.OPTIMIZATION OF MACHINING PARAMETERS FOR MACHINING BULLET PROFF GLASS USING AWJM

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ABSTRACT

Abrasive Water Jet Machining (AWJM) is one of the un-conventional machining processes. It has potential to cut a wide range of materials .This project assesses the influence of various process parameters in abrasive water jet machining while machining the Bullet Proof Glass. Surface roughness is measured with different process parameter settings- Traverse speed, Abrasive flow rate, and Standoff distance. These process parameters will mainly influence the machinability of the material. We are conduct the study in those machining parameter in Taguchi Grey Relational analysis is opted because of the multi response optimization. And select the optimum parameter to machining the bullet proof glass.

Keyword : - *Optimization , Machining Parameter, Bullet Proof Glass, Taguchi Grey analysis*

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1. INTRODUCTION

Abrasive water jet machining (AWTM) is one of the un-conventional machining process that employs high-pressure water for producing high velocity stream, along with abrasive particles for cutting wide variety of material from soft to hart materials. In abrasive water jet machining the various process parameters like Water pressure, Abrasive flow rate, Standoff Distance, and Traverse Speed will mainly influence in the machinability. And also it is very essential to study those parameters in the different material to improve the Machinability.

1.1 Basic Principle

Abrasive Water Jet Machining is a non-traditional machining process, which makes use of the principles of Abrasive Jet Machining (AJM) and Water Jet Machining (WJM).The Abrasive Jet Machining process involves the application of a high-speed stream of abrasive particles assisted by the pressurized air on to the work surface through a nozzle of small diameter. Material removal takes place by abrading action of abrasive particles Water jet machining is an erosion process technique in which water under high pressure and velocity precisely cuts through and grinds away minuscule amounts of material. The addition of an abrasive substance greatly increases the ability to cut through harder materials such as steel and titanium. Water jet Machining is a cold cutting process that involves the removal of material without heat.

This revolutionary technology is an addition to non- traditional cutting processes like laser and plasma, and is able to cut through virtually any material. The water jet process is combined with CNC to precisely cut machine parts and etch designs .Since water jet machining is done with abrasives, it is often synonymous with abrasive jet cutting. The combination of compressor, plumbing and cutting heads accomplishes the pressure and velocity to attain the cutting ability. High-pressure compressors create a jet of water under extreme pressure that exceeds the speed of sound. This slim jet of water produced from a small nozzle creates a clean cut. Before cutting, the materials are carefully laid on top of slates over or submerged in the catch tank. Abrasive water jet uses the technology of high-pressure water typically between 2069 and 4137 bar, to create extremely concentrated force to cut stuff. A water cutter pressurizes a stream of pure water flow (without abrasive) to cut materials such as foam, rubber, plastic, cloth, carpet and wood. Abrasive jet cutters mix abrasive garnet to a pressurized water stream to cut harder materials. Examples are stainless steel, titanium, glass, ceramic tile, marble and granite.

Water jet metal cutting machine yields very little heat and therefore there is no Heat Affected Zone (HAZ). Water jet machining is also considered as "cold cut" process and therefore is safe for cutting flammable materials such as plastic and polymers. With a reasonable cutting speed setting, the edges resulting are often satisfactory.

In Abrasive Water Jet Machining, the abrasive particles are mixed with water and forced through the small nozzle at high pressure so that the abrasive slurry impinges on the work surface at high velocity. Each of the two components of the jet, i.e., the water and the abrasive materials have both separate purpose and a supportive purpose. The primary purpose of the abrasive material in the jet stream is to provide the erosive forces. The water in the jet acts as the coolant and carries both the abrasive material and eroded material to clear of the work.

2. LITERATURE SURVEY

Mr. B.Satyanarayana,[1**]** et all studied The optimization of abrasive water jet machining process parameters using taguchi grey relational analysis. The objective of this paper was to optimize material removal rate and kerf width simultaneously using AWJM process on INCONEL 718. The process parameters are chosen as abrasive flow rate, pressure, and standoff distance. Taguchi Grey Relational Analysis is opted because of multi response optimization. And the conclusion of the paper was the optimal parameter values are abrasive flow rate at 20.41gm/sec, pressure at 344.7 Mpa and standoff distance at 3mm.at these parameters the values of MRR and kerf width are 1053.2mm^3/min and 1.54mm respectively.

