STUDY THE EFFECT OF DIFFERENT ELECTRICAL PARAMETERS ON ELECTRO-ABRASIVE MACHINING

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Abstract— *In the present work, laboratory develop setup was used for carrying out magnetic abrasive finishing. The present setup comprises of various components such as electromagnetic coil, voltage regulator, lathe machine, three jaw chuck. Minitab software is used for design of experiment and for statically analyzing the data. Three parameters such as magnetic flux density, Stand-off distance and voltage etc. with three levels were taken for finishing the mild steel work piece. For proper interaction of the various parameters design of experimentation has been carried out using Taguchi approach. Based on the Design of experiment, experimentation on the basis of various runs as depicted by Taguchi approach has been carried out and surface roughness values with respect to various runs were analyzed using the surface roughness tester (SJ201). For further identification of significant parameters and to determine the optimum parameters on which maximum machining has been carried out, Taguchi analysis was carried out by using larger the better approach. It has been found that Voltage is most significant factor followed by magnetic flux density and Standoff distance. Furthermore, modelling of the process has been carried out by using Regression approach. The equations predicted by the regression approach were further used for predicting the values of surface roughness. Furthermore for validating the statistical result experimentation was conducted and it was found that statistical results are in good agreement with the experimental results.*

Keywords— Magnetic Abrasive; Surface Finish; Taguchi; Regression

1. INTRODUCTION

To improve the quality of surface finish various finishing processes are employed. Degradation of the surface finish leads to a reduction in the service life of the component. Magnetic abrasive finishing (MAF) is one among the various processes which are employed for improvement in surface finish. MAF can be defined as a process in which surface finish takes place by employing the mixture of particles which comprises abrasive particles (Al2O3) and ferrous particles which magnetized due to the presence of magnetic coil towards the work surface and leads to surface finish by the abrasive action of the abrasive particles. Magnetic abrasive finishing is one of the advanced surface finishing processes, which induces high quality of surface finish on the surface. The various parameters which control the effectiveness of this process are machining time; standoff distance of the magnetic coil from the work piece surface. In this process mixture of non-ferromagnetic abrasive and ferromagnetic iron particle is prepared and placed internally inside the work piece which further magnetically energized due to magnetic field produced by the magnetic coil. MAF set up uses electromagnets which induces strong magnetic field in the work piece surface. The work piece is placed in between the two poles of an electromagnet which causes magnetization of the powder particles. There is no direct contact takes place in the whole process which resulted in the less production of heat on the surface of the work piece and retention of the properties in the work piece. A magnetic abrasive finishing process is a nontraditional process that employs magnetic field action and mixed magnetic abrasives [2-5].

In the present work, laboratory developed setup was prepared which comprised of various components such as electromagnetic coil, voltage regulator, lathe machine, three jaw chuck and erodent such as mixture of aluminium oxide and ferrite. Minitab software is used for design of experiment and statically analyzing the data. Three parameters such as magnetic flux density, standoff distance and voltage, etc. with three levels were taken on mild steel workpiece. For the proper interaction of the various parameters Design of Experiment has been carried out by using Taguchi approach. Based on the Design of experiment, experimentation on the basis of various Runs as depicted by the Taguchi approach has been carried out and surface roughness values of the samples with respect to various runs were analyzed by using the surface roughness tester. For further identification of significant parameters and to determine the optimum parameters on which maximum machining has been carried out, Taguchi analysis was carried out by using larger the better approach.

2. EXPERIMENTAL SET-UP

A schematic of experimental set up is shown in figure 1, which embodies the principles of internal finishing. The experimental setup has major components like electromagnet (1K Gauss, 3K Gauss), control unit, A.C. motor, and variable A.C. supply. The main elements of MAF equipment include the electromagnet a constant voltage/current A.C. regulated power supply of output voltage from 0 to 230 V and output current from 0.2 to 0.4 Ampere was used and abrasive powder (sintered Al2O3 + Fe). The cylindrical work piece of mild Steel was held in the lathe machine chuck attached to A.C. motor and abrasives were packed in the pipe and over the one end cap are provided with the help of dead centre to kept the abrasive inside of pipe. Magnetic field was applied to the abrasives by electromagnet. Magnetic field strength is varied for experimentation with the help of variable A.C. supply. Electromagnet plays an important role in present experimentation. The revolution of the work piece is kept constant. The voltage regulator is employed in the setup for regulating the voltage of the set up. The magnetic field strength depends upon weight percentage of the magnetic particles, present in the magnetic abrasive powder. Both the working gap and size of the work piece are taken into consideration, while designing. The objective of the design is to give rotational motion to the cylindrical work piece. The standoff distance between the work piece and electromagnet coil is kept as 10mm, 20mm and 30mm. An AC motor is chosen for providing rotational motion to the work piece. A working view of the setup is shown in the figure 1. Magnetic abrasive particles through magnetic pressure finish the work piece. Al2O3 based sintered magnetic abrasives are used as magnetic abrasives. The Al2O3 based sintered magnetic abrasives have been developed in sintering machine. The process parameters were the gap between work piece and magnet, rotational speed of work piece, magnetic flux density, current, concentration of particles and the work piece gap. The improvement of surface roughness was achieved due to the vibrational motion occurring in the particles effectively removes unevenness in rotational direction and direction orthogonal to it.

