DURABILITY OF AL_2O_3 GRINDING WHEELS WITH ZONE-DIVERSIFIED STRUCTURE IN SINGLE-PASS INTERNAL CYLINDRICAL GRINDING

Krzysztof Nadolny

Summary

The article presents results of the research on wear of grinding wheels with zone-diversified structure in the single-pass internal cylindrical grinding process. The essence of single-pass internal cylindrical grinding was discusses and the construction of the new type of the grinding wheels, designed for the purpose of realization of this process and made of Al_2O_3 abrasive grains, was presented. The conducted research allowed us to determine the durability period of the newly-developed grinding wheels with two material removal rate values: Q_w = 6.26 and 13.4 mm^3/s. The main criteria for evaluation of the wear of the examined grinding wheels were the value of the arithmetic mean deviation of the roughness profile of the grinded surface *Ra*, the grinding power *P* and the maximal roundness deviation of the grinding wheels Δ. The obtained results of investigations allow for a statement that in single-pass internal cylindrical grinding, proceeded with relatively high material removal rate, can be applied grinding wheels made of Al_2O_3 abrasive grains. Experimental tests show also that with the increase in material removal rate the durability of such tools significantly reduces.

Keywords: grinding wheel wear, single-pass grinding, Al_2O_3 abrasive grains, grinding power, surface roughness

Trwałość ściernic z ziarnami Al_2O_3 i strefowo zróżnicowaną strukturą w procesie jednoprzejściowego szlifowania otworów

Streszczenie

W artykule przedstawiono wyniki badań zużycia ściernic o budowie strefowo zróżnicowanej, podczas jednoprzejściowego szlifowania osiowego walcowych powierzchni wewnętrznych. Omówiono istotę jednoprzejściowego szlifowania otworów oraz ściernice nowego typu zbudowane z ziaren Al_2O_3, opracowanych do realizacji tego procesu. Przeprowadzone badania doświadczalne pozwoliły na określenie okresu trwałości tych ściernic dla dwóch wartości i wydajności ubytkowej szlifowania: Q_w = 6,26 oraz 13,4 mm^3/s. Głównymi kryteriami oceny zużycia ściernic była wartość średniego arytmetycznego odchylenia profilu chropowatości przeszlifowanej powierzchni *Ra*, moc szlifowania *P* oraz maksymalna odchyłka okrągłości narzędzi ściernych Δ. Analiza uzyskanych wyników badań pozwala na stwierdzenie, że w szlifowaniu jednoprzejściowym, prowadzonym z dużą wydajnością ubytkową, mogą być stosowane ściernice z ziaren ściernych Al_2O_3. Wykazano również, że wraz ze zwiększeniem wydajności ubytkowej szlifowania trwałość ściernic znacznie się zmniejsza.

Słowa kluczowe: zużycie ściernicy, szlifowanie jednoprzejściowe, ziarna ścierne z Al_2O_3, moc szlifowania, chropowatość powierzchni

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1. Introduction

The single-pass grinding processes are one of the latest developmental trends in the field of abrasive machining. Their essence consists in removal of the whole grinding allowance in a single-pass of the grinding wheel with simultaneous preservation of the required quality of the surface layer of the workpiece. This results in greater flexibility in comparison with conventional reciprocating grinding. Additionally, the process remains highly reliable and the high quality of the machined surface is retained [1-7].

In majority of the described grinding wheels from extra hard abrasive materials, such as CBN or Diamond are applied. The hitherto results revealed that it is possible to make use of the grinding wheels made from much cheaper abrasive materials, such as white alumina 99A or microcrystalline sintered corundum [5-7] in the process of single-pass internal grinding. These works finally resulted in development of grinding wheels with zone-diversified structure which would allow the grinding process to be performed in a single-pass with the grinding allowance of approximately up to 0.20 mm. At the same time, such a solution guarantees high quality of the machined surface [8].

A substantial limitation of the grinding wheels made from conventional materials is their durability, which is far shorter than in case of e.g. CBN grains. The hereby work presents results of the research on the influence of the material removal rate on the durability of the newly-developed grinding wheels.

2. Single-pass internal cylindrical grinding process

Removal of a layer of material approximately 0.1-0.2 mm thick in a single-pass is facilitated by the conical chamfer formed while dressing the grinding wheel on its active surface. It also allows the total grinding allowance ($a_{e\ tot}$) to be evenly distributed along a substantial length of the grinding wheel, and consequently, a higher number of active grains, removing the allowance corresponding to the value of effective grinding thickness ($a_{e\ eff}$), takes part in the rough grinding process – Fig. 1 [1-7]. The value of the chamfer angle χ and its width depend on a number of parameters, such as the working engagement a_e, the height of the rough grinding zone of the grinding wheel T_1 (Zone A) and also the surface quality requirements. The latter determine the width of the finish grinding and the sparking-out zones T_2 (Zone B) [1-3]. Due to the abrasive wear of the grinding wheel, the conical chamfer shifts towards the finish-grinding and sparking-out zones, which shortens the cylindrical part of the grinding wheel [5, 6].

