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Effect of Burnishing Forces on Turning Surfaces

Yaser A. Hadi*

Yanbu Industrial College, Royal Commission for Jubail and Yanbu, Saudi Arabia
*Corresponding author: hadiy@rcyci.edu.sa

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Abstract Forces play an effective role in a burnish surfaces. Where burnishing technique utilizes a moving force device, squeezed against the workpiece, to accomplish plastic twisting of the surface layer. Another burnishing device was presented in this investigation, which empowers ball-burnishing process in site in the wake of turning without discharging the workpiece. Impact of burnishing parameters, which are burnishing feed, burnishing speed, and burnishing force upon conclusive roughness surface were illustrated. Burnishing results demonstrated noteworthy viability of the burnishing tool simultaneously. The surface roughness of the turned test examples were enhanced by burnishing. For the treated material in this investigation, the best consequences of surface roughness was acquired with a range of ball burnishing forces, rate it 64, 136, and 200. The base surface roughness was acquired at a feed rate 0.088 mm/rev. what is more, a speed of 48.24 m/min. The littler roundness mistake additionally can be accomplished by utilizing burnishing velocities running between 48.24 to 68.56 m/min. with a polishing feed of 0.088 mm/rev. It was confirmed at the end of the research that the surface roughness increments with low burnishing force and at high speed for various feeds utilizing one ball burnishing.

Keywords: *burnishing force, surface roughness, burnishing parameters*

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1. Introduction

For symmetric rotational segments made of high-quality aluminum alloys, slide burnishing is suitable in view of its effortlessness and simple acknowledgment. The impact of the procedure parameters at first glance harshness has been examined [1]. The surface complete quality and roundness blunder of the machined segments are fundamental necessities because of its immediate impacts on the capacity of the parts. Completing procedures, for example, hard cutting, grinding, burnishing, and lapping are usually used to enhance the surface complete of the machined parts. A few looks into have been done as of late to enhance surface qualities by utilizing ball burnishing process. Ball burnishing process, as appeared in Figure 1, is one of the surface finishing procedures that outcomes in a plastic disfigurement on the workpiece surface by utilizing a ball or a roller [2,3]. 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 enhancement of the surface roughness through the burnishing process for the most part ran somewhere in the range of 40% and 90% [4,5]. Compressive burdens are additionally incited in the surface layer, giving a few upgrades to mechanical properties. Burnishing can enhance both the surface quality and unpleasantness [6]. The impacts of a few parameters for ball burnishing procedure, effectively affecting surface roughness, were examined utilizing Taguchi's technique to lead the lattice test to decide the ideal ball burnishing process parameters. Parameters that have impact in the process are the typical power, the polishing feed, and speed [7]. Unique roughness is likewise expected to apply an essential impact. The aim of this study was essentially to present polishing tool, which empowers single ball burnishing process in site subsequent to turning on a customary machine without discharging the workpiece. Influence of burnishing parameters, which are burnishing feed, burnishing rate, and burnishing force upon definite surface roughness and roundness were illustrated [8].

2. Experimental Investigation

As referenced, the principle concern of this work is to analyze the utilization of another ball-burnishing device, which will be utilized to enhance surface trademark, for example, surface roughness and roundness error as these variables assuming an essential role on the required tolerance and fit particularly amid gathering of parts. The impacts of burnishing parameters; in particular; burnishing speed, feed, and burnishing force on surface roughness and roundness error are extensively contemplated through this work.

2.1 Burnishing Tool

The tool utilized in the experiments was structured and constructed, as appeared in Figure 1. It comprises of a ball made out of Carbon chromium steel. The ball is in strong contact just with the surface to be burnishing, and is guided by idler ball to be allowed to come toward any path on the surface of the work piece. One tool was utilized for single ball burnishing, as appeared in Figure 1.

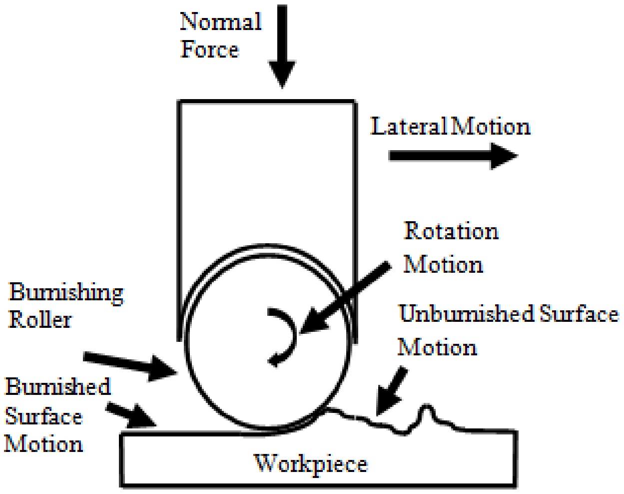


Figure 1. Principle of burnishing tool

The shank of one of the burnishing tools is structured in such a way, to the point that it tends to be just mounted or settled onto the tool holder of the machine, while the other device is mounted on extraordinary holder. This holder is settled on the machine seat to move with it as one section. At that point, variable feed rates for burnishing were connected for the tolls by the machine saddle. The tool were appropriately adjusted and leveled. As appeared in the Figure 2, burnishing device is finished with a flexible screw.

