International Journal of Modern Engineering Research (IJMER)
www.ijmer.com Vol.2, Issue.5, Sep-Oct. 2012 pp-3379-3383 ISSN: 2249-6645

# Experimental study of Roller burnishing process on plain carrier of planetary type gear box

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***Abstract:*** *Burnishing is cold working process where hard roller are being pressed against irregular surface, so that surface finish and the micro hardness increases. In this study internal roller burnishing tool is used to burnish the drilled hole. Speed, feed, and number of passes have been varied using taguchi method to examine the surface finish and microhardness. Anova analysis is carried out. Surface finish from 2.44 micron to 0.13micron is achieved.*

***Keywords:*** *Roller burnishing, Surface roughness, Microhardness, drilling.*

## I. INTRODUCTION

Surface finish is required to avoid friction losses, good corrosion resistant property and high fatigue life. Conventional machining process leaves surface irregularities, which causes additional cost of finishing operations. Burnishing is a plastic deformation process. In the burnishing process, the pressure generated by the rollers exceeds the yield point of the softer piece part surface at the point of contact, resulting a small plastic deformation of the surface structure of the piece part. All machined surfaces consist of a series of peaks and valleys of irregular height and spacing. The plastic deformation created by roller burnishing displaces the material from the peaks by means of cold work under pressure into the valleys. The result is a mirror-like finish with a tough, work hardened, wear and corrosion resistant surface.[11]

### *Literature Review*

A. Stoic et al.[1] investigated fine machining efficiency of 34CrMo4 steel using roller burnishing tool. Experimental results show that all smoothing outputs can be detected in all regimes. Roughness measured data before and after roller burnishing process have been compared. It was found that surface roughness is significantly lower after roller burnishing. Experimental results and numerical modeling of roller burnishing offers great potential in improving the efficiency and quality of parts. P. Ravindra Babu et al.[2] studied two internal roller burnishing tool to perform roller burnishing process on mild steel at different speed. The variation of surface finish and surface hardness are observed by varying speed.

Optimum increase in surface finish and surface hardness was at 62m/min. If speed is different than optimum value increase in surface finish is less. Basak et al.[3] carried out experiments using fuzzy model. Aluminium alloy (AL 7075 T6) has been burnished using different burnishing parameters such as number of revolution, feed, number of passes, and pressure force with burnishing apparatus. Using the experimental results a fuzzy logic model has been used to achieve the best parameters for the burnishing process. The fuzzy model prediction suggest that the most suitable values for minimum surface roughness are the pressure force of 200 N, and a feed 0.1mm/rev with two tool passes. These results obtained from the fuzzy model are highly consistent with the experimental results except for a small deviation in the case of surface hardness value for 0.2 mm/rev of feed & 400N of applied force. The results shows that fuzzy logic is suitable technique that may be efficiently use to optimize burnishing process. Binu C Yeldose et al.[4] investigated comparison of effect of uncoated & Tin coated by reactive magnetron sputtering on EN31 rollers in burnishing with varying process parameters such as burnishing speed, feed, burnishing force, number of passes upon surface roughness of EN24 steel work material. It was observed that the performance of the Tin-coated roller is superior to uncoated rollers in burnishing operation. The burnishing speed, feed, depth of cut and number of passes are influencing parameters on the burnishing operation. The burnishing speed, burnishing force and number of passes are having almost equal importance on the performance of the roller in burnishing, particularly with reference to the surface finish of the components produced. S. Thamizhmnaii et al.[5] investigated surface roughness and surface hardness by burnishing on titanium alloy. The test results produce improvement in surface finish. Studies can be extended to fatigue testing after burnishing process.T. Altan et al.[6] developed 2D & 3D FEM model was used to study the effect of process parameters burnishing pressure & feed rate on surface finish and residual stresses. The simulation results were evaluated and compared with the experimental data. Results shows that the established FEM model could predict the residual stresses and provide useful information for the effect of process parameters. Both FEM and experiments shows that burnishing pressure is the most influence, where high burnishing pressure produces less roughness and more compressive residual stress at the surface. S.Hassan et al.[7] studied multi roller burnishing on non ferrous materials, namely aluminium, brass and copper to improve surface finish and surface hardness. The surface roughness on non ferrous metal is improved by high feed rate and depth of penetration. N.S.M. El-Tayeb et al.[8] developed a simple burnishing tool, with interchangeable adapter for ball & roller. They fabricated the tool to perform roller burnishing processes on Aluminium 6061 under different parameters & different burnishing orientation. The impact of burnishing speed, force and burnishing tool dimensions on the surface qualities and tribological properties were investigated. It was found that burnishing speed of 330 rpm and burnishing force of 212N is capable of improving surface roughness as much as 40%. However, an increase in the roller contact width leads to less improvement in the surface roughness. In tribo test, burnished surface using small roller produces the lowest friction coefficient under dry contact condition. A substantial decrease in the friction coefficient and weight loss was obtained under lubricated contact condition. Furthermore, a 46% reduction in the friction coefficient was obtained when sliding took place in the direction parallel to burnishing orientation. These findings are further supplemented by SEM photomicrographs of tested surfaces.H. Hamadache et al.[9] developed a device for mechanical plastic deformation of structural Rb40 steel using ball and roller burnishing and investigated the change in roughness, hardness and wear resistance. They found that roller burnishing provide optimal roughness results, particularly when initial surface quality is close to 3 µm. In terms of hardness, ball burnishing process becomes interesting. For both cases, the optimum roughness and hardness are obtained for a specific regime whose decisive parameters are the applied force as well as number of burnishing tool passes. Based on roughness, it is recommended to limit the number of passes to two where as for the highest hardness, it is advised to go up to three passes while associating an effort of 150N. B.B. Ahuja et al.[10] carried out experiments based on $2^3$ factorial designs on turn master T-40 lathe. They studied that the effect of the combined turning and two ball burnishing parameters on the surface roughness and surface hardness of aluminum specimen. The results have been analyzed by the variance technique and the F-test. Analysis shows that the lubricant, force, speed and feed have significant effects on surface roughness and surface hardness.

