IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 3 Ver. I (May- Jun. 2016), PP 21-26
www.iosrjournals.org

Parametric Optimization of Roller Burnishing Process for Surface Roughness

R. G. Solanki[1], K. A. Patel[2], R. B. Dhruv[3]

[1]*(ME scholar, LDRP ITR, Gandhinagar)*
[2]*(Lecturer, LDRP ITR, Gandhinagar)*
[3]*(Lecturer, Govt. Polytechnic, Himatnagar)*

Abstract: *Better surface quality and longer functionality of cylindrical parts are the demands of the industries such as automobile, aircraft, machine tool, pneumatic and hydraulic equipment, railways and so on.Burnishing is considered as a chipless cold working finishing process and improves the surface finish of workpieces that have been previously machined. In Roller burnishing, Surface finish is achieved by flattening the rough peaks by compressive force of the rollers.*

In thispresent experimental work Al 6061 is used as the work piece material and the main aim isto develop a burnishing process having optimum process parameters for obtaining smooth surface finish for a solid cylindrical component. The burnishing parameters considered for this study are: Speed, Feed, Interference and Number of passes. The experiments are designed on the Taguchi's L25(4 factors & 5 levels) orthogonal array andperformed on lathe machine.The enhancement in surface roughness of roller burnished samples of Aluminum 6061 has been observed.The optimal burnishing parameters for minimum surface roughness is obtained at speed=400 rpm, feed= 0.065 mm/rev, Interference=3.25 mm and No. of tool passes=5.Also confirmation tests are conducted and results are verified.

Keywords: Roller burnishing, *Taguchi method, Surface roughness*

I. Introduction

To ensure reliable performance and prolonged service life of modern machinery, its components require to be manufactured with high surface finish and a more widely used method of surface finishing is burnishing. Burnishing process has gained higher acceptability in the industries not just because of its surface finishing capabilities, but due to many other surface characteristics that are enhanced by burnishing. In burnishing, As the pressure exceeds the yield point of the work piece material, plastic deformation at surface takes place. Due to this metal displacement takes place i.e. peaks on the machined surface are caused to flow into the valleys, which causes to reduce the height of the peaks of the machined surface as shown in fig 1. In this study surface roughness is the main response variable and the parameters considered are spindle speed in rpm, feed in mm/rev, Interference in mm and number of passes. In burnishing process, the metal on the surface of the work piece is redistributed without material loss.

Burnishing process is specially used where surface roughness value (Ra) play important role along with super finish of surface. To control the roughness value (Ra) with different machining parameters burnishing process is used. Roller burnishing process is used to produce accurately sized machined components finished with densely compacted surface.

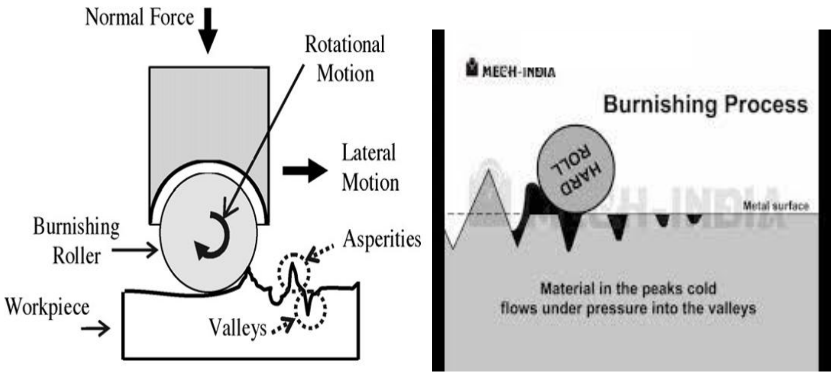

Fig 1 Basic principle of burnishing

II. Literature Review

Many investigations of burnishing processes have been focused on the roller burnishing process, due to its advantages, such as flexibility, simplicity, cost-effectiveness, etc.

