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Optimization of Magnetic Abrasive Finishing Parameters during finishing of Brass Tube

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Abstract- The Magnetic Abrasive Finishing (MAF) processes are emerging as one of the most suitable techniques for obtaining quality finish in which deep cutting marks left by conventional finishing processes like Grinding, Honing, Lapping, etc have been removed and replaced by a new surface texture. In this research, Al_2O_3 based sintered magnetic abrasives have been prepared in sintering machine with iron powder (80% by volume) of 300 mesh size and the abrasive is (20% by volume) of 300 mesh size. A cylindrical work pieces of Brass was finished using magnetic abrasive finishing process on developed apparatus for carrying out testing work. The experiments performed on Brass tubes examine the effects of different parameters like quantity of magnetic abrasives (5gm, 10gm and 15gm), speed of rotation of workpiece (200rpm, 400rpm and 600rpm), abrasive mesh size (120, 180 and 220), machine time (20 min, 50 min and 80 min) and workpiece gap (2mm, 4mm and 6mm). The optimum process parameters are 15gm quantity of magnetic abrasive, 220 mesh size (grit size 53μm) of abrasive particles, 4mm gap in between workpiece and magnetic poles, 600 rpm of workpiece rotation, and 80 min of machining time for finishing of brass tubes.

Keywords: Abrasive Flow Machining, Alumina Powder, Brass, Magnetic Abrasive Finishing

1. Introduction

The conventional finishing processes like Lapping, Honing, Grinding, etc are not good enough to produce parts of high surface finish which is required in industries like Aeronautics, optical electronics, medical instruments, nuclear reactors, etc. MAF is used to produce efficiently good surface quality on flat surfaces as well as internal and external surface of tube type workpieces. Magnetic abrasive finishing has been able to give good surface and edge finishing by means of a magnetic abrasive brush formed in a magnetic field. Small magnetic abrasives acts as cutting tool and when relative motion is given to the workpiece, these magnetic abrasives gets compressed against the surface to be finished and wear out the material in the form of very small chips [1].

Shinmura et al. [1] explored basic principle of MAF process and carried out experiments on finishing of SS41 work piece by using magnetic abrasive particles (average size:150 µm) made by mixing alumina of mean diameter 5 µm and iron sintered in vacuum sintering furnace at very high temperature and high pressure for about 1.5 hour, thereafter, crushing and dressing. After preparing magnetic abrasives by this technique and used for magnetic finishing machine, approximately 40 percent improvement in surface finish was obtained. Aizawa et al. [2] carried out study on the internal finishing of non-ferromagnetic tubing by magnetically assisted abrasive finishing process. Experiments were performed on stainless steel sanitary tubes and magnetic abrasives made by chemical reaction of aluminium oxide and iron powder were utilized. And surface finish obtained in their study was upto 48%. The effect of amount of lubrication used in MAP is studied and it is found that an optimum amount of lubricant affects the abrasive contact against the surface to be finished and results in better surface finish and form accuracy [3]. Khairy et al. [4] investigated the effectiveness and validity of a magnetic abrasive finishing (MAF) to refine rough surfaces and sharp edges of silver steel bars. The magneto-abrasive particles were produced by blending alumina and iron powders, compacting in a furnace at temperature 1400ºC and inert medium for 1 hour time period, crushing into smaller particles and sieving to different range of sizes. He found that process is capable of producing extremely high surface finish upto 52%. The surface smoothening, texture and layers are superior to similar finishing candidates such as honing, lapping abrasion by fine abrasive grits bonded to coarser particles of iron cement, this is distinguished as the main mechanism of MAF finishing.

J. E. Fernandez et al. [5] studied the abrasive wear on Ni based coated alloy using the full factorial based design is done. The statistical model was design to investigate effect of various factors on abrasive wear. It was concluded that abrasive grain size has the greatest effect.

Kaur A. [6] performed the magnetic abrasive finishing process using a simple conventional type of adhesive bonded magnetic abrasives made from aluminum oxide as abrasive component and iron as ferromagnetic component. The maximum improvement in surface finish obtained was 36%.

