Analysis of Effect of Ball and Roller Burnishing Processes on Surface Roughness on EN8 Steel

Mr. N. M. Qureshi
Assistant Professor (Mechanical Engineering)
D. Y. Patil College of Engineering and Technology,
Dist-Kolhapur, Maharashtra, India.

Mr. Vaibhav B. Patil, Mr. Basavaraj D. Teli,
Miss. Radhika S. Mohite and Miss. Sonal S. Patil
BE MECHANICAL, Department of Mechanical Engineering; D. Y. Patil College of Engineering and Technology, Dist-Kolhapur, Maharashtra, India.

***Abstract* - This experimental study focuses on effect of various parameters and optimization of burnishing processes on surface finish of EN8 material during burnishing operation. In industry area use various surface finishing operations such as lapping, honing, etc. which is removal of the material from its surface. In the present experimentation, ball and roller burnishing processes which is plastic deformation are used with varying machining parameters to achieve the desirable surface finish. The experiment is carried out on the CNC machine of a particular job of EN8 material. By use of the Taguchi methodology optimum machining parameters obtained gives improved surface finish.**

Keywords- Surface Finish, Ball and Roller Burnishing process, Taguchi Methodology.

I. INTRODUCTION

In this cold-working method, a large contact pressure is exerted on the surface of the work piece by a smooth roller or a ball burnishing tool to cause plastic deformation of surface irregularities without removing the material. The high burnishing pressure exceeding the yield strength causes roughness peaks to flow towards the valleys which suppress all the texture of the rough surface, resulting in smoother surfaces [1]. The burnishing process produces a good surface finish, increases dimensional and shape accuracy, enhances surface hardness and also induces residual compressive stresses at the metallic surface layers [2]. This method can be carried out using conventional machines, such as lathe machine. On account of its high productivity, it also saves more on production costs than other conventional processes such as super finishing, honing and grinding. Moreover, the burnished surface has a high wear resistance and better fatigue life [2].

The figure 1 shows the actual mechanism of burnishing process of plastic deformation with the movement of burnishing tool over the work piece. By use of the Taguchi methodology the burnishing parameters are analysed and optimisation to achieve considerable surface finish [6].

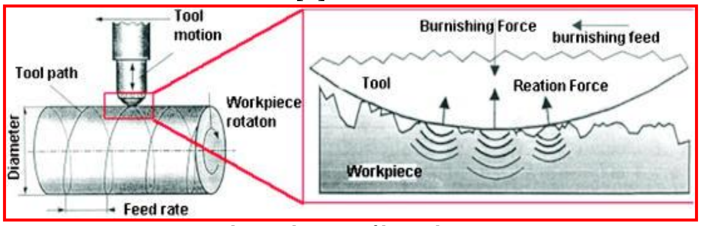


Figure 1: The mechanism of burnishing process

II. BENEFITS OF BURNISHING PROCESS

Burnishing process can provide the following benefits especially as following,

a) Polished surface finish
b) Dimensional Consistency and accuracy
c) Minimize the reworks and rejections
d) More utilization of machining capabilities
e) No chip accumulation

III. THE EFFECT OF VARIOUS BURNISHING PARAMETERS ON SURFACE ROUGHNESS

A. *Depth of Penetration*

As increase in the depth of Penetration results increase in burnishing force, the roughness value decreases up to a certain point and then starts to increase. The force at that point is termed the optimum force and optimum depth of penetration. It depends on various factors: material being burnished, burnishing speed, ball diameter, pre-machined surface finish, feed-rate and frequency of oscillation [3].

B. *Feed-rate*

The height of the irregularities and hence the transverse surface roughness is determined by the feed-rate of the ball which is in the general range of 0.1 to 0.2 mm/rev. The figure 2 shows a smaller feed-rate f_2 gives irregularities of lower height h_2, and hence better surface finish. The use of feed-rate is dependent on other factors such as ball diameter, burnishing speed and depth of penetration. With a larger ball diameter, the feed-rate can be increased as the factors have opposite effects on the surface irregularities. Figure 2 shows the height of the irregularities (shaded area) formed by varying the feed-rate [3].

