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Study on Magnetic Abrasive Finishing of Brass Rods Using SiC-Based Abrasives

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Abstract - Magnetic Abrasive Finishing (MAF) process is one of the advanced machining processes for finishing non-ferrous materials, in which the cutting force is controlled by input current to the magnetic coils. MAF set-up was designed and mounted on the lathe machine for finishing CuZn37 brass rods. Effect of different process parameters (current, rotational speed and percentage composition of abrasives) is evaluated by using Taguchi experimental design and further the most critical parameter for finishing CuZn37 is determined by using MINITAB software. The results along with observations are discussed in detail in the present study. Based upon the results, circumferential speed of the workpiece is very useful parameter in improving the surface roughness. The change in surface roughness increases by increasing circumferential speed in magnetic abrasive finishing process.

I.INTRODUCTION

There has been a rapid growth in the development of harder and difficult-to-machine metals and alloys during the last two decades. Traditional surface edged tool machining is uneconomical for materials and the degree of accuracy and surface finish attainable. The advancing strength level would have a catastrophic effect on the total machining technology. In view of the seriousness of this problem, Merchant (1960) emphasized the need for the development of newer concepts in metal machining. By adopting a unified programme and utilizing the results of basic and applied research, it has now possible to process some of the materials which were formerly considered to be unmachinable under normal conditions. The newer machining processes, so developed, are often called non-conventional machining processes. [1]

Hence it becomes essential to provide new unconventional technologies which when applied fairly meet the demand of modern industries. These manufacturing processes may be used to cut hard materials that cannot be cut easily, may employ method to give a special effect, and are so new that their impact on manufacturing process is unclear. Magnetic abrasive finishing (MAF) is one such advanced machining process in which cutting force is primarily controlled by the magnetic field. [2] This process can be used to produce efficiently good surface quality of the order of few nanometer finishes on flat surfaces as well as internal and external surfaces of tube type workpieces. In MAF, the cutting forces can be controlled by the input current to the magnetic coils. [3] In the present work, a new apparatus has been designed and manufactured which is capable of finishing the outer as well as inner surfaces of cylindrical rods or tubes respectively.

II.LITERATURE REVIEW

Magnetic abrasive finishing process was originated in U.S in the 1930's. University research in the Soviet Union, Germany, Bulgaria, and US began in the 1960's with practical usage appearing by the 1980's and 1990's. The growth of the semiconductor and aerospace industries have resulted in the continued development of better methods for attaining high form accuracy and surface integrity. Shinmura et al., 1990 studied the basic principle of the MAF process and confirmed experimentally in a model test that magnetic abrasive particles are subjected to the pressure, which is enough to finish the work surface. Fox et al., 1994 demonstrated finishing of non-magnetic rollers using both bonded and unbonded magnetic abrasives. Jain et al., 2001 studied the process principle and the f nishing characteristics of loosely bonded magnetic abrasive within cylindrical magnetic abrasive f nishing. Chang et al., 2002 studied that the Unbounded magnetic abrasive (UMA) could be employed in place of the sintered magnetic abrasive.

2.1 Design of test rig

In magnetic abrasive finishing process, a test rig was designed and used as an attachment and mounted on precision lathe. Fig.1 shows a schematic diagram of external magnetic abrasive finishing process and Fig.2 shows of actual set-up used during experimentation of external magnetic abrasive finishing process.

