SURFACE FINISHING BY SOME OF UNCONVENTIONAL MEDIA IN ABRASIVE FLOW MACHINING

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Abstract
Abrasive flow machining is a non traditional polishing process to polish metallic components using a semi-liquid paste and with this even complicated or miniaturized parts requiring high surface finish can be produced economically. In this process small quantity of work material is removed by flowing semi-solid abrasive dispersed putty or media under pressure through or across work piece material. In the present research some of unconventional abrasive laden media has been explored with a Thermal AFM (Th-AFM) setup. In the Th-AFM setup, temperature of AFM media can be controlled by using jacket around the media cylinders. Three media, 1sta paraffin wax, 2ndthe grease, 3rda blend of paraffin wax and SAE 40 base oil have been explored as AFM media. The AFM media is laden with aluminium oxide of mesh size 150 as abrasive and Abrasive-to-AFM media ratio of 1:1 is taken. Hollow cylindrical brass workpieces were finished by the Th-AFM setup for eight cycles. It is observed that aluminium oxide-paraffin wax based abrasive laden AFM media results in the maximum material removal of 11.67 mg and also leads to maximum improvement in the surface roughness to the extent of 41.5 % change in the surface roughness (% Ra) resulting in improvement in surface roughness from 2μm to 1.17μm. ANOVA was done and results are found to be significant at the confidence level of 95 %.
Keywords: Th-AFM ,Thermal abrasive flow machining, Material removal, Internal surface Finishing.

1. Introduction

The need for great exactness and high effectiveness machining of hard to–machine materials is making the utilization of rough completing innovations vital. The high works, non open region in making of accuracy parts incorporates last machining activities. For finishing of components surface finish cost suddenly rises The result of excellent finish on the section is better presentation and compelling rise in life of parts. Abrasive Flow Machining (AFM) process was initially applied in industry during sixties. The AFM filled innovative gap in generation of components of complex shape, having important and not easily accessible surfaces or edges. It became available due to specific machining system and non-conventional abrasive medium, a paste with viscous plastic polymeric carrier as a basic component [1]. Abrasive laden media (fabricated of a semi-solid polymer with abrasive) is imposed through a inhibited section for synchronous finishing of the required/internal surface with a large number of arbitrarily oriented points. The abrasive laden media can be tailor made with different viscosities, abrasive types and sizes, concentrations of the constituents etc. In the recent times, work has been largely towards the hybridization of AFM with other machining processes to achieve the higher material removal rate, faster and better surface finish for different shape/size work-pieces[2].Singh and Shan [3] developed Magnetic Assisted Abrasive Flow machining (MAAFM) they mixed the polymer base with iron material for achieving more number of dynamic grains in the cutting activity. Walia et al. developed Centrifugal Force Assisted AFM, by revolving the AFM media with different shaped rods [4&5] for better machining. The important process variables are; number of cycles, media viscosity, abrasive particle size and concentration, initial surface condition

2. PRINCIPLE AND EXPERIMENTAL SET-UP OF TH-AFM

Dabrowski et al. studied the Electro-chemical aid along with the AFM and achieve more material removal, but for finishing of flat surfaces only. Here we are using thermal effect along with AFM. The main innovative and functional characteristics of the equipment for processing by Thermal abrasive flow machining are:

- Maximum pressure for hydraulic Actuators: maximum 25 N/mm²
- I.D. of Hydraulic actuators (Di) : 100 mm
- Stroke length of piston (l) : 300 mm
- The media cylinders outer diameter: 73 mm
- The media cylinders inner diameter:63 mm
- Pillar to pillar distance longitudinal: 320 mm
- Pillar to pillar distance laterally: 50 mm

