Journal of Material Science and Mechanical Engineering (JMSME)
Print ISSN: 2393-9095; Online ISSN: 2393-9109; Volume 1, Number 2; October-December, 2014 pp. 45-49

http://www.krishisanskriti.org/jmsme.html

Investigation on Effect of Roller Burnishing Parameters on Surface Roughness of Aluminum 2024-T4 Alloy Using Taguchi's L9 Array

Pavan Kumar[1] and G.K. Purohit[2]

[1]Research Scholar, Department of Mechanical Engineering Shri Madhwa Vadiraja Institute of Technology and Management Bantakal-574115, Udupi, India
[2]Department of Mechanical Engineering PDA College of Engineering Gulbarga-585102, India
E-mail: [1]pavansmvitm@gmail.com, [2]geekey_purohit@rediffmail.com

Abstract: *Burnishing is a surface finishing operation in which peaks and valleys on machined surfaces deformed plastically by the application of hard and finished ball or roller against to it. In recent years burnishing is becoming popular among post finishing processes because of its many advantages along its primary role i.e. increasing surface finish. In this paper the effect of burnishing process parameters on Aluminium 2024-T4 is reported. Taguchi's L9 array is used followed by ANOVA to design the experiments and to find the optimum parameter levels among burnishing speed, feed, burnishing force and number of passes to give best output parameters viz., Surface finish and micro hardness. The results proved that all the parameters have significant effect on the above said two surface characteristics.*

1. INTRODUCTION

The convectional machining processes like turning and milling normally employed in order to produce the components metal working industries. During machining with these machine tools the cutting tool leaves tool scratches, tool marks or irregurities on the component. The traditional finishing processes used to produce fine surface finish on these components as a final operation in metal working process like grinding; lapping; honing etc gives required finishing by getting better surface finish but simultaneously induces tensile stresses on surfaces because of their chip removal based working nature. As a result components service life reduces. In other words the presence of compressive stresses increases life of components in their service period. Burnishing as shown in Fig. 1 along with increasing surface finish induces compressive stresses in surface by plastic deformation; also it improves hardness of the part burnished due to strain hardening.

The presence of compressive stresses and improved hardness in chip less finishing process i.e. burnishing further enhances properties like fatigue, wear resistance and corrosion resistance on surface. Reducing surface roughness reduces the friction to minimize the energy losses to increase its functional performance and also increases aesthetic look of the parts by producing mirror like surface finish. In burnishing the hard and finished roller or ball is pressed against the pre machined surface. The process is done on almost all convectional machine tools and with simple tool thus making this process economically cheaper than convectional finishing processes. The parameters selected in this work are speed, feed, force and number of passes, as they found more predominant in literature survey.

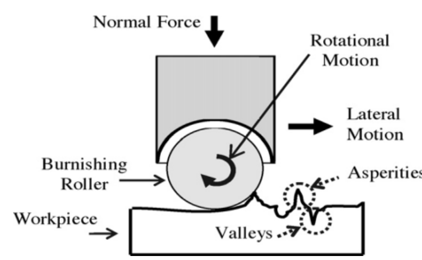

Fig. 1: Schematic representation of burnishing process

Many researchers have undertaken extensive work on burnishing processes. Classification of burnishing is given by [3]. A. M. Hassan [1] investigated the effect of burnishing parameters on surface roughness and hardness of non-ferrous metals like Al, Brass etc. Further, he also conducted experiments to find out the effect of burnishing process on wear resistance property of non ferrous metals [2]. El-Axir .M. H. [4] detailed description about roller burnishing process and effect of its parameter on surface finish and roughness using design of experiments. Statistical techniques viz. Factorial designs and Taguchi methods are used by many researchers [8-11] to optimize the parameters and suggested parameters to get surface finish and roughness at best level using ball burnishing process. The effect on tribological properties [5], residual stress distribution [7] are also became important outcomes of burnishing process. To conclude use of different burnishing processes, selection of different parameter, adapting suitable statistical tools, working on different work piece materials, objectives to find the surface characteristics and tribological related issues made this topic as hot selling one. The aim of this paper is to present the effect of parameters i.e. burnishing speed, feed, force and number of passes on surface finish of Aluminum2024-T4 material.