From the literature survey it was observed that MAF process parameters (Quantity of magnetic abrasives, Speed of rotation of workpiece, Abrasive grit size, Machine time, Workpiece gap and Magnetic Flux Density) effects the surface finish and workpiece metal removal rate.

2. Preparation of Magnetic Abrasives

In order to prepare the magnetic abrasives, iron powder/ Iron fillings (80% by volume) of 300 mesh size and the abrasive is Aluminium Oxide (20% by volume) of 300 mesh size are mixed manually and then sintering of mixture is carried out in a sintering machine at 1100°C temperature. The sintered magnetic abrasives were crushed into small particles by the small compacts and then sieving to different ranges of sizes in vibrating sieve apparatus (fig 1). The obtained mesh sizes are 120, 180, and 220 (grit sizes 106, 75 and 53 μm).

Table 1: Parameters of sintering for preparing magnetic abrasives

Parameter	Description
Powders	Aluminium oxide (20% by volume) Iron (80% by volume)
Sintering Temperature	1100ºC
Sintering time	50 min

Fig. 1: Photograph of vibrating sieve setup

3. Experimental setup and Test conditions

Fig.2 shows the photograph of the experimental setup used for internal MAF. Magnetic abrasives were packed inside the tube and the permanents magnets applied magnetic field. Two permanents magnets generated the magnetic field. The working gap between the workpiece and permanents magnets can be varied based on the outer diameter of the workpiece.

Fig. 2: Photograph of internal MAF setup

Table 2 lists the conditions used in MAF. The inner surface of brass tube was cleaned thoroughly with acetone before and after polishing. The finishing characteristics of magnetic abrasive powder was analysed by measuring the surface roughness (Ra). The Ra value was obtained using Mitutoyo surface roughness tester. The surface roughness tester can be inserted into the tube to measuring the changes in surface finish. The Ra value was measured at three points along the length of tube and mean value of Ra is calculated by minitab software.

Table 2: MAF experimental conditions

Workpiece	Commercially available Brass tube of 38 mm outer diameter and 2 mm thickness.
Magnetic abrasives	Al_2O_3 based sintered magnetic abrasives (20% Aluminium oxide and 80% iron by volume)
Variable Parameters	
Quantity of magnetic abrasives	5 gm, 10 gm and 15 gm
Abrasive grain size	120,180 and 220 mesh sizes (grit sizes 106, 75 and 53 μm)
Workpiece rotation speed	200 rpm, 400 rpm and 600 rpm

Machining time	20 min, 50 min and 80 min
Pole-workpiece gap	2mm, 4mm and 6mm

4. Results and Discussions

During the test some effective parameters like quantity of magnetic abrasives, speed of rotation of workpiece, abrasive sieve size, machine time and workpiece gap have been varied and their effect on surface roughness has been studied.

Fig 3 shows the effect of quantity of magnetic abrasives on Mean of Means of surface roughness. Graph plotted by utilizing the surface roughness results obtained by variation of Quantity of magnetic abrasives 5 to 15mm, Abrasive grain size 120 to 220 mesh size, gap between workpiece and pole 2 to 6mm, workpiece rotation speed 200 to 600 rpm, machining time 20 to 80 minutes.

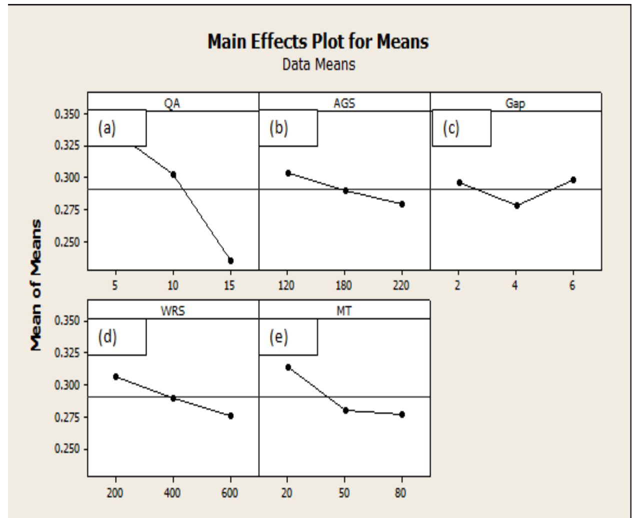

Fig. 3: shows the effect of various parameters on Mean of Means surface roughness

