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Review Paper on Process Parameters of Abrasive Water Jet Machining

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Abstract: ***Abrasive Water jet machining is one kind of non-traditional machining process, in which material is eliminated from the work piece by impact of pressurized high velocity jet mixture of water and abrasive particles on a work material. So many process parameters influence the AWJM cutting process. But the most significant parameters are water pressure, abrasive flow rate, traverse speed and stand-off distance and performance output measures in AWJM are Material Removal Rate, Depth of cut, taper of cut, Surface Roughness and Kerf width. This paper represents review of the research work done within past few years for abrasive water jet machining & reports on AWJM research relating to performance enhancement and process variables optimization.***

Keywords: Abrasive Water Jet Machining, Process Parameters, Optimization, Monitoring & Controlling

1. Introduction to AWJM

Abrasive Water Jet Machining is that manner of machining process which is known as non-traditional type machining and belongs to mechanical group of non-traditional processes like Abrasive Jet Machining and Ultrasonic Machining. In AWJM mechanical energy of water and abrasive particles mixture is utilize to carryout machining or material removal. It can be done by different approaches and methodologies like entrained three phases containing abrasive, water and air or suspended two phase mixer of abrasive and water.

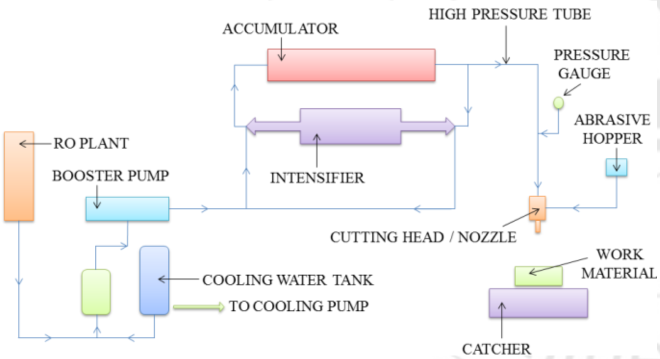

Figure 1: Schematic Diagram Of Abrasive Water Jet Machining

As shown in figure 1 Original concept remains the same where water is pressurised at a sufficient high pressure of 2000-4000 bar using intensifier. Water with such a high pressure is released from a orifice/Nozzle (Cutting head) of approx. 0.15 to 0.3 mm diameter along with abrasive particles and the potential or steady energy of water is converted into kinetic energy, hence a high velocity jet stream produced and Such high velocity water jet along with abrasive particles can be utilize for machining of some material like Metal Matrix Composite, Ceramic, Polymers, Steels and Non-ferrous alloys etc. Some of the Influencing parameters of abrasive water jet machining are as below:

Input Parameters:

1. Hydraulic Parameters
   a. Water pressure
   b. Water jet diameter
2. **Cutting parameters**
   a. Traverse speed
   b. Stand of distance
   c. Impact angle
3. **Abrasive parameters**
   a. **Abrasive mass** flow rate
   b. Abrasive particle diameter
   c. Abrasive particle shape
   d. Abrasive particle hardness
4. **Target material parameters**
   a. Hardness
   b. Elastics modulus
   c. Flow strength
5. **Mixing and acceleration parameters**
   a. Nozzle diameter

Output Parameters:

1. **Material removal rate**
2. **Kerf characteristics**
   a. Top kerf width
   b. Bottom kerf width
   c. Kerf angle
   d. Depth of cut
3. **Surface characteristics**
   a. Surface roughness
   b. Surface waviness or striation
4. **Geometrical and dimensional accuracy**

2. Literature Survey

A literature review of various published research work on Abrasive water jet machining is carried out to understand the research issues involved and is presented below,

M. Chithirai Pon Selvan et al. [1] had assessed the influence of process parameters of AWJM like water pressure, abrasive flow rate, stand of distance, traverse speed on depth of cut which is one of the important output parameter in cutting of stainless steel. Experimentation were conducted by varying these parameters and to correctively selection of parameters one empirical model for prediction of depth of cut using regression analysis was generated and verified with experimentation work. Results indicated that within operating range increase of water pressure results in increase of depth of cut while keeping other parameters constant. Likewise increase in abrasive mass flow rate results in high depth of cut but on other hand increase in traverse speed reduced the depth of cut.

S. R. Patel et al. [3] had evaluated application of abrasive water jet cutting for fibre reinforced plastic based on various literatures. A Study of variation in parameters like water pressure, traverse speed, abrasive flow rate and stand of distance observed for kerf width quality and summarized result as top kerf width increases as stand of distance and water pressure increases and decreases as traverse speed decreases. Bottom kerf width and kerf taper increases as stand of distance and water pressure increases and decreases as traverse sped decreases. Roughness increases as traverse speed and water pressure increases.

D. Sidda Reddy et al. [4] had utilized analysis of variance and noise ratio(SN ratio) to optimize AWJM parameters like water pressure, focusing nozzle diameter, abrasive flow rate and traverse speed for effective material removal rate and surface roughness. They had observed that traverse speed plays major role on influencing material removal rate by 60% as per ANOVA analysis then 30% material removal rate depended on abrasive flow rate on other hand for surface roughness stand of distance and traverse speed plays major role about 47% and 37% respectively and abrasive flow rate had sub significance influence on surface roughness.

Vinod B. Patel et al. [5] Investigated AWJM process parameters for response of material removal rate and surface roughness of EN8 material by taguchi's method and analysis of variance (ANOVA) to optimized parameters. Experiments were carried out using L25 Orthogonal array by varying abrasive flow rate, traverse speed, stand of distance for EN8 material. They had concluded that material removal rate increases with the increase in traverse speed and same for surface roughness, higher abrasive flow gives increase material removal rate and less influence on surface roughness.in case of stand of distance material removal rate increases up to some limit and then decreases.

