International Journal of Advance Research in Engineering, Science & Technology(IJAREST),
ISSN(O):2393-9877, ISSN(P): 2394-2444,
Volume 2, Issue 6, June- 2015, Impact Factor: 2.125

Parameters Optimization for Surface Roughness with AFM for Material EN-31

***Virender*[1], *Rahul O Vashiya*[2], *Vikas Kumar*[3], *Ravi Gupta*[4]**

[1]*Production and Industrial engg., PEC Chandigarh, virender9nov@gmail.com*

[2]*Production and Industrial engg., PEC Chandigarh, rahul_mv@yahoo.com*

[3]*Mechanical Engg., UIET (PU) Chandigarh, vdhanda07@gmail.com*

[4]*Mechanical Department, Lovely Professional University, raviarya43@gmail.com*

Abstract

Abrasive flow machining (AFM) is a non-conventional machining which is used to polish, deburr and radius surfaces & edges. It forces a semisolid abrasive-laden called "media" to pass through or across the surface of the work piece to be finished. Many researchers provided different optimized parameters for different materials. In present case EN-31 material was taken for getting the optimum parameters using abrasive flow machining. In this experimental study parameters like abrasive size, number of cycle and pressure were varied. L_9 orthogonal array based on Taguchi method was used for experiments. Experimental results shows that abrasive size have the highest contribution (89.96%) towards the surface quality improvement.

Keywords- Abrasive flow machining (AFM), surface finish, Taguchi Method, Optimization, EN-31.

I. INTRODUCTION

Abrasive Flow Machining is one of the non-conventional finishing processes, which is being used for surface finishing of complex and inaccessible surfaces. There are many conventional processes for surface finishing such as grinding, lapping, honing, boring etc. But their use is limited to the geometry of a work piece and up to a certain value. Inaccessible surfaces are very difficult to be surface finished by any conventional process. Abrasive flow machining is used for finishing of such complex inaccessible surfaces or cavities. This process uses a semi-solid abrasive laden called "media" for finishing the surface of the work piece. It removes a very small quantity of material. AFM set up uses two vertically opposite cylinders. Tooling with work piece is fixed between these two cylinders and the media is extruded back and forth through the passage formed by the tooling and the work piece. Media used is made of gel, polymer and abrasives. Tooling used is made of Teflon, nylon, steel or aluminium. In present case tooling used is made of Teflon. The main function of tooling is to hold the work piece. In AFM process different kind of abrasives can be used such as aluminium oxide, silicon carbide, boron carbides and diamond etc. These abrasive particles have large number of cutting edge with indefinite orientation and geometry which helps in material removal. Very thin chips are produced during process which produces better surface finish. In order to enhance the interaction between the work piece surface and the abrasive, a tooling rod was kept inside the cylindrical work piece. This rod restricts the passage of the abrasive laden media. This application of this process is in many areas like automobile, finishing of industrial valves, semiconductor equipments, aerospace, die making etc. The main elements of the process are machine work piece and tooling (fixture). In present case effect of different key parameters i.e. abrasive size, number of cycle and pressure is studied.

II. LITERATURE REVIEW

Lot of work has been done since 1960's in the field of AFM and its hybridisation with other manufacturing methods. The abrasive concentration, grit size and viscosity were major parameters which has a significant effect on surface finish. As the concentration of abrasive in the media increases up to a certain percentage, material removal increases while the surface roughness value decreases [1]. As abrasive grit size increases, ΔR_a value increases [2]. Magnetic field is applied to the AFM process which increases the number of active abrasives taking parts in abrasion which in turn improves the surface quality [3-4].Material removal is directly proportional to the slug length of flow [5]. It has been found that cutting is faster at an increased extrusion pressure, with all other parameters remaining constant. At higher pressure, the improvement in material removal just tends to stabilize probably due to localized rolling of abrasive particles [6]. Jain et.al used neutral networks & multivariable regression modelling of AFM process [7]. Rhoades suggested that depth of penetration mainly depends on abrasive grain size, extrusion pressure and hardness [8]. Hull reported the effect of temperature (within the range 30°- 70°C) on rheology of media used and stated that the media may sometimes undergo a permanent change in physical properties with increase in temperature [9]. This method employs design of orthogonal array to compute the effect of process parameters of surface finish [10-12]. Przylenk described that with small bore diameters of work piece, more grains comes in contact with surface, hence improves the surface finish.