## II. MATERIAL AND METHOD:

In this current research paper, an effort is being made to understand the improvement in the surface finish and microhardness of burnished surfaces along with the influence of the process parameters in "En-8" material, which is used as plain carrier in planetary type gear box to carry the planetary gears.

TABLE 1.Composition of EN-8

| %C | %Mn | %Si | %S | %P |
|---|---|---|---|---|
| 0.38 | 0.65 | 0.23 | 0.050max | 0.050max |

Fig.1 Specimen (Plain carrier) of EN-8 material

Fig.1shows the specimen prepared for this study. The work piece is of En-8 material has six number holes each. These holes are drilled to 16mm diameter on drilling machine. Burnishing is carried on DRO type boring machine shown in fig.2. Internal roller burnishing tool (fig.3) has five number of roller on the periphery, which pressed against the peaks on inside surface of the hole.

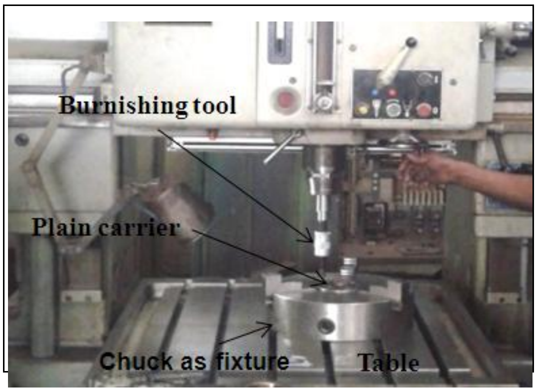



Fig.2 Experimental set up (Top gear transmission, satara)

Fig.3 Roller burnishing tool

TABLE 2.Process parameter and their range.

| levels / Parameters | 1 | 2 | 3 |
|---|---|---|---|
| Speed(rpm) | 560 | 800 | 1125 |
| Feed(mm/rev) | 0.04 | 0.12 | 0.21 |
| No.of passes | 1 | 2 | 3 |

In this study Taguchi L9 Orthogonal array has been used to check the results of input parameters. Process parameters are shown in table.2. Surface roughness values were measured before burnishing and after burnishing of each trial using roughness measurement device (Hommelwerke).

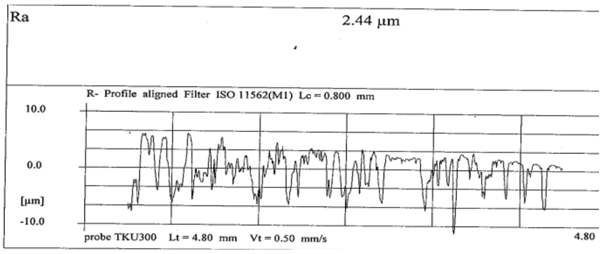



Fig.4 Roughness before burnishing

Comparison has been made with the help of graph plotted by roughness tester shown in fig.4&5. There is significant change in plastic deformation of higher picks after burnishing.

