A Review Of Analysis Of Surface Roughness In Abrasive Water Jet Cutting

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Abstract - **Although Abrasive jet and Water Jet technology has been around for years, abrasive jet equipment has just recently entered the machine tool market. There are a handful of early innovators replacing and complementing conventional machining with water jet cutting methods. Abrasive water jet machining is a non-conventional machining process in which removal of material takes place by impact erosion of high pressure, high velocity of water and entrained high velocity of grit abrasives on a work piece of aluminium. It is superior to many other cutting techniques in processing various materials, particularly in processing difficult-to-cut materials. This technology is being increasingly used in various industries. The objective of experimental investigation is to conduct research of machining parameters impact on surface roughness GMT garnet was used as abrasive material with 80 mesh. Surface roughness was measured across of depth of cut. The experimental results show that traverse speed has great effect on the surface roughness at the bottom of the cut. It was also discussed the correlation between the surface roughness and other abrasive water jet cutting variables. Based on the experiments, the optimal process parameters for each material thickness were defined.**

Keywords - **abrasive water jet cutting; aluminum; surface roughness; traverse speed; abrasive mass flow rate**

1. INTRODUCTION

Abrasive Water Jet Machining is accepted effective technology for cutting various material as of its advantages over other non-conventional techniques such as no heat is generated in the cutting process, high machining versatility, minimum stresses on the work piece, high flexibility and small cutting forces, the abrasives after cutting can be reused which allows for possible reduction of the cutting cost of the process, machining can be easily automated. The process has some limitations and drawbacks though. It may generate loud noise and a messy working environment, the machining is not applicable for machining too thick work pieces, limited number of materials can be cut economically, taper cutting is also a problem with water jet cutting in very thick materials. As in the case of every machining process, the quality of AWJC process is significantly affected by the process tuning parameters. Abrasive water jet (AWJ) cutting tool is used to machine a wide range of metals and non-metals, particularly 'difficult-to-cut' materials such as ceramics and marbles, and layered composites. Compared with the traditional and other non-traditional machining methods, the AWJ cutting technology has a number of distinct advantages, such as no thermal distortion, high machining versatility, ability to produce contours, good surface quality, easy integration with mechanical manipulators, and minimal burrs. The environment friendly nature of this process is makes it more enough preferable over many other processes. It has got some disadvantages too such as It cannot cut materials which degrades quickly with the moisture. Higher cutting speeds are frequently used for rough cutting purpose which degrades the surface. Thickness may cause the taper. High pressure handling, high pressure is always dangerous.

Abrasive water jet is not the quickest way to cut, and a long time spent cutting increases the cost of cutting. From these findings, it is clear that the water jet technique is the most suitable of those compared for cutting metals.

method of cutting	abrasive water jet	laser beam	plasma beam
speed	slow	fast	fast
material thickness	thick and thin	thin and medium	medium and thick
size details	small and large	small and large	large
shapes	complicated	complicated	simple
materials suitable for intersection	most of solid	homogeneous with no reflective bodies	metals and conductive materials
materials covered with rust	very good	good	average
composites	yes	no	no
material hardening	no	yes	yes
thermal deformation	lack	yes, small area	yes, wider area
hazardous vapors	no	yes	yes
multilayer cutting	possible	impossible	impossible
precision cutting	high	higher	good
burr formation	minimal	yes	yes
operating costs	topmost	lower	lower

There are numerous associated parameters in this technique among which traverse speed, nozzle speed, stand-off distance, diameter of focusing nozzle, abrasive mass flow and material thickness are of great importance but precisely controllable. The main process quality measures include attainable depth of cut, material removal rate and surface finish. The surface roughness is mainly a result of various controllable or uncontrollable process parameters and it is harder to attain and track than physical dimensions are. A considerable number of studies have researched the effects of the feed rate, stand-off distance, water pressure, abrasive grain size and other factors on the surface roughness. Thus, it is necessary to have a deeper knowledge about the optimum operation conditions, which will permit us to assure a good surface roughness.

One Variable at a time analysis (OVAT) analysis is very much important tool utilized widely in engineering analysis. Control factors and their levels are selected for experimentation by using OVAT analysis. The main purpose of performing OVAT analysis is to clear that whether the selected process parameters having influence on quality
characteristic. OVAT analysis perform by varying one process parameter from lower to higher value by keeping all other process parameter constant, and measure the effect on quality characteristic

The aim of this study was examined the effects of abrasive water jet variables such as traverse speed, abrasive mass flow and material thickness on surface roughness in abrasive water jet cutting of aluminum. The varied surface roughness across the depth of cut was also examined.