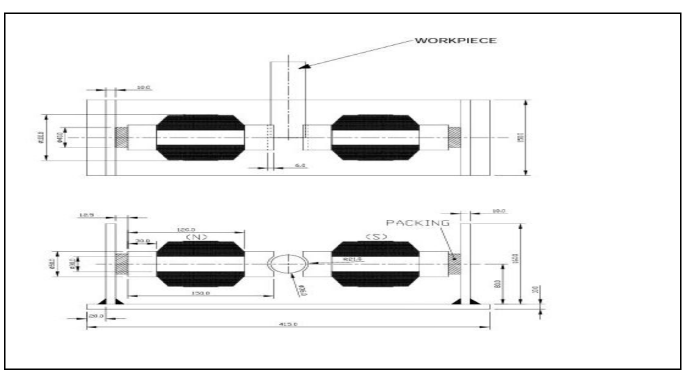

Fig. 1 Schematic diagram of external magnetic abrasive finishing process

The apparatus consists of a D.C Power supply by potentiometer-bridge, Frame, Electromagnet. An electromagnet was used for generation of magnetic flux density. Magnetic coil was designed to generate magnetic flux density of 1.2 Tesla (Approx). The N-S poles of the magnetic coil were kept at 180° to each other. Mild steel with high relative magnetic permeability was used as both magnetic core and poles material.

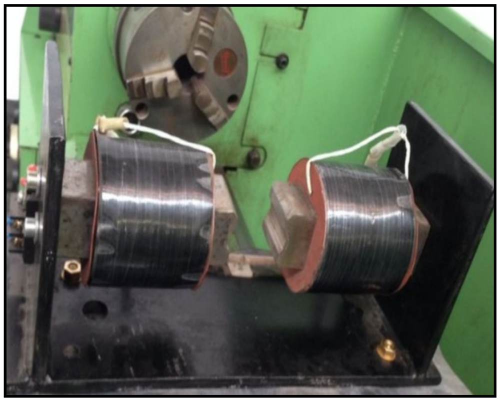

Fig. 2 Photograph of actual set-up used during experimentation of external magnetic abrasive finishing process.

2.2 Experimentation

Before experimentation, surface finish of the cylindrical workpiece (CuZu37) was measured. The working gap was 8mm kept constant and filled with a homogeneous mechanical mixture of silicon carbide (grit size 90) abrasive particles and ferromagnetic iron (grit size 200) particles in the different ratios by weight. The current to the electromagnets was put on. The magnetic field strength in the working zone could be varied by changing input current. The magnetic field strength also depended upon weight percentage of the magnetic particles, present in the magnetic abrasive powder. Surface finish was measured by using a stylus contact type of the surface roughness tester (SJ-301, Mitutoyo) after the completion of experiments.

2.3 Experimental conditions

Effect of different process parameters (Current, Rotational speed of workpiece, Working gap between workpiece & stationary magnetic poles, Finishing time, percentage of iron, Type of abrasives) during Magnetic abrasive finishing of nonferrous CuZn37(Brass) cylindrical workpiece roughness are studied. The variable parameters and fixed parameters used during magnetic abrasive finishing process are listed below in table 1 and table 2:

TABLE 1 VARIABLE PARAMETERS FOR MAGNETIC ABRASIVE FINISHING

PARAMETER	RANGE OF VALUES
Speed (rpm)	180-450
Current (ampere)	2-4
Percent composition of iron in MAP's	55 % - 75 %

TABLE 2 FIXED PARAMETERS FOR MAGNETIC ABRASIVE FINISHING

Working gap (mm)	Finishing time (sec)	Magnetic abrasives (grit size)	Workpiece
8	300	Fe (200)+ SiC (90)	CuZn37

III. RESULTS AND DISCUSSION

Effects of different process parameters (Coil current, circumferential speed, percentage composition) on percent improvement in surface finish (ΔRa) were studied. ΔRa value was always found to be positive hence surface finish was improved in all cases.

Effect of coil current on percent improvement in surface finish*:* Fig. 3 shows that, the percent improvement in surface finish at different coil currents. The trends of the curve were different for different coil current. It was observed that surface finish improves with increase in coil current because of the fact that higher coil current to electromagnet generates more number of lines of magnetic flux and strength of the magnetic brush with workpiece increases with increase in coil current.

