Reuse of abrasive particles in abrasive water jet cutting

Ponowne wykorzystanie ziaren ściernych w obróbce wysokociśnieniową strugą wodno-ścierną

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The article presents the possibility of reuse abrasive grains in abrasive water jet cutting. The disintegration particles of garnet # 80 used to create a new abrasive garnet, corresponding to the fresh garnet # 120. In order to determine the ability of cutting recycling abrasive grains was carried out the aluminium alloy cutiing by using fresh and recycling garnet # 120. The experimental study of cutting surface quality focused on evaluation of surface geometrical structure.

KEYWORDS: abrasive water-jet cutting, abrasive grains, surface geometrical structure.

In the high-pressure treatment of the water-abrasive processing, the de-cohesion of the material depends mainly on the hydraulic energy of the water jet and the kinetic energy of the abrasive particles contained in the jet [7]. Available research results indicate that the highest cutting efficiency is obtained with approximately 23% of the mass of the abrasive cloth [6]. Too many abrasive grains in the jet cause the likelihood of interlocking by the individual grains, and as the velocity decreases, their erosion capacity increases [3].

As an intensifier of the erosion process, almanac grenadine is most often used. Although it is a very hard abrasive, its grains undergo intensive crushing during forming and during cutting operations [4]. However, some of the abrasive grains retain their geometric parameters. This allows them to be reused in the cutting process [2]. Even a small addition of recycled abrasive can significantly reduce cutting costs. Therefore, the problem of abrasive recovery combined with the possibility of its reuse is important in the face of increasing use of waterjet technology.

Methodology of research

The purpose of the study was to determine the machinability of specially prepared recycled abrasive # 120 and compare its machinability to unused garnet # 120 [5]. The analysis included assessment of surface topography and parameters of the geometric structure [1] of the cut surfaces of the aluminum alloy EN AW-2017A using the abrasive additives compared. Thickness of cut material was 10 mm.

▪ **Parameters of the cutting process.** Table I summarizes the cutting parameters adopted for the experiment. The research was carried out on the APW 2010BB machine.

TABLE I. Cutting process parameters

Parameter	Unit	Value
Water pressure	MPa	280
Feedrate speed	mm/min	100
Amount of abrasive dosage	g/min	230
Nozzle distance from the cut material	mm	2
Diameter of water nozzle	mm	0,30
Diameter of the forming nozzle	mm	1,02
Length of forming nozzle	mm	75

▪ **Methodology of measurement.** Based on the sieve analysis of the grain composition of the unused garnet # 120, the corresponding abrasive grit was prepared. Recycled material was used as a worn garnet # 80, which was dried and cleaned of impurities. The composition of the prepared abrasive is shown in Fig. 1.

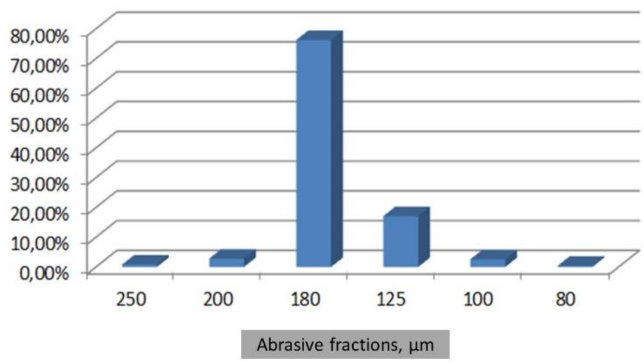

Fig. 1. Composition of the prepared abrasive

Geometric structure parameters were measured on a TOPO02 L120. Samples were examined in three sections, i.e. 1 mm below the upper edge of the cut material (P1), in the center of the workpiece thickness (P2) and 1 mm above the jet outlet (P3).

▪ **Test results.** The JEOL JSM-7610F field-based scanning electron microscope was used to correctly determine the machinability of the abrasives compared.

