An investigation of effect of combined Turning and ball burnishing dual process on the surface roughness performed on lathe

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***Abstract*— Burnishing is a cold rolling process without removal of metal.A set of balls rolls on the surface ofcomponent as a result of which all the premachined peaks get result into valleys thus giving mirror like surface. The burnishing is chip less machining which can be used to improve the surface roughness and surface hardness on any metal work piece. Machined surfaces by conventional manufacturing processes such as turning and milling have inherent irregularities and defects Like tool marks and scratches that cause energy dissipation (friction) and surface damage (wear). Burnishing is a kind of chip-less processing which improves the surface integrity of machined components. A new burnishing tool is introduced in this investigation which enables double ball burnishing process along with turning without releasing the workpiece. Effect of burnishing parameters namely burnishing feed, burnishing speed, and burnishing force upon final surface texture (roughness and roundness) were demonstrated. Burnishing results showed significant effectiveness of the burnishing tool in the process. The surface roughness and roundness error of the turned test specimens were improved by burnishing. For the treated material in this investigation, the best results of surface roughness and roundness error were obtained with double ball burnishing. The results of combined turning and double ball burnishing were better than that of performing individually**

***Keywords*— Ball burnishing, turning surface roughness, roundness error**

I. INTRODUCTION

The surface finish quality and roundness error of the machined components are an essential requirements due to its direct effects on the function of the components. Finishing processes such as hard cutting, grinding, polishing, and lapping are commonly used to improve the surface Finish of the machined components. Some researchers have been carried out recently to improve surface characteristics by using ball burnishing process. Ball burnishing process, as shown in fig. 1, which is one of the surface finishing processes that results in a plastic deformation on the workpiece surface by using a ball or a roller [1,2]. Plastic flow of the original asperities occurs when the yield point of the workpiece.s material is exceeded [4]; consequently the asperities will be flattened. The improvement of the surface roughness through the burnishing process generally ranged between 40% and 90% [3, 4]. Compressive stresses are also induced in the surface layer, giving several improvements to mechanical properties. Burnishing can improve both the surface strength and roughness [6]. The normal force, the burnishing feed, and speed, original roughness is also expected to exert an important effect [6].

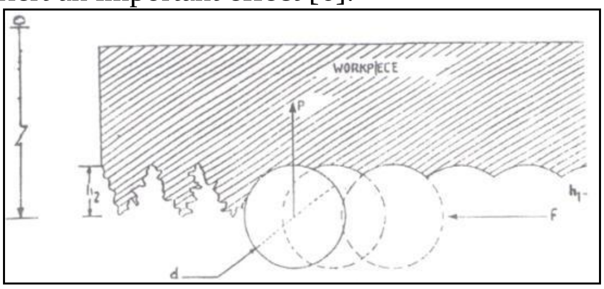


Fig. 1 Principle of burnishing process

The aim of this study is mainly to introduce a new burnishing tool which enables both turning and double ball burnishing process on a conventional lathe without releasing the work piece. Effect of burnishing parameters namely burnishing feed, burnishing speed, material hardness, ball materials and burnishing force upon final surface texture (roughness and roundness) were demonstrated.

II. EXPERIMENTAL INVESTIGATION

As mentioned, the main concern of this work is to examine the use of a new ball burnishing tool which will be used to improve surface characteristic such as surface roughness and roundness error as these factors playing an important role on the required tolerance and fit especially during assembly of parts.

The effects of burnishing parameters namely burnishing speed, feed, ball materials, and burnishing force on surface roughness and roundness error are comprehensively studied through this work. In this current research paper, an effort is being made to understand the underlying mechanism of improvement in the surface finish and surface micro-hardness of burnished surfaces along with the influence of the process parameters in "ferrous(mild steel) material " which is commonly used in shafts, press-rods and actuators. Consequently, it can be visualized that work-hardening phenomenon ob-served present in mild steel.

III. BURNISHING TOOL

The combined turning and two-ball burnishing tool is shown in figure 2 the balls are located inside an interchangeable adapter, are made of chromium steel and have a diameter of 16 mm each. The balls are free to rotate with the movement of the work piece due to frictional engagement between their surfaces. When balls are pressed against the surface of metallic Specimen, the adaptor compresses pre-calibrated springs. The springs are used to reduce the possible sticking effect of the balls and also to measure the applied vertical burnishing force. This tool includes two-ball bearings) and two flat-ended springs having stiffness 7.5 kg/mm. The combined turning and two-ball burnishing tool is designed in a simple manner so that it can be mounted easily on lathe machine.