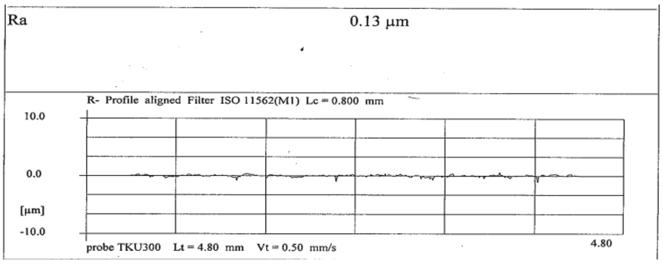



Fig.5 Roughness after burnishing

## III. Results & Discussion

From the trials it is found that there is significant change in surface roughness due to the variation in spindle speed, feed and number of passes.

## IV. Effect of feed:

Maximum surface finish is achieved at higher feed 0.21mm/rev shown in fig.6.As feed increases roughness is decreases.

**TABLE 3. L9 Taguchi Orthogonal array & observation**

| Experiment no. | Speed (rpm) | Feed (mm/rev) | No.of passes | Roughness (micron) | S/N |
|---|---|---|---|---|---|
| E1 | 560 | 0.04 | 1 | 0.63 | 4.013 |
| E2 | 560 | 0.12 | 2 | 1.21 | -1.655 |
| E3 | 560 | 0.21 | 3 | 1 | 0 |
| E4 | 800 | 0.04 | 2 | 0.17 | 15.391 |
| E5 | 800 | 0.12 | 3 | 0.23 | 12.765 |
| E6 | 800 | 0.21 | 1 | 0.13 | 17.721 |
| E7 | 1125 | 0.04 | 3 | 0.9 | 0.915 |
| E8 | 1125 | 0.12 | 1 | 0.19 | 14.424 |
| E9 | 1125 | 0.21 | 2 | 0.24 | 12.395 |

**TABLE 4. Response table of S/N ratio for smaller is better**

| Level | Speed | Feed | No. of passes |
|---|---|---|---|
| 1 | 0.7858 | 6.7731 | 12.0531 |
| 2 | 15.2925 | 8.5116 | 8.7104 |
| 3 | 9.2453 | 10.0390 | 4.5602 |
| Delta | 14.5067 | 3.2658 | 7.4929 |
| Rank | 1 | 3 | 2 |

**TABLE 5. Analysis of variance**

| **Source** | **D.O.F.** | **Seq. SS** | **Adj. SS** | **Adj. Mean Sq.** | **F** | **P** |
|---|---|---|---|---|---|---|
| Speed | 2 | 318.58 | 318.58 | 159.288 | 9.14 | 0.099 |
| Feed | 2 | 16.02 | 16.02 | 8.010 | 0.46 | 0.685 |
| No. of passes | 2 | 84.54 | 84.54 | 42.270 | 2.42 | 0.292 |
| Residual error | 2 | 34.87 | 34.87 | 17.436 | * | * |
| Total | 8 | 457.01 | * | * | * | * |

SS = Sum of Squares, D.O.F. = Degree of Freedom, SS = Sum of squares.

**TABLE 6. Optimal combination for better surface finish**

| Parameter | Speed | Feed | No.of passes |
|---|---|---|---|
| Better surface finish | 800 | 0.21 | 1 |

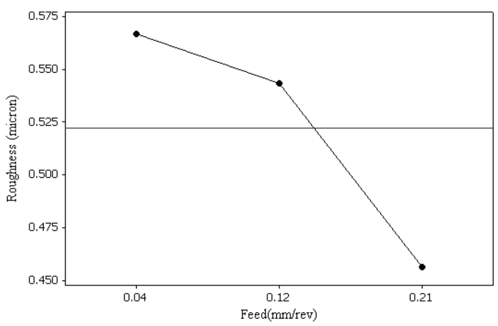



Fig.6 Feed Vs Surface roughness

***Effect of speed:***

Maximum surface finish is achieved at 800rpm. It is found that as speed increases than optimum value roughness start increasing shown in fig.7.

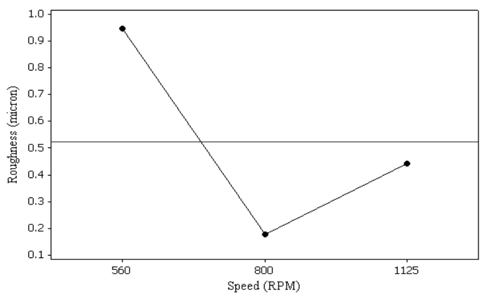



Fig.7 Spindle revolution Vs Roughness

***Effect of number of passes:***

Number of passes is also important factor. It is found that at one number of pass burnishing gives better microhardness. As number of passes increases roughness start increasing shown in fig.8.

