Analysis of flat elements' edge rounding in single-disk lapping

Analiza zaokrąglenia krawędzi elementów płaskich w docieraniu jednotarczowym

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DOI: https://doi.org/10.17814/mechanik.2017.10.140

Findings of the state of the edge of flat elements machined in single-disk arrangement were presented. Explorations covered entry zone of micrograins in the process, rounding off the edge of machined elements, and wear of abradant.
KEYWORDS: single-disk lapping, flat surfaces, rounding the edge off, wear of abrasive micrograins

Physicochemical phenomena occurring in the machining zone during the lapping of machine parts and tools are very complex. They are influenced by properties of the machining system related to the shaped object, lapping plate, abrasive suspension and liquid carriers [3]. Intensity of the relationship between basic elements of the process depends also on the technological conditions, such as: kinematic parameters, object load and numerous external disturbances [4].

One of the essential phases of the process is the moment of the dispensed abrasive micro-grains entry to the lapping zone and thus between the surface of the workpiece and the working surface of the lapping plate. This is accompanied not only by rounding (dulling) the edges of the workpieces, but also by reducing the average size of the abrasive grains. We are dealing with the so-called critical width of machining [5]. This problem, with regard to the single-sided lapping of flat surfaces, was the main aim of the studies.

Experimental stand and conditions

Experimental studies [1] were performed on a single disc lapping machine Abralap 380 (fig. 1a), dosing the abrasive suspension by droplets (corundum or silica carbide with machine oil). Elements made of steel 45 (24 HRC) and ŁH15 (60 HRC) of a triangular (with a side 17 mm) and a circular outline (diameter ⌀17 mm), were lapped.

Micro-grains 95A F400/17 and 98C F400/17 were used as a preliminary run, and for finishing operations - 95A F800/7 and 99C F800/7. The speed of the initial lapping was 50 m/min, while that of finishing lapping - 20 m/min.

Values of the specific pressure was: p = 291÷313 kPa (preliminary lapping) and 85÷213 kPa (finishing lapping). The initial lapping time was in the range of 5÷8 minutes, and for finishing - 15 to 25 min. This enabled - depending on the used abrasive, lapping pressure and velocity - to remove the oversize of 0.09 mm in the initial and 0.03 mm in the final treatment.

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In surface roughness studies, Hommel Tester T500 contact profilometer was used, and M10 profile profilometer was used in the analysis of sample edge profiles. Depending on the steel to be processed, the surface roughness was Ra = 0.37÷0.49 µm and Rz = 2.75÷3.70 µm. Measurements of grain size before and after lapping (after thorough cleaning) were performed with a stereoscopic microscope equipped with a CCD camera and MultiScan software v 6.08 (fig. 1b) [2].

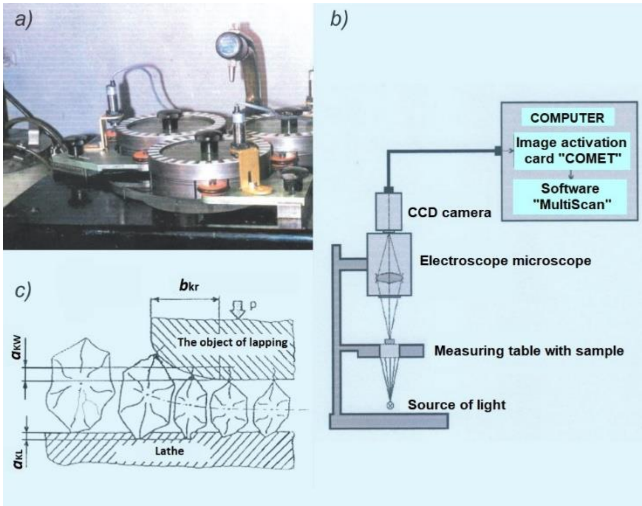

Fig. 1. Test benches: *a*) Abralap 380 lapping machine, *b*) diagram of abrasive micro-grains wear test stand, *c*) diagram of the zone of abrasive micro-grains entering during the flat surface lapping process (horizontal dimension b_{kr}, linear defect of lathe a_{KL} and object a_{KW})

Results

Sample results of the surface roughness after lapping are shown in fig. 2. Lower values of Ra parameter were obtained after pre-lapping with electro-corundum micro-grains, and in the case of finishing lapping - dosing the silicon carbide suspension.

Fig. 3 and fig. 4 show the histograms of the surface area of the micro-grains on the plane parallel to the microscope's measurement table prior to dosing and recovered from the machining zone after pre- and post-lapping.

It is noteworthy that the electro-corundum micro-grains are more crushed as compared to silicon carbide.

Lapping tests [1] also showed changes in the shape isometric coefficient and smaller granularity of the micro-grains belonging to the F800/7 dimensional group in relation to the F400/17 abrasive - both electro-corundum and silicon carbide.