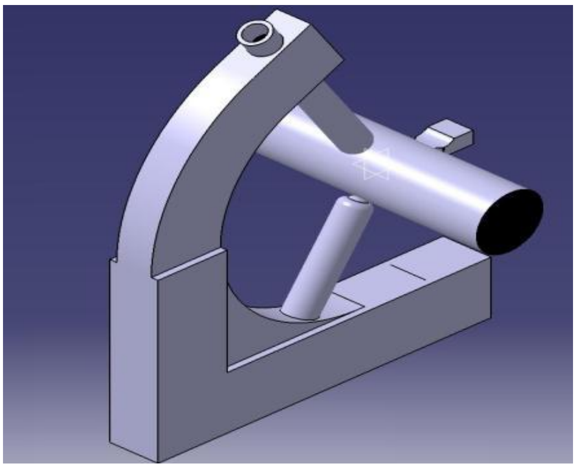
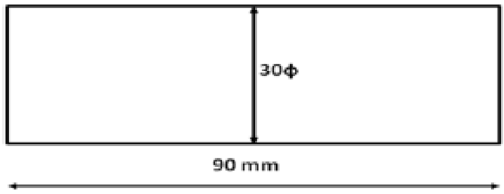


Fig. 1 Burnishing Tool

IV. MATERIAL OF THE TEST SPECIMENS

The material used in this study was carbon steel of 0.18%c. This material was selected due to its Importance in industry. The chemical composition is 0.18%c, 0.21%s, and 0.55%mn, and Mechanical properties are σu= 3100 N/mm2, and BHN= 121. The specimen configuration is shown below. Turning and burnishing processes were applied to the diameter 30 mm.



V. SETUP FOR THE EXPERIMENTATION

The workpiece to be finished and burnished is clamped by the three-jaw chuck of the lathe and if required it is guided from other side by the lathe tailstock. The burnishing process was applied after turning without release the workpiece from the lathe chuck to keep the same turning alignment. Initial dry turning conditions were unified for all workpiece as follows: Cutting speed= 57 m/min., depth of cut =0.25 mm, feed rate= 0.32 mm/rev., and using tool nose radius of 0.2 mm. As the aim of this investigation was to study the effect of the new turning and burnishing tool upon final surface texture (roughness and roundness), and to Study the effect of burnishing parameters namely burnishing feed, burnishing speed, and burnishing force upon final surface texture (roughness and roundness). The applied burnishing processes parameters and conditions are listed in table 1.

TABLE I
BURNISHING PARAMETERS AND CONDITIONS

Burnishing feed(f) m/rev.	0.03, 0.06, 0.11, 0.17, 0.21
Burnishing speed m/min.	10.5, 29.6, 60.3, 85.7, 116.5
Burnishing force (p)n	100, 150, 220
Burnishing conditions	Lubricant (Kerosene)

In this work, produced surface roughness, and roundness error were carefully measured after burnishing process. The surface finish of the burnished specimens was measured. Five readings of surface roughness (measured by Ra) were taken for each specimen, and the average values are calculated. For better results the arithmetic average of three readings was calculated. The pre-burnished surface of the test specimens were monitored by measuring of surface roughness and roundness values for four specimens which were machined under the same turning conditions as mentioned before.

VI. RESULTS AND DISCUSSION OF BURNISHING PARAMETERS ON SURFACE ROUGHNESS

Effect of feed rate:

As mentioned before five burnishing feeds were selected for this test. The effect of feed rate (f) was studied with constant burnishing speed of 60.3 m/min. and at different values of burnishing force (p) to study the interaction between the two parameters. The relations are plotted as shown in fig. 3 Fig.3 shows the results of double ball burnishing.

