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Using Advanced Computational method to Investigate the reduce Kerf angle in Abrasive water jet cutting Machine for Aluminum 6082 –t6 and SS304

Navneetsinh S Yadav[1],

[1] *P.hd Scholar, Gujarat Technological university ,Ahmedabad ,Gujarat, India.*

Dr. Neeraj K. Chavda[2,]

[2] *Associate Professor Mechanical Engineering Department M.B.I.T., New Vallabh Vidhyanagar, Anand ,Gujarat,India.*

***Abstract* - The Aluminum 6082 –t6 and SS304 is studied for identification of taperness in quality cutting with including polymeric additives to reduce tameness surface and to get flat parallel surface in cutting of material on Abrasive water jet cutting machine with using inputting parameters like water pressure ,Abrasive particle size ,nozzle size ,percentage ratio of polymeric additives with different mess size of Abrasive Particle with using combinations of process parameters to get reduction in taperness to get quality cut surfaces**

***Index Terms* -** *abrasive particle size , mess size of abrasive particle , taperness, aluminum 6082 –t6 , ss304 , abrasive water jet cutting*

Introduction

It is one of the most popular non-traditional mechanical processes because it is environmentally friendly. It uses a water jet that serves as a metal cutting tool. It is the same with the use of a bad jet unless the workplace is wet. In this mechanical process, a high-speed water jet smear compresses a piece of work that removes metal from the erosion-affected area. It is widely used to make soft materials. For the manufacture of solid materials such as carbide, ceramic, etc. abrasive particles added to water vapour to increase its performance quality. This process is known as abrasive water jet machining. It is widely used in the mining industry, in the aerospace industry to cut the required condition. This process works on the basic principle of water erosion. In this process, a high-speed water jet is used to cut the metal. It uses the kinetic energy of water particles to erode the metal in contact. The jet speed is approximately 600 m / s. It does not produce any natural hazards. To cut solid objects, explosive particles are used in the water jet.and material used for experiment The aluminum alloy 6082-t6 is a medium strength composite with excellent rust resistance. It has the strongest of all 6000 series alloys. Hybrid 6082 is known as structural hybrid. In plate form, Aluminum alloy 6082 is a composite commonly used in the manufacture and Stainless steel 304 is an austenitic grade that can be pulled very deep. This design has resulted in the 304 being the highest range used in systems such as sinks and pans [1].

Littarature Review

Jeyapooven et al. studied result of the biting particles, the materials break down in the target area with a significant loss of kinetic energy. This cutting job is quick and easy to remove part of the material effectively. Due to its excellent features in water jet machine techniques, the attention of many researchers is focused on this process by studying various input parameters, different abrasive mesh sizes in order to improve better working conditions at no additional cost. In this work, machine performance parameters will be developed on the AA6082 water abrasive jet machine to achieve minimal complexity and high level of material removal and hardness. Cutting parameters such as damage feed, stop distance and nozzle speed are considered to improve

AA6082 cutting using the Face Response System[1] .

Karthik et al. Abrasive waterjet cutting is a new process of making machines that are used successfully to cut a variety of materials from soft materials like rubber to hard materials like Inconel. This paper is about influence of the installation process parameters for the removal and width of the kerf at the top of the stainless steel processing grade 304. The main input parameters are water jet pressure, feed rate and destructive flow rate. Three different levels of input parameters selected to generate a design table using the L27 orthogonal array. The test is performed and the result of the input parameters in the output answers is read .. The maximum number of parameters obtained using Gray Relationship Analysis and Response Face The operating system is compatible. An examination of the answer graph illustrates that point Removal Rate is influenced by Water Jet Pressure and Feed Rate while factors affecting Kerf Maximum Feeding Feature and Abrasive Flow Rate[2].

Fuat Kartal et al. study analyzes the effects of machine parameters on higher size and larger area features when making a mixture of Al-6082 T6 diameter 30 and 240 mm in size using an abrasive water jet (AWJ) conversion processes. Deletion tests are performed using a computer numeric controller (CNC) jet abrasive cutting machine of different parameters of nozzle supply level , poor flow rate, spin speed and standing distance Pump pressure at 350 MPa, explosive type of Garnet with a size of 120 Mesh, and a diameter of 0.75 mm is maintained regularly throughout the study. When macro surface features were analyzed, it was found that the spin speed increased, decreased nozzle supply level, increased abrasive flow rate and low stop distance led to slipperiness more places [3].

