Experimental investigation of burst area in water jet cutting of granite

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Abstract— **Granite has broad applications as construction material, architectural stone, a decorative stone, bridges and countertops. Black pearl granite is excavated in large blocks providing slabs of suitable sizes. Machining of rocks with conventional method has low surface finish and incorporates cost in final finishing. Abrasive water jet cutting is used for precise cutting of granite. Burst occurs at the other side of the material which is undesirable. The burst has to be minimum for high production and minimum wastage of cost. The experiments were carried on Black pearl granite. By using Taguchi method a L27 Orthogonal Array was formed for deciding number of cuts. Input parameters such as traverse speed, abrasive flow rate and standoff distance were varied whereas water pressure and abrasive size were constant and burst area was the response which is to be calculated. After experimentation, with the help of ImageJ software area of burst is calculated for each cuts. Thereafter with the help of data acquired, coding was done in ANFIS in order to predict the burst area. The motive behind this is to increase the precision of machining and to reduce the cost behind the finishing of granite.**

Keywords—Abrasive water jet, Burst, prediction, Taguchi.

I. Introduction

Granite is a typical rock with granular in texture which finds its application as construction material, paving, architectural stone, indoor application and as a decorative stone. Abrasive Water jet machining is a non-conventional machining process used for cutting of material by dint of high pressure water with abrasives. Machining of granite with abrasive water jet requires proper choosing of input parameters for getting required output. Karakurt et al [1] performed an experiment and analyzed data using ANOVA. They predicted the major factor effecting the cut of depth and kerf angle. Liu et al [2] performed an experiment and they predicted the best condition and parameter for efficient AWJ process. Dani et al [3] carried out experiments using Taguchi method in order to find the parameters effecting surface roughness and MRR. It was found that MRR is affected by traverse speed and surface roughness by standoff distance (SOD). Chen et al [4] used numerical methods and found that parameters like jet velocity, number of jets, nozzle diameter and traverse velocity influenced the efficiency of rock breaking. The results also showed that rock breaking was accomplished because of two threshold water pressures. Zhang et al [5] conducted analysis on the striation formation mechanism. Their investigation concluded that the striations can't get eliminated fully. Selection of proper parameters enables smooth machined surface. They explored parameters which could have an effect on surface roughness, and an experimental model was built. Predicting surface quality was achievable using this model.

Tripathi et al [6] worked on identification, recording and examining the various disintegrating mechanisms of rock by using acoustic emission. It gives idea about fracture and fatigue pattern. Aydin et al [7] followed Taguchi in order to find the factors influencing the quality of surface finish. The data acquired was examined by using ANOVA. It states that the water pressure along with abrasive flow rate are the important factors affecting the roughness. Hlavac et al [8] carried out experimental analysis of the taper cut walls of different materials. The different rock materials at different composition. The difference between the widths at both ends is used to calculate taper angle. The conclusion was based on the comparison of regression model developed on experimental results. Aydin [9] explored recycled abrasives with surface roughness, kerf width, taper angle, cutting depth. Due to recycling of abrasives a negative impact was observed in cutting depth and surface roughness. Hence, this work used integrated Taguchi L27 with ANFYS for optimal process parameters of combined value of burst area and productivity with more weight factor to burst area and less weight factor to productivity. The more weight factor is given to burst as it is the deciding factor for proper machining and overall cost. The overall methodology of taguchi-ANFYS is shown in Fig.1.

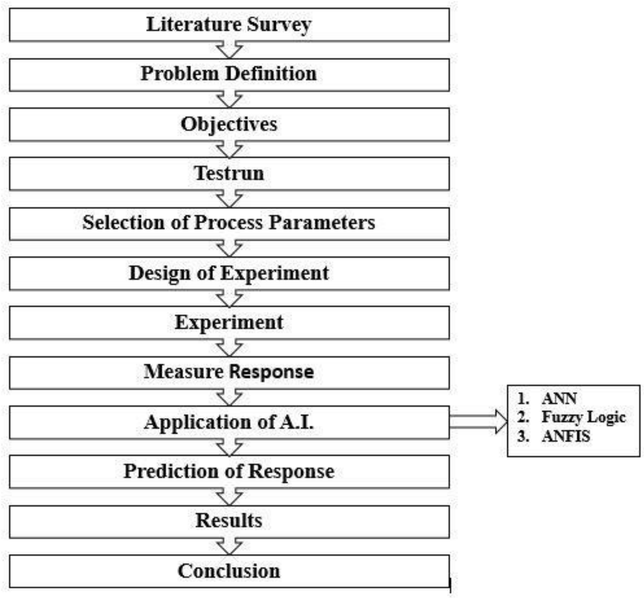

Fig. 1. Overall methodology.

II. Experimental details and measurement

The AWJ cutting test were carried on KMT Water jet streamline (SL-V 30 Classic C) with power of 30hp and pressure of 60000 psi. The experiment were performed on sample of Black pearl granite with compressive strength above 200 MPa and density varies between 2.65-2.75 g/cm^2 with dimension of 800mm x 76 mm x 18 mm. The detail of AWJ machine is displayed in the Table 1. The granite was clamped to rack and via CNC cuts were taken one after other. In this study after the experimentation the bursts were used as responses which needed to be measured after the experimentation. The final machining is illustrated in Fig.2. The burst area of each cut was measured by the ImageJ software.

Fig. 2. Abrasive Water jet Machine

Prior to the measurement of burst area, the image of the burst is opened in the software and reference is set. Further with free hand, tracing of burst section is done and then by clicking measure we get the area of the traced section.

TABLE I. Specification of AWJ Machine

Description	Unit	Value
Nominal Power Rate	hp	30
Maximum Pressure Range	psi	60000
Max. water flow rate	gpm	0.6
Maximum Single Orifice Diameter	mm	0.279
Control Voltage	V	24
Power Supply	Amps	10
Max. Noise Level	dB	72.5
Length	m	1.7
Width	mm	914
Height	mm	1453
Weight	kg	953

III. Conclusions

This article includes an experimental study of proper parameters selection for AWJ machining of granite. It was seen that standoff distance and traverse speed majorly influenced the burst area, whereas abrasive flow rate had less effect.

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