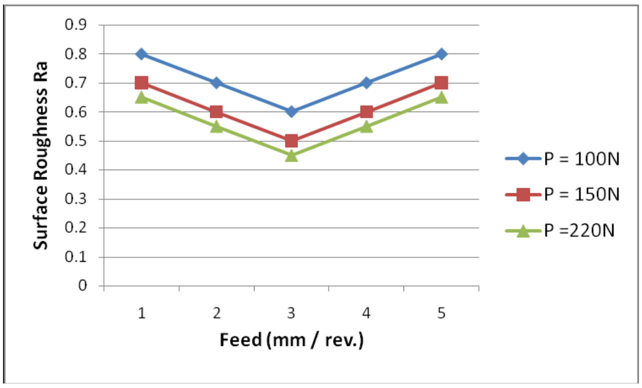


Fig. 3 Effect of burnishing feed on surface roughness for different burnishing force

The resulted surface roughness values figures are considerably reduced compared to Machined surface roughness (Ra= 2.5 m) i.e. before burnishing process, which give the Conclusion that the burnishing tool is effective. The trend of the relation between feed rate and the burnished surface roughness, as shown in fig.3, are approximately the same. First the surface roughness slightly decreased as the feed rate increased. Then after when feed rate increased above 0.11 mm/rev. The surface roughness was increased. To explain that behavior considers fig. 5. This figure shows increasing of feed increasing the distance between the peaks which lead to increasing of surface roughness. Using of very low feed values caused over hardening that may be caused flaking for the surface.

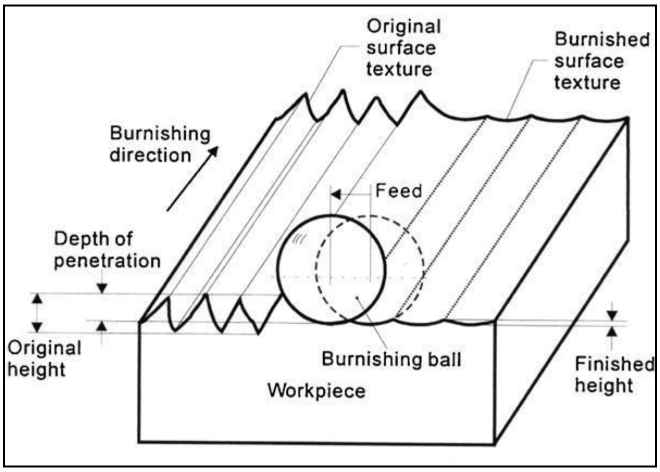


Fig. 4 Schematic representation of the ball burnishing process

The minimum surface roughness was obtained with a burnishing force of 150 N, at a feed rate of 0.11 mm/rev. After this feed value the surface roughness increased as the feed rate increased. The maximum surface roughness values were obtained with a burnishing force of 100N. The Improvement of surface roughness when increasing the force from 100N to 150N is expected as The increase of the force increase the depth of penetration resulting in compressing more Asperities and increases the metal flow that leads to the filling of more valleys that were existed On subsurface due to the previous turning process When the burnishing force increased from 150N to 220N the surface roughness was increased. This may be due to the over hardening and consequently flaking of the surface layer. The increase of force above a certain value (150N) also Increases the bludge in front of burnishing ball and widens the region of plastic deformation which damages the burnished surface and increased the surface roughness? So there is an Optimum burnished force that gives the best surface roughness.

Effect of burnishing speed:

The relations between burnishing speed and surface roughness are shown in figs. 5. Fig. 5 shows the effect of burnishing speed on surface roughness at constant feed rate of 0.11mm/rev. and under different burnishing forces. While fig. 8 shows this effect at constant force of 150N and at different feed rates. Referring to fig. 7a it can be noticed that, with a single ball the increasing of speed decreases the surface roughness for the force 100N, but for the forces 150N and 220N surface roughness first decreased with the increase of speed up to a speed of 60.3m/min. then slightly increased for further increasing of speed. The rate of increasing with a force of 220N is higher than that with the force of 150N. This is partially may be due to chatter which usually existed at high speeds with high forces. Fig. 7a also shows that, at low speeds the surface roughness is optimum at the force of 220N, while the worst one was obtained with a force of 100N. This can be attributed to the fact that, at low speeds the deformation action of the ball is high which deteriorate the surface roughness. In this case high force is required to press the peaks of the burnished surface. But at high speeds the reverse was true. Fig. 7a also shows that, the minimum surface roughness was obtained at a speed of 60.3 m/min. and burnishing force of 150N at 0.11 mm/rev. feed. In situation where double balls were used for burnishing fig. 7b, it can be seen that, using low burnishing force (100N) the surface roughness is increased as the speed increased. The same result was obtained when using the force 150N but at with low gradient. While with burnishing force of 220N the burnished surface roughness is reduced as the speed increase. This phenomenon can be attributed to the interaction between burnishing force and speed when using double ball burnishing.

