DESIGN, FABRICATION AND ANALYSIS OF ABRASIVE JET MACHINING

M.Bhanu Sankar[1], Y.Mahesh[2]
[1]IV Mechanical Engineering, [2]Assistant Professor,
Dept.of Mechanical Engineering, R.S.R Engineering College, Kadanuthala, Kavali,

Abstract: Abrasive Jet Machining (AJM) is an unconventional machining process of removal of material from a work piece by the application of a high speed stream of abrasive particles carried in air or gas medium from a nozzle. The material removal process is mainly by Erosion. The AJM will chiefly be used to cut shapes in hard and brittle materials like glass. In this paper some important AJM process parameters and their effects on Metal Removal Rate (MRR) are discussed. Taguchi method was employed to optimize the AJM process parameters.
Keywords: AJM system, MRR, Taguchi method, orthogonal array.

I. INTRODUCTION

Abrasive Jet Machining (AJM) is a non –traditional machining process in which the abrasive particles are mixed with compressed air and directed on the target surface through a nozzle. The particle coming out of the nozzle with very high velocities impinges the target surface and removes the material by erosion. The use of fine abrasives as a projectile is one of the appropriate solutions because smaller particles tend to make the material removal behavior more ductile. Indeed, the size of the particles used in AJM process is much finer. One of the practical applications of the AJM process is suitable of brittle materials, for instance, window glass and mirrors, where the engraved holes provide an optical effect on the surface.

One of its primary uses is as a building material, traditionally as small panes set into window openings in walls. Because glass can be formed or moulded into any shape, as it is a sterile product. Glass is both reflective and refractive of light, and these qualities can be enhanced by cutting and polishing to make optical lenses, prisms and fine glassware. Glass can be coloured by adding metallic salts and also can be painted. These qualities have led to the extensive use of glass in the manufacturing of art objects and particularly in stained glass windows. Silica (the chemical compound SiO_2) is a common fundamental constituent of glass.

1.1 Abrasive Jet Machining Working Principle

Abrasive Jet Machining (AJM) is the removal of material from a work piece by the application of high speed stream of abrasive particles carried in gas medium from a nozzle. The AJM process is different from conventional sand blasting by the way that the abrasive is much finer and the process parameters and cutting action are both carefully regulated. The process is used chiefly to cut intricate shapes in hard and brittle materials which are sensitive to heat and have a tendency to chip easily. This process is also used for drilling, de-burring and cleaning operations. AJM is fundamentally free from chatter and vibration problems due to absence of physical tool. The cutting action is cool because the carrier gas itself serves as a coolant and takes away the heat.

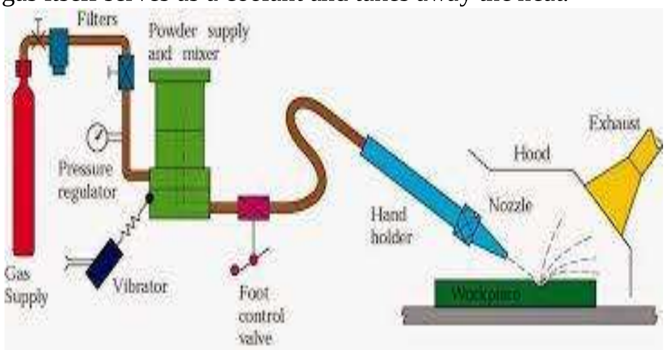

Fig I: Set up of Abrasive Jet Machining

II. LITERATURE REVIEW

Non-Traditional Machining Processes

These processes are non-traditional or unconventional in the sense that do not employ a conventional or traditional tool from removal, instead, they directly utilize some form of energy from mental machining Non-traditional machining processes can be classified into various groups according to the type of fundamental machining they employ namely mechanical, electrical, chemicals, electro-chemical, thermo-electric, etc. The classification of the machining processes, based upon the type of energy used. In the Mechanical methods of non-traditional machining, the material is principally removed by mechanical erosion of the work-piece material. The non-traditional machining processes are

1. Abrasive Jet Machining (AJM)
2. Water Jet Machining (WJM)
3. Ultrasonic Machining (USM)
4. Abrasive Water Jet Machining (AWJM)

B. Process Parameters Affecting the Abrasive Jet Machining

The process can be easily controlled by varying the following parameters:

Pressure

In this Abrasive Jet Machining the increase in pressure increases the Material Removal Rate of work piece and the decrease in the pressure decreases the Material Removal Rate of work piece.

