GRINDING INCONEL 718 USING A GALVANIC GRINDING WHEEL

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ABSTRACT

This work is focused on grinding Inconel 718, which belongs to the group of hard-to-machine materials. The aim of this work was to verify a galvanic grinding wheel when the surface roughness was the main criterion. This type of grinding wheel will be used for grinding the mechanical test samples. It is necessary to achieve the lowest values of surface roughness.

The experiments in this work focus on the influence of the grinding parameters on the surface roughness. In addition to surface roughness, the transverse waviness and clogging of the grinding wheel, which are also problematic, are also investigated in this work.

KEYWORDS

Grinding, Galvanic wheel, Inconel 718, Roughness, Grinding parameters

INTRODUCTION

Grinding is a process in which a grinding wheel removes a defined layer from the material of a workpiece. This process is intended for machining hard-to-machine materials. This includes Inconel 718 because of the hardening of its machined surface, low thermal conductivity, extreme sensitivity to thermal damage (re-tempering burn and re-hardening burn) and the formation of sectional chips during machining. Inconel 718 is being used more and more often for heavily loaded components and machine components which are exposed to extreme conditions such as working at either high or freezing temperatures. The chemical composition and mechanical properties of Inconel 718 are shown in the tables below.[1] [2]

Ni [%]	**Cr [%]**	**Nb [%]**	**Mo [%]**	**Ti [%]**	**Al [%]**	**Co [%]**	**Cu [%]**	**C [%]**	**Si, Mn [%]**	**P, S [%]**	**B [%]**	**Fe [%]**
50 - 55	17 - 21	4.75 – 5.5	2.8 – 3.3	0.65 – 1.15	0.2 – 0.8	≤ 1	≤ 0.3	≤ 0.08	each ≤ 0.35	each ≤ 0.015	≤ 0.006	balance

Table 1 Chemical properties of Inconel 718 [3]

Tensile strength (R_m)	**Yield strength ($R_{p0.2}$)**	**Elongation at break (ε_R)**	**Modulus of elasticity (E)**	**Hardness Rockwell**	**Hardness Brinell**
1400 ± 100 MPa	1150 ± 100 MPa	15 ± 3 %	170 ± 20 GPa	47 HRC	446 HB

Table 2 Mechanical properties of Inconel 718 [3]

As already mentioned, Inconel 718 is classed as a hard-to-machine material. One of the options for machining this material is grinding. The effective removal of materials, high quality and accuracy of surfaces is achieved by grinding. But the problem arises with the thermal influence on the material at the point of cut, which can negatively affect the surface. Therefore, it is important to select the right grinding parameters for each grinding wheel, which include cutting conditions, grinding strategies and so on. [1] [2] [4] [5]
This work is focused on the verification of the suitability of a galvanic grinding wheel for grinding Inconel 718. The main aim of this verification is to find suitable grinding conditions to achieve a surface roughness of Ra 0.2 um. This work also deals with transverse waviness and clogging of the grinding wheel.

EXPERIMENTS

Several experiments were carried out to find effective grinding conditions when grinding Inconel 718 for minimizing surface roughness, high precision, minimal impact on the ground material and high tool life. The technology of grinding for all the experiments was cylindrical grinding. The shape of the samples was cylindrical. The experimental principle is shown in Fig. 1.