Revenger et al. [1] used the Taguchi method for the optimization and analysis of burnishing parameters (i.e. burnishing speed, feed, force and number of passes) and the output parameters were surface roughness and surface hardness. The optimization results revealed that burnishing feed and speed are significant parameters to minimize the surfaceRoughness, while burnishing force and number of passes play important roles to maximize the hardness.The experimental work on 6061-aluminum alloy carried out using Taguchi method by M. H. EL-AXIR et al. [2]. The effect of burnishing parameters; namely, burnishing speed, burnishing feed, depth of penetration and number of passes on the surface finish and fatigue life were investigated. They found that the optimal burnishing parameters for the best surface finish were: burnishing speed =25m/min, burnishing feed =60 μm/rev, depth of penetration =6 μm/rev and number of passes = 1. The optimum performance for fatigue life was obtained at burnishing speed of 125m/min, burnishing feed of 100μm/rev, depth of penetration of 9μm and No. of passes of 3.Malleswara Rao J. Net al. [3] Studied the Roller Burnishing Process using Design of Experiments and experiments were done on Aluminium work Pieces. In this,surface roughness is the output parameter and the burnishing parameters considered were spindle speed, feed and number of tool passes.Design of Experiments (Taguchi) techniques determines simultaneously the individual and interactive effects of many factors which affects the output results in any design.The finest Ravalueobserved is 0.32 µm. The burnishing process is superior over the others due to its Excellent surface finish as well as an increase in surface hardness.

The most important parameters of burnishing process are force, speed, feed and number of tool passes. Most of the research work for optimization of burnishing process focused on these parameters. The effect of the process parameters – burnishing force, speed, feed and number of tool passes on the surface roughness, micro-hardness, improvement ratio of surface roughnessandsurface micro-hardness were studied by El-Taweelet al.[4]. They optimized these parameters using Taguchi’s technique. The contribution effect of each parameter on certain considered characteristics was determined by ANOVA. The results showed that burnishing force has a contribution effect of 39% on surface roughness and 42% on micro-hardness. Roller burnishing of internal surfaces of mild steel specimen for improved surface finish was studied by P RavindraBabuet al.[5]. In this study, they proposed two tools to perform the internal roller burnishing. They studied the effect of burnishing speed on the surface roughness and surface hardness. They found that the surface finish and surface hardness increases as burnishing speed increases up to an optimum value of 62 m/min and then decreases. M.R. Stalin John et al.[6] used response surface methodology for optimization of the process parameters for tool steel material work pieces. The input parameters are burnishing force, feed, speed and number of passes. The optimum surface roughness and its surface hardness are 0.17 µm and 35.99 HRC respectively. The surface roughness has reduced by 88.8% and hardness has improved by 33.14%. AysunSagbas et al. [7] studied the effect of burnishing parameters i.e. burnishing force, feed rate and number of tool passes on the surface hardness and for that full factorial design and analysis of variance (ANOVA) was used. From the experiments designed on the base of Taguchi’s L9 orthogonal array,Optimal ball burnishing parameters were determined and they were: the burnishing force at 200 N, number of passes at 4, feed rate at 0.25 mm/r. The surface roughness and Hardness were investigated by S. Thamizhmnaiiet al. [8] by using a multi roller burnishing tool on square titanium alloy material. The variables considered for the study were sliding speed/ spindle speed, feed rate and depth of penetration. They concluded that the roller burnishing is very useful process to improve upon surface roughness and hardness, to impart compressive stress and to improve fatigue life. The titanium alloy is a difficult to machine and burnishing is difficult process for this grade material also flaws and micro cracks on the surface of work piece were developed by increasing burnishing parameters. Dr. M. Satya Narayana Gupta et al. [9] studied the effect of burnishing parameters on surface roughness. The input parameters were burnishing speed, burnishing feed and number of passes. The experiments were conducted on MS specimens based on design of experiments (DOE) to reduce the number of experiments. The results revealed that surface roughness decreases as the burnishing feed, speed and number of passes decreases.Khalid. S. Rababa et al. [10] presented the experimental results of burnishing with a diamond pressing process having different pressing force i.e.105N, 140N, 175N, 210N. The results showed that the stress of material has been increased of about 150 MPa. The improvement in surface quality has been observed by 12.5%. finally, the U.T.S. has been increased by 166 MPa.

III. Experimental Detail

In this current research work, an attempt is made to understand the improvement in the surface finish of burnished surface as well as the study of the process parameters on Aluminium material.