The grinding process performed in this way is characterized by variable load of the grinding wheel in its four basic areas (Fig. 1). Area I is marked by the load increasing to its constant value in Area II. The load value in Area II can be determined by the specific material removal rate given by the expression (1) [1, 2]:

$$Q'_w = \pi \cdot d_w \cdot n_w \cdot a_f \cdot \ \mathrm{tg}\, \chi \ \ [\mathrm{mm^2/s}] \tag{1}$$

where: d_w – workpiece diameter, mm, n_w – workpiece peripheral speed, s^{-1}, a_f – axial feed (feed engagement), mm, χ – angle of conic chamfer, °.

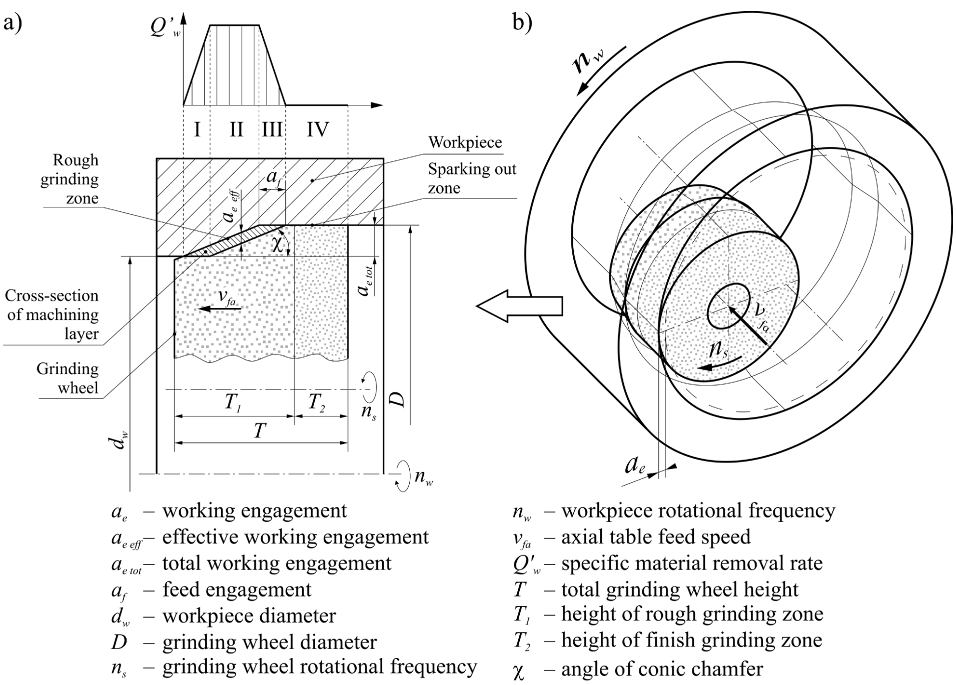


Fig. 1. Single-pass internal cylindrical grinding using grinding wheels with zone-diversified structure: a) load of grinding wheel active surface, b) kinematics of grinding [1, 2]

Area III is marked by a decrease in load parallel to its increase in Area I, with the difference that except for the removal of the grinding allowance, the finish grinding process is also performed. When it comes to area IV, both the finish grinding and the sparking out processes take place in it, however, the latter results from resilient deformations occurring between the machined object and the grinding wheel spindle.

3. Grinding wheels with zone-diversified structure

The experiments in question were carried out on the grinding wheels developed in Koszalin University of Technology (Poland) [9]. The new grinding wheels based on polycrystalline grains of white alumina 99A or microcrystalline sintered corundum SG bonded with special glass-crystalline binder. It is composed of crystalline phase (1-5 μm) dispersed in the vitreous matrix. By generating an evenly distributed crystalline phase harder than the matrix from glass, it was possible to improve the mechanical properties of such binders (including the hardness). Furthermore, due to the occurrence of the intergranular boundaries in the binder, the mechanism of binder destruction was very similar to that which takes place in case of the abrasive grains, especially the microcrystalline ones [10]. The developed grinding wheels differ in type and size of the abrasive grains in both functional zones (A and B) – Fig. 2.

