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Experimental Investigation and Preparation of Electromagnets and Their Effect on Surface Roughness in Abrasive Flow Machining Process

Sachin Dhull[1], R S Walia[2], Q Murtaza[3]
[1,2,3]*(Mechanical Department, Delhi Technological University, India)*

Abstract: Abrasive Flow Machining (AFM) is a nano-level finishing process of internal passages using the flow of abrasive laden polymer media with the help of extrusion pressure. In the paper, the preparation steps of electromagnets is studied and different roughness graphs are plotted and studied in details. The effect of number of turns and the effect of magnetic field is studied on abrasive flow machining. In addition, the various applications of the process are studied in details.
Keywords: AFM, optimization, variants

1. Introduction to Abrasive Flow Machining Process

Abrasive flow machining (AFM) is a process of fine finishing in which media is flown past the internal surface of job through high pressure.

1.1. Principle of Operation

The process principle is based on pressurized abrasion of the surface. AFM is basically finishing process of internal passages and the required pressure is obtained by extrusion with the help of two cylinder piston arrangements on both sides of the job.

1.2. Applications of AFM: Spherical Electrode, Micro Tool, Die and Mould Surface, Carbide End Mill, Die Cavity, Bevel Gear, etc

In this paper, a new method, which combines one pulse electrical discharge machining technology with electrochemical etching to fabricate micro spherical electrodes is present. results show that applied voltage of 6 V, discharge duration of 60 s and peak current of 3 A are preferred for micro pin of about 20 [1].With the spherical electrodes fabricated by OPED, three microholes with no taper and three micro hemispherical cavities were fabricated by EMM process. The two-stage magnetic polishing of curved surface was analyzed and experimented using the types of magnetic polishing tool devised in mini CNC milling machine and obtained following results. 1. Three-dimensional die and mold surface polishing is possible using magnetic polishing tools which has flexibility of following the complex surface profile [2]. The polishing pressure can be estimated by equivalent magnetic circuit and, thus, can be changed to the desirable value by changing the working-gap. Machining of large diameter cutting tools restrains the inprocess reshaping of the magnetic abrasive tool. Compared to machining the cutting edge in obtuse angle, by operation of magnetic abrasive along the cutting edge smoother rounding surface results [3].Well shaped cutting edges (Fig. 38) can be processed by Magnetfinish technology using the process knowledge as given. The proposed method can realize the unitary polishing of the pierced die cavity. The polishing effect at the plane surface of the pierced die cavity is good, but the polishing effect at the corner surface is not satisfied [4].The magnetic induction intensity at the pierced die cavity corner increased along with the radius of the corner, and the surface roughness obviously improves with the increase of the radius of the corner. It is suggested that the radius of the corner should be designed as large as possible. The abrasives in the UAAFM processs cratch the asperity peaks of the workpiece surface at a higher velocity than in the AFM in the corresponding machining conditions. The simulation studies confirm significant changes in the medium behavior in the UAAFM process with reference to the classical AFM in terms of velocity and pressure profiles [5]. The additional ultrasonic vibration causes the abrasives to interact with the workpiece asperities to an angular shift 'θ'.

2. Different Steps of Preparation of Electromagnetic Solenoids used for Enhancing Material Removal in AFM Process and Set Up

A lot of problems were encountered while preparing solenoids. The electromagnet was prepared on different machines and the number of copper turns played a major role in magnetic field generation. It includes following sreps. The fixing of wooden frame over the soft iron core, as shown in fig.1. The wrapping of copper wire over the soft iron core over the machine showing the no.of turns is shown in fig.2.

Fig.1. Drilling operation

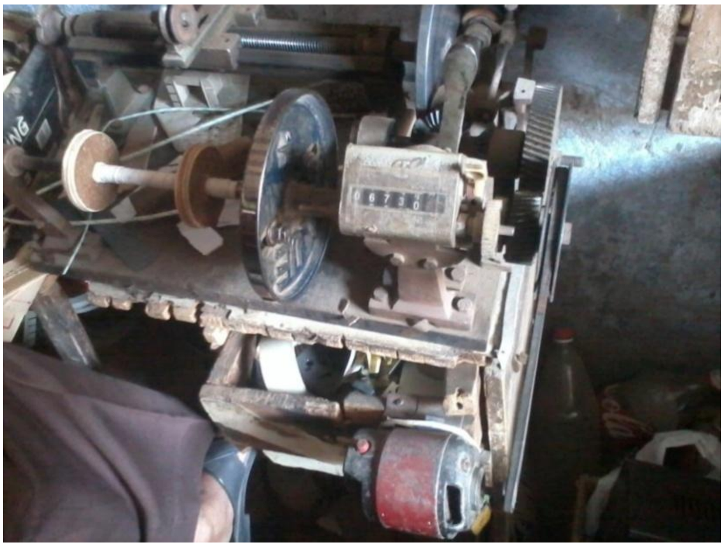


Fig. 2. Machine showing the number of turns

2.1. Initial readings on the machine and calculation of number of turns:
27 gauge copper wire electromagnet: No. of turns= 6720
25 gauge copper wire electromagnet: No. of turns= 5800

