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A Study Of Abrasive Water Jet Machining Process On Granite Material

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ABSTRACT

Abrasive water jet machine (AWJM) is a non-conventional machining process where material is removed by impact erosion of high pressure, 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 material removal rate (MRR) of granite material. The approach was based on Optimum factorial method and analysis of variance (ANOVA) to optimize the AWJM process parameters for effective machining. Experiments are carried out to study the effect of varied hydraulic pressure, stand off distance (SOD) and traverse speed on material removal rate in the abrasive water jet machining. A Mathematical model was developed to predict the MRR in terms of the cutting parameters of AWJM.

Keywords: AWJM, MRR, SOD, traverse speed

1. INTRODUCTION

Abrasive water jet machining is a relatively new machining technique it use the impact of abrasive material with water to erode the work piece material.[1]. AWJM is a non-conventional machining process where material is removed by impact erosion of high pressure high velocity of water and entrained high velocity of grit abrasives on a work piece. The water afterwards carries both the spent abrasive and the eroded material solid tool to cut the material usually by a shearing process. [2]. It is a well-established non-traditional machining process used for cutting difficult-to machine materials. It is a machining process with no heat generation and the machined surface is virtually without any heat affected zone or residual stress [3]. This technology is less sensitive to material properties and has high machining versatility and high flexibility. The major drawback of this process is, it generate loud noise and a messy working environment [4].

2. EXPERIMENTAL WORK

2.1. Equipment

The equipment used for machining the samples was DWJ1525-FA at A innovative international ltd, Ahmadabad. The machine is equipped with a gravity feed type of abrasive hopper, An abrasive feeder system, a pneumatically controlled valve and a work piece table with dimension of 1600mm×2600mm. Nozzle diameter 0.25 mm, 80 mesh abrasive size silica and abrasive flow rate 300 gm/min. was used and is constant for every experimental work. During the experiment the jet angle is 90^0.

2.2. Material

In this experimental work Granite of 10 mm thickness is used.

2.3. Experimental design

In the present study, three machining parameters were selected as control factors. The parameters and levels were selected primarily based on the literature review. This investigation carried out by varying three control factors pressure, stand of distance and traverse speed. Control factors along with their levels are listed in Table 1. Full factorial design of experiments would require a large no. of runs hence Optimal factorial design of experiment method was implemented. It helps to learn the whole parameter space with a minimum experimental runs.

Process Parameter	Level 1	Level 2	Level 3	Level 4	Level-5
Pressure bar	200	210	220	230	240
SOD mm	1	2	3	4	5
Traverse Speed mm/min	120	140	160	180	200

Table 1. Process parameters and their levels

2.4 Specimen detail

Using Optimal factorial design of experiment total 66 nos. of experiments has been carried out and then pieces of 40 mm x 15 mm are cut from 300 mm x 300 mm x 10 mm Granite material. Specimen after machining is shown in figure 1. MRR is calculated on the base of mass difference and the unit is gm/min.

Figure1: Specimen after Machining Granite: Size 30 mm x 15 mm x 10 mm

3. RESULTS AND DISCUSSIONS

3.1. Analysis of variance

The effect of control factors were investigated through the analysis of variance (ANOVA). It is a computational technique conducted mainly to learn about the influence of various design factors and identify which are the most significant factors. It observe the degree of sensitivity of the result to different factors affecting the quality characteristics. ANOVA is done by Design-Expert 8.0.6 software. This analysis was carried out for a 95% confidence level. Control factor c (traverse speed) is the most significant factor influencing the assessment of MRR .Meanwhile, control factors A (pressure) and B (stand off distance) have almost equally significant effect on MRR

3.2. Effect of control factors on MRR

The effect of control factors were investigated through the analysis of variance (ANOVA). It is a computational technique conducted mainly to learn about the influence of various design factors and to observe the degree of sensitivity of the result to different factors affecting the quality characteristics. In the present work, experiments have been conducted under different pressure. Influence of pressure on MRR is illustrated in Fig. 2. A higher hydraulic pressure increases the kinetic energy of the abrasive particles and enhances their capability for material removal. As a result MRR increases with increase of hydraulic pressure.

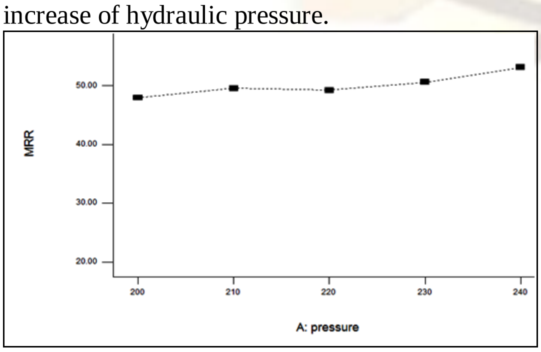

Figure 2: Effect of variation of pressure (bar) on material removal rate(gm/min).

