface [1, 7]. The position of the abrasive grains vertices in the machining zone differs significantly from their position in the unloaded state [8]. The standard deviation of the peak heights of the grains in the machining zone is smaller than those determined in measurements of the film topography [9]. The article presents the results of the investigation of the contact zones of the grain peaks with the processed material, taking into account the deformations of the film in the machining zone. Diamond abrasive foils with grain sizes: 3, 9, 15 and 30 μm were tested. Data regarding the number of contact fields, the average contact area of the wells in the workpiece and the average distance between the contact areas allow to determine the ability of the film to be smooth [5]. It is also possible to determine the active total active surface of the

film [3], taking into account the aforementioned data and the distribution of pressures in the machining zone and the relationship between the speed of surface displacement of the object and film [2, 10].

Research on the ability to micro-smoothing abrasive foils

The Olympus OLS 4000 confocal microscope from Olympus was used to examine the topography of abrasive foils with nominal grain sizes of 3, 9, 15 and 30 μm . In order to map the machining conditions, i.e. the elastic pressure of the abrasive film to the workpiece, a pressure simulation was carried out in the Matlab computing environment. The elastic pressure of the abrasive film ensures optimal utilization of its processing potential.

The simulation results of the pressure of the tool with the pressure roller are shown in fig. 2. The characteristics of the contact zones for the depression of grains corresponding to 30% and 35% of the S_t parameter of the film surface were determined. Fig. 2 indicates the contact of the abrasive foil with the workpiece material: red - for the variant with no pressure, black - for the variant with elastic clamp. It is possible to observe a significant increase in the contact area due to the deformation of the elastic film (fig. 2) and to reduce the standard deviation of the abrasive grains tops in the machining zone (fig. 10).

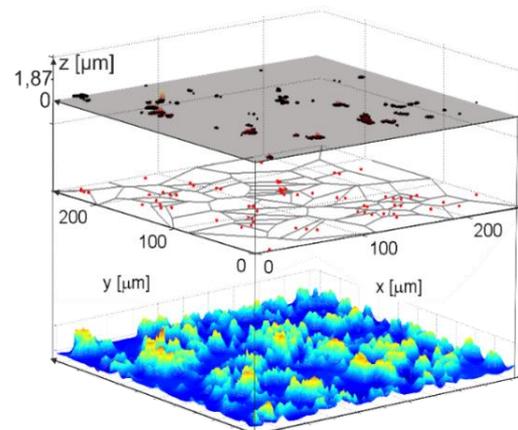


Fig. 1. Topography of an abrasive film with a nominal grain size of 3 μm . Decomposition of the surface for Woronoj cells, the center of which is the peak of grains, and the image of the surface of grain contact fields at a depth of 35% of the S_t parameter of the film

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Contact zones for the depression of grains
corresponding to 30% and 35% of the St parameter of the 9IDLf surface

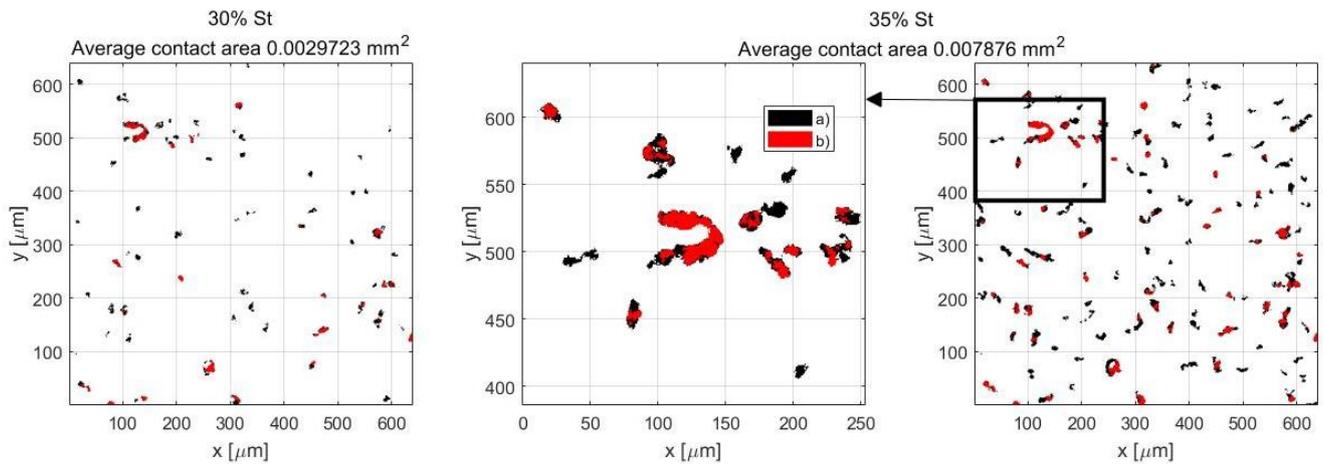


Fig. 2. Illustration of the impact of deformation of 9 IDLF film in the micro-smoothing zone: a) image of contact areas in the treatment zone, taking into account film deformation and displacement of abrasive grains, b) results of topographic film surface measurements

