Abrasive Jet Machining using Grease for Internal Polishing of Aluminium Tubes

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Abstract—this study deals with a new approach to understand the finishing of abrasive flow machining process in which grease fluid is used to finishing the aluminium tubes. The present study develops optimization for AFM process of Aluminium tubes using Taguchi method. Various parameters such as concentration of abrasive 20 to 60gm, abrasive grit size 100 to 300 grits, number of cycles 20 to 60 are to be considered for analyzing the abrasive flow machining (AFM) performance criteria e.g. Surface finish and material removal. The lowest surface roughness is noted i.e. 0.68 Ra, at 60 gm of concentration of abrasive, 300 grit grain size of abrasive, and 40 number of cycle. The highest material removal is noted i.e. 0.074gm, at 60 gm of concentration of abrasive, 200 grit grain size of abrasive, and 20 number of cycle. For higher Material removal, the optimum parameters for abrasive flow finishing are at 60 gm of concentration of abrasive, 300 grit grain sizes of abrasive, and 60 number of cycle. The optimum parameters for lower Surface roughness, abrasive flow finishing are at 60 gm of concentration of abrasive, 300 grit grain size of abrasive, and 60 number of cycle.

Key words: AFM Process, Grain Size, Material Removal Rate, Surface Finish

I. INTRODUCTION

An abrasive is a material that is used to shape or finish a workpiece through rubbing which leads to part of the workpiece being worn away. While finishing a material often means polishing it to gain a smooth, reflective surface which can also involve roughening. Each abrasive particle acts like a single point cutting tool to remove the material from the workpiece surface. Abrasive flow machining was developed by the extrude Hone Corporation, USA in 1960s. Abrasive flow machining can be thought of a process generating a self- forming tool that precisely removes workpiece material and finishes the surface at those areas restricting to the medium flow. AFM method is used for precision deburring, edge, contouring, and surface finishing. It is capable of finishing areas which are difficult to reach by flowing abrasive mixed with polymer of special theological properties. AFM produces uniform, repeatable and predictable results on an impressive range of finishing operations. The properties of carrier in AFM are important. They should be visco-elastic and nonsticky in nature. Generally used carrier belongs to the category of silicon rubber, i.e. polyborosiloxane/ polydimethylisiloxane / silly putty. This carrier is a very viscous fluid and highly compressible and can flow in any blind recess. Important feature which differentiates AFM from other finishing processes is that it is possible to control and select the intensity and location of abrasion through fixture design, medium selection and process parameters. In general abrasive medium, the type of fixture and the type of machine determine the type of abrasion, place where to abrade and how much to abrade. In abrasive flow machining, the finishing action on the workpiece surface takes place by forcing a self-deformable medium which is a mixture of visco-elastic putty and abrasive particle across the workpiece surface. In AFM two vertically opposed cylinders extrude media back and forth through passages formed by the workpiece and tooling. In this process tooling plays a very important role in finishing of material, therefore design of tooling should be done carefully.

Gudipadu Venkatesh et al[1], used the Abrasive abrasive-based precision finishing process for achieving surface finish in micro and Nano-level. The AFM polishes surfaces by extruding a visco-elastic media in contact with the workpiece. Martin Swat et al[2], optimized the process control that is proposed by combining different levels of piston pressure in one machining procedure. This can be compared to roughing and finishing in conventional machining and is supposed to reduce the lead time while achieving the lowest possible surface roughness. Jose cherian and Jeouj M Issac[3], stated that in abrasive flow machining (AFM), an abrasive mixture and a polymer of special rheological properties is forced through a restricting medium. The objective of the present paper is to study the effect of process variables on surface finish and material removal. E. Uhlmanna, M. Doitsb, C. Schmiedela[4], said that Abrasive Flow Machining (AFM) uses the visco-elastic properties of a polymeric carrier, combined with abrasive grains, as a tool for machining of difficult to reach geometries, such as holes or cavities. Due to the design of the workpiece holding device and variable flow rates, the complex shear modulus of the polymer can locally be influenced and thus a targeted removal on the workpiece can be produced. As a result there is a reproducible material removal, causing requested polishing, deburring or edge rounding. Due to shear thinning and visco-elastic behavior of the tool, the process simulation for AFM is very complex and has not been implemented yet including an exact physical material model.

