

Parametric Optimization of the Surface Characteristics of Rock Dust Reinforced Aluminium Composites for Automobile Applications

Shivashankar Melinamane¹, Prof. P.S. Patil²

¹PG Student, Department of Mechanical Engineering, BLDEA's V P Dr. P G H CET VIJAYAPURA, KARNATAKA, INDIA.

²Professor, Department of Mechanical Engineering, BLDEA's V P Dr. P G H CET VIJAYAPURA, KARNATAKA, INDIA.

Abstract: The enormous development of elite materials, for example, composites which are difficult to machine, with major prerequisites for items with complex shapes requires the advancement of good machining methods, especially the non-traditional machining techniques. Abrasive suspension water jet machining which is one of the non-traditional machining techniques, is a unique innovation that utilizes a flood of fine-grained abrasive particles blended in legitimate extent with water that is eventually centered on a workpiece through an appropriately structured nozzle setup. Material expulsion in this process happens because of disintegration brought about by the effect of high-speed abrasive particles on the work surface. This innovation is as yet developing and enhancing step by step finding far reaching applications in different zones, which can be relied upon to increment extensively. This research is thus aimed at parametric optimization of the surface characteristics of rock dust reinforced aluminum composites.

Keywords: AWSJ (Abrasive Water Suspension Jets), MRR (Material Removal Rate), ANOVA (Analysis Of Variance), NS (Not Significant), Aluminium composite, Zycoprint.

1. INTRODUCTION

Abrasive Water Suspension Jet (AWSJ) machining:

The most productive method for creating grating water planes is to pass a pressurized suspension of rough particles in water through the spout to shape a two-stage fly (no air entrainment). The expansion of polymers in water suspends the rough particles and create progressively homogeneous slurry henceforth the name Abrasive Suspension Jet.

Abrasive water suspension jet machining is a one of a kind procedure that supplements and upgrades cutting abilities of Abrasive Water Jet. The suspension technique for abrasives can create multiple times more cut surface region every moment than abrasives entrained water stream. An AWJ is framed by entraining abrasive particles conveyed noticeable all around into a high-speed water stream, though an AWSJ is shaped by straightforwardly siphoning a grating suspension through a nozzle.

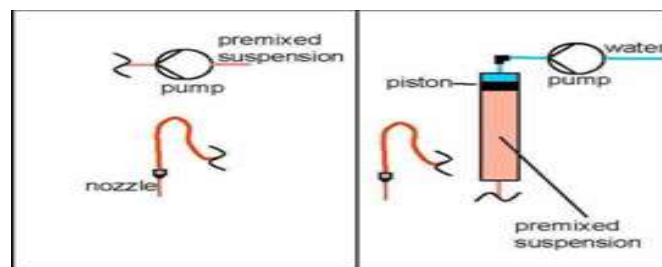


Figure 1. Mechanism of an AWSJ

In this process, abrasives are premixed with a suspended fluid which is only polymerized water to frame a suspension blend. The suspension is siphoned straightforwardly or by implication and removed through a spout to frame a suspension jet. Figure 1.6 shows diverse strategies for creating rough suspension planes.

The direct siphoning technique creates the suspension stream by pressurizing the premixed suspension specifically by methods for a high-pressure siphon. In spite of the fact that this strategy is extremely easy to apply, it has never achieved monetary significance, for the most part in view of the high abrasive water in the siphon amid pressurization of the suspension (figure 1, left side).

The second strategy for producing AWSJ is the pressurization of a premixed suspension (figure 1, right). Water is pressurized and drives a drifting cylinder in the weight vessel. This pushes a premixed suspension out of a high-weight vessel and quickens the suspension in the spout. So as to balance out a suspension, a polymer arrangement of consistency around four requests of

greatness higher than water is utilized as a fluid segment of the cutting medium. With this strategy, AWSJs of high weight and intelligibility have been created. In any case, they have constrained capacity limit of the suspension in the pressurized chamber and in this manner, the cutting time is restricted. The trial setup created for the present investigation depends on this guideline.