2. BURNISHING TOOL

It has been decided to conduct experiments in current work using roller burnishing among its two forms viz. ball and roller burnishing. The selection of the specific form of process is due to the fact that it becomes interesting in case of surface finish improvement. The self designed and fabricated roller burnishing tool is as shown in following Fig. 2. Detailed description is also give in Fig. 3. The tool assembly consists of many parts to perform smooth operation and to get fixed in simple, easily available lathe machine. It has 26mm OD & 10mm ID roller as a burnishing agent, made of carbon steel which is usually used as bearing and essentially finished to higher surface finish. This hard and soft roller is a cause for plastic deformation of the micro irregularities in the wok piece left after machining process. The spring measures force applied in the operation and the stiffness of the same is found by simple force- deflection experiments. The deflection in spring at different loads is shown in following figure.4

Fig. 2: Roller Burnishing Tool

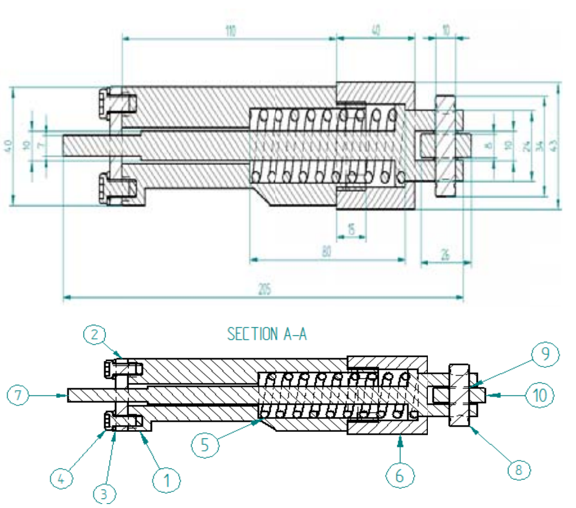

Fig. 3: Details of roller burnishing tool developed.

1. Lower body 2.locking plate 3. Spring washer 4. Nuts 5.spring 6. Upper body 7. Roller holder with tool shaft 8. Roller shaft 9. Roller washer 10. Roller (ball bearing)

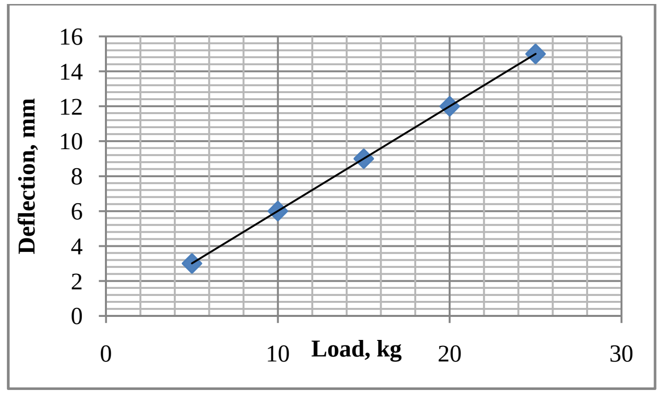

Fig. 4: Load vs. Deflection of spring.

3. TEST SPECIMEN (WORK PIECE)

Most of the engineering materials can be worked with hot or cold conditions to alter their microstructures to modify properties. But the Aluminum 2024-T4 is exception to this kind and cannot be hot or cold worked to modify its properties or to increase its hardness. So, commercially available Aluminum 2024-T4 is chosen as work piece in current work. First it is turned to 16 mm diameter from its raw size 18 mm diameter under said parameters to get certain level of constant surface finish on entire its surface and then it is divided into 9 parts to carry out burnishing process as per Taguchi's L9 array test conditions. The composition and properties of Aluminum 2024-T4 are given in table 1 and table.2

Table 1: Composition of Al-2024-T4

Cr	CU	Fe	Mg	Mn	Si	Zc	Balance
0.1	4.2	0.4	1.4	0.6	0.4	0.21	Al

Table 2: Properties of Al-2024-T4

Hardness	128 VHN
Ultimate tensile strength	320 Mpa
Tensile yield strength	457 MPa

4. TESTING EQUIPMENTS

The two output responses i.e. surface roughness and hardness were measured by using Surftronic 3+ Surface Finish Testing equipment as shown in following Fig. 5 and Vickers hardness testing machine. On each work piece three readings were taken for the above tests on different points on entire length of the work piece and then average value is taken in order to reduce error.

Fig. 5. Surftronic 3+ surface finish tester.

Fig. 6: Roller burnishing operation.Experimental Details

The experiments are designed using Taguchi's L9 orthogonal array and conducted in all geared lathe as shown in Fig. 6. The unique advantage of this technique is it offers a simple and systematic approach to optimize design for performance, quality and cost. The effect of four input parameters namely burnishing or spindle speed (rpm), and feed (mm per revolution), force (kg) and number of passes are studied in present work on surface finish. Parameters and their coded levels are given in table 3. The experiments are conducted at 9 different parameters settings as per L9 array to investigate the effect of parameters at three different levels. The experimental runs are given in table 4.