Mr P. Shanmughasundaram,[2**]** (2014) studied the Influence of abrasive water jet machining parameters on the surface roughness of eutectic al-si alloy– graphite composites. In this study, the influence of abrasive water jet machining (AWJM) parameters such as water pressure, standoff distance, and traverse speed each at three different levels were analyzed on the surface roughness of the Al- graphite composites which are fabricated through the squeeze casting method. The experiments were conducted using L9 Taguchi technique. The percentage contribution of each process parameter on surface roughness was analyzed by means of analysis of variance. The outcomes of investigation show that the water pressure (74.08 %) has the highest influence on surface roughness followed by traverse speed (17.28 %) and standoff distance (7.18 %) in machining of Al-Gr composite. Obtained mathematical modeling can be successfully employed to predict the surface roughness of composites.

Mr.k.Ravikumar,[3] et all (2017) studied the Characterization and Optimization of Abrasive Water Jet Machining Parameters of Aluminium /Tungsten Carbide Composites. The present study aims to optimize the Abrasive Water Jet Machining parameters while machining aluminium/tungstencarbide composites. Investigations were carried on 2,4,6,8 and 10wt% tungsten carbide reinforced composite specimens fabricated by stir casting technique. Response surface methodology was employed to explore the influence of abrasive jet parameters and their relations on the responses. Microstructure of the machined surfaces was examined by scanning electron microscope. Material removal rate is greatly influenced by transverse speed followed by % reinforcement and standoff distance respectively, while surface roughness is highly influenced by % tungsten carbide followed by transverse speed and standoff distance. The optimum parameter set in maximizing the material removal rate and minimizing the surface roughness is standoff distance -4.22 mm, transverse speed-223.28 mm/min, and percentage WC-2.10 %.

3. BULLET PROOF GLASS

Bulletproof glass (also known as ballistic glass, transparent armor, or bullet-resistant glass) is a type of strong but optically transparent material that is particularly resistant to being penetrated when struck. Like any material, however, it is not completely impenetrable. It is usually made from a combination of two or more types of glass, one hard and one soft[citation needed]. The softer layer makes the glass more elastic, so it can flex instead of shatter. The index of refraction for both of the glasses used in the bulletproof layers must be almost the same to keep the glass transparent and allow a clear, undistorted view through the glass. Bulletproof glass varies in thickness from 3⁄4 to 3 1⁄2 inches (19 to 89 mm).

Fig-1 : Bullet Proof Glass

4. TAGUCHI GREY RELATIONAL ANALYSIS

Taguchi's method is an efficient tool for the design of high a quality manufacturing system; it is employed when the number of parameters is high. Dr.Genichi Taguchi, a Japanese engineer has developed a method based on orthogonal arrays (OA). In this method quality is measured by the deviation of a characteristic from its target value. A loss function is developed from this deviation. Uncontrollable factors which are also known as noise cause such deviation and result in loss. Taguchi method seeks to minimize the noise since the elimination of noise factor is impractical and so a parameter called signal to noise ratio (S/N) is defined. To solve multiple performance characteristic problems, the Taguchi method is coupled with Grey Relational Analysis (GRA). In GRA experimental data are first normalized in the range of zero to one. Grey relational coefficients are calculated to represent the correlation between the ideal and the actual normalized data.

4.1 Controllable parameters

The possible controllable parameters of AWJM are water jet orifice size, water jet pressure, abrasive grit size, abrasive material, abrasive flow rate, traverse rate, standoff distance, angle of attack, composition of work piece. From the above a full factorial experimental set consisting of abrasive flow rate, traverse speed and standoff distance as process parameters considering each at 3levels with all possible combinations leading to a total of 9experiments is chosen. The process parameters range is specified in Table below. Selection of the particular orthogonal array from the standard OA depends on the number of factors, levels of each factor. Nearest OA fulfilling this condition is L9 (3^3). It can accommodate a maximum three number of control factors, each at three levels with 9 experiments. All 9experiments are conducted at 90º jet impingement angle only. The specimen is weighed before and after the experimentation. The ratio of the volume difference to total cutting time gives the volumetric material removal rate.

- Checking and preparing the AWJ machine ready for performing the machining operation.
- Performing cutting operation on specimens to ensure a higher MRR.
- Calculating the weight of the specimen before and after machining, for the calculation of MRR.
- Calculate the surface roughness of the specimen after the machining for the calculation of surface roughness.

