

## Experimental Investigation of the Influence of Burnishing Parameters on Surface Roughness and Hardness of Brass Alloy

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### Abstract

Burnishing is a cold working surface finishing process in which peaks and valleys on machined surfaces deformed plastically by the application of hard and finished ball or roller against to it. Recently 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 surface roughness and hardness of brass alloy is experimentally investigated. A simple roller burnishing tool was used for the experiential work of the present study, surface test and micro hardness test were used to demonstrate the effects of the burnishing force and feed rate on surface roughness and surface hardness of a brass alloy. The smoothing process under consideration can be performed on standard machine tools without additional reconfiguration tasks. Process is very useful for any workshop and can be carried out without coolant. The results proved that all the parameters have significant effect on the above said two surface characteristics. The results revealed that improvements in the surface finish and increase in the surface hardness are obtained by reduce the burnishing feed and increase the burnishing force.

**Keywords:** Burnishing; Hardness; Surface roughness; Burnishing feed; Burnishing force

### Introduction

Roller burnishing is an economical and feasible mechanical treatment for the quality improvement of rotating components, not only in sense of surface roughness but in compressive residual stresses as well. Burnishing is a plastic deformation process in which the force is applied to a workpiece surface by a hard smooth ball or roller. The mechanism of a burnishing operation is that asperities peaks of the workpiece are compressed to fill in the valleys and thus characteristics of the surface under consideration are changed [1-4]. The characteristics of a burnished surface depend upon controlling burnishing parameters such as applied burnishing force (burnishing depth), burnishing speed, burnishing feed rate, and number of passes, geometry and material of burnishing tool, as well as the material of burnished surface.

Burnishing is considered as a cold-working finishing process, differs from other cold-working, surface treatment processes such sand blasting, in that it produces a good surface finish and also induces residual compressive stresses at the metallic surface layers [5]. Also, Burnishing is one of the important finishing operations carried out generally to enhance the fatigue resistance characteristics of components. Additionally, burnishing is economically beneficial, because it is a simple and less costly process, requiring less time. High quality surface finish can be obtained with semi skilled operators [6].

Roller burnishing is a fine machining process that is used to improve certain physical and mechanical properties, such as surface roughness, corrosion resistance, friction coefficient, wear, and fatigue resistance. 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.,.

Many researchers have undertaken extensive work on burnishing processes. Hassan [7] 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 [8] investigated the roller burnishing process on aluminum components

and concluded that surface finish improvement is better with the burnishing process. Thamizhmanai [6] presented the improvement of surface hardness and roughness of titanium alloy by burnishing process.

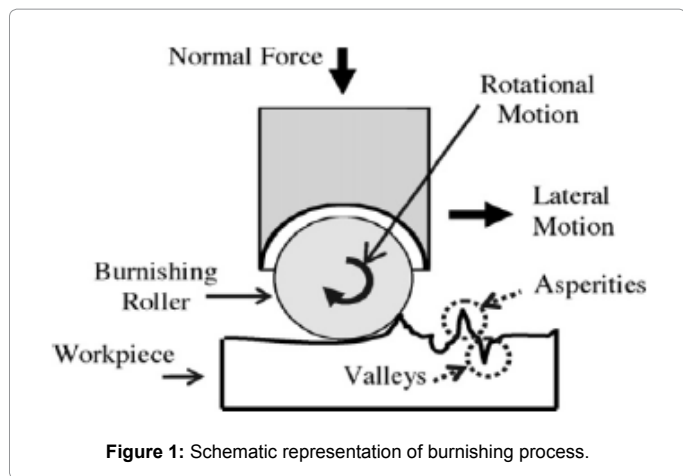
Hassan [9] investigated the effect of burnishing parameters on surface roughness and hardness of non-ferrous metals like Al, Brass etc. Further, he also conducted experiments to find out the effect of burnishing process on wear resistance property of non-ferrous metals [10]. El-Axir [11] detailed description about roller burnishing process and effect of its parameter on surface finish and roughness using design of experiments. The principle of the burnishing process, shown in Figure 1, is based on the rolling movement of a tool (a ball or a roller) over the work piece's surface. With application of roller burnishing process, plastic deformation of machining surface and allocation of material starts from peaks to valleys. Roller burnishing is a material micro-displacement process which is shown in Figure 1 in comparison with other finishing processes, like grinding process, also lowers the surface roughness height but the burnishing process can be achieved by applying a highly polished and hard roll on to a metallic surface under pressure. Microscopic "peaks" on the machined surface are during roller burnishing process exposed to cold flow into the "valleys," creating a plateau-like profile in which sharpness is reduced or eliminated in the contact plane. 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

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Cu %	Pb %	Fe %	Zn %
68.5	0.07	0.05	remaining

**Table 1:** Chemical composition in weight percent for (C2600) brass alloy.

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 feed, and force as they found more predominant in literature review. The main object of this work is to investigate the effect of burnishing speed and force on surface roughness and hardness of brass alloy.