T V K Gupta et al. Extrusion rate (MRR) analysis of pocket grinding by Abrasive Water Jet The Machining Method (AWJM) of stainless steel (SS304) is being discussed in modern times function. it is found that the interval speed (interaction time between aircraft and a function surface) has a significant effect on the MRR of all considered parameters. Some of the above investigation, MRR calculated stop distance, harmful flow rate,abrasive sizes have different cutting speeds. Using a dimensional analysis process, a a prediction model for removal rate is performed as a process function boundaries. It was found that the predicted model was consistent with the experiment results with a deviation from 0.2% to 10% [4].

R. Sanghani et al. The test was by varying these parameters to cut AISI 304 austenitic stainless steel using abrasive waterjet machining process. The result showed a kerf taper and a larger size increase while power consumption decreases with an increase in medium speed, standing distance and abrasive flow rate and reduced water pressure[5].

Jiyue Zeng et al. Erosion machine-The creatures seen in this study include the breakdown of the intergranular network and the flow of plastic. Removal of items due to network crashes is calculated with a crack network model related to over-breaking capacity to create a broken network and pressure impact force bwaves. The plastic flow offering is tested on the model of Finnie. The erosion model detected is confirmed by bad watejet erosion to check [6].

Jiyue Zeng and Thomas J. Kim et al. It concludes that the cutting process is associated with seductive particles at the angles of the lower event and that removal of ce objects Ramic target materials are caused by intergranular cracks and plastic flow. Statistics prediction cutting depth is obtained by attaching the degree of material removal to the macro front cut collected level for removing small items with a single scratch particles. The rate of removal of large assets is calculated based on previous research of waste of energy in the AWJ cutting system. The elasto-plastic model, found earlier well for removal of brittle material due to the low effects of a single particle, is used to check the rate of removal of small items. Parameter for an important new feature, called "Erosion Resistance", is based on the statistics of cutting depth.[7].

Gyliene et al. The experimental study of the Abrasive Water Jet has been made by cutting sample 6082-Al alloy of thickness - 30 mm. And the impact of the traverse rough speed was tested. AWJ experimental studies have shown that cutting speed is the main factor influencing cutting depth reaches a high apparent hardness[8]

Tarek M.Ahmed et al. Abrasive waterjet cutting (AWJ) is considered one of the best cutting techniques for cutting a showing,conductive, or heat-sensitive materials such as aluminum alloys. The purpose of this work is to Understand the effect of waterjet abrasive cutting parameters (cutting speed, water pressure and standing distance) to the rigidity of the area of the cutting process. The study article states Aluminum hybrid 7075 widely

used in space workplaces. Experimental design and statistics modeling techniques used to establish relationships between control and output elements answers. Response Surface Method (RSM) is used to model the intensity of the area. The results showed that the development of higher gravity can be achieved by increasing the ground water pressure dabula speed or lowering the pressure with greater crossing speed, or lowering the stopping distance down cutting speed and low pressure in the probe range [9].

Supriya S B et al.Numerous studies have shown the benefits of using Stainless Steel in the automotive sector and other industrial applications. Stainless steel is often a major challenge to the machine due to its high alloying content. I The main problems with the standard Stainless Steels machine are high performance durability, poor chip breakdown, versatility. tools with geometry of different tools, the use of large cooling discovery during the machine. These problems lead to an increase production time and cost. When making stainless steel it is important to make sure that there is no vibration of the machine or tool discussion tools and general tools tend to prevent. Because of these problems other strategies are being considered to make Stainless Steel. Abrasive Water Jet Machining (AWJM) is an effective way of making machines, cutting and piercing of stainless steel. AWJ machining is an unconventional procedure to perform when the material is removed by erosion high-speed abrasives are placed in a water jet. This paper discusses machine studies in Stainless Steels by Abrasive Water [10]

Vu Ngoc Pi et al. introduces a new study on AWJ modeling of cutting power required. model of predicting the required cutting force is proposed in combination visual mathematical models and test methods. Various jet parameters results as and the effects of explosive size, explosive materials and material impact on the required cutting strength is considered[11].