Table 3: Parameters and their levels in coded form

Parameters/ levels	Level 1	Level 2	Level 3
Speed, rpm	510	770	1170
Feed, mm/rev	0.049	0.098	0.152
Load, Kg	5	7	10
Number of pass	1	2	3

Table 4: Taguchi L9 array

Run	1	2	3	4
1	510 (1)	0.049 (1)	5 (1)	1 (1)
2	510 (1)	0.098 (2)	7 (2)	2 (2)
3	510 (1)	0.152 (3)	10(3)	3 (3)
4	770 (2)	0.049 (1)	7 (2)	3 (3)
5	770 (2)	0.098 (2)	10(3)	1 (1)
6	770 (2)	0.152 (3)	5 (1)	2 (2)
7	1170(3)	0.049 (1)	10(3)	2 (2)
8	1170(3)	0.098 (2)	5 (1)	3 (3)
9	1170(3)	0.152 (3)	7 (2)	1 (1)

5. RESULTS

Experimental values of the tests are given in table 5. Table 6 shows the average values of The graph drawn between burnishing speed and surface roughness is shown in Fig. 7 indicates that when speed increases the roughness value starts decreases and next increases with increases in speed. This is due to fact that at lower speed the plastic deformation will be less and at higher speed the chattering in tool causes deterioration of finish producing higher surface roughness. Hence moderate level of speed is required to get better surface finish. Fig. 8 shows effect of feed on surface roughness. As feed level increases roughness value decreases. This is due to fact that, increase in feed decreases the distance between consecutive peaks present on surface. At lesser feed rates the time available to deform the peak elements on the will be more which decreases increase with the same. The load is found to have significant effect on roughness as shown in Fig. 9 As load increases from 5 kg to 7 kg the effect is less on roughness level but it drastically increases as load is increased to 10 kg. The reason may be at higher load level the plastic deformation increases in the workpiece and this leads to flaking or chattering effect in tool, thus increases roughness. Fig. 10 indicates that lower number of passes is sufficient to produce better finish at surface. As passes number increases to 2, the value comes down. This is unexpected, since the deformation increases producing higher finish at surface as number of passes increases to 2 and further increase in passes increases over hardening reducing roughness level of surface.

Table 5: Experimental observations

Runs	Trial 1	Trial 2	Trial 3	S/N Rati0
1	0.42	0.4	0.44	7.52
2	0.5	0.44	0.44	6.73
3	0.48	0.6	0.42	5.92
4	0.58	0.56	0.52	5.13
5	0.52	0.58	0.62	4.81
6	0.82	0.78	0.72	2.22
7	0.28	0.28	0.22	11.64
8	0.74	0.82	0.94	1.541
9	0.93	1.06	1.04	-.1003

Table 6: Average Values and main Effects of Surface Roughness in Roller Burnishing

Process paramete r	level	Speed		feed		load		NOP	
Types of data		Raw data	S/N data	Raw data	S/N data	Raw data	S/N data	Raw data	S/N data

Average values	L1	0.46	6.72	0.46	8.1	0.67	3.76	0.66	4.07
	L2	0.63	4.05	0.62	4.35	0.67	3.91	0.49	6.86
	L3	0.7	4.36	0.76	2.68	0.44	7.46	0.62	4.19
Main effects	L2-L1	0.17	-2.67	0.16	-3.75	0	0.15	-0.17	2.79
	L3-L2	0.07	0.31	0.14	-1.62	-0.23	3.55	0.13	-2.67

Table 7: Pooled ANOVA (Raw data)

Source	DOF	SS	MSS	F-Ratio	SS*	P%
Speed, rpm	2	0.0914	0.0457	17.57	0.09	20.93
Feed, mm/rev	2	0.1379	0.0687	25.92	0.14	32.60
Load, kg	2	0.1058	0.0529	20.84	0.10	23.25
No. of Passes	2	0.0477	0.0239	9.19	0.05	11.63
Error	18	0.0472	0.0026		0.05	11.63
Total	26	0.430			0.430	100

Table 8: Pooled ANOVA (S/N data)

Source	DOF	SS	MSS	F-Ratio	SS*	P%
Speed, rpm	2	12.79	6.397	-	12.79	13
Feed, mm/rev	2	46.22	23.11	-	46.22	46
Load, kg	2	26.31	13.15	-	26.31	26
No. of Passes	2	14.92	7.463	-	14.92	15
Error	0	0.4571	0		0.4571	negligible
Total	8	100.6971			100.6971	100