III. EXPERIMENTAL SET-UP

The schematic diagram of set up of AFM process is shown in Figure.1. It was a two way AFM set up. Fixture used was made of Teflon and was divided into three parts as shown in Figure.3. Work piece taken was of EN-31 material and was in cylindrical shape having inner dia. 8 mm, outer dia. 13 mm and length was 17mm as shown in Figure. 4. Abrasive laden media was consist of three parts i.e. silicon based polymer, gel and abrasives as shown in Figure.2. The abrasives used in these experiments were Al_2O_3 of different grit size. Two vertically opposite cylinders were used. Work piece was held within the fixture and the fixture was

All Rights Reserved, @IJAREST-2015

put in between the cylinders. Abrasive laden media was extruded back and forth through the work piece from one cylinder. Initially the work piece was prepared by drilling followed by boring. Range of Initial Ra of the work pieces was 2.35-2.75. After machining the work piece was taken out and it was well cleaned using acetone and then final Ra was measured. Ra was measured using a roughness tester called Talysurf.

Figure 1. AFM set up

Figure 2. Three parts of fixture

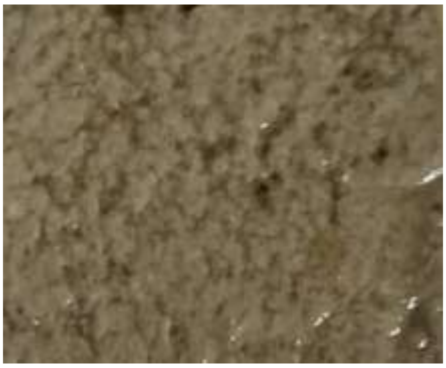

Figure 3. Abrasive laden media

Figure 4. Work pieces

IV. RESPONSE CHARACTERSTICS

Surface Finish was taken as a response parameter in AFM process. The average of R_a values was calculated and the percentage improvement in roughness was estimated as:

$$\Delta R_a = \frac{(\text{initial roughness} - \text{roughness after machining}) \times 100}{\text{initial roughness}}$$

Table 1: Process Parameters And Their Range

S. No.	Process Parameter	Range	Unit
1	Extrusion Pressure	2, 4, 6	N/mm^2
2	Number of cycles	4,6, 8	No.
3	Abrasive particle size	60, 100, 200	ppm
4	Media Flow Volume	290	cm^3
5	Abrasive to media concentration	1:1	% by weight
6	Polymer-to-Gel Ratio	1:1	% by weight

V. RESULTS AND DISCUSSION

The scheme of experiments was based on Taguchi's L_9 orthogonal array for the setting of various parameters is given as under:

Table 2. L_9 orthogonal array table with response

S.N.	A	N	P	-	R1	R2	R3	S/N
1	60	4	2	1	5.42	5.56	5.81	14.94
2	60	6	4	2	10.91	10.25	10.23	20.38
3	60	8	6	3	6.45	6.21	6.14	15.93
4	100	4	4	3	15.32	15.41	15.25	23.70
5	100	6	6	1	16.82	16.76	16.71	24.48
6	100	8	2	2	14.23	14.12	14.36	23.06
7	200	4	6	2	20.74	19.82	19.55	26.02
8	200	6	2	3	25.85	25.36	26.57	28.27
9	200	8	4	1	27.86	27.32	27.21	28.77
A (Abrasive Size), N (Number of Cycle), P (Extrusion Pressure) R1, R2, R3 are repetitions one , two & three								

From Figure 5 it is cleared that as mesh size increases the quality of surface finish increases. It is because of the fact that as abrasive size becomes finer it produces better surface quality.