In order to quantify the abrasive film's capacity for smoothing, the following parameters were determined: number of contact fields (figs. 3-7), medium contact area (figs. 3-6 and 9), average distance between contacts of abrasive grains with workpiece (figs. 3-6 and 8) and the scatter depth of the recesses (figs. 3-6 and 10) as a function of the tip of the grain tips into the workpiece. The average distance between contacts was determined using Woronj cells (fig. 1). On the surface of the film (taking into account its deformations) the active tops were cut off - by means of the surface typical of the surface condition during smoothing, distant from the highest point by a certain fraction of the St parameter value of the film surface. The tests were carried out for hollows in the range of 0÷35%. Geometric measures of vertices were determined, which at the same time are central points of Woronj cells (fig. 1). Figs. 3-6 present the developed parameters, used further to assess the smoothing ability depending on the maximum penetration of the vertices into the workpiece for subsequent abrasive foils: 3 IDLF (fig. 3), 9 IDLF (fig. 4), IDLF (fig. 5) and IDLF 30 (fig. 6). In order to assess the diamond abrasive capacity of micro-smoothing abrasive foils, the w index was developed, which allows a comparative assessment of a film with a similar grain size. This indicator also allows comparing the predicted velocity reduction rate of inequality.

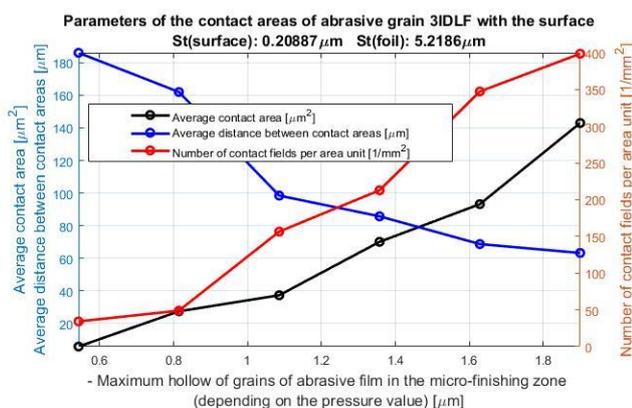


Fig. 3. Average contact area, the average distance between the contact areas and the number of contact areas of the abrasive film with a nominal grain size of 3 μm depending on the maximum depth of grain in the workpiece

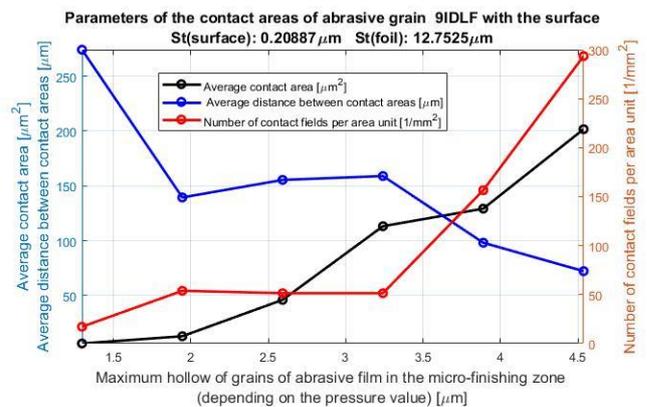


Fig. 4. Medium contact area, average distance between contact areas and number of contact areas of the abrasive film with a nominal grain size of 9 μm depending on the maximum depth of grain in the workpiece

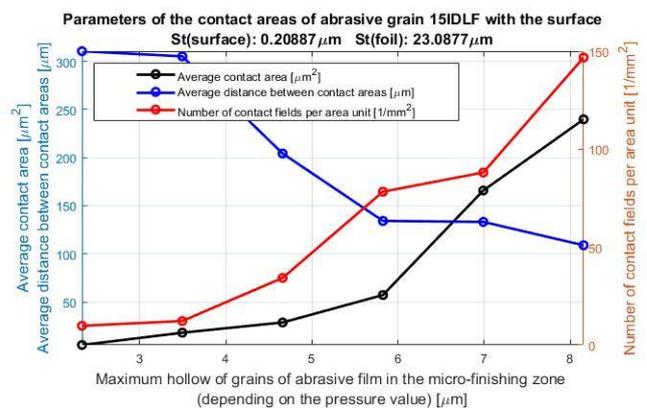


Fig. 5. Average contact area, average distance between contact areas and number of contact areas of the abrasive film with a nominal grain size of 15 μm depending on the maximum depth of grain in the workpiece