IV. Workpiece Material& Tool

Al alloy 6061 is used for the present investigation due to its wide variety of industrial applications. The typical composition of the experimental materials is given in Table.3.2

Table1 Typical composition of aluminum alloy 6061

Component	Al	Mg	Si	Fe	Cu	Zn	Ti	Mn	Cr	Others
Amount (Wt %)	Balance	0.8-1.2	0.4 – 0.8	Max. 0.7	0.15-0.40	Max. 0.25	Max. 0.15	Max. 0.15	0.04-0.35	0.05

A single roller carbide burnishing tool of diameter 40 mm as shown in fig 2 is used to perform the burnishing experiments.

Fig 2 Single roller burnishing tool

V. Work Piece Preparation

Burnishing experiments are conducted on conventional lathe.The Lathe Machine Tool has the following specifications shown in Table 1. Al 6061 work piece which is in the form of round bars of 42 mm diameter and 300 mm length is turned to 40 mm diameter having 5 steps and grooves in between them. The length of each groove is taken as 10 mm between each 40 mm step. In actual experiments, by applying different parameters on each step, this long work piece can be utilized as 5 different specimens. The aluminium work picese after turning and The basic tool and setup used for burnishing are shown in Fig.3 & fig 4 respectively.

Fig 3 AL 6061 alloy Workpiece after Turning

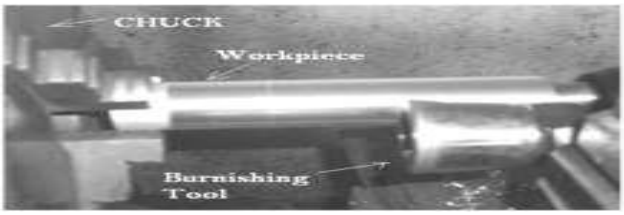

Fig. 4Experimental set up

Table 2 Lathe m/c specification

DSB SUPER PRIZE 1650/1000 LATHE	
Height of Centre	200 mm
Centre Distance	1000 mm
Swing over bed	400 mm
Swing over cross slide	260 mm
width of Gap	176 mm

VI. Taguchi Method

Taguchi employs the design of experiments based on "Orthogonal Arrays" (OA) that are specially constructed table to treat the design process. According to Taguchi, the quality is built into the product during the product design stage. Orthogonal Arrays are the special set of Latin squares to lay-out the product design experiments.The selected Burnishing process parameters with their different levels are tabulated as shown in table3. In this study,the results have been checked by the use of Taguchi L25 Orthogonal array which has 25 rows corresponding to the number of experimental runs (24 degree of freedom) and 4 columns corresponding to 4 parameters at five levels.The first column of table is assigned to speed, the second to the feed rate, the third column is assigned to the Interference and the forth column to no. of tool passes. In this, total 25 experimental run must be conducted using the combination of levels for each independent factor (speed, feed, Interference, and no. of tool passes) and the experimental results are then transferred to Signal to Noise (S/N) ratio. The smaller-the-better characteristic is used to calculate the S/N ratio for minimum surface roughness. Surface roughness is measured with the help of SJ-210 Mitutoyo surface roughness tester and observations are tabulated as shown in table4.

Table 3 Range and level of parameters selected

Factors	Level 1	Level 2	Level 3	Level 4	Level 5
Burnishing speed(rpm)	75	270	400	620	980
Burnishing feed (mm/rev)	0.065	0.078	0.092	0.102	0.127
Intereferance(mm)	1	1.75	2.5	3.25	4
No. of Tool passes	1	2	3	4	5

Table4 Observation Table

Ex. No.	Parameters				Surface roughness Ra (μm)
	Speed (RPM)	Feed (mm/rev)	Interference (mm)	No. of Tool passes	
1	75	0.065	1	1	0.911
2	75	0.078	1.75	2	1.042
3	75	0.092	2.5	3	1.480
4	75	0.102	3.25	4	1.050
5	75	0.127	4	5	0.430
6	270	0.065	1.75	3	1.259
7	270	0.078	2.5	4	0.585
8	270	0.092	3.25	5	0.477
9	270	0.102	4	1	1.330
10	270	0.127	1	2	2.226
11	400	0.065	2.5	5	0.429
12	400	0.078	3.25	1	0.711
13	400	0.092	4	2	0.569
14	400	0.102	1	3	0.870
15	400	0.127	1.75	4	0.534
16	620	0.065	3.25	2	0.561
17	620	0.078	4	3	0.743
18	620	0.092	1	4	0.956
19	620	0.102	1.75	5	0.490
20	620	0.127	2.5	1	0.966
21	980	0.065	4	4	0.445
22	980	0.078	1	5	0.720
23	980	0.092	1.75	1	0.731
24	980	0.102	2.5	2	0.697
25	980	0.127	3.25	3	0.641

