A LITERATURE REVIEW ON THE ABRASIVE WATER JET MACHINING - AWJM PROCESS

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ABSTRACT

Abrasive jet machining is the non-conventional material elimination method. It is an efficient machining method for processing a range of Hard and Brittle objects and has a variety of distinctive advantages over the additional non-traditional cutting technology, such as, high machining adaptability, smallest amount of stress on the work-piece, more flexibility no thermal deformation, and little cutting forces. This paper presents a widespread analysis of the existing situation of research and growth in the abrasive jet machining process. Advance challenges and extent of future growth in abrasive jet machining be as well anticipated. This review paper will assist researchers, manufacturers and strategy makers broadly.

Keywords: Abrasive water jet machining (AWJM), Traverse speed, Material Removal Rate (MRR), Stand-off distance (SOD), Surface roughness.

INTRODUCTION

Abrasive Water Jet machining (AWJM) is a non-traditional mechanism which operates material exclusive of producing shock and high temperature. AWJM is applied for several purpose like drill, cutting, clean-up, and engraving operation. In Abrasive Water Jet machining (AWJM), abrasive particles are prepared to invade on the work material at elevated speed. A jet of abrasive particle is passed by carrier gas or air. The high speed stream of abrasives is produced by converting the pressure energy of carrier gas or air to its Kinetic energy and therefore the high velocity jet. Nozzles direct abrasive jet in a restricted manner on the work material. The high velocity abrasive particles take away the material by micro-cutting action as well as brittle crack of the work-material. Machining and Drilling, Surface Finishing are the Major Processes that can be performed efficiently. The AWJM Process has certain advantages over other non conventional machining processes:

1. Faster set up and programming
2. Absence of chatter
3. Less sensitivity
4. Very little fixturing for most of the parts
5. No Heat affected zone (HAZ)
6. Can machine thick materials

The practical applications for abrasive water jet machining involves the paint removal, turning, pocket milling, drilling, medical surgery etc.

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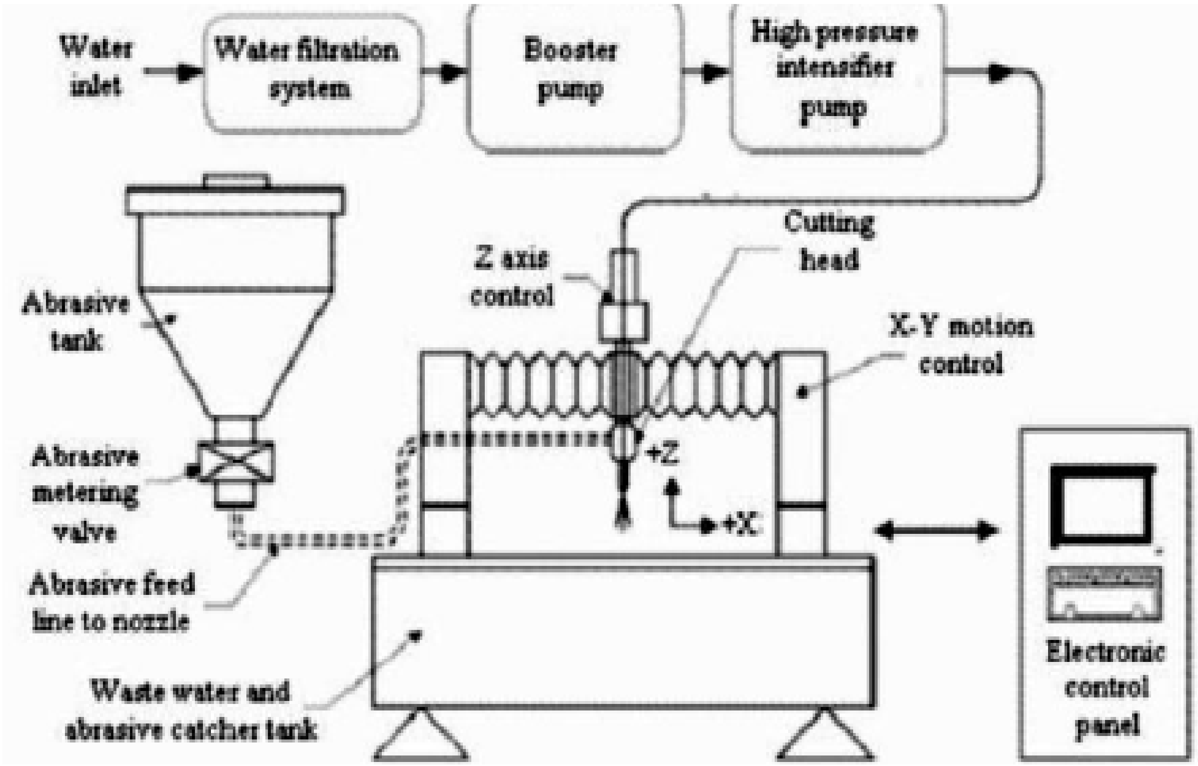

