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superfinishing, microfinishing film,
surface topography

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EFFECT OF SUPERFINISHING METHODS KINEMATIC FEATURES ON THE MACHINED SURFACE

The carried out research of the processes for the treatment of superfinishing with the application of microfinishing films of IMFF type with heaping the grain from the alundum with the nominal size of 15 micrometers for the different cinematic system proved that the topography of surface after smoothening depends on the cinematic features of process. It is demonstrated that the machining with oscillation can be substituted and the similar effects can be obtained as a result of the deviation from the parallelism of the directions of object feed and foil feed. This means the possibility to apply the super finisher attachments with a simpler building.

1. INTRODUCTION

Superfinishing with the use of abrasive foils is different from other methods of machining. This is finishing machining which is realized through the feed of a microfinishing film which is slow in relation to the movement of the object, optionally through imparting on it an oscillatory movement and pressing it with a pressure roll to the surface being machined [1]. The characteristic feature of the process of superfinishing with microfinishing films is a single use of the tool, the result being the need of the maximization of the machining potential of the tool [2]. The one-time use of the active surface of the tool, i.e. active abrasive grains over a certain time only, which is dependent of the foil feed rate, means that once the grains have left the contact area of the tool with the object machined are no longer used. Another characteristic feature of the process is the fact that active abrasive grains form very long machining marks, which result from very high value of the relation of the object's speed to the tape feed rate [3],[4],[6].

2. TEST STAND

GW-1 super finisher attachment (Fig. 2) was used in the investigations of the machining process. The super finisher attachment of GW-1 type is adapted

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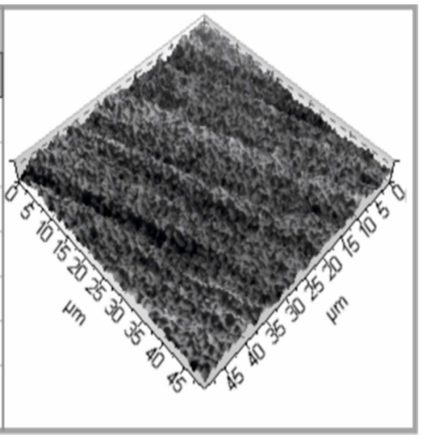
to be mounted on an engine lathe in the cutter holder seat. This allows an interchangeable use of tools with the width of 1/2”,1” or 2”. The tool feed rate is v_f =0…90 (max. 500) mm/min, the oscillation frequency is f=0…500 1/min and the oscillation amplitude is A=2,5mm. The range of the roll’s pressure forces is F_n=10…90 (max. 200) N, and it was realized with a pneumatic actuator supplied from a system with the pressure of 0,6MPa. The input voltage was 230V, the installed power was 400W, the overall dimensions were 575x250x300mm and the mass was ca. 25kg .

A plate from a solid disk made from aluminum alloy and covered with an anti-ferromagnetic coat (AFC) constituted the object machined [7]. This coat consists of two cobalt layers divided by a three-atomic ruthenium coat. A sample this type was made selected due to its very smooth surface (Fig. 1a). The tests were carried out for IMFF type microfinishing film with the nominal size of the alundum grain of 30 micrometers (Fig. 1b, Fig. 3). The measurements of the surface topography of the plate were carried out with the use of the CCI 6000 measuring system manufactured by Taylor Hobson company, and the TalyMap Platinum 4.0 application was used for analyzes. It was demonstrated that the maximum height of the peak S_p of the examined surface of the sample was 2,07 nanometer, while the maximum height of the hollow S_v of the surface was 2,12 nanometer [5].

The investigations were carried out with the use of a pressure roll with the hardness of 50 Sh. The pressure force of the roll to the object machined was 50N, the microfinishing film feed rate was 160mm/min, the speed of the object’s feed motion in the machining area was 105m/min, the oscillation frequency was 80Hz and the machining time was 20s. The investigations were conducted for four technological versions (Fig. 4), **I** – the directions of the feed motion of the object and of the tool feed are parallel, and the microfinishing film does not perform any oscillatory movement, **II** – the directions of the feed motion of the object and of the foil feed are parallel with the use of oscillation, **III** – the directions of the feed motion of the object and of the tool feed are not parallel with no oscillation used, **IV** – the directions of the feed motion of the object and of the tool feed are not parallel, with the use of oscillation.

a)

ISO 25178		
Height parameters		
Sq	0.552	nm
Ssk	-0.0747	
Sku	2.96	
Sp	2.07	nm
Sv	2.12	nm
Sz	4.20	nm
Sa	0.441	nm



b)

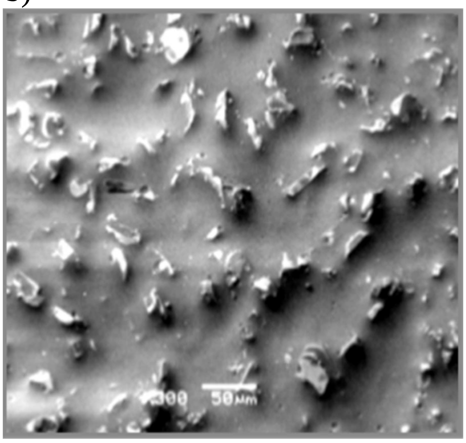


Fig. 1. Surface of the sample for the investigations of the contacts of grains (a), SEM image of the surface of IMFF film with the grain nominal size 30µm (b)

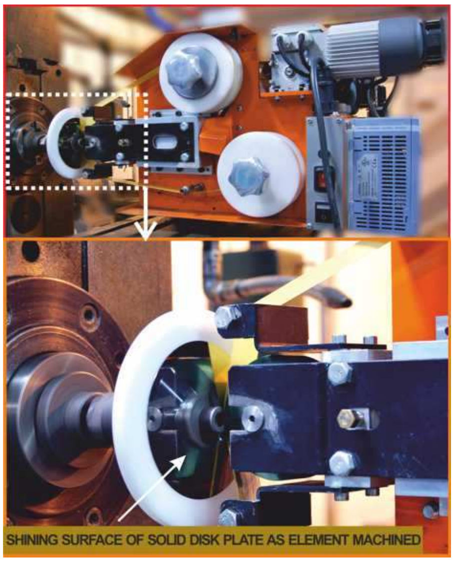


Fig. 2. Test stand of superfinishing processes

a) b)