2.1.1. Electromagnet pole:
Length of pole over which copper winding is done = 8 cm
Average number of turns on one layer= 128
Total number of layers= 26
1st layer: 8 turns made with the 1 foot(30 cm) length of copper wire, i.e. 0.2667 turns per cm
2nd layer: 8 turns/ foot, i.e. 0.2667 turns per cm
3rd layer: 7 turns/foot, i.e. 0.233 turns per cm
4th layer: 5.5 turns/foot, i.e. 0.1833 turns per cm
and so on
26th layer: 4 turns/2feet, i.e. 0.0667 turns per cm

2.1.2. Total no. of turns= no. of layers × no. of turns
= 26 × 128 = 3328 turns
Length of wire used in each layer: (Total of no. of turns/ turns per cm)
1st layer : 128/0.2667= 479 cm
2nd layer: 128/0.2667= 479 cm
3rd layer: 128/0.233= 549 cm
4th layer: 128/0.1833= 698 cm
and so on
26th layer: 128/0.0667= 1919 cm
Total length of copper wire= 305.75 m.
Gauge specification of wire= 25 gauge
Voltage and Current Readings:
The electromagnet showed 200V at 250 mA and 260V at 500mA
Copper wire resistivity= 1.7 micro-ohm cm

2.2. Magnetic and electrical calculation of electromagnetic solenoid and experimental set up
Step-down transformer 12012, denoting 12V, 0,12V, 5408- 4 diodes used to build bridge rectifier, having filter capacitor (2200µF, 50V). Voltage regulator 7812 I.C. having 3 pins, 1st pin is input 24V, 2nd pin is ground, 3rd pin is output 12V Capacitors of 470µF, 25V, 555 I.C. (It needs 12V, othervise it will burn). Copper wire Gauge = 21, No. of layers = 21, No. of turns in each layer = 54. Voltage/ Magnetic field sensor, Capacitor of 1000µF, 25V, Voltage regulator 7805, 05 denotes 5V output. Three ceramic capacitors of 104 pico farad, Capacitors of 470µF, 16V. The AFM set up is shown in fig.3. The electromagnetic fixture is shown in fig.4.

Fig.3. Working set-up, AC (220V) to DC (24V) transformer with 4 diodes: 3 for 3 electromagnet poles and 1 for electrolytic circuit

Fig.4. Electrolytic fixture showing spring-loaded rotating contact for anode

2.3 Workpiece preparation:

Brass workpiece have been used in this research work for determination of Material Removal and Percentage improvement in surface Roughness. The workpiece taken is of outside diameter of 10 mm and length of 16 mm.

Problems while preparation of workpieces:

Fig.5. Preparation of job on lathe

Fig.6. Drilling operation on lathe machine

Workpiece is prepared by first of all drilling of 7 mm drill bit and after that 1mm diameter is removed by the boring operation so that there will be clear boring tool mark, which is our aim to remove by finishing operation. The workpiece has internal diameter of 8 mm.

3. Surface Roughness Calculation

The abrasive flow machining was done on brass workpieces, initial weight and roughness and final was measured and the material removal and roughness improvement was analysed. Measurement involved assigning quantitative values to the parameters of weight and surface roughness of all the 130 pieces procured as explained earlier. The measurements will be later used for the sampling process. Surface roughness, often shortened to roughness, is a component of surface texture. It is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth. Fig. 7 to 11 represents profile curve, R and W motifs, Rk, distance and step height measurements respectively.

