A Review on Effect & Optimization of Abrasive Water Jet Machining Process Parameters

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Abstract— Abrasive water jet machining is one of the recent non-traditional manufacturing technologies for material processing. It has advantages of no thermal distortion, high machining versatility, high flexibility and small cutting forces. A design of experiments approach was taken, considering variables such as water jet abrasive size, water jet pressure, abrasive flow rate, standoff distance, the angle of attack and transverse speed. And these are optimized to investigate their influence on Metal Removing Rate (MRR) and Surface Roughness (SR) of Inconel-188. Taguchi robust design analysis is employed to determine an optimal combination of process parameters. Every day scientists are developing new materials and for each new material, we need economical and efficient machining. It is also predicted that the Taguchi method is a good method for optimization of various machining parameters as it reduces the number of experiments.

Key words: SR, MRR, AWJM

I. INTRODUCTION

Abrasive water jet machining is one of the types of the non-conventional machining process. It is the combination of both abrasive jet machine and water jet machine. It is used for machining all type of material metal as well as a nonmetal. It is also known as 'Micro-abrasive blasting'.

The abrasive water jet is first recommended in the 1980s in this method small abrasive particle mixed with water jet in such manner that water jet momentum is partly transferred to the abrasive particle. Abrasive used is generally garnet 80mesh size. the main role of water is to accelerate large quantities of abrasive particles to high velocity and produce a high-velocity jet this jet performs a cutting operation [17]. In this process, water is used as an accelerating medium and the abrasive will perform the operation of material removal

This type of technique is cost-effective and environmentally friendly. Having an advantage of flexibility, low heat production and ability to machine hard and brittle material but the disadvantage of this type of machining process is it creates a loud noise and a messy working environment [20]. This technique is used for many purposes like drilling, cutting, cleaning, and etching operation.

INCONEL is an alloy of cobalt+ nickel+ chromium+ tungsten. cobalt is the main alloy. It has a property of high temperature strength, ductility and good resistance to oxidation. For optimization of abrasive water jet machine, we used Taguchi method for formation of 27 orthogonal arrays and MINITAB software for formation of S/N ratio graph

There are a number of parameters are considered for this technique they are abrasive flow rate, a stand of distance, transverse speed. The main process quality measure includes material removal rate, surface roughness and kerf width in this paper MRR, SR, KW is considering as the main consideration in order to effectively optimize the AWJM process productive model on MRR, SR, KW have been already developed for cast iron, ceramic, aluminum, stainless steel but no model has been developed for Inconel 188. this paper asset the effect of AWJM process parameters on MRR, SR, KW of Inconel 188 an empirical model for the prediction of MRR, SR, KW of in AWJM. The process of Inconel 188 is developed using regression analysis

II. LITERATURE REVIEW

Arun S, Balaji N. and Kannam S. [1] experimented on Inconel-188 for abrasive water jet machining parameter like Metal Removal Rate and surface finish. It was concluded that Traverse speed is the most significant factor on Metal Removal Rate and Surface finish during Abrasive Water jet machining; also Abrasive flow rate and Standoff distance are significant in influencing.

G. A Escobar- Palafox, R. S Gault, K. Ridgway [2] conducted the experiment on pocket milling in Inconel-718for characterization of abrasive water-jet process, and considered experimental variables are depth of cut and pocket geometry. It was concluded that water pressure has a non-linear behavior and is of paramount importance for controlling the depth of cut and geometrical errors. Nozzle diameter and the interaction between feed rate and abrasive mass flow are critical factors which are affecting the depth of cut.

B. Satyanarayana and G. Srikar [3] experimented on material removal rate and kerf width by using AWJM process for Inconel -718.It was concluded that water jet pressure has more influencing effect on Kerf width and MRR rather than abrasive flow rate and standoff distance. The performances characteristics abrasive flow rate, standoff distance and water jet pressure are improved together. This was achieved by Taguchi grey relational analysis method.