Fig. 1: Abrasive Water Jet Machining Setup

The materials that can be cut by abrasive water jet machining are:

1. Stainless steel
2. Titanium
3. Composites
4. Ceramics
5. High resistant steels
6. Super alloys
7. Carbides etc.

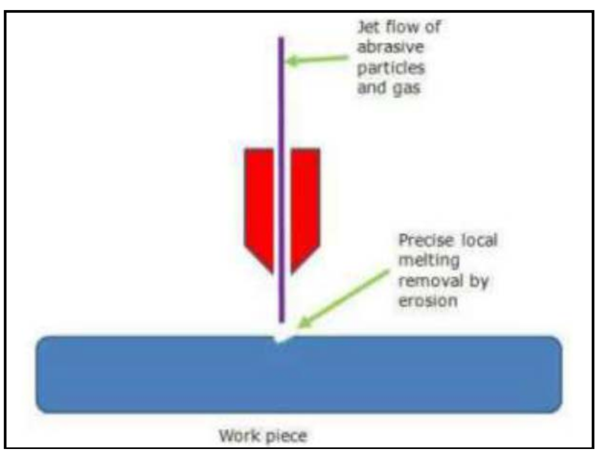

Fig. 2: Material Removal using erosion

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LITERATURE REVIEW

Gursewak Kesharwhani [1] experimented on using non-spherical sharp edges ceramics abrasives for machining work-pieces in case of applications in aerospace industry. It was concluded that traverse speed has the significant role in controlled depth milling in case of abrasive water jet machining process. They found that by modifying setup, a reduction of 20% time for milling titanium based alloy can be achieved. The surface waviness can also be reduced as traverse speed increased using modified abrasive feeding system.

B. Sidda Reddy at al. [2] investigated optimization of the input parameters of abrasive water jet machining process by means of Taguchi method. The use of Analysis of Variance (ANOVA) and signal to noise ratio (S/N) ratio to optimize different parameters for obtaining efficient Material Removal Rate (MRR) and surface roughness.

Derziza Bagic-Hajdervic et al. [3] studied the effect of thickness of the material, abrasive flow rate and traverse speed during abrasive water jet machining of aluminium for surface roughness. It was concluded that traverse speed has significant effect on surface roughness at bottom of cut and relation between surface roughness and other variables.

K.S. Jai Autrin and M.Dev Anand [4] studied work on optimizing of machining parameter in abrasive water jet machining process for copper alloy by means of regression analysis. They investigated the effect of standoff distance, nozzle diameter and water pressure on material removal rate (MRR) and surface roughness.

Dr. A. K. Paul et al. [5] studied the effect of the air on the material removal rate. Experiments were conducted using silicon carbide as abrasive particles at different air pressure. It was found out that material removal rate has increased due to increase in grain size and nozzle diameter. The MRR increases with increase of Standoff distance (SOD).