2. RESEARCH METHODOLOGY

This experiment deals with the experimental investigation of the effect of various process parameters on the performance of AWSJ machining. The experimentation is carried out on rock dust reinforced Aluminium (composite plate), to study the effect of various process parameters on the performance on AWSJ machining. The experimental studies have been performed using design of experiments (DOE). The DOE tool such as orthogonal Array (OA) has been used to design the experiments. Minitab (Version 15), statistical software is used for experimental design, data analysis. Results of the current research are discussed at the end of the experiment.

2.1 Materials used

Abrasive Materials

A large number of abrasive materials are used in the abrasive water-jet machining technique. Since the abrasive particles erode the target material, it is necessary that they must be hard so that they are the eroders as opposed to being the eroded. The type of abrasives used in the present research is Garnet of different grain size. Garnet is a gathering of minerals that share a typical crystalline structure and a comparative substance arrangement. The most well-known assortments of monetarily accessible garnet are Almandite (or Almandine) and Andradite. Despite the fact that Almandite is the heaviest and hardest and Andradite is the lightest and gentlest of the garnet family, both are generally hard and substantial.

Properties of Zycoprint Polymer

Zycoprint is a water soluble chemical polymer emulsion of polyacrylic acid with a copolymer of ammonium salt and other ingredients like surfactants and paraffinic oils which is used to improve the viscosity of a solution. Zycoprint is a new polymer used in the preparation of abrasive suspension and its properties are listed in table 3.3. Its molecular formula is similar to that of polyacrylic acid $(CH_2=CHCOOH)_n$ and its structure contains an ionizable group on each repeat unit $(-COOH)$. The Zycoprint polymer solutions have better suspension capability even at low concentrations that helps in the preparation of stable abrasive suspension for experimentation. The pH values are ranging from 7.2 to 7.65 for these concentrations which are not harmful for working.

Work material

The work material is used in the present experimental study is Rock dust reinforced Polymer composite (Aluminium) for the determination of Material Removal Rate (MRR), kerf width and surface roughness during both under water and surface water cutting. The selection of this material is based, mainly on their brittle property which is suitable for AWSJ cutting as well as their availability. The size of work piece is 75×50×6 mm.

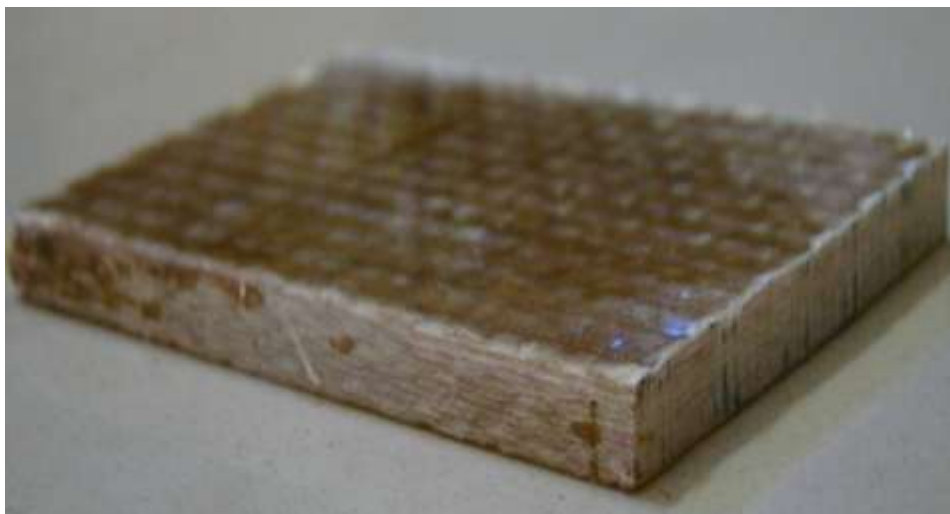


Figure 2.1 Aluminium composite plate

3 Results

3.1 Results of Aluminium composite during above water machining

The results of the experimental investigation that has been carried out on rock-dust reinforced composite during above water cutting, is summarized in table 4.13. It can be identified that all the process parameters have been significant effect on MRR, TKW, BKW and SR. The percentage contribution of each factor towards the total variation in each of the response parameter is also listed in the same table.

