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# Experimental Investigation of the Influence of Roller Burnishing Tool Passes on Surface Roughness and Hardness of Brass Specimens

[1]J. N. Malleswara Rao, [2]A. Chennakesava Reddy, [3]M. Sumalatha
[1,3]V. R. Siddhartha Engg. College, Vijayawada, AP, India
[2]JNT University Hyd, AP, India

**Abstract**
The process of Roller Burnishing is performed by applying a highly polished and hardened roller with external force onto the surface of a cylindrical work piece. There are many advantages of the Roller Burnishing process. The burnishing process increases the surface hardness of the work piece, which in turn improves wear resistance, increases corrosion resistance, improves tensile strength, maintains dimensional stability and improves the fatigue strength by inducing residual compressive stress in the surface of the work piece. Roller burnishing tool is used in the present experimental work. Experiments are conducted to investigate the performance of the roller burnishing tool on lathe, along with the influence of number of burnishing tool passes on the surface roughness and surface hardness of brass specimens. The results revealed that improvements in the surface finish and increase in surface hardness are obtained by the increase of the number of burnishing tool passes in roller burnishing on the brass specimens.

**Keywords**
Roller Burnishing, Surface Roughness Value (Ra), Surface Hardness, Brass and Number of Burnishing Tool Passes.

## I. Introduction

A hard and highly polished roller is made to press against the surface of a metallic work piece with high pressure in roller burnishing process. As a result, the peaks of the metallic surface are plastically deformed, when the applied burnishing pressure exceeds the yield strength of the metallic material, to fill the valleys, as shown in Figure 1 and fig. 2 [4]. The surface of the metallic work piece will be smoothened as a result.

Because of the plastic deformation, the material is left with a residual stress distribution that is compressive on the surface, as shown in fig. 3 [3]. The result is that the surface hardness, wear resistance, fatigue resistance, yield strength, tensile strength and corrosion resistance are improved because of the changes in surface characteristics due to the burnishing, as mentioned by many authors [1-2]. Burnishing is considered as a cold working finishing process, differs from other cold working, surface treatment processes such as shot peening, and sand blasting, etc., in that it produces a good surface finish and also induces residual compressive stresses at the metallic surface layers [4]. Also, burnishing is economically beneficial, because it is a simple process; it costs less and requires minimum time.

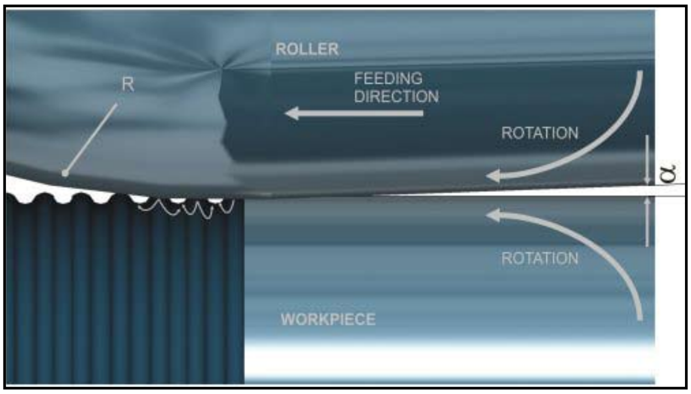

Fig. 1: Roller Burnishing Process

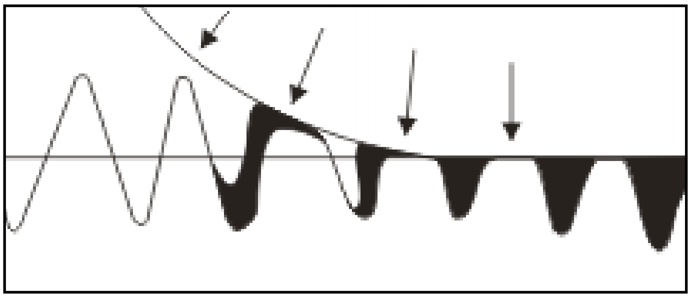
Fig. 2: Material Flow From Peaks to Valleys in the Roller Burnishing Process