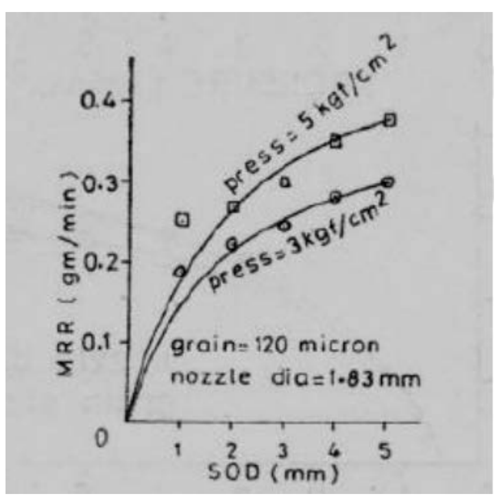

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Fig. 3: Material Removal Rate vs. SOD

Dr. M. Srenevasa Rao [6] explained the effect of abrasive mass flow rate on the MRR in AWJM. It was concluded that SOD increases the MRR and depth rate increase and on attaining optimal value it begins decreasing.

J.Woolak and K.N. Murthy [7] studied that after threshold pressure, material removal rate and depth rate increase with nozzle pressure. The highest MRR for the ductile and brittle materials are obtained at the separate impingement angles. For the ductile material impingement angle of 15-25 results in maximum material removal rate and for brittle material normal to surface results in maximum material removal rate.

A.Ghobety et al. [8] experimented on process repeatability in AWJM. They demonstrated that use of mixing chamber can improve the process repeatability. They measured depth of machined surface for finding out process repeatability.

Domiaty et al. [9] performed drilling of the glass with different thicknesses for finding out the machinability for different controlling parameters. The large nozzle diameter gives high abrasive mass flow which gives high MRR and lower size of abrasives gives low MRR.

Mr. Bhaskar Chandra [10] investigated changing in MRR according to variation in pressure and nozzle diameter. The MRR goes on increasing with increase in pressure. However, MRR reduces with large nozzle diameter.

Aliraza Moridi et al. [11] experimented effect of process parameters on the cutting performances in AWJM Process. The excessive abrasive mass flow rate increases inter particle collision reducing average removal rate per particle.

Zhobeity et al. [12] conducted the experiment on particle size distribution which can greatly affect shape and penetration of profile. It was concluded that uniform particles distribution helps in maintaining uniform velocity of abrasive jet causing enhanced MRR.

K.R. Chang [13] investigated the kerf formation in AWJM for a ceramic plate. During experiment, they found that kerf width increases with increase in pressure and abrasive flow rate. Taper ratio increase with traverse speed and has no effect with increase in abrasive flow rate.

Mahabalesh Pandlla [14] studied the effect with different chemical environments in the ratio of 30% with 70% of water and SOD on taper angle and MRR of drilled holes in AWJM. MRR is highest when slurry is added and MRR goes on increasing with SOD due to momentum of collision of abrasive particles on the work surface creating craters of more depth.

A.K. Ehsan [15] investigated the surface roughness and kerf taper ratio of composite machined by AWJM. They find out that by increasing the kinetic energy of jet, better cut quality is produced. Types of abrasive are more significant for kerf taper ratio while SOD and traverse speed are almost equally significant for that.

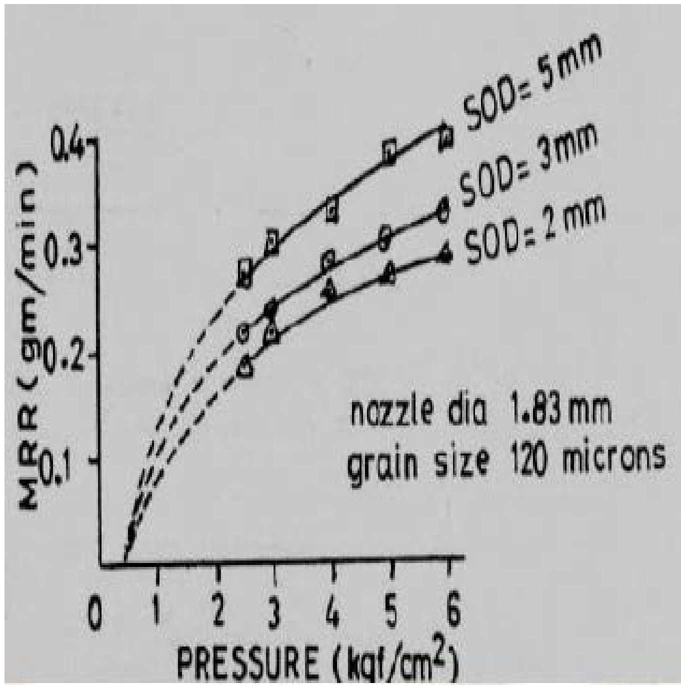

Fig. 4: Material Removal Rate vs. Pressure

J.John Rozario [16] considered the variation of orifice and focusing nozzle diameter for cutting aluminium alloy. Any increase in the orifice size and focusing nozzle has not so effect on the surface quality but larger size of orifice produces a better surface finish on the cut surface.

