A Review of Abrasive Jet Machining: Advanced Approaches

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ABSTRACT

As the world is advancing forth technically in the field of space research, missile and nuclear industry; very complicated and precise components having some special requirements are demanded by these industries. The conventional methods, in spite of recent advancements are inadequate to machine such materials from stand point of accuracy, precision and economic production. The metal like hastalloy, Nitra alloy, nimonics, composites and many harder to machine material are such that they can't be machined by conventional methods but require some special techniques. Different non conventional machining methods like Abrasive jet machining(AJM), laser beam machining, ultrasonic machining , electric discharge machining give a machining option for geometrically challenging and/or brittle material parts that are difficult to machine by conventional processes. In this paper a review related to papers on abrasive jet machining was discussed. Developments in the critical areas of the process like nozzle, abrasive types, machine tool technology, machining mechanism, hybrid machining, composites machining with challenges have been discussed. Potential research issues have been explored for future work. Possible application areas have been identified.

Keywords: Abrasive Jet Machining, Times New Roman

I INTRODUCTION

Abrasive machining is a machining process where material is removed from a work piece using a multitude of small abrasive particles. Common examples include grinding, honing, and polishing. Abrasive processes are usually expensive, but capable of tighter tolerances and better surface finish than other machining processes chances, delectability, costs and safety aspect etc.) The literature study of Abrasive Jet Machining [1-6] reveals that the Machining process was started a few decades ago. Till date there has been a through and detailed experiment and theoretical study on the process. Most of the studies argue over the hydrodynamic characteristics of abrasive jets, hence ascertaining the influence of all operational variables on the process effectiveness including abrasive type, size and concentration, impact speed and angle of impingement. Other papers found new problems concerning carrier gas typologies, nozzle shape, size and wear, jet velocity and pressure, stand off distance (SOD) or nozzle tip distance (NTD). These papers express the overall process performance in terms of material removal rate, geometrical tolerances and surface finishing of work pieces, as well as in terms of nozzle wear rate. Finally, there are several significant and important papers which focus on either leading process mechanisms in machining of both ductile and brittle materials, or on the development of systematic experimental statistical approaches and artificial neural networks to predict the relationship between the settings of operational variables and the machining rate and accuracy in surface finishing. In recent years abrasive jet machining has been gaining increasing acceptability for deburring applications. AJM deburring has the advantage over manual deburring method that generates edge radius automatically. This increases the quality of the deburred components. The process of removal of burr and the generation of a convex edge were found to vary as a function of the parameters jet height and impingement angle, with a fixed SOD. The influence of other parameters, viz. nozzle pressure, mixing ratio and abrasive size are insignificant. The SOD was found to be the most influential factor on the size of the radius generated at the edges. The size of the edge radius generated was found to be limited to the burr root thickness.

Abrasive jet finishing combined with grinding gives rise to a precision finishing process called the integration manufacturing technology, in which slurry of abrasive and liquid solvent is injected to grinding zone between grinding wheel and work surface under no radial feed condition. The abrasive particles are driven and energized by the rotating grinding wheel and liquid hydrodynamic pressure and increased slurry speed between grinding wheel and work surface achieves micro removal finishing Abrasive water jet machines are becoming more widely used in mechanical machining. These machines offer great advantages in machining complex geometrical parts in almost any material. This ability to machine hard to machine materials, combined with advancements in both the hardware and software used in water jet machining has caused the technology to spread and become more widely used in industry. New developments in high pressure pumps provide more hydraulic power at the cutting head, significantly increasing the cutting performance of the machine. Analysis of the economic and technical has been done by researchers. Those technology advancements in applying higher power machining and intelligent software control have proven to significantly improve the overall performance of the abrasive water jet machining operation, thus widening the scope of possible applications of this innovative and promising technology. Quality of the surface produced during abrasive water jet machining of aluminum has been investigated in recent years. The type of abrasive used was garnet of mesh size 80. The cutting variables were stand off distance of the nozzle from the work surface; work feed rate and jet pressure. The evaluating criteria of the surface produced were width of cut, taper of the cut slot and work surface roughness. It was found that in order to minimize the width of cut; the nozzle should be placed close to the work surface. Increase in jet pressure results in widening of the cut slot both at the top and at exit of the jet from the work. However, the width of cut at the bottom (exit) was always found to be larger than that at the top. It was found that the taper of cut gradually reduces with increase in standoff distance and was close to zero at the stand off distance of 4 mm. The jet pressure does not show significant influence on the taper angle within the range of work feed and the stand off distance considered. Both stand off distance and the work feed rate show strong influence on the roughness of the machined surface. Increase in jet pressure shows positive effect in terms of smoothness of the machined surface. With increase in jet pressure, the surface roughness decreases. This is due to fragmentation of the abrasive particles into smaller sizes at a higher pressure and due to the fact that smaller particles produce smoother surface. So within the jet pressure considered, the work surface is smoother near the top surface and gradually it becomes rougher at higher depths.