K. Shanmugam et al. Kerf taper is a special and unpretentious geometric element associated with an abrasive waterjet (AWJ) equipment. In this study, a diagnostic test is performed to reduce or eliminate kerf taper in AWJ cutting of alumina ceramics using kerf-taper compensation method. Between tested cutting parameters, kerf-taper compensation angle is found to have the most significant effect in kerf taper and the kerf taper angle varies approximately in terms of this compensation angle. It shows that with this process, it is possible to achieve an angle of zero kerf taper without compromise the speed of cutting the nozzle or the cutting rate., it has been found that the compensation angle of kerf-taper in grades 4-51 can reduce kerf taper. angle to circle zero. Using a dimensional analysis process, a predictable model of kerf taper angle then developed and validated. Model tests show that the model can provide enough forecasts with a rate of 6.2% deviation and a standard deviation of 13.4% from relevant test data[12]

Jun wang et al. studied to test the depth of cutting multipass abrasive waterjet (AWJ) alumina cut Ceramics with oscillation of a controlled nozzle are introduced. It is found that this method of cutting can be very practical increase cutting depth by an average of 50.8% as compared to single-phase cutting without nozzle oscillation under the corresponding cutting conditions and within same cutting time[13].

Yigit Ozcan et al. proposed AWJM process model is used in the predictive framework of 3D in-process workpiece (IPW) geometry, i.e. represented using a signed distance field method (SDF). The process model is verified by measurement results 15% error, in which machine profiles are measured with confocal optical microscopy. In some of the tests, unchanged the removal of material due to the constant supply of the system, which is considered to be large source of error predicting kerf depth. The IPW simulation model is validated by the AWJM test for flexible jet speed, taking into account the significant impact of jet traverse velocity on the kerf depth[14].

D. Curtis et al.The Buckingham pi Theorem was introduced stating the basic mathematical structure of that ancient effect. In this context it becomes a theorem in line algebra, and constructed without reference to tangible values, units, measurements, etc. Also, Birkhoff's classical approach is revisited some points in his testimony were added [15].

1. Materials and Methods

Grade 6082 aluminum is a medium strength alloy with excellent corrosion resistance. The addition of magnesium, manganese and silicon enhances the mechanical resistance and corrosion properties of the 6082 while maintaining good usability and heat. With aluminum grade 6082 providing the highest strength of the 6000 series it is widely regarded as a material for the use of the type of structure.In addition the power levels of the aluminum grade 6082 have seen it replace 6061 in many systems. Alloy 6082 offers good joining options

although it should be noted that mechanical strength will decrease in the area affected by heat. Grade 6082 is also very efficient and produces strong coils when using chip breakers..[16]

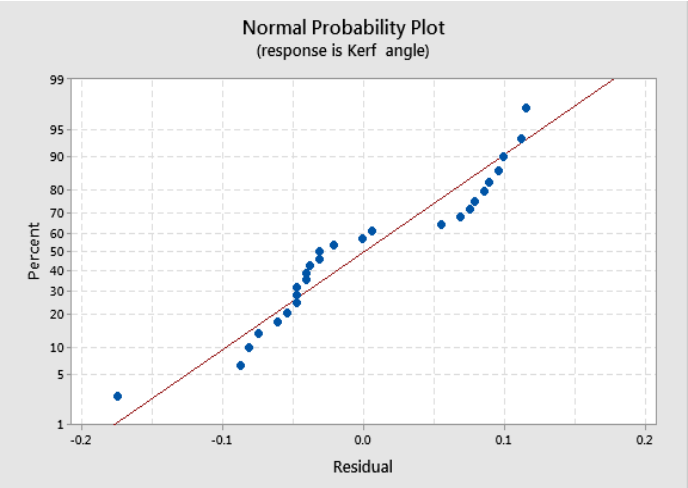
Grade 304 is a flawless "18/8" level. It is a stainless steel that is widely available and widely used, although there are many different types available; and has excellent construction features and welding features. The equivalent austenitic structure of Grade 304 makes it more durable without moderate lifting. This means that this standard steel is at the forefront of the construction of stainless steel parts such as sinks, empty containers and pans. In these applications, it is common to use a special "304DDQ" (Deep Drawing Quality) alternative. Grade 304 can be easily brushed or built into various components for industrial, construction, and transportation use. It also has outstanding welding features. Post-weld annealing is not required when welding small parts.[16-17]