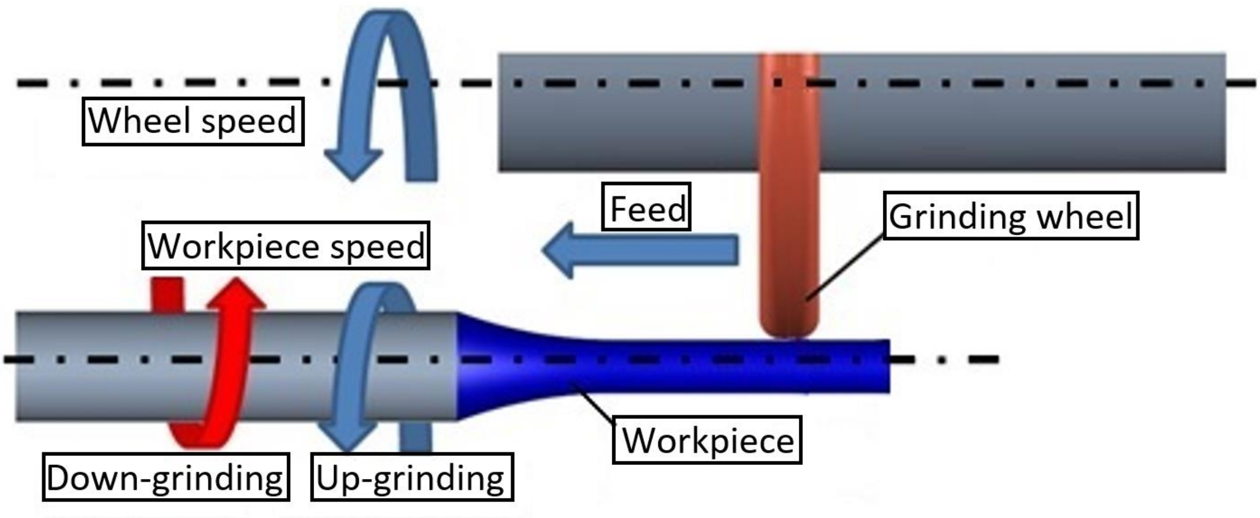

Fig. 1 Used technology of grinding on experiments

The main idea of this work is to find effective grinding conditions to achieve the lowest values of surface roughness. Therefore, the grinding conditions were based on previous measurements. Moreover, one experiment was done to verify the value of the clogging of the grinding wheel. Also, the transverse waviness of the surface was monitored, because in some grinding parameters it is manifested by the formation of flat faces.

USED EQUIPMENT

Experimental grinding was done on the ANCA MX7 5-axis grinding machine. A grinding wheel with mark 1LL1 150 10 5 10 B 46 S 200 GAL RADIUS 3 is used for grinding. The marking of the grinding wheel is shown in Fig. 2. An IFM G4 scanning optical microscope is used for measuring the value of surface roughness. This microscope was also used for scanning the clogging of the grinding wheel and the surface of samples for evaluating the transverse waviness.

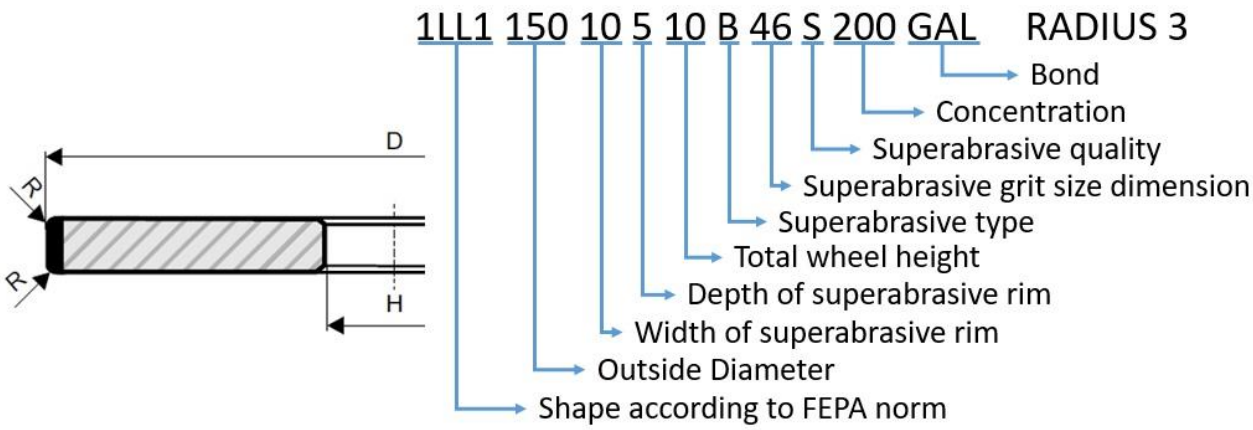

Fig. 2 Grinding wheel marking [6]

RESULTS

Various grinding conditions were used in this experimental grinding: cutting speed, workpiece speed, feed rate, radial cutting depth and workpiece rotation. The experiment was divided into several tests. The purpose of the test was to find suitable grinding conditions for grinding Inconel 718. The surface roughness parameters Ra and Rz were evaluated in the first test. The value of grinding conditions is shown in Table 3Table 3 Value of grinding conditions for experiments.