## Experimental Details

### Burnishing tool

Roller burnishing is a surface finishing technique in which hardened; highly polished steel rollers are brought into pressure contact with a softer piece part. Burnishing processes are used in manufacturing to improve the size, shape, surface finish, or surface hardness of a workpiece. A 20 mm diameter hardened roller of 5 mm width was used for burnishing. The shanks of the burnishing tools are designed to be simply mounted or fixed onto the tool holder of a machine tool such as a lathe machine; as shown in Figures 2a and 2b.

### Material

The work piece was received in the form of cylindrical bars of 20 mm diameter. The bars were turned to 18 mm diameter and 130 mm length. Brass alloy used in this experimental work, is made of copper and zinc and other element alloy, its chemical composition is shown in Table 1. The brass it is ideal for workmanship because it is has many properties like it is draw ability and its low hardness number in addition, it is easy to scribe and plating.

### Burnishing procedure and parameters

In this experimental investigation five specimens were obtain by sawing operation of the rod brass. Each specimen was turned to length 130 mm and to diameter 18 mm by TRIUMPH 2000 lathe. After each specimen turning, the cutting tool was replaced by the roller burnishing tool. 4. Finally, the roughness measured roughness was measured by

means of roughness machine tester (SURFCORDER SE 3500 Surface Tester) and hardness was measured using Micro hardness machine tester (model HWDN-3). The burnishing condition considered in this work is shown in the Tables 2a and 2b.

## Results and Discussion

These experiments were aimed to examine the effect of burnishing parameters on surface roughness and surface hardness.

### Roughness results

The initial surface roughness before burnishing was equal to 0.99  $\mu\text{m}$ . Figure 3 shows the effect of burnishing feed on the surface roughness at a constant force of 300 N.

The burnishing feed of specimen (1) feed was varied from 0.04 to 0.1 mm/rev, for specimen (2) the feed was varied from 0.12 to 0.30 mm/rev. and for specimen (3) feed from 0.35 to 1.00 mm/rev. It is clear that, as the burnishing feed rate increases, the surface roughness tends to be lowers. The optimum feed rate is an intermediate. Moreover, at higher feed rates, fast rubbing, the roughness (Ra) value is slightly increased.

The effect of burnishing force on the surface roughness at a constant feed of 0.06 mm/rev is illustrated in Figure 4. For specimen (4) the force was varied force from 200 to 400 N and for specimen (5) the force varied from 450 to 650 N. It is noticed that the surface

Specimen Number	Pressing Force (N)	Zone Number	Feed (mm/rev)
1	300	1	0.04
		2	0.05
		3	0.06
		4	0.08
		5	0.1
2	300	1	0.12
		2	0.15
		3	0.20
		4	0.25
		5	0.30
3	300	1	0.35
		2	0.40
		3	0.45
		4	0.70
		5	1
Spindle Speed=350 rpm		Number of passes=3	

**Table 2a:** The burnishing condition considered in this work.

Specimen Number	Feed (mm/rev)	Zone Number	Pressing Force (N)
4	0.06	1	200
		2	250
		3	300
		4	350
		5	400
5	0.06	1	450
		2	500
		3	550
		4	600
		5	650
Spindle Speed=350 rpm		Number of passes=3	

**Table 2b:** The burnishing condition considered in this work.



Figure 2a: Roller burnishing tool.