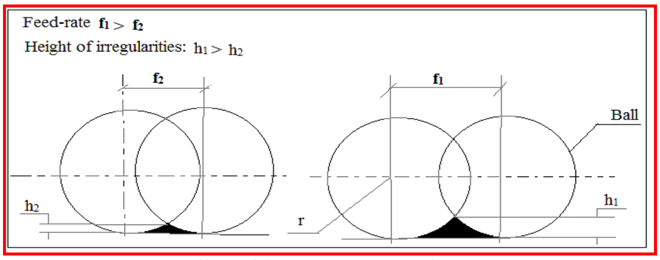


Figure 2: Effect of feed-rate on the surface roughness

C. Burnishing speed

As the speed increases the surface roughness start to decreases due to increases in compressive deforming force and the stability of burnishing tool at high speed. But up to a certain value of speed then it starts to decrease.

D. Number of burnishing passes

When number of passes is used more, more surface irregularities are suppress into the valley which reduce the surface roughness, but the number of passes must be optimum to avoid increase in machining cycle time.

E. Burnishing tool size

The height of irregularities is inversely proportional to tool contact size used as more contact area between work piece and tool. Thus, as the burnishing tool size increases surface finish improves [3].

IV. WORK PIECE MATERIAL AND ITS PROPERTIES

EN8 also known as 080M40 unalloyed medium carbon steel. It is a medium strength steel, and has good tensile strength.

A. EN-8 Steel (080M40) Specifications

Table I
Chemical Composition (In Percentages)

C	Mn	Si	P	S
0.35-0.45	0.60	0.35	0.015	0.015-0.6

B. Mechanical Properties

- Hardness = 201 to 255 BHN.
- Yield stress = 465 MPa.
- Max Stress = 700 to 850 MPa.
- Tensile Stress = 550 MPa.
- Elongation % = 16.
- Length of each compartment= 40mm.
- Diameter= 30mm.
- Number of trial compartments for each process= 16.