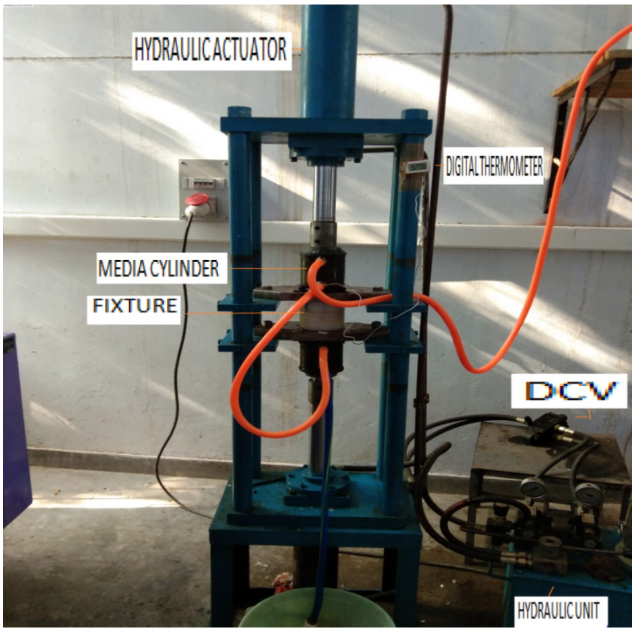

Figure. 1 Photogragh of Th-AFM setup

In the current research work, Th-AFM setup with a nylon fixture is used which contains specimen. Figure 1 shows Th-AFM setup which has digital thermometer to record temperature of media, machine has two hydraulic actuators and two media cylinders one is upper media cylinder and other is lower media cylinder, hot or cold water is circulated around the media cylinder with the help of thermal jacket around media cylinder water dispenser is used to send cold water. The designed setup has highest extrusion pressure of 25N/mm². Media is pushed by two actuators which are connected to two media cylinders, media passes from one media cylinder to another media cylinder through the workpiece. When this stroke is complete reverse stroke occurs and both upward and downward stroke complete one cycle. The stroke length is permanent value of 300 mm and volume of media is taken as 310 cc. Media cylinder I.D 63 mm. when media passes through the work-piece, It aim the finishing of inner surface of the work-piece

3. Experimental design

For the current study, the effect of abrasive media has been studied and so the experimental design is according to one-factor-at-a-time approach. A Nylon Fixture is designed in Cylindrical shape as shown in Figure 2. Nylon cylinder of diameter 4 inch is taken and machining is done on lathe. Length of fixture is 110 mm and fixture is made in two parts. Specimen was put in fixture and two parts of fixture is assembled with three screws of hardened steel fitted at 120°each, taper angle in fixture is 80°.In the present investigation, a hollow cylindrical work piece of brass (BHN hardness 156) is taken. Boring process is used to make inner suface of workpiece .Work-piece is a hollow cylindrical piece with I.D.10 mm,O.D.13.8 mm and length 16 mm for abrading the material of brass. During the experimentation, abrasive laden media is extruded through the hollow cylindrical work-piece. A combination of upward and downwards stroke completes a cycle and for the present set of experimentation the media has been extruded for eight cylces. 450 g of paraffin wax and 450 g Aluminum oxide abrasive is taken as 1st media type, 250 g paraffin wax +200 g SAE 40 base oil +450 g Aluminum oxide abrasive is taken as 2nd media and 450 g Grease + 450 g Aluminum oxide abrasive is taken as 3rd media type. The extrusion pressure is 0.8 Kgf/cm².The main process parameter for present experimentation is media type, while the other parameters of the experimentation have been kept constant.

TABLE I: Material Removal Of Different Media

Media Type	Repetition 1	Repetition 2	Repetition 3	Repetition 4	Mean
	MR in mg	MR in mg	MR in mg	MR in mg	MR in mg
paraffin wax	8.9	10	14.7	13.1	11.67
P.wax+SAE 40 oil	1.2	3.7	3.4	6.1	3.6
grease	11	6.3	13.6	10.3	10.3

Abrasive to paraffin wax ratio is 1:1,workpiece material ;Brass, Abrasive type: Al2O3, Abrasive grit size 150 (89 micron) Media Flow volume 310 cm3,Reduction ratio 0.97 Temperature of media is 32 °C ,Initial Surface Roughness of work Ra 2.7-3.2

TABLE II: Percentage improvement in surface roughness (% Ra)

Media Type	Repetition 1 % Ra in µm	Repetition 2 % Ra in µm	Repetition 3 % Ra in µm	Repetition 4 % Ra in µm	Mean % Ra in µm
paraffin wax	45.68	52.93	34.80	32.81	41.55
P.wax-+SAE 40	7.06	7.72	11.20	11.0	9.24
grease	10.00	8.27	9.43	11.0	9.67

Instrument Mitutoyo SJ-201 is used for measurement of surface roughness% improvement in surface roughness (% Ra). The average Ra is calculated and the percentage improvement in roughness is estimated as:

$$(\%\Delta Ra) = \frac{InitialRa - FinalRa}{InitialRa} * 100$$

Fig. 2 Fixture top and bottom and brass specimen

4. Result and Discussion

The effects of the process parameter (media type) are determined based on the average of raw response data. The main effects for media type are plotted in the Figure 3 & Figure 4. The analysis of variance (ANOVA) is performed to determine the significance of the media type parameter and the results are reported in table No. 3 & 4)

4.1 The Effect Of Media Type On MR (Material Removal)

The main effects for the material removal for the process parameter media type show that more material is removed by paraffin wax in comparison to grease and paraffin wax +SAE 40 oil . From the ANOVA Table 3, it is observed that the effect of media type on material removal in Th-AFM process is significant for the quality characteristic of material removal (MR).By observing means of Material Removal of three media, paraffin wax Excess material removal takes place in comparison to other two media.