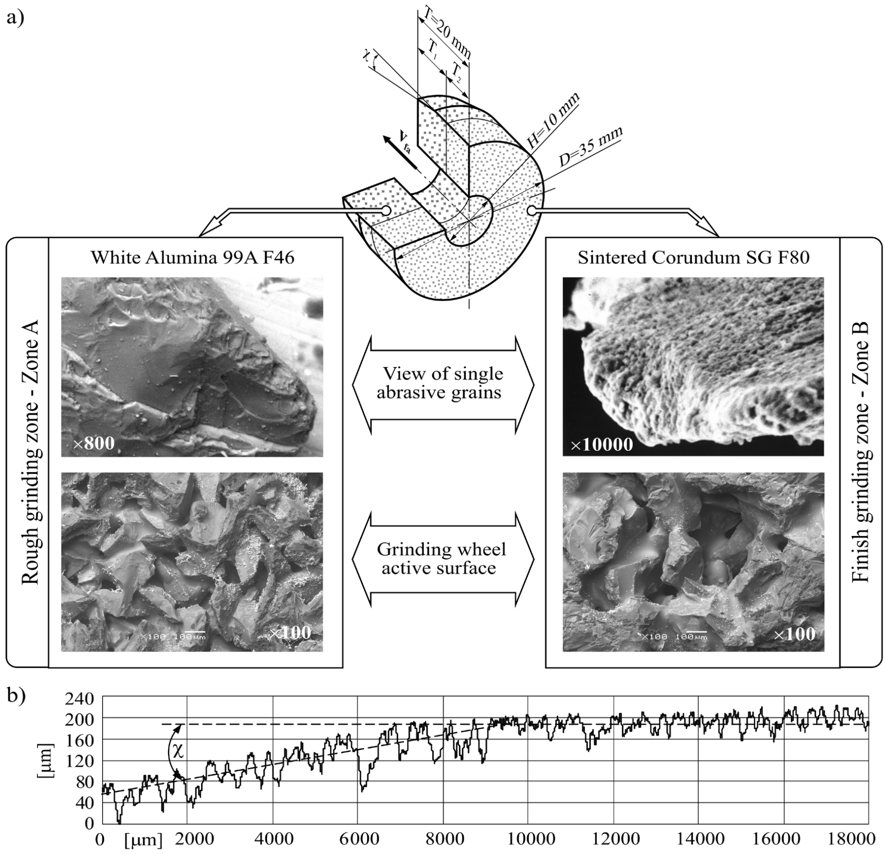


Fig. 2. Example of structure of the grinding wheel for single-pass internal cylindrical grinding: a) view of single abrasive grains and grinding wheel active surface, b) microgeometrical axial profile of the grinding wheel active surface with an exposed conical chamfer angle χ [9]

Due to application of the single-pass grinding wheels with zone-diversified structure in the grinding process, good results were achieved regarding both the required material removal rate and the quality of the machined surface.

4. Experimental research

4.1. The aim of the research

The object of experimental research on the single-pass internal cylindrical grinding using grinding wheels with zone-diversified structure was determining the durability of the newly-developed grinding wheels. Since this type of abrasive machining process involved considerable load of the active surface of the grinding wheel, it was necessary to investigate wear resistance of the grinding wheels composed of different types and sizes of abrasive grains. Moreover, the influence of the material removal rate on the durability of the grinding wheels was examined.

4.2. Research methodology

The experiments were aimed at determining the durability of grinding wheels with zone-diversified structure in the process of internal cylindrical grinding and were divided into two stages: the diagnostic and specific examinations.

The first stage (diagnostic examinations) focused on the durability of grinding wheels of a relatively small value of the material removal rate amounting to Q_w = 6.26 mm^3/s (for a_e = 0.1 mm, v_{fa} = 1.0 mm/s). The grinding wheels designed for the tests comprised in 70% (T_1 = 14 mm) of the coarse-grained (46) rough grinding zone (Zone A) and in 30% (T_2 = 7 mm) of the finish grinding zone made from grains size 80 (Zone B). These grinding wheels were marked with symbols which stand for the type of abrasive grains in respective zones of tools: 99A/SG, SG/99A and SG/SG (Table 1).

Examinations of the durability of the grinding wheels consisted in grinding 20 holes with each of the grinding wheels, in addition to which the grinding wheels were only once profiled and dressed – prior to the process of grinding. Volumetric wear and shape deviations, the machined surface roughness and grinding power were recorded in the course of grinding.

In the second stage (specific examinations), the material removal rate was increased to the value Q_w = 13.4 mm^3/s (for a_e = 0.15 mm, v_{fa} = 1.5 mm/s). In this case, the durability period was determined for grinding wheels made of SG grains both in the rough grinding zone (Zone A) and the finishing one (Zone B), where the zone designed for finish grinding was made from grains size 60 and 80. The following symbols were used for marking the grinding wheels: SG F46/SG F80 and SG F46/SG F60 (Table 2).

Table. 1. Grinding wheels with zone-diversified structure assigned to the first stage of testing

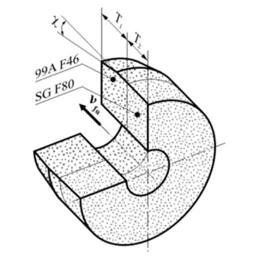
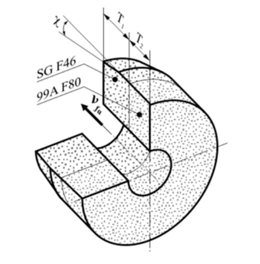
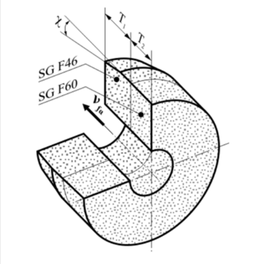
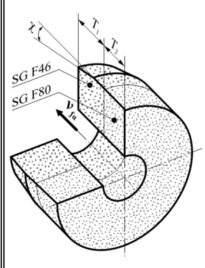
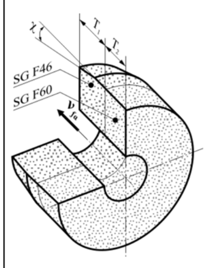
Designation	99A/SG	SG/99A	SG/SG
Zone A	Abrasive grain kind: 99A Size of grains: 46 Height: T_1=70%	Abrasive grain kind: SG Size of grains: 46 Height: T_1=70%	Abrasive grain kind: SG Size of grains: 46 Height: T_1=70%
Zone B	Abrasive grain kind: SG Size of grains: 80 Height: T_2=30%	Abrasive grain kind: 99A Size of grains: 80 Height: T_2=30%	Abrasive grain kind: SG Size of grains: 80 Height: T_2=30%
Construction diagram			
Complete designation	1 - 35x20x10 - 99A/F46K7VDG70% / SG/F80I7VDG 30%	1 - 35x20x10 - SG/F46K7VDG70% / 99A/F80I7VDG30%	1 - 35x20x10 - SG/F46K7VDG70% / SG/F80I7VDG30%