Fig. 2a shows the view of abrasive grains of unused abrasive # 120. This abrasive is dominated by grains of isometric and pillar-shaped, mostly oblique. Fig. 2b

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shows grain prepared from recycled abrasive. On the basis of the visual assessment, it can be said that most abrasive grains, which have not been excessively crushed, have retained an isometric shape, all with sharp edges. The absence of larger, pillar-shaped grains can be explained by the susceptibility of such grains to crumbling.

a) *b)*

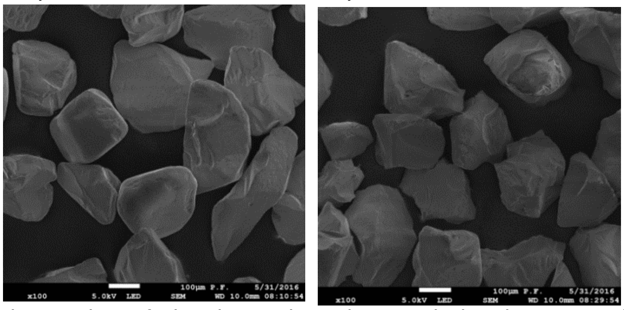

Fig. 2. View of abrasive grains: *a)* unused abrasive # 120, *b)* abrasive # 120 recycled

In order to evaluate the geometric structure of the surface of cut samples by the abrasive test, the parameters based on the profile *R* were compared, such as the arithmetic mean of the profile elevations (R_a), the highest profile height (R_z) and the total profile height (R_t). The results of the measurements are summarized in Table II.

TABLE II. Selected parameters of surface geometry depending on the profile tested and type of abrasive

Parameter	Type of abrasive					
	Fresh abrasive # 120			Prepared abrasive # 120		
Profile	P1	P2	P3	P1	P2	P3
Ra, µm	3,97	6,03	8,54	4,01	5,19	6,54
Rz, µm	32,60	38,91	50,76	32,73	36,79	40,31
Rt, µm	41,02	48,02	69,30	45,01	44,02	46,80

The tested parameters on the P1 profile indicate that this area is characterized by improved cutting quality. As the abrasive jet enters the cut material, its kinetic energy decreases, which translates into the quality of the cut surface obtained. Therefore, the area near the P3 profile is characterized by reduced quality of the cutting surface. Table III shows the percentage changes in surface geometric parameters evaluated after using specially prepared abrasive # 120.

The use of abrasive derived from recycled garnet resulted in a reduction in the tested parameters of P2 and P3 profiles. Particularly visible are changes in the P3 profile, where for each of the parameters tested, the difference was over 20%. On the other hand, the P1 profile showed slight deterioration of the parameters tested, while the parameters R_a and R_z practically did not change the values. There was only a noticeable increase in the R_t value.

TABLE III. Changes in surface geometric parameters after application of specially prepared abrasive # 120

Parameter	Parameter change, %		
Profile	*P1*	*P2*	*P3*
Ra, µm	1,00	-13,93	-23,42
Rz, µm	0,40	-5,45	-20,59
Rt, µm	9,73	-8,33	-32,47

The reduction in values of the parameters tested based on the *R* profile is directly related to the abrasive capabilities of the individual abrasive grains. Most abrasive grains used to prepare abrasive # 120 have isometric shapes with numerous sharp cutting edges. These grains sucked by the water jet have a higher kinetic energy than unused abrasive grains, which increases the erosion capacity of the stream in the lower working area.

A slight decrease in the value of tested geometric surface parameters, especially the R_t parameter for the P1 profile, corresponds to the shape of the abrasive grains. In the case of abrasive preparation # 120, there is practically no complete absence of grainy shapes that perform smoother cuts as compared to sharp-edged grains directly contributing to deeper machining.

Conclusions

The recycled abrasive grains are mostly isometric in shape, which is additionally characterized by numerous sharp edges. This contributes to the increased erosion potential of the water jet using this type of abrasive additive.

The use of recycled abrasives improves the erosion efficiency of the stream, which is manifested by smaller geometric values of the surface geometry at the outlet of the cut material in the so-called *lower cutting zone*.

Unused abrasives have grains of abnormal shapes that perform smoother cuts as compared to sharp-edged grains. This is shown in the form of smaller values based on the profile *R* in the input zone of the workpiece.

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