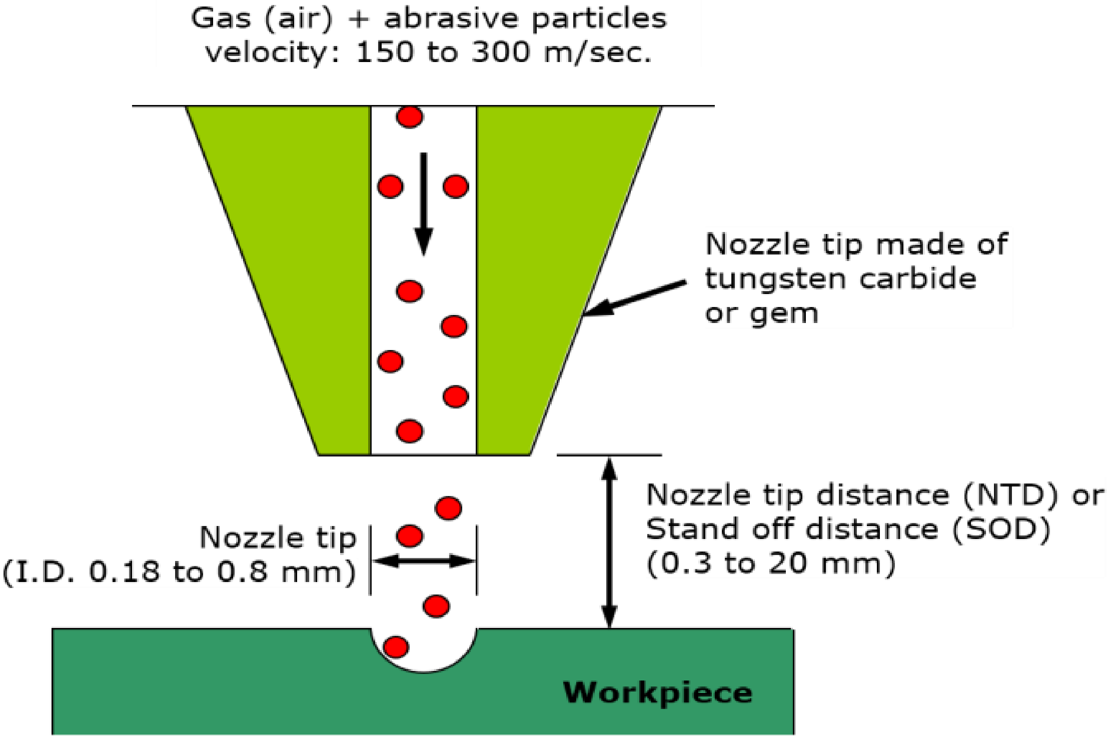

Fig. 1- Principle of working abrasive jet machining

Source-https://me-mechanicalengineering.com/abrasive-jet-machining/

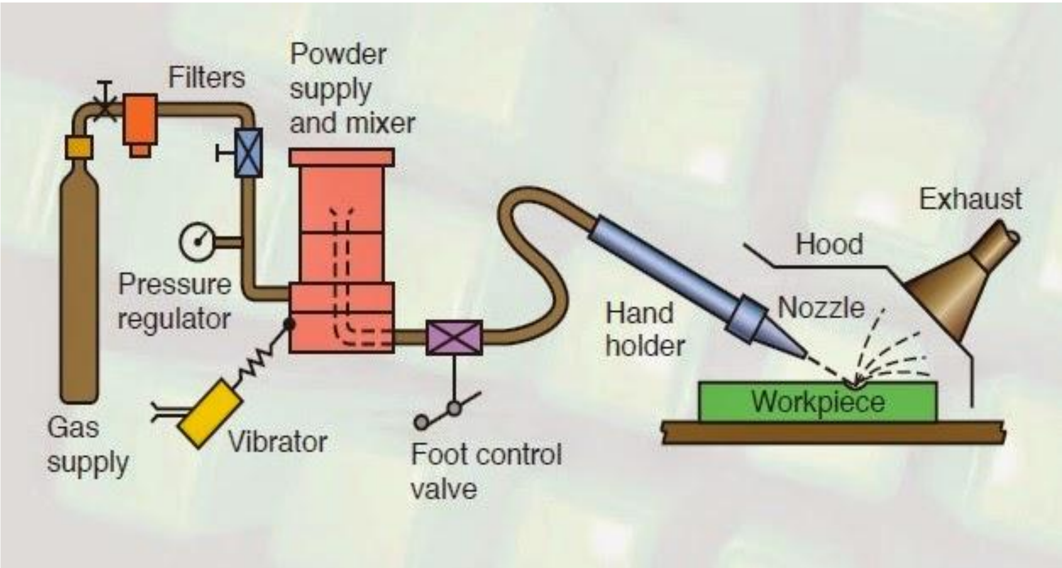

Fig.2AJM set up

Process parameters of abrasive jet machining- there are process parameters of abrasive jet machining which effect the efficiency, material removal rate of AJM process , some of them are discussed in this sectionmrr

- the abrasive: composition; strength; size; mass flow rate
- the gas composition, pressure and velocity
- the nozzle: geometry; material; distance to work; inclination to work

The effect of process parameters on material removal rate also shown here in graphical from also.