It is clear that there is decrease in surface roughness with the increase of quantity of magnetic abrasives. It means surface finish is improved by increase of magnetic abrasive particles quantity. It is clear that there is constant decrease in surface roughness with the increase in abrasive grit size. It is also clear that there is decrease in surface roughness form level 1 to level 2 and than sudden increase in surface roughness from level 2 to level 3 with increase in gap between the workpiece and magnetic poles. Form the figure; It is notice that there is constant decrease in surface roughness with the increase in workpiece rotation speed. It is also notice that there is constant decrease in surface roughness from level 1 to level 2 and than almost negligible effect from level 2 to level 3 on surface roughness with the increase in machining time.

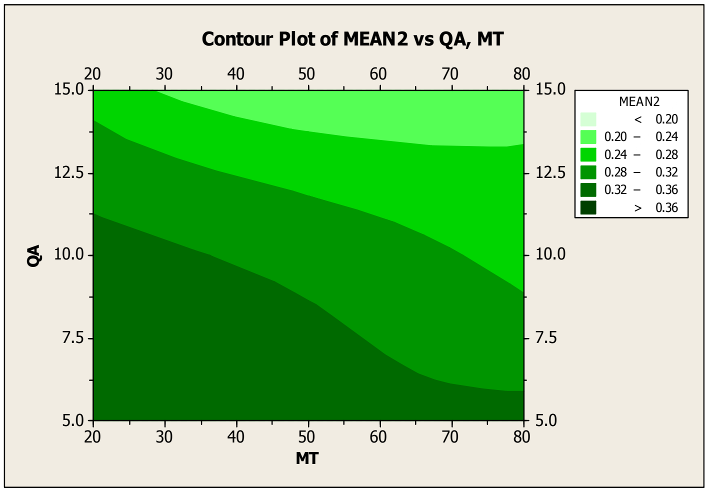

Fig. 4: Contour Graph between machining time and quantity of abrasives on surface roughness

The Figure 4 shows contour graph between machining time and quantity of magnetic abrasives on surface roughness of brass tube. It is clear that the Mean of surface roughness of brass tube increases with the increase in quantity of magnetic abrasive which is shown as dark green colour. Surface roughness of brass tube decreases by increasing the machining time at same point by increasing the quantity of magnetic abrasives.

The Figure 5 shows contour graph between workpiece rotation speed and abrasive grit size on surface roughness of brass tube. It is clear that the Mean of surface roughness of brass tube is maximum between 120-150 mesh size with the increase in abrasive mesh size which is shown as dark green colour. Surface roughness of brass tube decreases by increasing the workpiece rotation speed at same point by increasing the abrasive mesh size

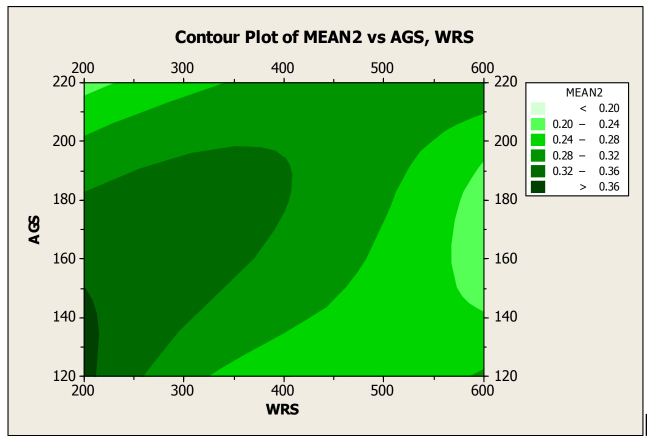

Fig. 5: Contour Graph between workpiece rotation speed and abrasive grit size on surface roughness