V. TOOL MATERIAL AND PROPERTIES

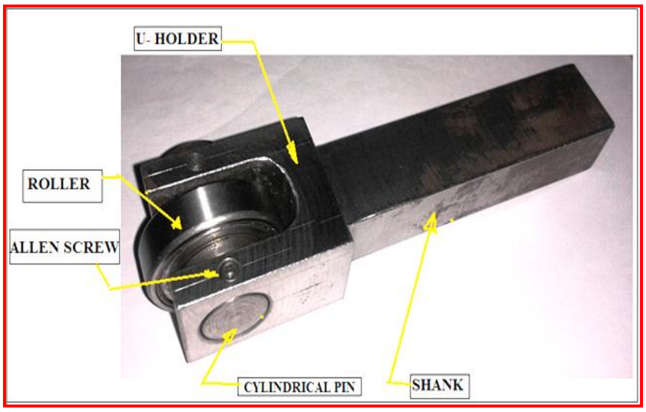


Figure 3: The roller burnishing tool

Figure 4: The ball burnishing tool

Parts used for tool assembly are

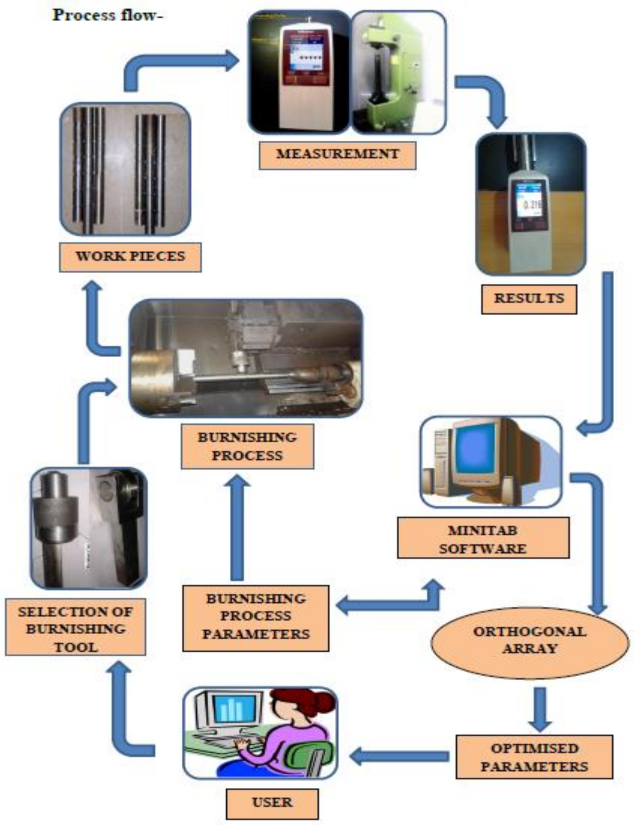
1. Ball bearing:
   - Hardness of bearing of outer case= 700 BHN.
   - Surface roughness value= 0.12 micron.
   - Inner diameter= 20 mm.
   - Outer diameter= 42 mm.
   - Face width= 12 mm.
2. Roller holder
3. Cylindrical pin
4. Side bush, Allen screw for holding bearing in the tool at exact center [9] [12].

Table II
Chemical composition of ball bearing (In percentage)

C	Cr	Mn	Si	Ni
1.05	0.13	0.05	0.03	0.018

- Ball hardness= 771 BHN.
- Ball surface roughness= 0.12 micron.

VI. METHODOLOGY



International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 06, June-2015

VII. EXPERIMENTAL SET UP

The experiment is carried out on CNC Machine. The set-up is as shown in figure 6 and 7.

Figure 5: Photograph of CNC Machine

Table III
CNC Machine specifications

Sr. No.	Parameters	Capacity
1	Capacity	20 KW
2	Input Voltage	415 Volts
3	Input Power	20 KW
4	Spindle Speed Range	50 to 4000 rpm
5	Max. Rapid Speed	24000 mm/min.
6	Name of Axes Drive	FANUC

The experiment is performed on CNC machine on each compartments of work piece with the different parameters as shown in figure 6 and 7. Total L16 experimental runs were carried out as shown in table IV.

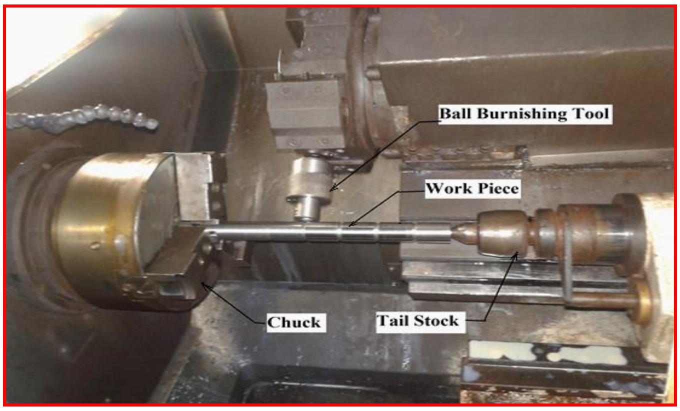


Figure 6: Ball burnishing process on CNC Machine

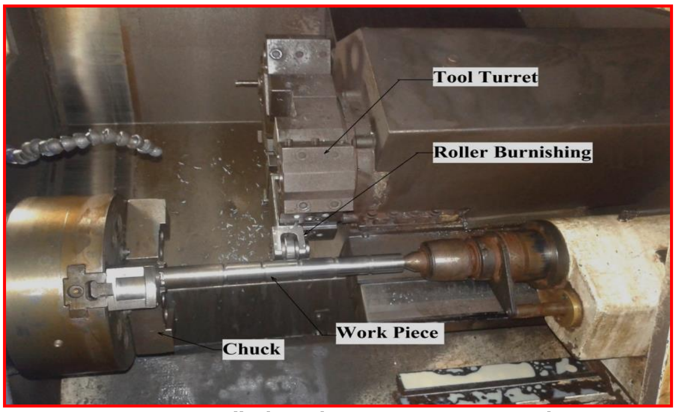


Figure 7: Roller burnishing process on CNC Machine

- Total number of trial taken for each process = 16.
- Trial compartment diameter 30 mm and 40 mm length.