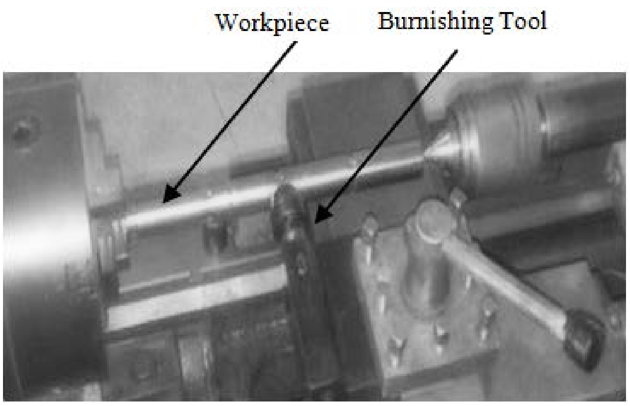


Figure 2. Installation of burnishing tools on a lathe

This setup has the accompanying preferences:

The typical force is steady, controlled by torque arm wrench; the procedure is then reliable and simple to replicate.

The ball can pivot uninhibitedly toward any path; this limit the sliding contact with the workpiece.

The tool can be introduced on a conventional machine; burnishing can be therefore completed with the workpiece in the equivalent clipped position concerning a typically turning.

2.2. Material of the Test Specimens

The material utilized in this investigation was carbon steel of 0.18%C. This material was chosen because of its significance in industry. The concoction structure is 0.18%C, 0.21%S, and 0.55%Mn, and mechanical properties are σu= 380 N/mm2, and BHN= 121. The specimen is rectangular and has a length of 80cm and a diameter of 20cm.

2.3. Setup for the Experiments

The workpiece to be burnished is cinched by the three-jaw throw of the machine and guided from opposite side by the machine tailstock. The burnishing procedure was connected in the wake of diverting without discharging the workpiece from the machine toss to keep a similar turning arrangement. Starting dry turning conditions were brought together for all workpieces. As the aim of this investigation was to contemplate the impact of the new burnishing tool in single ball burnishing process upon conclusive surface roughness and roundness, and to study about the impact of burnishing parameters to be specific burnishing feed, burnishing speed, and burnishing force upon definite roughness surface and roundness. The applied burnishing processes parameters and conditions are listed in Table 1.

Table 1. Burnishing parameters and conditions

Burnishing feed rate, mm/rev.	0.024, 0.048, 0.088, 0.136, and 0.168
Burnishing speed, m/min.	8.4, 23.68, 48.24, 68.56, and 93.2
Burnishing force, N	64, 136, and 200
Apparatus Nose Span	0.2 mm
Burnishing conditions	Lubricant

In this work, produced surface roughness, and roundness error were measured after burnishing process, Figure 3. The surface finish and roundness error of the burnished specimens was measured using Mirotoyo Talysurf model. The measurements were carried out across the lay using diamond stylus of radius 2.5 microns and adjusted meter cut-off 0.8 mm. Five readings of surface roughness (R_a) 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 turned under the same turning conditions as, mentioned before.

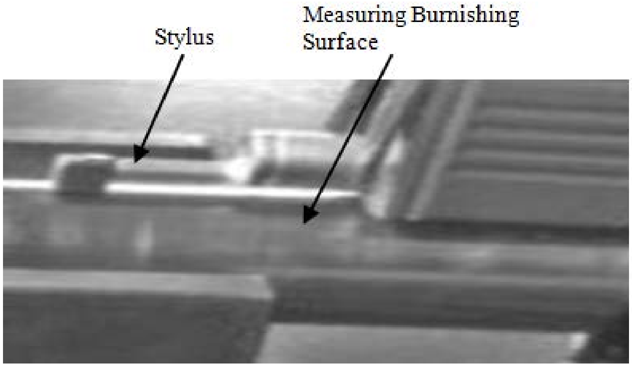


Figure 3. Measuring of Surface roughness

3. Results and Discussion

To study the effectiveness of the new burnishing tool, and effect of burnishing parameters on the burnished surface roughness and roundness the experimental results are plotted as shown in Figure 4, and Figure 6-Figure 10. The relations are drawn for single burnishing ball to study which one has more effect that is appreciable. The results of turned specimens were as follows: The average of surface roughness (R_a) and roundness error (O) for four specimens is 2.5μm, and 7.3 μm respectively. The results of burnishing tests and discussion are as follows:

3.1. Effect of Burnishing Feed Rate Parameter on Surface Roughness

As mentioned before five burnishing feeds were selected for this test. The effect of feed rate (f) was studied with constant burnishing speed of 48.24 m/min. and at different values of burnishing forces (P) to study the interaction between the two parameters (f, P). The relations are plotted as shown in Figure 4.

