ISSN No:-2456-2165

Effect of Chemically Prepared Diamond Based Abrasives on Magnetic Abrasive Finishing of Brass Pipes

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***Abstract*:-Magnetic abrasive finishing (MAF) is a polishing/finishing technique used primarily to achieve higher levels of surface finish. The process is widely used for finishing of very hard and brittle nonmagnetic materials. It utilizes magnetic force and ferromagnetic abrasive particles for finishing of work piece. Ferromagnetic particles are conglomerate of abrasives and iron particles. In MAF set up used in present work, the work piece to be finished internally is kept between two poles of a magnet. The magnetic abrasive particles are placed inside the stainless steel tube to be polished/ finished. The magnetic abrasive particles join each other forming a magnetic abrasive flexible brush in the work piece due to the force applied by the magnetic poles. This brush behaves like a multi-point cutting tool for the finishing operation. The work piece was a non-magnetic brass tube. The magnetic abrasive particles used in present work were prepared chemically of iron and diamond particles. The input parameters which were considered for the study include rotational speed of poles, working gap, MAP size, quantity of abrasive particles. The range of parameters had been decided by preliminary experimentation and literature review. The effect of MAF parameters have been studied on Percentage Improvement in Surface Finish. The working gap, MAP size and interaction of rotational speed & MAP size have shown predominant effect on the percent improvement in surface finish. Then the SEM analysis of the finished work pieces was done which indicates that the tool marks are completely removed by the MAF process. The maximum PISF (69) was obtained at gap = 3 mm, speed = 575rpm, MAP size = 163µm and weight = 6gm.**

Keywords:-magnetic abrasive finishing; diamond particles; etc.

I. INTRODUCTION

There are some materials used in high technology industries which are difficult to finish by conventional machining and polishing techniques with high accuracy and minimal surface defects, such as micro cracks, geometrical errors and distortions on the work surfaces. To solve this problem some new machining methods were developed which are known as ‘Unconventional machining methods'. These were so called so as they do not use conventional edges tools for machining. One such method of machining called ‘Magnetic abrasive machining' (MAF) was developed to overcome difficulties of machining.

Magnetic abrasive finishing (MAF) is a relatively new super finishing technique used primarily to obtain nanometers level of surface finish especially on the non ferrous and hard materials like stainless steel, aluminium and ceramics. Magnetic abrasive finishing (MAF) is one such alternate process for improving the surface finish on complicated profiles at a reasonably low cost.

II. METHDOLOGY

MAF is a newly developed machining technology. In the MAF process, a cutting tool that consists of ferrous particles and non-ferrous abrasives under oil lubricant has flexibility. Due to this flexibility, the tool can remove a very small amount of materials from a work piece and then a better surface can be produced after polishing the work piece without damages on the surface. Nevertheless, it is very difficult to polish non-ferrous materials off using the MAP process because this process is fundamentally through the help of magnetic forces.

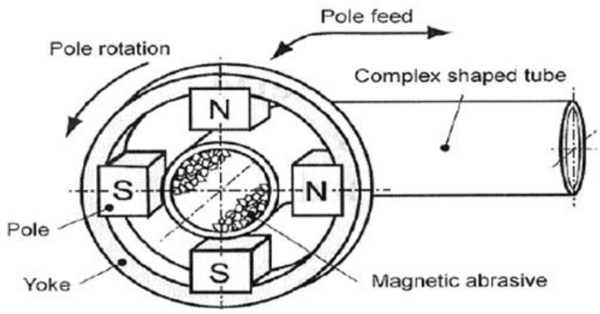

Fig 1: Working Principle of MAF Process

Fig. 1, below shows the principle of magnetic abrasive finishing process. A magnetic force is generated between the inductor and work- piece. The magnetic force aligns magnetic abrasive particles from the inductor to the work piece along lines of magnetic force, thus it forms a flexible magnetic abrasive brush. The brush rotates in accordance with the inductor, presses down the work piece and then removes the surface material little by little. Fine surfaces like a mirror are easily obtained under this process.