Figure 1. Schematic of Magnetic Abrasive Machining

TABLE 1. DIMENSIONS OF ELECTROMAGNET

Parameters	Values
External Diameter of Magnet	50mm
Height of Magnet Pole	22mm
Permissible Current Value	0.1-0.5ampere
Wire Used for Winding	Copper
Permissible Required Voltage	0-240V
Magnetic Field Intensity	0-1.3 Tesla

3. EXPERIMENTAL CONDITIONS

In this work, Al2O3 based sintered magnetic abrasives were used for internal finishing of cylindrical Mild steel pipe. The Alumina (Al2O3) based sintered magnetic abrasives were prepared by blending of Al2O3 (50%) of 300 mesh size (74µm) and iron powders (50%) of 300 mesh size (51.4µm), compacting them by using a Universal Testing Machine (UTM), further mixture was sintered using a sintering set up at 1100°C in H2 gas environment, crushing the compacts into small particles and then sieving to different ranges of sizes. The obtained sizes are 150µm.The dimensions of electromagnet are provided in Table 1. The experimental conditions are shown in table 2, mild steel pipes (Ø34 x80 mm) were used for the experiments as work pieces. In this work, experimental variables such as voltage, magnetic flux density and standoff distance between work piece and electromagnet coil was considered for the study purpose. Effect of various parameters with respect to material removal rate was carried out. The finishing characteristics of magnetic abrasives were analyzed by measuring the surface roughness, which was measured at four points before and after finishing using a Mitutoyo surface roughness tester (SJ-210P) having a least count of 0.001 µm (cut off length = 2.5 cm)and roughness on average scale reading is taken.

TABLE 2. EXPERIMENTAL CONDITIONS OF WORK PIECE

Parameters	Values
Mesh size of Abrasive Particle	50 microns
Current	0.1-0.5 ampere
Compositions of Iron in MAPs	40%-60%
Velocity	1200 rpm
Voltage	150, 180 and 240 V
Magnetic Flux Density	1000, 2000 and 3000 gauss
Finishing Time	15, 30 and 45 minutes
Stand Off Distance	10, 20 and 30 mm
Size of Iron Particles	100 microns
Abrasive Used In MAP	Al_2O_3
Work Pieces	Mild Steel

4. EXPERIMENTATION

In experimentation part firstly setup was prepared having three different coils with different number of turns was prepared which resulted into inducement of different magnetic flux density in the set up. Mild steel work piece was used for experimentation. Work piece consist of cylindrical tube in which mixture of aluminium oxide and iron oxide is placed, measurement of weight reading was carried out using weight balance prior to testing and post testing as to assess the effect of various parameter on the surface finish of work piece. The design of experiment was carried out using Taguchi L9 approach. Run sheet along with post testing results with respect to range of parameters are shown in table 3.

TABLE 3. OBSERVATION SHEET WITH RESPECT TO VARIOUS RUNS FOR MILD STEEL

Run No.	Voltage	Magnetic flux density	Standoff distance	Roughness(µm)
1	240	1000	10	0.780
2	240	2000	20	0.750
3	240	3000	30	0.980
4	180	1000	20	0.86
5	180	2000	30	0.820
6	180	3000	10	0.850
7	150	1000	30	0.950
8	150	2000	10	1.222
9	150	3000	20	1.050

5. RESULTS AND DISCUSSIONS

To assess the effectiveness of various parameters on machining using magnetic abrasive finishing, extensive experimentation was carried out on the basis Taguchi L9 design matrix. Experiments were conducted on the basis of run sheet and the findings of trial runs along with various parameters which influenced the finishing process are discussed below. In this study, the range of parameters such as voltage i.e. 150,180 and 240 Volt, magnetic flux density i.e. 1000,2000 and 3000 gauss, and standoff distance i.e.10mm,20mm and 30mm are taken along with with duration of machining as 10, 30 and 45 minutes were taken for experimentation. It was observed that the improvement in surface finish is more with the medium range of standoff distance and machining time. The improvement in surface finish can be due to more abrasives that come in contact with the work piece during experimentation.

