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# Study of the Effect of Material Machinability on Quality of Surface Created by Abrasive Water Jet

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**Abstract**

The paper investigates the effect of material machinability on the quality of cutting surfaces created by abrasive waterjet in selected aluminium alloys. The texture of studied surfaces was measured by an optical profilometer and consequently assessed using the standardized amplitude parameters of the profile roughness *Ra*, *Rz* and *Rq*. It was found that the quality of a cutting surface is significantly influenced not only by the cutting speed and determined machinability of particular aluminium alloy but also by its strength properties.

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*Keywords:* machinability; surface roughness; abrasive waterjet; study of quality; aluminium alloy; optical profilometer

## 1. Introduction

Abrasive waterjet (AWJ) technology is becoming an increasingly popular machining method due to its unique properties, such as the universality, environmental friendliness and near zero thermal impact on the cutting surface. Water of very high pressure being forced through a small nozzle forms a liquid jet where small abrasive particles are added into. High kinetic energy of the water flow accelerates the abrasive particles which enable destruction of a target material in the area of their interaction with the material. Mechanism of material disintegration can be defined as a continuous grinding process caused by abrasive grains using the water jet as a cooling agent as well as a medium for the transport of new abrasives into the cut and removal of the used abrasive grains from the cut.

There are many factors which determine the final quality of the cutting surface created by the AWJ. In addition to the properties of the water jet as a cutting tool (water pressure at the nozzle inlet, diameter of the water nozzle, abrasive type, size of grains and amount of the abrasive used, cutting speed – i.e. traverse speed of the water jet over the material, stand-off distance of the nozzle from the material, etc.), the final appearance of the cutting surface is also influenced by the properties of the machined material. One of these properties which was studied in the presented paper is material machinability, i.e. the ease with which a material can be machined. The machinability is usually defined as a combined impact of physical properties and chemical composition of material on the progress, economic and qualitative results of the machining process [1]. The knowledge of particular material machinability enables to predict appropriate setting of input technological parameters in order to achieve required quality of a cut and to optimize the production process. Material machinability using the AWJ can be determined by a special method [2] based on the creation of non-though cuts (kerfs) in the studied material by the jet under pre-defined conditions. The machinability is then defined based on the amount of the material removed.

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## 2. Amplitude parameters of profile roughness

Quantified form of surface texture of studied materials is described by roughness amplitude parameters (parameter *Ra*, *Rq* and *Rz*). Rules and procedures for the assessment of surface textures are specified in more details in the standard of CSN EN ISO 4288 [3]. This standard establishes the basic roughness sampling length *lr* and the evaluation length *ln* needed for the measurements of R-parameters of periodic and non-periodic surfaces.

***Ra* – arithmetical mean deviation of the assessed profile** is the arithmetical mean of the absolute values of *Z(x)* in a sampling length *lr*. It is one of the commonly-used roughness parameters in the engineering practice. However, the qualitative value of the parameter *Ra* is low as it is not sensitive to the extreme heights of profile peaks and depths of profile valleys. [4]

***Rq* – root mean square deviation of the assessed profile (RMS)** is the root mean squared of *Z(x)* in a sampling length *lr*. Parameter *Rq* is more sensitive to unwanted peaks and valleys of the assessed surface. Therefore, it reaches higher values that the parameter *Ra.* [4]

***Rz* – maximum height of profile** expresses the sum of the maximum value of profile peak height *Zp* on the profile curve, and the maximum value of profile valley depth *Zv* in a sampling length *lr*. [4]

## 3. Machinability assessment of materials

Methodology for assessment of material machinability by AWJ [2] is based on the comparison of removal per unit volume of the tested material with the standard (etalon) material. The weight of the material $m_1$ is measured with an accuracy of ± 0.01 g and the volume $V$ is determined. The specific weight $\rho$ of the tested material is calculated using the relation (1)

$$\rho = \frac{m_1}{V} \ \left[\mathrm{kg} \cdot m^{-3}\right] \tag{1}$$

Consequently, a kerf is done in the tested material during test cutting. The material should not be cut through the entire width. Three kerfs are finally created in all tested materials to ensure higher stability of material removal. The so-created kerfs determine the volume of material removed. The testing sample with kerfs is then dried with a stream of air. The final weight $m_2$ of the tested material is measured. The weight removal $\Delta m$ and volume removal $\Delta V$ of the material are calculated according to the equations (2) and (3):

$$\Delta m = m_1 - m_2 \ [\mathrm{kg}] \tag{2}$$

$$\Delta V = \frac{\Delta m}{\rho} \ \left[\mathrm{m}^3\right] \tag{3}$$

Removal per unit volume of the tested material is determined using the relation (4) where $L$ is the length of the testing kerf. When the removal per unit volume $\Delta V_U$ is known, the machinability index is calculated according to the equation (5) where $\Delta V_{Uet}$ is the removal per unit volume of the standard (etalon) material.

$$\Delta V_U = \frac{\Delta V}{L} \ \left[m^2\right] \tag{4}$$

$$M_1 = \frac{\Delta V_U}{\Delta V_{Uet}} \ [\text{-}] \tag{5}$$

Materials with the machinability index lower than one show worse machinability than the standard (etalon) material. On the contrary, materials with the machinability index higher than one have better machinability than the standard (etalon) material. The standard (etalon) material is aluminium alloy EN AW-1050.