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A Review on Research and Development in Optimization of Parameter of Abrasive Waterjet Machining

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ABSTRACT: Abrasive waterjet machining (AWJM) is a developing machining technology choice for hard material parts that are very challenging to machine by conventional machining processes. A fine stream of high velocity water mixed with abrasive particles provides relatively low-cost and environment responsive fabrication with practically high material removal rate. The abrasive waterjet machining has become one of the prominent manufacturing technologies in a relatively small period of time. This paper reviews the research work approved out from the inception to the development of AWJM within the previous decade. It reports on the AWJM research concerning to improving performance measures, monitoring and control of process, optimizing the process parameters. A comprehensive range of AWJM industrial uses for diverse category of material are described with variations. The paper also confers the future development of research work in the area.

KEYWORDS: Process parameter, Abrasive waterjet machining, Process optimization, Monitoring, Control.

I. INTRODUCTION

Abrasive Waterjet cutting machines on track to operate in the early 1970s for cutting wood and plastics material and cutting by abrasive waterjet machine was first commercialized in the late 1980s as a revolutionary innovation in the area of unconventional processing technologies. In the early 1980s, AWJ machining was deliberated as an unrealistic application. Today, state-of the art abrasive jet technology has grown-up into a full-scale production process with precise, reliable results.

In AWJ machining process, the work piece material is machined by the action of a high-velocity jet of water mixed with abrasive particles established on the principle of erosion of the material upon which the water jet impact. AWJ is one of the most unconventional modern approaches used in manufacturing engineering for material machining. AWJ has advantages such as high machining flexibility, lesser cutting forces, high flexibility and zero thermal distortion. Linking with other corresponding machining processes, no heat affected zone (HAZ) on the work piece is created. Great speed and high cutting efficiency, multidirectional cutting ability, capability to cut intricate shapes of even non flat surfaces very effectively at close tolerances, negligible heat build-up, little deformation stresses within the machined part, stress-free completion of changeover of cutting patterns under computer control, etc. are a few of the advantages existing by this process which make it best for automation. Due to its flexibility, this cutting tool is finding use not only in contour cutting, but also in additional machining techniques such as milling, drilling, threading, turning, cleaning, and hybrid machining. AWJ Machine is widely used in the processing of materials such as titanium, brass, steel, aluminium, Inconel, stone, and any kind of glass and composites. Being a modern manufacturing method, abrasive waterjet machining is however to undergo enough superiority so that its fullest potential can be gained. This paper offers a review on the several research activities carried out in the previous decade on AWJM. The paper

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categorizes the major AWJM academic research region with the titles of AWJM process optimization, AWJM process monitoring and control. The Schematic diagram of an abrasive waterjet cutting system is shown in Fig. 1

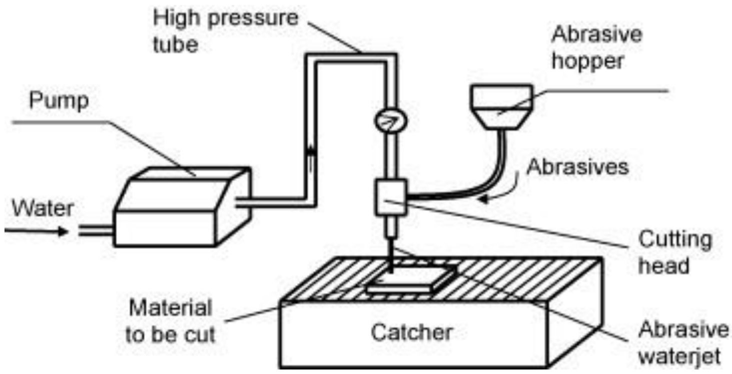

Fig -1: Schematic of an abrasive waterjet cutting system

II. LITERATURE SURVEY

Leeladharnagdeve, vedanshchaturvedi&jyotivimal [1]performed experiment on Abrasive water jet machine to find out optimum process parameter for supreme Material removal rate and quality surface finish after cutting. Before this the work has performed in this field that Previous examination indicated even that through some efforts have been made to increase the material rate , the taper of the drilled holes was not being decrease. This effort has been made to amplify MRR and to decrease the taper by varying standoff distance with different chemical setting and chemical concentration. Methodology used is Taguchi approach L9 array, ANOVA & F-Test, they have taken four parameters Pressure, Stand of distance, Abrasive flow rate, Traverse rate, and T material for experimentation is Aluminum. Conclusions from this they got are, Pressure is the most important factor on MRR throughout AWJM, In case of surface Roughness Abrasive flow rate is most major control factor.