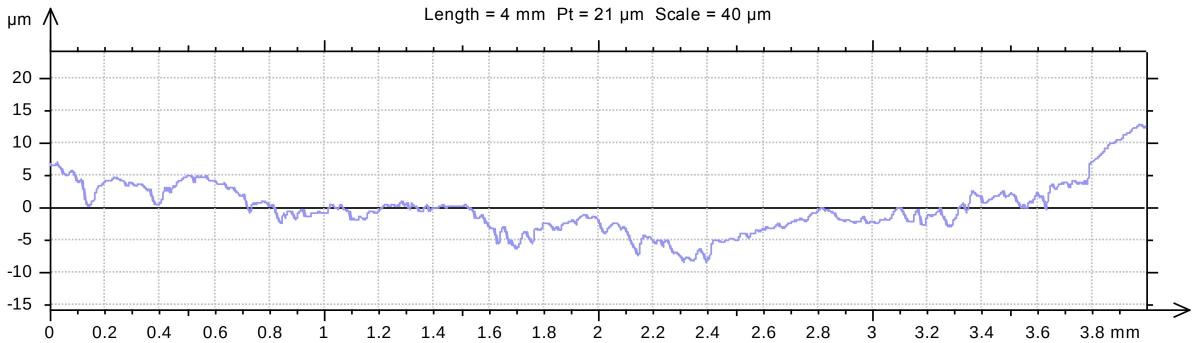


Fig.7. Profile curve

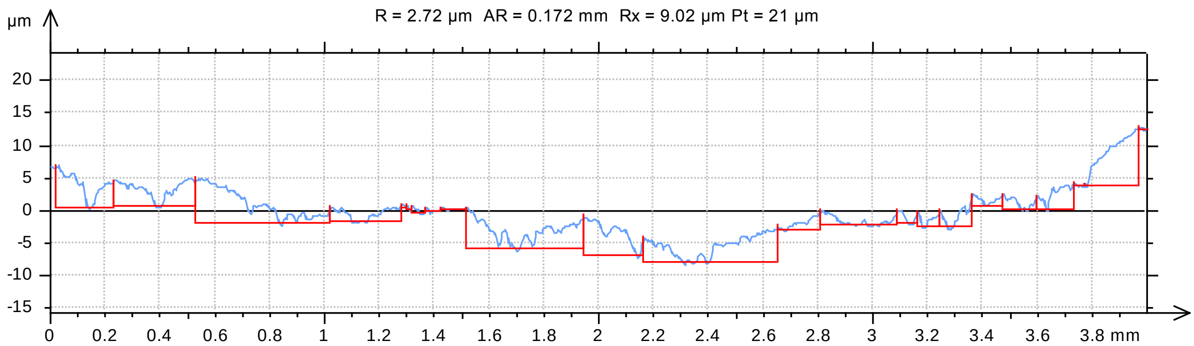


Fig.8. R and W motifs

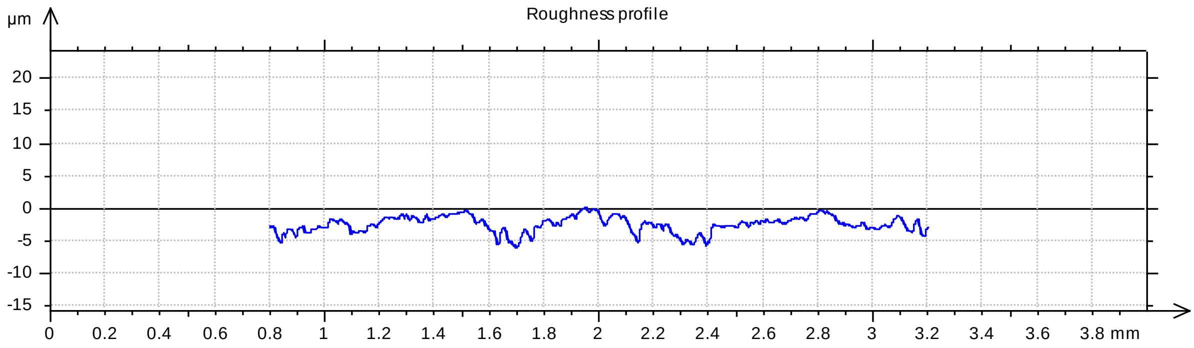
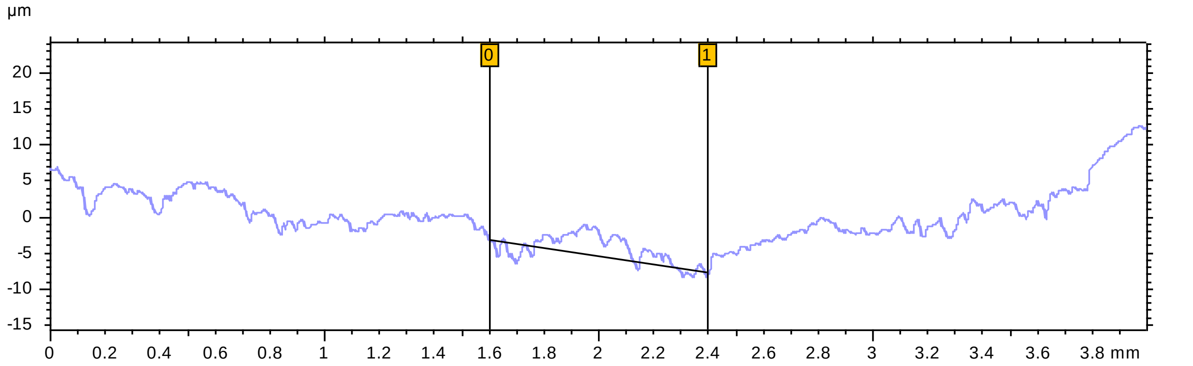
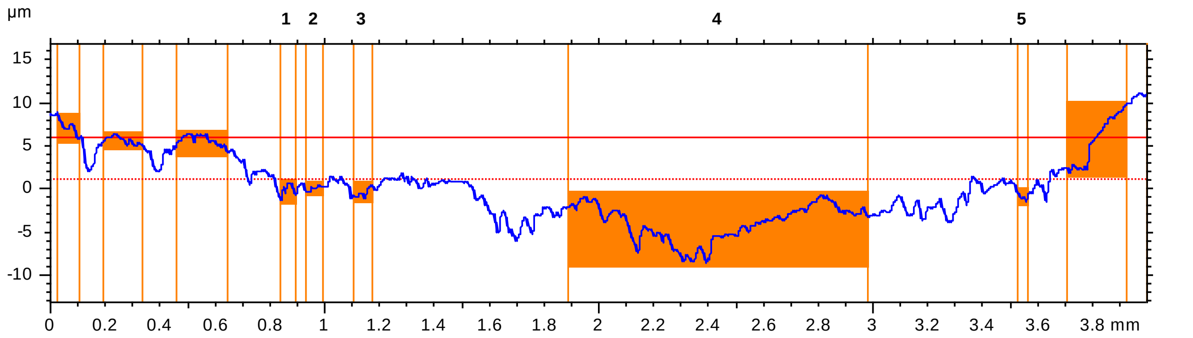