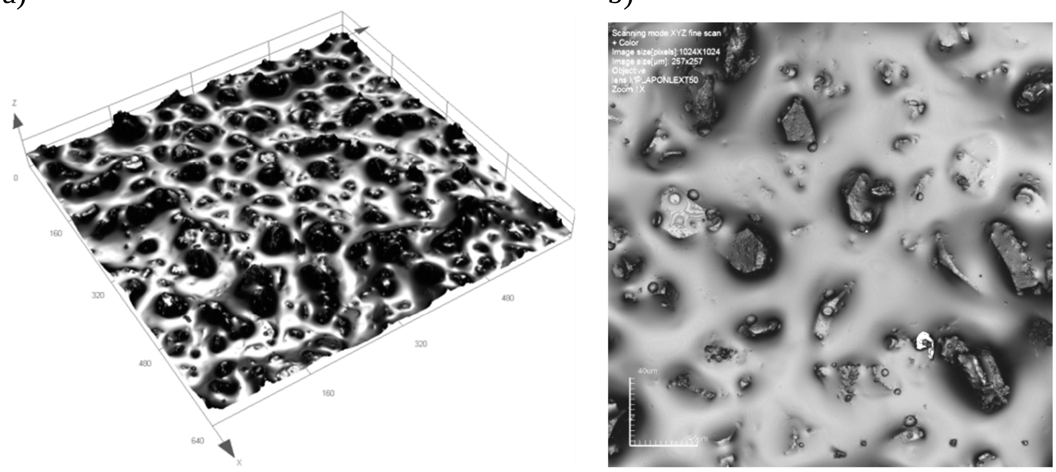


Fig. 3. Image of the surface of IMFF 30 film obtained from OLS4000 Olympus confocal microscope with the lens used: 20x (a), 50x (b)

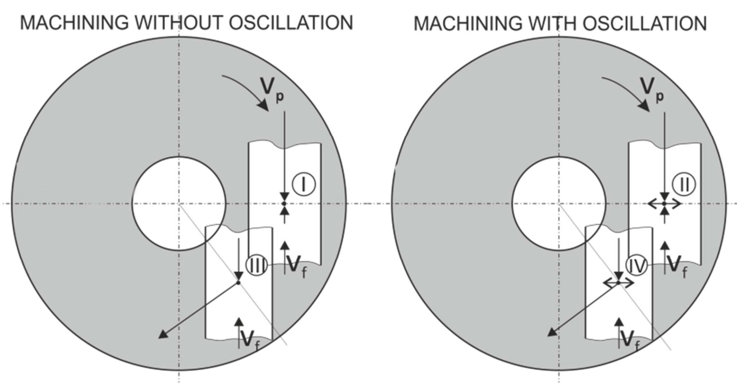


Fig. 4. Diagram to illustrate the features of the machining methods compared

3. ANALYSIS OF THE FEATURES OF SURFACES MACHINED

A special methodology of an analysis of the stereometric properties of surfaces was developed in order to assess the topography features of the surface after machining with the use of the abovementioned technological versions. Analyzes were carried out of the features of elevations over the surface being parallel to the nominal surface and located at different levels *h* from 20 to 60% of the value of the *St* parameter from the highest vertex of the surface (Fig. 5). Figs. 9,10,11 and Fig. 12 present the images of the fragments of the surface machined over the cut-off plane. The number of islands was determined (Fig. 6), i.e. elevations over surface O_{xy} and the relation of the increment of the number of islands to the increment of the distances between the successive levels examined of the location of the cut-off plane (Fig. 7).

The most favourable arrangement of the topography of elevations is to be considered as one where the number of islands at a certain level is the greatest and which is distinguished with the largest increment of the number of islands near the maximum. A significant dissipation of the distribution of the number of islands at different levels *h* also means a significant dissipation of the elevations of the surface vertices, which should be considered to be unfavourable. According to this criterion, the best method of machining method **IV**, i.e. when the directions of the tool feed and the feed motion of the object are not parallel, with the application of oscillation; then, comparable results were obtained for methods **II** and **III**, i.e. when the directions of the tool feed and the feed motion of the object respectively are parallel, with the application of oscillation, and when directions of the foil feed and the feed motion of the object are not parallel, with no oscillation applied. The worst results were obtained method **I**, i.e. when the directions of the film feed and the feed motion of the object are parallel, without any oscillation.

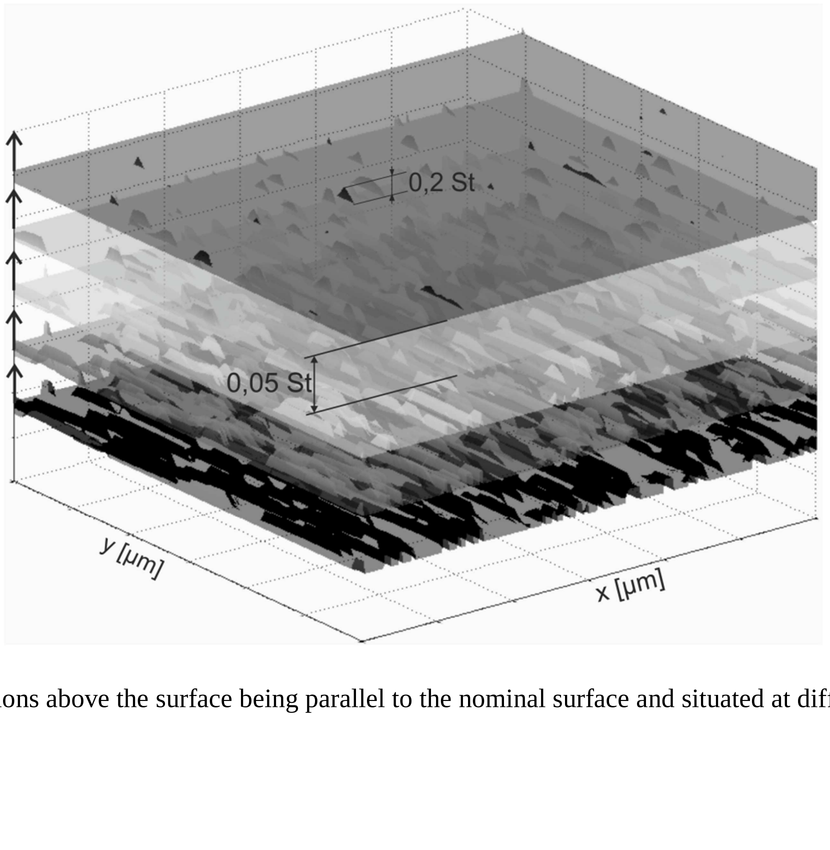


Fig. 5. Elevations above the surface being parallel to the nominal surface and situated at different levels *h*