Table I Range of Process Parameters

Parameters	Symbol	Level 1	Level 2	Level 3
Abrasive flow rate (gm/ min)	(A)	350	400	450
Standoff distance (mm)	(B)	3	4	5
Traverse speed (mm/min)	(C)	36	72	72

All 9experiments are conducted at 90º jet impingement angle only. The specimen is weighed before and after the experimentation. The ratio of the volume difference to total cutting time gives the volumetric material removal rate.

a) Checking and preparing the AWJ machine ready for performing the machining operation.

b) Performing cutting operation on specimens to ensure a higher MRR.

c) Calculating the weight of the specimen before and after machining, for the calculation of MRR. Calculate the surface roughness of the specimen after the machining for the calculation of surface roughness

Table II Response for the input parameters

S No	(A) Abrasive Mass Rate (gm/min)	(B) Standoff Distance (mm)	(C) Traverse Speed (mm/min)	MRR (gm/min)	RA (µm)
1	350	3	36	26.34	2.43
2	350	4	72	111.36	2.78
3	350	5	108	281.33	2.77
4	400	3	72	252.90	2.69
5	400	4	108	471.15	2.45
6	400	5	36	182.01	2.56
7	450	3	108	869.62	2.55
8	450	4	36	248.25	2.68
9	450	5	72	551.09	2.56

4 Experimentation

The equipment used for machining the samples is DWJ Flying Arm CNC abrasive water jet cutting machine equipped with KMT model of water jet pump with the designed pressure of 3500 bar (50763psi) and rated discharge of 350gm/min to 450gm/min. The machine is equipped with a gravity feed type of abrasive hopper, an abrasive feeder system, a pneumatically controlled valve and a work table with dimension of 240mm×300mm. For the nozzle assembly, it has an orifice of 1.1mm diameter of sapphire jewel. The abrasives were delivered using compressed air from a hopper to the mixing chamber and were regulated using a metering disc. All the cutting experiments were performed on bullet proof glass material and are single pass experiments conducted by choosing standoff distance of 3mm to 5mm and the jet impact angle of 90º. Garnet 80mesh sand abrasives were used as abrasives.

Fig 2 Nozzle of AWJM

5 MINITAB

MINITAB is a powerful statistical software package used in the areas of mathematics, statistics, economics, sports and engineering. It is highly interactive software which makes entering data, conducting regression analysis, ANOVA analysis, designing experiments using DOE, performing Taguchi analysis, drawing control charts for processes, performing reliability/survival tests, multivariate tests, plotting time series plots, etc. very easy and time saving. It is the best tool for data driven quality improvement programs. In this project, MINITAB (version 17) has been used for ANOVA analysis and for plotting various graphs

MRR VERSUS ABRASIVE FLOW RATE, TRAVERSE SPEED RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS

Table Response table for SN ratios

Level	ABRASIVE FLOW RATE	STANDOFF DISTANCE	TRAVERSE SPEED
1	39.44	45.09	40.50
2	48.91	47.43	47.94
3	53.84	49.67	53.74
Delta	14.39	4.58	13.24
Rank	1	3	2

Table IV Response Table for Means

Level	ABRASIVE FLOW RATE	STANDOFF DISTANCE	TRAVERSE SPEED
1	139.7	383.0	152.2
2	302.0	276.9	305.1
3	556.3	338.1	540.7
Delta	416.6	106.0	388.5
Rank	1	3	2