Standoff Distance

Stand off distance is defined as the distance between the face of the nozzle and the working surface of the work piece. A large standoff distance results in flaring up of the jet which leads to poor accuracy.

Nozzle Angle

Nozzle Angle is defined as the varying the different angles of the nozzle and removing of the material from the given work piece. If the nozzle angle is changes the material removal rate is also changed by the work piece.

Nozzle diameter

Nozzle diameter is defined as the different diameters of nozzles are used, if the nozzle diameter is decreases then the material removal rate is increases due to high velocity of flow coming out from the nozzle and if the diameter of nozzle is increases then the material removal rate is decreases.

III. METHODOLOGY

A. Materials

In this project we used glass plate of dimensions 150*50*6 mm as a work material and we determined the metal removal rate of the glass plate according to various process parameters. The various abrasive particles used in AJM are silicon carbide (SiC) grain size of 25,40 microns, Aluminum oxide (Al_2O_3) grain size of 12, 20, 50 microns, Sodium bicarbonate grain size of 27 microns, Sea sand grain size of 0.5mm.

B. Experimental Procedure

The Abrasive Jet Machine is fabricated by using an air compressor, control valve, pressure gauge, air filter, mixing chamber and nozzle. Here we used a 2HP 25Liters air compressor with 8bar to compress the fresh atmospheric air into high pressure air. By using the control valve the air flow coming out from the air compressor output is regulated and with the help of a pressure gauge it also controls the pressure. The unwanted dust and moisture is removed by an air filter. Out of three pipes of mixing chamber inlet pipe is connected to the outlet of air filter and another pipe is used for supplying the abrasive particles and the outlet pipe is connected to the nozzle. The main purpose of mixing chamber is to mix the fresh air with abrasive particles. Finally the mixed particles come out with a high pressure by using a nozzle.

Fig II: Experimental setup of AJM

In this present study, in order to indentify the influence of process parameters with maximum distribution in the AJM for glass Taguchi method and Grey relational analysis along with S/N ratio and their levels are given in table1.Orthogonal arrays are helpful in arranging the control parameters.L-9 series orthogonal array is used for arrange the these parameters as shown in Table II.

Table I: Levels of AJM process parameters

Exp/parameter	**Pressure (Pascal)**	**Nozzle Angle (degrees)**	**Standoff distance (mm)**
Level-1	50	30	60
Level-2	65	60	80
Level-3	80	90	100

Table II: Arrangement of actual parameters of Material Removal Rate in orthogonal L-9 series

Exp/parameter	**Pressure (Pascal)**	**Nozzle angle (degrees)**	**Standoff distance (mm)**	**Material removal rate(mm^3/sec)**
1	50	30	60	0.0341
1	50	60	80	0.0270
1	50	90	100	0.0179
2	65	30	80	0.0180
2	65	60	100	0.0138
2	65	90	60	0.0172
3	80	30	100	0.0193
3	80	60	60	0.0944
3	80	90	80	0.0480

IV. RESULTS & EXPERIMENTAL ANALYSIS

A.Taguchi method

The Taguchi method uses special design of orthogonal arrays to study the the entire parameter space with only a small number of experiments.The greatest advantage this method is the saving of effort in conducting experiments, saving experimental time,reducing the cost, and discovering the significant factors quickly.Taguchi's robust design method is a powerful tool for the design of a high-quality system. In addition to the S/N ratio, a statistical analysis of variance (ANOVA) can be employed to indicate the impact of process parameters on mechanical properties. a)S/N ratio

Taguchi method stresses the importance of studying the response variation using signal-to-noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter. The Metarial Removal Rate (MRR) was considered as the quality characteristic with the concept of "the larger-the-better". The S/N ratio used for this type response is given by [1] and the results are shown in the Table III.