J. Kenda[5], investigated the the influence of the process parameters on surface integrity, i.e. surface roughness and induced residual stresses.

II. EXPERIMENTAL PROCEDURE

Experiments have been conducted on a mini set-up of abrasive flow machine, specially designed and fabricated for this purpose. The present chapter deals with its details related to design, assembly, and part drawings, and working. The abrasive flow machining setup has been designed keeping in view the fundamental mechanism process and the basic requirements. The drawing of the assembled machine is as shown in fig.1 and the part list is given in table1. The whole setup is a free mount setup in which no mounting of the cylinder and workpiece required. A CAD model for the same is shown in figure 1. The setup consists of two media cylinder aligned along the length. One media cylinder is push fitted into tube on one side of aluminium tube and second cylinder to the other side of the tube. The media cylinder is a cylinder piston arrangement. The media cylinder is spring loaded mechanism with washer on the piston rod. The cylinders have lever-1 and lever-2 as shown in fig 2. The workpiece is hold between the nozzles of the cylinders.

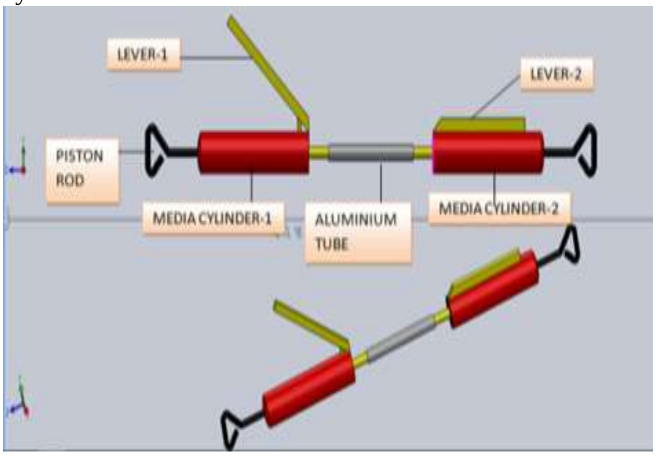

Fig. 1: CAD model of the AFM Set-Up

The working of the set-up can be understood as described below:

The piston of the media cylinder is spring loaded which pressurizes the media in the media cylinder-1 and Lever-1 pushes the media to flow through the aluminium tube and vice-versa. When lever-1 is pressed in the downward direction the spring loaded piston pressurize the media to flow through the media cylinder-1 to Aluminium tube the media will extrude through the hole and enters the media cylinder -2 by sliding the piston rod towards body. This is the one stroke. Than same step is followed in reverse direction by pressing the lever-2 is in the downward direction the spring loaded piston pressurize the media to flow through the media cylinder-1 to Aluminium tube the media will extrude through the hole and enters the media cylinder -1 by sliding the piston rod towards body. The workpiece are machined for number of cycles depending upon the number of cycles. After completing the predetermined number of cycles, the workpiece is removed from media cylinders. Before any measurement, clean the workpiece with acetone so as to get those media free.

Fig. 2: AFM working Set-up

In order to study how the surface finish is affected by various process parameters, measurement of Ra value is essential. For this purpose a workpiece is cut symmetrically from Centre. The instrument used to numerical assessment of surface roughness in terms of Ra measurement.

For measuring surface roughness of workpiece, follow the procedure given below:

– Put the instrument gently on the workpiece, so that the stylus of the instrument will be in contact with the surface to be measured.
– Press the start button, which is placed at the top left hand side corner of the instrument.
– After completing its transverse length it will display Ra value.

For preparing these specimen pieces, aluminium tube is divided into nine equal lengths. The aluminium tube is cut in the size of 80mm. the diameter of tube is 8mm and the thickness of tube is 2mm. The media is a mixture of grease (used for lubrication of mechanical joints) and abrasive particles (silicon carbide). The abrasive particles of specified mesh size in definite proportion are mixed with grease to achieve the desired concentration. Before performing actual experiments, the fresh media is run for 20-25 cycles with a trial workpiece, so as to get uniform mixture of grease and abrasives. The experiments are designed according to number of variables and responses to be measured for that variable. Based on the preliminary experiments, three important variables are identified i.e. number of cycles, % concentration, abrasive mesh size.