Table. 2. Grinding wheels with zone-diversified structure assigned to the second stage of testing

Designation	SG F46/SG F80	SG F46/SG F60
Zone A	Grain kind: SG Size of grains: 46 Height: T_1=70%	Grain kind: SG Size of grains: 46 Height: T_1=70%
Zone B	Grain kind: SG Size of grains: 80 Height: T_2=30%	Grain kind: SG Size of grains: 60 Height: T_2=30%
Construction diagram		
Complete designation	1 - 35x20x10 - SG/F46K7VDG70% / SG/F80I7VDG30%	1 - 35x20x10 - SG/F46K7VDG70% / SG/F60I7VDG30%

The active surface of the grinding wheels was only once profiled and dressed prior to the process of grinding. The life-period of the grinding wheels was determined by grinding the maximal number of holes with each of the grinding wheels, preserving the required results of abrasive machining. As the criterion for determining the total loss of machining properties, the exceeding of the limiting value of grinding power P_l = 1400 W, determined on the basis of the results from earlier research work [8], was assumed.

A grinding wheel was dressed using single-grainy diamond dresser. The grinding power was measured using the high-speed spindle control system and roughness of machining surfaces were measured by the stylus profilometer Hommel Tester T8000 (Hommelwerke, GmbH, Germany).

4.3. Investigation conditions

What was used for the tests was a universal grinding machine RUP 28P (Fig. 3) equipped with spindle, type EV-70/70-2WB produced by FISHER, Switzerland (maximum rpm 60 000 1/min, power of machine cutting 5.2 kW). Semi-fabricated bearing rings made of 100Cr6 steel (hardness 63±2 HRC) were grinded. Cooling liquid was prepared as 5% water solution of oil Castrol Syntilo R HS. The coolant flow rate was equal to Q_c = 5.0 l/min.

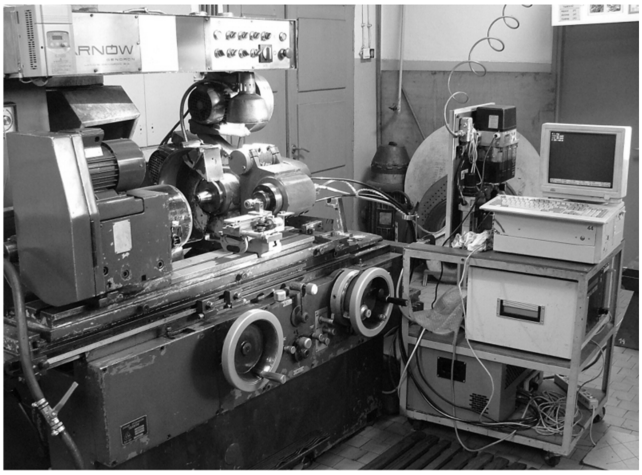


Fig. 3. Investigative position – RUP 28P grinding machine with EV-70/70-2WB spindle

4.4. Precision dressing device

A special attachment for precise shaping of the conical chamfer at a small angle (χ < 1.5°) on the active surface of the grinding wheels was developed. A slide plate which is equipped with a disk-shaped holder for a diamond dresser and a micrometer screw, which enables precise setting of the required value of a chamfer angle (±0.03°) is the most important component of this attachment.

This screw fastened to the lower part of the base directly displaces its upper part, which supports the slide plate (Fig. 4).