AzlanMohdZain, HabibollahHaronb, Safian Sharif[2] has performed experimentation on Abrasive water jet machine to find out which optimization techniques is more efficient and precise to find out optimum solution for surface roughness analysis, they have performed the experimentation on Aluminum Al 7075 alloy by using methods Genetic Algorithm, Regression modeling, Stimulated Annealing, Experimental Data, integration GA-SA type1,SA-type2.from the experiment authors have found that integration GA -SA type 1 and SA-GA type2 methods are very efficient and gives precise optimum solution.

Mehul.A.Raval, Chirag. P. Patel[3] has performed experimentation on Abrasive water jet machine parameter optimization on Steel material by using Design of Experiment Taguchi orthogonal Array L9,and further Gray Relation Analysis technique to get conclusion about at what machine parameters the process is optimum and efficient. They have taken controllable variables, namely, abrasive grain size, pressure, tip distance, pole distance. And they also found out that magnetic Abrasive in water jet machining is feasible alternative to aluminium oxide and other abrasives.

M.SreenivasaRao, S.Ravinder and A. Seshu Kumar[4] performed the trial on mild steel material by using control parameters in three levels, to find out optimum surface roughness and which parameter having most significant effect on the surface roughness. Authors have used ANOVA and F test and S/N ration techniques to complete the experiment. the conclusion they got is Traverse Speed is the most significant aspect on Surface roughness during Abrasive water jet machining and The commended parametric combination for optimum surface roughness.

P. P. Badgujar, M. G. Rathi[5] have done experiment on steel SS304 material to find out the optimum parameters combination for optimum process and factors which affects the most for the surface roughness after machining of SS304 by using Taguchi's L27 orthogonal array further using S/N ratio analysis and ANOVA technique. The parameters they have considered are pressure within the pumping system, abrasive material grain size, stand-off distance, nozzle speed and abrasive mass flow rate. They have got the optimum combination of parameter on which the surface roughness is minimum and they come to know that abrasive material grain size is most effective factor on quality of surface roughness of the machined steel material.