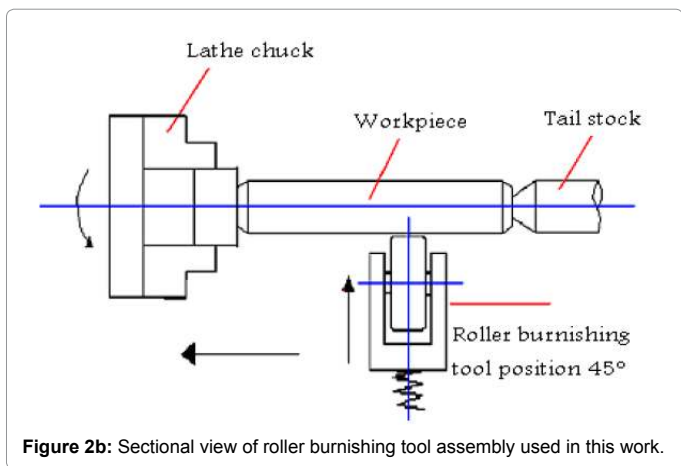


Figure 2b: Sectional view of roller burnishing tool assembly used in this work.

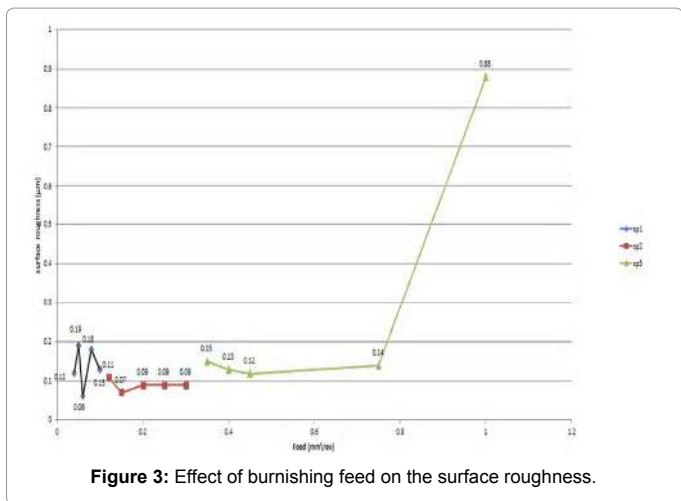


Figure 3: Effect of burnishing feed on the surface roughness.

roughness decreases with the increase of the applied force up to the maximum value of 300 N, after which the surface roughness increases with further increase of the force. This behavior can be explained that

when increasing the force beyond the mentioned optimum value, the swell of metal in front of the tool becomes large and the region of the plastic deformation widens which damages the already burnished surface, i.e., increase the surface roughness. Surface roughness is also found to be crucial. When the burnishing force is increased up to 300 N, the surface roughness is found to be decreased. Again when the force is increased above 300 N, the surface roughness is increased i.e., material get deteriorated surface roughness.

It can be seen that, the surface roughness decrease for the specimens 1 and 2, while for the specimen (3) the surface roughness increased when the feed increased, this is due to very short exposure time the specimen compared to other specimens.

For specimen (5) the surface roughness increases because the burnishing tool vibration was increased.

The optimum roughness value was at burnishing force equal 300 N and feed equal 0.06 mm/rev.

### Surface microhardness t Results

The initial hardness before burnishing operation was equal 136 HV. Figure 5 shows effect of burnishing feed on the surface hardness at a constant force of 300 N. The burnishing feed for specimen (1) is varied between feed from 0.04 to 0.1 mm/rev and specimen (2) varied from 0.12 to 0.30 mm/rev and for specimen (3) feed varied from 0.35

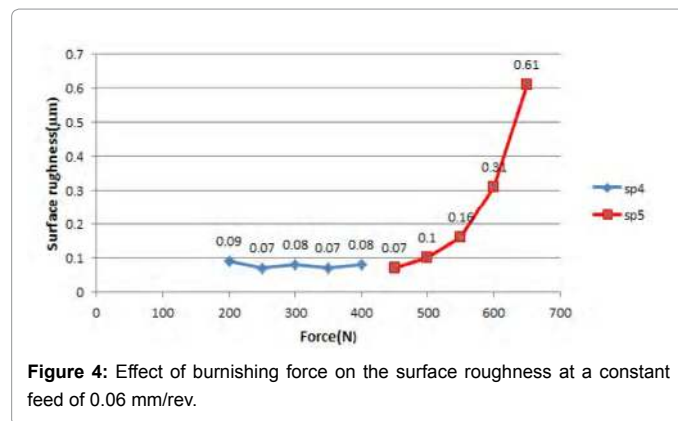


Figure 4: Effect of burnishing force on the surface roughness at a constant feed of 0.06 mm/rev.