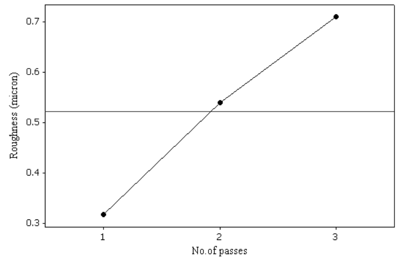
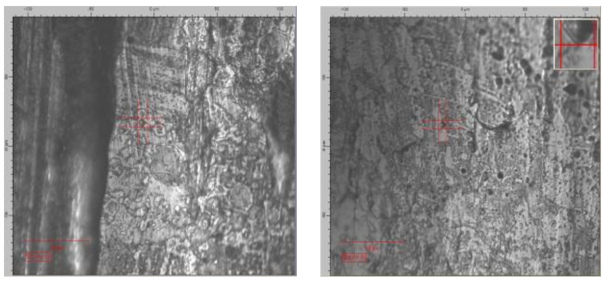



Fig.8 No. of passes Vs Roughness

The ANOVA results and optimal combination for surface finish are shown in Tables.5 & 6 respectively.

**Study of micro hardness:**

In this study microhardness testing is carried out on inside surface of burnished hole using Wilson instrument/402MVO microvicker hardness tester. Table.7. shows the microhardness reading taken randomly on burnished surface. Microhardness testing images of before and after burnishing are shown in fig.9.



(a) (b)

Fig.9 Microhardness testing image by tester(a)Before burnishing(b)After burnishing

***Effect of feed:***

Maximum microhardness is achieved at lower feed. At 0.04mm/rev feed value microhardness is achieved maximum shown in fig.10.

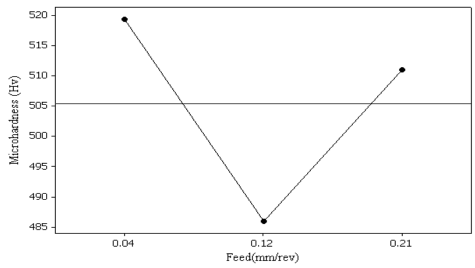



Fig.10 Microhardness Vs Feed

***Effect of speed:***

Microhardness increases as speed increases. It is observed that at 1125rpm speed microhardness value is maximum shown in fig.11.

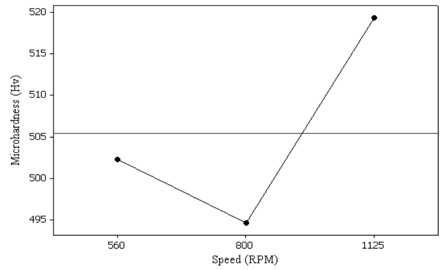



Fig.11 Microhardness Vs Speed

***Effect of number of passes:***

It is found that at one number of pass, microhardness is maximum. As number of passes increases microhardness decreases shown in fig.12.

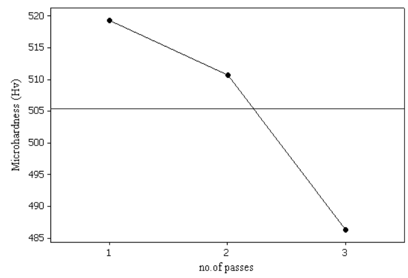



Fig.12 Microhardness Vs No. of passes

The ANOVA results and optimal combination for Microhardness are shown in Tables.9 & 10 respectively.

**TABLE.7. L9 Taguchi Orthogonal array & observation**

| Experiment no. | Speed (rpm) | Feed (mm/rev) | No. of passes | Microhardness (Hv) | S/N |
|---|---|---|---|---|---|
| E1 | 560 | 0.04 | 1 | 528 | 54.452 |
| E2 | 560 | 0.12 | 2 | 502 | 54.014 |
| E3 | 560 | 0.21 | 3 | 477 | 53.570 |
| E4 | 800 | 0.04 | 2 | 502 | 54.014 |
| E5 | 800 | 0.12 | 3 | 454 | 53.141 |
| E6 | 800 | 0.21 | 1 | 528 | 54.452 |
| E7 | 1125 | 0.04 | 3 | 528 | 54.452 |
| E8 | 1125 | 0.12 | 1 | 502 | 54.014 |
| E9 | 1125 | 0.21 | 2 | 528 | 54.452 |

**TABLE.8. Response table of S/N ratio for larger is better**

| Level | Speed | Feed | No. of passes |
|---|---|---|---|
| 1 | 54.01 | 54.31 | 54.31 |
| 2 | 53.87 | 53.72 | 54.16 |
| 3 | 54.31 | 54.16 | 53.72 |
| Delta | 0.44 | 0.58 | 0.59 |
| Rank | 3 | 2 | 1 |

