Advancement of Abrasive Jet Machining and Its Review

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Abstract-*In the advanced areas of space, missile and nuclear technologies, there arise a need for machining components to maintain exact sharp edges, high accuracy, and precisely sized components. In the present era of modern machining, these requirements can be achieved with the help of advanced machining process like Abrasive Jet Machining (AJM).This paper presents an extensive review of the current state of research and development on abrasive jet machining process.*

Keywords: Abrasive Jet Machine, Experimental, Mathematical, optimization approach.

I. INTRODUCTION

Abrasive Jet Machine (AJM): Abrasives are very expensive but abrasive jet process requires low capital cost and operational cost because the investment on equipment is very low in comparison with other nontraditional machining processes giving tighter tolerances. As the carrier gas serves as a coolant, the cutting action is cool and hence better surface finish can be obtained. Now days it is widely used in manufacturing of electronic devices, LCD's, tribo-elements, MEMS, and semiconductors. There exists an increasing demand to develop micromachining technologies for these difficult-to-machine materials due to their properties of extreme hardness, brittleness, corrosion resistance and low melting temperatures. Abrasive jet machining (AJM) is a nontraditional machine process which operates without producing shocks and heat. In this machining process, the high - velocity stream of abrasives is generated by converting the pressure energy of carrier gas or air to its Kinetic energy and hence the high - velocity jet results. A nozzle directs abrasives in a controlled manner onto the work material. AJM is applied for many applications like cutting, cleaning, polishing, debarring, etching, drilling and finishing the operation. The nozzle is the most critical part in the abrasive air-jet equipment .Response variables like surface finish, Material Removal Rate (MRR), kerfs width is producing a cylindrical hole. This novel technology was first demonstrated by Franz to cut laminated paper tubes in 1968 and was first introduced as a commercial system in 1983. In the 1980s garnet abrasive was added to the water stream and the abrasive jet was born. In the early 1990s, water jet pioneer Dr. John Olsen began to explore the concept of abrasive jet cutting as a practical alternative for traditional machine shops. His ultimate goal was to develop a system that could eliminate the noise, dust, and expertise demanded by abrasive jets at that time. In the last two decades, an extensive deal of research and development in AJM has been carried out. Based on the literature review of AJM Process the published works on this can be classified based on the performance measure considered into three different categories, namely experimental approach, Optimization approach and Analytical approach.

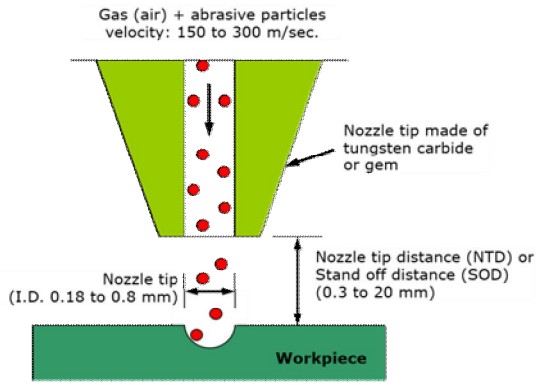

Fig.1: Schematic Diagram of AJM

II. REVIEW OF AJM

In this section, experimental analysis of abrasive jet machine is discussed. The experiments and research are done by the various researchers regarding abrasive jet machine are focused. Parameters such as the velocity of gas,pressure, nozzle tip distance (NTD) are explained. also material removal rate (MRR), substance integrity discussed along with operation such as cutting, drilling.

Jiuan-Hung Ke gives novel method along with feng-CheTsai, Jung-Chou Hung, and biing –Hwa Yan on characteristics study of flexible magnetic abrasive in abrasive jet machining which suggests that self-made magnetic abrasive with elasticity are utilized to get machining characteristics in Abrasive jet machining [1].abrasive jet machine has may other advantages as high etch rate, good machining flexibility low capital and operation cost.

Nowadays the quality of abrasive jet machined surface could be improved by parameter optimization just because jetted particles was affected by air resistance after performing the experiment they made a result, Taguchi trial. According to Taguchitrial, a magnetic field is a main factor for surface roughness difference and material removal. In abrasive jet machining, they use the flexible magnetic abrasive not only to restrain the abrasive jet direction and enhance more uniform actual operational area and material removal rate but also have a permanent effect to obtain good surface roughness than normal machining process.

Kumar Abhishek and Somashekharhire math studied wide applications of the micro abrasive jet machine. i.e Machining of Micro-holes on Sodalime Glass using Developed Micro-Abrasive Jet Machine To produce micro features such as micro holes on brittle materials [2].This process is also favorable for to machine heat sensitive materials. It has wide industrial applications and in engineering fields also. This paper analysis optimal machining parameter to machining hole on soda lime glass thickness about 1.6mm for multiple parameter characteristics.

Kumar Abhishek and Somashekharhiremath stated that gray relational analysis (GRA) is used for escalation the process parameter for the material removal rate (MRR) based on gray relational grade obtained for the actual process. Development of process parameter has been carried out. Air pressure was found to be a most significant factor for multiple parameter characteristics. the importance of selected performance parameter such as air pressure, a standoff distance are confirmed using gray relational analysis .the result obtained from the experiment of machining of micro holes on soda lime glass including the size of hole, material removal rate and radial outlet are presented in this paper.

