A REVIEW PAPER ON MOST SIGNIFICANT AND SUB SIGNIFICANT PARAMETERS OFABRASIVE WATER JETMACHINING

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ABSTRACT

In this review paper, Experimental investigation is carrying out onAbrasive Water jet Machining. This paper shows the effect of various input parameters, viz . Normal jet impact angle, Orifice diameter, Mixing tube and nozzle diameter, Abrasive particle size, Abrasive mass flow rate water pressure, Traverse speed, and Standoff distance e.t.c onvarious output parameter viz. depth of cut, material removal rate and surface roughness e.t.c. So that to concludethe most significant and sub significant parameter irrespective of work piece material.

Keywords: Abrasive Water Jet Machine, Depth of Cut, Material Removal Rate, Surfac Roughness

I. INTRODUCTION

With the ever-increasing demands for high surface finish and complex shape geometries, conventional metal removal methods are now being replaced by non-traditional machining (NTM) processes. These NTM processes use energy in its direct form to remove materials in the form of atoms or molecules to obtain the required accuracy and burr-free machined surface. In order to exploit the optimal capabilities of the NTM processes, it is often required to determine the best possible combinations of their controllable parameters. Different non-conventional optimization techniques have been used for dealing with these process optimization problems because of their inherent advantages and capabilities for arriving at the almost global optimal solutions. [1]The need for rapid prototyping and small production batches is increasing in modern industries. These trends have placed a premium on the use of new and advanced technologies for quickly processing raw materials into usable goods; with no time being required for tooling. Material cutting by abrasive water jet was first commercialized in the late 1980s as a pioneering breakthrough in the area of unconventional processing technologies. Abrasive Water jet Cutting (AWJC) has various distinct advantages over the other non-traditional cutting technologies, such as no thermal distortion, high machining versatility, minimum stresses on the work piece, high flexibility and small cutting forces and has been proven to be an effective technology for processing various engineering materials. [2] However, the cutting capacity of this technology in terms of depth of cut (or depth of jet penetration) and kerf quality is still the major obstruction that limits its applications. Considerable research and development effort has been made in recent years to develop new techniques to enhance the cutting performance of this technology such as the depth of cut and surface finish. [3]

The abrasive waterjet machine is an effective technology for processing various materials. In this process the metal removal takes place by impact erosion of high pressure, high velocity of water with high velocity of abrasives on a work piece. The abrasive waterjet offers several advantages over conventional cutting techniques as it environmental friendly and it can cut metals and nonmetals also.

II. PRINCIPLE

In abrasive water jet machining process, a focused stream of abrasive particle i.e water pressure or air pressure at a velocity of about 150-300(m/sec) are made to impings on work surface through a nozzle. So that material remove from workpiece due to erosion produced by the high velocity of abrasive particles. Here particle hve irregular shape and consist of sharp edges.[4]

Medium	Air, water, CO_2,N_2
Abrasive	SiC, Al_2O_3, garnet, Olive, Quartz sand, Steel grit, limonite, staurolite, corundum, cu-slag e.t.c
Material of nozzle	Stainless steel, sapphire
Work material	Non metal like glass, ceramics, and granites. Metal and alloys of hard material like germanium, silicon etc
Part application	Drilling, cutting, de- burring, cleaning

III.LITERATURE REVIEW

1. **Ushasta Aich, Simul Banerjee, Asish Bandyopadhyay, Probal Kumar Das** Abrasive Water Jet Cutting of Borosilicate Glass". In this paper, author used one of the most regularly shaped amorphous engineeringmaterial borosilicate glass. This material is tough to machinethrough conventional machining processes due to its brittleness property. They are conducted experiments on cutting of borosilicate glass by AWJM. Depth of cut is measured with different machine parameter settings – water pressure, abrasive flow rate, traverse speed and standoff distance. Here optimum result of 20.8114 mm depth of cut obtained by PSO when input parameters are 1499.9985 bar water pressure, 54.0000g/min abrasive flow rate, 200.0011 mm/min traverse speed, 59.9967 mm stand off distance. [5]
2. **Mr. Sachin Kumar, Mr. Deepak Bhardwaj, Mr. Jitender Panchal** "A research paper on study the MRR of Soda lime glass at different parameters of Abrasive Jet Machine"use Abrasive jet machine at different parameters to study the metal removal rate of Soda lime glass. Various parameters such as pressure, angle, abrasive size, nozzle tip distance, time, initial weight and final weight are taken in consideration to achieve the desired objective. Then, by using L9 values we have find out the MMR.[6]
3. **J Wang** Predictive depth of jet penetration models for abra-sive waterjet cutting of alumina ceramics". A study of the depth of jet penetration (or depth of cut) in abrasive waterjet (AWJ) cutting of alumina ceramics with controlled nozzle oscillation is presented and discussed. An experimental investigation is carried out first to study the effects of nozzle oscillation at small angles on the depth of cut under different combinations of process parameters. Depending on the other cutting param-eters in this study, it is found that a high oscillation frequency (10-14 Hz) with a low oscillation angle (4-61) can maximize the depth of cut. Using a dimensional analysis technique, predic-tive models for jet penetration when cutting alumina ceramics with and without nozzle oscillations are finally developed and verified. An experimental