VII. Result &Discussion

According Taguchi orthogonal array L25, the experiments are performed as per the levels and factors mentioned in TABLE 4. The results of Surface Roughness are obtained after performing burnishing operations for all 25 workpieces. Each workpiece represented one experiment as shown in the orthogonal array TABLE 4. The experimental results for burnishing test under the application of four parameters are recorded. Latter, the results were analysed by employing main effects, and the signal-to-noise ratio (S/N) analyses. Also to compare the experimental results with the estimated results Confirmation test has been carried out.

As Surface roughness should be as minimumas possible, the S/N ratio of "smaller-the-better" type of quality characteristic is used and recorded.

$S/N = -10 * \log (\Sigma (Y2)/n))$

The S/N ratios have been calculated to find out the effects of different parameters as well as their levels.

Table 5 Response Table for Signal to Noise Ratios for Ra (Smaller is better)

Level	Speed	Feed	Interference	No. of Tool passes
1	0.79125	3.64329	-0.33666	0.86227
2	-0.06947	2.53679	2.40164	1.14871
3	4.37230	2.20551	2.40595	0.45135
4	2.89825	1.53029	3.57131	3.42149
5	3.92264	1.99908	3.87272	6.03114
Delta	4.44177	2.11300	4.20938	5.57979
Rank	2	4	3	1

Table 6 Response Table for Means for Ra

Level	Speed	Feed	Interference	No. of Tool passes
1	0.9825	0.7209	1.1365	0.9299
2	1.1755	0.7604	0.8113	0.0190
3	0.6227	0.8427	0.8315	0.9984
4	0.7432	0.8873	0.6879	0.7140
5	0.6467	0.9593	0.7035	0.5093
Delta	0.5528	0.2384	0.4485	0.5097
Rank	1	4	3	2

A. Main Effect: The presence of main effect is observed when different levels of a factor affect the response differently. Fig 5 shows the main effects plot for the response mean at each parameter level. The surface roughness values for each parameter at each level is obtained from Minitab 17.

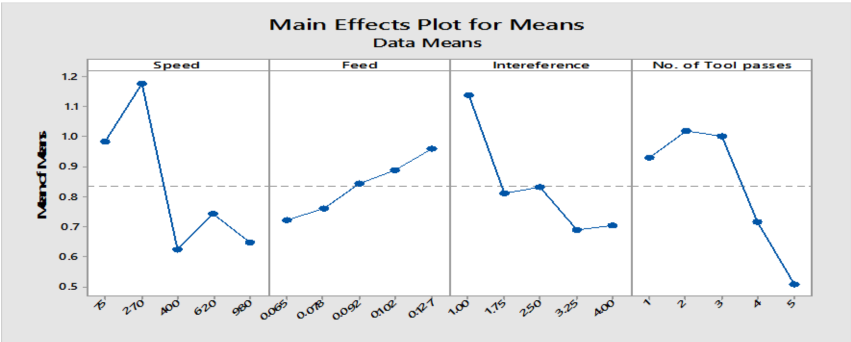

Fig 5 Main Effect plots for Means for Ra

B. S/N Ratio: Responses relative to the nominal value under different-different noise conditions is measured with the help of signal-to-noise (S/N) ratio. In this study, the response quality characteristic of "smaller-is-better"typeis used i.e. the smaller surface roughness is better in experiment. Main effects plot for SN ratios are obtained using Minitab 17.

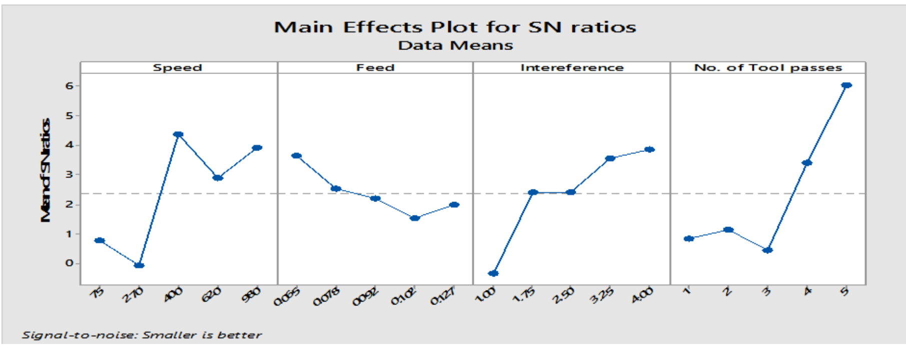

Fig 6 Main Effect plots for SN ratios for Ra

- By analysing the SN ratio, the optimal parameter combination for minimum surface roughness is obtained and The optimal parameters for surface roughness from fig 5 are tabulated as below:

