"EFFECT DISSIMILAR PARAMETERS FROM ABRASIVE WATER JET MACHINING WITH GLASS MATERIAL"

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ABSTRACT: Different types of abrasives are used in abrasive water-jet machining (AWJM) like garnet, aluminium oxide, olivine, silica sand, silicon carbide, etc. Experimental investigations were conducted to assess the influence of AWJM process parameters on surface roughness (Ra) of glass. It was found that the type of abrasive materials, hydraulic pressure, standoff distance and traverse rate were the significant control factors in controlling the Ra. The present work gives a comparative analysis of the performance of different parameters during abrasive water-jet machining of glass. Due to increase in cutting speed and S.O.D. roughness is also increase. Increasing the hydraulic pressure and abrasive mass flow rate may result in a better machining performance for both criteria and decreasing the standoff distance and traverse rate may improve both criteria of machining performance.

I. INTRODUCTION

Abrasive water jet machining (AWJM) is a well-established non-traditional machining process used for cutting difficult-to machine materials. This technique is especially suitable for very soft, brittle and fibrous materials. It is a machining process without much heat generation and the machined surface is virtually without any heat affected zone or residual stress [5]. But it has some drawbacks; especially it may generate loud noise and a messy working environment [4]. Different types of abrasives are used in AWJM like garnet, olivine, aluminium oxide (Al_2O_3), silica-sand, glass bead, silicon carbide (SiC), zirconium, etc. The cut geometry depends on the type of abrasives and cutting parameters like cutting speed, standoff distance (SOD) of the nozzle from the target, work feed rate, abrasive mass flow rate, etc. Efforts have been made to improve the cutting performance of the abrasive water jet. In the present work an investigation has been carried on to study the comparative cutting performance of different parameters during AWJM of glass. In the AWJM process, the possibilities of environmental contamination due to fibrous materials are significantly reduced or eliminated since water jet washes away the eroded material from the surface of the work piece [3].

II. Material Removal Rate Principle for Abrasive Water Jet Machining

The general domain of parameters in entrained type AWJ machining system is given below:

- Pressure – 2500 to 4000 bar
- Abrasive – garnet and olivine - #125 to #60
- Abrasive flow - 0.1 to 1.0 Kg/min
- Standoff distance – 1 to 2 mm
- Focussing Tube – WC – 0.8 to 2.4 mm
- Orifice – Sapphires – 0.1 to 0.3 mm
- Machine Impact Angle – 60^{o} to 90^{0}
- Traverse Speed – 100 mm/min to 5 m/min
- Depth of Cut – 1 mm to 250 mm

Mechanism of material removal in machining with water jet and abrasive water jet is rather complex. In AWJM of ductile materials, material is mainly removed by low angle impact by abrasive particles leading to ploughing and micro cutting.
In water jet machining, the material removal rate may be assumed to be proportional to the power of the water jet [6].

$$MRR \alpha P_{wj} \alpha C_d \times \frac{\pi}{4} d_o^2 \times \sqrt{\frac{2p_w^3}{\rho_w}}$$

$$MRR = u \times C_d \times \frac{\pi}{4} d_o^2 \times \sqrt{\frac{2p_w^3}{\rho_w}}$$

The proportionality constant *u* is the specific energy requirement and would be a property of the work material [6].