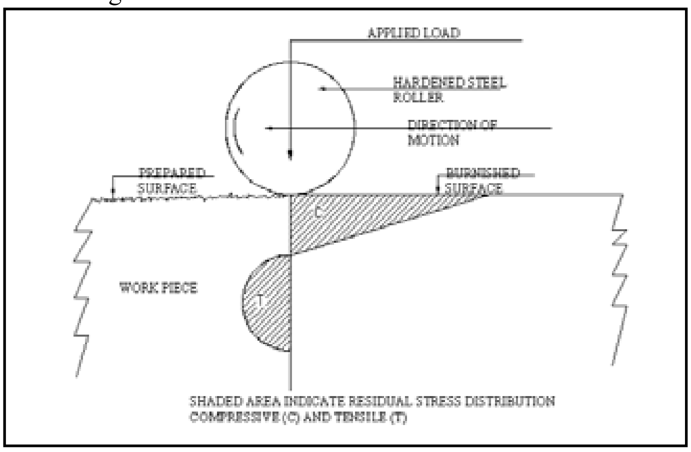

Fig. 3: Schematic of Burnishing Process

There are two types of burnishing process. i. Ball burnishing and ii. Roller burnishing. In the present experimental work, the influence of the number of burnishing tool passes on the surface roughness and surface hardness of Brass specimens is studied in roller burnishing process. Number of burnishing tool passes is selected as the variable parameter in the present work.

## II. Literature Review

Shneider, Yu. G. [1] conducted experiments to study the characteristics of burnishing components. Wear has important technological and economical significance because it changes the shape of the work piece, and the tool and the interference. Burnishing is considered as a cold working process which can be used to improve surface characteristics. Surface roughness and hardness plays an important role in many areas and is factor of great importance for the functioning of machine parts such as valve seats, internal surface of hydraulic cylinders, pistons, bearings, etc.,. Hassan, A. M., et al [2] explained the effects of ball and roller burnishing on the surface roughness and hardness of some non ferrous metals. It was suggested by many investigators that an improvement in wear resistance can be achieved by burnishing process. Siva Prasad, T., et al [3] investigated the roller burnishing process on aluminum components and concluded that surface finish improvement is better with the burnishing process. Thamizhmnaii et al [4] presented the improvement of surface hardness and roughness of titanium alloy by burnishing process.

## III. Burnishing Tool

A 40 mm diameter and 12 mm width hard roller is utilized for roller burnishing process. The chemical composition and some properties of the roller are shown in Table 1. The detailed and assembly drawings of the roller burnishing tool are shown in fig. 4. A dynamometer is used to measure the applied burnishing force.

Table 1: Some Properties of the Roller Burnishing Tools

| Burnishing tool | Ra (μm) | HRC |
|---|---|---|
| Roller | 0.14 | 62 |

In the present experimental work, dry turning and dry burnishing are used completely.

### A. Roller Burnishing Tool

A Roller burnishing tool is designed and fabricated as shown in Figure 4. It consists of the following parts. 1. Roller 2. Special bolt. 3. Nut 4. Bush 5. Washers 6. Shank. The shank is fixed in the dynamometer and it is tightened with bolts. The chemical composition of Roller material is given below: Fe 97.003, Si 0.18, Mn 0.26, Ni 0.12, Cr 1.44, C 0.99, S 0.007

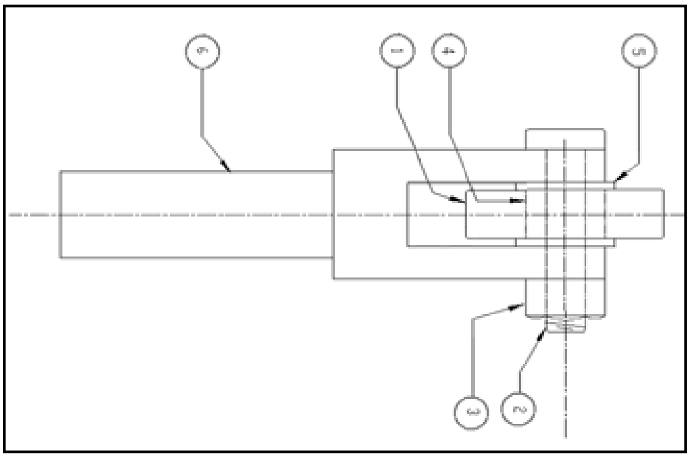

Fig. 4: Roller Burnishing Tool Assembly

## IV. Equipment and Machines

In the present experimental work, the following machines and equipment are utilized. i. Lathe, PSG A 141, Coimbatore make. ii. Surface Roughness Tester, Mitutoyo, Japan make. iii. Rockwell hardness testing machine.

### A. Work Piece Material

Commercially available Brass is used in the present experimental work. Work piece diameter is 38 mm.