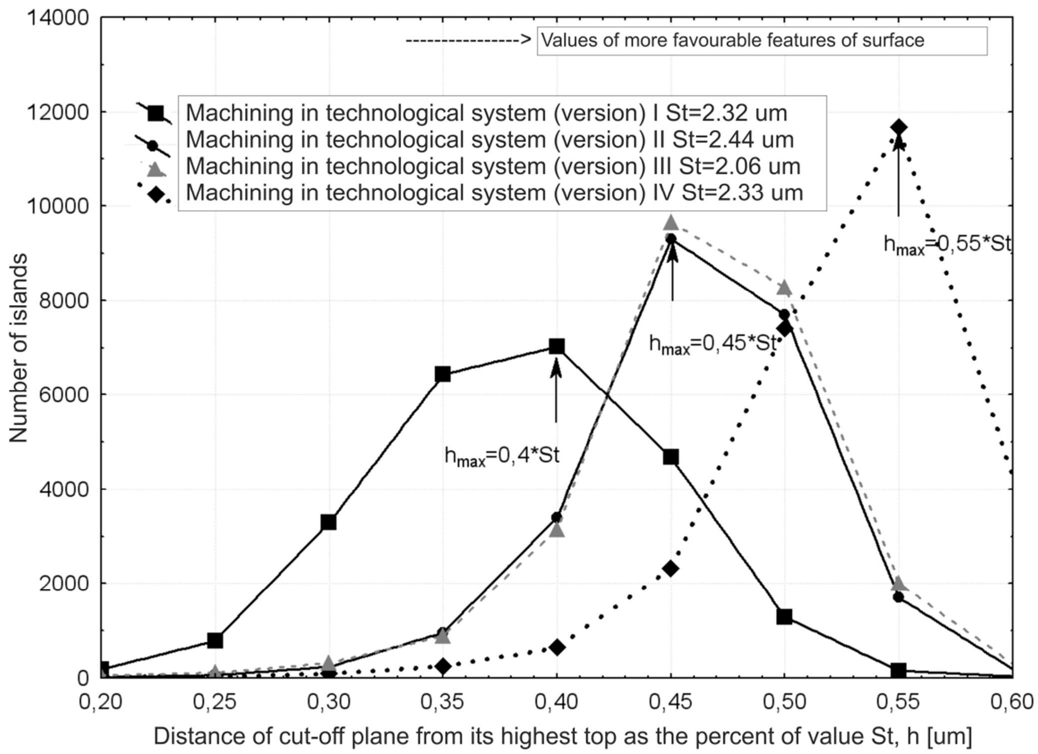


Fig. 6. Number of islands depending of the location of cut-off plane

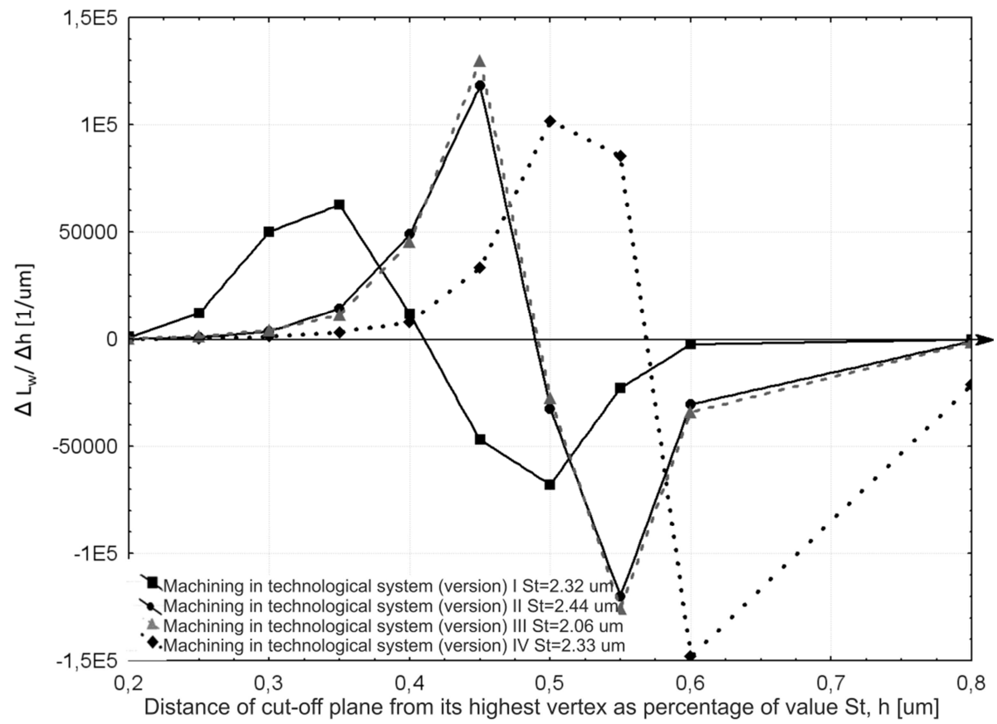


Fig. 7. Ratio of the increment of the number of islands to the increment of distance between successive levels examined of the location of cut-off plane

It is evident from a comparison of the topography of elevations above the cut-off plane that for machining **IV**, i.e. the axle of the pressure roll is lowered in relation to the axle of the object machined, with the application of oscillation, the largest increment of the number of elevations occurs in the range between 0,4-0,6 St. This means that the vertices of elevations are even and lie at the level of ca. 0,6 St. It is also evident from this that there occur sparse high elevations, yet it can be assumed that they shall be quickly removed in next operation (machining with next tool with smaller abrasive grains).

The conclusions presented above were also confirmed in the analyzes of the value of the ratio of the elevation height to the area of its base (Figs. 14,15,16,17,18) and the development of the perimeter of the elevation base in comparison with the circumference of the circle with an equivalent field (1), which was illustrated in Fig. 8.

$$W_{rp} = \frac{O_w}{2\sqrt{\pi}\sqrt{P_w}} \tag{1}$$

***O_w** – perimeter of the base of island*
***P_w** – area of island, **W_{rp}** – coefficient of development of surface*