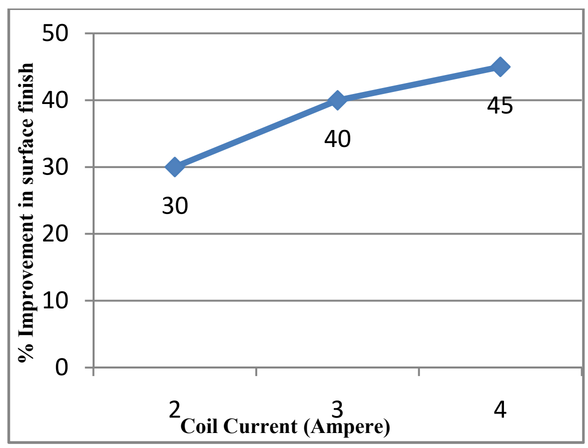

Fig. 3 Effect of coil current on percentage in surface finish

Effect of Circumferential speed on percent improvement in surface finish*:* Fig. 4 shows that, percent improvement in surface finish (ΔRa) starts increasing with the increasing in circumferential speed of the workpiece. Because when the circumferential speed of the workpiece increases, the cutting velocity also increases and larger number of cutting edges takes part in finishing, which results in more improvement in surface finish.

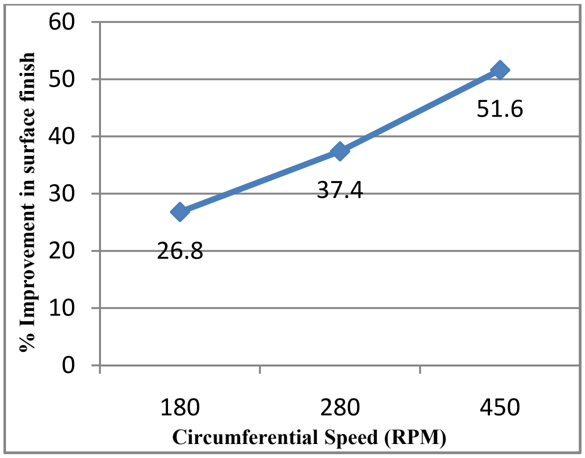

Fig. 4 Effect of Circumferential speed (RPM) on percentage in surface finish.

Effect of composition of Fe-SiC on percent improvement in surface finish*:* Fig. 5 shows that, the percent improvement in surface finish at different composition of Fe-SiC (55-45%, 65-35%, and 75-35%). The trends of the curve were different for different composition. Because in the mixture of magnetic-abrasive particles, when the percentage of magnetic particles increases, the magnetization power also increases. This magnetization power makes better contact between the rotating workpiece and abrasive particles (SiC) which results better surface finish of the workpiece.

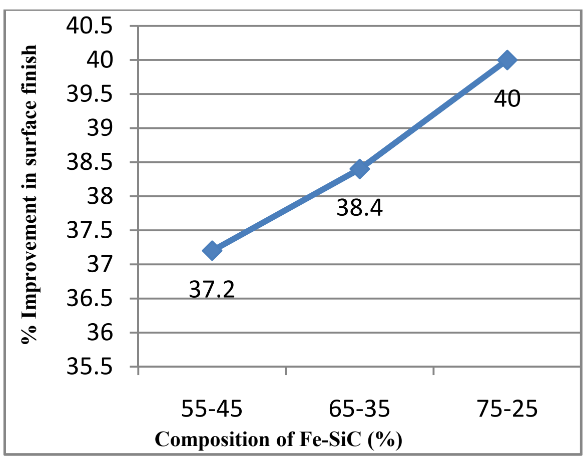

Fig. 5 Effect of composition of Fe-SiC on percent improvement in surface finish.

IV. CONCLUSION

In the present study, magnetic abrasive finishing setup is designed. The performance of the setup is also studied and evaluated.

I. The percentage improvement in surface finish linearly increases with increase in percentage composition of Fe-Sic.
II. The circumferential speed of the workpiece is the most important parameter which significantly influences the material removal and percentage improvement in surface finish.

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