A. *CONTROLLING FACTORS IN MAF*

1. Gap b/w magnets and work piece (flux density)
2. Grit Size (Abrasives)
3. Quantity and Type of Lubricant
4. Machining time

5. Rotational speed
6. Material and Size of work piece
7. Vibration Frequency
8. Vibration Amplitude
9. Percentage of iron in magnetic abrasive

B. ABRASIVES

An abrasive is a material, often a mineral that is used to shape or finish a work piece through rubbing which leads to part of the work piece being worn away.
Common uses of abrasives include grinding, polishing, buffing, cutting, drilling, sharpening and abrasive machining.

Abrasive particles are of two types:-

1. Natural abrasives

2. Artificial abrasives

III. EXPERIMENTATION

The present study is experimental in nature. The experimental method of research is undoubtedly the most widely used method in mechanical engineering.

The present study has been conducted in the following steps:-

1. Collection of raw materials.

2. Preparation of magnetic abrasives.

3. Preparation of work pieces for experimentation.

4. Experimentation of magnetic abrasive finishing set up.

5. Comparison of work pieces.

A. COLLECTION OF RAW MATERIALS

Magnetic abrasive needed in the present study are prepared by using iron powder and Diamond Powder. Iron particles are attracted by the magnet and diamond powder act as abrasive the finishing capability of magnetic abrasive Powder depends upon the size of abrasive particles. The size of iron powder is 300 mesh and the size of diamond powder is 100 -300 mesh.

B. PREPARATION OF MAGNETIC ABRASIVE

Preparation of magnetic abrasive by chemical method

Chemically Magnetic abrasives were prepared in following steps:

a. Mixing of iron powder and diamond powder abrasives.

b. Preparation of mixed powder compacts.

c. Preparation of magnetic abrasives by crushing of chemically prepared Compacts.

d. Sieving of crushed powder.

A. MIXING OF POWDER:

The magnetic abrasives must be able to be magnetized (Fe) and have the ability of finishing (diamond powder). So, Iron powder (mesh number-300) and diamond powder(mesh number100-300) were mixed mechanically in the ratio 3:7 by weight. Blend this mixture properly in a container.

B. PREPARATION OF COMPACTS:

After blending add favorite bonding tubes by properly mixing with each other in abrasive mixture. Then blend this whole things properly that the mixture soaks the bonding glue. Take this mixture a day for drying properly .A large compact is formed.

C. PREPARATION OF ABRASIVE WITH CHEMICAL METHOD:

In first step take 30% iron and then take diamond powder 70 % for making chemical abrasive Blend this mixture properly in a container. After blending add fevitite bonding tubes by properly mixing with each other in abrasive mixture. Then blend these whole things properly that the mixture soaks the bonding glue. Take this mixture a day for drying properly. A large compact is formed then crush the compact in fine powder form as we required for magnetic abrasive with help of press or hand blender

D. CRUSHING AND SIEVING OF COMPACTS:

The large compacts were crushed mechanically into desired size with help of press or hand blender. Then the powdered abrasives were separated by sieves to get a single abrasive size by using sieve set for experimentation. The size of abrasives used in this study is 150 mesh.

E. PREPARATION OF WORK PIECES FOR EXPERIMENTION

Brass pipe is selected as a material of work piece for experimentation. The diameter of pipe is 30mm and its thickness is 2mm. Specimens are prepared by cutting pieces from pipe of size 2m length. The specimens are machined by turning process to get uniform roughness for MAF experimentation.

F. MAF SET UP:

The experimental setup for finishing of Brass tube using MAF process consists of 4 permanent cylindrical magnets mounted on a stainless steel chuck which serves two purposes one as a carrier and other as an insulator to separate them. The magnets can move up and down so as to machine different sizes and at variable gap between the work piece and the face of the magnet. This magnetic chuck can be rotated at the desired speed with a belt drive where in a DC motor is used to vary the rpm of the chuck.