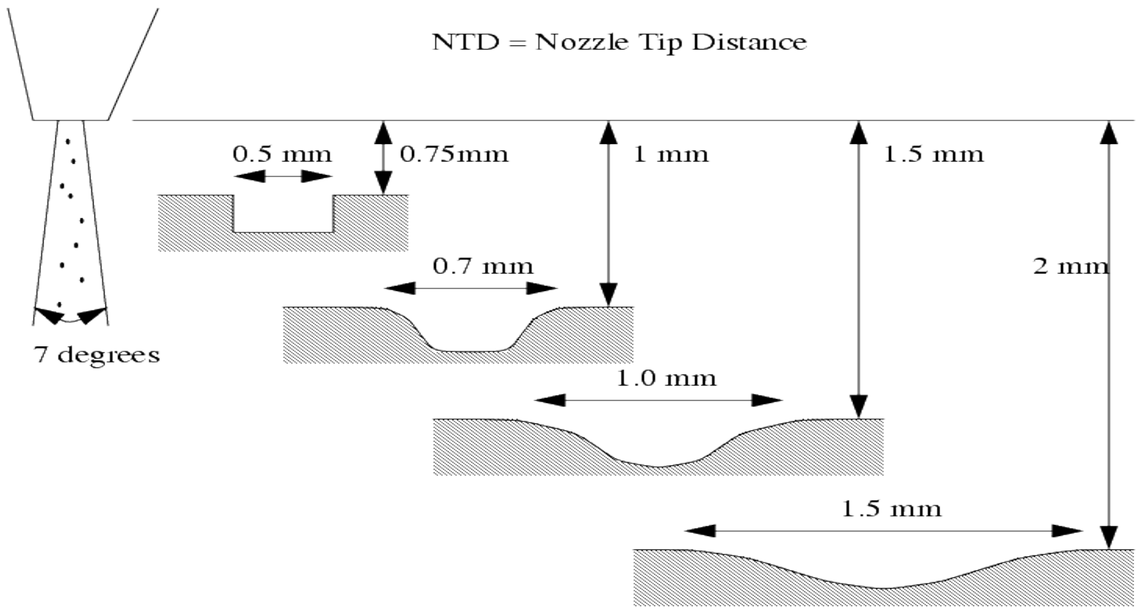

Figure 3- effect of NTD on MRR

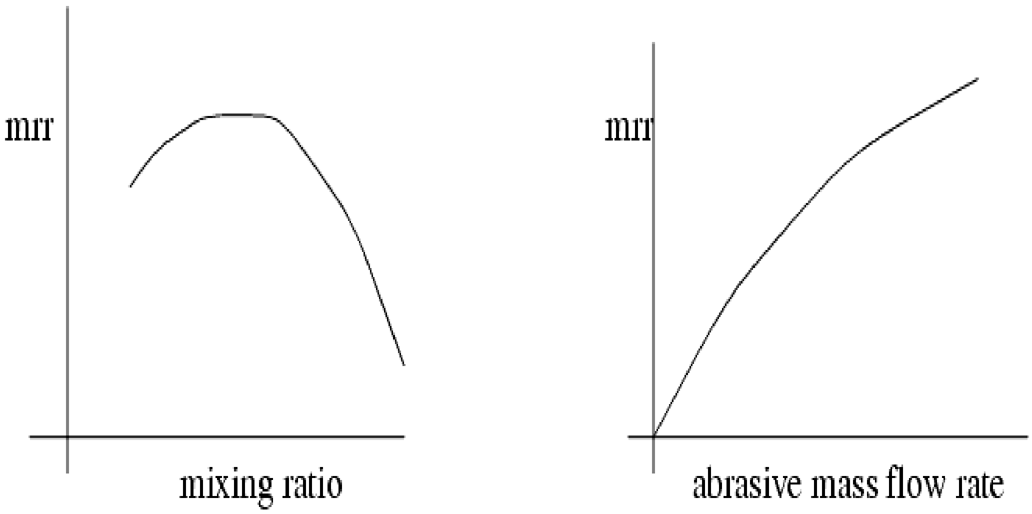

Figure 4- Effect of mixing ration and abrasive flow rate on MRR

II LITERATURE REVIEW

Wu Xia, etc. found(7) that a system structure for water jet cutting machine fault diagnosis based on multi-information fusion is presented, which takes the time-varying, redundancy and uncertainty of the multi-fault characteristic information into consideration. We make use of the neural network's ability of better fault tolerance, strong generalization capability, characteristics of self-organization, self-learning, and self-adaptation, and take advantage of multi-source information fusion technology to realize comprehensive processing for uncertainty information. The characteristic layer fusing model of the water jet cutting machine fault diagnosis, which makes use of fuzzy neural network to realize feature layer fusion and D-S evidence theory to complete decision layer fusion, has been established. The simulation results of water jet cutting machine fault diagnosis show that the method can effectively improve the diagnostic credibility and reduce diagnostic uncertainty.