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ZoranJurkovic, MladenPerinic, Sven Maricic, RijekaCroatia ,MilenkoSekulic, SerbiaVesnaMandic [6] have an aim to conduct the experimental research of process parameters effect on surface roughness of the machined parts, and to study the effects of certain process parameters on the surface roughness. The examination was approved out for two materials, stainless steel and aluminium alloy for given process parameters type of material stainless steel aluminum, abrasive flow rate, stand-of distance, water pressure, traverse rate, sample thickness using orthogonal array experiment and factorial design. Based on the acquired experimental results are defined mathematical models of surface roughness using different methods. The optimal process parameters, tested through confirmation tests.
D. Sidda Reddy, A. Seshu Kumar, M.SreenivasaRao[7] have an aim to conduct the experimental research of process parameters effect on material removal rate & surface roughness of the machined component. The process parameters are Traverse rate, Abrasive flow rate and Standoff distance by using ANOVA, F test. With the help of S/N ratio Authors have got the optimum combination of parameters for maximum material removal rate and surface roughness and Traverse Speed plays a major part on impelling material removable rate and In case of surface Roughness Standoff distance and Transverse speed plays major implication.
M. Chithiraiponselvan, n. Mohanasundararaju, h. K sachidananda[8] have done experiment on steel Aluminium material,paper displays the effect of process parameters on surface roughness which is a significant cutting performance measure in abrasive water jet cutting of aluminium. Taguchi's design of experiments was agreed in order to gather surface roughness values. Experiments were conducted in varying water pressure, abrasive flow rate, nozzle traverse speed, and standoff distance for cutting aluminium using abrasive water jet cutting method. Conclusions which they got are pressure is the most effective factor in improving and reducing the surface roughness quality, as the pressure increases the surface roughness decreases. Abrasive flow rate is the second most significant factor.
Mayur C. Patel, Mr. S. B. Patel, Mr. R.H. Patel[9] have done experiment on Aluminium6351 T6 material, paper displays effect of process parameters on surface roughness and kerf angle. Experiment were conducted by using parameters like Traverse rate, Abrasive flow rate, Standoff distance, by considering two different orifice diameters. Authors got the conclusion that Abrasive material flow rate and traverse rate are most significant factors in controlling surface roughness quality and reduction of kerf angle.
Vinod B. Patel*, Prof. V. A. Patel[10]Experimental investigations were lead to judge the effect of abrasive water jet machining process parameters on response-Material removal rate and Surface roughness of material EN8. The method was based on Taguchi's method and analysis of variance to optimize the Abrasive Water Jet Machine process parameters for effective machining. Trials were carried out using L25 Orthogonal array by variable traverse speed, abrasive flow rate and stand of distance for EN8 material. Study Analysis found that varying parameters are affected. Traverse speed is a most important governing factor for Material removal rate and Abrasive flow rate and Stand of Distance are equally significant control factor for Material removal rate. Stand of Distance is the utmost major control factor on Surface Roughness. Mixing ratio of water and abrasive material is a most significant control factor for both.
M. A. Azmir, A.K. Ahsan, A. Rahmah, M.M. Noor1 and A.A. Aziz[11]In the present effort, the optimization of the abrasive water jet machining process parameters with multiple performance characteristics built on the orthogonal array with the grey relational analysis has been studied. Optimization of multiple response characteristics is far more intricate compared to optimization of single performance characteristic. Four machining parameters, abrasive mass flow rate, namely hydraulic pressure,standoff distance and traverse rate are optimized with attention of multiple performance characteristics .surface waviness at four different heights of a Kevlar composite laminate.
Y.B Gaidhani, V.S.Kalamani[12] paper have proposed the method of selection of process parameters for optimization of water jet abrasive machine for optimum result for the higher surface texture quality of the steel material applying Analytical Hierarchy Process Approach and by calculation they have found out the importance of the different parameters affecting the quality of the surface finish in percentage value .By ranking the parameters they conclude which parameters are more effective and to select those parameters.
Preeti, Dr. Rajesh Khanna, Rahul Dev Gupta, Vishal Gupta[13] this paper have an aim to conduct the experimental research of process parameters effect on material removal rate of the machined component,makrana white marble was used as a material; the process parameters are pressure, Abrasive flow rate and Standoff distance by using ANOVA, F test. Conclusion pressure and abrasive flow rate plays major part on impelling material removable rate.
Kapil Kumar Chauhan, Dinesh Kumar Chauhan[14] have conducted experiments on the titanium alloy material to find out at what levels of parameters the Physical Vapor Disposition coated cemented carbide tool can get maximum life on milling machine. They have used taguchi technique and with help of S/N ratio analysis they came to conclusion at what levels of parameters like cutting speed, Feed, Depth of cut and coolant flow rate the tool life is maximum.
J. Laxman, Dr. K. Guru Raj[15] deals with the optimization of Electro Discharge Machining process parameters using the grey relational analysis based on an orthogonal array for the multi response process. The experiments are

directed on Titanium super alloys with copper electrode constructed on the Taguchi design of experiments L27 orthogonal array by selecting several parameters such as peak current, pulse on time, pulse off time and tool lift time for Electro Discharge Machining process to obtain multiple process responses specifically Metal removal rate and Tool Wear Rate . The combination of Taguchi method with GRA allows determining the optimal parameters for multiple response process. Gray relational analysis is used to find a performance index called gray relational grade to optimize the Electro Discharge Machine process with higher Material Removal Rate and lower Tool Wear Rate and it is evidently found that the performance of the Electro Discharge Machine has significantly amplified by optimizing the reactions the influence of individual machining parameters also examined by using analysis of variance for the grey relational grade.

III. SUMMERY

The examination on various process parameters of AWJM displays that MRR increases with increase in water pressure, but the major disadvantage is that the surface roughness and surface destruction increases with rise in pressure. Types of abrasives and traverse speed also influence the various quality parameters of work piece.

IV. CONCLUSION

Quality of cut surface in AWJM is dependent on so many process parameters. Process parameter which affect less or more on quality of cutting in AWJM are water pressure, size of abrasives, Standoff distance, abrasive flow rate, types of abrasive, orifice size, nozzle diameter, and traverse speed. Quality of machining is measured by material removal rate, kerf width surface roughness, taper ratio. From the literature survey compare to above all cited parameter traverse speed is most active parameter for MRR. Abrasive flow rate is too an important parameter for increasing MRR. But further than some limit with rise in abrasive flow rate and traverse speed the surface roughness falls. Increasing traverse speed also upsurge the kerf geometry. So it is essential to discover optimum condition for process parameter to give improved quality of cutting surface. Traverse speed is directly proportional to output (productivity) and should be selected as high as possible deprived of compromising kerf quality and surface roughness.

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