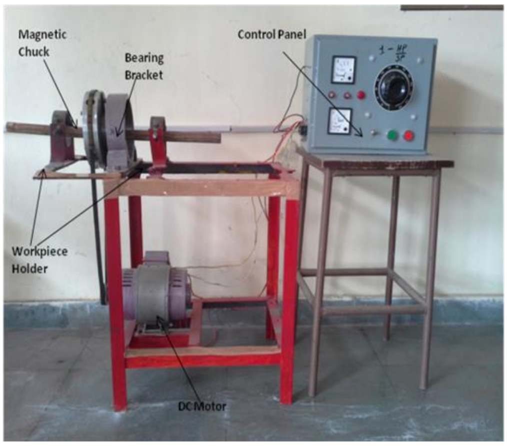

Fig. 2:- MAFset up

Fig. 3:- Magnetic chuck and work piece

G. *EXPERIMENTAL PROCEDURE*

To evaluate the performance of the developed set up following procedure was adopted. Brasstubes were prepared for the experimentation by turning their inner surface to get uniform roughness. Then the initial surface roughness values that are the R_a values of work pieces were measured. The work piece is clamped in the stainless steel chuck in the centre of the magnetic poles. The constant gap b/w the poles and the work piece has been maintained for experimentation. The sintered magnetic abrasive powder, which is prepared just before each test by adding the lubricant, was placed inside the brass tube mounted in the magnetic chuck. Same procedure is used for chemical magnetic abrasive the rotational motion to the magnets was given through the motor. The finishing operation was continued for 120 minutes and monitored with a stop watch (0.01s accuracy) after which the work piece was removed from the chuck. After cleaning the specimen with ethanol, its surface finished was measured using a Mitutoyo surface roughness tester having a least count of 0.001µm (cut off length = 0.8mm).

Magnetic abrasive powder introduced in the work piece surface join each other to form a flexible magnetic abrasive brush. The abrasive particles of the flexible magnetic abrasive brush shear off the peaks of the irregularities on the surface of work piece being finished thereby improving its surface finish. To hold abrasives in the finish zone for a longer time period, lubricating oil (5% of wt.) is added to the MAPS. The process was repeated with different parameters with both types of abrasives.

H. *SELECTION OF VARIABLES*

Selection of the independent variables is mainly governed by the findings from the literature and the earlier experimentation as discussed below.

I. *PERCENTAGE OF ABRASIVE (DIAMOND POWDER) IN MAGNETIC ABRASIVES:*

Abrasive act as a cutting tool in the finishing process . As the percentage of abrasive increase in the magnetic abrasive the force of brush decreases. 30% abrasive are taken for experimentation as this percentage has shown highest PISF during preliminary experimentation.

Ex. No.	%age of abrasive	Speed in r.p.m	Grit Size µm	Gap in mm	Qty. of mag. abrasive in gm	PISF (%)
1	10	500	163	4	5	62.20
2	20	550	163	4	5	78.25
3	30	600	163	4	5	80.70
4	40	650	163	4	5	66.65

Table 3.1 Preliminary Results Of Percentage Of Magnetic Abrasives

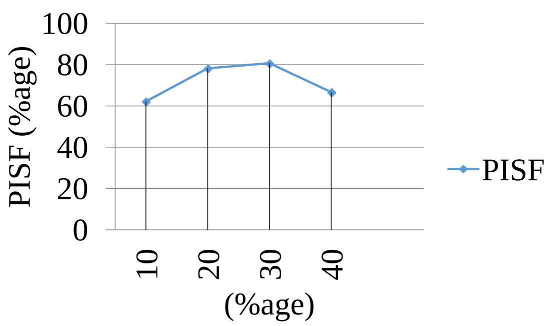

Fig. 4:- Effect of % age of abrasive on PISF

J. *ROTATIONAL SPEED:*

As per literature material removal increases with work piece rotational speed and after some value of speed jumbling of abrasives starts which decreases surface finish. In the present study five levels of Rotational speed of magnetic poles ranging from 350 to 650 rpm were selected. Figure 5 shows that PISF increases up to 300 rpm and then starts decreasing.

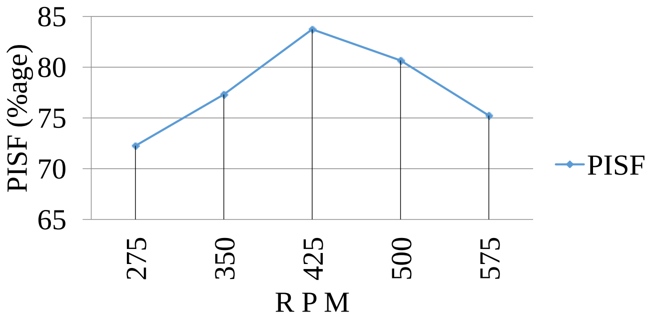

Fig. 5:- Effect of Rotational speed of magnetic poles on PISF

K. MACHINING TIME:

Fig. 6 shows that PISF increases for first 2hrs and these after decreases slightly. So machining time of 2hrs is selected for experimentation.

