PROCESS PARAMETER EFFECT ON SURFACE FINISH IN ABRASIVE WATERJET MACHINING-A REVIEW

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Abstract

Abrasive waterjet cutting has been proven to be an effective technology for processing various engineering materials. Surface roughness is one of the major machining characteristics that play a vital role in determining the quality of components which is to be machined. This paper assesses the influence of process parameters on surface roughness (R_a) which is an important cutting performance measure in abrasive waterjet machining. The effects of various parameters on surface roughness have been reviewed through various literatures and it is found that transverse speed and waterjet pressure plays a significant role in determining the surface roughness.

Keywords: AWJM, Surface Roughness, transverse speed, cutting direction, abrasive material.

1.Introduction:

Water jet technology is a non-traditional industrial method that can be used for cutting operation. Today, the abrasive water jet technology has become a very competitive non-conventional cutting technology. It is the Fastest growing machining process. The mechanism behind the material removal in conventional AWJM is erosion caused by abrasive particles entrained in high velocity water jet. It is cheaper than other processes.It can cut virtually any material. (pre hardened steel, mild steel, copper, brass, aluminum; brittle materials like glass, ceramic, quartz, stone). It has various advantages over conventional machining there are no thermal distortion, high flexibility, small cutting force. The process can be controlled easily to vary the metal removal rate which depends on flow rate and size of abrasive particles. This process is best suited for machining super alloys and refractory type of materials, and also machining thin sections of hard materials and making intricate hard holes. The cutting action is cool because the carrier gas serves as coolant.

2. Literature Survey:

In this section we will discuss the experimental analysis of Abrasive water jet machining.

Rongrong li, Mats ekevad, Xiaolei, Pingxiang Cao, Quingquing Chen, and Hong Xue[1] have conducted experiment on surface roughness for recombinant bamboo abrasive water jet cutting. They did this experiment by using recombinant bamboo of two different thicknesses 10mm,15mm and they were cut both longitudinally and transversely (cutting direction). By doing this experiment they found that Surface roughness was higher when cutting fiber transversely than when cutting longitudinally and also it was found that within the limit of study decreasing the feed rate and abrasive mass flow rate may improve the surface quality.

Experimental investigation of surface roughness obtained on various materials have been summarized as follows in machining hard ox steel[2] by using AWJM experimental results show that transverse speed plays a vital role in determining the quality of the material. While machining Aluminum 7475[3] the results showed that water jet induces compressive residual stress which generate increase in surface roughness. During machining of HSS ,316L stainless steel [4-5] by AWJ by considering parameters like jet water speed, abrasive flow and standoff distance the optimal results were obtained as pressure=80.5 mm/min, mass flow rate=299.37 g/min, standoff distance=1.2 mm.During machining borosilicate glass[6] which is an amorphous material it was found that high velocity abrasive impinges on the surface hence brittle fracture occurs on the top surface which eventually reduces the surface quality.During machining of Cast Iron[7] it was found that optimal selection of four basic parameters water pressure, abrasive flow rate,transverse speed,nozzle standoff distance are the important parameters for controlling surface roughness.In case of Machining Fiber Reinforced Polymer [8] the experimental results showed that operating pressure,standoff distance,jet transverse speed were the significant control factors which affects surface roughness.

Based on Taguchi method, AWJM is reviewed as follows mean surface roughness and kerf ratio are being optimized and the results shows that nozzle diameter affect the surface roughness by 74.47% and the second most parameter that affect the surface roughness is standoff distance by 9.03% .the results show that surface roughness decreases with the decrease in standoff distance, nozzle diameter and transverse speed[9-10].AWJM of mild steel based on taguchi approach shows that the most significant factor that affect the surface roughness is transverse speed and the sub significant parameters that affect the surface roughness are water pressure and standoff distance[11-12].

Sreekesh and Dr. Govindan[13]
Has done investigation on various process parameters of AWJM shows that MRR increases with increase in water pressure, but the major drawback is that the surface roughness and sub-surface damage increases with increase in pressure. Types of abrasives and traverse speed also effects the various quality parameters of work part. See Table 1 for a comparative analysis and a summary of results.