investigation of the depth of jet pen-etration in AWJ cutting of alumina ceramics with controlled nozzle oscillation has been carried out and reported. Hence oscillation frequencies (10-14 Hz) and small oscillation angles (4-61)are recommended for maximizing the depth of cut in nozzle oscillation cutting.[7]

4. **leeladhar Nagdeve, Vedansh Chaturvedi And Jyoti Vimal** Implementation of taguchi approach for ptimization of abrasive water jet machining process parameters", worked on non–traditional Abrasive Water Jet Machining to find optimum process parameter.Abrasive water jet machining is a process of removal of material by impact erosion of high pressure, high velocity of water and entrained high velocity of grit abrasives on a work piece.Experimental investigation were conducted to assess the influence of abrasive water jet machining (AWJM)Processes Parameter such as Pressure (P) MPa, Stand of Distance (S) mm, Abrasive Flow rate (A) g/s, Traverse rate (T)mm/s on MRR and surface Roughness (Ra) of aluminium. The approach was based on Taguchi's method and analysis of variance(ANOVA) to optimize the AWJM process parameter for effective machining and to predict the optimal choice for each AWJM parameter such as pressure, standoff distance, Abrasive flow rate and Traverse rate. Main effects of MRR of each factor for various level conditions are shown in figure1.MRR increases with four major parameter Pressure, Stand of Distances, Traverse rate, Abrasive flow rate. Pressure is the most significant factor on MRR during AWJM. Meanwhile standoff distance, Abrasive flow rate and Traverse rate are sub significant in influencing. The surface Roughness decreases with four major parameter Pressure, Stand of Distances, Traverse rate, Abrasive flow rate.Abrasive flow rate is most significant control factor and hence the optimum recommended parametric combination for optimum surface Roughness. [8]\
5. **M. A. Azmir, A.K. Ahsan, A. Rahmah, M.M. Noor And A.A. Aziz** Optimization of abrasive waterjet machining process parameters using orthogonal array with grey relational analysis", this paper discusses surface roughness obtained consequently to abrasive jet cutting. Optimisation of the machining system was achieved by intervening on five selected input quantities (factors), with two set points considered for each. Upon applying Taguchi methods, eventually the combination of factor set points was determined that ensures robust behaviour of the systemthe optimization of the abrasive water jet machining (AWJM) process parameters with multiple performance characteristics based on the orthogonal array with the grey relational analysis (GRA) has been studied. Optimization of multiple response characteristics is far more complex compared to optimization of single performance characteristic. A grey relational grade (GRG) calculated based on grey relational analysis is used to optimize the AWJM process with the multiple performance characteristics. In the present study, four machining parameters, namely hydraulic pressure, abrasive mass flow rate, standoff distance and traverse rate are optimized with consideration of multiple performance characteristics viz., surface waviness at four different heights of a Kevlar composite laminate. Experimental results have shown that machining performance in the AWJM process can be improved effectively using this approach.[9]
6. **M.Chithirai Pon Selvan And N. Mohana Sundara Raju** Assessment of process parameters in abrasive waterjet cutting of stainless steel",this paper assesses the influence of process parameters on depth of cut which is an important cutting performance measure in abrasive waterjet cutting of stainless steel. The process variables considered here include traverse speed, abrasive flow rate, standoff distance and water pressure. Experiments were conducted in varying these parameters for cutting stainless steel using abrasive waterjet cutting process. In order to correctly select the process parameters, an empirical model for the prediction of depth of cut in abrasive waterjet cutting of stainless steel is developed using regression

analysis. This developed model has been verified with the experimental results that reveal a high applicability of the model within the experimental range used.[10]

