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Experimental Investigation of Surface Roughness in Abrasive Water Jet Machining

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Abstract- In this paper the effect of abrasive flow rate, water pressure and Stand-off distance (SOD) on surface roughness of Aluminum using abrasive water jet cutting was examined. Here garnet was used as abrasive material which is having 80 mesh. The Experiment gave the relation between surface roughness and various process parameter. The surface roughness (Ra)plays a most important factor which determines the quality of the engineering components. Here the experiment was carried out by varying water pressure, abrasive grain mass flow rate and standoff distance for cutting aluminum using abrasive water jet machining process. The effect of these various level parameter is that when jet pressure increases, surface roughness decreases, when abrasive flow increases, Ra decreases and with last parameter that is SOD increases, Ra increases. It was concludedthat water pressure should be high, abrasive flow rate also should be high while standoff distance should be less to get good quality cutting.

Index Terms-Abrasive water-jet, garnet, water pressure, abrasive mass flow rate, design of experiment.

1. INTRODUCTION

The abrasive water jet machining [AWJM] has been found to be the most recent developed technology of non-traditional methods that are used in industries as there is no thermal distortion here. As the name suggests abrasive water jet machining make use of both the principle of abrasive jet machining and water jet machining. In this type of machining, a jet of water which contains the abrasive particles are struck against the work piece at high velocity and high pressure. Due to erosion, the materials is being removed here. AWJM is being used in many industries for a long time. AWJM is used for machining of various materials like composite, brittle, ferrous and non-ferrous. The impact of water is sufficient to remove the material but the material must be soft so with the addition of abrasive particles, now harder materials can also be machined.

The characteristics of the engineering components largely depends upon surface roughness. The surface roughness for a materials indeed depends on factors like jet pressure, standoff distance, traverse speed, work material etc. There have been many researches that were carried out on various parameter of AWJM. Fecaier [1] and Ohlsson and Magnusson [2] have investigated the structure and properties of water jet. Mr Tikhomirrow [3] worked on feed rate depending upon the distance between nozzle and work piece. The AWJM is inertia less cutting process that offers advantages like narrow kerf width, negligible heat affected zone, material waste reduced and flexibility to machining process in different way [4]. There are many parameters and factors of AWJM process that can influence the surface finishing quality of AWJ machined surface [4-6].

AWJM is superior to many other machining process and is used extensively in industry [7]. However there are some limitations and drawbacks like it generates loud noise, create tapered edge on kerf at high traverse

speed [8-9]. The main quality measure are done in terms of surface finish, kerf width and depth of cut [10-13]. In order to optimize AWJM process, many predictive models for depth of cut have been developedfor brass, titanium, aluminum, stainless steel etc [14-16]. In this paper, surface roughness is considered to measure the quality of engineering components.

2. EXPERIMENTAL WORK

Aluminum is taken as the work piece material. Aluminum is a silvery white metal which is non-magnetic and excellent conductor of electricity. The dimensions of aluminum plates were 5mm x 300mm x 350mm.

2.1. *Machine specifications*

Type- CNC Mach 2B

Current- 34.42 Amp

Frequency- 50/60 Hz

Table size – 2 x 4 m

Model - M2-4020B

Jet impinging angle-90^{o}

Fig.1.AWJM

All the Experiment have been conducted on CNC Mach 2B Abrasive water jet machining manufactured by flow. The main part of Abrasive water jet machining are pump, CNC control, nozzle, power supply, Intensifier, Hopper etc.

Fig.2. work piece

2.2. *Experimental parameters*

The process parameters like stand-off distance, abrasive material, abrasive particle size, abrasive flow rate, mixing tube diameter have significant effect on machining of material.

In Table 1 there is constant parameters and in Table 2 selected parameters like abrasive flow rate, SOD and pressure with different levels are taken.

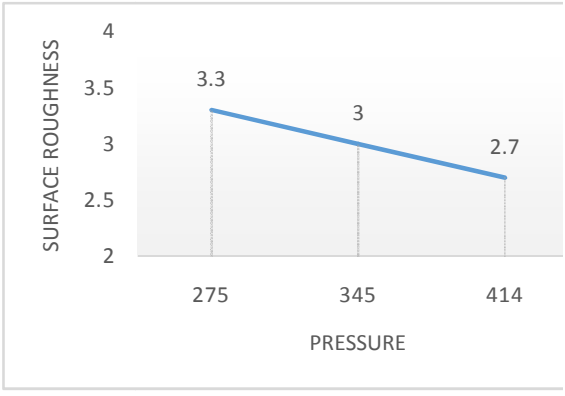
Table 1. Fixed Parameters

Parameter	**Value**
Abrasive type	Garnet
Mesh	80 mesh
Jet Offset	0.5588mm
Water Flow Rate	3 litres/min
Angle	90^{o}
Orifice Diameter	1.01mm