The S/N ratio for the larger-the-better is:

S/N ratio= -10*log(mean square deviation)………[1]

Table III: Analysis of Variance for SN ratios

Source	DF	Seq SS	Adj SS	Adj MS	F-ratio	% of contribute
Pressure (Pascal)	2	82.83	82.83	41.416	4.34	40.86%
Nozzle angle (degrees)	2	25.00	25.00	12.500	1.31	12.33%
Standoff distance (mm)	2	75.75	75.75	37.876	3.97	37.37%
Residual Error	2	19.10	19.10	9.551		9.42%
Total	8	202.68				

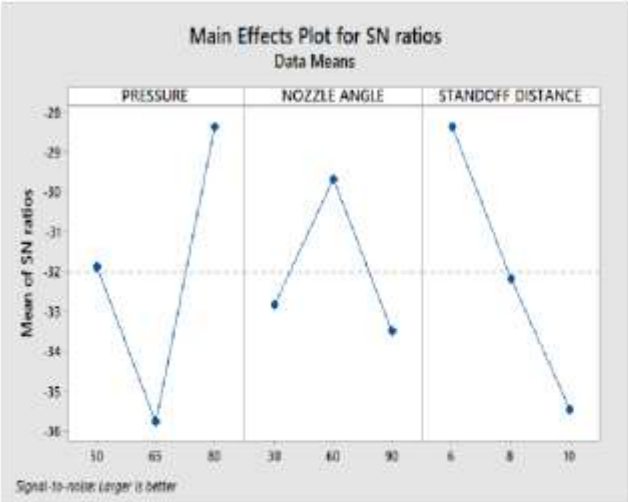

Fig III: Main effects of plot for S/N ratios *b) Confirmation test*

The experimental confirmation test is the final step in verifying the results drawn based on Taguchi's design approach. The optimal conditions are set for the significant factors (the insignificant factors are set at economic levels) and a selected number of experiments are run under specified cutting conditions. The average of the results from the confirmation experiment is compared with the predicted average based on the parameters and levels tested. The confirmation experiment is a crucial step and is highly recommended by Taguchi to verify the experimental results. In this study, a confirmation experiment was conducted by utilizing the levels of the optimal process parameters, (A3B2C1) for Material Removal Rate is 0.0944(mm^3/sec).

V. CONCLUSION

In this investigational experiment we find the optimum parameter setting for material removal rate as tabulated below

Table IV: Optimum parameters of MRR

Mechanical property	Optimum value(m^3/sec)	Pressure (Pascal)	Nozzle angle (degrees)	Standoff distance (mm)
Material Removal Rate	0.0944	80	60	60

The Taguchi method and ANOVA analysis was applied on to the results obtained from testing to determine the most influential process parameters.

- From the Taguchi and ANOVA method we conclude that the pressure is most significant parameter and then follows the standoff distance and nozzle angle
- The contribution of pressure on the Material Removal Rate is 40.86%
- The contribution of standoff distance on the Material Removal Rate is 37.37%
- The contribution of nozzle angle on the Material Removal Rate is 12.33%.

REFERENCES

[1] Matthew w. chastagner and albertj.shihmechanical Engineering "abrasive jet machining for edge generation" Transactions of NAMRI/SME Volume 35, 2007.
[2] Krushnaprasadpradhan, "design and fabrication of abrasive jet machine '' department of mechanical engineering national institute of technology rourkerla2009.
[3] A. El-Domiaty, H. M. AbdEl-Hafez, and M. A. Shaker, "Drilling of Glass Sheets by Abrasive Jet machining" , World Academy of Science, Engineering and Technology 32 2009
[4] K.B. Sehgal"study and optimization of process parameters in abrasive jet machining" ITM University, Sector-23A, Gurgaon-122017, Haryana, India.Vol. 7, 2011.
[5] Alina Oancea1, Lorelei Gherman2, Laurenţiu Slătineanu3 andVasile Braha4, "modified nozzle for abrasivejetengraving"Nonconventional Technologies Review Romania, June, 2012
[6] NPTEL introduction and abrasive jet machining, version2 ME, IIT kharagpur.