All Rights Reserved, @IJAREST-2015

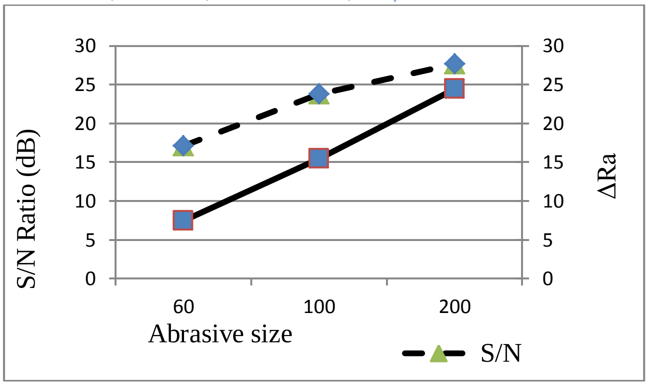

Figure 5: Effect of abrasive size on %age improvement of Ra

From Figure 6, it can be noted that increase in the number of cycles initially leads to improvement in the surface finish and after the second level of number of cycles (6 cycles) the surface finish starts deteriorating. This fact can be attributed to the initial material removal from the peaks, which leads to the improvement in the surface finish. After the peaks are removed and a good surface finish has been achieved, the further cycles lead to deterioration of this surface due to abrasives.

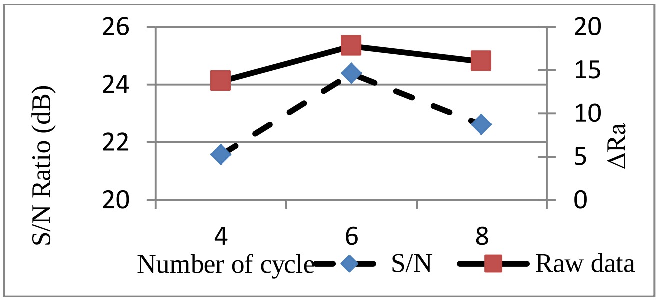

Figure 6: Effect of number of cycle on %age improvement of Ra

Figure 7 show the increase in extrusion pressure improves the work surface finish. Within the range of extrusion or axial pressure applied the higher the pressure the greater is the improvement in surface finish, which tends to stabilize beyond a certain level. Higher axial pressure enables the abrasive particles to roll on the surface with more force resulting in faster removal of metal peaks on the work surface and hence rapid achievement of the required surface finish.

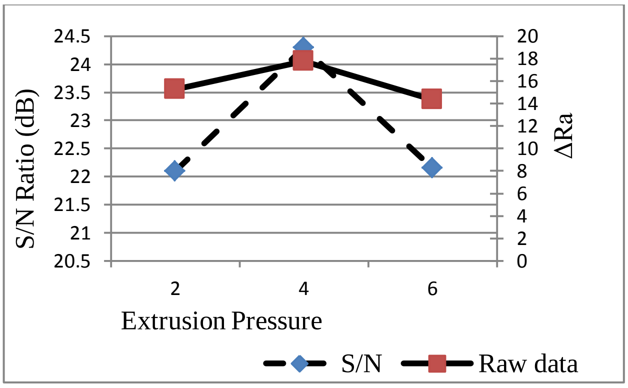

Figure 7: Effect of Extrusion Pressure on %age improvement of Ra

From the table 3 & table 4 it is observed that all the three parameters i.e. abrasive size, number of cycle, pressure significantly affect the surface quality improvement. Abrasive size has the highest contribution i.e 89.96% followed by number of cycle i.e. 5.15% and after that pressure has the lowest contribution i.e. 3.83%.

