Int. Res. J. of Science & Engineering, 2018; Special Issue A2 : 251-255
ISSN: 2322-0015
SJIF Impact Factor 4.11
UGC Approved Journal No. 63628
RESEARCH ARTICLE
OPEN ACCESS

Application of Optimization Techniques in Water Jet Cutting of Granite

Vavhal Prashant[1], Katale Chetan[2] Beloshe, Tejas[2], Patil Navnatha[2], Durge Mayur[2]

[1]Mechanical Engineering Department, Savitribai Phule Pune University, Pune (MS), India,[2]*Departemnt of Engineering, P. K. Techanical Campus, Chakan (Pune) India*
Email: prashantvavhal44@gmail.com

Manuscript Details
Available online on http://www.irjse.in
ISSN: 2322-0015

Editor: Dr. Arvind Chavhan

Cite this article as:
Vavhal Prashant, Katale Chetan, Beloshe, Tejas, Patil Navnatha, Durge Mayur. Application of Optimization Techniques in Water Jet Cutting of Granite, *Int. Res. Journal of Science & Engineering,* January 2018; Special Issue A2: 251-255.

ABSTRACT

This paper attempts to select the significant process parameters by Taguchi methodology while machining of STAINLESS STEEL 410 by AWJM. Different process parameters like pressure, feed rate, and standoff distance in three different levels are selected for optimization with three contravene responses, higher MRR and low machining timing by a single parametric combination. For Design of experiment L9 orthogonal array is prepared to set the input significant parameters for final product is calculated for better optimization purpose also different combinations of the factors are ranked on basis of grey relational grade.

Keywords: Teaching-learning-based optimization (TLBO), Taguchi method, Stand-off distance, nozzle transfer speed, Abrasive flow rate

INTRODUCTION

"Gabbro", commonly known as black granite refers to a large group of dark, often phaneritic (coarse-grained), mafic intrusive igneous rocks chemically equivalent to basalt. It forms when molten magma is trapped beneath the Earth's surface and slowly cools into a holocrystalline mass. Much of the Earth's oceanic crust is made of granite, formed at mid-ocean ridges. Gabbro is also found as plutons associated with continental volcanism. applied loosely to a wide range of intrusive rocks, many of which are merely "gabbroic". Black granite Due to its variant nature, the term "gabbro" may be applied loosely to a wide range of intrusive rocks, many of which are merely "gabbroic". Black granite has numerous applications for structural and decorative purposes. It is utilized for outdoor sculpture, external walls, floor covering, decoration, stairs, and pavements, table tops, and novelties. Traditionally granite is cut using diamond tools .To obtain complex shapes of the stone, it is necessary to know how the type of diamond grains, hardness of matrix, water cooling and machining process influence the quality and productivity of machining. Because of the present problems encountered in conventional cutting of granite, attempts can be made for cutting of granite using non-traditional machining process such as Ultrasonic machining , Water jet machining (WJM), Abrasive Water Jet machining (AWJM), Laser beam machining (LBM) etc. Ultrasonic machining can be applied to non-conductive as well as brittle materials, but it is a slow and time consuming process, tool wear rate is very high even greater than the metal removal rates expected from the process. Machining is an important manufacturing process because, it is almost always involved if precision is required and is the most effective process for small volume production. In production/manufacturing context, optimization of machining processes is one of the most important areas of research to find out the best process environment for any machining operation. Using various techniques, this optimization problem is solved for various kinds of metals. It has been seen that these methods are not efficient enough due to so many assumptions and limitations imposed upon it as compared to the actual environmental working conditions. Therefore, researchers are emphasizing on hybridizing various methods to empower advantageous aspects which ultimately results into elimination of inherent limitations of the proposed methodology. The present study aimed to develop such a hybrid method which could efficiently be applied for continuous quality improvement for a process/product and to facilitate in off-line quality control of any manufacturing process. The modern machining processes are now replacing the conventional machining processes rapidly for many applications due to their significant advantages which are proving beneficial to a greater extent to the present industrial scenario The various modern machining processes getting widely used in the industries are: electric discharge machining (EDM), abrasive jet machining (AJM), ultrasonic machining (USM), electrochemical machining (ECM) and laser beam machining (LBM) including various modified versions of these processes. .These processes work on a particular principle by making use of certain properties of materials which makes them most suitable for some applications and at the same time put some limitations on their use. These processes involve large number of respective process variables (also called as process parameters) and selection of exact parameters setting is very crucial for these highly advanced machining processes which may affect the performance of any process considerably. Due to involvement of large number of process parameters, random selection of these process parameters within the range will not serve the purpose. The situation becomes more severe in case if more number of objectives are involved in the process. Such situations can be tackled conveniently by making use of optimization techniques for the parameters optimization of these processes.