Process parameters	MRR		TKW	
ABR SIZE (grit)	NS	18.97	NS	21.85
SOD (mm)	S	51.74	NS	35.59
ABR CONC (gm)	NS	10.5	NS	1.16
FEED (mm/min)	NS	4.13	NS	20.02

S– significant at 90% confident level; NS– not significant; SS(%)– percentage contribution ; Ave SS(%)– average contribution across all the response parameters (MRR, TKW, BKW and SR)

Table 3.1 Significant factors and contribution to total variance in response parameter during above water cutting

Process parameters	BKW		SR		Avg SS%
ABR SIZE (grit)	NS	2.98	NS	0.1	10.97
SOD (mm)	NS	6.06	S	11.98	26.34
ABR CONC (gm)	NS	14.85	NS	3.79	7.58
FEED (mm/min)	S	67.05	S	80.21	42.88

3.2 Results of Aluminium composite during under water cutting

The results of the experimental investigation that has been carried out on Aluminium composite during under water cutting, is summarized in table 4.14. It can be identified that all the process parameters have been significant effect on MRR, TKW, BKW and SR. The percentage contribution of each factor towards the total variation in each of the response parameter is also listed in the same table.

Process parameters	MRR		TKW	
ABR SIZE (grit)	NS	18.25	NS	10.67
SOD (mm)	S	44.18	S	26.66
ABR CONC (gm)	NS	13.77	NS	0.99
FEED (mm/min)	NS	5.00	S	50.01

Table 3.2 Significant factors and contribution to total variance in response parameter during under water cutting

Process parameters	BKW		SR		Avg SS%
ABR SIZE (grit)	NS	5.82	NS	3.29	9.51
SOD (mm)	NS	4.36	NS	7.31	20.62
ABR CONC (gm)	NS	16.42	NS	9.51	10.17
FEED (mm/min)	S	63.20	S	69.28	46.87

4. Comparison of results

4.1 Comparison of MRR during above water and under water cutting

The MRR is more in under water cutting compared to above water cutting as shown in table 4.3 and 4.4 respectively. In the underwater cutting of Aluminium composite the jet of abrasive and water mixed with the column of water during cutting it get accelerate the water. Because of this it must have removed the glue (matrix) between the layers of fibers.

4.2 Comparison of TKW during above water and under water cutting

The TKW is more in above water cutting compared to under water cutting as shown in table 4.3 and 4.4 respectively. In the above water cutting there is a chance of air entrapped in to the abrasive water jet after exiting the nozzle it will increase the radial expansion of jet. Hence, it will increase the TKW. But, in the underwater cutting there is no chance of air entrapped in to the jet because, the nozzle is keeping in water hence, the TKW will be small.

4.3 Comparison of BKW during above water and under water cutting

The BKW is more in above water cutting compared to under water cutting as shown in table 4.3 and 4.4 respectively. In the above water cutting because of damping of abrasive particle each other while traveling it will move upward direction as a result increase the kerf width. But in the underwater cutting after damping the abrasive particles are dissipated in to the water hence there is no chance of the abrasive particles moving upward direction as a result decrease in kerf width.

4.4 Comparison of surface roughness during above water and under water cutting

The surface roughness is more in case of above water cutting compared to the underwater cutting as shown in table 4.3 and 4.4 respectively. In case of underwater cutting the cohesiveness of the jet increases, because there is no chance of air entrapped in to the jet after exiting from the nozzle. Also vibration of the nozzle as well as abrasive water jet is minimum. Hence it will decrease the surface roughness. But in case of above water cutting the vibration of the jet is more and decrease in jet cohesiveness will results in increase in the surface roughness.

5. Conclusions

On the basis of experimental results, calculation of analysis of variance (ANOVA), F-test Values the following conclusions can be drawn for effective machining of Aluminium composite during above water and under water cutting by AWJM process as follows.

1. The standoff distance is the most significant control factor on MRR. Meanwhile, abrasive size, abrasive concentration and traverse rate are insignificant in influencing MRR since they failed the test of significance during above water and under water cutting.
2. In case of TKW, abrasive size, standoff distance, abrasive concentration and traverse rate are considered insignificant in controlling TKW since they failed the test of significance during above water cutting. During under water cutting traverse rate is the most significant control factor on TKW followed by Standoff distance. Abrasive size and abrasive concentration are considered insignificant in controlling TKW since they failed the test of significance.
3. In case of BKW, traverse rate is the most significant control factor. Abrasive size, standoff distance and abrasive concentration are considered insignificant in controlling BKW criteria during both above water and under water cutting.
4. In case of surface roughness, traverse rate is the most significant factor followed by standoff distance. Abrasive size and abrasive concentration are insignificant in controlling surface roughness during above water cutting. During under water cutting traverse rate is the most significant factor in controlling the surface roughness. Abrasive size, abrasive concentration and standoff distance are considered insignificant in controlling surface roughness since they failed the test of significance.
5. It was also confirmed that the machining of rock-dust reinforced aluminium composites during under water cutting is prepared compared to above water cutting.