## V. Experimental Set Up

The roller burnishing tool is fixed in the dynamometer, which is mounted on the lathe. The experimental set up is shown in Figure 5. It consists of the following parts. 1. 3- Jaw chuck 2. Live center 3. Brass work piece 4. Dead center 5. Roller burnishing tool 6. Dynamometer fixed to the cross slide of lathe 7. Hand wheel for cross slide of lathe 8. Input power to the dynamometer 9. Strain reader. Burnishing experiments are conducted on turned brass work piece, which is corrosive resistant, good conductor and available in the form of round bars. The brass work piece is specially fabricated, as shown in fig. 6. All the dimensions are shown in millimeters here. Photograph of brass work piece is shown in fig. 7.

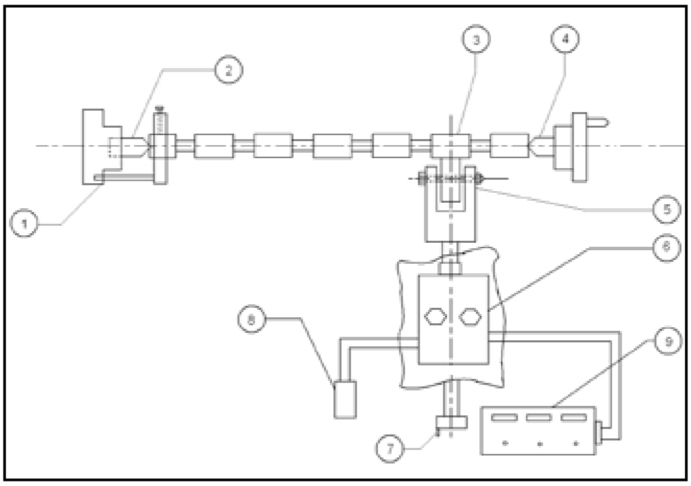


Fig. 5: Experimental Set Up With Roller Burnishing Tool

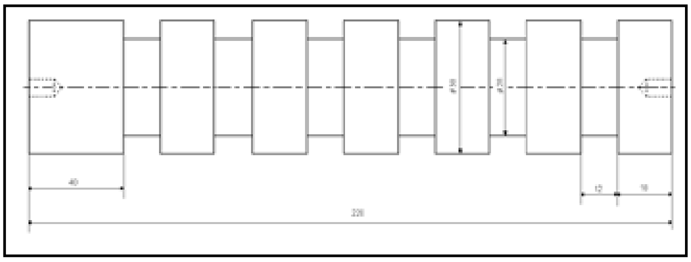

Fig. 6: Brass Work Piece for Roller Burnishing

Fig. 7: Photograph of Brass Work Piece

Fig. 8 shows the photograph of the experimental setup when roller burnishing tool with 40 mm diameter roller finishes brass work piece in PSG lathe.

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Fig. 8: Photograph of Experimental Set Up of Roller Burnishing Process on Lathe With Brass Work Piece

Fig. 9: Photograph Showing Close Up View of Experimental Set Up of Roller Burnishing Process on Lathe

## VI. Measurement of Surface Roughness Values

Initial value of surface roughness (Ra) is measured by using Surface roughness tester – 211 model, Mitutoyo, Japan make, as shown in fig. 10. Centre line average (CLA) or Ra value is the arithmetic average roughness height.

Fig. 10: Photograph of Surface Roughness Tester

## VII. Experiments with Roller Burnishing Tool on Brass Work Piece

### A. Influence of the Number of Roller Burnishing Tool Passes on Surface Roughness

The Roller burnishing tool is fixed to the dynamometer, which is mounted on the compound rest of the lathe. The first step of the Brass specimen i.e., the step near the dead center is finished with roller burnishing tool one time by keeping the burning force, feed rate and burnishing speed constant. Here, Pr= 50 kgf, V= 20.1 m min-1, f= 0.060 mm rev-1 and dr= 40 mm. Again, the second step is finished two times, the third step three times, and the finishing process by roller burnishing tool is continued up to five steps. Corresponding surface roughness values (Ra) are measured on all the steps of the brass specimen, as shown in Table 2.

Table 2: Effect of Number of Burnishing Tool Passes on the Surface Roughness of Brass Specimens by Roller Burnishing

| No. of Burnishing tool passes | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Surface roughness (Ra) µm | 1.82 | 1.15 | 0.67 | 0.42 | 0.53 |

A graph is drawn between number of burnishing tool passes and surface roughness value (Ra) as shown in fig. 11.