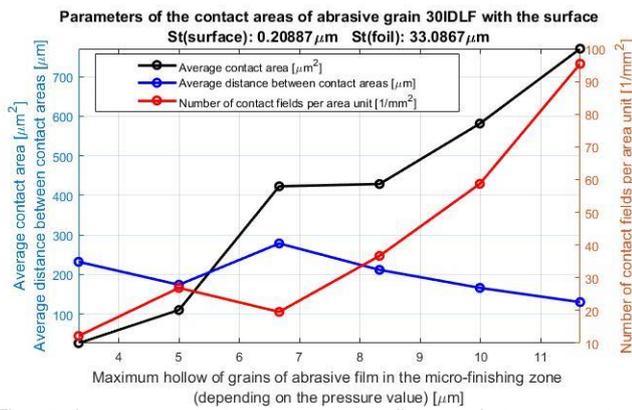


Fig. 6. Average contact area, average distance between contact areas and number of contact areas of the abrasive film with a nominal grain size of 30 μm depending on the maximum depth of grain in the workpiece

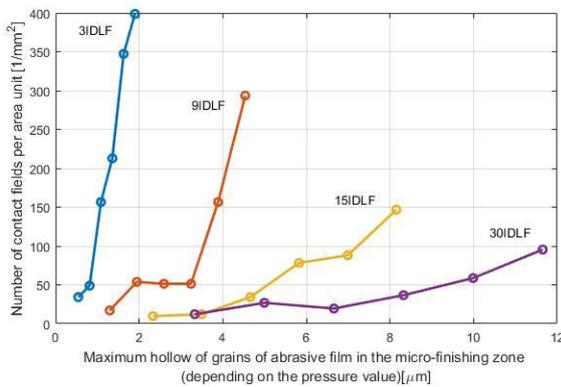


Fig. 7. Number of contact areas of diamond abrasive foils with the work material depending on the maximum depth of the grains

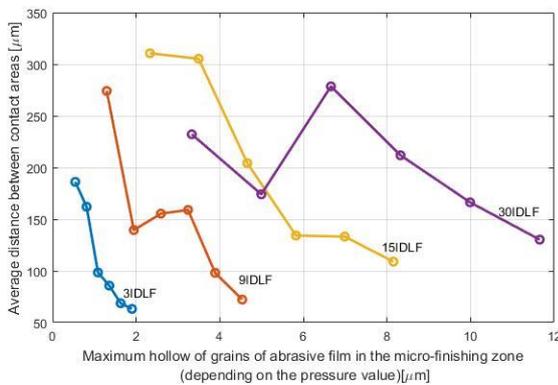


Fig. 8. Average distance between contact areas of diamond abrasive foils and workpiece depending on the maximum depth of grain

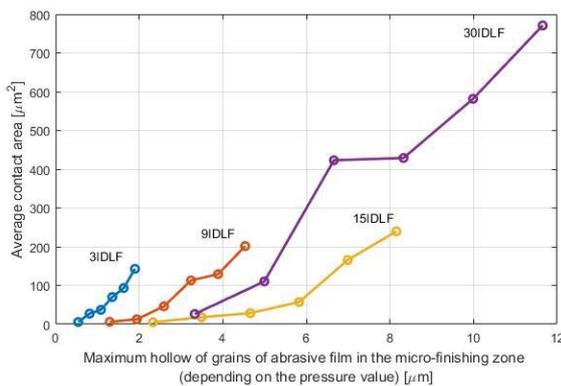


Fig. 9. Average contact area of diamond abrasive foils with the workpiece depending on the maximum depth of the grains

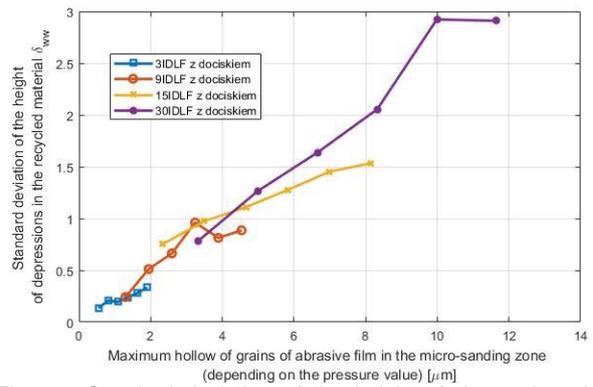


Fig. 10. Standard deviation of the height of depressions in the recycled material depending on the maximum depth of grains