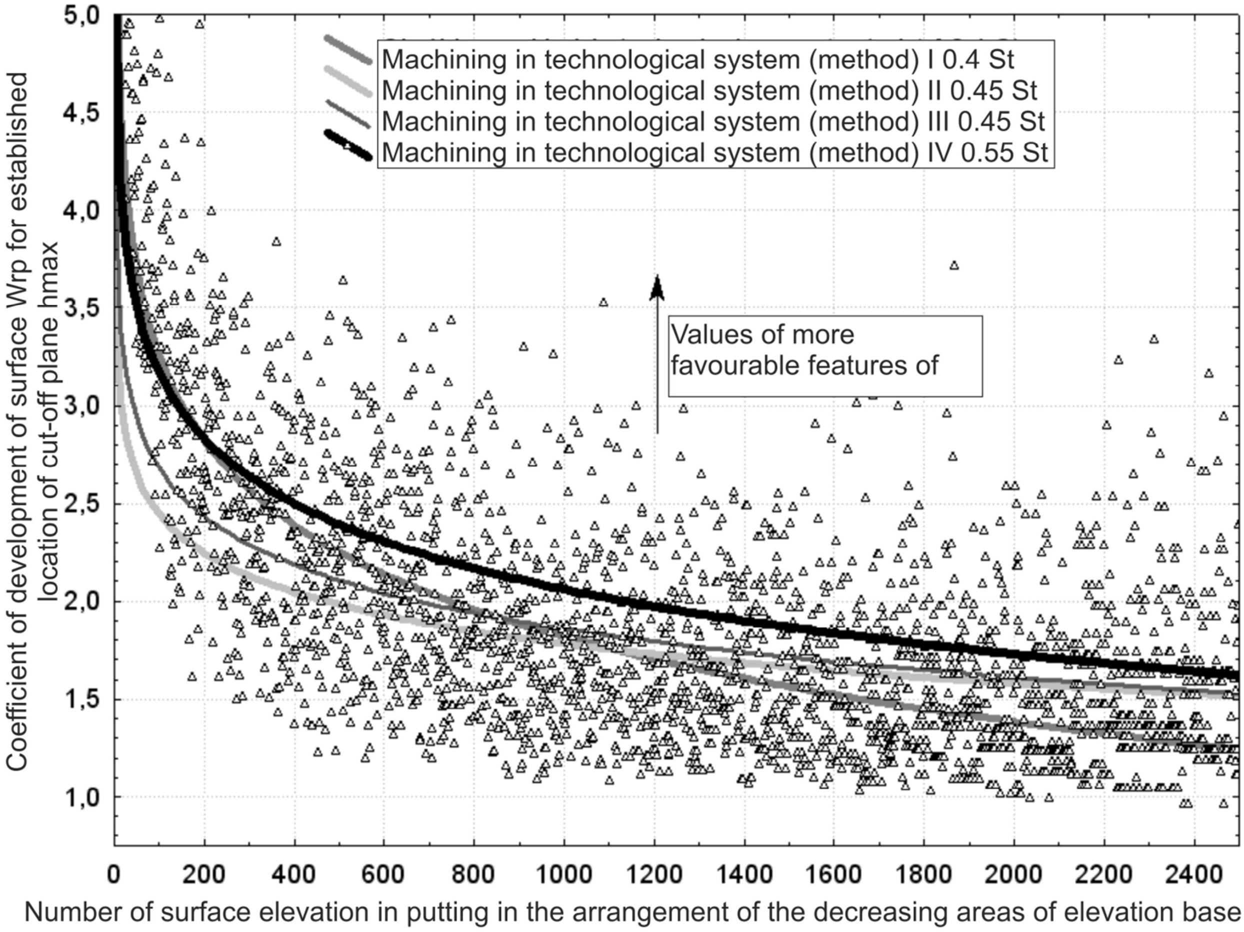


Fig. 8. Coefficient of development of surface W_{rp}

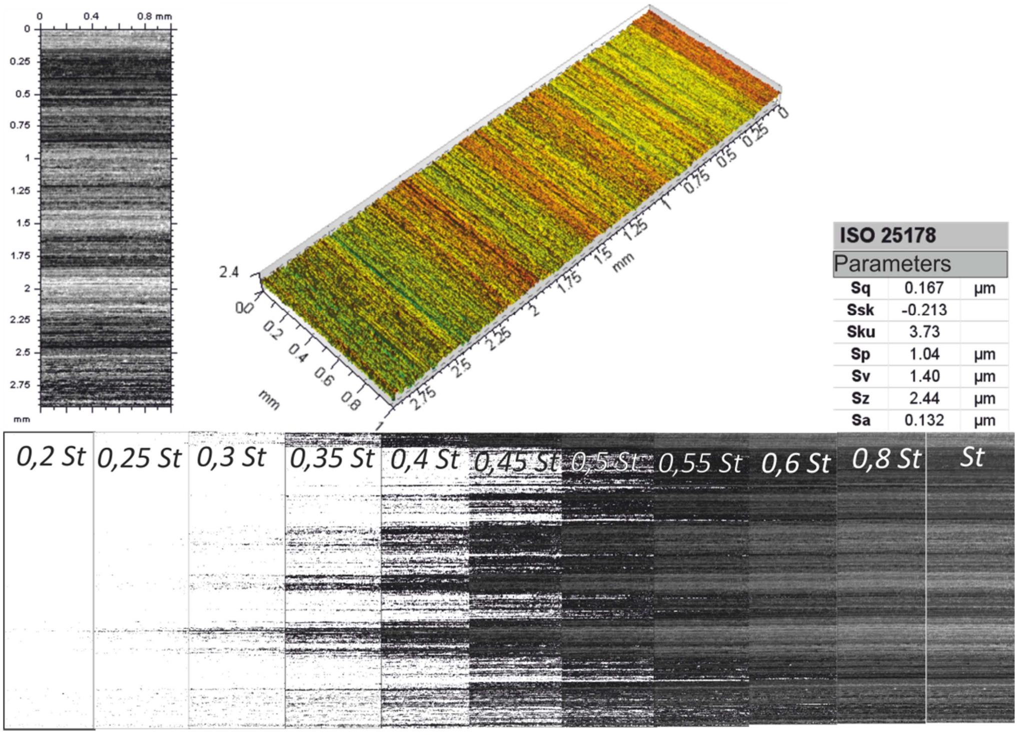


Fig. 9. Images of surface over the cut-off plane after machining in technological system (version) I, i.e. when the directions of the object's feed motion and the foil feed are parallel, with no oscillation applied, for the different levels of the location of the cut-off plane h (%St)

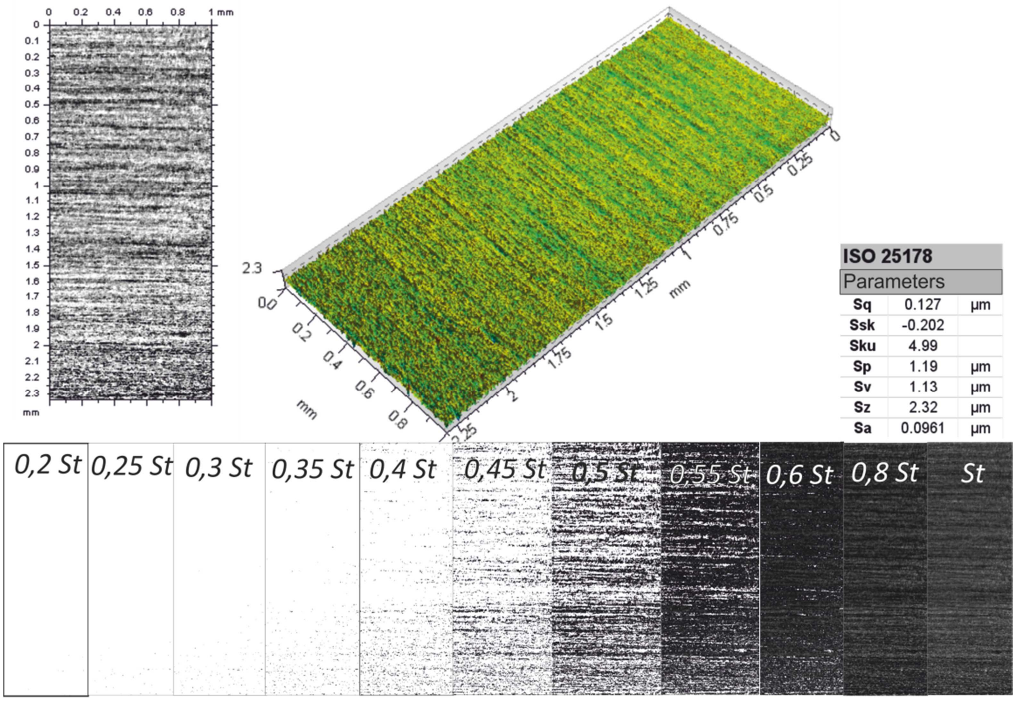


Fig. 10. Pictures of the surface over the cut-off plane after machining in the technological system (version) II that is when the direction of the feed motion of object and foil feed are parallel, machining with oscillation for the different levels of the location of cut-off plane h (%St)