Sl. no.	**Machining Parameter**	**levels**			
		1	**2**	**3**	**Units**
1	Abrasive Flow Rate	480	420	360	gram/min
2	SOD	10	6	4	mm
3	Pressure	414	345	275	M-Pa

Table 2. Factors with levels

The controlled parameter has been the surface roughness which was measured in terms of surface



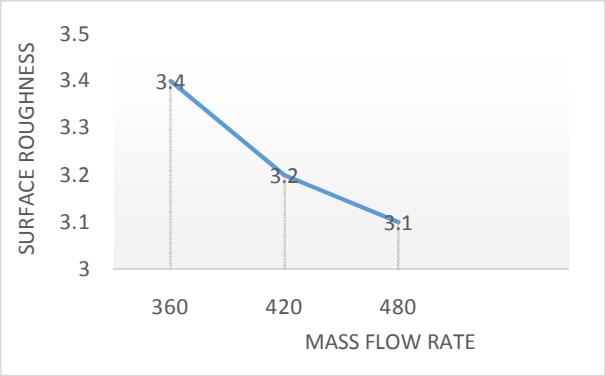
roughness (Ra) in µm using surface-test stylus instrument.

3. RESULTS

In this sections, the effect of different level factors on surface roughness during cutting of aluminum plate with AWJM was analyzed.

3.1. *The effect of Abrasive mass flow rate on surface roughness*

The effect of the abrasive mass flow rate on surface roughness on Aluminum was shown in fig-4.



Experiments were made at constant traverse speed

Fig.3**.** Abrasive Mass Flow Rate vs. Ra

80mm/min. There need to be a larger number of impact per unit area under certain pressure to overcome the bond strength of any material, so with the increase in abrasive mass flow rate, the surface roughness decreases.

3.2. *The effect of water pressure on surface roughness*

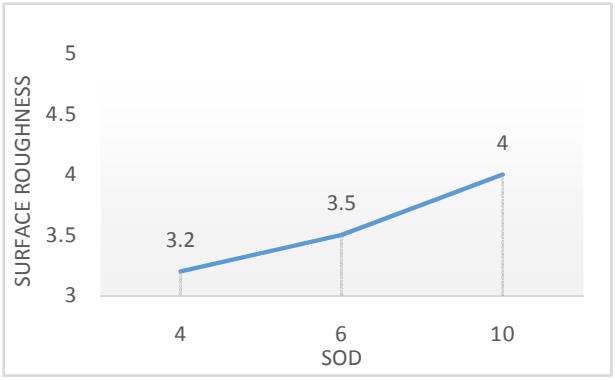
The effect of water pressure on surface roughness is that, the surface roughness will decrease with increase in water pressure as shown in the given below figure. Here Abrasive mass flow rate is 320 gram/min and SOD as 4mm.

So it is advisable to keep pressure maximum possible.

Fig.4. Pressure vs. Ra

3.3. *The effect of stand-off distance on surface roughness*

The effect of SOD on surface roughness is that it increase with increase in SOD. The higher SOD will allow the jet to spread before impingement which may increase drag from the surroundings. Here jet pressure is 270MPa and Abrasive mass flow rate 240 gram/min.So it is advisable to keep Stand-off



distance as less as possible.

Fig.5. SOD vs. Ra

4. CONCLUSION

From the above experiment, the conclusion is that,

- Surface roughness Ra decrease as abrasive mass flow increases. So use higher amount of abrasive mass to decrease surface roughness.
- Surface roughness Ra decreases with increase in pressure. So it is recommended to use high pressure during cutting operations.
- Surface roughness Ra increases as distance between jet and work piece increases. So it is recommended to keep low stand-off distance to achieve good cutting performance.

The Abrasive water jet machining is suitable machining process to meet the demand of today's applications. The glass and advance ceramics which is showing growing trend in industries have been experimented using AWJM process. It is being used as there is no thermal stress in materials and it can be combined with other process to improve the surface characteristics. Apart of cutting, many operations like drilling, turning and milling can be done using AWJM. Very less research has been done to study the effect of abrasive mass flow rate on surface characteristics. Hence there is a scope of improvement there.

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