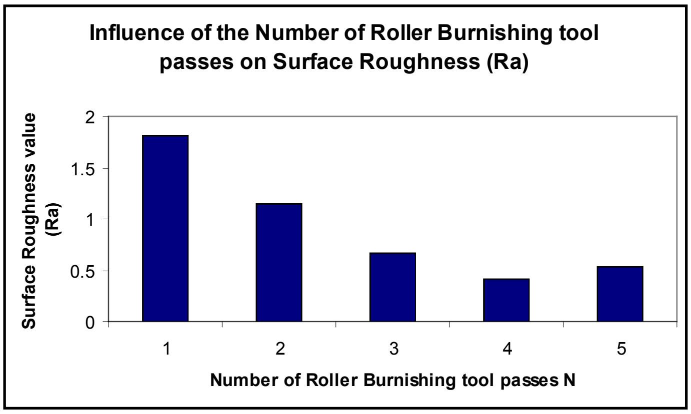


Fig. 11: Variation of Surface Roughness with the No. of Roller Burnishing Tool Passes

### B. Influence of the Number of Roller Burnishing Tool Passes on Surface Hardness

Different steps of the Brass specimen are finished with Roller burnishing tool by changing the number of burnishing passes. The final surface hardness values (HRB) are measured on all the steps, as shown in Table 4. Initial hardness of work piece, HRBi= 63. A graph is drawn between number of burnishing tool passes and surface hardness for roller burnishing experiment, as shown in fig. 12.

Table 3. Effect of Number of Roller Burnishing Tool Passes on the Surface Hardness of Brass Specimens

| No. of Burnishing tool passes | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Surface Hardness HRB | 65 | 65.75 | 66.5 | 67.25 | 68 |

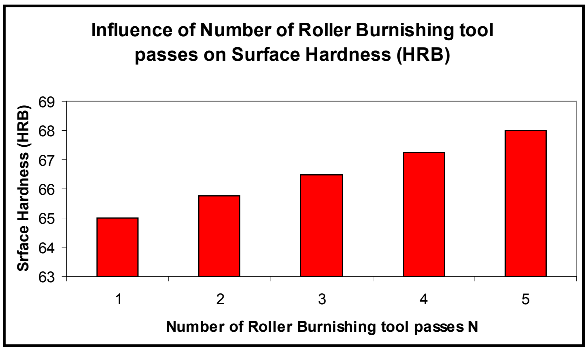


Fig. 12: Variation of Surface Hardness With Number of Roller Burnishing Tool Passes (N)

## VIII. Results

### A. Influence of the Number of Roller Burnishing Tool Passes on Surface Roughness

It can be seen from the graph in fig. 11 that the surface roughness decreases with the increase in number of roller burnishing tool passes. This minimum value of surface roughness for brass material occurs at the fourth pass. The reason is explained below. In each tool pass, the tool is being applied under a constant burnishing force to the plastically deformed surface of the previous pass. Similarly, the effect of burnishing force after a particular number of burnishing passes, the surface layer becomes highly work hardened, causing flaking to occur. This will lead to the deterioration of the surface and an increase in the surface roughness.

### B. Influence of Number of Roller Burnishing Tool Passes on Surface Hardness

Fig. 12 shows the influence of the number of roller burnishing tool passes on the surface hardness. It is inferred from the graph that the surface hardness on brass specimens increases with the increase in the number of roller burnishing tool passes. Also, it is noted from the curve that the increase in surface hardness is more at four passes. The metallic surface is continuously deformed with the increase in this burnishing parameter. It should be mentioned here that the increase in surface hardness will level off at high values of number of burnishing tool passes or furnishing force. This is because all metals will have a definite capacity for cold working. When this capacity exceeds further, considerable cracks will be developed within the surface of the metal and failure will occur.

## IX. Conclusion

A. In Roller Burnishing process on Brass work piece, the surface roughness decreases to a minimum value with the increase in the number of burnishing tool passes. At four tool passes, minimum surface roughness value (Ra) 0.42 μm is achieved in the present experiment. After attaining this minimum value, it starts to increase with number of burnishing tool passes.

B. The surface hardness increases with the increase in number of burnishing tool passes in Roller burnishing process on Brass work piece. In the present experiment, at four burnishing tool passes, the increase in surface hardness value obtained is from 63 HRB to 67.25 HRB.

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J. N. Malleswara Rao completed B. Tech. (Mech Engg) from JNTU, Kakinada in 1983; and M. Tech. (Prod. of Machine Tools) from REC, Warangal in 1993. He has teaching experience of 25 years and also 3 years Industrial experience in the manufacturing of Machine tools. He registered for Ph. D. (part time) at JNTU, Hyderabad. Presently Mr. J. N. M. Rao is working as Associate Professor in the dept. of mechanicl Engineering at V. R. Siddhartha Engineering, Vijayawada, A. P. His areas of interest are: Surface finish improvement by Burnishing process, Fuel Cell, Nano Technology, Rapid Prototyping, M/C Tools, etc.