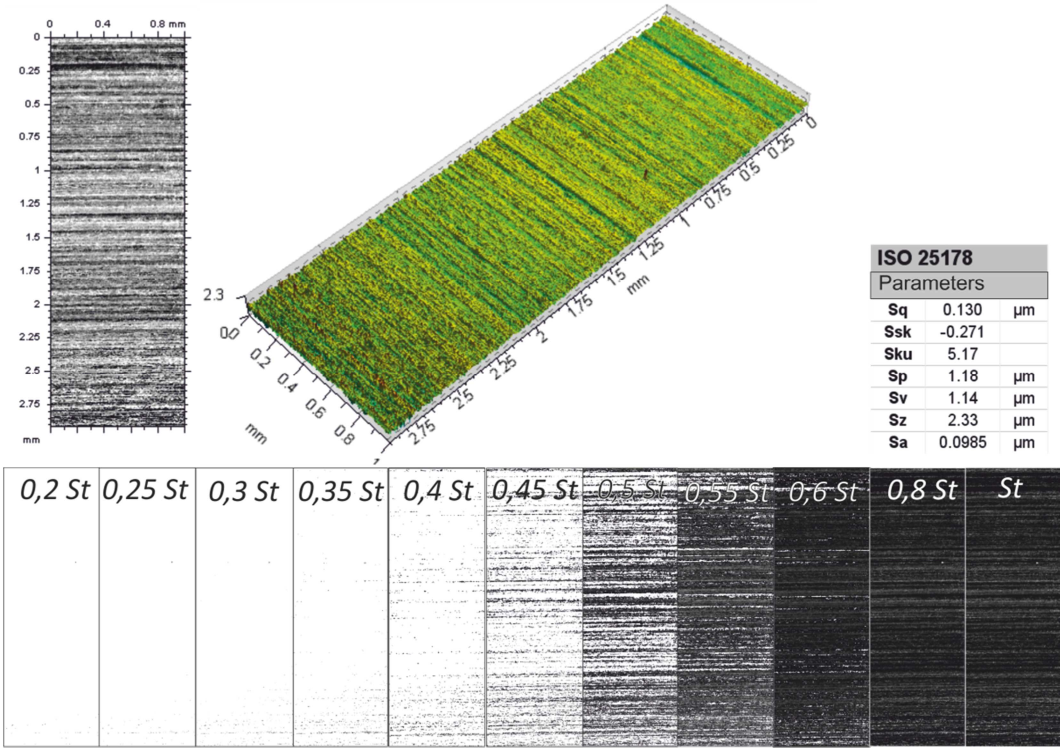


Fig. 11. Pictures of the surface over the cut-off plane after machining in the technological system (version) III that is when the direction of the feed motion of object and foil feed are not parallel, machining without oscillation for the different levels of the location of cut-off plane h (%St)

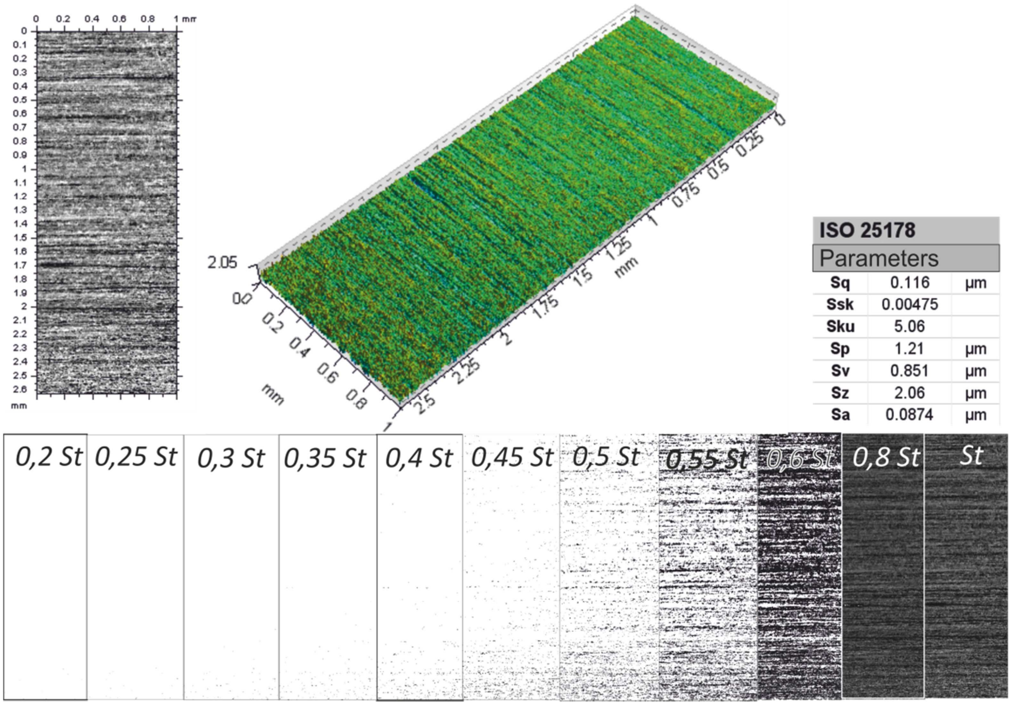


Fig. 12. Image of the surface over the cut-off plane after machining in technological system (version) IV, i.e. when the directions of the object's feed motion and the foil feed are not parallel, machining with oscillation for the different levels of the location of the cut-off plane h (%St)

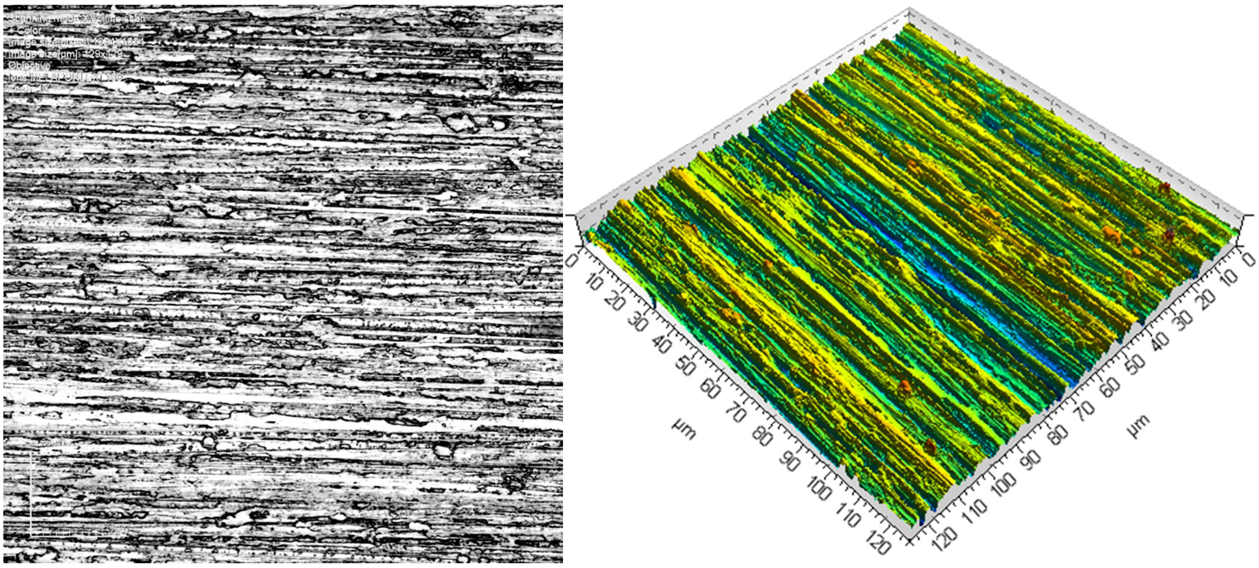


Fig. 13. Surface after machining in technological system (method) **IV** from OLS4000 Olympus confocal microscope with lens 100x