During the past two decades, few researchers had developed some good quality advanced optimization techniques such as genetic algorithm (GA), simulated annealing (SA), artificial bee colony (ABC), ant colony optimization (ACO), particle swarm optimization (PSO), teaching-learning-based optimization (TLBO), etc. which had already proved their significance in the field of parameters optimization of various manufacturing processes. Modelling and optimization of parameters of a modern machining process through advanced optimization techniques is now proving as a milestone for the future in manufacturing field.

METHODOLOGY

In this investigation, the work piece material stainless steel was used with the following main properties: Tensile Strength 90 MPa, Modulus of elasticity 69 GPa, and Density 2.71 g/cm3. The abrasive used was garnet with mesh size of 80 and hardness of 7.5 Mohs.

PROBLEM STATEMENT:

GRANITE is usually cut by using conventional diamond cutting tool machine. Kerf is observed while the cutting operation. Also design of diamond tool for complex structures is a difficult process. In this, we are using water jet machine to cut the granite with standoff distance, Nozzle traverse speed and Abrasive flow rate as work parameters and optimize the cutting process. Taguchi method is applied to find optimum process parameter for Abrasive water jet machining (AWJM). Abrasive water jet machining is a non–traditional process of removal of material by impact erosion of high pressure, high velocity of water and entrained high velocity of grit abrasives on a work piece. Experimental investigation were conducted to assess the influence of abrasive water jet machining (AWJM) process parameters on MRR of STAINLESS STEEL The approach was based on Taguchi's method and analysis of variance (ANOVA) to optimize the AWJM process parameter for effective machining and to predict the optimal choice for each AWJM parameter such as pressure, standoff distance, Abrasive flow rate and Traverse rate. For each combination of orthogonal array we have conducted three experiments and with the help of ANOVA it is found that these parameters have a significant influence on machining characteristics such as metal removal rate (MRR). The analysis of the Taguchi method reveals that, in general the standoff distance significantly affects the MRR while, Abrasive flow rate affects the surface Roughness. Experiments are carried out using orthogonal array by varying pressure, standoff distance, Abrasive flow rate and Traverse rate respectively. Experimental results are provided to verify this approach.

OBJECTIVE:

To optimize the process parameter (Standoff Distance, nozzle traverse speed, abrasive flow rate) of water jet cutting of granite material.

To apply regression model coupled with TLBO in water jet cutting of granite material.
To minimize the kerf obtained during water jet cutting of granite.

SCOPE:

The water jet cutting of granite are published by many researchers but optimization of water jet cutting using combination TLBO and ANN are not yet reported in literature.

PROBLEM IDENTIFICATION:

Experimental investigation were conducted to assess the influence of abrasive water jet machining (AWJM) process parameters on MRR of STAINLESS STEEL The approach was based on Taguchi's method and analysis of variance (ANOVA) to optimize the AWJM process parameter for effective machining and to predict the optimal choice for each AWJM parameter such as pressure, standoff distance, Abrasive flow rate and Traverse rate. For each combination of orthogonal array we have conducted three experiments and with the help of ANOVA it is found that these parameters have a significant influence on machining characteristics such as metal removal rate (MRR). The analysis of the Taguchi method reveals that, in general the standoff distance significantly affects the MRR while, Abrasive flow rate affects the surface Roughness. Experiments are carried out using orthogonal array by varying pressure, standoff distance, Abrasive flow rate and Traverse rate respectively. Experimental results are provided to verify this approach.

CONSTRUCTION AND WORKING

CONSTRUCTION

There are five main process characteristics to water jet cutting

1. Uses high velocity stream of Ultra High Pressure Water 30000-90000 psi (210-620 MPa) which is produced by an intensifier pump with possible abrasive particles suspended in the stream.
2. Is used for machining a large array of materials, including heat-sensitive, delicate or very hard materials.
3. Nozzles are typically made of sintered boride or composite tungsten carbide.
4. Produces a taper of less than 1 degree on most cuts.

5. Distance of nozzle from workpiece affects the size of the kerf and the removal rate of material. Typical distance is .125 in(3.2 mm).

The equipment used for machining the samples is STREAMLINE SL-V 50S Plus jet machining centre as shown in Figure 4.1. A plate of Black granite having size 304.8mm x 304.8mm x 35mm is chosen as the work piece. Table 4.2 indicates the important properties of Black granite (material chosen for experimentation). As discussed in the literature review, a large number of variables are involved in the AWJM and virtually all these variables affect the cutting results. Therefore only those parameters are selected which shows a considerable influence on objectives of the study i.e. kerf taper angle. These parameters are nozzle traverse speed, stand-off distance and abrasive mass flow rate. The rest of the parameters are kept constant which are given in