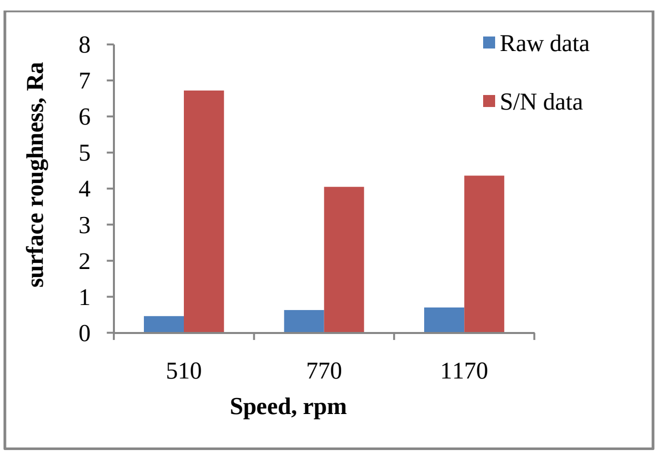

Fig. 7: Effect of burnishing speed on surface roughness, Ra.

Fig. 11 and 12 gives the contribution of individual parameters on surface roughness. Accordingly Feed is found to be effective parameter and Speed is less significant one. Table 6, 7 and 8 shows the ANOVA values for the results of surface roughness. the optimum parameter level to get better surface finish will be S1 F1 L3 N2.

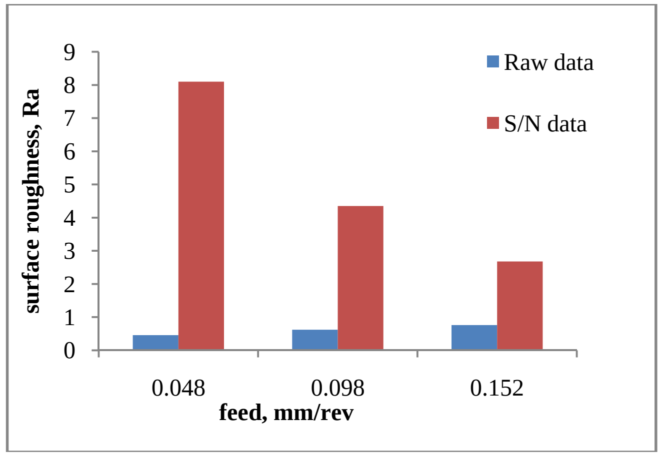

Fig. 7: Effect of burnishing feed on surface roughness, Ra.

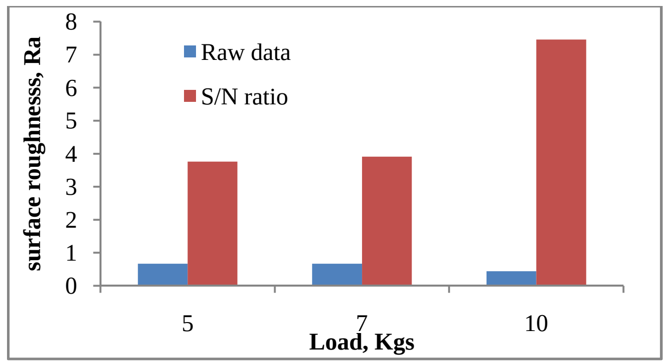

Fig. 8: Effect of load on surface roughness, Ra.

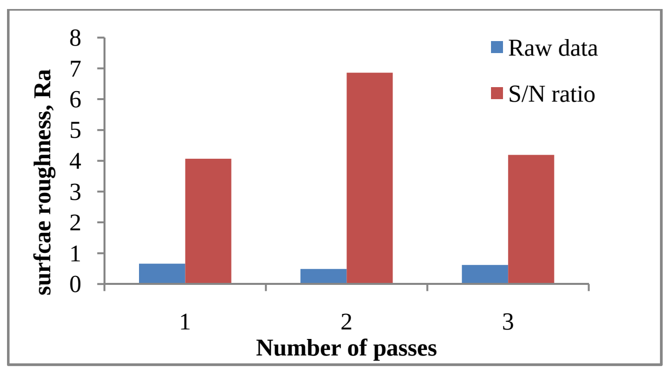

Fig. 9: Effect of number of passes on surface roughness, Ra.