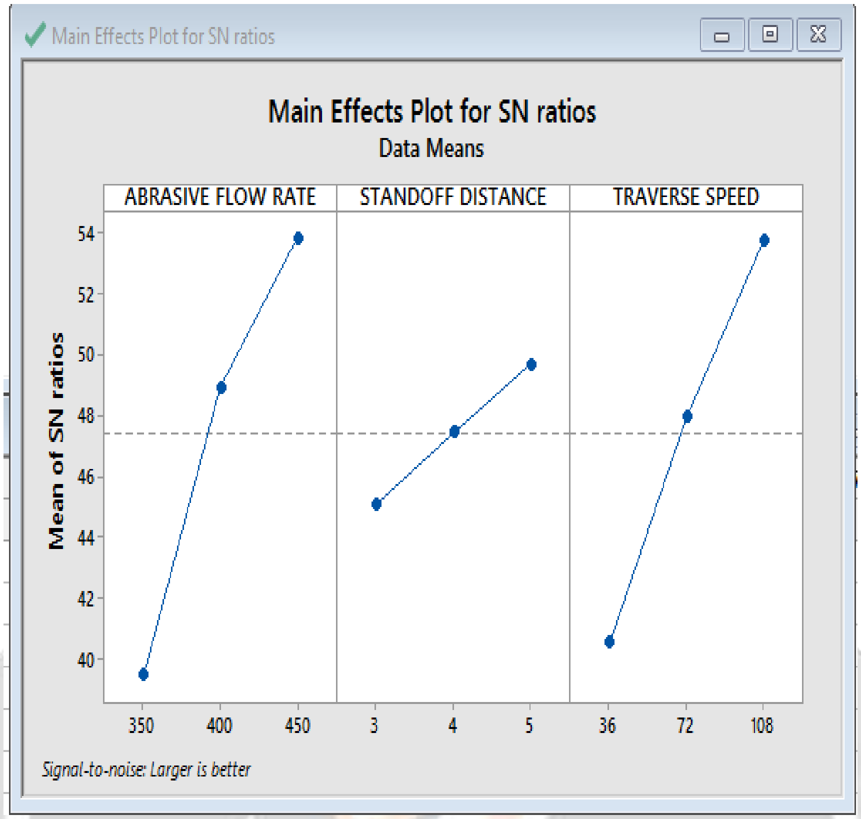

Fig Main effects plots for SN ratios

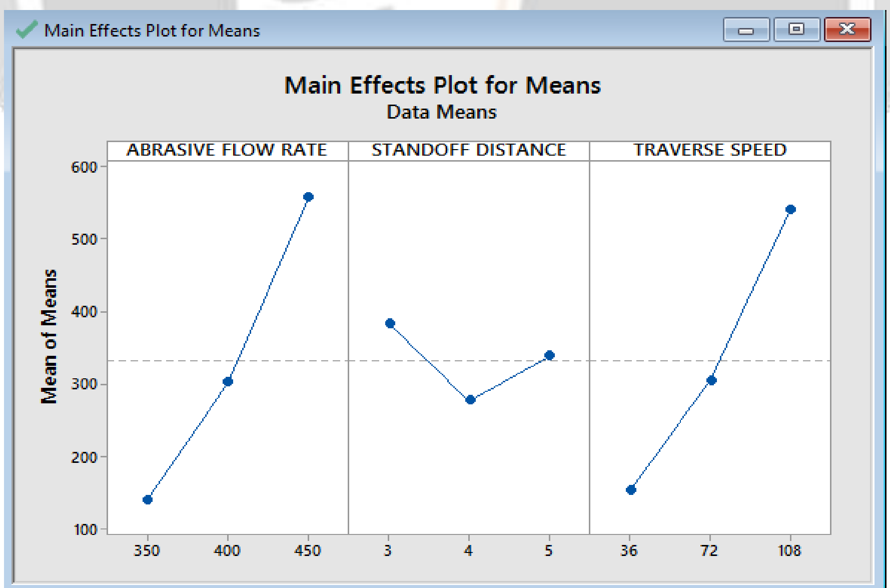

Fig Main Effects plots for Mean

RA vs ABRASIVE FLOW RATE, TRAVERSE SPEED

Table 6.3 Response Table for Means

Level	ABRASIVE FLOW RATE	STANDOFF DISTANCE	TRAVERSE SPEED
1	2.660	2.557	2.557
2	2.567	2.637	2.677
3	2.597	2.630	2.590
Delta	0.093	0.080	0.120
Rank	2	3	1

Table 6.4 Response Table for Signal to Noise Ratios

Level	ABRASIVE FLOW RATE	STANDOFF DISTANCE	TRAVERSE SPEED
1	-8.481	-8.146	-8.147
2	-8.181	-8.409	-8.547
3	-8.286	-8.393	-8.255
Delta	0.300	0.263	0.400
Rank	2	3	1

