STUDY IN MAFM USING BOUNDED MAGNETIC ABBRESIVES

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***Abstract*—With the recent improvement in properties of materials like hardness, strength, and temperature resistance it became necessary to improve the existing machining methods/techniques. The modern metal working industries face several challenges such as providing excellent surface finish on difficult to-approach regions on a wide range of components, control cost, decrease lead time from design to production. Magnetic abrasive flow machining (MAFM) processes are relatively new finishing processes. In the present work, the machining capabilities of the abrasive flow machining and magnetic abrasive flow machining have been compared. It has been found that the percentage improvement in surface finish and MRR is better in magnetic abrasive flow machining as compared to abrasive flow machining.*

Keywords*—Magnetic abrasive flow machining, MRR(material removal rate), PISF(persentage improvement in surace finish)

1. INTRODUCTION

The AFM process is originally developed by Extrude Hone Corporation, USA, in 1960s. Abrasive Flow Machining (AFM) is a nonconventional finishing process that works by forcing an abrasive-laden viscoelastic polymer across the work piece surface. But abrasive flow machining has some limitations like low material removal rate, Surface irregularities such as scratch, bumps, out of roundness cannot be corrected, more number of cycles is required for high material removal rate. To overcome these limitations, many Hybrid versions of the abrasive flow machining are introduced one of which is with the use Magnetic field around the AFM setup this setup is known as Magnetic abrasive flow machining (MAFM) The process is capable of achieving surface roughness of the order of nanometric level. as well as internal and external surfaces of tube type workpiece with a semisolid media consisting of a polymer based carrier and abrasive grains embedded into iron (ferromagnetic particles) matrix.

2. LITERATURE REVIEW

Singh et al. Investigate magneto Abrasive Flow Machining (MAFM) process to improve the material removal rate and reduces surface roughness by applying a magnetic field around the workpiece. ANOVA technique has been used to identify the most significant parameters - magnetic flux density, volume flow rate, number of cycles, medium flow volume, abrasive grit size, abrasive concentration and reduction ratios. Improved surface finish and MRR is observed in MAFM over AFM.

Shinmura et al. have applied magnetic abrasive finishing to the internal surface of workpiece such as vacuum tubes and sanitary tubes. The principle of this method is that a magnetic abrasive brush formed in the magnetic field and the workpiece are rotated and vibrated in a direction perpendicular to the direction of rotation simultaneously, to provide relative motion between the workpiece and the brush. A rotating magnetic field for relative motion is used in cases where the workpiece is not rotated.

Jain et al. have studied the MAF process on non-magnetic stainless steel workpiece with loosely bounded magnetic abrasives and concluded that the working gap and circumferential speed are the parameters which significantly influence the surface roughness value (Ra).

Kim has developed the new type of magnetic abrasives composed of WC/Co sintered powder for the production of cleaning tubes, and found the optimal finishing characteristics.

Fox et al. have found that unbounded magnetic abrasive particle (UMAP) yield higher material removal rate (MRR) and bounded MAP gives better surface roughness. Surface roughness value (Ra) of a ground rod has been achieved as low as 10 nm.

Jha et al. conducted experiments to study the effect of magnetic flux density on the surface finish improvement. And The role of magnetic field strength in MRAFF process is clearly distinguished, as at zero magnetic field conditions no improvement in surface finish is observed, and the improvement is significant at high magnetic field strength. This is because, in the absence of magnetic field the CIPs and abrasive particles flow over the workpiece surface without any finishing action due to the absence of bonding strength of CIPs. As the magnetic field strength is increased by increasing magnetizing current, CIPs chains keep on holding abrasives more firmly and thereby result in increased finishing action. Even magnetic flux density of 0.1521 T is capable of removing to some extent, loosely held ploughed material left after grinding process and expose the actual grinding marks made by abrasives.

R. Singh et al. Abrasive flow machining (AFM) is a relatively new non-traditional micro-machining process developed as a method to deburr, radius, polish and remove recast layer of components in a wide range of applications. Material is removed from the work-piece by flowing a semi-solid viscoelastic plastic abrasive laden medium through or past the work surface to be finished. Components made up of complex passages having surface/areas inaccessible to traditional methods can be finished to high quality and precision by this process. The present work is an attempt to experimentally investigate the effect of different vent/passage considerations for outflow of abrasive laden viscoelastic medium on the performance measures in abrasive flow machining. Cylindrical work-piece surfaces of varying cross-sections & lengths having different vent/passage considerations for outflow of abrasive laden.

P.D. Kamble et al. A magnetic field has been applied around a component being processed by abrasive flow machining and an enhanced rate of material removal has been achieved. Magnetic field significantly affects both MRR and surface roughness. The slope of the curve indicates that MRR increases with magnetic field more than does surface roughness. Therefore, more improvement in MRR is expected at still higher values of magnetic field. For a given number of cycles, there is a discernible improvement in MRR and surface roughness. Fewer cycles are required for removing the same amount of material from the component, if processed in the magnetic field. Magnetic field and medium flow rate interact with each other. The combination of low flow rates and high magnetic flux density yields more MRR and smaller surface roughness. Medium flow rates do not have a significant effect on MRR and surface roughness in the presence of a magnetic field. MRR and surface roughness both level off after a certain number of cycles.

3. PRINCIPLE AND EXPERIMENTAL SETUP

Medium is prepared in following steps:

- Preparation of polymer
- Preparation of gel
- Preparation of abrasives
- Preparation of medium.