7. **M. Chithirai Pon Selvan And Dr. N. Mohana Sundara Raju** Analysis of surface roughness in abrasivewaterjet cutting of cast iron", this paper assesses the influence of process parameters on surface roughness (R_a) which is an important cutting performance measure in abrasive waterjet cutting of cast iron. Taguchi's design of experiments was carried out in order to collect surface roughness values. Experiments were conducted in varying water pressure, nozzle traverse speed, abrasive mass flow rate and standoff distance for cutting cast iron using abrasive waterjet cutting process. The effects of these parameters on surface roughness have been studied based on the experimental results.[11]
8. **Mehul.A.Raval, Chirag. P. Patel** Parametric optimization of magnetic abrasive water jet machining of aisi 52100 steelusing grey relational analysis", In this paper, abrasive machining is one of the most non-conventional processes for finishing. It is widely used in industry to machine the materials like mild steel, aluminum, copper, titanium, glass, hard rock material, graphite, composite material, ceramics etc.Like in abrasive jet machining. This technique uses jet which contains abrasive material. Now a day water-magnetic abrasive machining is one of the new alternative concepts that the magnetic field (line of magnetic force) is used to precisely machine the surface of the work-piece. When it is a magnetic work-piece and the work-piece is magnetized and then become a new magnetic pole. On the country when it is non-magnetic it cannot be magnetized. In this research the precise processing phenomenon and the condition on abrasive machining of material by a high velocity of water and magnetic abrasive and other abrasive material whose hardness and grain size similar to magnetic abrasive are examined. And the final experiment result shows the comparison between effectiveness of the mixing of water and abrasive on the surface finish of the AISI 52100 steel materials.[12]
9. **D. V. Srikanth, Dr. M. Sreenivasa Rao** Response Surface Methodology for Optimization of Process Parameters in Abrasive Jet Drilling of Composites". In this paper, abrasive jet machining is an Emerging machining process in which the metal removal takes placedue to abrasion. A stream of abrasive particles mixed with carrier gas (generally air) is subjected to the work surface with high velocity (150-300 m/Sec). The abrasive particles used for this machining are Silicon carbide, Aluminium oxide, boron carbide, etc. This process is effectively adopted for cleaning, polishing, deburring, drilling and cutting of Hard and Brittle materials. Abrasive jet cutting involves a high velocity jet of air with entrained Abrasive particles onto the material to be cut. In the present study focused on experimental research and evaluation of the abrasive jet drilling process in order to evaluate the technological factors affecting the Metal Removal rate of FRP Composite of various thickness using Optimization modelling called Response Surface Methodology and The adequacy of the model is evaluated using analysis of variance (ANOVA) technique.[13]
10. **Chirag M Parmar, Mr. Pratik K Yogi, Mr. Trilok D Parmar** Optimization of Abrasive Water Jet Machine Process Parameter for AL-6351 using Taguchi Method" . In this paper, abrasive Water jet (AWJ) Machining is a recent non-traditional machiningprocess. Major part of this technology is a very high-pressure beam of water and abrasives, which is used for machining. Abrasive water jet cutting of material involves the effect of a high pressure velocity jet of water with entrained abrasive particles on to material to be cut. This technology is widely used in industry for cutting difficult -to-machine materials, milling slots, polishing hard materials, cleaning contaminated surfaces, etc. In the present study commercially three

different materials AL-6351 is machined with the abrasive water jet machine. Experimental investigations should conduct to assess the influences of Abrasive water jet machining (AWJM) process parameter on surface roughness. The approach is based on Taguchi's method to optimize the AWJM process pa rameter for effective machining. It was found the process parameters are stand-off-distance from the work surface; work feed rate, jet pressure Abrasive type are effective to evaluate criteria of the work surface roughness. The Experiment will be conducted at "SUNCORE ENGINEERING INDIA" Manjusar G.I.D.C Vadodara. AL-6351 is select as work piece material and will be machined under abrasive water jet machine model DWJ 2030-FB.The effect of various parameters as Traverse Speed, Abrasive flow rate, and standoff distance will be checked on output parameter like surface roughness measured by Surface Roughness Tester TR100. The Taguchi method will be used for designing the experiment and optimum result can be achieved through ANOVA and Compare it With Minitab 16 at the end.[14]

