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SURFACE ROUGHNESS OF ALUMINIUM ALLOY CUT BY ABRASIVE WATERJET

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ШОРСТКІСТЬ ПОВЕРХНІ АЛЮМІНІЄВОГО СПЛАВУ ПІСЛЯ АБРАЗИВНО-СТРУМИННОЇ ОБРОБКИ

Різні алюмінієві сплави часто застосовуються в різних областях промисловості, таких як космічна або автомобільна промисловість. Первинна механічна обробка таких деталей звичайно - гідроабразивне різання. Гідроабразивне різання - один з найбільше широко використовуваних нетрадиційних методів механічної обробки. Якість обробленої поверхні наближається до якості після токарної обробки. У даній роботі містяться деякі результати дослідження, спрямовані на характеристики поверхневого шару.

Различные алюминиевые сплавы часто применяются в различных областях промышленности, таких как космическая или автомобильная промышленность. Первичная механическая обработка таких деталей обычно – гидроабразивная резка. Гидроабразивная резка – один из наиболее широко используемых нетрадиционных методов механической обработки. Качество обработанной поверхности приближается к качеству после токарной обработки. В данной работе содержаться некоторые результаты исследования, направленные на характеристики поверхностного слоя.

Different aluminium alloys are frequently applied in different fields of industry like aerospace or automobile industry. First machining operation of these parts is often the abrasive waterjet cutting. Abrasive waterjet cutting is one of the most widely used non-traditional machining methods. Quality of the machined parts is determined by the surface roughness of the cut. Some results of research work oriented to the surface characteristics are summarised in this paper.

1. INTRODUCTION

High pressure waterjet cutting (WJC) is one of the so-called non-traditional machining methods using a very high energy density to dissipate material from the workpiece. Abrasive waterjet (AWJ) systems have been commercially available since 1983. This process relies on erosion caused by liquid or solid particle impact, giving the possibility of machining almost all kind of material.

Surface roughness of the cut surfaces is one of the important questions of abrasive waterjet cutting. Efficiency of the waterjet cutting always effects to the accuracy and quality of the cut. For decreasing of the machining costs every user try to choose the feedrate of the cutting head as high as possible, but increasing the traverse speed always causes increasing of inaccuracy and surface roughness.

Experimental investigation was planned for investigation of the problem of cut surfaces at abrasive waterjet cutting. Experiments were accomplished on 10 mm thick AlMgSi0.5aluminium alloy. Microgeometric characteristics were measured on the upper, middle and lower side of the cut section.

2. QUALITY OF THE MACHINED SURFCE

Appearance of striation curves is very characteristic for the abrasive waterjet cutting (Figure 1.) Cut surface is usually divided into two zones: fine cutting zone and rough cutting zone. For the second one appearance of striation curves is very characteristic. From top down of the cut surface inaccuracies increase noticeably.

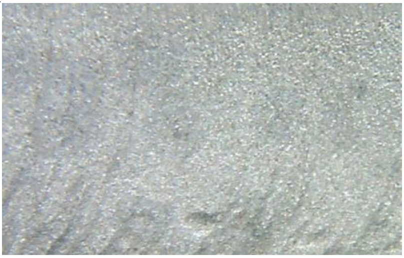

Figure 1 – Characteristic Surface of Aluminium Alloy Cut by Abrasive Waterjet

However measuring results of the mean surface roughness does not show difference in the upper and the lower field of the cut surface. At both side mean roughness $R_a \approx 6$ µm. Reports in the professional literature [1, 2, 3, 4] as well show no significant connection between the mean surface roughness and the technological parameters. For exploring the contradiction between the measured result and the view of the cur surface cutting through experiment were carried out on, after which we measured different roughness parameters (like mean surface roughness R_a, maximum surface roughness R_t, ten-point roughness R_z, waviness W_t and the total profile error P_t.

3. MEAN SOURFACE ROUGHNESS

During the experiments the federate of the cutting head (f), the pressure of the water (p) and the abrasive mass flow rate (m) were changed. Experimental results prove the observations in the professional literature.

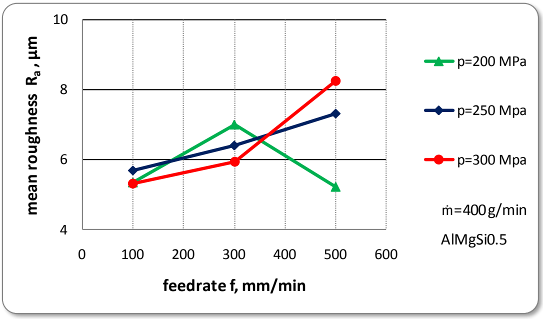

Figure 2 – Change of Mean Surface Roughness in Function of Feedrate

Effect of the federate (f) can be seen on the Figure 2. It can be seen that increasing the extent of the feedrate does not affect unequivocally the mean surface roughness. The measured values of mean surface roughness change in the function of feedrate not synonymous. Basically the mean roughness increases, but at feedrates near the cut through limit thickness the roughness can decrease as well. On the other hand the whole interval of the mean roughness is relatively narrow (5-10um), and dispersion of the measured values is relatively high, influence of the casual effects seems to be high too.

Results coincide with uncertainty of the observations in the professional literature.

Effect of the pressure (p) on the mean surface roughness can be seen on Figure 3.