Workpiece	Commercially available Aluminium tube of 8 mm diameter and 2 mm thickness.
Abrasives	Silica based mechanically alloyed abrasives
Constant Parameters	
Grease	80gm
Variable Parameters	
Concentration of Abrasives	20, 40 and 60 gm
Abrasive grain size	100, 200 and 300 grits
No. of cycles	20, 40 and 60

Table 1: AFM experimental conditions

Experiments will be conduct based on Taguchi's method with three factors at three levels each. The levels of parameters will be decided through detailed study of literature review, and by performing the pilot experimentation.

III. RESULTS AND DISCUSSIONS

Taguchi method, a powerful tool in the design of experiment, is to be used to optimize the AFM machining parameters of effective machining of aluminium. Determine the S/N ratio, analysis of variance (ANOVA) and 'F' Test values for indicating the most significant parameters affecting the micro machining performance criteria, i.e., the surface roughness and to determine the material removal rate. The main purpose of the ANOVA is to investigate the design parameters and to indicate which parameters are significantly affecting the quality characteristics. The optimal parametric setting value will directly help to set the parametric combination during finishing of aluminium tube using AFM machining. MINITAB SOFTAWRE is utilized to analyze the results.

Figure 3(a) shows the effect of concentration of abrasives on Mean of SN Ratios of surface roughness. Graph plotted by utilizing the surface roughness results obtained at variation of concentration of abrasives 20 to

60gm, Abrasive grain size 100 to 300 grits and number of cycles 20 to 60.

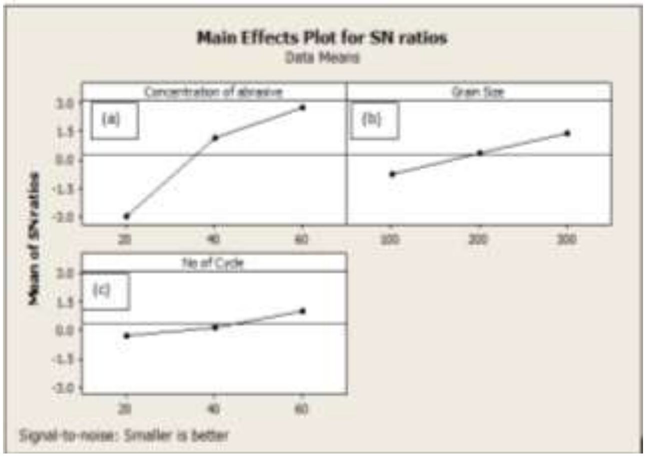

Fig. 3: Mean of SN ratio of Surface Roughness

From figure, it is clear that there is increase in surface roughness with the increase of concentration of abrasives. Figure 3 (b) shows the effect of grain size on Mean of SN Ratios of surface roughness. Graph plotted by utilizing the surface roughness results obtained at variation of concentration of abrasives 20 to 60gm, Abrasive grain size 100 to 300 grits and number of cycles 20 to 60. From figure, it is clear that there is increase in surface roughness with the increase in grain size. Figure 3 (c) shows the effect of no. of cycles on Mean of SN Ratios of surface roughness. Graph plotted by utilizing the surface roughness results obtained at variation of concentration of abrasives 20 to 60gm, Abrasive grain size 100 to 300 grits and number of cycles 20 to 60. From figure, it is clear that there is increase in surface roughness with the increase in no. of cycles.