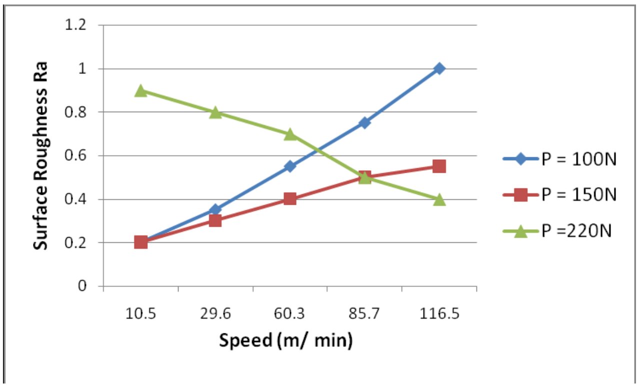


Fig. 5 Effect of burnishing speed on surface roughness at 0.11 mm/rev. Feed rate

For double ball burnishing better surface roughness can be achieved using low values of forces with low speeds, or using high forces with high speeds. Effect of burnishing speed on surface roughness at different feeds under constant burnishing force (150N) is shown in fig. 6 In case of single ball burnishing, the surface roughness decreases with the increase of burnishing speed until 60.3 m/min. speed and then slightly increases with the burnishing speed as shown in fig. 8a. On the other hand, Fig. 6 shows that, the surface roughness increases with burnishing speed for different feeds using double ball burnishing. The deterioration of surface roughness with the increase of speeds is believable as the two balls guided the specimen without any permission for elastic deformation. This may be cause the system to fall in chatter with the increase of speeds. At high speeds also there is a lubricant loss due to insufficient time for it to penetrate between the ball and the burnished surface which is essential for double ball burnishing [6].

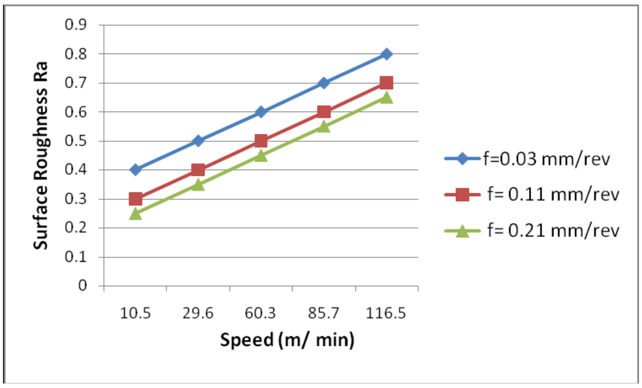


Fig. 6 Effect of burnishing speed surface roughness at 150N burnishing force

Effect of burnishing parameters on roundness error:

Roundness error plays an important role in the efficiency of any mechanical component. This error could be due to deflection of the workpiece as a result of the forces generated during cutting. This may be also due to incorrect in position or misalignment of the workpiece during machining. One of the objectives of this investigation is to study the effectiveness of the used burnishing tool and burnishing parameters in improvement the machined surface roundness

Effect of feed rate:

Fig. 7 shows the effect of feed on the burnished surface roundness error .Hence further increase of feed above 0.11 mm/rev. increased roundness error. This can be explained by the fact that, at very low feeds the deformation action of the ball is accumulated due to its small axial movement that may cause shear of subsurface layer (flaking) leading to deterioration of roundness error. Increasing of roundness error for the feeds above 0.11 mm/rev. is expected due to the increase of axial distance moved by the tool during burnishing process.

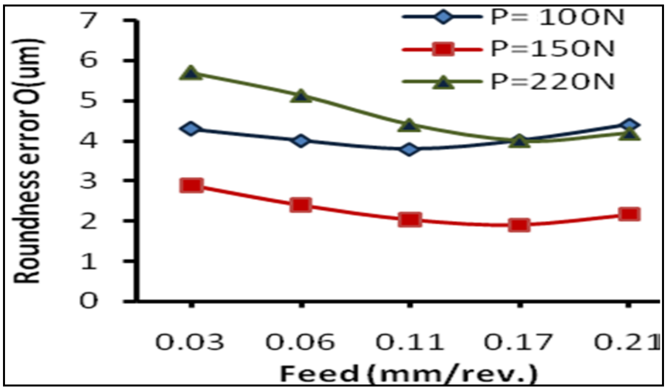


Fig. 7 Effect of burnishing feed on roundness error at 60.3m/min burnishing speed