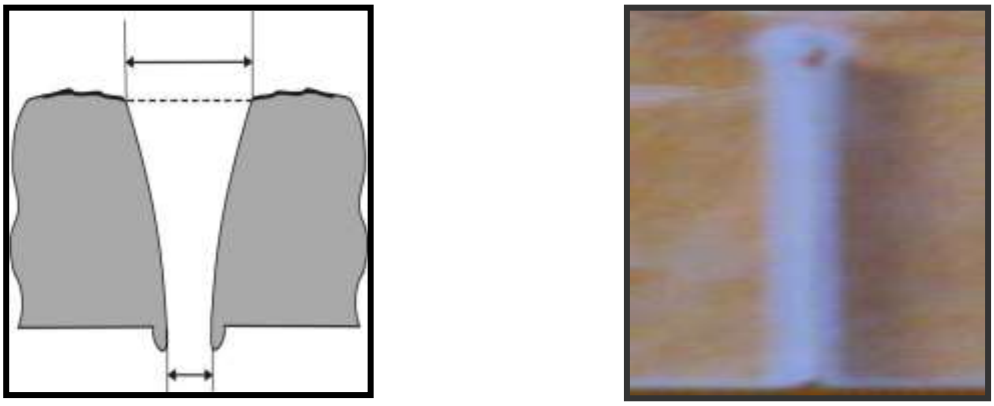

Fig. 1 (A) Schematic of AWJM kerf (B) Kerf width of speciment

Fig. 1 show the cut generated by an AWJM in different sections. It is called a kerf. The top of the kerf is wider than the bottom of the kerf. Generally the top width of the kerf is equal to the diameter of the AWJ. Once again, diameter of the AWJ is equal to the diameter of the focusing tube or the insert if the stand-off distance is around 1 to 5mm. The taper angle of the kerf can be reduced by increasing the cutting ability of the AWJ. Fig. 12 shows the longitudinal section of the kerf. It may be observed that the surface quality at the top of the kerf is rather good compared to the bottom part. At the bottom there is repeated curved line formation. At the top of the kerf, the material removal is by low angle impact of the abrasive particle; whereas at the bottom of the kerf it is by plastic failure. Striation formation occurs due to repeated plastic failure.

Thus, in WJM and AWJM the following are the important product quality parameters.

- Striation formation
- Surface finish of the kerf
- Tapering of the kerf
- Burr formation on the exit side of the kerf

Models proposed by Finnie, Bitter, Hashish and Kim though are very comprehensive and provide insight into the mechanism of material removal; require substantial information on different aspects and parameters which may not be readily available.

III. Experimental procedure

The work material used in this investigation was glass. The main properties of glass are: hardness, 600 knoops; density, 2200 kg/m3; tensile strength, 70MN/m2; specific heat capacity, 750 J/kg ◦C. Abrasives used in the present study were silica-sand. The experiments were conducted on a water jet machine DWJ3020-BA/B. The machine was equipped with a controller type 2100 CNC Control. The nozzle used for the abrasive water jet was made of carbide with the orifice diameter of 0.25 mm. The jet was perpendicular to the work surface.

IV. Results and discussions

In the investigation on the effect of different parameters during AWJM of glass, following result was conducted which is given in the table 1.in which when one parameter is varied other are constant such as cutting speed is 400 mm/min, SOD is 2 mm and abrasive flow rate is 600 gm/min. The abrasive use for the following parameters is silica sand.

Fig 2. Specimens of glass

Table 1. Observation table of different parameters of AWJM

Name of parameters	SR No.	Variation	Surface roughness (micrometer)
cutting speed (mm/min)	1	200	3.47
	2	400	5.27
	3	600	5.45
	4	800	6.45
	5	1000	7.55
Abrasive flow rate (gm/min)	1	200	4.93
	2	400	6.66
	3	600	5.32
	4	800	8.43
	5	1000	5.56
SOD (mm)	1	2	5.03
	2	4	5.7
	3	6	5.96
	4	8	6.13
	5	10	6.42

4.1 Effect of cutting speed on surface roughness

In the investigation on the effect of cutting speed during AWJM of glass, it was found that when the speed was increase the roughness of glass material also increases. Consequently, the surface of cuts became smoother at lower speed as seen in Figure 3.

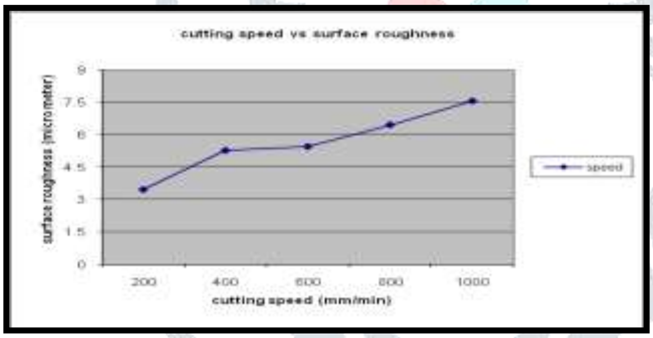

Fig.3. Effect of cutting speed

4.2. Effect of Abrasive flow rate on surface roughness

An increase in abrasive flow rate leads to a proportional increase in the depth of cut. When the abrasive flow rate is increased, the jet can cut through the laminate easily and as a result, the cut surface becomes smoother. However, the roughness increases with an increase in abrasive mass flow rate up to a certain limit and beyond that limit it was found to decrease as illustrated in Figure 4.