Fig.9. Rk calculation profiles



	0-1
Horizontal distance :	0.8 mm
Variation in height :	-4.67 µm

Fig.10. Distance measurement



	1	2	3	4	5
Maximum depth	7.27 µm	6.34 µm	6.98 µm	14.5 µm	7.39 µm
Mean depth	5.9 µm	5.85 µm	6.39 µm	9.88 µm	6.93 µm
Width	0.055 mm	0.058 mm	0.0735 mm	1.09 mm	0.036 mm

Fig.11. Step height measurement

Roughness is typically considered to be the high-frequency, short-wavelength component of a measured surface (see surface metrology). However, in practice it is often necessary to know both the amplitude and frequency to ensure that a surface is fit for a purpose. Roughness plays an important role in determining how a real object will interact with its environment. Rough surfaces usually wear more quickly and have higher friction coefficients than smooth surfaces (see tribology). Decreasing the roughness of a surface will usually increase its manufacturing costs. This often results in a trade-off between the manufacturing cost of a component and its performance in application.

4. Taguchi Analysis: Surface Roughness versus Pressure, No. of Cycles, Abrasive Media

The Taguchi analysis was applied for optimizing results and the output results and graphs are shown below. In case of mean value of roughness. pressure increases, no of cycles decrease and media increases as shown in fig.12.

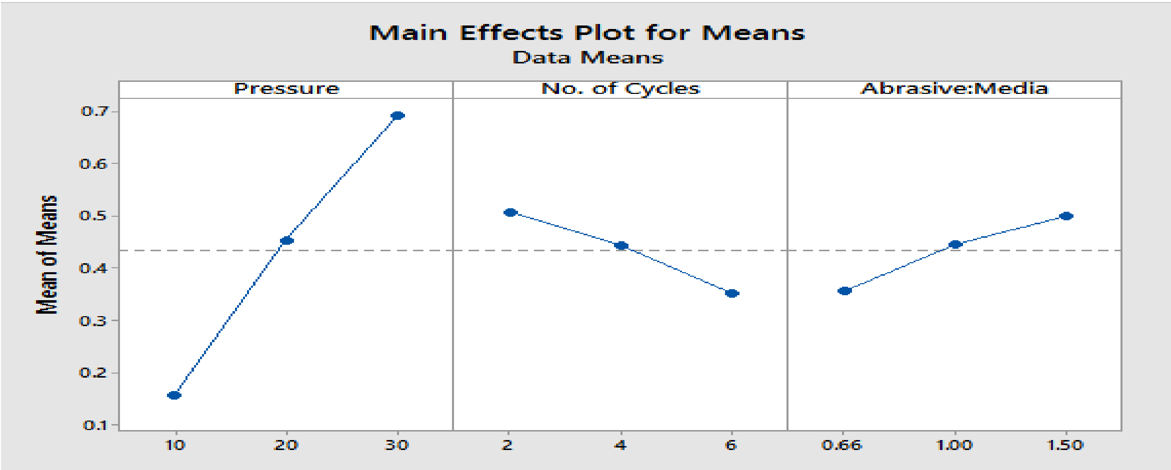


Fig. 12. Plot for the effect of different parameters on the mean value of Surface Roughness.

5. Conclusion

It can be concluded that AFM process results in higher material removal and better surface finish. In the paper, surface roughness analysis was done extensively and different graphs related to roughness were plotted.

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