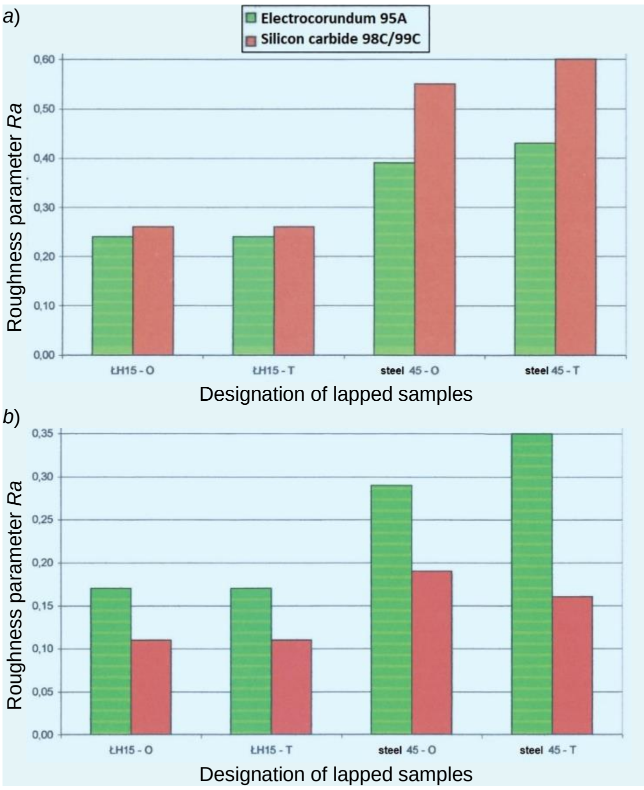

Fig. 2. Effect of used abrasive on the surface roughness after lapping: *a*) preliminary, *b*) finishing (samples with outline: *O* – circular, *T* – triangular)

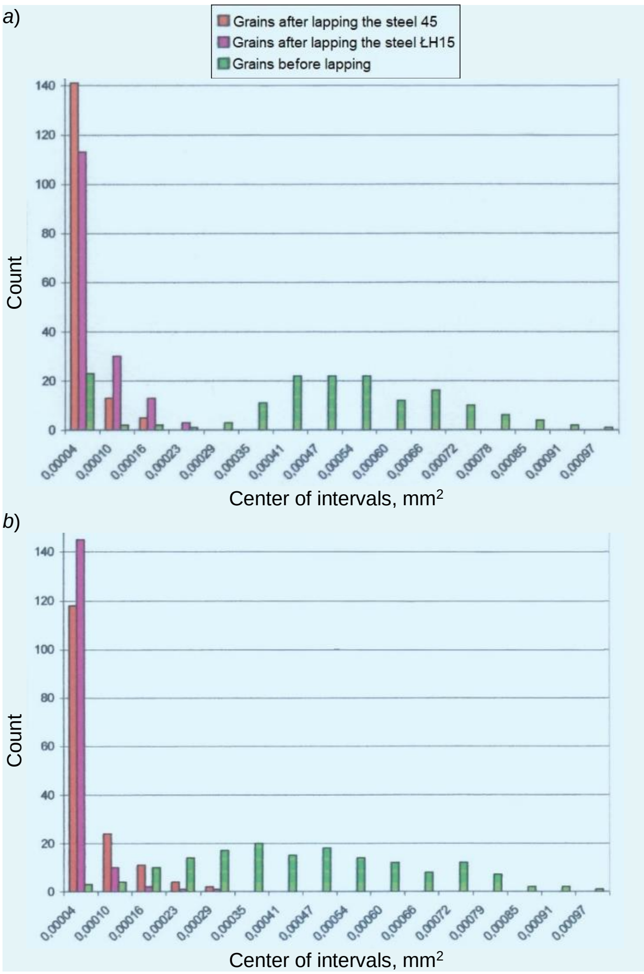

Fig. 3. Distribution of the surface area of the micro-grains projection on the plane parallel to the field of observation: *a*) pre-lapping with micro-grains 95A F400/17, *b*) pre-lapping with micro-grains 98C F400/17