N. Jagannatha et al. [6] had attempted to use hot air as carrier medium in machining. They had utilized modified taguchi's robust design analysis to determine combination of parameters in ANOVA for material removal rate and surface roughness, and concluded that at higher temperature there is a sufficient present of more plastic deformation archieved by brittle failure which results in increase in material removal rate (MRR) and Surface Quality.

M. Chithirai Pon Selvan et al. [7] had assessed the influence of parameters like pressure, nozzle traverse speed, abrasive mass flow rate and stand of distance on depth of cut by conducting experiments and concluded within operating range increase in water pressure and abrasive mass flow rate increases depth of cut but in case of nozzle traverse speed it decreases.

Saikat Kumar Kuila [8] attempted to select the most significant process parameters by mixing taguchi and grey taguchi methodology for machining of aluminum. AWJM parameters like water pressure, abrasive flow rate, stand of distance and feed rate were selected in three levels and optimized for two output material removal rate and surface roughness respectively and concluded that feed rate is most significant parameters to achieve higher material removal rate and low surface roughness.

K.S. Jai Aultrin et al. [9] investigated process Parameters in AWJM for Copper Iron Alloy Using Response surface methodology (RSM) and Regression Analysis where parameters selected were water pressure, abrasive flow rate, orifice diameter, focusing nozzle diameter and standoff distance. They analyzed the effect of above parameters on metal removal rate (MRR) and surface roughness (SR) and found that major influencing processing parameters were water pressure, abrasive flow rate, and stand of distance and minor influencing processing parameters are orifice and focusing nozzle diameter.

A. Alberdi et al. [10] had studied the behavior of machinability model for composite in which machinability index for various composite for different thickness were found experimentally and then the evaluation of the process parameters on the quality of cut was done. They had used ANOVA analysis method and one of their conclusions point was roughness increases as traverse rate increases and it's the only significant parameter in their experimentation towards roughness.

R. H. M. Jafar et al. [11] performed experimentation on the effect of particle size, velocity, and angle of attack for evaluation of Surface roughness of unmasked channels machined in borosilicate glass using abrasive water jet cutting. Based on these observations, the assumed location of lateral crack initiation in a relatively simple analytical model from the literature was modified, and used to predict the roughness and erosion rate.

Dr.A. K. Paul et al. [12] evaluated the effect of the carrier fluid pressure on the Material removal rate, air flow ratio, and the material removal factor, experimentally on abrasive water jet machining set-up developed in the laboratory with Sic abrasive particles at various Air pressures and Observed that MRR had increased with increase in grain size and increase in nozzle diameter also MRR increases with increase in SOD at a particular pressure ranges.

El-Domiaty et al. [13] did the drilling of glass at different thicknesses which was done by Abrasive jet Machining process to determine machinability under different controlling parameters of process. They had observed that the large diameter of the nozzle lead to the high abrasive flow and which lead to more material removal rate and lower size of abrasive particle lead to the low material removal rate.

R. Balasubramaniam et al. [14] concluded that as the particle size goes on increasing, the Material removal rate at the central of the jet also increases on the other hand the increase in Material removal rate nearer to the periphery is very low and as the stand-off distance increases the entry side diameter and the entry side edge radius increases, Increase in stand-off distance also increases MRR.

Mr. Bhaskar Chandra [15] evaluated the variation in Material Removal Rate according to variation in Gas pressure and Hole diameter. Various experiments were carried out on glass using alumina abrasive. The effect of gas pressure on the material removal rate is represented in figure 2 which states that it increases as pressure increases.

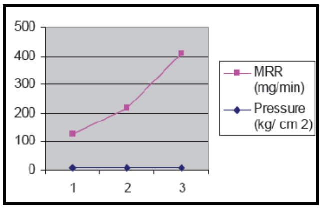

Figure 2: Graph shows the Relationship between pressure and material removal rate (MRR)

3. Summary

Table No 1 represents the effect of processing input parameters on performance output parameters based on above literature survey.

Table 1: Literature Summary based on relationship of processing input and performance output parametrs of AWJM.

Performance Measures → / *Process Parameters ↓*		*Material Removal Rate*	*Surface Roughness*	*Depth Of Cut*	*Kerf Width*
Water Pressure	Increase	↑	↑ up to some extend	↑	↑
	Decrease				
Traverse Speed	Increase	↑	↑		
	Decrease			↓	
Abrasive Flow Rate	Increase	↑		↑	
	Decrease		↓		
Stand Of Distance	Increase		↑ up to some extend		
	Decrease				
Work Feed Rate	Increase	↑			
	Decrease				

4. Conclusion

From above literature review it is observed that normally combination of processing parameters (water pressure, abrasive flow rate, stand of distance, traverse rate, nozzle diameter) are investigated for performance parameters like material removal rate, surface roughness, depth of cut and kerf width etc.

Material removal rate can be improved by increasing the abrasive flow rate and traverse speed but by doing this as we have increased traverse speed surface quality and kerf width will decreased.so it is very important to get optimum condition for all process parameters for better machining.

5. Future Scope

It is found that many researcher have utilized various different techniques and methodologies like taghuchi, Regression, AVOVA but very less work is done using multi objective optimization of AWJM process and also very few work reported on two process parameters which are Nozzle and Orifice Diameter So more work is required to done on that aspects.

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