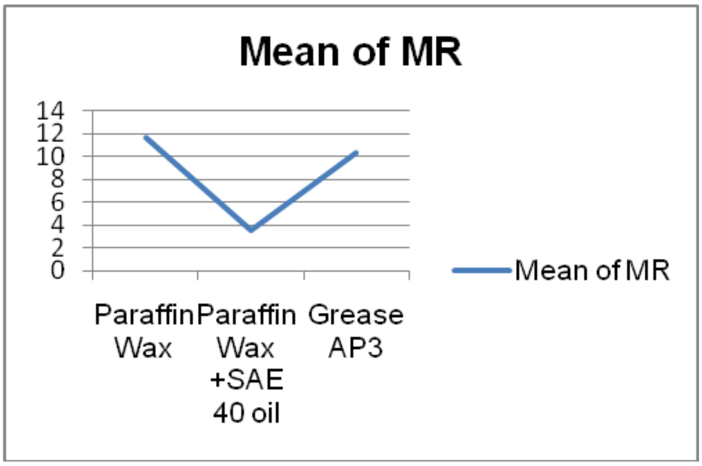

Figure. 3 On Y axis Mean of material removal is taken and on X axis media type

4.2 The effect of media type on Percentage improvement in Surface Roughness

During the experimentation % Ra for paraffin wax of 41.5% was noted. Paraffin wax helps in more abrasion during abrasion cutting action. From Figure 4 it is observed that Percentage improvement in Surface Roughness(% Ra) for paraffin wax is much better than P.wax + SAE 40 Oil and grease.

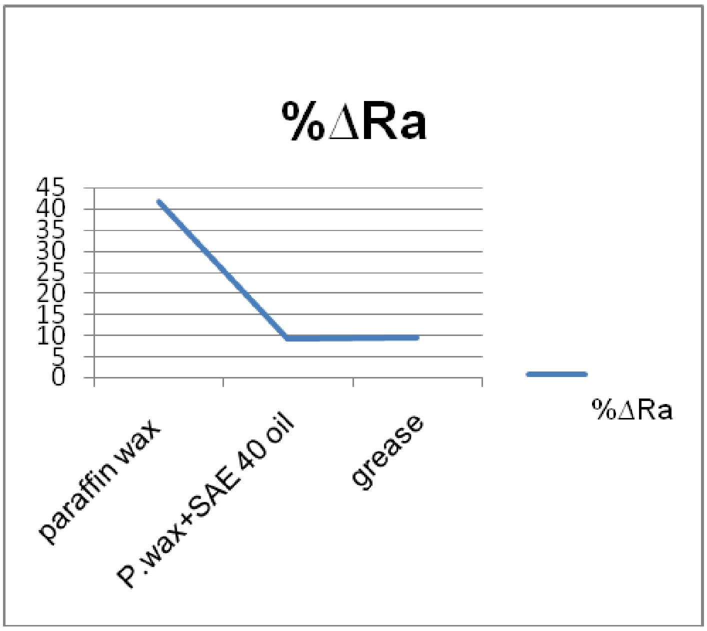

Figure. 4 On Y axis Mean of %ΔRa is taken and on X axis media type.

By observing Table 4,Finishing by Paraffin wax is better than grease and paraffin wax+ SAE 40 oil. It is observed that the effect of media type on Percentage improvement in Surface Roughness(% Ra) in Th-AFM process is significant for the quality characteristic of Percentage improvement in Surface Roughness.

Table 3 -ANOVA (Material Removal)

SOURCE	DOF	SUM OF SQUARES	MEAN SQUARE	F RATIO
Abrasive laden media type(treatment)	2	149.315	74.657	10.99
Error	9	61.1275	6.7919	
Total	11			

Significant at 95% confidence level
Fcritical=4.26
DOF-Degree of freedom ,SS-Sum of squares,MS-Mean of squares

Table 4-ANOVA(Percentage improvement in surface roughness (% Ra))

SOURCE	DOF	SUM OF SQUARES	MEAN SQUARE	F RATIO
Abrasive Laden Media Type(Treatment)	2	2747.27	1373.635	43.16
Error	9	286.405	31.8228	
Total	11			

Significant at 95% confidence level
Fcritical=4.26
DOF-Degree of freedom ,SS-Sum of squares,MS-Mean of squares

5. CONCLUSIONS

- Different AFM media like paraffin wax perform satisfactorily in the Abrasive Flow Machining Process.
- Material removal with paraffin wax was observed 11.67 mg which is better than blend of paraffin wax + SAE 40 oil and grease as used as media in Th-AFM setup.
- Percentage improvement in the surface roughness of paraffin wax was observed to be 41.5%, which is better than blend of paraffin wax + SAE 40 oil and also grease.

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