6. Reference

- [1] St. Brandt, H. Louis, W. Milchers, M. Mohamed, F. Pude and Ch. Von Rad, "Abrasive Water Jets – Aflexible Tool for Non-conventional Machining," in *Proc. Of 19th AIMTDR Conference*, Narosa Publishing House, New Delhi, India, 2000, pp.129-134.
- [2] M.Ramulu, S.Kunapurn, D.Arola and M.Hashish, "Waterjet machining and Peening of Metals" *Transactions of the ASME, Journal of pressure Vessels Technology*, vol. 122, pp.90-95, Feb 2000.

- [3] Adnan Akkurt, Mustafa Kemal Kulekci. "Effect of feed rate on surface roughness in abrasive water jet cutting applications," *Journal of Material Processing Technology*, vol.147, 389-396, 2004.
- [4] M.A. Azmir, A.K. Ahsan, "A study of abrasive water jet machining process on glass/epoxy composite laminate," *Journal homepage; www.elsevier, com/locate/wear*.
- [5] M.A. Azmir, A.K. Ahsan, "An experimental investigation of rectangular pocket milling with abrasive water jet," *Journal of Material processing Technology, Transactions of ASME*, vol. 106, pp. 92-100, 1994.
- [6] D. Anjaiah, A.M. Chincholkar and B. Siddeswarappa., "Effect of process parameters on the material removal rate on glass in low pressure abrasive slurry jet machining" Proc. of National Conference on World Class manufacturing, May 2003, pp. 20-24.
- [7] D. Anjaiah and Chincholkar A.M, "*Transactions of ASME*, vol. 106, pp. 88-100, 1984. Cutting of glass using low pressure abrasive water suspension jet with the addition of Zycoprint polymer," Proc. of 19th International Conference on Water Jetting, BHR Group, UK, 2008, pp. 105-119
- [8] S. Paul, A. M. Hoogstrate, C. A. Van Luttervelt and H. J. J. Kals, "An experimental investigation of rectangular pocket milling with abrasive water jet," *Journal of Material processing Technology*, vol. 73, pp. 179-188, 1998.
- [9] G. Fowler, I.R. pashby, The effect of particle hardness and shape when abrasive water jet milling titanium alloy Ti6Al4V, *Journal homepage; www.elsevier.com/locate/wear*.
- [10] M. Hashish, "A Modeling Study of Metal Cutting with Abrasive Waterjets," *journal Engineering Materials and technology*,
- [11] M. Hashish, "Steel Cutting with Abrasive Waterjets," presented at 6th International Symposium on Jet Cutting Technology, University of Surrey, U.L., BHRA Fluid Engg., 1982.
- [12] M. Hashish, "A Model for Abrasive Waterjets Machining," *Journal Engineering Materials and Technoloty, Transactions of ASME*, vol. 111, pp. 154-162, 1989.
- [13] Hashish, "Comparative Evaluation of Abrasive Liquid Jet Machining Systems," *Transactions of the ASME, Journal of Engineering for Industry*, vol.115, pp. 44.-50, Feb 1993.
- [14] M. Hashish, "Abrasive-fluidjet machinery systems: entainment versus direct pumping," in *Proc. Of 10th International Conference on jetting Technology*, 1991, pp. 99-113.
- [15] M. Ramulu and D. Arola, "The influence of Abrasive Water Jet cutting conditions on the surface quality of Graphite/Epoxy laminates," *Int. Journal of Machine Tools and Manufacture*, vol. 34, pp,295-313, 1994.

AUTHOR PROFILE

Shivashankar Melinamane

Obtained his Bachelor's degree in mechanical Engineering from Visvesvaraya Technological University (VTU). He is presently pursuing Master Degree in Mechanical Machine Design from VTU.