Experiment	v_c [m.s^{-1}]	v_f [mm.min^{-1}]	n_f [rpm]	a_e [mm]	Grinding

K – G01	40	200	350	0.01	Up-grinding
K – G02	40	200	350	0.01	Up-grinding
K – G03	40	200	185	0.01	Up-grinding
K – G04	50	200	185	0.01	Up-grinding
K – G05	50	100	180	0.01	Up-grinding
K – G06	50	100	180	0.005	Up-grinding
K – G07	50	100	770	0.01	Up-grinding
K – G08	50	100	1210	0.01	Up-grinding
K – G09	50	100	1210	0.01	Down-grinding
K – G10	50	100	1210	0.005	Down-grinding
K – G11	30	100	892	0.01	Down-grinding
K – G12	25	100	603	0.01	Down-grinding
K – G13	50	100	1206	0.01	Down-grinding
K – G14	50	100	1206	0.01	Down-grinding

Table 3 Value of grinding conditions for experiments

The measured values of surface roughness are shown in two graphs; Ra is shown in Fig. 3 and Rz is shown in Fig. 4. The differences in values of the experiments is shown in the graphs, but the differences are very small because it is in hundredths of micrometres for the Ra values. Although different grinding conditions were tested, the desired surface roughness value was not achieved. The same is true for the Rz parameter values, but the differences in values are in the order of tenths of micrometres.