1.1 EXPERIMENTAL SETUP

i. The experiments were conducted on a NC 3015 EB abrasive water jet cutting system.
ii. KMT Streamline SL-V 50 ultra-high-pressure pump.
iii. Maximum water pressure of 413.7 MPa.
iv. Cutting was performed on aluminium plates of different thicknesses 15 mm and 30 mm.

Constant Parameter	Value
Orifice Diameter	0.20 mm
Focusing Tube Diameter	0.762 mm
Water Jet Pressure	350 MPa
Abrasive Type	GMT Garnet
Abrasive Size	80 Mesh

Table 1 Constant Process Parameters

	Transverse Speed(mm/min)	Abrasive Mass Flow Rate(g/min)
Material Thickness 15 mm	70,100,139,250,350	100,130,200,250,320
Material Thickness 30 mm	37,49,69,109,130	240,285,320,350,390

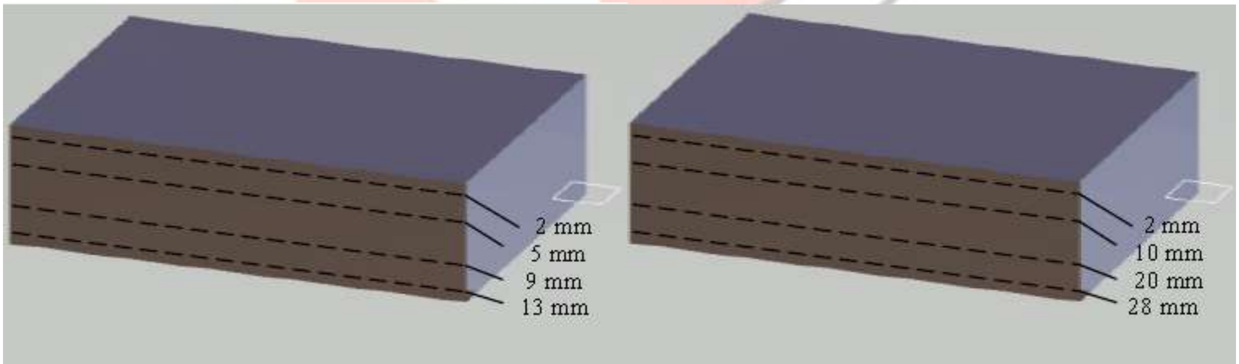
Table 1 Variable Process Parameters

1.2EXPERIMENTAL PROCEDURE

The controlled parameter has been the surface roughness. Surface roughness (with a cutoff of 0.8 mm) on the cut surface was measured in terms of the average roughness *Ra*, using the Surf-Test Mitutoyo stylus instrument. (Fig. A & B) The measurement of surface roughness was performed in the Laboratory for Cutting Technologies-LaTOOS, Faculty of Mechanical Engineering in Sarajevo. Surface roughness (R*a*) measurements are made at different zones of the cut surface. (Fig. C&D)

Fig. A: the samples with linear cuts prepared for the measurement of surface roughness

Fig. B: The measurement of surface roughness



Schematic view of the cut surface where roughness was measured: C) sample of 15 mm; D) sample of 30 mm thickness

2. RESULTS & DISCUSSIONS

The effect of the process parameters such as: traverse speed, abrasive mass flow rate and material thickness on the surface roughness during AWJ cutting of aluminum plate were analyzed.

Case 1: The effect of the traverse speed on the surface roughness.

The effect of the traverse speed on the surface roughness during AWJ cutting of a 15 mm thick rate, *m*= 320 g/min. Experiments were made at the constant value of abrasive mass flow rate, *m* = 390 g/min.

The effect of the traverse speed on the surface roughness in AWJ cutting of a 30 mm thick aluminum plate is shown in Fig. F. Experiments were made at the constant value of abrasive mass flow rate, *m* = 390 g/min