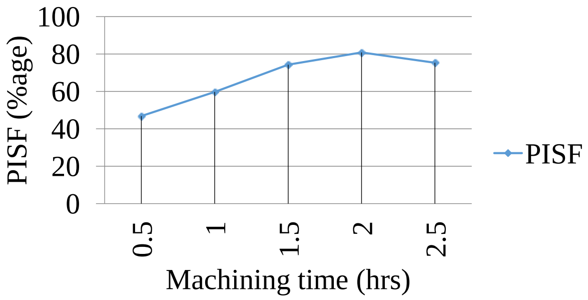

Fig. 6:- Effect of Machining time on PISF

M. SIZE OF MAGNETIC ABRASIVES:

Different researches varied size of magnetic abrasive from 50 µm – 600 µm . Figure 7 shows that PISF increase up to 165 µm grit size and then decrease so grit size 163 um is selected for present experimentation.

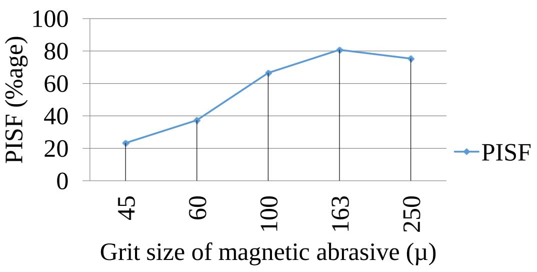

Fig. 7 :- Effect of grit size of magnetic abrasive on PISF

L. GAP BETWEEN WORK PIECE AND MAGNETIC POLES:

The gap between the work piece and magnetic poles determines the force acting on the abrasiveparticles, which generates finishing pressure on the work piece surface during MAF. In preliminary experimentation gap is varied in the range of 2mm to 6mm. PISF is maximum at 3mm gap and hence it selected for experimentation.

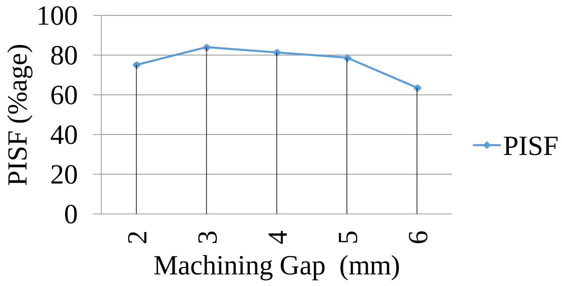

Fig. 8:- Effect of Machining Gap on PISF

O. 6 PERCENTAGE IMPROVEMENT IN SURFACE FINISH:

Percentage improvement in surface finish is calculated to evaluate the performance of magnetic abrasive in MAF process PISF is given by

PISF (%age) = [(ISR– FSR) x 100]/ISR

ISR= Initial surface Roughness

FSR=Final surface roughness

IV. EXPERIMENTATION AND RESULTS

Taking into consideration the result of preliminary experimentation and range of factors on the design setup, different experiments are performed for final experimentation. the quantity of abrasives used is 4 to 10 gm and the rotational speed of magnetic poles is varied from 350 to 650 rpm.gap between the poles and work pieces is fixed at 3mm.Different experiments were performed to study the performance of magnetic abrasives prepared by chemical method. Table 5.1 shows the effect of varying the rotational speed on PISF by using 4gm of abrasive for experimentation. All other factor are fixed as shown below.

The result plotted in the form of graph to get clear picture of the effect of rotational speed of the magnetic poles on the surface finish of the work piece. The rotational speed is plotted along horizontal axis and PISF is plotted along vertical axis as shown in figure 5.1. Figure shows that PISF increases as we increase the rotational speed of poles, but PISF decreases after 575 rpm.