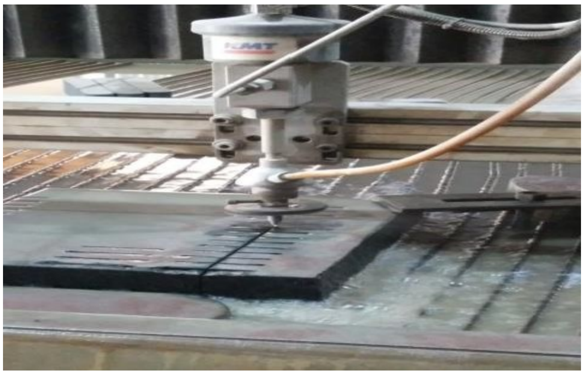

Fig1: Experimental setup

Fig2: Water jet Machine

WORKING

To achieve a thorough cut it was required that the combinations of the process variables give the jet enough energy to penetrate through the specimens. Screening experiments are performed to limit the range of process parameters at which cutting through the full thickness of the work piece can be performed. The minimum value of stand-off distance as well as abrasive flow rate at which through cutting can take place come out to be 1mm and 150 g/min respectively. Experiments were also conducted to find out maximum value of nozzle traverse speed for the through cut. It comes out to be 100 mm/min at threshold levels of other two input variables for through cutting. The higher levels of stand-off distance and abrasive flow rate and lower level of nozzle traverse speed are selected at the threshold levels permitted by the machine tool as input. Table 4.3 indicates variable process parameters and their levels selected.

parameters	level 1	level 2	level 3	level 4
Stand-off Distance (mm)	1	2	3	4
Nozzle Traverse Speed (mm/min)	25	50	75.5	100
Abrasive Flow Rate (g/min)	150	300	450	600

For experimentation, a full factor experimental design is done by first dividing the range of each parameter in 4 levels and obtaining 64 experimental combinations. In order to quantitatively evaluate experimental results, a measurement of the kerf characteristics such as top kerf width and kerf taper angle was made. The measurement of kerf taper, top kerf width and depth of cut was carried out from the end of the kerf prior to separating the specimens to measure the smooth depth of cut. It was anticipated that in AWJ contouring the two kerf wall might not be symmetrical due to the jet tail back effect. Thus the kerf taper and smooth depth of cut was obtained on each of the kerf walls. The kerf taper was obtained by measuring the kerf wall inclination (Wt – Wb) from the top kerf edge as shown in Figure 3.The taper angle is calculated by the following relation. Table 4 presents the design matrix as well as data about the observations.

$\theta = \tan^{-1} \{(Wt-Wb)/2t\}$

Where Wt is the top kerf width, Wb is the bottom kerf width and 't' is the thickness of the work piece.

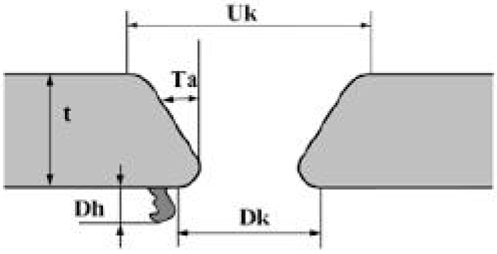

Fig.3. Kerf geometry of an AWJ cut

ADVANTAGES

1. Extremely fast step and programing
2. No. start hole required
3. There is only one tool
4. Low capital cost
5. Less vibration
6. No heat generate in work piece
7. Environmental friendly

CONCLUSION

Present work explored the abrasive water jet machining of Granite using TLBO and subsequent analysis. From the work, following inferences can be drawn:

- Optimal settings of process parameters for minimum top kerf width are Stand-off distance, nozzle transfer speed and Abrasive flow rate are 4 mm, 27.305 mm/min and 589.5 g/min.
- Average error was with
- Regression model and TLBO was applied accurately.
- Confirmation test was in proper limit.

Conflicts of interest: The authors stated that no conflicts of interest.

REFERENCES

1. Aultrin KS, Jai Anand Dev M. Optimization of Machining Parameters in AWJM Process for an Copper Iron Alloy Using RSM and Regression Analysis, *International Journal of Emerging Engineering Research and Technology*, 2014, Volume 2, Issue 5, 19-34
2. Dixit Abhishek, "Water Jet Machining: An Advance Manufacturing Process" International Journal of Engineering Research and General Science ,2014Volume 3, Issue 2, Part 2.
3. Xu Jiazhong, You Bo, Xiangbing Kong Xiangbing " Design and Experiment Research on Abrasive Water-jet Cutting Machine Based on Phased Intensifier" Proceedings of the 17th World Congress The International Federation of Automatic Control Seoul, Korea,2011, 2008
4. Ali1 Md. Irfath, Kalpana K, Sastri A.Pathanjali, Lakshmi B" A Holistic Approach to Risk Assessment and Decision Analysis to Improve Project Performance " International Journal of Emerging Engineering Research and Technology,2014,Volume 2, Issue 5, 99-103
5. Senthilkumar N, "Optimization of Process Parameters in Abrasive Water Jet Machining" International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization), 2016,Vol. 5, Special Issue 8.