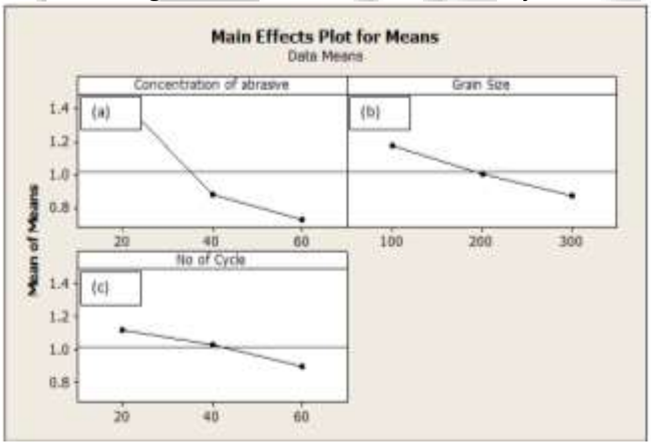

Fig. 4: Mean of means of surface roughness

Figure 4(a) shows the effect of concentration of abrasives on Mean of Means of surface roughness. Graph plotted by utilizing the surface roughness results obtained by variation of concentration of abrasives 20 to 60gm, Abrasive grain size 100 to 300 grits and number of cycles 20 to 60. From figure 4, it is clear that there is constant decrease in surface roughness with the increase of concentration of abrasives from level-1 to level-2 and level-2 to level-3 the surface roughness decreases at fast pace.

Figure 4(b) shows the effect increase in Grit size on Mean of Means of surface roughness. Graph plotted by utilizing the surface roughness results obtained by variation of concentration of abrasives 20 to 60gm, Abrasive grain size 100 to 300 grits and number of cycles 20 to 60 From figure 4, it is clear that there is constant decrease in surface roughness with the increase of abrasive grit size from level-1 to level-3.

Figure 4 (c) shows the effect of number of cycles on Mean of Means of surface roughness. Graph plotted by utilizing the surface roughness results obtained by variation of concentration of abrasives 20 to 60gm, Abrasive grain size 100 to 300 grits and number of cycles 20 to 60 From figure 4, it is clear that there is constant decrease in surface roughness with the increase of number of cycles from level-1 to level-3.

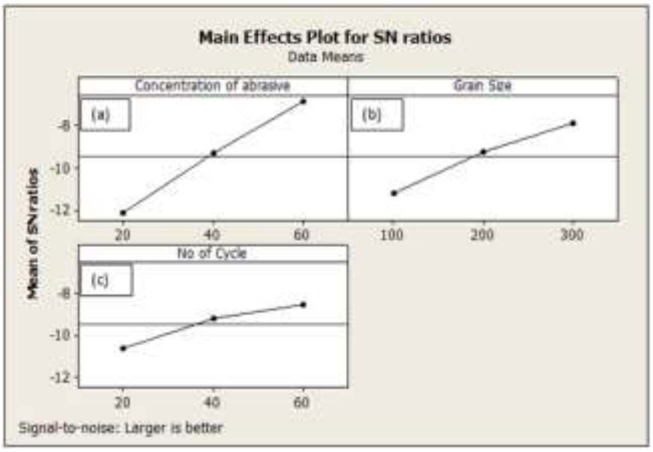

Fig 5: Mean of SN ratio of Material Removal

Figure 5 (a) shows the effect of concentration of abrasives on Mean of SN Ratios of material removal. Graph plotted by utilizing the material removal results obtained at variation of concentration of abrasives 20 to 60gm, Abrasive grain size 100 to 300 grits and number of cycles 20 to 60. From figure, it is clear that there is increase in material removal with the increase of concentration of abrasives. Figure 5 (b) shows the effect of grain size on Mean of SN Ratios of material removal. Graph plotted by utilizing the material removal results obtained at variation of concentration of abrasives 20 to 60gm, Abrasive grain size 100 to 300 grits and number of cycles 20 to 60. From figure, it is clear that there is increase in material removal with the increase in grain size. Figure 5 (c) shows the effect of no. of cycles on Mean of SN Ratios of material removal. Graph plotted by utilizing the material removal results obtained at variation of concentration of abrasives 20 to 60gm, Abrasive grain size 100 to 300 grits and number of cycles 20 to 60. From figure, it is clear that there is increase in material removal with the increase in no. of cycles.