Quality parameters→ Process parameters↓		Surface roughness
Pressure	Increases	↓
	Decreases	
Traverse Speed	Increases	↑
	Decreases	
Standoff Distance	Increases	↑
	Decreases	
Abrasive Flow Rate	Increases	↓
	Decreases	
Work Feed Rate	Increases	↑
	Decreases	

Table 1. Effect of processing parameters on process outputs in AWJM

M.Amar, Navin Prasad, Trusanta Saha, Prof A V N L Sharma [14] has done an experimental investigation of surface roughness in AWJ and the effect of abrasive flow rate, water pressure and Stand-off roughness of Aluminum using abrasive water jet cutting was examined. Here garnet was used as abrasive which is having 80 mesh.The surface roughness (Ra)plays a most important factor which determines the components. Here the experiment was carried out by varying water pressure, abrasive standoff distance for cutting aluminum using abrasive water jet machining process. The effect of parameter is that when jet pressure increases, surface roughness decreases, when abrasive flow rate decreases and with last parameter that is SOD increases, Ra increases. It was concluded that water pressure should be high,abrasive flow rate also should be high while standoff distance should be less to get good surface quality.

Parameter	Value
Abrasive type	Garnet
Mesh	80 mesh
Jet offset	.5585 mm
Water flow rate	3 litre/min
Angle	90
Orifice diameter	1.01 mm

