

# A Review on Machining of Granite by Abrasive Water Jet

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**Abstract:** Granite is a very hard, granular, crystalline, igneous rock consisting mainly of quartz, mica, and feldspar and often used as a building stone. Abrasive Water Jet Machining (AWJM) process is usually used to through cut materials such as granite (hard and tough) which are difficult to cut by conventional machining processes. This paper deals with the current status of machining of granite by abrasive water jet and optimization of the machining parameters different outputs. Traverse speed, abrasive flow rate, standoff distance, water pressure and abrasive size are the major controlling parameters.

**Keywords:** Granite, abrasive water jet machining, water pressure, traverse speed, standoff distance.

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## I. INTRODUCTION

Granite is one of the most durable stones used in artistic and architectural applications, including outdoor sculpture. It forms from the slow crystallization of magma below Earth's surface. Granite is composed mainly of quartz and feldspar with minor amounts of mica, amphiboles and other minerals. It is tough, hard, waterproof, highly scratch resistant and heat resistant. Abrasive Water Jet Machining used to cut much harder materials and it is effective for machining of granite as compare to conventional machining processes. It makes all sorts of shapes and leaves a satin smooth finish, thus reducing secondary operations. The kerf width and kerf angle in AWJ machining is very small, and very little material is wasted.

## II. LITERATURE REVIEW

**Rupal V. Shah, Prof. Dhaval. M. Patel [1]** on the basis of Optimum factorial method and analysis of variance (ANOVA) machining was performed on granite of 10 mm thickness at to optimize the AWJM parameters hydraulic pressure, standoff distant (SOD) and traverse speed for effective machining. 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 module for MRR:

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

Where **A** is pressure, **B** is SOD and **C** is traverse speed.

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

**IZZET KARAKURT [2]** investigated the effects of process parameters and the material properties (i.e. textural properties) of the granite to minimize the kerf angle. Taguchi method provided an efficient approach to assess the performance and quality. Machining parameters traverse speed, abrasive flow rate, standoff distance, water pressure and abrasive size was considered at various levels for machining of Baltic Brown, Aksaray Yaylay and Bergama Grey granites. The kerf taper angle was determined from the equation:

$$\theta = \tan^{-1} [(W_{\text{top}} - W_{\text{bottom}}) / H]$$

Where,  $W_{\text{top}}$  and  $W_{\text{bottom}}$  are the top and bottom kerf widths respectively and  $H$  is the distance from the top kerf to where the cut is measured. Analysis of variance (ANOVA) was used to assess the resulting experimental data to determine the process parameters statistically affecting the kerf angle of the granite.

Granites having higher alkali feldspar and quartz ratio have higher kerf angles and having higher plagioclase contents and uniaxial compressive strength (UCS) have lower kerf angle. Based on the results the kerf angle of granites increased with the increasing of traverse speed, standoff distance and the water pressure and also by fine-grained abrasives but increase in abrasive flow rate did not have appreciable effect on kerf angle. The kerf angle for Baltic Brown and Aksaray was most affected by traverse speed, whereas for Bergama Grey it was standoff distance.

**M. CHITHIRAI PON SELVAN [3]** focused on the depth of cut in AWJM of granite. Water pressure, traverse speed, mass flow rate and standoff distance were selected as the control parameters, other parameters kept constant and machining was performed. It was examined that the depth of cut increases with increase in water pressure and mass flow rate and depth of cut decreases with increase in traverse speed and standoff distance. On the bases of experimental results mathematical model for depth of cut is empirically developed:

$$D_c = 1.18 \times 10^4 \times \frac{P^{2.033} m_a^{0.426} d_p^{1.154} \rho_p^{0.443}}{E^{1.902} u^{0.688} s^{0.006} \rho_w d_j}$$

Where,  $D_c$  depth of cut (mm),  $m_a$  mass flow rate of abrasive particles (g/s),  $\rho_p$  density of particle ( $\text{kg/m}^3$ ),  $\rho_w$  density of water ( $\text{kg/m}^3$ ),  $d_j$  diameter of jet (mm),  $d_p$  average diameter of particle (mm),  $u$  traverse speed of nozzle (mm/s),  $P$  water pressure (MPa),  $E$  modulus of elasticity of material (MPa) and  $s$  standoff distance (mm).