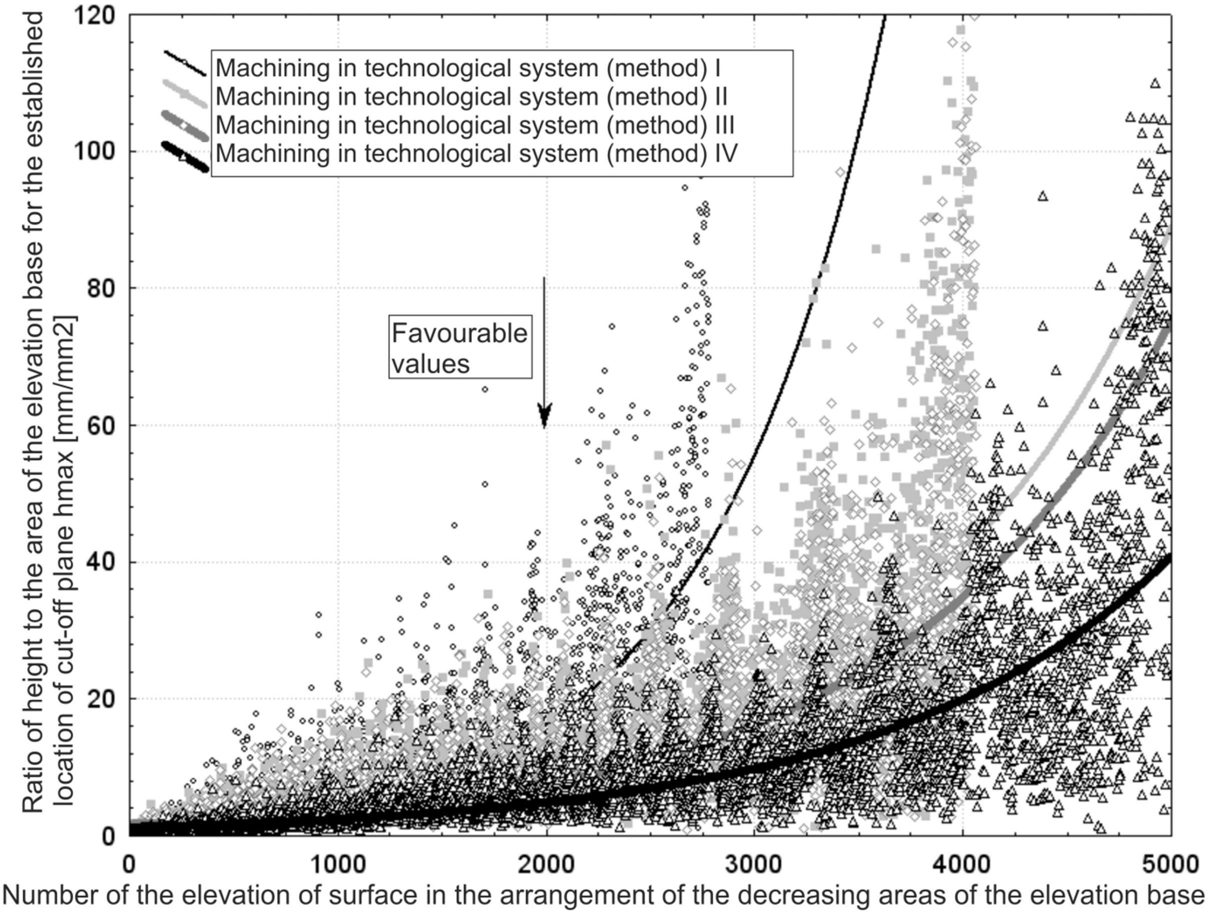


Fig. 14. Ratio of height to the area of elevation base for a specific location of cut-off plane h_{max}

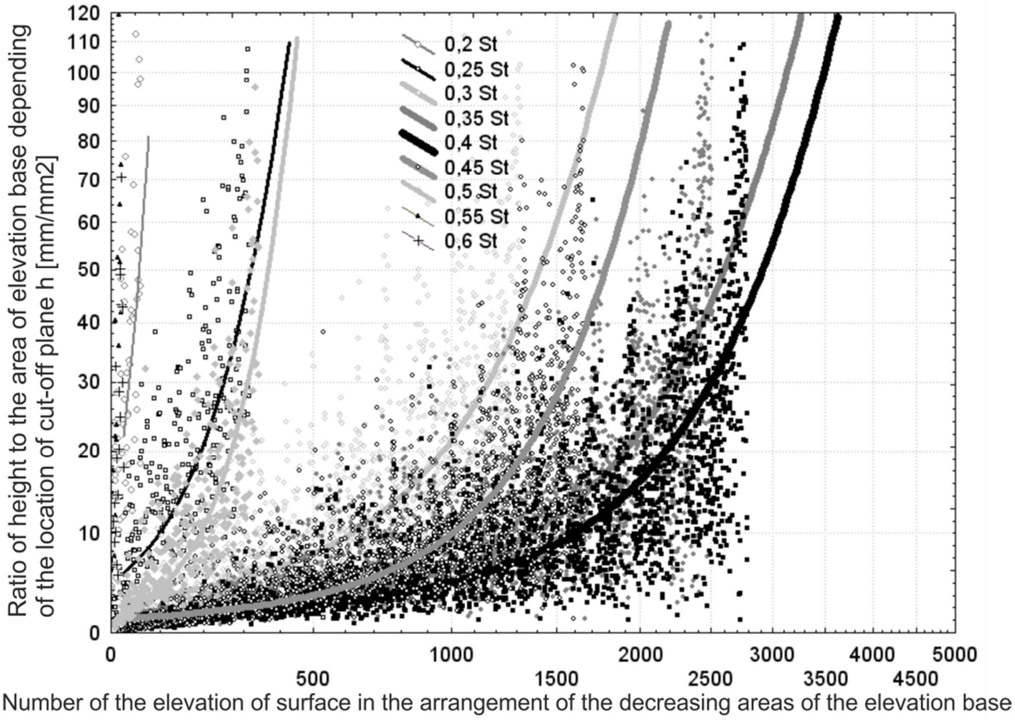


Fig. 15. Ratio of height to the area of the elevation base on the surface after machining in technological system (version) I for various locations of the cut-off plane *max*