Table 2. Fixed Parameters

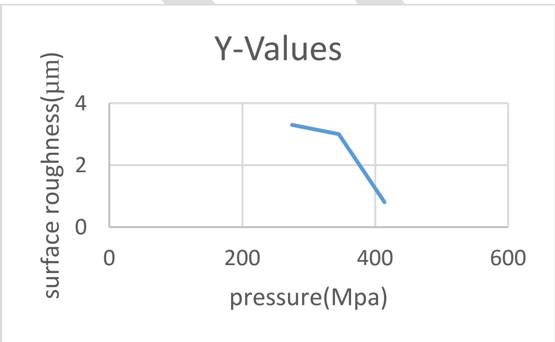

Fig 1. Pressure Vs Surface Roughness

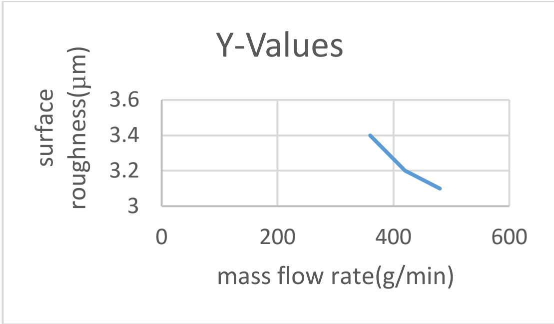

Fig 2. Effect of Abrasive Mass Flow Rate on Surface Roughness

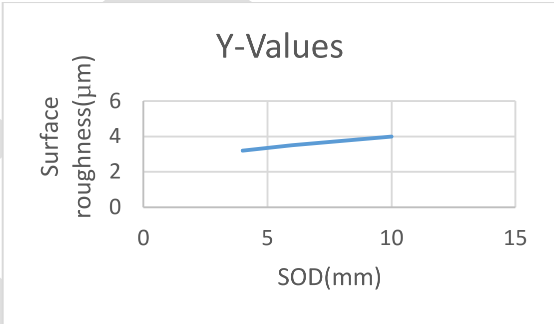

Fig 3.SOD vs Ra

M.A. Azmir, A.K. Ahsan [15] conducted a practical study for analyzing the surface roughness and kerf taper ratio of glass/epoxy composite laminate machined using abrasive water jet machine. The various process parameters considered are abrasive types (2-level), hydraulic pressure (3-level), standoff distance (3-level), abrasive flow rate (3-level), traverse rate (3-level), cutting orientation (3-level). The optimization of AWJM was done with the use of Taguchi method and ANOVA (analysis of variance). The ratio of top kerf width to bottom kerf width is called Kerf taper ratio. Types of abrasives and traverse speed are insignificant parameter for surface roughness while hydraulic pressure is most significant factor that influences surface roughness in AWJM. Standoff distance (SOD), cutting orientation and abrasive mass flow rate are equally significant factors that influence surface roughness, but the kerf taper ratios are influenced by hydraulic pressure, abrasive mass flow rate and cutting orientation. Abrasives type, standoff distance and traverse speed are most significant factors that had significant influences on kerf taper ratio. The quality of cutting in AWJM can be increased by increasing the kinetic energy of the water jet.

Adnan Akkurt, Mustafa Kermal Kulekci, Ulvi Seker, Fevzi Ercan[16] have studied the effect of feed rate and thickness on surface roughness considering the effect of composition of material. In this study pure Al, Al-6061, brass 353 are cut with AWJ at different feed rate. Experimental results showed that “cutting wear” and “deformation wear” mechanism are effective in cutting both mild and brittle material using AWJ. The pressure of the AWJ negatively affects the surface roughness as the thickness of the material decreases. From the experimental results it was found that pure Al has higher surface quality than Al-6061 alloy when machined by AWJ. Higher reduction in feed rate for the same thickness specimen of Al based material results in limited improvement in surface quality. Higher strength of the material results in higher cutting force between the cutting tool and material interface. As a result of this situation deformation effect of AWJ is higher on thinner intersection and deteriorates the surface quality of the thinner material.

a) t=5 mm, f=1355 mm/min, x-axis depth of measurement(mm), y-axis surface roughness (µm)

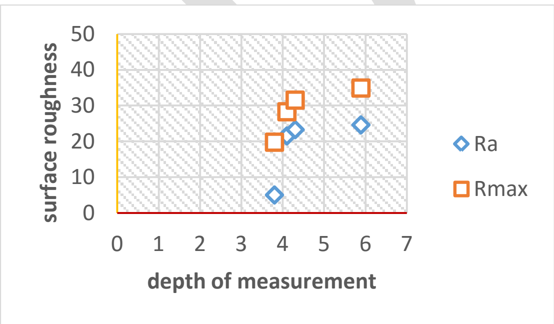

Fig 4. Effect of Depth of Cut on Surface Roughness

b) t=20 mm, f= 40mm/min

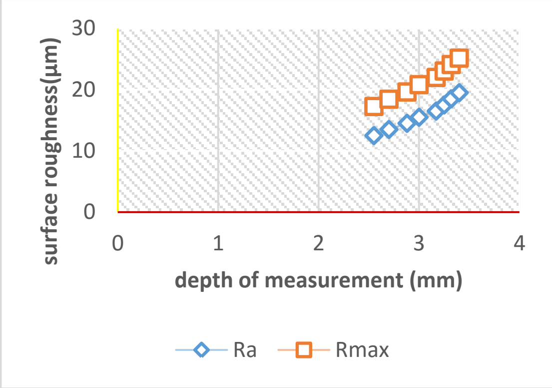

Fig 5. Effect of Depth of Cut on Surface Roughness

Derzija Begic Hajdarevic, AhmetCekic, MuhamedMehmedovic, Almina Djelmic[17] have done experimental study on surface roughness in AWJ and measured the surface roughness along the depth of cut. The experimental results showed that the transverse speed has significant effect on surface roughness at the bottom of the surface. The experiment was done on Al of different thickness 15 mm,30 mm. The experimental results showed that the optimal solution of choice was to maintain the transverse speed at a known medium level so as to achieve a high productivity with acceptable surface roughness and also the surface roughness increases with decreasing the abrasive mass flow rate.