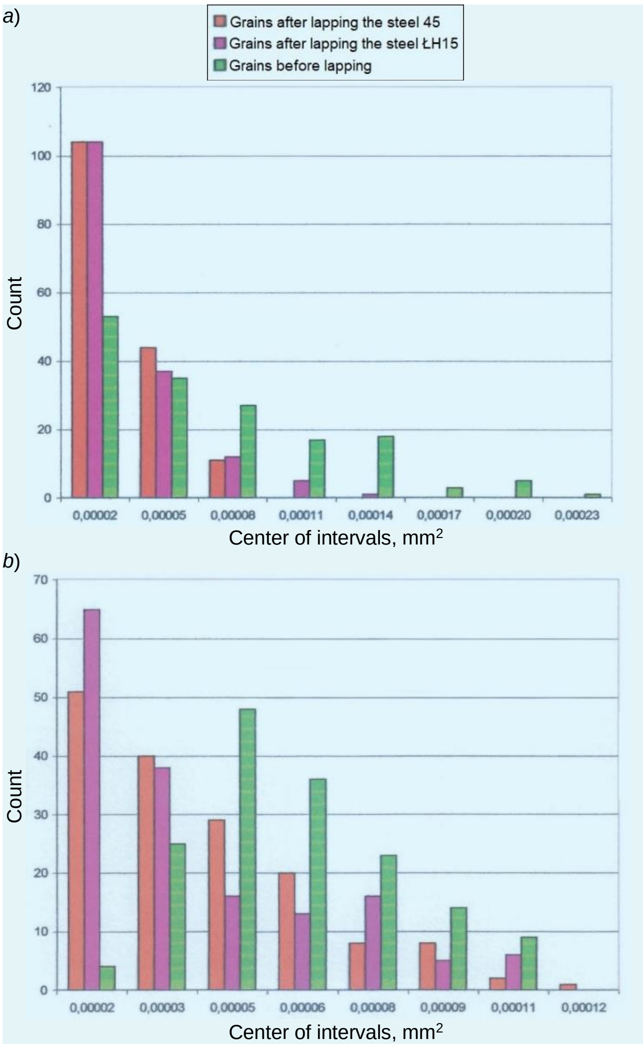

Fig. 4. Distribution of the surface area of the micro-grains projection on the plane parallel to the field of observation: *a*) finishing lapping with micro-grains 95A F800/17, *b*) finishing lapping with micro-grains 98C F800/17

As a result of preliminary and finishing lapping, the contour of the workpieces edges in the cross-section (rounding) was changed from the initial state after lapping, both round samples of steel 45 (fig. 5) and Ł15 (fig. 6). The difference between the individual places on the triangular sample is also noticeable (fig. 7).

Taking the equation describing the transverse edge profile as:

$$y = a^x \cdot b$$

where: $0 < a < 1$, $b > 0$ (here: $b = 40$) (where $a \to 1$, the rounding increases, while $a \to 0$, it increases the edge sharpness); values are presented in tables I and II.

TABLE I. Values of factor *a* for round samples

Abrasive used for lapping	Ground steel	*a*		
		After grinding	After preliminary lapping	After finishing lapping
95A or 98C	45	0,78	0,59	0,48
95A	ŁH15	0,59	0,49	0,38
98C	ŁH15	0,59	0,38	0,28

TABLE II. Factor coefficient *a* for triangular steel samples of Ł15 steel after lapping

Abrasive micro-grains	*a*	
	For the corner	For the opposite edge
98C F400/17	0,89	0,19
99C F800/17	0,88	0,18

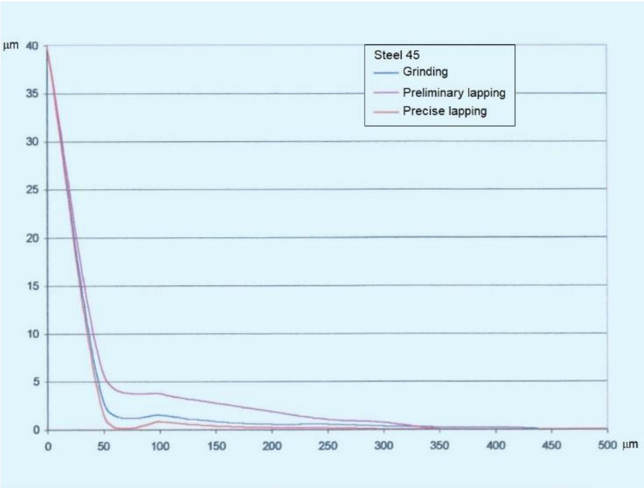

Fig. 5. Comparison of transverse profile changes (rounded edges) of round samples of steel 45 after grinding and lapping with silicon carbide micro-grains