The double ball burnishing increases the feed rate limit at which the roundness error begins to increase from 0.11mm/rev. The increase of force from 100N to 150N decreased roundness error. This is due to compressing more asperities on the burnished surface with the force 150N. Further increase of the force to 220N increasing roundness error because shear failure occurred for subsurface layer (flaking) under the action of this force, which in turn increased roundness error. This lead the manufacturer to give more attention for the value of burnishing force as it is affect the result of burnishing process. In this investigation the best surface roughness and roundness can be obtained using 150N burnishing force.

Effect of burnishing speed:

Effect of burnishing speed on roundness error is shown in figs. 8and 9. Fig. 8 was plotted to study the interaction between speed and force, while fig. 9 for that between speed and feed. Fig. 8 also shows the best result of roundness error was obtained with double ball burnishing by using burnishing force of 150N. Fig. 9 shows the effect of burnishing speed at various feed.

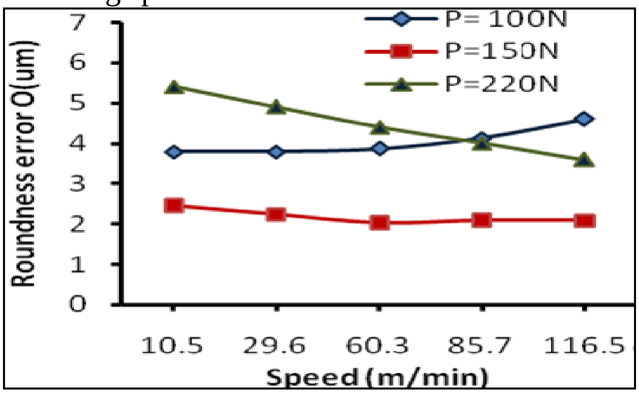


Fig. 8 Effect of burnishing speed on roundness error at 0.11mm/rev. feed rate

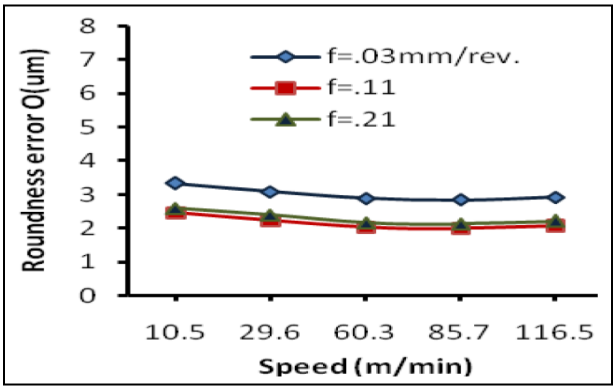


Fig. 9 Effect of burnishing speed on roundness error at 150N burnishing force

Figs. 8 and 9 also shows the best result of roundness error was obtained with double ball burnishing and while using burnishing force 0f 150N. The smaller roundness error also can be achieved by using burnishing speeds between 60.3, and 85.7 m/min. with a burnishing feed of 0.11 mm/rev.

VII. CONCLUSION

A new burnishing tool was introduced in this investigation which enables double ball burnishing process with turning without releasing the workpiece. Effect of burnishing parameters upon final surface texture (roughness and roundness) was demonstrated.

- Burnishing results showed significant effectiveness of the burnishing tool in the process. The surface roughness and roundness error of the turned test specimens were improved by burnishing from about Ra = 2.5 to about 0.2 μm, and roundness error from about 7.3 to about 2 μm
- For the treated material in this investigation the optimal value for burnishing force that gave best surface roughness and roundness error was 150N.
- The minimum surface roughness was obtained at a feed rate 0.11 mm/rev. and a speed of 60.3 m/min
- For double ball burnishing better surface roughness can be achieved using low values of forces with low speeds, or using high forces with high speeds.
- The best results of surface roughness and roundness error were obtained with double ball burnishing using burnishing force of 150N. The smaller roundness error also can be achieved by using burnishing speeds between 60.3, and 85.7 m/min. with a burnishing feed of 0.11 mm/rev.

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