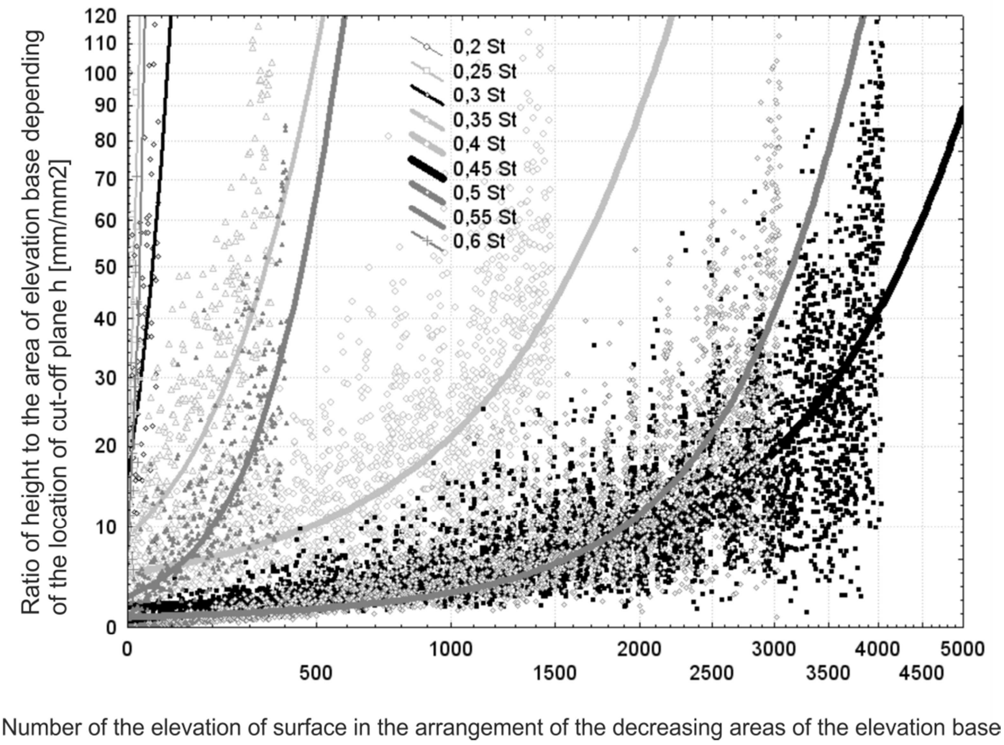


Fig. 16. Ratio of height to the area of the elevation bases on the surface after machining in the technological system (version) I for various locations of the cut-off plane *h*

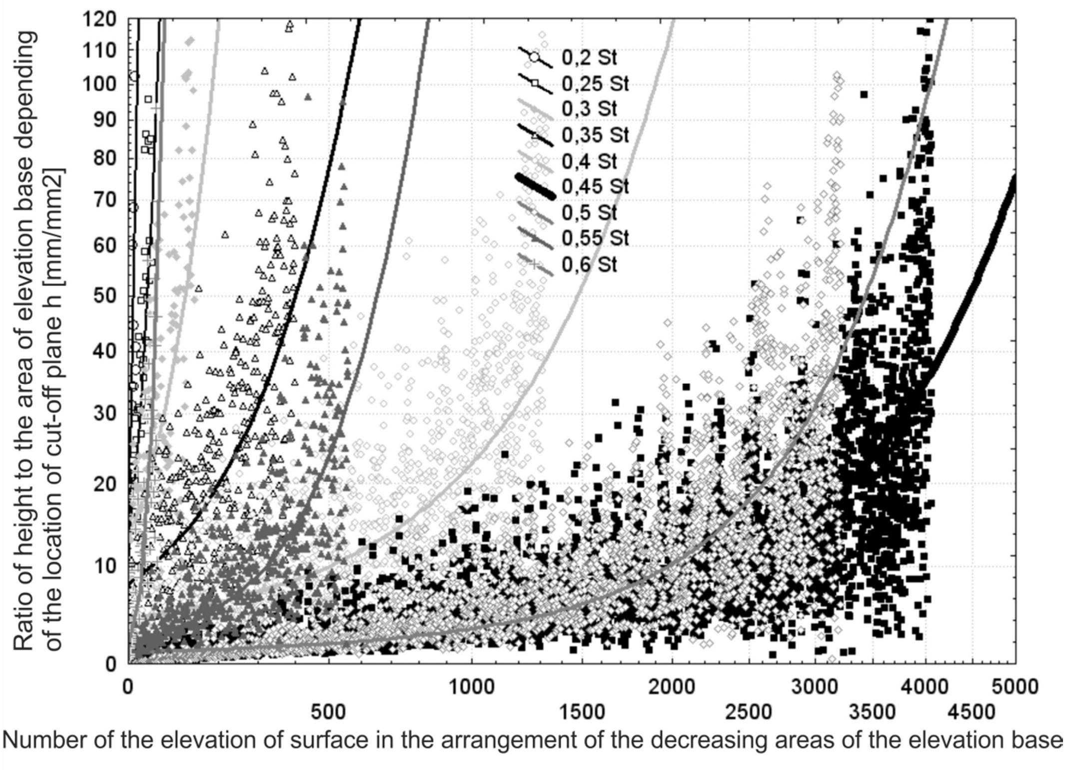


Fig. 17. Figure caption Ratio of height to the area of the elevation base on the surface after machining in technological system (version) III for various locations of cut-off plane *h*

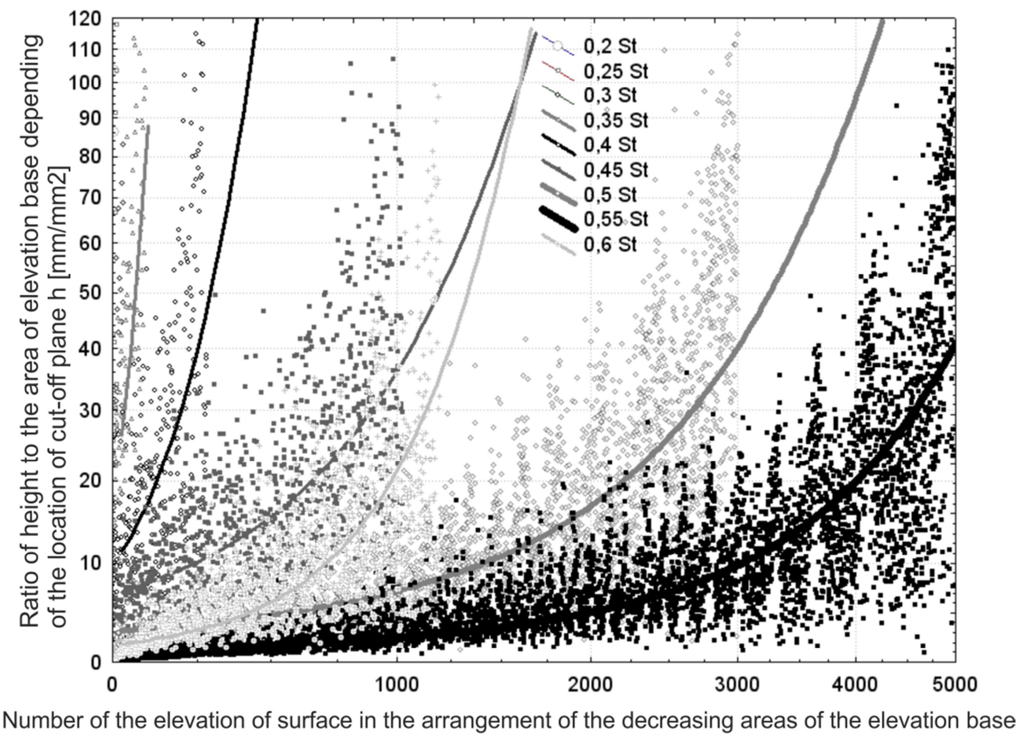


Fig. 18. Ratio of height to the area of the elevation base on the surface after machining in technological system (version) IV for various locations of cut-off plane *h*