Taguchi method initially used for making orthogonal array and to conduct experiment run by making different combination of input parameters with different values to look effect on water jet lagging beacuase to decrease water jet lagging means ultimately decrease of kerf width which is necessary need now a day while cutting with Abrasive water jet cutting Technology due to thickness limitation of for SS304 ,Aluminium 6082 -t6 material ,then result is validated by Mathematical Model which is generated by using of experiential Reading an as well as Reg-ration analysis at 95 % Confidence level and also with Buckingham PI theorem to get constant of and exponent of Mathematical Model and for better accuracy it is again checked by Computational analysis method Matlab to Compare both Mathematical result and experimental result to get better accuracy of result [17]

3.1. Parameters

With using L27 orthogonal array with above mentioned parameters like nozzle diameter, pressure, Polymer additive, Abrasive Particle, Particle mess size number,for final output for reducing kerf angle with using different polymeric additives in different proportion,it can be researched with using polymeric additive kerf angle can be reduce significantly by experiment

Fig. 1 General linear Model of Kerf angle of Aluminium 6082-t6



FACTORS	LEVLE1	LEVEL2	LEVEL3
Nozzle diameter (mm)	0.2	0.5	0.92
Pressure (MPa)	450	550	650
Polymer additive(% mass)	0	0.25	0.5
Abrasive particle(% mass)	5	15	25
Particle mesh number	80	100	120

Fig. 2 L27 orthogonal array

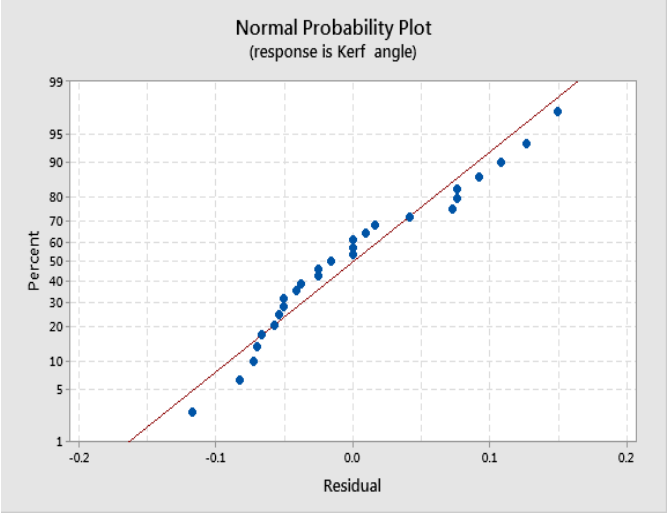


Fig. 3 General linear Model of Kerf angle of SS304

3.2 Mathematical Model development

From the experimental study, it is evident that the kerf taper is something that can be reduced by using a controlled combination of performance parameters. In doing so, a basic understanding of kerf taper formation begins with the characteristics of the jet. The radial velocity distribution of the jet is believed to be a key factor in calculating the kerf in order to change the jet speed it must overcome the breaking force required to destroy the property. In the abrasive injection system the material is considered to be removed only by the changing force of the particles and therefore the flow rate of water is not calculated in the model. The shortest distance between the orifice and the cover exit particle speed, V1, and waterjet speed at the outlet of the pipe, V, can be treated alternately. Using the Bernoulli equation for unbalanced flow V through orifice provides when P is water pressure and w water density [15-17, 21].