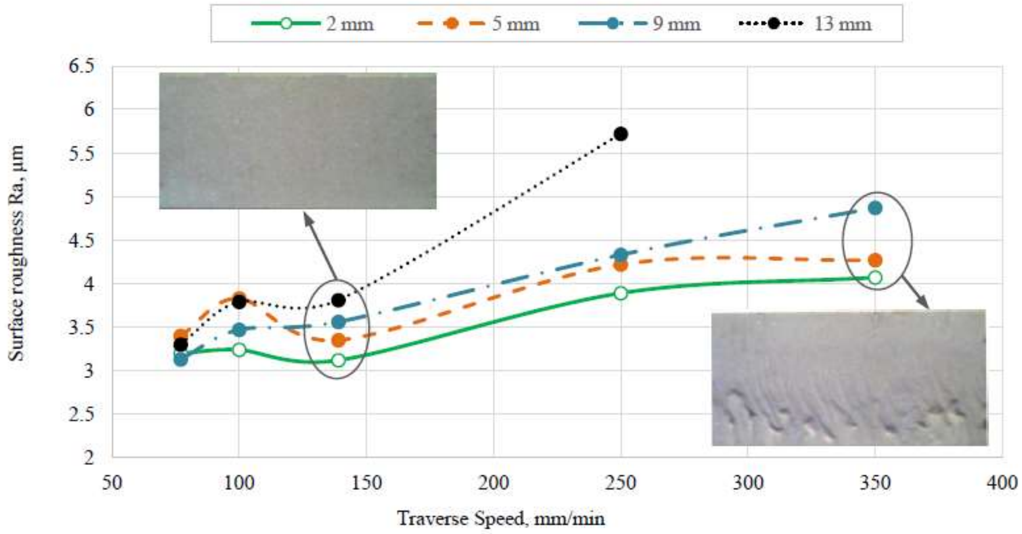


Fig. E: The effect of traverse speed on the surface roughness on different zones of the cut surface – 15 mm thickness.

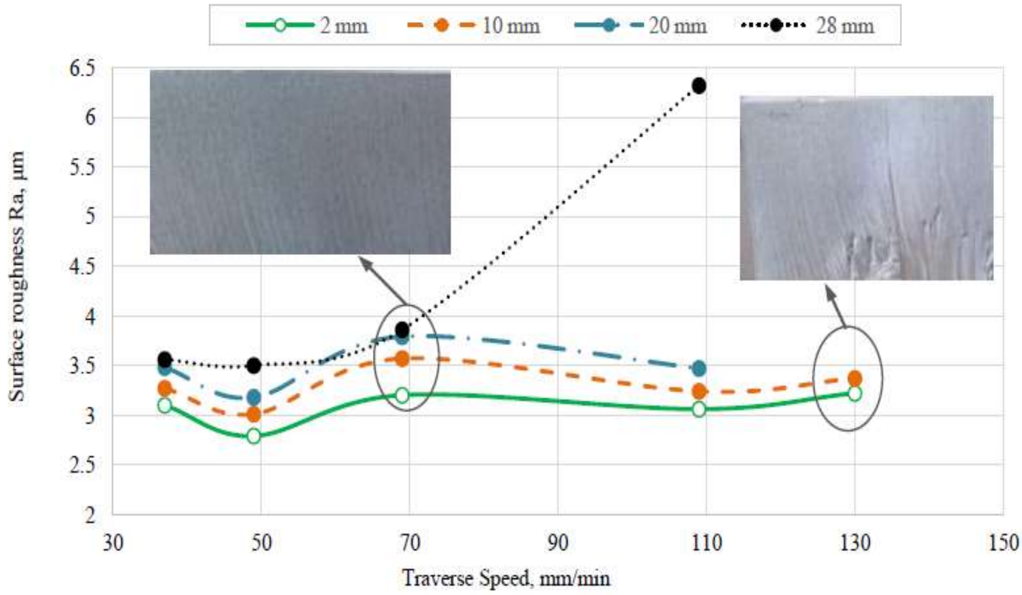


Fig. F: The effect of traverse speed on the surface roughness on different zones of the cut surface – 30 mm thickness

It can be seen that the surface roughness increases by increasing of traverse speed. Also, it can be observed that the roughness *Ra* slightly changes through the whole depth of cut surface at low traverse speeds e.g. at a speed of 139 m/min and less. The surface roughness increases by increasing of the depth of cut surface, especially at the higher traverse speeds. The cut sample was considered unacceptable at a speed of 350 mm/min, because the roughness has been unable to measure at the depth of 13 mm from the entry jet.

Case 2: The effect of the abrasive mass flow rate on the surface roughness

The effect of the abrasive mass flow rate on surface roughness during AWJ cutting of a 15 mm thick aluminum was shown in Fig. G. Experiments were made at the constant traverse speed, v = 77 mm/min.

The effect of the abrasive mass flow rate on surface roughness during AWJ cutting of a 30 mm thick aluminum was shown in Fig. H. Experiments were made at the constant traverse speed, v = 37 mm/min.