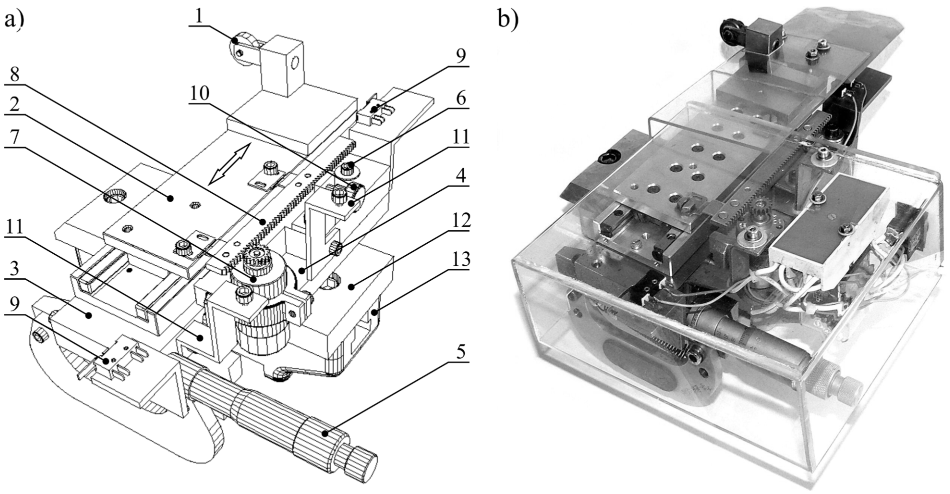


Fig. 4. Functional elements (a) and view of the test-ready device to precision dressing (b): 1 – dresser, 2 – slide plate, 3 – upper basis turning about specified angle, 4 – immovable bottom base, 5 – micrometer screw, 6 – axis of rotation of upper base, 7 – driving motor, 8 – toothed rack, 9 – limit switch, 10 – blockade of table, 11 – bracket of casing, 12 – backing plate, 13 – dresser base

The attachment featuring a power transmission system for a slide plate consists of a power pack, a driving motor, a worm gear and a toothed rack. The to-and-fro motion is controlled by switches located at extreme positions of the slide plate. The whole system was fixed to the upper part of the base in order to maintain the stable kinematics of dressing at various values of the angle. The components of the attachment were mounted on a standard dresser base of a RUP 28P grinding machine.

4.5. Results of diagnostic experiments

The first stage of experimental investigations was aimed at checking the effects of the type of grinding wheels in respective functional zones of the grinding wheels (Zones A, B) exerted on the changes in parameters of the machined surface roughness as a function of tool wear, at lower values of the material removal rates (Q_w = 6.26 mm^3/s).

According to the diagram of changes in the arithmetic mean deviation of the machined surface roughness *Ra* for 20 rings machined in turn in a single-pass process presented in Fig. 5, there occurs a slight variation in the roughness of the workpiece machined with the tested grinding wheels.

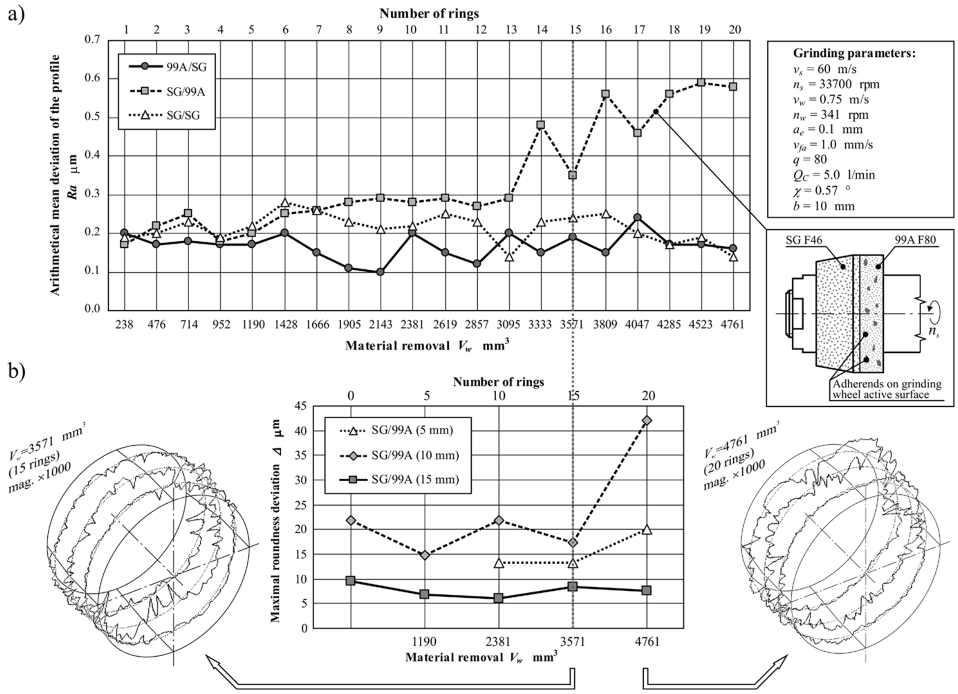


Fig. 5. Influence of material removal V_w on arithmetical mean deviation of the workpiece profile *Ra* (a) and roundness deviation of 99A/SG grinding wheel (b) – maximal roundness deviation Δ measured within the distance of 5, 10 and 15 mm from front of grinding wheel

An exception to the rule was SG/99A grinding wheel – after exceeding the value of material removal rate V_w = 3095 mm^3 corresponding to the grinding of 13 rings, the surfaces were machined at higher and higher values of the parameter *Ra*. It followed from the progressive wear of the grinding wheel manifesting itself, among others, in increasing values of the roundness deviations (Fig. 5). As a result of the growing roundness error there occurred the vibrations of a grinding wheel and the real contact between the tool and the workpiece was reduced. It caused clogging of the active surface in the finishing zone of the grinding wheel made from grains of white alumina 99A size 80.