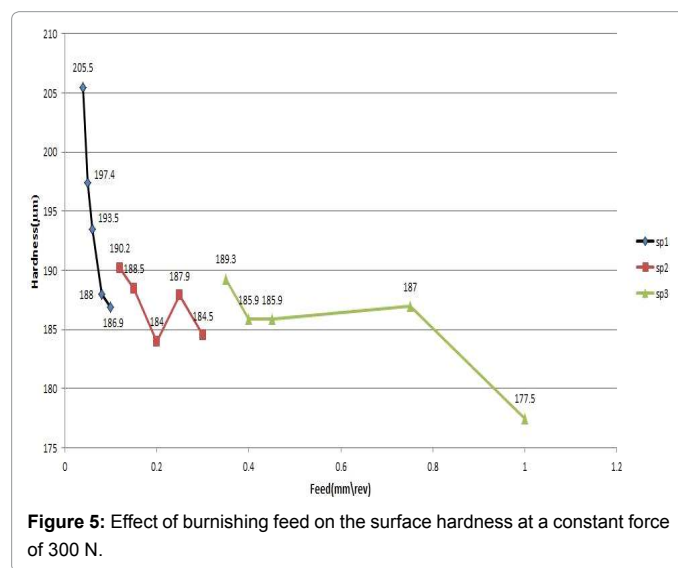


Figure 5: Effect of burnishing feed on the surface hardness at a constant force of 300 N.

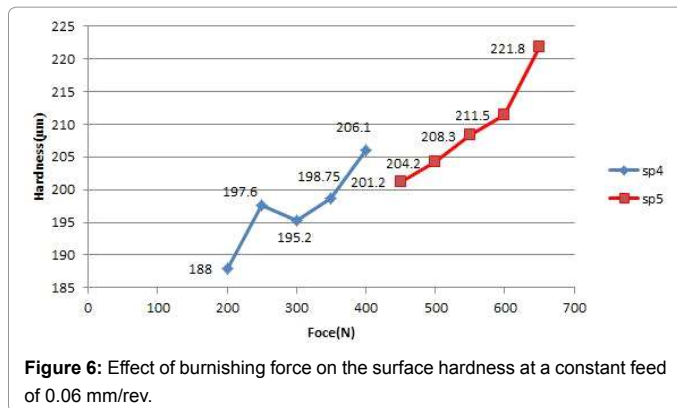


Figure 6: Effect of burnishing force on the surface hardness at a constant feed of 0.06 mm/rev.

to 1.00 mm/rev. It is obvious that can be seen that the relationship between the and when the force constant and equal and the feed for each specimen was like that the effect of burnishing force on the surface hardness at a constant feed of 0.06 mm/rev is depicted in Figure 6. The force for specimen (4) was varied from 200 to 400 N and for specimen (5) varied from 450 to 650 N.

It can be seen; from the above Figures 6 that the hardness increases as the force increased due to strain hardening when a metal is strained beyond the yield point. More stress is required to produce additional plastic deformation and the metal apparently becomes stronger and more difficult to deform. Whereas when the feed is increased the hardness was decreased. There are some irregularities in curves of micro hardness test values and since the pressure exerted by tool burnishing on the unit area along the specimens is not uniform and accurate in direction and magnitude. In addition there were non-homogeneities in the chemical elements and there are some impurities within the specimens which cause a hard spots on the surface. The maximum hardness value was obtained at a force of 650 N and feed of 0.06 mm/rev.

## Conclusions

This article presents the results of the experimental investigation of fine machining conditions with roller burnishing of brass alloy. Roller burnishing process of cylindrical surface can be performed on standard performance machine tools. Surface quality improvement is obvious and can be visually detect when comparison of two parts before and

after burnishing is conducted. The following conclusions can be drawn from this experimental work, the micro hardness increase as the burnishing force increases while it decreases with the increase in burnishing feed, Increasing the burnishing feed rate showed a negative impact on improvement of surface roughness especially at lower forces, the surface roughness depends on burnishing process parameters and work piece material as well as pre-machining condition, the maximum improvement percentage of surface roughness was found to be 48.9% and the maximum improvement percentage of micro hardness was equal to 63.1%. Under the different roller burnishing parameters, the obtained surface roughness is dependent also on work piece hardness and pre-machining conditions. The roller burnishing tool can be used as a promising finishing method.

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