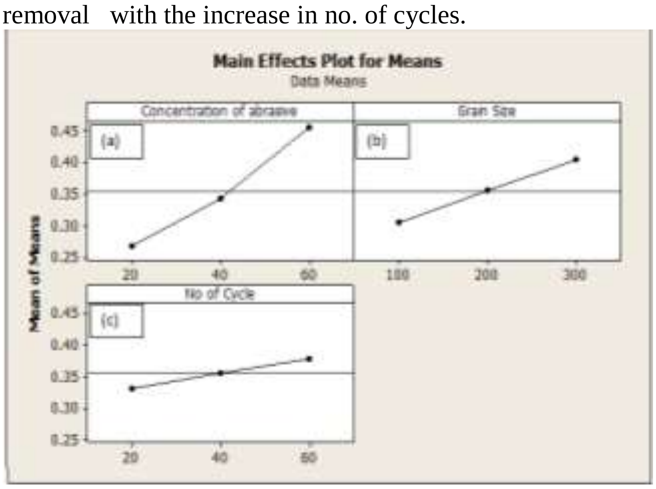

Fig 6: Mean of SN ratio of Material Removal

Figure 6 (a) shows the effect of concentration of abrasives on Mean of Means of material removal. Graph plotted by utilizing the material removal results obtained by variation of concentration of abrasives 20 to 60gm, Abrasive grain size 100 to 300 grits and number of cycles 20 to 60. It is clear that there is constant increase in material removal with the increase of concentration of abrasives from level-1 to level-2 and level-2 to level-3 the material removal increases at fast pace. Figure 6 (b) shows the effect increase in Grit size on Mean of Means of material removal. Graph plotted by utilizing the material removal results obtained by variation of concentration of abrasives 20 to 60gm, Abrasive grain size 100 to 300 grits and number of cycles 20 to 60. It is clear that there is constant increase in material removal with the increase of abrasive grit size from level-1 to level-3. Figure 6 (c) shows the effect of number of cycles on Mean of Means of material removal. Graph plotted by utilizing the material removal results obtained by variation of concentration of abrasives 20 to 60gm, Abrasive grain size 100 to 300 grits and number of cycles 20 to 60. From this figure, it is clear that there is constant increase in material removal with the increase of number of cycles from level-1 to level-3.

IV. CONCLUSION

The lowest surface roughness is noted i.e. 0.68 Ra, at 60 gm of concentration of abrasive, 300 grit grain size of abrasive, and 40 number of cycle.

- Surface roughness is decreased by increasing concentration of abrasive due to more abrasive is in contact with surface of tubes.
- Surface roughness is decreased by increasing the grain size of abrasive; because of more grit size means powder size is low which is act as lapping.
- Surface roughness is decreased by number of cycle; because more time is allowed for finishing.
- For lower Surface roughness, the optimum parameters for abrasive flow finishing are at 60 gm of concentration of abrasive, 300 grit grain size of abrasive, and 60 number of cycle.
- The highest material removal is noted i.e. 0.074gm, at 60 gm of concentration of abrasive, 200 grit grain size of abrasive, and 20 number of cycle.
- Material removal is increased by increasing concentration of abrasive due to more abrasive is in contact with surface of tubes.
- Material removal is increased by increasing the grain size of abrasive.
- Material removal is increased by number of cycle; because more time is allowed for finishing.
- For higher Material removal, the optimum parameters for abrasive flow finishing are at 60 gm of concentration of abrasive, 300 grit grain size of abrasive, and 60 number of cycle.

REFERENCES

[1] Gudipadu Venkatesh, Apurbba Kumar Sharma, and Nitish Singh, "Simulation of media behavior in vibration assisted abrasive flow machining", Simulation Modelling Practice and Theory 51 (2015) 1–13.

[2] Martin Swat, Horst Brunnet, Nataliya Lyubenova, Joachim Schmitt, Stefan Diebels, and Dirk Bahre, "Improved process control and model of axial forces of one-way abrasive flow machining", Procedia CIRP 14 (2014) 19 – 24.

[3] Jose Cherian, and Jeoju M Issac, "Effect of Process Variables in Abrasive Flow Machining", International Journal of Emerging Technology and Advanced Engineering, 3, 2013, 554-557.

[4] J. Kenda, F. Pusavec, G. Kermouche, and J. Kopac, "Surface Integrity in Abrasive Flow Machining of Hardened Tool Steel AISI D2", Procedia Engineering 19 (2011) 172 – 177.