Table 3. ANOVA (raw data)

SOURCE	SS	DOF	V	F-RATIO	P%
A	1307.20	2	653.60	859.15	89.96
N	74.89	2	37.44	49.22	5.15
P	55.72	2	27.86	36.62	3.83
E(pooled)	15.22	20	0.761	--	1.05
Total(T)	1453.03	26	--	--	100

Significant at 95 % confidence level, $F_{critical}$ = 3.4928

SS – Sum of Squares, DOF – Degree of Freedom, V- Variance

Table 4. ANOVA (S/N data)

SOURCE	SS	DOF	V	F-RATIO	P %
A	172.34	2	86.17	374.43	88.66
N	12.20	2.00	6.10	26.50	6.28
P	9.38	2.00	4.69	20.38	4.83
E (Pooled)	0.46	2	0.23	--	0.24
Total (T)	194.38	8	--	--	100

Significant at 95 % confidence level, $F_{critical}$ = 3.4928

SS – Sum of Squares, DOF – Degree of Freedom, V – Variance

Percentage Improvement in Ra

The mean at the optimal percentage improvement in R_a (optimal value of the response characteristic) is estimated as:

$$\Delta Ra = A_3 + N_2 + P_2 - 2\overline{T}$$

$\overline{T}$ = overall mean of the response = 15.78%

A_3 = Average value of % age improvement in R_a at the third level of abrasive size = 24.48%

N_2 = Average value of % age improvement in R_a at the second level of number of cycle = 17.72%

All Rights Reserved, @IJAREST-2015

P_2 = Average value of %age improvement in R_a at second level of extrusion pressure= 17.75%

Substituting these values, % age improvement in R_a =28.3768%

The confidence interval of confirmation experiments (CI_{CE}) and of population (CI_{POP}) is calculated by using the following equations :

$$CI_{CE} = \sqrt{F_\alpha(1, f_e) V_e \left[\frac{1}{n_{eff}} + \frac{1}{R}\right]} \qquad CI_{POP} = \sqrt{\frac{F_\alpha(1, f_e) V_e}{n_{eff}}}$$

where $F_\alpha(1, f_e)$ = The F-ratio at the confidence level of (1-α) against DOF 1 and error degree of freedom f_e = 4.35 (Tabulated F value)

f_e = error DOF = 20 (Table 6.5)

N = Total number of result = 27 (treatment = 9, repetition = 3)

R = Sample size for confirmation experiments = 3

V_e = Error variance = 0.761

$$n_{eff} = \frac{N}{1 + [\text{DOF associated in the estimate of mean responce}]}$$

= 3.86

So, $CI_{CE} = \pm 1.961$ and $CI_{POP} = \pm 0.8576$

The 95% confirmation interval of predicted optimal range (for confirmation run of three experiments) is: 26.42<%age improvement in Ra >30.33. The 95% confirmation interval of the predicted mean is: 27.51 <%age improvement in Ra >29.23.

SEM images for EN-31 before & after machining process are shown in Fig. 8 & Fig. 9 respectively.

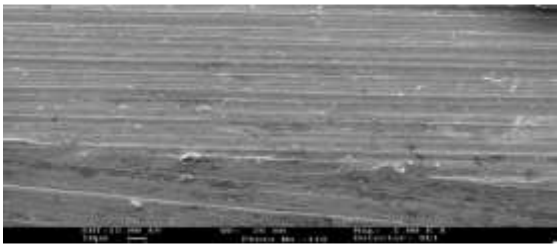

Figure 8. SEM image before AFM process

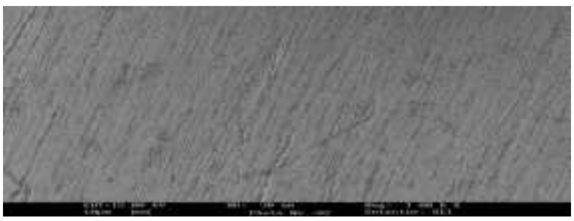

Figure 9. SEM image after AFM process

For maximum percentage improvement in Ra, the optimal levels of process parameters obtained are A_3, N_2, and P2. In order to confirm the result three confirmation experiments were conducted taking optimal level of process parameters.

VI. CONCLUSION

The important conclusions for this research work are enlisted below:

1. The Three main process parameters Abrasive size, number of cycle and pressure has significant effect on the response parameters of percentage improvement in the surface finish.