Table 7 Optimum condition for Minimum Surface roughness

burnishing speed	feed rate	Interference	No. of passes
400 rpm	0.065 mm/rev	3.25 mm	5

VIII. Confirmtion Test

To verify the results drawn based on Taguchi's design approach, the experimental confirmation test is very crucial step.The confirmation test is conducted at the optimum condition of the process parameters as per table 7 and the result of the confirmation experiment for surface roughness is shown in **Table 8**.

Table 8 Confirmation test result

Response value	Surface roughness (µm)
Predicted value	0.038
Actual value	0.055

IX. Conclusions

This experimental work has led to the following conclusions.

- A single roller Burnishing Tool can successfully be used to obtain the superior finish for outer surface of Al6061.
- It has been established that taguchi analysis is an effective optimization technique.
- Speed has the greatest influence on the surface roughness followed by No. of tool passes and then Interference. Feed has the least effect on the surface roughness.
- As Speed increases, small change in surface roughness value and further increase in speed surface roughnessdecreases to lowest. Maximum surface finish is obtained at 400 rpm.
- As Feed increases, surface roughness increases.
- As No. of burnishing tool passes increases, the surface roughness initially increases, but after 2^{nd} No. of pass, it starts to decrease & at 5^{th}passreaches to a minimum value.
- Optimum condition for minimum surface roughness is obtained at 400 rpm speed, 0.065 mm/rev feed, 3.25 mm Interference and 5 No. of tool passes.
- Initial surface roughness of turned specimen is 2.511 µm whereas at optimum condition of burnishing process, it is 0.055 µm.

References

[1] G.Revankar, R. Shetty, S. Rao, and V. Gaitonde, Selection of optimal process parameters in ball burnishing of titanium alloy, Machining Science and Technology,18(3), 2014, 464-483.

[2] M. El-axir, and M. El-khabeery, Ball burnishing process optimization for Aluminium alloy using taguchi technique, International Journal of Mechanical Engineering, 1(3),2014,1-14.

[3] J. Rao, A.Reddy,andP. Rama Rao, Study of roller burnishing process on Aluminium work pieces using design of experiments,International Journal of Mechanical Engineering and Technology (IJMET), 1(2),2011,0976-6340.

[4] T. El-TaweelandM. El-axir,Analysis and optimization of the ball burnishing process through the Taguchi technique, The International Journal of Advanced Manufacturing Technology,3(41),2009,301-310.

[5] P.RBabu, T. SPrasad, AVSRaju,andAJBabu, Effect of internal roller burnishing on surface roughness and surface hardness of mild steel,Journal of Scientific and Industrial Research,1(68),2009,29-31.

[6] M. Stalin John, and B. K. Vinayagam, Optimization of Roller Burnishing Process on Tool Steel Material using Response Surface Methodology,Journal of Machining and Forming Technologies,3-4(3),2011,1-18.

[7] A. Sagbas, and F. Kahraman, Determination of optimal ball burnishing parameters for surface hardness, Materiali in tehnologije,5(43),2009,271-274.

[8] S. Thamizhmnaii, B. Bin Omar, S. Saparudin, and S. Hasan, Surface roughness investigation and hardness by burnishing on titanium alloy,Journal of Achievements in Materials and Manufacturing Engineering,2(28), 2008,139-142.

[9] M. S Gupta, D.Ramana Reddy and G.ThirupathiReddy,Effect of Roller Burnishing Parameters On Surface Roughness and Hardness,International Journal of Engineering Research and Applications,2015,50-54.

[10] KRababa, and M Al-mahasne, Effect of roller burnishing on the mechanical behavior and surface quality of O1 alloy steel,Research Journal of Applied Sciences, Engineering and Technology,3(3),2011,227-233.