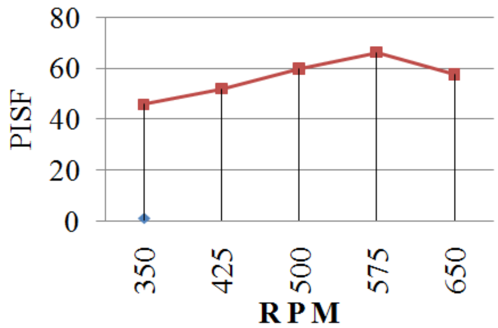

Fig. 9:- Effect of Rotational Speed of Magnetic Poles on PISF with 4g of magnetic abrasive

The result plotted in the form of graph. as shown in figure 10 figure shows that PISF in case of sintered magnetic abrasive is higher as compared to magnetic abrasives prepared by chemical method. Similar trend is seen in both cases as first there is increase in PISF and then it decreases but values are different for both cases. In case of sintered magnetic abrasives PISF increases up to 425 rpm and then start decreasing. In case of magnetic abrasives prepared by chemical method PISF increases up to 575 rpm and then decreases.

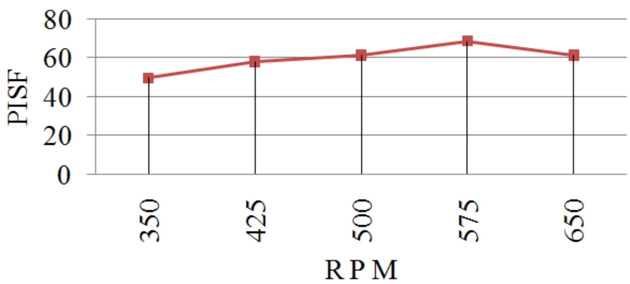

Fig.10 :- Effect of Rotational Speed of Magnetic Poles on PISF with 6g of magnetic abrasive

The result is plotted in the form of graph as shown in figure 11. In case of sintered magnetic abrasive PISF increase up to 500 rpm and maximum value is reached at this value after this the PISF starts decreasing. In case of sintered magnetic abrasive PISF increase up to 425 rpm and then starts decreasing.

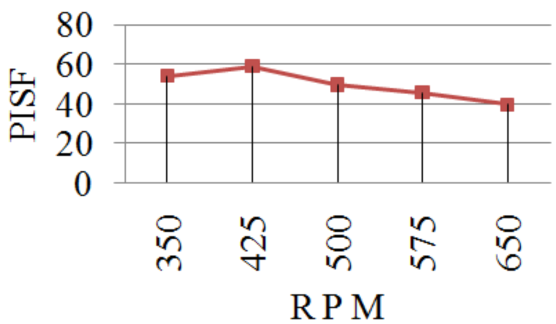

Fig. 11:- Effect of Rotational Speed of Magnetic Poles on PISF with 8g of magnetic abrasive.

A. SCANNING ELECTRON MICROSCOPE

A scanning electron microscope (SEM) is a type of electron microscope that images a sample by scanning it with a beam of electron in a raster scan pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample's surface topography, composition, and other properties such as electron conductivity. The ace one or two condenser lenses to a spot about 0.4 nm to 5 nm in diameter. The beam passes through pairs of scanning coils or pairs of deflector plates in the electron column, typically in the final lens, which deflect the beam in the *x* and *y* axes so that it scans in a raster fashion over a rectangular area of the sample surface. The scanning electron microscope (SEM) uses a focused beam of high-energy electrons to generate a variety of signals at the surface of solid specimens. The signals that derive from electron-sample interaction reveal information about the sample including external morphology (texture), chemical composition, and crystalline structure and orientation of materials making up the sample. In most applications a 2-dimensional image is generated that displays spatial variations in these properties. The surface roughness alone does not reflect the behavior of abrasive cutting edges.Therefore, the scanning electron microscope images of the magnetic abrasive finished workpiece were taken to provide in depth comparison of the surfaces generated before and after magnetic abrasive finishing.All the samples to be subjected to magnetic abrasive finishing were prefinished by the turningoperation.Work piece for SEM analysis were prepared by cutting them into size 10x10 mm by using high speed steel blade.SEM micrographs of the workpiece surface before and after the magnetic abrasive finishing are shown in the Figure 12-13. The observations reveal that the scratches and the grinding marks were completely removed by magnetic abrasive finishing. Therefore, we conclude that MAF is capable of finishing Brass tube.The initial surface profile has periodic peaks and valleys generated by turning.Most of the peaks have been sheared off to a much smaller height resulting in improved surface finish.