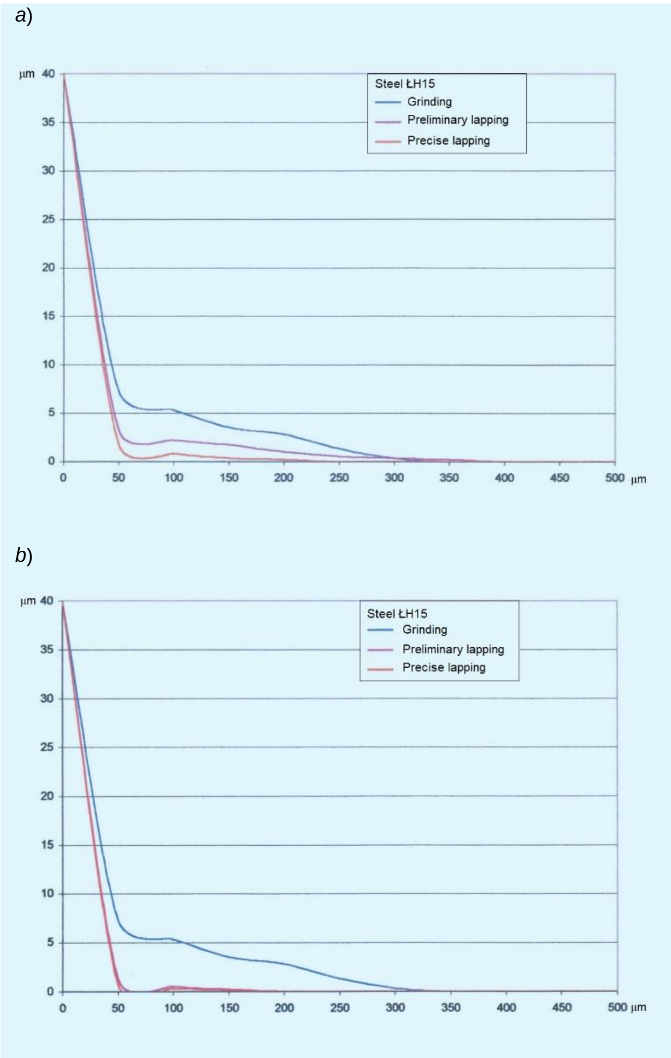

Fig. 6. Comparison of transverse profile changes (rounded edges) of round samples of steel ŁH15: a) after grinding and lapping with electro-corundum micro-grains, b) after grinding and lapping with silicon carbide micro-grains

Conclusions

Experiments have shown the impact of the basic lapping conditions on the edges of the elements, as well as the fragmentation of abrasive micro-grains.

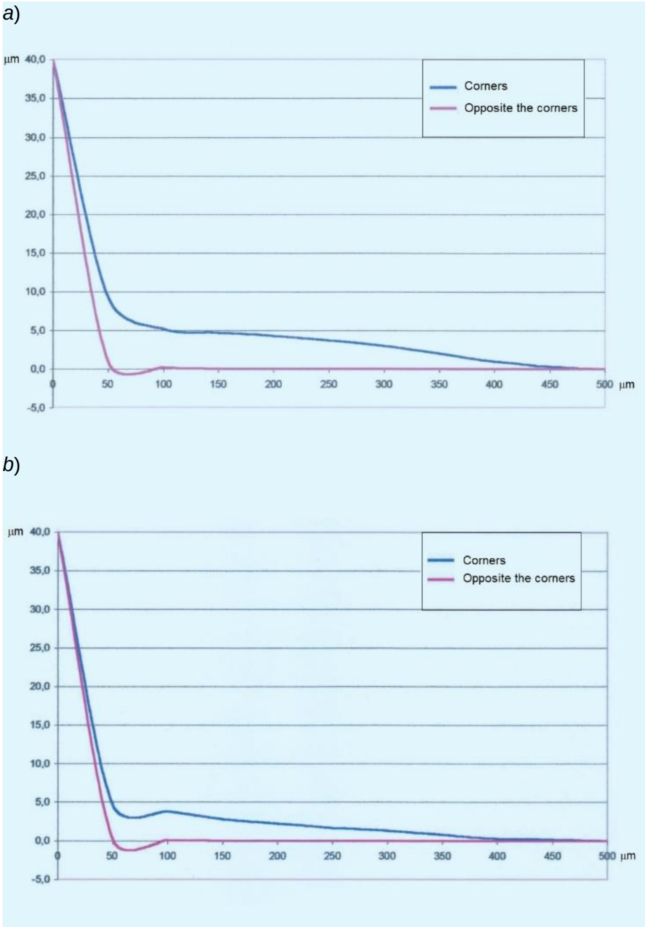

Fig. 7. Comparison of transverse profile changes (rounded edges) of triangular samples of steel LH15 lapped with silicon carbide micro-grains: a) F400/17, b) F800/7 (on the corner and opposite edge)

The intensity of these changes depends not only on the type of steel to be processed and on the hardness and type of the abrasive used and on the grain profile, but on the contours of the machined surfaces. Further studies should include an assessment of the effect of the suspension dosage intensity on the treatment zone in conjunction with the kinematic conditions of lapping and pressing applied to the elements. Interference of the workpiece separators, the grooving method and the flatness of the work surface can also be of particular importance - especially during very accurate lapping. It is clear that the requirements for the rounding of edges of the lapped parts result from their operational purpose.

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