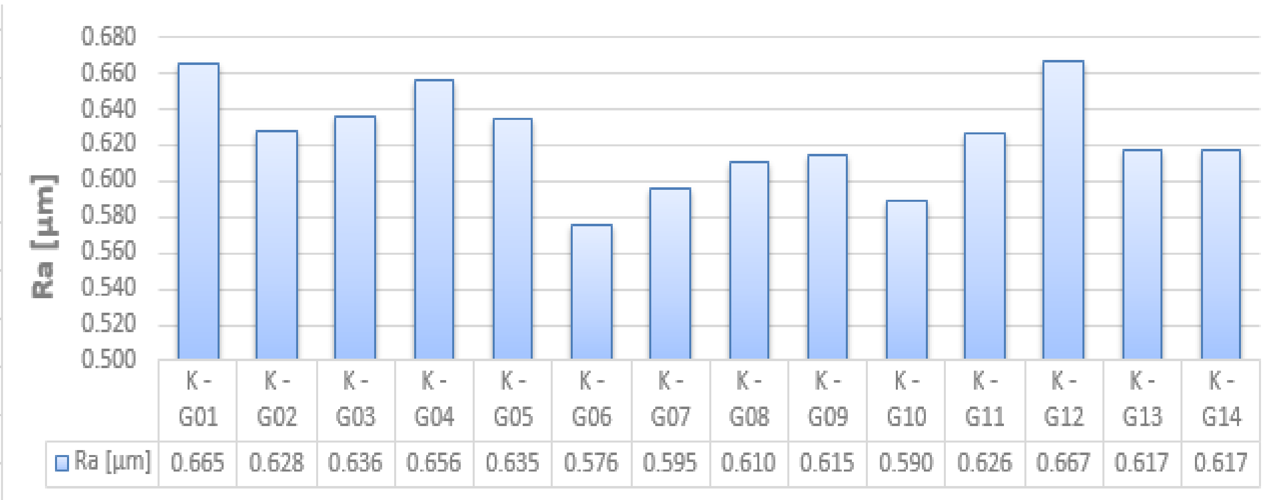

Fig. 3 Values of roughness Ra

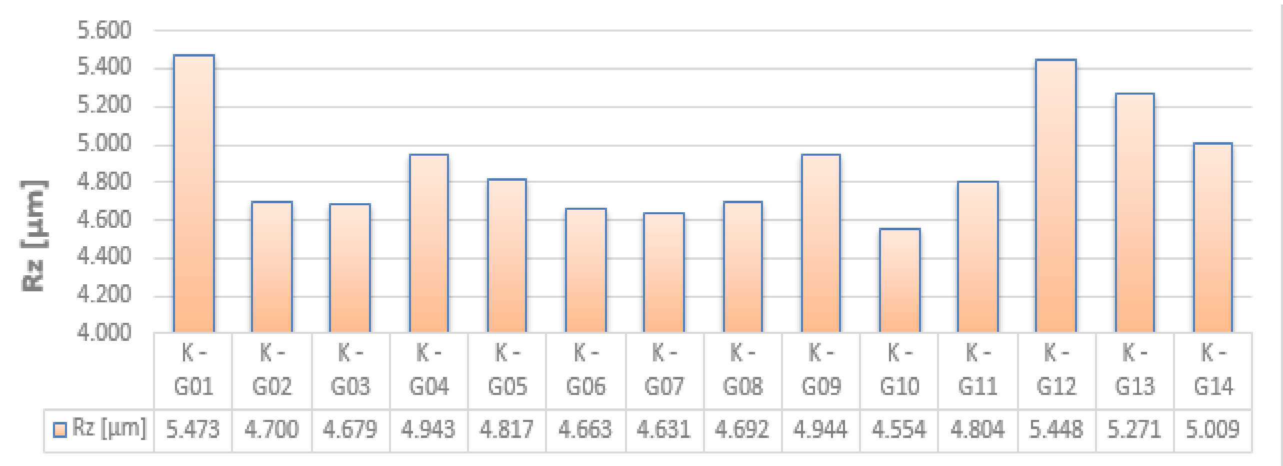

Fig. 4 Values of roughness Rz

The next experiment was focused on the systematic wear of the grinding wheel. This experiment showed the effect of systematic wear of the grinding wheel on the surface roughness. Grinding conditions for grinding the wheel into the hardened steel with the input grinding conditions for the experimental grinding is shown in Table 4.

Grinding conditions for grinding hardened steel				
v_c [m.s^{-1}]	v_f [mm.min^{-1}]	n_f [rpm]	a_e [mm]	Grinding
40	10	500	0.01	Up-grinding
Grinding conditions for grinding experiment				
v_c [m.s^{-1}]	v_f [mm.min^{-1}]	n_f [rpm]	a_e [mm]	Grinding
50	100	1206	0.01	Down-grinding

Table 4 Value of grinding conditions for grinding hardened steel and experiment

The measured values of roughness from the experiment are plotted in the graph shown in Fig. 5, where Z-G00 indicates the value of the surface roughness of the new grinding wheel. As can be seen in the graphs, the value of surface roughness start to worsen with the growing number of grindings of the hardened steel.

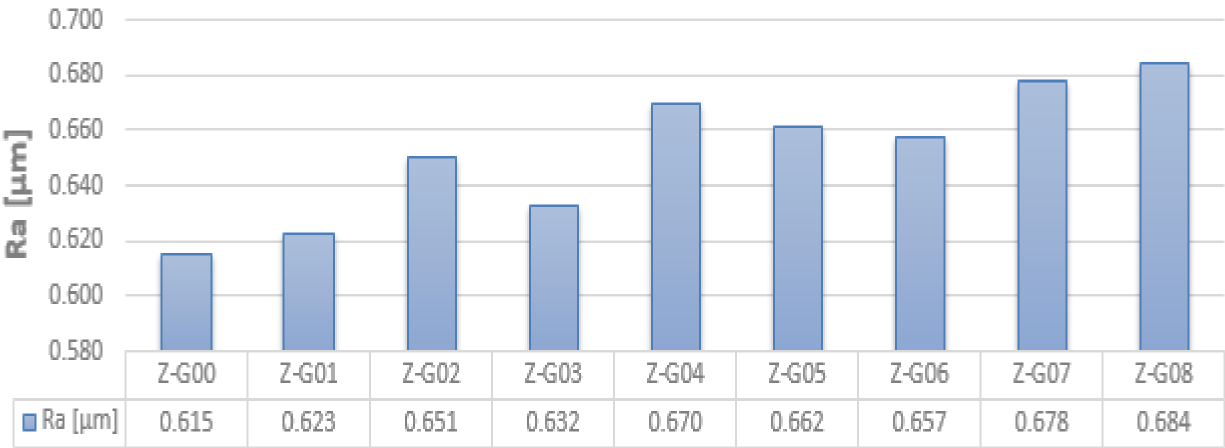

Fig. 5 Values of roughness Ra

The transverse waviness, which depends on the speed ratio between the grinding wheel and the ground part, was also monitored. The surface of the part affected by transverse waviness is shown in Fig. 6. This surface had a lot of flat surfaces. The second figure shows the surfaces without the transverse waviness (Fig. 7).

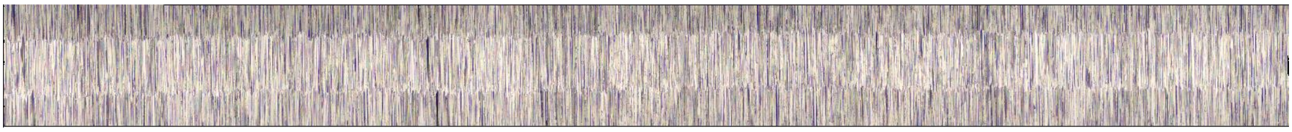

Fig. 6 Surfaces with the transverse waviness

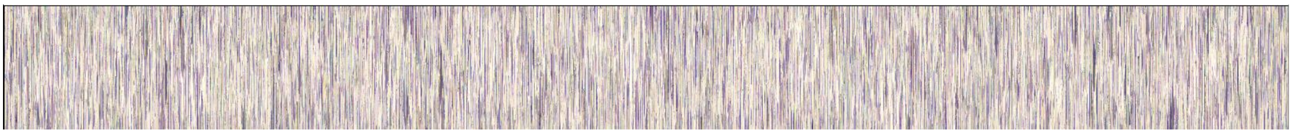

Fig. 7 Surfaces without the transverse waviness

The clogging of the grinding wheel was observed during the experiments. The pictures below show the progress of clogging of the grinding wheel. The first picture (Fig. 8) shows the clogged surface after the first grinding. The second picture (Fig. 9) shows the clogged surface after ten grindings and the last picture (Fig. 10) shows the clogged surface after a further ten grindings.