TABLE. Values of w index for the tested diamond abrasive foils

Foil	3 IDLF	9 IDLF	15 IDLF	30 IDLF
W_w	14,68	0,85	0,26	0,17

The indicator developed is given by the formula:

$$W_w = \frac{L_k \cdot \sqrt{P_k}}{h_k \cdot \sigma_{h_k}}$$

where: L_k - normalized number of contacts, P_k - normalized mean contact area, h_k - normalized average depth of grains, σ_{h_k} - standardized standard deviation of height of active tops for maximum micro-smoothing depth of 20% St foil; normalization by specifying the degree of belonging to a value between $\langle 0,1 \rangle$.

Conclusions

- Number of contact fields in the function of the maximum depth (in the range 0÷35% St parameter of the foil) abrasive grains with a nominal grain size of 3 μm in the micro-smoothing zone grow linearly with simultaneous linear decrease in the distance between the contact areas.
- The number of contact fields in the function of the maximum depth, in the range of 14÷26% of the parameter St abrasive foil 9 IDLF, does not change, which means that a relatively small number of active grains is characterized by an equalized penetration into the workpiece.
- For abrasive foils with nominal grain sizes of 15 and 30 μm , the depth of micro-honing above 30% of the St foil value should be used, which is caused by a small increase in the number of contact fields below this value.
- For small grain hollows (small abrasive forces of the abrasive film to the surface of the object), the total contact surface area is greatest for 3 IDLF foil and the smallest for 15 IDLF foil (fig. 9), which means that the 15 IDLF foil can be skipped in design sequential micro-smoothing operations.

REFERENCES

1. Kacalak W., Tandecka K. „Analiza procesów mikrowygładzania stopów niklowo-chromowych z wykorzystaniem wyników badań topografii powierzchni i cech powstających mikrowiórow”. *Mechanik*. Nr 8–9/2016 (2016): pp. 1170÷1171,
2. Kacalak W., Tandecka K., Mathia T.G. „Ocena potencjału obróbkowego folii ściernych z wykorzystaniem sumarycznego aktywnego profilu wyznaczonego z uwzględnieniem kształtu strefy obróbki”. *Mechanik*. Nr 8–9/2015 (2015): pp. 173÷178,
3. Kacalak W., Tandecka K., Mathia T.G. „A method and new parameters for assessing the active Surface topography of diamond abrasive films”. *Journal of Machine Engineering*. Vol. 16, No. 04 (2016): pp. 95÷108,
4. Kacalak W., Tandecka K., Szafranec F. „Analiza form zużycia i trwałości folii ściernych”. *Mechanik*. Nr 10/2017 (2017): pp. 870÷872.

5. Kacalak W., Tandecka K., Szafranec F. „Analiza aktywności ziaren ściernych w procesie wygładzania foliami ściernymi”. *Mechanik*. Nr 10/2017 (2017): pp. 885+887,
6. Khellouki A., Rech J., Zahouani H. „The effect of lubrication conditions on belt finishing”. *International Journal of Machine Tools & Manufacture*. Vol. 50 (2010): pp. 917+921.
7. Mezghani S. El Mansori M.. „Abrasive properties assessment of coated abrasives for precision belt grinding”. *Surface & Coatings Technology*. Vol. 203, (2008): pp. 786+789
8. Mezghani S. El Mansori M., Zahouani H.. „New criterion of grain size choice for optimal surface texture and tolerance in belt finishing production”. *Wear*. Vol. 266, (2009): pp. 578+580
9. Serpin K., Mezghani S., El Mansori M.. „Wear study of structured coated belts in advanced abrasive belt finishing”. *Surface & Coatings Technology*. Vol. 284, (2015): pp. 365+376
10. Serpin K., Mezghani S., El Mansori M.. „Multiscale assessment of structured coated abrasive grits in belt finishing process”. *Wear*. Vol. 332–333, (2015): pp. 780+787
11. Spadło S., Młynarczyk P., Łakomiec K.. „Influence of the of electrical discharge alloying methodson the surface quality of carbon steel”. *Int J Adv Manuf Technol*. Vol. 89, Issue 5–8, (2017): pp 1529+1534,

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