Table IV
Machining Parameters and their levels for Ball Burnishing and Roller Burnishing Processes

Parameters	Level 1	Level 2	Level 3	Level 4
Speed (rpm)	200	500	800	1100
Feed (mm/rev)	0.05	0.3	0.7	1
Depth of Penetration (mm)	0.2	0.3	0.4	0.5
Number of passes	1	2	3	4

The Experiments are performed as per Taguchi methodology with L16 orthogonal array created in Minitab- 17 software. The range of the burnishing parameters used in this experiment shown in Table V and Table VI.

VIII. WORK PIECE AFTER BURNISHING

Figure 8: Burnished work piece

The surface roughness of burnished work piece is measured by use of Mitutoyo Surface Roughness Tester SG 210 as shown in figure 9 and Table V and VI shows the Roughness Average (Ra) value of Roller burnishing and Ball burnishing process respectively.

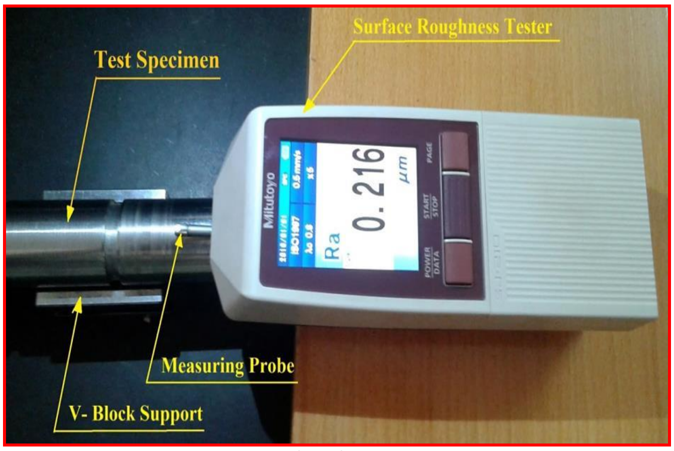


Figure 9: Photograph of Surface Roughness testing set up

Table V: Ra value for Roller Burnished components:

Sr. No.	Speed (rpm)	Feed (mm/rev)	DOP (mm)	NOP	Surface Roughness Ra (micron)
1	200	0.05	0.2	1	1.219
2	200	0.30	0.3	2	1.574
3	200	0.70	0.4	3	1.472
4	200	1.00	0.5	4	1.216
5	500	0.05	0.3	3	1.259
6	500	0.30	0.2	4	1.475
7	500	0.70	0.5	1	1.614
8	500	1.00	0.4	2	1.174
9	800	0.05	0.4	4	0.207
10	800	0.30	0.5	3	0.400
11	800	0.70	0.2	2	0.387
12	800	1.00	0.3	1	0.502
13	1100	0.05	0.5	2	0.114
14	1100	0.30	0.4	1	0.241
15	1100	0.70	0.3	4	0.429
16	1100	1.00	0.2	3	2.533

Table VI: Ra value for Ball Burnished components:

Sr. No.	Speed (rpm)	Feed (mm/rev)	DOP (mm)	NOP	Surface Roughness Ra (micron)
1	200	0.05	0.2	1	1.916
2	200	0.30	0.3	2	0.618
3	200	0.70	0.4	3	1.112
4	200	1.00	0.5	4	0.918
5	500	0.05	0.3	3	0.162
6	500	0.30	0.2	4	0.343
7	500	0.70	0.5	1	1.002
8	500	1.00	0.4	2	1.588
9	800	0.05	0.4	4	0.770
10	800	0.30	0.5	3	1.405
11	800	0.70	0.2	2	1.598
12	800	1.00	0.3	1	1.180
13	1100	0.05	0.5	2	0.490
14	1100	0.30	0.4	1	0.639
15	1100	0.70	0.3	4	1.082
16	1100	1.00	0.2	3	1.225