**G. AYDIN [4]** the performance optimization of AWJM in granite was assisted by design of experiment technology and Taguchi  $L_{16} (4^4 \times 2^1)$  orthogonal array including signal to noise (S/N) ratio. Machining parameters traverse speed, abrasive flow rate, standoff distance, water pressure and abrasive size were varied at different stages of experiment. On bases of average S/N ratio, surface roughness appreciably affected by traverse speed, standoff distance, abrasive size, water pressure and not by abrasive flow rate. The depth of cut was most affected by transverse speed, abrasive flow rate and abrasive size rather than other machining parameters. It also examined that Taguchi's approach effectively reduce cost, time and improve productivity for experimental study of granite.

**IZZET KARAKURT & GOKHAN AYDIN [5]** conducted AWJ machining based on Philosophy of Taguchi on Rosa Minho (Pink Granite) and optimized the control factors for kerf width and cut depth by Analysis of variance. He determined that increase in abrasive flow rate, water pressure increase both cut depth and kerf width. Also noticed cut depth and kerf width decreases with increase in traverse speed; increase in standoff distance increases kerf width but decreases cut depth.

**GOKHAN AYDIN [6]** carried out the abrasive water jet machining on the granite to obtain the better cut surface quality. The cutting performances are examined in terms of surface roughness and cutting wear zone on the basis of Taguchi's orthogonal array. Machining result data was examined by analysis of variance (ANOVA). He concluded that lower traverse speed resulted in better surface quality because of deeper cutting wear zone, increase in abrasive flow rate increases cutting wear zone little bit and decreases surface roughness to a certain value of abrasive flow rate and further increases. Increase in SOD and water pressure resulted in increase of cutting wear zone and surface roughness to a limit with further increase in SOD surface roughness slightly increases and cutting wear zone decreases; with further increase in the water pressure caused a slowly decrease in the cutting wear zone and surface roughness.

## CONCLUSION

AWJ machining is the satisfactory process for cutting of granite as it result finer surface finish of cutting zone, lower kerf angle and width and higher depth of cut as compare to other non conventional machining and traditional

machining processes. AWJ machining of granite reduces the secondary operations on it. Traverse speed, abrasive flow rate, standoff distance, water pressure and abrasive size are the major controlling factors for Abrasive Water Jet Machining of granite.

## REFERENCES

- [1]. Rupal V. Shah, Prof. Dhaval. M. Patel “A Study of Abrasive Water Jet Machining Process on Granite Material” International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Vol. 2, Issue4, July-august 2012, pp.2031-2033
- [2]. İzzet Karakurt\*, Gokhan Aydin & Kerim Aydiner “Analysis of the kerf angle of the granite machined by abrasive waterjet (AWJ)” Indian Journal of Engineering & Materials Sciences Vol. 18, December 2011, pp. 435-442
- [3]. M. Chithirai Pon Selvan, Dr. N. Mohana Sundara Raju “Assessment of Process Parameters in Abrasive Waterjet Cutting of Granite” International Conference on Trends in Mechanical and Industrial Engineering (ICTMIE'2011) Bangkok Dec., 2011
- [4]. G. Aydin, I. Karakurt, K. Aydiner “PERFORMANCE OPTIMIZATION OF ABRASIVE WATERJET TECHNOLOGY IN GRANITE CUTTING” 2011 WJTA-IMCA Conference and Expo September 19-21, 2011 • Houston, Texas
- [5]. İzzet KARAKURT\*, Gökhan AYDIN\*, Kerim AYDINER\* “A Machinability Study of Granite Using Abrasive Waterjet Cutting Technology” Gazi University Journal of Science 24(1):143-151(2011)
- [6]. Gökhan AYDIN\*, İzzet KARAKURT\*, Kerim AYDINER\* “ASSESSMENT OF THE SURFACE QUALITY OF THE GRANITE CUT BY ABRASIVE WATERJET” Technology, 13(1), 41-48, (2010)