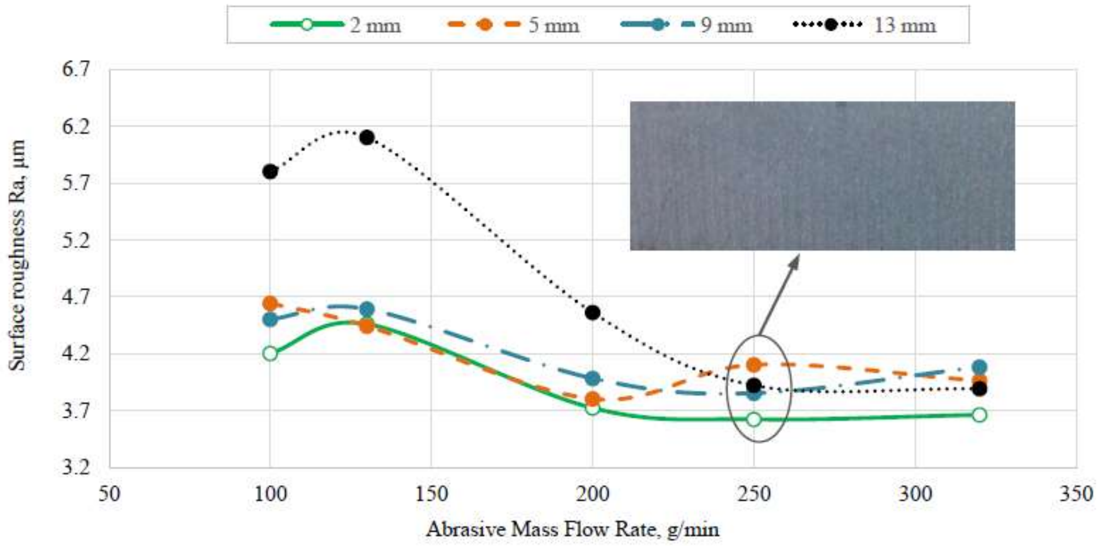


Fig.G: The effect of abrasive mass flow rate on the surface roughness on different zones of the cut surface – 15 mm thickness.

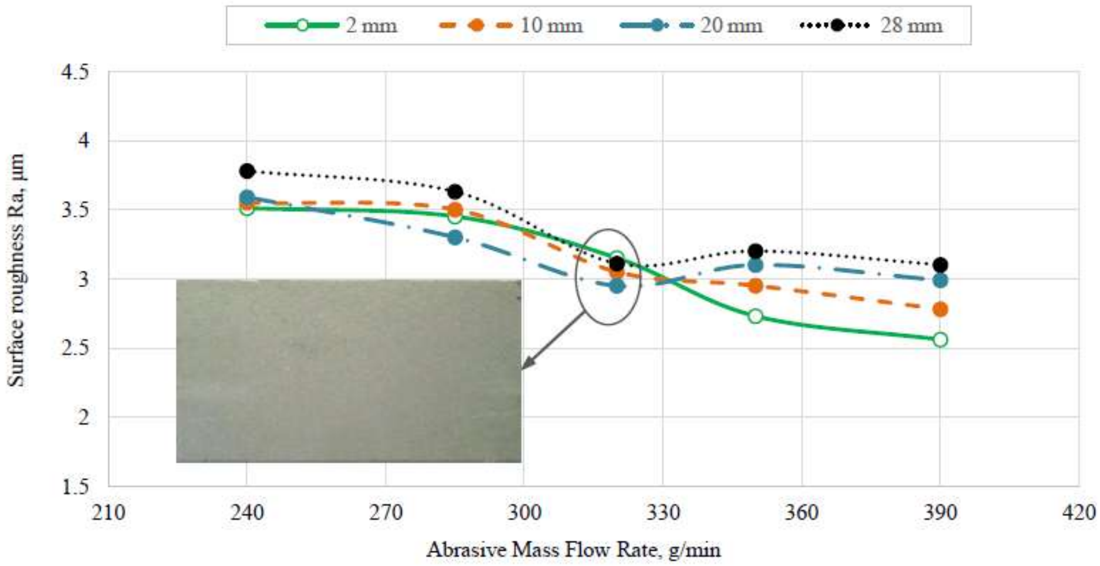


Fig.H: The effect of abrasive mass flow rate on the surface roughness on different zones of the cut surface – 30 mm thickness.

As seen in Figs. g and h, the surface roughness decreases by increasing of abrasive mass flow rate. Under the analyzed conditions, the effect of abrasive mass flow rate depends of the cut's depth. As shown in Fig. G, the effect of abrasive mass flow rate on the surface roughness increases as the cut's depth increases. Based on the above results, the optimal abrasive mass flow rate was 250 g/min and 320 g/min during AWJ cutting of aluminum plate of 15 mm and 30 mm thickness, respectively.