*DOP: Depth of Penetration, NOP: Number of Passes

IX. TAGUCHI ANALYSIS

The experimental results are transferred to a mean to mean ratio with the criteria smaller-the-better is used to determine the surface quality by use of minitab-17 software. The response table of the analysis as shown in Table VII and VIII and corresponding graph of main effect for means for same.

Table VII
Response table for means for Roller Burnishing:

Level	Speed	Feed	DOP	NOP
1	1.3703	0.6997	1.6535	0.8940
2	1.3805	0.9225	0.9410	1.0622
3	0.6240	1.2255	0.7735	1.4160
4	0.8293	1.3562	0.8360	0.8317
Delta	0.7565	0.6565	0.8800	0.5843
Rank	**2**	**3**	**1**	**4**

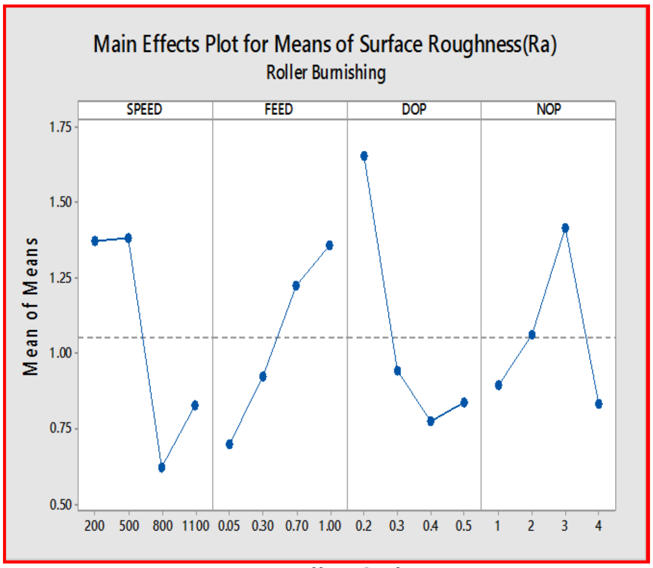


Figure 10: Main Effect Plot for Means

Table VIII
Response table for means for Ball Burnishing:

Level	Speed	Feed	DOP	NOP
1	1.1410	0.8350	1.2705	1.1843
2	0.7738	0.7512	0.7605	1.0740
3	1.2382	1.1985	1.0273	0.9760
4	0.8595	1.2277	0.9543	0.7783
Delta	0.4645	0.4765	0.5100	0.4060
Rank	**3**	**2**	**1**	**4**

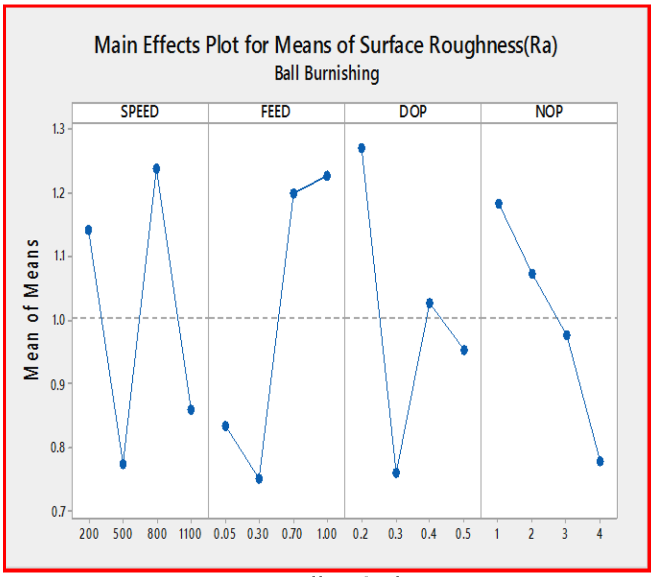


Figure 11: Main Effect Plot for Means

X. CONCLUSIONS

In this experimentation, the burnishing speed, feed, depth of penetration & number of passes these all factors are optimized by using TAGUCHI Methodology.