5.1 Effect of Magnetic Flux Density

To establish the feasibility of usage of MAM, the experiments were conducted by selecting the electrical parameters. Range of magnetic flux density has been taken for comparative study i.e. 1000-3000 Gauss. With respect to these MFD, study was carried out to find out the effect of magnetic flux density on to the surface finish improvement of the work piece. So that a relationship will be established which will able to predict the response of surface finish improvements with respect to magnetic flux density. In this study, the three materials named as Mild steel, SS-304 and Brass are taken with duration of machining time as 15-45 minutes was taken for experimentation. It was observed that the improvement in surface finish is more with the medium range of magnetic flux density as shown in Figure 5.1. The improvement in surface finish can be due to more magnetic field which will carried out the machining as it attracts more number of particles towards the wall of cylinder as they interact with internal wall of cylinder and machining of the internal walls of cylinder will be due to the abrasives that come in contact with the work piece as a result of more magnetic force.

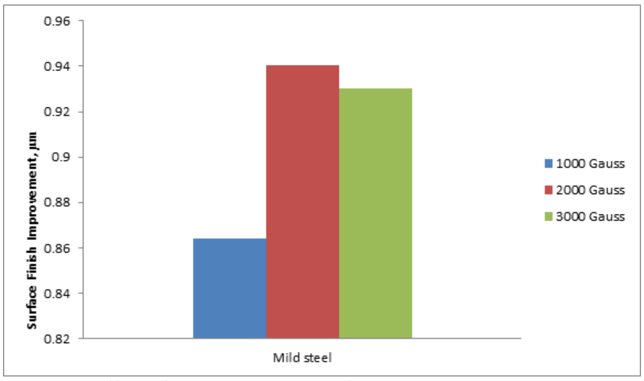

Figure 2. Effect of change in magnetic flux density on Magnetic abrasive machining

5.2 Effect of Voltage

To establish the feasibility of usage of MAM, the experiments were conducted by selecting the electrical parameters. Range of Voltage has been taken for comparative study i.e. 150V, 180V and 240V with respect to these voltages, study was carried out to find out the effect of change in voltage on to the surface finish improvement of the work piece. So that a relationship will be established which will able to predict the response of surface finish improvements with respect to voltage. For variation in voltage different transformer has been used. It was observed that the improvement in surface finish is more with the minimum range of voltage i.e.150V as shown in figure 5.2. The improvement in surface finish can be due to more magnetic field which will carried out the machining as it attracts more number of particles towards the wall of cylinder as they interact with internal wall of cylinder and machining of the internal walls of cylinder will be due to the abrasives that come in contact with the work piece as a result of more magnetic force.

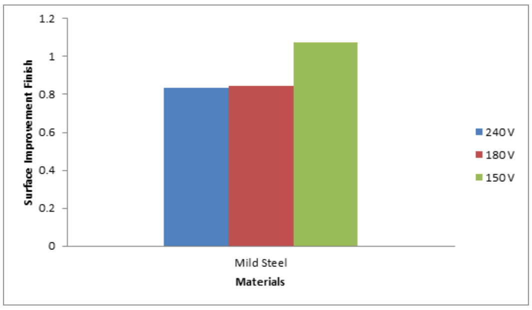

Figure 3. Effect of Voltage on Surface roughness improvement

5.3 Effect of Standoff Distance

To establish the feasibility of usage of standoff distance on MAM, the experiments were conducted by selecting the electrical parameters. Range of standoff distance has been taken for comparative study i.e. 10mm, 20mm and 30mm. With respect to these standoff distances, study was carried out to find out the effect of change in on to the surface finish improvement of the work piece. So that a relationship will be established which will able to predict the response of surface finish improvements with respect to standoff distance. In this study, the material named as Mild steel is taken with duration of machining time as 15-45 minutes was taken for experimentation. It was observed that the standoff distance is significant factor which affects the performance of magnetic abrasive finishing process.