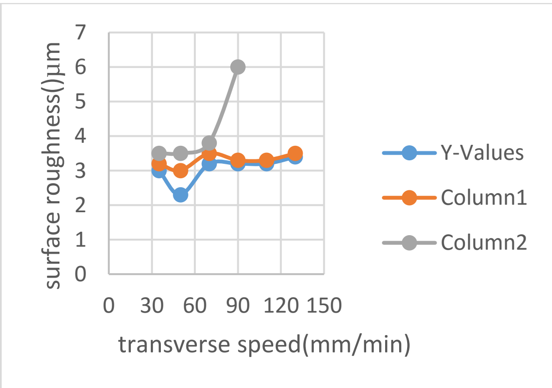

Fig 6. Effect of Transverse Speed on Ra On Different Zones of Cut Surface

Ahsan Ali Khan, Noraziaty Bt. Munajat, Harnisah Bt. Tajudin[18] has conducted study on Al with Garnet abrasive in AWJ process and the results showed that for good surface finish the feed rate must be maintained within 30 mm /min and increase in jet pressure shows a positive effect on surface quality this occurs due to the fragmentation of abrasive particle into smaller sizes at higher pressure and due to that smaller particle produces smoother surface. The results showed that the cut surface is smoother near the top surface and gradually decreases.

By using different abrasive in AWJ Ravi R. Modi, Prof. Vallabh D.Patel[19] have conducted experiment and the results showed that using Aluminum oxide grit of mesh 80 gives better surface finish compared to garnet abrasive grit and also it shows that transverse speed is the most important control factor for MRR and Surface roughness and Standoff distance are equally important parameter for both the parameters.

Experiment on surface roughness obtained by AWJM conducted by Veselko Mutavgjic, Zoran Jurkovic [20] shows that abrasive flow rate increases surface roughness decreases and increase in water pressure cause decrease in surface roughness.Also increase in Transverse speed increases surface roughness. Here stainless steel of 2mm thickness has abrasive flow rate of 220 g/min and SOD of 2mm and Aluminum also has equal values for thickness of 4mm.

Based on Regression Analysis on AWJM showed that for Al of different thickness 15 mm and 30 mm multiple regression analysis appears to be acceptable approach and depth of cut, transverse speed, abrasive flow rate are independent variables [21-22].

P. Jankovic, T. Igic, D.Nikodijevic[23] has studied the Process parameter effect on material removal and cut quality of AWJM and the following results are drawn out of it they are in the top region the surface quality is better and decrease gradually when moving down the depth and with the an increase in abrasive flow rate the roughness reduces and roughness is sensitive to feed rate.

Surface roughness of AL6061 in AWJ Drilling process was conducted by S. Prabhakaran,D.S. Balaji, T.Mailsamy[24] and the optimal results were obtained at the following points abrasive flow arte 220 g/min, feed rate 110 mm/min and standoff distance at 2mm. At theses points that surface roughness and circularity was found by 3.99 µm and 10.10 mm respectively.

An experiment was conducted on Ti-6Al-4V and pure TI and the results shows that higher values of average roughness were obtained due to increase in transverse speed and it also shows that cutting head angle has no effect on surface roughness of the material [25-26].

Effect of process parameter on AWJ plain milling has been conducted by S.J. Ebeid and M.M. Sayed[27] in mild steel showed the following results.

Process variable	Effect of variable	Surface roughness
Traverse speed	increases	Decreases
Jet pressure	increases	Increases
Abrasive flow rate	increases	Decreases
Standoff distance	increases	Decreases

Table 3. Effect of processing parameters on process outputs in AWJM

Conclusion:

Following are the important conclusions of the literature that are reviewed.

- Traverse speed is the most influence parameter for material removal rate. Increase in traverse speed, there are increase in material removal rate.

- Higher abrasive flow rate increases surface roughness decreases. Abrasive flow rate is less significant control factor for MRR.
- MRR increases with the increase in SOD (2 to 4 mm) up to certain limit and further increase in SOD beyond the limit results in decrease in MRR and increases surface roughness with increase in SOD.
- Traverse speed is a most significant control factor for MRR and SR and abrasive flow rate and SOD are equally significant control factor for the both parameters.

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