Case 3: The effect of the material thickness on the surface roughness

The effect of material thickness on the surface roughness during AWJ cutting of aluminum plate of 15 mm and30 mm thickness was shown in Fig. I. Experiments were made at the constant abrasive mass flow rate, 320 g/min (for thickness of 15 mm) and 390 g/min (for thickness of 30 mm).

An increase in material thickness caused an increase in surface roughness, especially on the bottom of cut. The smallest change in the surface roughness was occurred at the lower traverse speeds.

The traverse speed has no great effect on the surface roughness at the beginning of cut. By increasing the depth of cut and the traverse speed, the surface roughness increases. As shown in Fig. I, the traverse speed strongly depends of the material thickness, by increasing the material thickness, the traverse speed decreases.

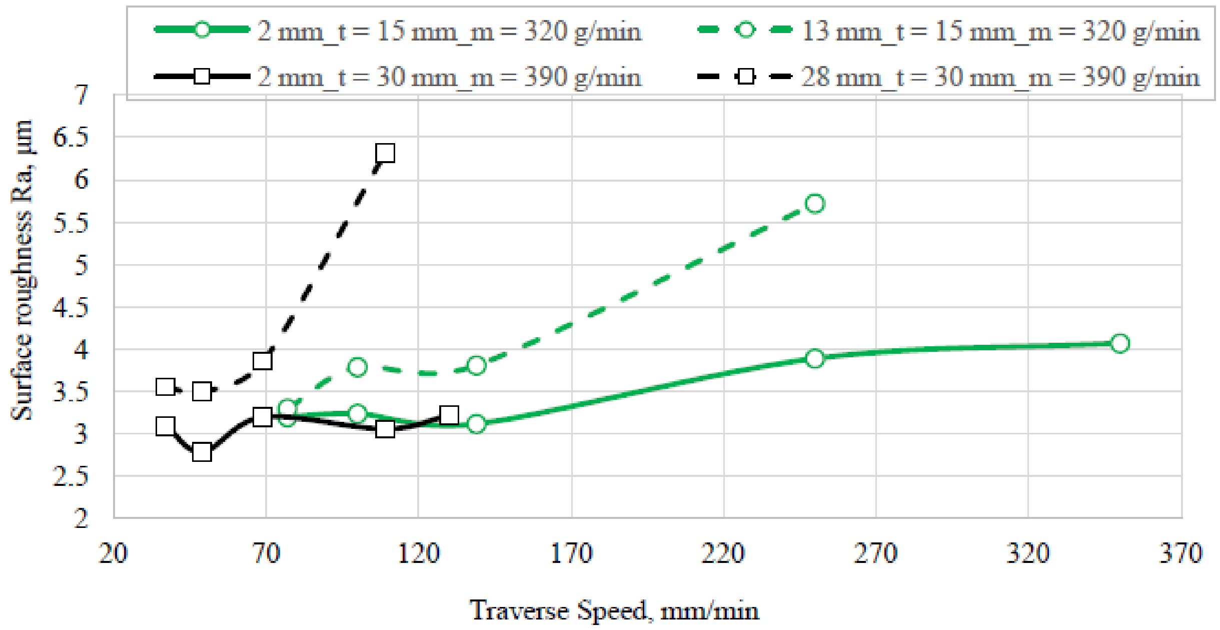


Fig. I: The effect of material thickness on the surface roughness at the different traverse speeds.

3. CONCLUSION

Abrasive Water jet cutting is the most versatile method for the separation of materials, and that this technique can cut through almost any material such as steel, stone, ceramics, aluminium, glass, wood, plastics, laminates, etc. There is no limit related to current conductivity and reflection of light. This method of cutting is an environmentally friendly process that does not produce any harmful fumes. The only materials used are water and the abrasive. The water jet technique can cut thick as well as thin materials which is not the case with other methods which are only successful when cutting to a certain thickness. Compared to laser and plasma cutting, water jet cutting material is a method by which there is no thermal deformation of the cut material. Due of comprehensive experimental research, detailed theoretical investigations and performed analysis, it is possible extract followed conclusions:

- The surface being cut by the abrasive water jet was characterized by two types of surface texture. The first texture was located at the beginning of the cut and was characterized by the smooth surface. The second texture was located at the bottom of the cut and was characterized by the rough surface.
- The optimal solution is the choice of medium traverse speed with which can be achieved higher productivity with acceptable surface roughness.
- Also, in order to reduce processing costs, the abrasive mass flow rate may be reduced in relation to the manufacturer's recommended value, because the surface roughness slightly changes by increasing the abrasive mass flow rate.

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