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Copper alloys disintegration using pulsating water jet

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ABSTRACT

This paper deals with on the investigation of surface topography, morphology and anisotropy of copper alloys – brass and bronze, created by pulsating water jet with frequency 20.38 kHz. The material was disintegrated using more passes of a pulsating water jet using flat nozzle, at pressure 40 MPa and stand off distance $z = 55$ mm. The average values of *Ra*, *Rq*, *Rz* roughness were analyzed at changing traverse speed and number of transitions. The effect of tensile strength and material hardness as mechanical properties of material affecting the average value of the roughness has been evaluated. It is assumed that this new way of metal eroding can be used in the automotive and engineering industries in the future e.g. for surface treatment.

1. Introduction

Water jet is currently used for cutting of various types of materials. This technology has several modifications. A continuous water jet is the basic type, to which the modifications of abrasive and pulsating water jet are related. In the case of pulsating water jet (hereinafter referred to as PWJ), the effectiveness of the jet is increased by the generation of pulses. Water jet exiting from the nozzle is continuous at first and later it starts to form individual clusters of fluid. Material is subsequently disintegrated by individual drops of water with high kinetic energy. The field of copper alloys disintegration by PWJ has not been subject to any scientific papers to date. Therefore the experimental observation of groove surface topography formed in the experimental material by disintegration using PWJ has become the objective of the presented research. Comparison of average roughness of *Ra*, *Rq* and *Rz* of grooves and the evaluation of the impact of hardness and tensile strength on the resulting average hardness of individual grooves in brass and bronze were the main objectives of the research. The evaluation of surface topography described in this paper is mainly important for the assessing the required microgeometry and purity of surfaces, creating suitable adhesiveness of new layers, and improving the mechanical properties of surfaces.

Surface isotropy can be an important factor in the process of shaping the surface, improving efficiency, functionality and durability of the parts used in industrial applications. Through careful analysis of surface direction, we can extend the operating life of machinery parts, increase wear resistance and prevent premature failure of parts.

The experiment was implemented in cooperation with the Faculty of Manufacturing Technologies in Presov, Opole University of Technology and with the Institute of Geonics of the CAS, v.v.i. in Ostrava where measurements were carried out. This institute has the technological assembly for the disintegration of materials using PWJ activated by an ultrasonic device. The principle of creating pulses excited

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Nomenclature

PWJ	pulsating water jet	*Ssk*	skewness
WJ	water jet	*Sku*	kurtosis
AWJ	abrasive water jet	*Sa*	average roughness
Ra	mean arithmetic deviation of roughness	*Sp*	maximum peak height
Rq	root mean square deviation of the profile	*Sv*	maximum valley depth
Rz	maximum height of the roughness profile	*Sz*	maximum height of surface
Sq	root mean square roughness	*Sa*	average roughness

in the aforementioned way is based on the generation of vibrations in an ultrasound converter, which are transmitted to water in a nozzle using a waveguide and ultrasonic tool. The water jet exiting the nozzle is continuous, yet it starts to form individual clusters of fluid in a certain distance from the nozzle (Fig. 1). The material is subsequently disintegrated by the shock impacts of water clusters with high kinetic energy.

The erosion effect of water on materials of various types is known from the history Cook [1]. Today, clean (WJ) or abrasive water jet (AWJ) is usually used in industry for the cutting of different materials. However, the application of WJ and AWJ at high pressures has both technological and economic limits. The current trend is the erosion of materials at lower pressures, by the means of pulsating water jet (PWJ) with application in different branches of industry. Many attempts to achieve jet discontinuity had been made, yet the modulation of continuous jet that subsequently starts to form pulses has appeared as the most prospective.

Modulated water jets can be generated by three methods as follows:

The first is represented by internal mechanical modulators of the flow rate, which Nebeker and Rodriguez [2] and Nebeker [3–6] deal with. The authors proposed a mechanical device for achieving pulsating jet that is located in a nozzle and causes the forced periodical modulation of the jet. However, this method has not been applied in practice because the service life of moving components in a nozzle was very short.

The second method of modulation of continuous jets is represented by devices working on the principle of self-resonating nozzles. The authors who discussed these issues were Johnson et al. [7], Chahine et al. [8], Chahine and Conn [9] and Sami and Anderson [10]. Self-resonating nozzles modulate the water jet by creating impact pressure during the flow of liquid through the outlet of a resonant tube that runs back to the inlet where a stationary oscillation is created. If the frequency of impact pressure corresponds to the natural frequency of flow, pressure resonance occurs, and the water jet starts to create discrete annular whirls creating pulses or cavitation Foldyna [11]. Experiments under water were carried out using self-resonant nozzles Gao et al. [12], where paraffin was the cutting medium and cavitation disintegrated material under water.

The generation of ultrasonic vibrations using a natural device, an ultrasound converter, is the third method of continuous water jet modification. This method allows the change of frequency and deviation of amplitude of an

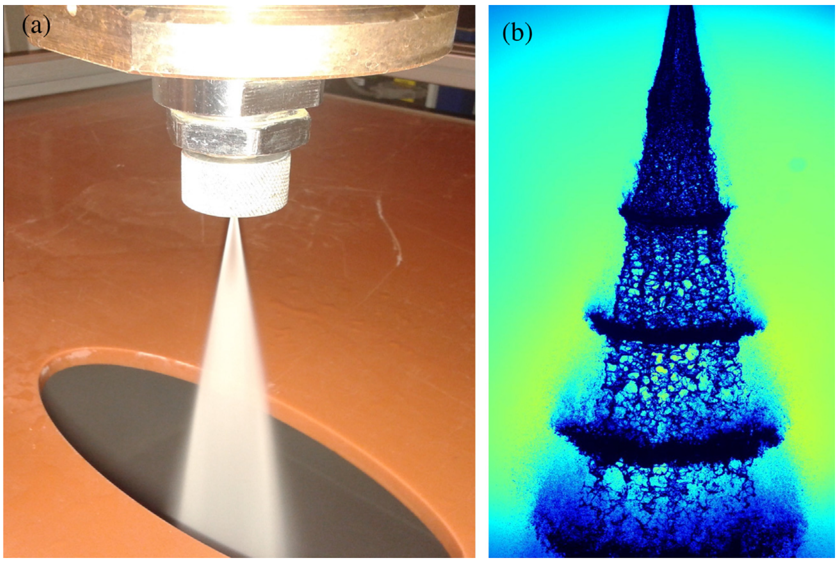

Fig. 1. Pulsating water jet flow (a) real photo, (b) visualization measured by LitronNano TRL 25-250 PIV laser at p = 8 MPa, f = 20.55 kHz, P = 130 W.