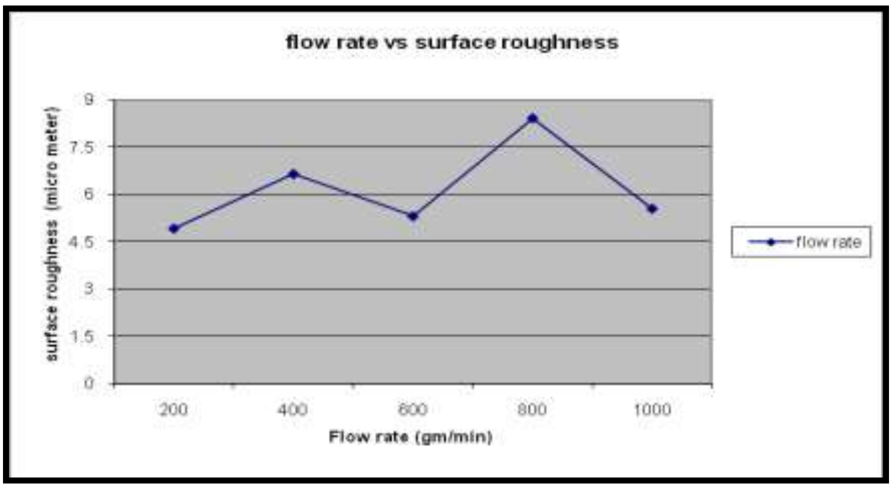

Fig. 4.Effect of Abrasive flow rate

4.3. Effect of SOD on surface roughness

In the investigation on the effect of SOD during AWJM of glass, it was found that when the speed was increase the roughness of glass material also increases. Consequently, the surface of cuts became smoother at lower sod as seen in Figure 5.

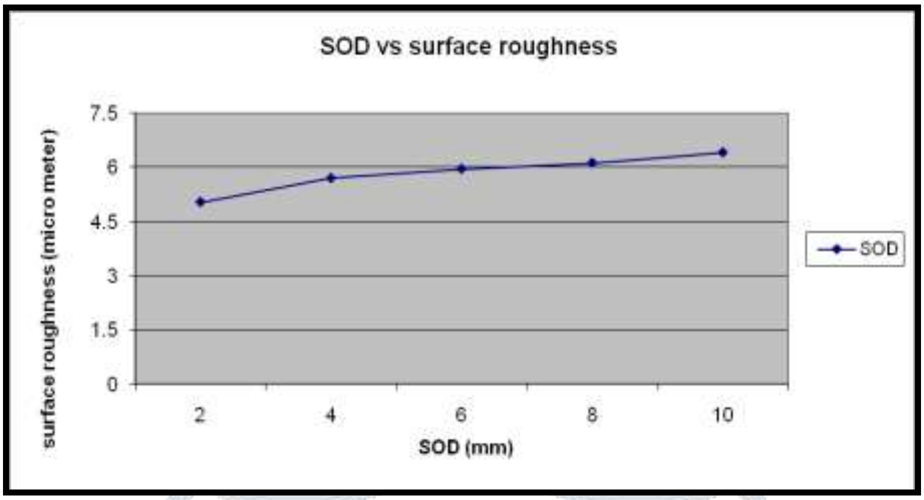

Fig. 5.Effect of SOD

V. Conclusions

From the above discussions, it can be concluded that roughness increases with increase in SOD. Garnet abrasives produce a larger taper of cut followed by Al2O3 and SiC. This is due to higher hardness of SiC compared to Al2O3 and garnet. An increase in SOD increases the focus area of the jet and increases the average width of cut. As a result, its cutting ability is also higher than that of Al2O3 and garnet. Standoff distance (mm) and cutting speed (mm/min) were considered as the most significant control factor in influencing **Ra** respectively. Decreasing the standoff distance and traverse rate may improve both criteria of machining performance. Cutting orientation does not influence the machining performance in both cases. The type of abrasives is the most significant control factor on surface roughness during AWJM. Abrasive flow rate (gm/min) is equally significant.

VI. References

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