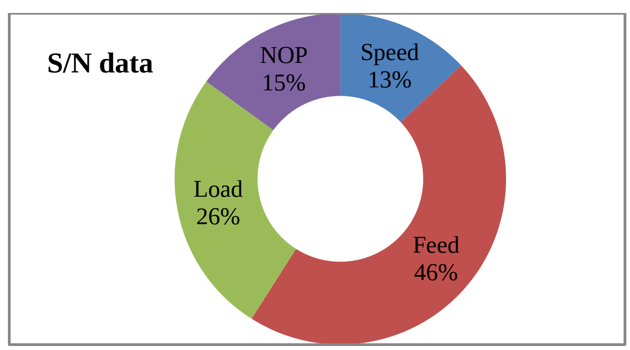

Fig. 10: Effect of parameters.

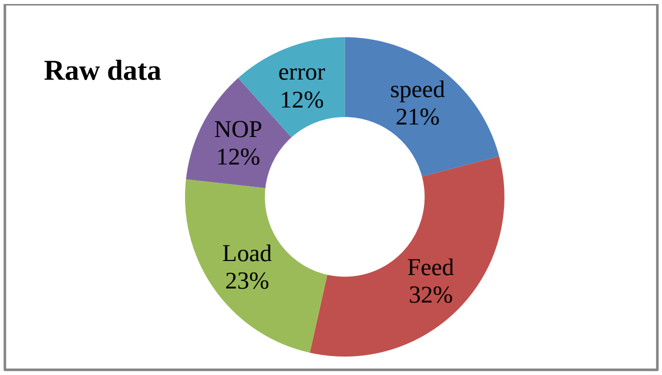

Fig. 11: Effect of parameters

6. CONCLUSIONS

The roller burnishing tool can be used as a promising finishing method based on the results obtained in this process. Within the test conditions the following conclusions can be drawn:

1. The burnishing process can be used as effective finishing process for Aluminum 2024-T4 material, which is difficult to work with heat treatment processes to increase properties
2. The roughness value can be brought down to 0.22 µm
3. Feed is having 46% effect on the surface roughness, hence to be controlled properly
4. Believed that due to plastic deformation hardness at surface also increased
5. The parameters feed, load contributes more to the surface roughness
6. The burnishing tool can be fixed to the same machine tool in which turning is carried out thus reduces tool set up time
7. It Can be easily applied on all materials as a finishing technique, with lower cost tool

REFERENCES

[1] Hassan, A.M. and A.S. Al-Bsharat, "Influence of burnishing process on surface roughness, hardness, and microstructure of some non-ferrous metals', *Wear*, 1996, 199: 1-8.

[2] Hassan, A.M. and A.D. Sulieman, "Improvement in the wear resistance of brass components by the ball burnishing process", 1999.

[3] Shneider, Y.G., "Classification of metal-burnished methods and tools", *Mach. Tool. XL*, 1969, 1: 35.

[4] El-Axir, M.H., "An investigation into roller burnishing", *Int. J. Mach. Tool Manuf.*, 40: 1603-1617.

[5] El-Tayeb, N.S.M., K.O. Low and P.V. Brevern, "Enhancement of Surface Quality and Tribological Properties During Ball Burnishing Process:, *Proceedings of the ICOMAST, Melaka, Malaysia, GKH Press,* ISBN: 983-42051-1-2, 2006, pp: 335-340.

[6] Fattouh, M., M.H. El-Axir and S.M. Serage, "Investigation into the burnishing of external cylindrical surface of 70/30 Cu-Zn-alloy", *Wear*, 1988. ,127:123-137.

[7] Fattouh, M. and M.M. El-Khabeery, "Residual stress distribution in burnishing solution treated and aged 7075 aluminum alloy", *Int. J. Mach. Tools Manuf.*, 1989, 29(1): 53.

[8] Loh, N.H., S.C. Tam and S. Miyazawa, "A study of the effects of ball burnishing parameters on surface roughness using factorial design", *J. Mech. Working Technol.*, 1989, 18: 53-61.

[9] Loh, N.H., S.C. Tam and S. Miyazawa, "Statistical analyses of the effects of ball burnishing parameters on surface hardness", *Wear*, 1989, 235:243.

[10] Ugur Esme, "Use of grey based taguchi method in ball Burnishing process for the optimization of Surface roughness and microhardness of AA7075 aluminum alloy", *Materials and technology* 44 (2010) 3, 129–135.

[11] C. S. Jawalkar and R. S. Walia, "Study of roller burnishing process on En-8 specimens using design of experiments", *Journal of Mechanical Engineering Research* Vol. 1(1), 2009, pp. 038-045.