The Figure 6 shows contour graph between of gap in workpiece and pole and quantity of magnetic abrasives on surface roughness of brass tube. It is clear that the Mean of surface roughness of brass tube decreases with the increase in quantity of magnetic abrasives which is shown as light green color. Surface roughness of brass tube decreases by increasing the gap between workpiece and pole at same point by increasing the quantity of magnetic abrasives.

The Figure 7 shows contour graph between abrasive grit size and quantity of magnetic abrasives on surface roughness of brass tube. It is clear that the Mean of surface roughness of brass tube decreases with the increase in quantity of magnetic abrasives which is shown as light green color. Surface roughness of brass tube decreases by increasing the abrasive grit size at same point by increasing the quantity of magnetic abrasives.

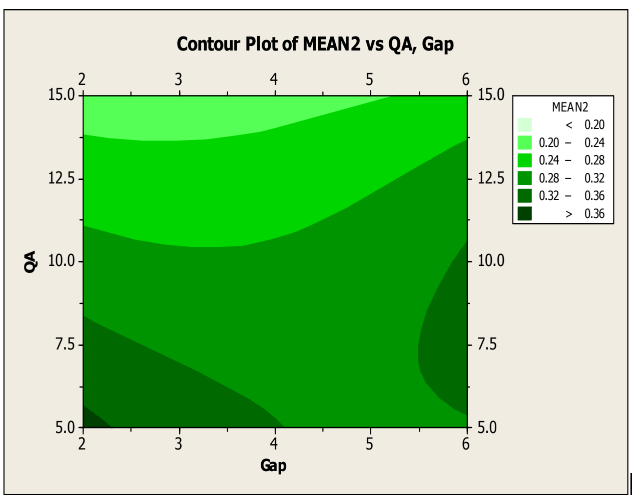

Fig. 6: Contour Graph between gap in workpiece and pole and quantity of abrasives on surface roughness

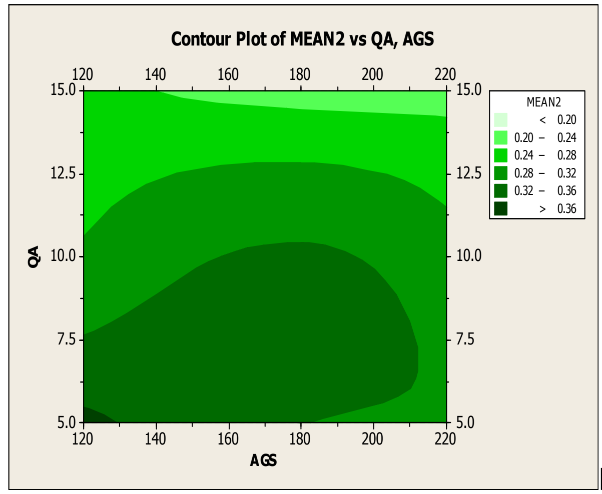

Fig 7: Contour Graph between abrasive grit size and quantity of abrasives on surface roughness

5 Conclusions

1. It is noted that the minimum value of Surface Roughness (SR) is 0.15µm, which is obtained at 15gm quantity of magnetic abrasive, 180 mesh size of abrasive particles, 2mm gap in between workpiece and magnetic poles, 600 rpm of workpiece rotation, and 50 min of machining time.

2. The pooled version of ANOVA for surface roughness indicates that quantity of magnetic abrasives and machining time are significant parameters affecting surface roughness.

3. The optimum processes parameters are 15gm quantity of magnetic abrasive, 220 mesh size of

abrasive particles, 4mm gap in between workpiece and magnetic poles, 600 rpm of workpiece rotation, and 80 min of machining time for finishing of brass tubes.

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