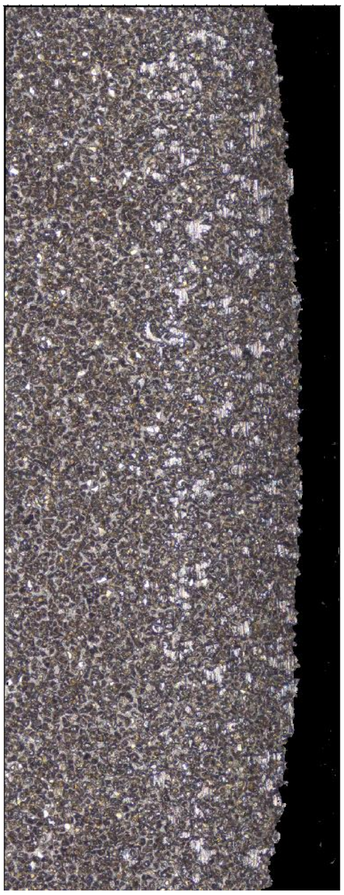

Fig. 8 Wheel after first grinding

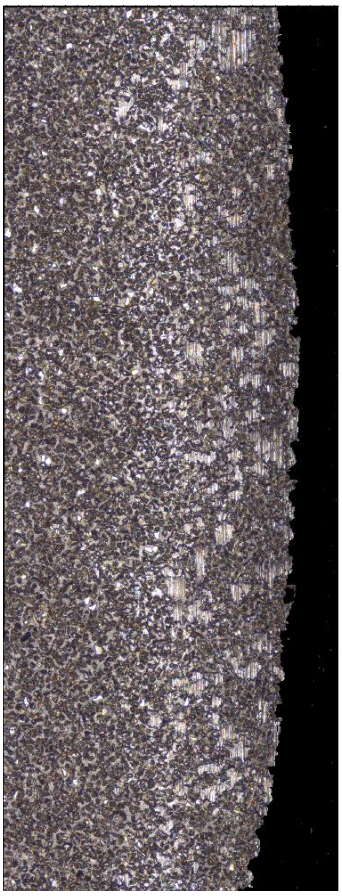

Fig. 9 Wheel after ten grinding

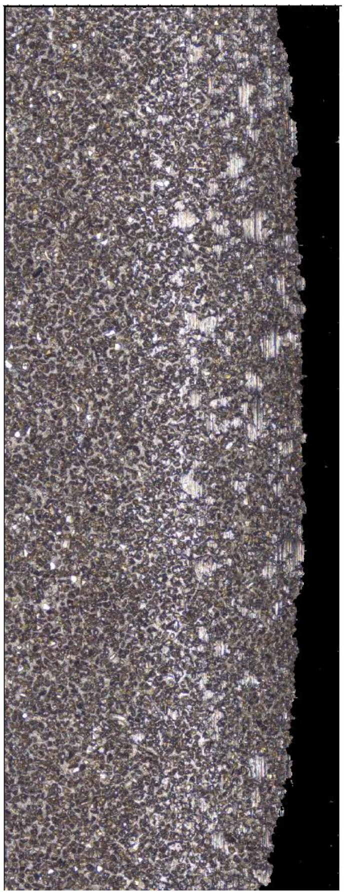

Fig. 10 Wheel after twenty grinding

CONCLUSION

This experiment was carried out to verify the use of a grinding wheel with a galvanic layer which has been specially developed for grinding Inconel 718. The results from this first experiment show that the grinding conditions do not work because the surface roughness does not reach a value of Ra 0.2 or better. But we found the correct speed ratio between the grinding wheel and the part for removing transverse waviness. Also, we verified that the clogging of the grinding wheel increases by a minimum after ten grindings. In the future, we will try to verify further grinding conditions and use other types of grinding wheels.

ACKNOWLEDGMENTS

This paper was supported by the Internal Grant Agency of the University of West Bohemia, project No. SGS-2019-008.

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