3.3 Dimensional analysis

Dimensional analysis has proven to be successful and effective in generating analytical formulae for complex systems involving a large number of variables , Mathematically a non-dimensional quantity is proportional to the product of other dimensionless groups raised to a rational power Because of the simplicity and wide use of this power-law formulation, it is used in this study, so that the complete dimensional equation is given by

$$\theta = f\left(\frac{p}{\delta_w}, \frac{d_j}{t}, d_p, m_a, m, H, E\right) \quad (1)$$

and Group will be formed by Buckingham pie theorem

$$f(\pi_1, \pi_2, \pi_3, \pi_4, \pi_5) = 0 \quad (2)$$

π1,π2,π3,π4,π5, Respectively Represent Kerf taper angle,Represent effect of Jet diameter,Represents the effect of exposure time,Represent Abrasive Mass Effect,Represent effect of Young Modulus

$$\theta = \left(\frac{p.Mp}{\delta_w\,(dp)^3\,H}\right)^a \left(\frac{dj}{v}\sqrt{\frac{dp.H}{mp}}\right)^b \left(\frac{ma}{mp}\right)^c \left(\frac{E}{H}\right)^d \quad (3)$$

where a, b, c and d are the exponents, k1, is the correction factor[18-20, 22]

4 Model implementation

In industrial applications, if the kerf taper angle is unpredictable, it can be compensated during the design stages and planning processes. Therefore, Eq. is used to verify test data. Constants in is determined by the analysis of multiple dynamic retreat with a 95% confidence interval. Using Matlab using data obtained from the experimental part of this investigation [23, 25-28]

4.1 Regression analysis

Regression analysis used to find unknown exponent to complete Mathematical model equation so Here, K is curve fitting constant and a to d be indices which needs to be calculated by multi variable regression analysis at 95 percent confidence interval by uisng Matlab ,by using data obtained in experimental part of this investigation and substituting these parameters in equation number (4).The predictive model follow as .[24]

$$\log \pi 1 = \log k + a \log \pi 2 + b \log \pi 3 + c \log \pi 4 + d \log \pi 5$$

(4)

As per multi variable regression analysis at 95 percent confidence interval using data obtained in experimental part of this investigation . [29, 31, 33]

4.2 Advanced Computational method

MATLAB is the most efficient computer programming language. It incorporates calculations, visualization, and systems in an easy-to-use environment where problems and solutions are presented in the standard mathematical text of MATLAB that has emerged over the years with input from multiple users. In the university environment, it is a common teaching tool for presenting and advanced studies of mathematics, engineering, and science. In the industry, MATLAB is the preferred tool for research, development, and analysis that is highly productive. The term MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to the LINPACK matrix software and the EISPACK project, integrated representing modern matrix computing software. [30 ,32].

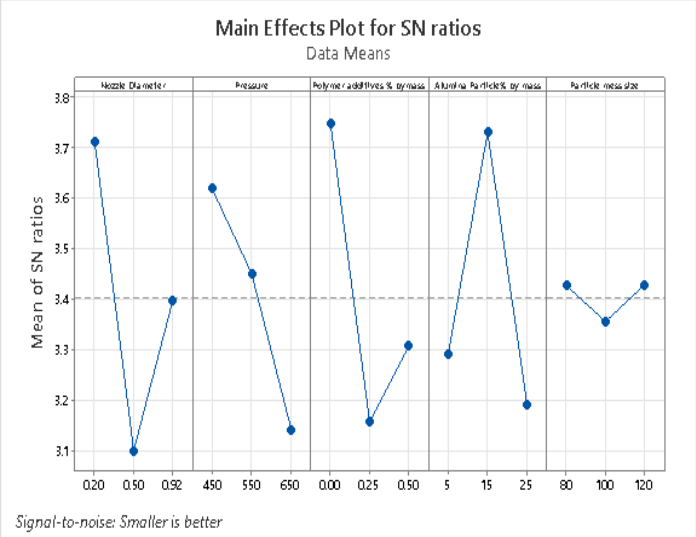
4.3 Conformation Test

The improved $\pi 1$ model relative to the kerf angle is analyzed by calculating the percentage error between the test values and the values obtained in the mathematical model. Parameter values based on $\pi 1$ in the mathematical model are obtained by placing independent variable values in the generated mathematical model. The deviation from the values obtained in the statistical model from the actual test values of the dependent parameters indicates the proximity of the mathematical model by the real-life process. Price fluctuations can be determined by the percentage error. Following a mathematical relationship will give a percentage error between real values and statistical values. $\Pi 1$ percent error associated with the obtained kerf angle is less than 10%. Indicates that the values obtained in the mathematical model are closer to the actual test values

$$\text{Percent Error} = [(\text{Test values} - \text{Model values}) / (\text{Test values})] \times 100$$