Experimented results at predicted optimum level for Roller Burnishing from figure 10:

Speed	Feed	DOP	NOP
800	0.05	0.40	4

Experimented results at predicted optimum level for Ball Burnishing figure 11:

Speed	Feed	DOP	NOP
500	0.30	0.30	4

REFERENCES

[1] Loh, N. H., Tam, S. C. and Miyazawa, "Investigations on the surface roughness produced by ball burnishing," International Journal Machine Tools Manufacture 1991, 31, 75-81.
[2] N.H. LOH, S.C. TAM, "A study of the effects of Ball-burnishing parameters on surface roughness using factorial design", Journal of Mechanical Working Technology, 18 (1989) 53-61.
[3] N. H. Loh and S. C. Tam, "Effects of ball burnishing parameters on surface finish A literature survey and discussion", Precision Engineering 0141635, 9/88/040215 © 1988 Butterworth & Co (Publishers).
[4] P. S. Kamble1, V. S. Jadhav2, P.G. Student of Govt. College of Engineering, Karad, 415124, Maharashtra, India, "Experimental study of Roller burnishing process on plain carrier of planetary type gear box", International Journal of Modern Engineering Research (IJMER).
[5] Malleswara Rao J. N1., Chenna Kesava Reddy2, "The effect of Roller burnishing on surface hardness and surface roughness on Mild Steel Specimens", International Journal of Applied Engineering Research, Dindigul, Volume 1, No 4, 2011.
[6] P. Ravindra Babu1, K. Ankamma2, T. Siva Prasad3, A.V. S. Raju4 and N. Eswara Prasad5, "Optimization of Burnishing Parameters by DOE and Surface Roughness, Microstructure and Micro Hardness Characteristics of AA6061 Aluminium Alloy in T6 Condition", Journal of Engineering Research and Applications (IJERA) ISSN: 48-9622, Vol. 2, Issue 2, Mar-Apr 2012, pp.1139-1146.
[7] R.A. Fisher, Statistical Methods, Experimental Design and Scientific Inference, 1990.
[8] Malleswara Rao, Chenna J. N Kesava Reddy A. , Rama Rao P. V.(2011) "Study Of Roller Burnishing Process on Aluminium Work Pieces using Design Of Experiments", International Journal of Mechanical Engineering and Technology (IJMET), ISSN 0976 –6340 No.1, Jan-April(2011), pp.22-35.
[9] Mr. Pavan Kumar and Purohit G K, "Design and Development of Ball Burnishing Tool", International Journal of Engineering Research and Technology. ISSN 0974- 3154 Volume 6, Number 6 (2013), pp. 733-738.
[10]J.N. Malleswara Rao, Dr. A. Chenna Kesava Reddy, Dr. P. V. Rama Rao, "Study of Roller Burnishing Process on Aluminium Work Pieces using Design of Experiments'', International Journal of Mechanical Engineering and Technology ISSN 0976 – 6340 ISSN 0976 – 6359(Online) Volume 2.
[11]Malleswara Rao J. N., Chenna Kesava Reddy A. Rama Rao P. V., "The effect of roller burnishing on surface hardness and surface roughness on mild steel specimens'', International Journal Of Applied Engineering Research, Dindigul Volume 1, No 4, 2011 ISSN 09764259. R.C. Jack and M.B. Grant, Inter. J. Mech. Tools Manf., 32, 1992, 57.
[12]M. H. El-Axir and M. M. El-Khabeery," Ball Burnishing Process Optimization For Aluminium Alloy Using Taguchi Technique", International Journal of Mechanical Engineering (IJME) ISSN(P): 2319-2240; ISSN(E): 2319-2259 Vol. 3,