**TABLE 9. Analysis of variance**

| Source | D.O.F. | Seq.S.S. | Adj. S.Sq. | Adj. Mean Sq. | F | P |
|---|---|---|---|---|---|---|
| Speed | 2 | 0.2981 | 0.2981 | 0.1491 | 0.99 | 0.502 |
| Feed | 2 | 0.5519 | 0.5519 | 0.2759 | 1.83 | 0.353 |
| No. of passes | 2 | 0.5563 | 0.5563 | 0.2782 | 1.85 | 0.351 |
| Residual error | 2 | 0.3008 | 0.3008 | 0.1504 | * | * |
| Total | 8 | 1.7071 | * | * | * | * |

SS = Sum of Squares, D.O.F. = Degree of Freedom, SS = sum of squares.

**TABLE 10. Optimal combination for better surface finish**

| Parameter | Speed | Feed | No.of passes |
|---|---|---|---|
| Better surface finish | 1125 | 0.04 | 1 |

## V. Conclusions

1. Roller burnishing produce superior finish. Ra value observed is finest upto 0.13 micron (Table.3).
2. Before burnishing microhardness found 377Hv and after burnishing it increases upto 528Hv (fig.9).
3. Many researchers carried out experiments on external work piece by single roller burnishing tool. From this study it is observed that roller burnishing also gives better result in drilled hole.

## Acknowledgement

The authors gratefully acknowledge Top Gear Transmission, Satara for the cooperation and help. The authors are also thankful to UGC Lab division, Pune and TMC measurement lab, Pune for providing the microhardness and roughness testing facilities respectively.

## REFERENCES

[1] A. Stoić, I. Lackovic, J. Kopac, I. Samardzic, D. Kozak, "An Investigation of Machining Efficiency of Internal Roller Burnishing", Journal of Achievements in Material and Manufacturing Engineering, Volume 40,Issue2, June 2010.

[2] P. Ravindra babu, T. Siva Prasad, A. V. S. Raju, A. Jawahar Babu, "Effect of Internal Roller Burnishing on Surface Roughness and Surface Hardness of Mild Steel", Journal of Scientific & Industrial Research, Volume.68, January 2009, pp. 29-31.

[3] Hudayim Basak, H. Haldun Goktas, "Burnishing Process on Al-alloy & Optimization of Surface Roughness and Surface Hardness by Fuzzy Logic", Journal of Material & Design, 30(2009) 1275-1281.

[4] Binu C. Yeldose, B. Ramamoorthy, "An Investigation into the High Performance of Tin-coated Rollers in Burnishing Process", Journal of material processing technology, 207 (2008) 350-355.

[5] S. Thamizhmnaii, B. Bin Omar, S. Saparudin, S. Hasan, "Surface Roughness Investigation and Hardness by Burnishing on Titanium Alloy", Journal of Achievements in Material and Manufacturing Engineering, Volume 28, Issue2, June 2008

[6] Taylan Altan, Partchapol Sartkulvanich,Francisco Jasso, Ciro Rodriguez, "Finite Element Modeling of Hard Roller Burnishing: An Analysis on the effect of Process Parameters upon Surface Finish and Residual stresses", ASME Journal of Manufacturing Science and Engineering, August 2007, Vol. 129

[7] S. Hassan, S.Thamizhmanii, B. Saparudin, S. Hasan, "A Study of Multi-Roller Burnishing on Non-Ferrous Metals", Journal of Achievements in Material and Manufacturing Engineering, Volume 22, Issue2, June 2007.

[8] N.S.M.El-Tayeb, K.O.Low, P.V.Brevern,"Influence of Roller Burnishing Contact Width and Burnishing Orientation on Surface Quality and Tribological Behavior of Aluminium 6061", Journal of Material Processing Technology 186 (2007) 272-278.

[9] H.Hamadache, L.Laouar, N.E.Zeghib, K.Chaoui, "Characteristics of Rb40 Steel Superficial Layer under Ball and Roller Burnishing", Journal of Material Processing Technology 180(2006) 130-136.

[10] B. B. Ahuja & U. M. Shirsat, "Parametric Analysis of Combined Turning and Ball Burnishing Process", Indian Journal of Engineering & Material Science, Vol.11, October 2004, pp.391-396.

[11] P.S.Kamble, V.S.Jadhav & C.Y.Seemikeri, "Surface finish improvement by Roller Burnishing Process on En-24", Proceeding of National Conference on Recent Advancements in Engineering-2012,India. Vol.1, pp.197-200.ISBN:978-93-82062-37-0.