The experimental setup is a modified version of the existing AFM setup by using two Electromagnets the sides of workpiece. it is a two-way MAFM Setup and the major components are couple of hydraulic a medium containing Cylinders, Electromagnets, Control unit, A.C. motor, D.C. valve, rotary gear pump, flow control valve, pressure reducing valve, pressure gauge, oil filter, oil tank, limit switch and hydraulic oil. When the power is applied to the poles, magnetic field generates the necessary finishing pressure between the poles. This gradient of the magnetic field produces the attraction force between the abrasives. The magnetic abrasive particles are joined to each other magnetically between the magnetic poles S and N along the lines of magnetic force, forming a flexible magnetic abrasive brush. This setup is being used for the internal finishing of brass pipe the magnetic abrasives containing medium is allowed to move through the brass workpiece from the upper medium containing cylinder to the lower one generating a finishing force on the inner surface of the workpiece, while the medium is attracted by the magnetic field around it which increases the finishing force and hence the material removal rate. This finishing pressure develops a micro ploughing and micro cutting type conditions at inner surface of workpiece. Bonded magnetic abrasives are prepared by mechanically alloying ferromagnetic iron powder and abrasive powder (Diamond) at a very high temperature in H2 gas atmosphere then mixed in a definite percentage with the medium. This magnetic medium causes finishing inside the pipe along the lines of magnetic force and provides necessary machining force inside the workpiece. The space between workpiece and the electromagnet is kept constant. The magnetic flux strength depends upon the weight percentage of ferromagnetic iron particles, both the working gap and size of the workpiece are taken into consideration the objective is to get batter surface finish and increase material removal rate.

Machin Setup

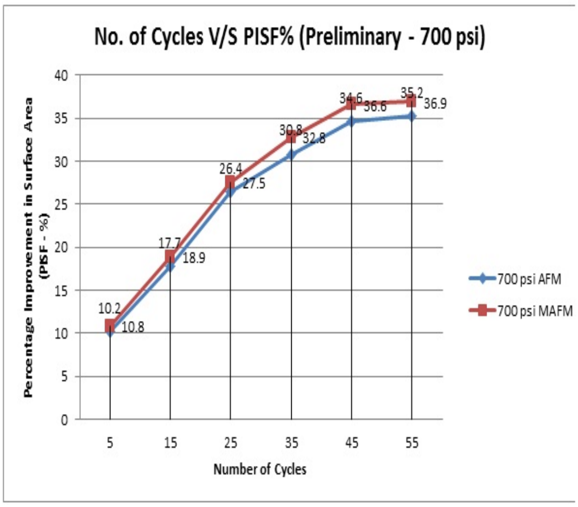
4. EXPERIMENTAL RESULTS AND DISCUSSIONS

TABLE WITH PISF% AND MRR IN AFM SETUP

S. No.	Extrusion Pressure (psi)	Number of Working Cycles	Percentage Improvement in Surface Finish (PISF) % (AFM)	Percentage Improvement in Surface Finish (PISF) % (MAFM)	Material Removal per Cycle (mg/cycle) (AFM)	Material Removal per Cycle (mg/cycle) (MAFM)
1.	300	15	9.9	10.6	1.42	1.49
2.	500	15	11.1	11.6	1.55	1.65
3.	700	5	10.1	10.8	1.71	1.91
4.	700	15	17.7	18.9	1.05	1.25
5.	700	25	26.2	27.5	0.65	0.69
6.	700	35	30.8	32.8	0.45	0.59
7.	700	45	34.9	36.6	0.41	0.43
8.	700	55	35.2	36.9	0.38	0.41

The preliminary experiments were done thrice on each pressure value on a different specimen on both AFM and MAFM setup. The readings of the preliminary experiments are recorded on figure. As it is clearly illustrated from the plotted graph that there has been a steep increase when the pressure value switched from 500 psi to 700 psi and PISF%

is slightly greater in case which magnetic field is applied. The improvement beyond the 700 psi appeared to be of much significance as compared to before and on 600 psi value. One factor has to be constant for finding the range of the other parameter. So the selected numbers of the cycles for the prelims were 15. The selection of number of cycles was also based on trial experiments which are well depicted from the figure. The constant parameter was extrusion pressure i.e. 700 psi. It infers from graph that the number of cycles more than 50-55 fetches almost constant results. So the selected range for the number of cycles was from 5 to 55 cycles with a gap of 10 cycles each.



Graph plot for selecting range of number of cycles

5. CONCLUSION

After carrying out the machining on brass tubes (HRB 68) with Abrasive Flow Machining and Magnetic Abrasive Flow Machining by using Diamond based magnetic abrasive in special prepared media, conclusion that emerged are extrusion pressure and number of cycles in the process is the significant parameters that influenced the percentage improvement in the surface finish and MRC.

The results of this research can be summarized as follows:

- The process yields results for PISF = 65 % by using the input parameters as Extrusion Pressure = 1100 psi and Number of Cycles = 55 of AFM setup and at same parameters in MAFM Setup the process yields best results for PISF = 68.3 % which mean it clearly is an improvement by adding magnetic flux of 0.7 tesla in MAFM setup.
- The extrusion pressure has a predominant effect on the PISF. High extrusion pressures are more effective on PISF as compared to low extrusion pressures.

There is a significant effect of temperature and pressure on PISF. As the temperature rises it affects the viscosity of the media and further it decreases the PISF.

More material is removed for higher values of pressure and increase in magnetic flux value.

For higher value of pressure, the number of finishing cycles for attaining value of PISF is less as compared to lower values of pressure.

Mechanically Bounded Diamond Abrasive gives higher value of material removal rate.

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