Fig.3 shows the effect of SOD on the MRR. It can be observed from the fig that the MRR increased with increase in SOD. With increase of SOD there is increase in momentum of impacting abrasive particles on the work surface creating craters of more depth. As a result more erosion of work material cause higher material removal rate. However, from the work, it is found that initially MRR increased with increase in SOD then MRR remains almost constant for a small range and then decreased as SOD is further increased.

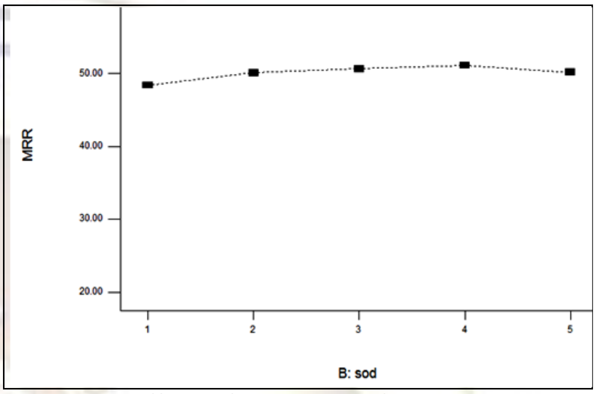

Figure 3: Effect of variation of SOD (mm) on material removal rate (gm/min).

Fig.4 shows the effect of traverse speed on the MRR. It can be observed from the fig that the MRR increased with increase in traverse speed. With increasing the traverse rate there is less overlap machining action hence MRR increased but surface roughness is reduced.

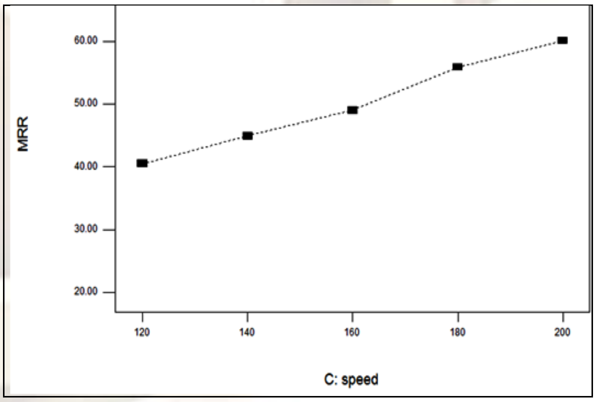

Figure 4: Effect of variation of traverse speed (mm/min) on material removal rate (gm/min).

3.3. Mathematical model

Based on the experimental data set the empirical model for MRR in terms of control factor was developed using the Design-Expert 8.0.6 software. The model for MRR is shown in Eq.(1) it is quadratic model. The coefficients of determinations (R^2) were found 0.9890 for the quadratic model. The mathematical model is useful in predicting the machining response (MRR) of AWJM process during machining of Granite material. There is a reasonable correlation between the measured experimental and predicted values for MRR as shown in Fig. 5.

MRR = 49.02 +1.97A + 0.98B + 10.45C -0.29 AB + 0.61AC - 0.28BC + 0.35A^2 + 0.021B^2 + 2.20C^2 (1)

Where A is pressure, B is SOD and C is traverse Speed.

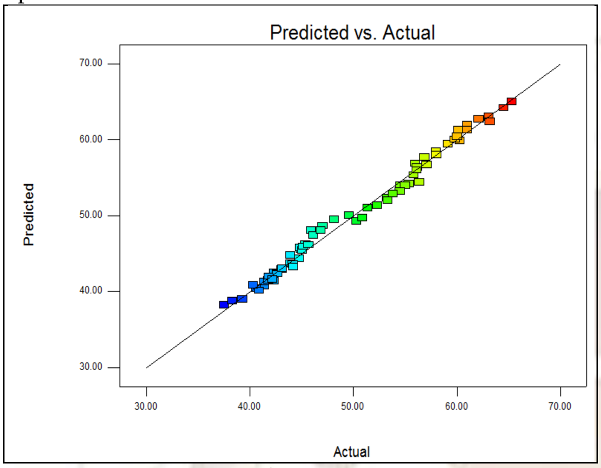

Figure.5: Comparison of experimental and predicted values of MRR in gm/min (line indicate the ideal case)

4. CONCLUSION

On the basis of experiments conducted, analysis of variance (ANOVA) and the effect of machining parameters on MRR for graphite material, following conclusions are made:

1. The traverse speed is the most significant control factor for MRR.
2. The MRR increases with increase in hydraulic pressure.
3. The MRR increase with the SOD increases for certain limit, beyond the limit with increase in SOD there is decrease of MRR.
4. The developed mathematical models successfully predicate the MRR for granite material in AWJM.

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