Vinod B. Patel, etc.(8) found that abrasive water jet machine (AWJM) is a mechanical base non-conventional machining process. This is process of removal of materials by impact erosion of high pressure (1500-4000 bar), high velocity of water and entrained high velocity of grit abrasives on a work piece. Experimental investigations were conducted to assess the influence of abrasive water jet machining (AWJM) process parameters on response-Material removal rate (MRR) and Surface roughness (Ra) of EN8. The approach was based on Taguchi's method and analysis of variance (ANOVA) to optimize the AWJM process parameters for effective machining. Experiments are carried out using L25 Orthogonal array by varying traverse speed, abrasive flow rate and stand of distance (SOD) for EN8 material. In present study, Analysis found that varying parameters are affected in different way for different response.
This paper presents they discussed about analysis of various process parameters and drawn following conclusions from the experimental study:

- Process parameters affect different response in different ways. Hence need to set parameter based on requirement.
- MRR increases with the increase in Traverse speed (50 to 65 mm/min) and also Surface Roughness increase with increase in Traverse speed.
- Higher Abrasive flow rate give increase MRR and less influence on Surface Roughness. Abrasive flow rate is less significant control factor for MRR.
- MRR increases with the increase in SOD (2 to 8 mm) up to certain limit and further increase in SOD beyond the limit results in decrease of MRR and Surface Roughness increase with increase in SOD.
- Traverse speed is a most significant control factor for MRR and Abrasive flow rate and SOD are equally significant control factor for MRR. SOD is the most significant control factor on Surface Roughness.
- Mixing ratio is a most significant control factor for MRR and Surface Roughness.

M chithirai, etc. (9)found that abrasive waterjet cutting has been proven to be an effective technology for processing variety of engineering materials.It is an emerging technology and 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.This paper presents an extensive review of the current state of research and development in the abrasive waterjet cutting process. Further challenges and scope of future development in abrasive waterjet cutting are also projected. This review paper will help researchers, manufacturers and policy makers widely.

In order to correctly select the process parameters, reliable predictive mathematical models can be developed for the depth of cut in AWJC process of aluminium, brass, cast iron, ceramics, copper, composites, granite, mild steel stainless steel and titanium. These depths of cut models can be used as practical guidelines for selecting optimum process parameters in AWJC of these materials. Therefore the need for extensive experimental work in order to select the magnitudes of the most influential abrasive waterjet cutting parameters on the depth of cut can be eliminated.

Johan Fredin (10) , etc. found that **a**brasive waterjet cutting (AWJ) is a highly efficient method for cutting almost any type of material. When holes shall be cut the waterjet first needs to pierce the material. This paper presents a vast experimental analysis of piercing parameters effect on piercing time. Results from experimentation on feed rates, work piece thicknesses, abrasive flow rates, standoff distances and water pressure are also presented as well as studies on three methods for dynamic piercing. It is shown that a large amount of time and resources can be saved by choosing the piercing parameters in a correct way. The large number of experiments puts demands on the experimental setup. An automated experimental setup including piercing detection is presented to enable large series of experiments to be carried out efficiently.

UshastaAich et al. (11) carried out experiments on cutting of borosilicate glass by AWJM. Depth of cut is measured with different machine parameter settings as water pressure, abrasive flow rate, traverse speed and standoff distance**.** Optimum condition of control parameter setting is also searched through particle swarm optimization (PSO).Also, scanning electron microscopic (SEM) image reveals to some extent, and the nature of cut surface and erosion behavior of amorphous material qualitatively

Experiments on standoff distances show that a slightly larger standoff distance can preferably be chosen for piercing in comparison with cutting, with no risk of increasing the piercing time but with less risk of clogging the nozzle. This study shows examples where the benefits of using an automated measurement setup are clearly seen due to the big amount of tests done. A lot of time was saved during the experimentation due to the efficiency of the automated experimental setup. Large series of experiments could be run without human interference. A similar measurement set-up can be used for normal cutting and can therefore be used to improve productivity in waterjet cutting in general and not only for piercing. Future studies should be made focusing on specific important parameter ranges and also including the effects of economic aspects for different piercing approaches.

III CONCLUSION

This paper presents the effect of process parameters of AJM on the material removal rate (MRR) .some papers were discussed in literature review about the research going in abrasive jet machining. It is one of the emerging process for machining ceramics in non conventional machining methods.

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