2. The result shows that the percentage contribution of Abrasive size is 89.96% for %age improvement in Ra

3. The percentage contribution of Number of cycle is 5.15% for the Ra. As the number of cycles increases from 4 to 6, the Ra goes on increasing.

4. The Pressure is also significant for the present setup and its contribution is 3.83% for the Ra.

5. Result shows that abrasive size has the highest contribution towards %age improvement of Ra.

REFERENCES

[1] Jain, V. K. & Adsul, S. G., 2000. Experimental investigations into abrasive flow machining (AFM). *International Journal of Machine Tools and Manufacture,* Volume 40, pp. 1003-1021.

[2] V.K. Jain, C. Ranganatha, K. Muralidhar, Evaluation of rheological properties of medium for AFM process. Journal of Machining Science & Technology 5(2001), 151-170.

[3] Singh S & Shan H.S, 2002, Development of magneto abrasive flow machining proces, International J. of Machine Tools and Manufacture, Volume 42, pp. 953–959.

[4] Singh S, Shan H.S & Kumar P, 2002, Wear behavior of materials in magnetically assisted abrasive flow machining, Journal of Materials Processing Technology, Volume 128, pp155-156.

[5] Kohut, T. A., 1988. Surface finishing with abrasive flow machining. *SME technical paper, Prc. 4th International Aluminium Extrusion Technology Seminar, Washington D.C.,* Volume 2, pp. 35-43.

[6] Jain, R. K. & Jain V. K., 1999. Abrasive fine finishing processes - a review. *International Journal of Manufacturing Science and Production,* 2(1), pp. 61-69.

[7] Jain V. K. & Adsul S. G., 2000. Experimental investigations into abrasive flow machining (AFM). *International Journal of Machine Tools and Manufacture,* Volume 40, pp. 1003-1021.

[8] Rhoades, L. J., 1991. Abrasive flow machining: a case study. *Journal of Materials Processing Technology,* Volume 28, pp. 107-116.

[9] Hull, J. B. et al., 1992. Hull J.B., Jones A.R., Heppel AThe effect of temperature rise on the rheology of carrier media used in abrasive flow machining. *Surface Engineering,* Volume II, Engineering Applications, pp. 235-244.

[10] Brar B.S., Walia R S, Singh V.P, National conference on advancements and futuristic trends in mechanical & material engineering, (2011), 7-8.

All Rights Reserved, @IJAREST-2015

[11] Walia R S, Shan H S, Kumar P, Multi response optimizationof CFAAFM process through taguchi method & utility concept. Taylor & francis, Material manufacturing process 21 (2006) 1-8.

[12] Harlal Singh & Alakesh Manna, Optimum selection of abrasive flow machining condition during fine finishing of Al/15 wt% Sic MMC using Taguchi method. International Journal Advanced Manufacturing Technology (2010) 50, 1013-1024.

[13] Perry W.B, 1985, Abrasive flow machining, principles and practices", Proc. Non-Traditional Machining Conference, Cincinnati, Ohio, pp. 121-128

[14] Davies P. J. & Fletcher A. J, 1995, The assessment of rheological characteristics of various polyborosiloxane/grit mixtures as utilized in the abrasive flow machining process. Proceedings of Institution of Engineers, Part C, Journal of Mechanical Engineering Science, Volume 209, pp. 409-418.

[15]Sharma M, 2011, Study of helical abrasive flow machining. Chandigarh, India: M.E. Thesis, PEC University of Technology.

[16] Abbas F. Ibrahim, Saad K.S Shather & Wissam K. Hamdan, 2014, Studying Abrasive Flow Conditions by using Taguchi Method, Eng. & Tech Journal, Volume 32, Part (A), No. 4.

[17] Walia, R. S., Shan, H. S. & Kumar, P., 2009. Enhancing AFM process productivity through improved fixturing. International Journal of Advanced Manufacturing Technology, Volume 44, pp. 700-709.

All Rights Reserved, @IJAREST-2015

All Rights Reserved, @IJAREST-2015