11. **T. Nguyen, D.K. Shanmugam, J. Wang** Effect of liquidproperties on the stability of an abrasive water jet". Theeffect of liquid properties after adding polymeric additives on the stability of an abrasive slurry (or suspension) jet (ASJ) is presented and discussed with a view to enhance the jet stability for ASJ machining. It is shown that jet disintegration is a result of the jet internal disturbances associated with the fluid properties and the external air friction acting upon the jet surface. A jet becomes more stable with the addition of polymeric additives, which is found to be mainly attributed to the increase of fluid viscosity. Based on the findings of the experimental investigation, a parametric model is then developed using a dimensional analysis approach to predict the jet compact length, i.e. the length of the jet stable region. The developed model is finally verified experimentally, which shows that the model predictions are in good agreement with the experimental data. If the slurry is uniformly mixed, the particle velocity may be assumed to be equal to the water solution velocity or jet velocity (v) at the nozzle exit. In forming an ASJ, it is believed that there are energy or momentum losses in the jetting system due to nozzle wall friction, fluid flow disturbances and the compressibility of the slurry. It has been shown that the liquid viscosity is the major jet internal factor that contributes to the jet cohesion, and the addition of polymeric additives increased the liquid viscosity and hence the jet stability. A parametric model has been developed for predicting the jet stability, taking into account the liquid properties and jetting parameters.[15]
12. **Gokhan Aydin, Izzet Karakurt, Kerim Aydiner** Investigation on "Prediction of the Cut Depth of Granitic Rocks Machined by Abrasive Water jet (AWJ)". A variety of nine types of granitic rocks were used in the cutting experiments. The experimental data were used to assess the influence of AWJ operating variables on the cut depth. Using regression analysis, models for prediction of the cut depth from the operating variables and rock properties in AWJ machining of granitic rocks were then developed and verified. The influence of the traverse speed on the cut depth is plotted. The figure shows that the cut depths of all granites decrease with an increase in the traverse speed. The influence of the abrasive mass flow rate on the cut depth. It can be seen that the cut depth slowly increases with increasing abrasive mass flow rate. The standoff distance plays a limited role in influencing the cut depth. The standoff distance has no discernible influence on the cut depths of the granites tested. The experimental data depicted illustrate the influence of the water pressure on the cut depths. It is noticed that the cut depths increase initially in all granites when the water pressure increases. The experimental data depicted illustrate the influence of the abrasive size on the cut depths of the granites studied. It can be noted that higher cut depths were obtained by coarse-grained abrasives. [16]

IV. SUMMARY

The effect of various process parameters of AWJM onDOC, surface roughness and MRR are shown in table. 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, size of abrasive particle, nozzle oscillation angle, nozzle oscillation frequency and traverse speed also effects the various quality parameters of work part. See Table 1 for a comparative analysis and a summary of results.

Table 1. Parameters effect on process outputs in AWJM by increasing control parameter

Increasing Control parameter	MRR	DOC	Surface roughness	Kerfs width	Width of cut	Taper of cut	Bottom width of cut	Top width of cut
Water pressure	↑	↑	↓	↑	↑	↑	↑ to small extend	↑
Stand of distance	↑ to small extend	↓	↑		↑	↑	↑ to small extend	↑
Traverse speed		↓	↑					
Abrasive flow rate	↓	↑	↓					
Abrasive grit size			↓					
Feed rate					↓	↑		
Nozzle oscillation angle		↑ if osci. Freq. low						
Nozzle oscillation frequency		↑if traverse speed high						
Nozzle diameter	↑	↓						

V. FUTURE SCOPE

It has been found that mostly research work on optimization has been carried out on process parameters for improvement of a single quality characteristic such as depth of cut, surface roughness, material removal rate, kerfs geometry and nozzle wear. But still no one do a research on optimization for the power consumption, dimension accuracy and multi-objective optimization of AWJM process. Future research work can be done on this area.

VI. CONCLUSION

1. This paper shows effect of various parameters like. Normal jet impact angle, Orifice diameter, mixing tube and nozzle diameter, Abrasive particle size, Abrasive mass flow rate water pressure, Traverse speed, and Standoff distance, of Abrasive Water jet Machine (AWJM) for ductile and brittle material on depth of cut, material removal rate and surface roughness.
2. Traverse speed is most significant factor on SR during AWJM. Mean while water pressure and standoffdistance is sub significant in influencing parameters.
3. Water jet pressure has more significant effect on kerfs width and MRR rather than abrasive flow rate and standoff distance.
4. By using the application of magnetic abrasive in water jet machining has proved to be a feasible alternative to aluminum oxide and other abrasives, if it can be applied properly. There is a considerable decrement in surface roughness and quality of product produced.

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