Ajay D. Kumbar and Manavendra Chatterjee [4] investigated that MRR increasing with increase in stand-off distance. They also studied the effects of inherent characteristics of the water jet flaring on straightness and effect of different process parameters on major cutting performance measures in AWJM. When work feed rate increases, surface roughness is also increased.

Krishankant Jatin Tanuja, Mohit Bector and Rajesh kumar [5] experimented on EN24 steel material by turning process. It was concluded that if there is an uncontrollable parameter then minimization of quality characteristic is minimized, and Metal Removal Rate and S/N ratio was good quality characteristics with the concept of "larger-the-better". It was also predicted that Taguchi method is good method for optimization for various process parameters.

Chirag M. Paramar, Pratik K Yogi and Trilok D. Parmar [6] experimented on AWJM process parameter for

AL-6351.It was found that process parameter like standoff distance from work surface, work feed rate, jet pressure and abrasive type are the effective parameter to evaluate the criteria for work surfaceroughness. It was concluded that traverse speed is the most control factor for Surface roughness and also the abrasive flow rate and standoff distance was less influencing for AL-6351 on the process AWJM.

Viswanath J., CH Lakshmi Tulasi, and Anand Babu K. [7] worked on input process parameters of AWJM to find out fine surface finish and high material removal rate by using Taguchi method and ANOVA for material Inconel 625.It was concluded that higher material removal rate and fine surface roughness are found out through analysis of variance (MINITAB) in graphical form.MRR and SR are influenced over abrasive process parameters.

Derzija Begic-Hajdarevic, Ahmet Cekic, Muhamed Mehmedovic and Almina Djelmic [8] worked on surface roughness in abrasive water jet cutting. It was concluded that surface roughness increased by increasing traverse speed. Also surface roughness increased by increase in depth of cut surface.

D. V. Srikanth, M. Sreenivasa Rao [9] studied on the presents an extensive review of the current state of research and development tin the abrasive jet machining process. It was also projected that the further challenges and developments in abrasive water jet machining.

M. M. Korat, G. D. Acharya [10] worked on Abrasive water jet machining (AWJM) is very important machining technology option for hard material parts that are extremely difficult-to-machine by conventional machining processes. AWJM is suitable for precise machining such as polishing, drilling turning and milling. It was also state that the more research work is required in nozzle size and orifice diameter, power consumption, dimension accuracy and multi objective optimization for abrasive water jet machine process.

M. Chithirai Pon Selvan and N. Mohana Sundara Raju [11] studied that the various effects of process parameters on abrasive water jet cutting in stainless steels. It was concluded that Increase in nozzle standoff distance decreases the depth of cut when the other parameters considered as constant, Increase in abrasive mass flow rate also increases the depth of cut. Also. the increase of traverse speed decreases the depth of cut within the operating range selected and increase of water pressure results in increase of depth of cut while keeping mass flow rate, traverse speed and standoff distance as constant. When water pressure is increased, the jet kinetic energy increases that leads to more depth of cut.

K.S. Jai Aultrin, M. Dev Anand [12] worked on effects process parameter on MRR and SR by using Response surface methodology and regression analysis for a copper iron alloy. It was found that experimental results an empirical model for the prediction of material removal rate in abrasive water jet cutting process of copper iron alloy was developed using regression analysis. Also major influencing parameters are pressure; abrasive flow rate and standoff distance and the minor influencing parameters are orifice diameter and focusing nozzle diameter to provide maximum MRR.

M.Sreenivasa Rao, S. Ravinder and A. Seshu Kumar [13] worked on parametric optimization of abrasive water jet machining for Mild Steel by Taguchi approach. It was concluded that traverse Speed (S) is the most significant factor on SR during AWJM. Meanwhile water pressure and Standoff distance is sub significant in influencing.