MM.Hague [17] studied different abrasives for machining of glass. For all types of abrasive particles used, taper of cut decreases with increase in jet pressure. For the silicon carbide abrasives, taper of cut is small.

Ushata Aich et al. [18] conducted experiment on cutting of glass using AWJM process. Depth of cut calculated for SOD, water pressure and traverse speed. The Scanning Electron Microscope (SEM) study was done to estimate the nature of cut surface and the erosion behavior of the material. The optimum condition of machining parameters was searched.

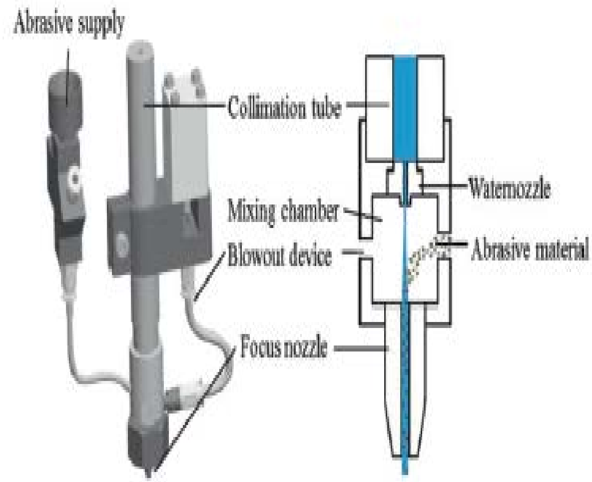

Fig. 5: Cutting head composition

T.N.K Gupta et al. [19] studied the role of process parameters for pocket milling on stainless steel material using AWJM Process. It was concluded that higher traverse speed produces a better surface finish. Also, increase of SOD and abrasive flow rate reduces the MRR as jet loses its focus and collision between particles.

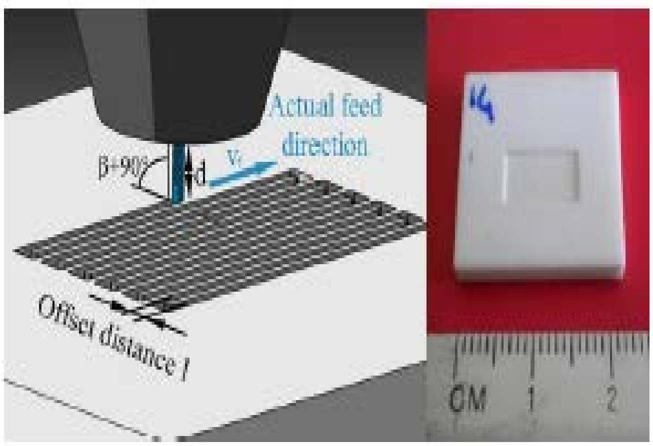

Fig. 6: Implementation of machining strategy (left) and machined work-piece (right)

G.E. Escobar et al. [20] find out that water pressure has a non-linear behavior and has importance for restricting the depth of cut and geometrical errors. The nozzle diameter and relation between abrasive mass flow rate and feed rate are critical components having the effect on depth of cut.

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Performance Measures → / Process Parameters ↓		MRR	Surface Roughness	Kerf Width	Depth of Cut
PRESSURE	Increases	↑	↑ to some extent	↑	↑
	Decreases				
TRAVERSE SPEED	Increases	↑	↑	↓	
	Decreases				
STAND-OFF DISTANCE	Increases		↑ to some extent		
	Decreases				
ABRASIVE FLOW RATE	Increases	↑	↓	↑	
	Decreases				
WORK FEED RATE	Increases	↑			
	Decreases				

(↑) Increase ; (↓) Decrease

Fig. 7: Effect of input parameters on output parameters in AWJM Process

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