Kumar Abhishek and Somashekharhire math works on the improvement of geometrical accuracy of the micro holes along with the dimensional tolerances[3]. While assembling the parts of any machine or to disassemble it we roughly need their geometrical accuracies. micro holes machined through .tapered hole causes poor cylindricity .the effect of cylindricity can be minimized by reducing taper angle of the hole. Initial experiment was based on conventional approach of micro abrasive jet machine, in which the nozzle is stationary and hence time taken to the machine to be hole found to be more in this paper they basically deals with the novel approach towards machining holes on the brittle materials with the help of micro abrasive jet machine (µ-AJM.The holes machined using novel approach and conventional approach very much differ. In a novel approach, the entrance and an exit diameter of the hole are reduced. Using µ-AJM experimentally using the novel approach i.e. nozzle is given feed rate of to average rate of change of work piece thickness it concludes that taper angle of machined hole of the work pieceis reduced approximately 58%. In-house developed micro abrasive jet machine setup gives an open loops nozzle feed system.

D.V.srikanth Dr. M Sreenivasarao deals with the metal removal and kerf analysis in abrasive jet drilling machine of glass sheets [4]. The study states that a high velocity jet of dry air ,nitrogen or carbon dioxide containing abrasive particles aimed at the work surface under controlled conditions .the major process parameters that affects material removal rate (MRR) in abrasive jet machine are gas pressure velocity of abrasive particles, abrasive mass flow rate, mixing ratio and nozzle tip distance. the abrasive jet machine removes the material through the action of the focused beam. drilling get carried out by abrasive jet drilling process with varying pressure and different nozzle diameters. In this paper escalation of process parameters of abrasive jet machining by Taguchi methodology is presented value obtained in the Taguchi analysis was compare with analysis with variance. this paper presents extensive result of experiments have been conducted by changing pressures ,nozzle tip distance (NTD) ,SOD on different thickness of glass tubes or glass plates the effect of their process parameters on the material removal rate (MRR) is studied with the help of Taguchi method and it is compared by using analysis of variance ANOVA[11]. the further experimental study states that Taguchi process is nearly matching with ANOVA result Vasanth S , Muthuramalingam T, Vinothkumar P, Geethapriyan T, Murali G studies the Performance Analysis of Process Parameters on Machining Titanium (Ti-6Al-4V) Alloy Using Abrasive Water Jet Machining Process (AWJM).[5]. Titanium (Ti-6Al-4V) alloy has high strength hence use in fabricating medical device applications. It is very difficult to machining alloy using conventional machining. the Abrasive water jet machining process has a big advantage this process has less heat effect on the body and material removal rate The main key factor is to improve machinability of the work piece this paper deals with the for the present study experimental procedure to analyzing effects of process parameters on machining Titanium (Ti-6Al-4V) alloy using AWJM process. they have attempted to find the influence of process parameters on surface roughness and topography [14]for improvement of the process. The abrasive flow rate and standoff distance have the most significant role in determining surface quality. Surface quality and Higher abrasive flow rate with higher standoff distance produce higher surface roughness owing to larger and random energy distribution.

Dirk Biermanna, Robert Aßmutha, Sebastian Schumann, Michael Rieger, Bernd Kuhlenkötte studies Wet

abrasive jet machining to prepare and design the cutting edge micro shape[6]. This paper is basically concerned with the requirements and challenges in preparing and designing the cutting edge micro shape using wet abrasive jet machining. The results show that by means of water jet abrasive machining with robot-guided systems cutting edge preparation is useful in a wide range regarding the examined characteristic values. With respect to the cutting edge handling parameters, it has been studied that the jet feed speed and the relative jet inclination angle have a strong effects on the resulting average cutting edge rounding and the form-factor In this context, it is essential to consider the relation between the form-factor and the rounding size when designing the cutting edge micro shape In order to evaluate the sensitivity and reproducibility of wet abrasive jet machining with a robot guided system, future investigations will consider varying jet parameters and workpiece specifications. The specific findings will then be transferred to real cutting tools.

Vishal Guptaa , P.M. Pandeya ,Mohinder Pal Garg , Rajesh Khannab ,N.K.Batrab works on Minimization of kerf taper angle and kerf width with the help of Taguchi's method in abrasive water jet machining of marble [7].

Abrasive water jet cutting is a non-traditional machining method that gives a productive alternative to conventional techniques. This paper attempts to investigate kerf characteristics in abrasive water jet machining of marble which is having wide applications in domestic, commercial and industrial construction work. The experimental conclusion made on the experiment is basic study created the range of selected process parameters taking into consideration to the minimum values of water pressure and abrasive flow rate. For top kerf width, nozzle transverse speed has emerged as most significant parameter taken into consideration It was found that abrasive flow rate failed the test of significant at 95% confidence level, therefore, it was pooled out. For minimum kerf taper angle lowest levels of water pressure and nozzle transfer speed at 200 M Pa and 50 mm/min emerged as optimal settings.

III. APPLICATIONS OF ABRASIVE JET MACHINING

Abrasive Jet Machining is employed in micro welding, fine drilling and aperture drilling for electronic microscope.

This machining process used for intricate profiles on fragile and hard metalsAbrasive Jet Machining employed to perform cleaning and cutting operations on materials like silicon, germanium, quartz and also for machining for semiconductors.

III. CONCLUSION

According to the various research papers available till date, a lots of work has done on abrasive particles and its geometry, different process parameters, the volume of material removal during machining. An extensive review of the research and development in the AJM has been conducted in this paper. It was shown that AJM process is receiving more and more attention in the machining areas, particularly for the processing of difficult-to-cut materials. Its unique advantages over other conventional and unconventional methods make it a new choice in the machining industry. Very less research has been done on the study of the effect of abrasive flow rate on performance characteristics. Hence there is scope for improvement for the study of the effect of abrasive flow rate on performance characteristics like material removal rate and taper angle. Improper mixing chamber construction causes various problems such as abrasive powder stratification, powder compaction, powder humidification etc. This affects the machining results undesirably.

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