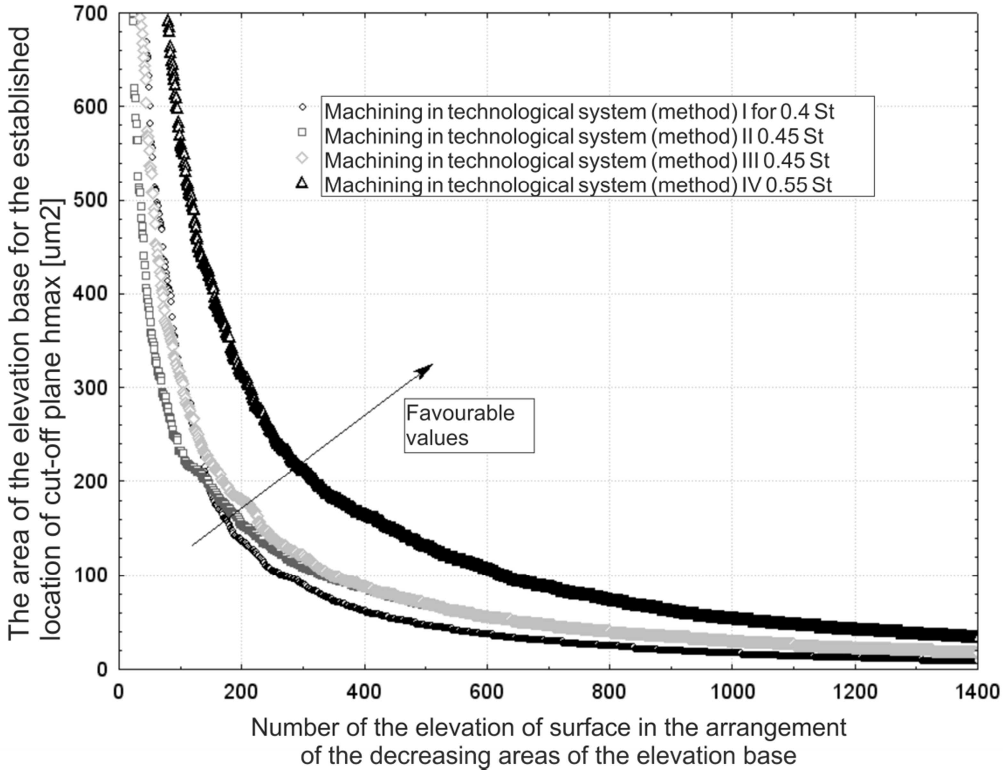


Fig. 19. Areas of elevation base on the surface after machining for the established location of cut-off plane h_{max}

The relation of the height h_{wi} of elevation above the surface which is moved away by h from the highest top of the examined surface to the surface area of its base P_{wi} is the indirect measurement of flatness of elevation.

$$S_{hi} = \left. \frac{h_{wi}}{P_{wi}} \right|_{h} \qquad \overline{S_h} = \sum_{i=1}^{n_h} \left(\frac{h_{wi}}{P_{wi}} \right)_h \tag{2}$$

$$S_k = \frac{\left. \overline{S} \right|_{h=0,5St}}{\left. \overline{S} \right|_{h=0,2St}} \tag{3}$$

where:

h_w – height of elevation [mm],

P_w – surface area of elevation [mm^2],

$\overline{S_h}$ - average value of the quotient of height and the area of the elevation base for the specific value h, S - ratio of height to the area of the elevation bases on the surface after machining in the given technological system for the different location of cut-off plane h [mm/mm^2],

S_k – relation of the average value of the quotient of height to the area of the elevation bases for the location of cut-off plane h=0,5St to h=0,2St.

The smaller the value S_{hi} is, the flatter the elavation is.

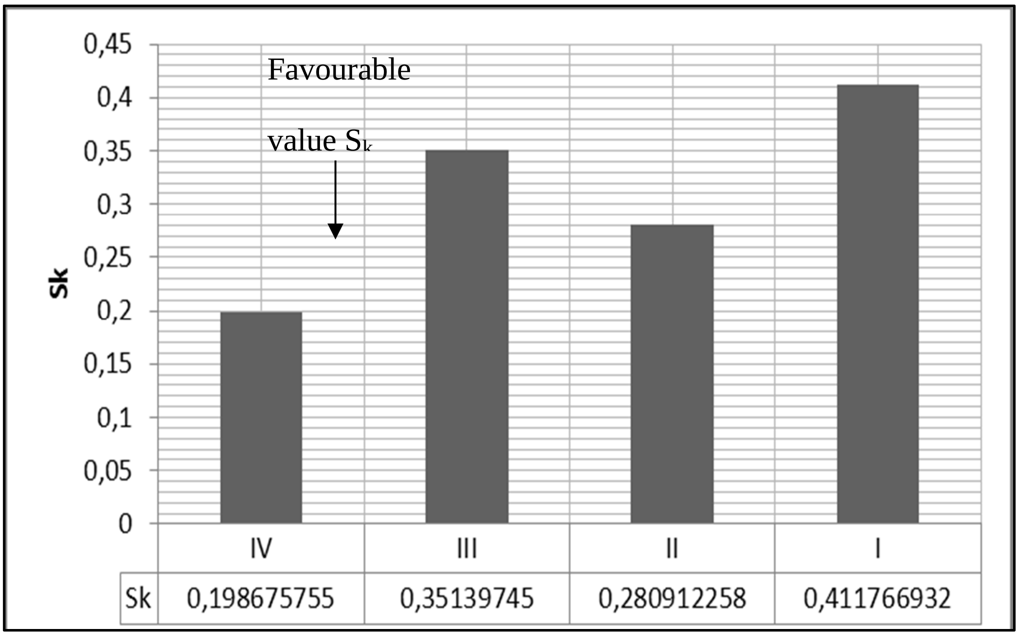


Fig. 20. Ratio of the average values of the quotient of height to the area of the elevation bases for the location of cut-off plane h=0.5St and h=0.2St in technological systems of I, II, III, IV type

4. CONCLUSIONS

The carried out research of the processes for the treatment of superfinishing with the application of microfinishing films of IMFF type with heaping the grain from the alundum with the nominal size of 15 micrometers for the different cinematic system proved that the topography of surface after superfinishing depends on the cinematic features of process. It is demonstrated that the machining with oscillation can be substituted and the similar effects can be obtained as a result of the deviation from the parallelism of the directions of object feed and tool feed. This means the possibility to apply the super finish attachments with a simpler building.

The best effects were obtained for machining in the fourth cinematic system that is when the directions of the feed motion of object and tool feed are not parallel and the crosswise oscillations of foil are additionally applied. The deviation of the direction of microfinishing film feed from the direction of the feed motion of object causes crossing the machining tracks and favourably influences on the topography of surface machined. The susceptibility of foil and pressure roll causes that the scope of the applications of drawn up method extends not only to the machining of flat surfaces but also rotary surfaces and on the surfaces of free shape.

LITERATURE

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