(5)

the advanced model is verified by using the operating process parameters in the following scope for practical objectives and machine limits & to show the advanced model compliant with the test parameters of all operating parameters.[34-37]

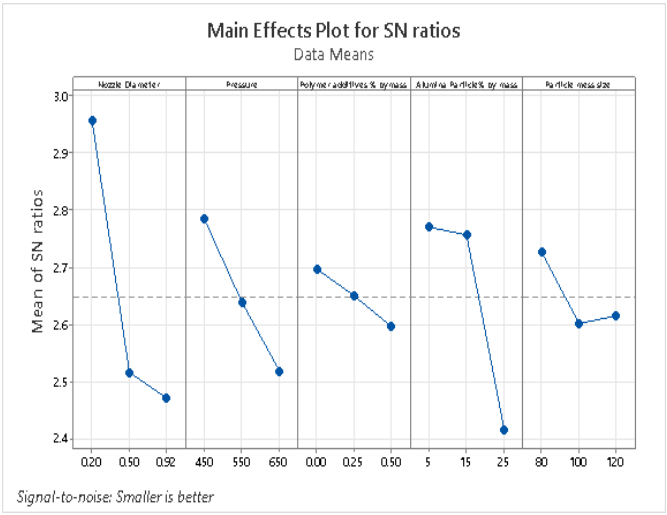


Response Table for Signal to Noise Ratios

Smaller is better

Level	Nozzle Diameter	Pressure	Polymer additives % bymass	Alumina Particle% by mass	Particle mess size
1	3.714	3.619	3.748	3.291	3.427
2	3.101	3.451	3.157	3.731	3.356
3	3.398	3.142	3.307	3.191	3.429
Delta	0.613	0.477	0.590	0.540	0.073
Rank	1	4	2	3	5

Fig 4 Main effect of SS304



Response Table for Signal to Noise Ratios

Smaller is better

Level	Nozzle Diameter	Pressure	Polymer additives % bymass	Alumina Particle% by mass	Particle mess size
1	2.956	2.785	2.697	2.770	2.727
2	2.516	2.639	2.650	2.757	2.601
3	2.471	2.518	2.596	2.416	2.615
Delta	0.486	0.267	0.101	0.354	0.125
Rank	1	3	5	2	4

Fig 5 Main effect of Aluminium 6082-t6

5 Conclusion

By using different parameters as per above values, validation test has been carried out with like water pressure ,Abrasive particle size ,nozzle size ,percentage ratio of polymeric additives with different mess size of Abrasive Particle And get 6.01% percentage error which is below 10 percentage by comparing experimental and mathematical model values.

5.1 Result and Discussion of Aluminum 6082 -t6

A generalized field data-based model is developed to predict effect. Methodology of dimensional analysis is used. It is found that the independent pi terms influencing the dependent pi term $\pi 1$ in descending order. The following primary conclusions appear to be justified from the above model. The absolute index value of $\pi 3$ is highest and is equal to 0.1610 Thus, terms used in $\pi 3$ group are most influencing. The value of the index is

positive indicating π1 directly varying with respect to π3 ,The absolute index value of

π5 is lowest and is equal to −0.3412 Thus, terms used in π5 group are least influencing. The value of the index is negative indicating π1 inversely varying with respect to π5. so effect of exposure time is very essential parameter for Aluminium for quality cutting

5.2 Result and Discussion of SS304

It is found that the independent pi terms influencing the dependent pi term π1 in descending order. The following primary conclusions appear to be justified from the above model. The absolute index value of π3 is highest and is equal to 0.1610 Thus, terms used in π3 group are most influencing. The value of the index is positive indicating π1 directly varying with respect to π3 ,The absolute index value of π4 is lowest and is equal to −0.2908. Thus, terms used in π4 group are least influencing. The value of the index is negative indicating π1 inversely varying with respect to π4.so effect of exposure time is most useful parameter which directly affecting qaulity cutting of ss304 justified

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