D. Sidda Reddy, A. Seshu Kumar, M. Sreenivasa Rao [14] worked on the effects of process parameters of Abrasive Jet Machining for material Inconel 800H using Taguchi method. It was found that the surface Roughness decreases with three major parameter transverse speed (S), abrasive flow rate (R), and standoff distance (H). By the ANOVA test observed that traverse speed plays major role on influencing material removal rate by 60%. Standoff distance is sub significant in influencing MRR. In case of surface Roughness, Standoff distance of about 47% and Transverse speed is about 37% plays major significance. Abrasive flow rate is having sub significance influence on SR.

G. Shiva Kiran Kumar and G. Krishna Mohana Rao [15] tried for Traverse speed, Abrasive flow rate and Standoff distance are considered as process parameters and their effect on performance measures i.e. Material removal rate (MRR) and Surface roughness (SR) through the experimental investigation. Grey relational analysis will be applied to generate grey relational grade to identify the optimum process parameters. These optimum parameters can be adjusted to improve performances of AWJM. It was concluded that Grey relational analysis in taguchi method for the optimization of multi response problems for predicting the Material removal rate and Surface roughness in abrasive water jet machining of Titanium Alloy Grade 2.

Pravin R. Kubade, Palash Patil, Akshay Bidgar, Akshay Papti, Pranav Potdar, Ravindranath G. Kshirsagar [16] tried for parametric Optimization of Abrasive Water Jet Machining of Inconel-718 material. It was studied that the influence of various process parameters of abrasive water jet machining on Material removal rate (MRR) and Surface roughness (Ra) of Inconel-718. Experiments are carried out using L9 Orthogonal array by varying Water Pressure (WP), traverse speed (TR), abrasive flow rate (AFR) and stand of distance (SOD) for Inconel-718 material.

M. Chithirai Pon Selvan. Mohana Sundara Raju, R. Rajavel [17] investigatedthat effect of process parameters on depth of cut in abrasive waterjet cutting of cast iron. It was considered four different process parameters as water pressure, nozzle traverse speed, abrasive mass flow rate and standoff distance. It was observed thatincrease of water pressure results in increase of depth of cut when mass flow rate, traverse speed and standoff distance were kept constant. When increases in abrasive mass flow rate also increases the depth of cut. Additionally, increase of traverse speed decreases the depth of cut within the operating range selected. When standoff distance increases, depth of cut decreases by keeping other parameters constant. It was concluded that operational parameters have direct effect on depth of cut.

M. A. Azmir, A.K. Ahsaz, A. Rahmah, M. M. Noor and A.A. Aziz [18] studied that the optimization of the abrasive water jet machining (AWJM) process parameters with multiple performance characteristics for material Kelvar-129.This optimization is based on orthogonal array with gray relational analysis. Hydraulic pressure, abrasive

mass flowrate, standoff distance and traverse rate are four parameters which are optimized. It was concluded that the performance characteristics of the AWJM process like hydraulic pressure, abrasive mass flow rate, standoff distance and traverse rate are improved together by using the method orthogonal array with gray relational analysis.

M. M. Chatterjee, B. A. Modi and Ankit Hansaliya [19] established the effect of inherent characteristics of water jet flaring on straightness of the through cut. For different materials like aluminum, Stainless steel, sand stone and marble, it was concluded that when increase in abrasive water jet then traverse speed gives rise to taper of the through cut. It was observed that increase in traverse speed increases the waviness and becomes more prevalent and a limiting traverse speed at which there was non-through cut was also established for each material. It was also found that the limiting traverse speed for brittle materials is higher as compared to ductile materials.

III. SUMMARY

Process Parameter / Quality Parameter	Abrasive Flow Rate		Traverse speed		Stand Off Distance	
	Increases	Decreases	Increases	Decreases	Increases	Decreases
Surface Roughness	Decreases		Increases			
Material Removal Rate	Increases				Increases	
Kerf Width			Decreases		Increases	

Table 1: Effect of Processing Parameters on Process Outputs in AWJM

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