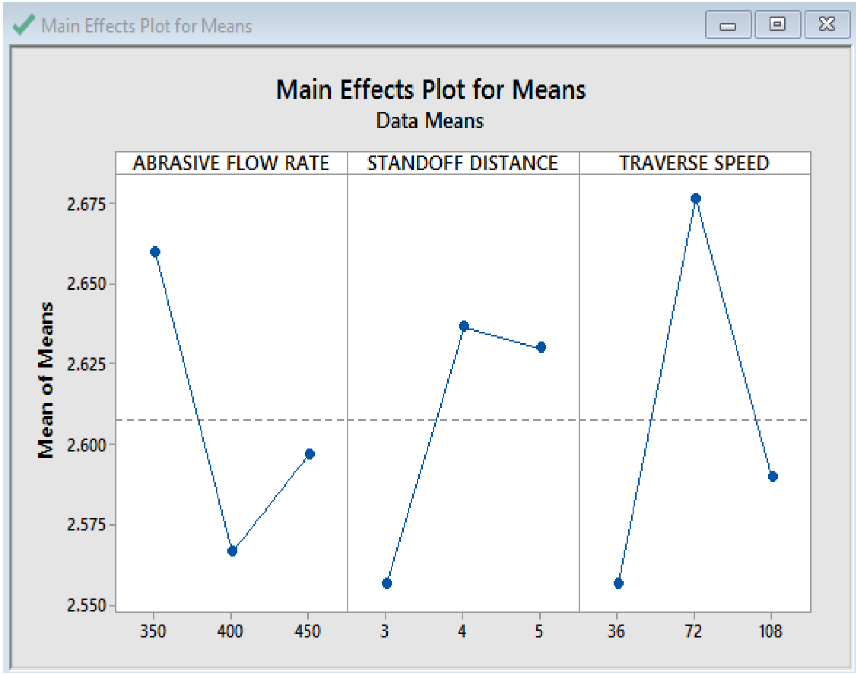

Fig Main Effects for Means

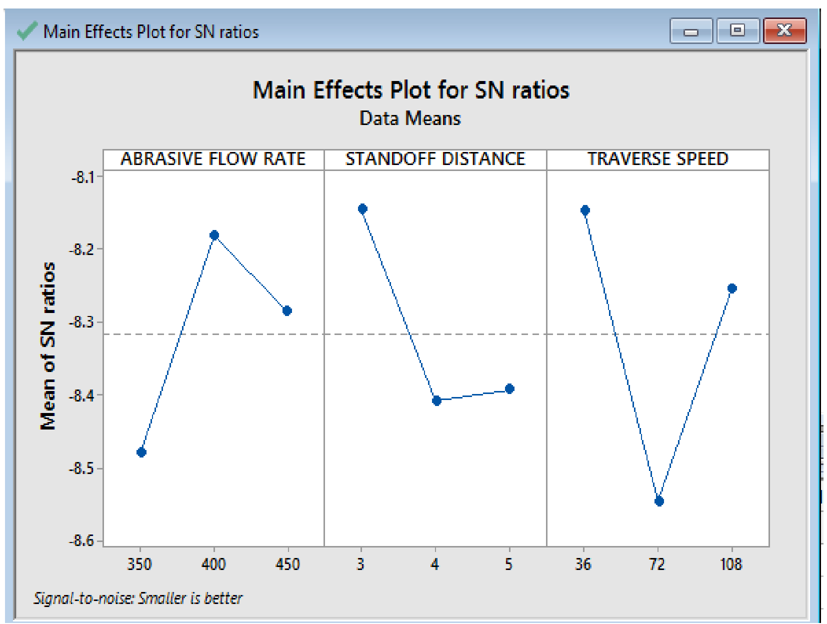

Fig Main Effects for SN ratios

Table 6.5 optimum set of control factors

FACTORS/LEVELS	ABRASIVE FLOW RATE (gm/min)	STAND OFF DISTANCE (mm)	TRAVERSE SPEED (mm//min)
Optimum Value	450	3	108

CONCLUSION

In Abrasive Water Jet Machining (AWJM) the various process parameter will influence the machinability. So that the Optimization of machining parameter is very essential to select the optimum condition. The optimization is achieved by means of taguchi L9 technology from this the optimum parameter to cut the bullet proof glass is selected. The optimal parameters values are abrasive flow rate 450gm/min and standoff distance 3mm and traverse speed 108mm/min .At these parameters the values of MRR and Surface roughness are 869.62gm/min and 2.55µm respectively .it is shown that the performance characteristics of AWJM process. Namely water jet abrasive flow rate and standoff distance and traverse speed are improved together by using Taguchi Grey Relational Analysis.