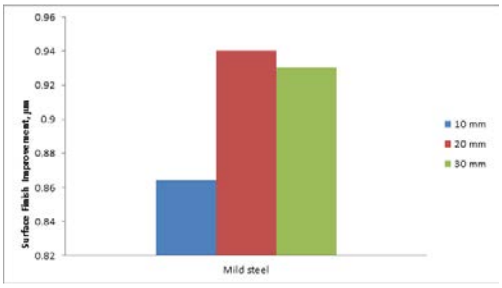

Figure 4. Effect of Standoff distance on surface finish of the work piece

It has been noticed that in case of SS-304 at 30mm standoff distance improvement in surface finish is more in comparison to other standoff distances. In case of brass maximum improvement in surface finish has observed with 20mm standoff distance, followed by 30mm and 10mm.The improvement in surface finish can be due to more magnetic field which will carried out the machining as it attracts more number of particles towards the wall of cylinder as they interact with internal wall of cylinder and machining of the internal walls of cylinder will be due to the abrasives that come in contact with the work piece as a result of more magnetic force.

5.4 Main Effect Plot for Mild Steel

Figure 5.4 shows the main effect plot of the various parameters on the machining of Mild steel. These effect plots tell us about the effect of parameters on the results. It has been observed from the figure that with increase in voltage S/N ratio decreases. It was observed that lowest voltage is best parameter for carrying out the analysis as shown in the figure. In case of Magnetic flux density, it has been observed that surface improvement increases with increase in magnetic flux density up to a critical value.

After that value again, it started to decreases with further increase in magnetic flux value. In case of Standoff distance similar results has been observed up to a critical value surface improvement has been taken place after that value it started to decrease. So, from all these observations we can determine the optimum parameters for the machining so that maximum improvement in case of Mild steel takes place.

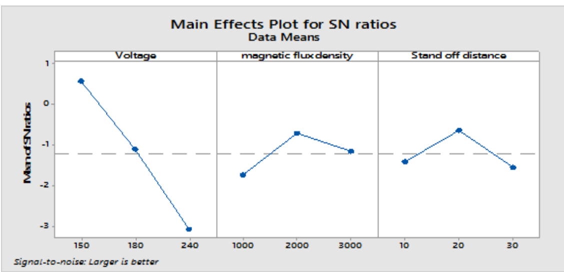

Figure 5. Main effect plots for Mild Steel

5.5 Regression Analysis: Mild Steel versus Voltage, Flux Density, Standoff Distance

In order to identify the significant parameters for Mild-steel substrate, an ANOVA analysis was carried out. Table 4. indicates the static 'F' values obtained through ANOVA along with corresponding variable percentage contributions of each factor on machining of mild steel. It can be revealed from the table that for mild steel, the voltage factor has the larger value of static 'F', followed by magnetic flux density and Standoff density of the magnets.

TABLE 4. ANOVA RESULTS OF MILD STEEL

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	3	20.1771	6.7257	4.74	0.063
Voltage	1	19.6569	19.6569	13.85	0.014
Magnetic flux density	1	0.4916	0.4916	0.35	0.582
Standoff distance	1	0.0287	0.0287	0.02	0.893
Error	5	7.0986	1.4197		
Total	**8**	**27.2757**			

Regression Equation for Mild steel is predicted and the results obtained from those equations were compared with the experimental results and it was found that the obtained result was in line with the results obtained by experimentation. Regression equations for mild steel cases are well defined below:

Mild Steel = 1.445 - 0.00322 *Voltage + 0.000048*flux density - 0.00170 *Stand Off Distance

TABLE 5. ANOVA SUMMARY SHEET

S	R-sq	R-sq(adj)	R-sq(pred)
0.114964	93.14%	89.02%	74.40

To verify the relevance of equation ANOVA summary sheet of the equation result was prepared as shown in table 5. The value of R-sq verified the fact that equation will predict good results.

6. CONCLUSIONS

The present work is done set up to check the effect of electrical parameters (magnetic flux density, current and voltage) on abrasive machining process on cylindrical work pieces by taking different input parameters and then the results are taken. It is found that all the electrical parameters have significant effect on outputs considered in the present study. Finally, an attempt has been made to estimate the optimum values of voltage, current and magnetic flux density on different machining conditions to produce the best possible output within the experimental constraints.

- From these studies it was found that magnetic flux density around 2000gauss give a significant fine improvement in surface finish with magnetic abrasive machining.
- It was also found that voltage around 150 Volt with a 1200 rpm found to give a significant improvement in surface finish.
- It has been found that with the increase in number of turns in a electromagnetic coil magnetic flux density also increases as a result of which maximum material removal rate will be occurring.
- An effort has been made out to find out the best electrical as well as mechanical parameters for electromagnetic abrasive machining with respect to various machining

Parameters so that maximum surface finishing can be achieved.

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