Changes in the roughness of the surface machined as a function of the volume of the removed material are much more favorable for workpieces machined with 99A/SG and SG/SG grinding wheels. It logically follows that applying the microcrystalline grains of sintered corundum to the finish-grinding zone guarantees higher quality of machined surfaces.

The diagrams of the grinding power recorded while machining the successive holes are marked by an initial increase due to the loss of the machining properties of grinding wheels invested in the process of dressing (Fig. 6).

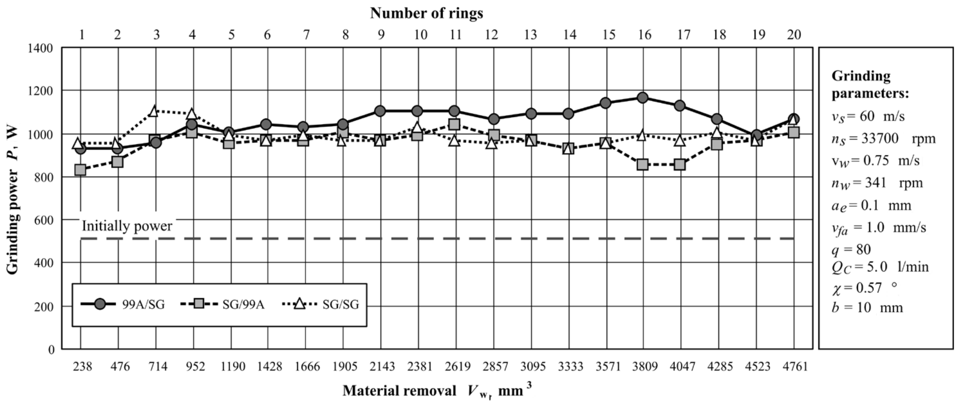


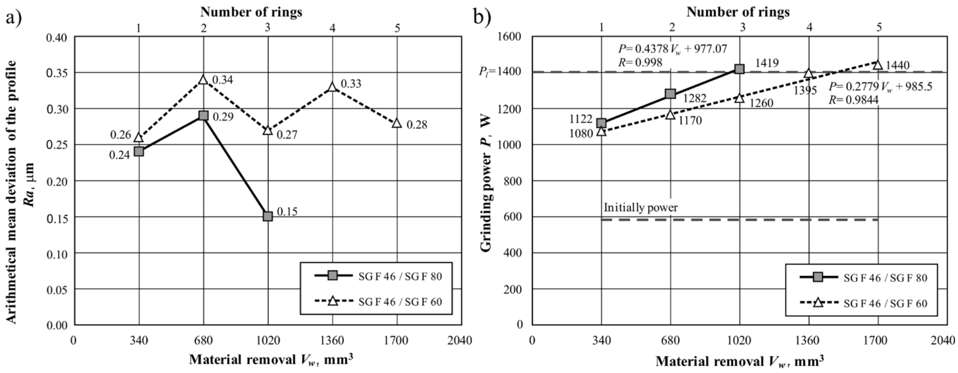
Fig. 6. Influence of material removal V_w on grinding power P during single-pass internal cylindrical grinding process (initially power – the power of grinding wheel spindle in idle running)

The consecutive measuring points indicate the presence of stabilized changes in the grinding power. It follows that the active surface of the grinding wheel wasn't dulled and its grinding ability was maintained for a long period of machining. It shows that the active surface of the tested grinding wheels is regenerated due to the progress of the self-sharpening process. This feature applies to all of the tested grinding wheels and does not depend on the type of grains used in their structure, which confirms the favorable effect of the glass-crystalline binder in use. The designed structure of this composite guarantees the constant and uniform micro-chipping of the abrasive grains and the binder, as well in the course of the grinding process [10]. The diagram also shows the higher level of power corresponding to the process conducted with the use of grinding wheel with grains of white alumina in the rough grinding zone (99A/SG). In case of the other grinding wheels, where this zone was made from grains of sintered corundum, the power P was slightly lower. This results from the better machining properties of SG grains, which due to their microcrystalline structure allow the material to be removed with many micro-vertexes generated in the course of self-sharpening.

4.6. Results of specific experiments

Since diagnostic experiments on the single-pas grinding conducted at the material removal rate Q_w = 6.26 mm^3/s did not lead to the total loss of the machining properties of the developed grinding wheels in the course of machining 20 consecutive rings, the value of material removal rate was increased to Q_w = 13.4 mm^3/s on the subsequent stages of experimental investigations (specific experiments).

The diagram of changes in roughness of the machined surface (Fig. 7a) illustrates the more favorable values of the parameters obtained for the grinding wheel with grains size 80 in the finish grinding zone, which results from a higher concentration of relatively finer abrasive grains (compared with the other grinding wheel with grains size 60 in this zone) and consequently a higher number of cutting vertexes producing the smoother surface.