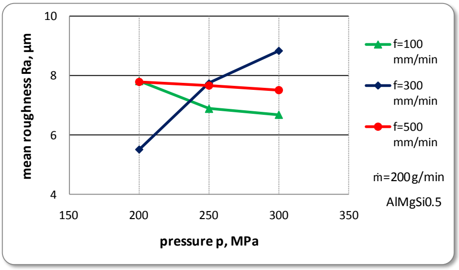

Figure 3 – Change of Mean Surface Roughness in Function of Pressure

Extent of the water pressure, similarly to the federate, does not effects clearly on the mean surface roughness. On different federate values increase of the pressure sometimes increases sometimes decreases the extent of the mean roughness. There is no significant connection between the pressure and the mean roughness.

More significant effects can be observed related to the abrasive mass flow rate (m). Increase of the abrasive mass flow rate unequivocally causes better surface quality ie. decreases the mean roughness. This phenomenon can be explained by that when abrasive mass flow rate increases the number of abrasive grains beat the surface increases, which causes more wear of the surface like if the grains would polish it. This effect results smaller mean surface roughness values.

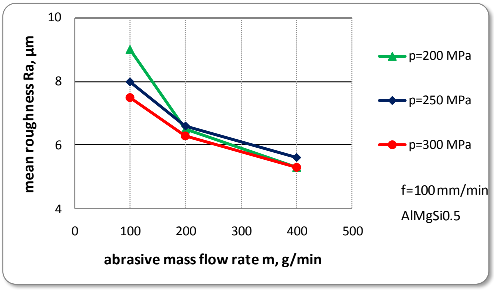

Figure 4 – Change of Mean Surface Roughness in Function of Abrasive Mass Flow Rate

From the result it can be determined, that mean surface roughness is not suitable parameter for characterisation of surfaces cut by abrasive waterjet. New surface topography parameter should be found for qualification of these surfaces.

4. *WAVINESS OF THE CUT SURFACE*

After the cutting experiments the waviness of the surfaces were measured as well. Connection between the technological parameters and the waviness shows a very good correlation. Dependences of the waviness from the federate can be seen on the Figure 5.

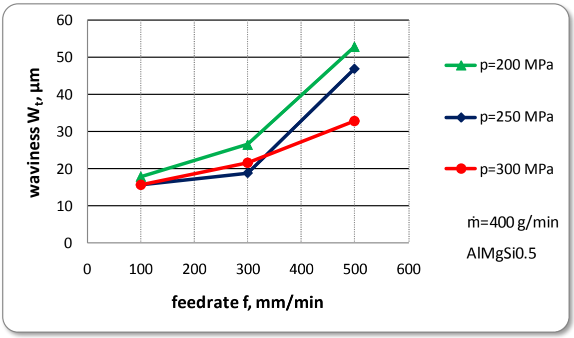

Figure 5 – Change of the Waviness in Function of Feedrate

From Figure 5 it can bee seen that increase of the feederate increases the waviness of the surface very characteristically. It means that the waviness explains the view of the cut surface. Striation of the jet highly changes with the technological parameters and it causes inaccuracies in the waviness.

Effect of all the three parameters (federate, pressure, abrasive mass flow rate) can be recognised on the Figure 6.

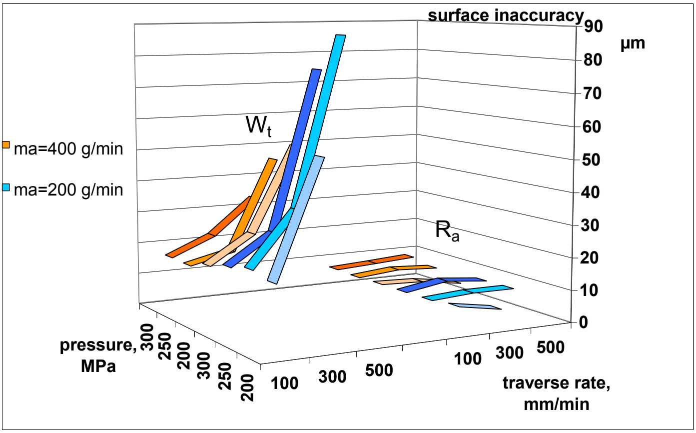

Figure 6 – Microgeometrical Inaccuracies of Surfaces Cut by Abrasive Waterjet Cutting

From the figure it is easy to see that while waviness depends on significantly from the technological parameters, the mean roughness does not show that type of tendency. It is also can be read from the figure that the federate increases, the pressure and the abrasive mass flow rate decrease the waviness of the machined surface.

5. *MATHEMATICAL CORRELATION*

On the base of experimental results a mathematical correlation was established between the technological parameters and the waviness of the cut surfaces. The mathematical connection was looked for in the following form:

$$W_t = A \cdot p^B \cdot m^C \cdot f^D$$

where:

- W_t: waviness
- f: feedrate
- p,: pressure of the water
- m: abrasive mass flow rate
- A, B, C, D: constants should be determined by regression

Results of the regression analysis are summarised in Table 1.

Table 1 – Constants of mathematical correlation between the surface roughness and the technological parameters

Roughness parameter	A	B	C	D	R^2
Waviness W_t	436,51	-0,482	-0,649	0,672	90,4%
Mean roughness R_a	1,419	0,454	-0,159	-0,006	42,4%

In Table 1 correlation coefficient (R^2) is very small for the mean roughness. It means, that there is no correlation between the technological parameters and the mean surface roughness (R^2=42,4%). However a very significant correlation exists between the technological parameters and the waviness of the cut surface (R^2=90,4%). The signs before the constants in Table 1 very clearly show the effect of the different technological parameters on the waviness. Constants of the pressure and the abrasive mass flow rate have minus sign, which means that these parameters increase the extent of the waviness, while the federate decreases it.

On the base of accomplished research it can be summarised that mean surface roughness is not suitable for characterisation of surfaces cut by abrasive waterjet cutting. For qualification of these surfaces waviness is a more suitable parameter.

ACKNOWLEDGEMENT

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