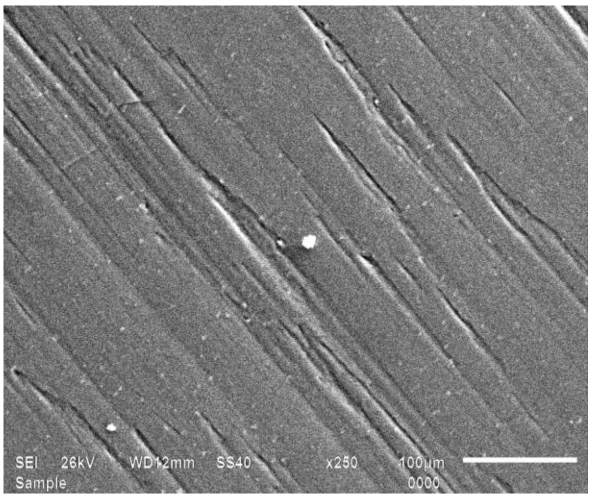

Fig. 12:- Surface before finishing

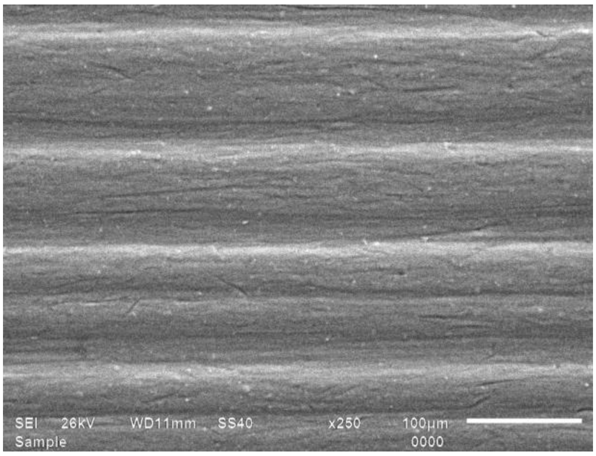

Fig. 13:- surface after finishing with chemical method

Figure 12 shows SEM photographs of a work piece surface before finishing and Figure 13 after finishing with chemical abrasives. These Figures reveals that the finished surface was quite smother than before, indicating that the magnetic abrasive finishing process improves the surface roughness of Work piece. The best surface finish obtained by MAF with abrasive prepared by chemical method is 0.65 µm of R_a

B. THE SURFACE TESTER RESULTS

Mitutoyo surface roughness tester (SJ-210P) having a least count of 0.001µm (cut off length = 0.8 mm) was used to study the effect of different abrasive finishing on work piece and to view the profile after magnetic abrasive finishing. The surface generated by turning consists of deep scratches as shown in the figure 14. The result of the surface produced after the magnetic abrasive finishing is shown in figure 15. This profile indicates that the peaks and valleys are reduced to greater extent leading to acquire a surface finish to a value of 0.65 µm of R_a in chemical magnetic abrasive.

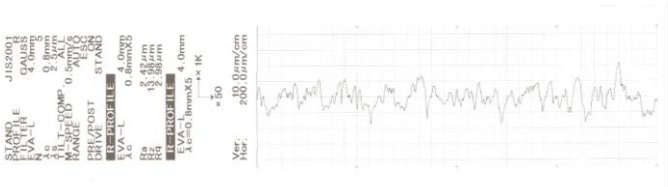

Fig. 14 :- Surface report before finishing

Fig. 15 :- Surface report after finishing with chemical abrasive

V. CONCLUSION

After carrying out the machining on Brass tubes with MAF process by using magnetic abrasive prepared by chemical method, conclusion that came out are that the abrasives influence the percentage improvement in magnetic abrasive.

The result of this research can be summarized as follows

- In case of chemical magnetic abrasive process yield best result at 575rpm and 6gabrasive was used PISF value 69 %
- PISF increase as we increase rotational speed of magnetic poles and then start decreasing slightly.

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