Grinding	v_s = 60 m/s	v_w = 0.75 m/s	a_e = 0.15 mm	q = 80	χ = 0.60; 0.68 °
parameters:	n_s = 35300÷39200 rpm	n_w = 341 rpm	v_{fa} = 1.5 mm/s	Q_C = 5.0 l/min	b = 14.4; 12.6 mm

Fig. 7. Influence of material removal V_w on arithmetical mean deviation of the workpiece profile *Ra* (a) and on grinding power *P* (b) (P_l – limiting value of grinding power)

In case of SG F46/SG F80 grinding wheel, a slight increase in the surface roughness of the second hole was recorded, and after grinding the third ring, the significantly lower roughness of the workpiece was observed. The ensuing conditions did not allow the active surface of the grinding wheel to be renewed and the phenomenon of self-sharpening the microcrystalline grains SG to occur. The period of the SG F46/SG F60 grinding-wheel durability was longer for the same reason, for which the machined surface roughness was generated on the higher level than in case of SG F46/SG F80 grinding wheel. The surface of the cylindrical part of the grinding wheel with a smaller number of relatively larger grains was marked by a properly reduced number of cutting vertexes, and also larger intergranular spaces, allowing the process products to be removed from the grinding zone. As a result of clogging the active surface of a grinding wheel, they were growing slower and the loss of machining properties occurred later.

The progress in the loss of machining properties of the tested grinding wheels along with an increase in the volume of removed material V_w, is proved by the diagrams of changes in the recorded grinding power (Fig. 7b). In case of both grinding wheels one can observe a distinct linear tendency in a power increase as a function of V_w. For SG F46/SG F80 grinding wheel, the deterioration of grinding conditions was proceeding much faster, which can be also concluded from the slope value of a straight line approximating the recorded values, amounting to 0.44 compared with 0.28 for SG F46/SG F60 grinding wheel. Consequently, SG F46/SG F80 grinding wheel exceeded the limiting value of grinding power (P_l = 1400 W) just while grinding the third hole, and a SG F46/SG F60 grinding wheel – the fifth.

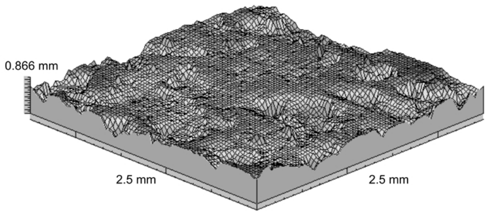
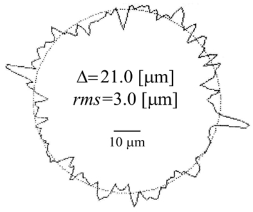
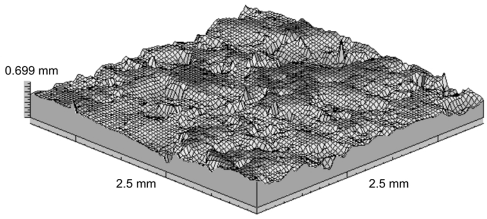
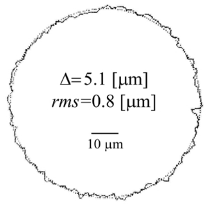
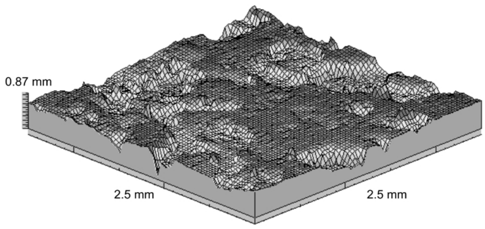
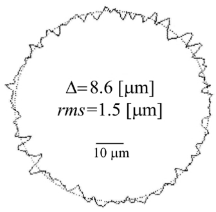
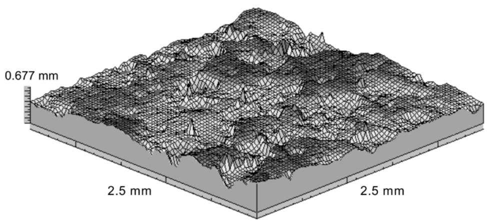
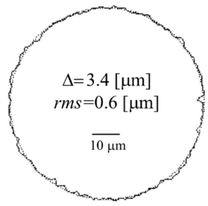
Despite the significant load applied to the abrasive grains, the measurement taken after grinding each hole did not indicate any changes in the diameter of the grinding wheels. It means that despite application of glass-crystalline binder marked by the mechanism of the bond-bridge destruction similar to the self-grinding mechanism of sintered corundum grains, these phenomena had nature not strong enough to influence the diameter of the grinding wheels. Therefore, one may suppose that the regeneration of the active surface was not sufficient and did not guarantee long periods of operation for the described grinding wheels accomplishing the process of a single-pass internal grinding with established parameters.

For the SG F46/SG F60 grinding wheel, the changes in micro-topography resulting from wear and the shape error of the active surface of the grinding wheel were measured. The comparison of the state of the grinding wheel after dressing and grinding three rings which means the removal of 1020 mm^3 stock is presented in Table 3.

Smoothing of the active surface of both the zones of the grinding wheel is clearly visible on circumferential profiles measured in order to determine the shape errors of the tested tool. The value of the maximal roundness deviation of the measured in the cylindrical part of finish grinding from the value of 5.1 μm after dressing to 3.4 μm after grinding the three rings. Blunting of the active surface of the grinding wheel caused by wear can be observed on the 3D image of the measured micro-topographies and in changes of its roughness rough grinding zone Δ was reduced nearly three times from 21.0 to 8.6 μm as a result of abrasive machining, distinctly showing a decrease in the irregular height of the circumferential profile. Similar, but not so distinct, was the change in Δ parameters. The most significant reaction to changes in the topography was caused by the parameter *Sds*. (density of summits of the surface) and *Sdr* (developed interfacial area ratio).

The parameter *Sds* determined for the conical zone was equal to 223 peaks per mm^2 after dressing, and after grinding the three rings it was reduced by 15% to the value 189 mm^{-2}. The situation was similar in case of the cylindrical zone of the finish grinding. The density of profile irregularities on this surface was 199 mm^{-2} and after dressing it was reduced by 17% to the value of 166 mm^{-2}. The developed interfacial area ratio *Sdr* was also reduced from 352 to 324% in case of the conical zone and from 241 to 217% for the cylindrical zone of the grinding wheel. These numbers clearly correspond to changes in the grinding power, which increased by 22% from 1080 W while grinding the first hole to 1395 W while grinding the fourth workpiece.

Table. 3. Surface roughness parameters, 3D views of active surface micro-topography and circumferential profiles of grinding wheel SG F46/SG F60, after dressing and after removing of 1020 mm^3 of stock

Zone conditions		Surface roughness parameters	3D view	Roundness deviation
After dressing	Rough grinding zone (Zone A)	*Sa* = 0.082 mm *Sq* = 0.104 mm *Sz* = 0.765 mm *Ssk* = -1.03 *Sku* = 3.95 *Sds* = 223 pks/mm^2 *Sal* = 0.153 mm *Str* = 0.675 *Std* = -45 ° *Ssc* = 0.212 1/µm *Sdq* = 3.31 µm/µm *Sdr* = 352 % *Sbi* = 0.44 *Sci* = 1.08 *Svi* = 0.168		
	Finish grinding zone (Zone B)	*Sa* = 0.0629 mm *Sq* = 0.0792 mm *Sz* = 0.529 mm *Ssk* = -0.916 *Sku* = 4.03 *Sds* = 199 pks/mm^2 *Sal* = 0.16 mm *Str* = 0.645 *Std* = -45 ° *Ssc* = 0.156 1/µm *Sdq* = 2.71 µm/µm *Sdr* = 241 % *Sbi* = 0.904 *Sci* = 1.16 *Svi* = 0.153		
After grinding of 3 rings (V_w=1020 mm^3)	Rough grinding zone (Zone A)	*Sa* = 0.0796 mm *Sq* = 0.104 mm *Sz* = 0.749 mm *Ssk* = -1.27 *Sku* = 4.63 *Sds* = 189 pks/mm^2 *Sal* = 0.185 mm *Str* = 0.531 *Std* = -45 ° *Ssc* = 0.193 1/µm *Sdq* = 3.23 µm/µm *Sdr* = 324 % *Sbi* = 0.516 *Sci* = 0.908 *Svi* = 0.184		
	Finish grinding zone (Zone B)	*Sa* = 0.0572 mm *Sq* = 0.0724 mm *Sz* = 0.538 mm *Ssk* = -0.818 *Sku* = 3.91 *Sds* = 166 pks/mm^2 *Sal* = 0.152 mm *Str* = 0.753 *Std* = -45 ° *Ssc* = 0.163 1/µm *Sdq* = 2.6 µm/µm *Sdr* = 217 % *Sbi* = 0.786 *Sci* = 1.21 *Svi* = 0.154		

5. Conclusions

The most important conclusions come from experimental investigations on the wear of zone-diversified grinding wheels in single-pass internal grinding:

1. Developed grinding wheels are marked by limited period of durability in the course of machining with the material removal rate on a level of 13.4 mm^3/s.

2. Over 2-fold increasing the material removal rate Q_w from 6.26 to 13.4 mm^3/s caused the significant decrease in grinding wheel life.

3. On the first stage of investigations, the grinding wheel successfully ground over 4700 mm^3 of stock, which corresponded to grinding 20 rings, in addition to which the tested grinding wheel did not lose its machining properties entirely. The active surface of the tested grinding wheels was easy to regenerate and they retained the quality of the machined surface and the grinding power on a steady level at relatively low volumetric wear V_s.

4. An intensification of abrasive machining caused the grinding conditions to deteriorate, which led to exceeding the limited value of the grinding power P_l = 1400 W just while machining the third (a grinding wheel SG F46/SG F80) and fifth workpiece (a grinding wheel SG F46/SG F60).

It follows that in case of an increased material removal rate, the abrasive machining should be carried out applying the process of dressing after each pass. It does not impose any limitations on the process in question because such solutions are applied universally in various industries in order to retain full repeatability of the grinding results.

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