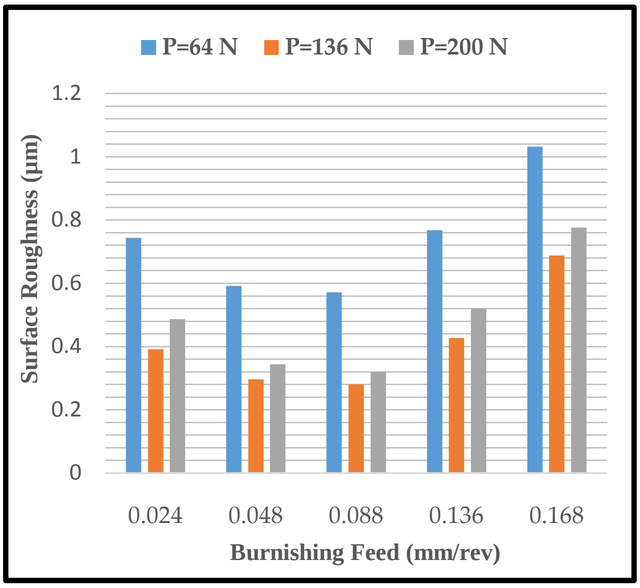


Figure 4. Effect of burnishing feed on surface roughness for different burnishing force

The resulted surface roughness values in both figures are considerably reduced compared to machined surface roughness (R_a= 2.0µm) i.e. before burnishing process, which gives the conclusion that the burnishing tool is effective. The trend of the relation between feed rate and the burnished surface roughness, as shown in Figure 4, indicates that, the surface roughness slightly decreased as the feed rate increased. Then when feed rate increased above 0.088 mm /rev., the surface roughness was increased.

To interpret the above phenomenon, a schematic representation of ball burnishing process is shown in Figure 5. The figure shows increasing of feed increasing the distance between the peaks that lead to increasing of surface roughness. Using of very low feed values caused reduction of area opposite to the tool, which increased the compressive stress, more which caused overhardning that may cause flaking for the surface and deteriorate the surface finish. This figure demonstrates increasing of feed expanding the separation between the pinnacles, which lead to expanding of surface roughness. Utilizing of low feed values caused decrease of territory opposite to the tool, which increased the compressive stress, more which caused overhardning that may cause chipping for the surface and fall apart the surface finish.

The minimum surface roughness was obtained with a burnishing force of 136 N, at a feed rate of 0.088 mm/rev. After this feed esteem the surface roughness expanded as the feed rate expanded. The maximum surface roughness esteems were acquired with a burnishing force of 64N. The enhancement of surface roughness while increase the force from 64N to 136N is normal as the increase of the force increment the profundity of penetration bringing about packing more severities and builds the metal stream that prompts the filling of more valleys that were existed on subsurface due to the previous turning process [9].

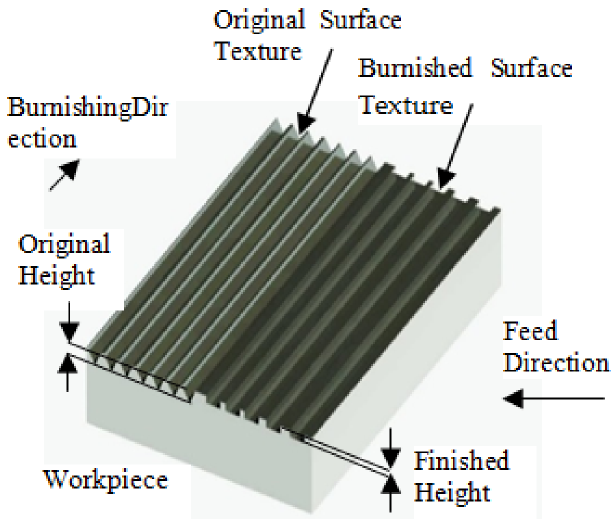


Figure 5. Schematic representation of the burnishing process

When the burnishing force increased from 136N to 200N, the surface roughness was increased. This may be due to the overhardning and consequently flaking of the surface layer. The increase of force above a certain value (136N) also increases the bludge in front of burnishing ball and widens the region of deformation, which damages the burnished surface and increased the surface roughness. Therefore, an ideal burnished force gives the best surface roughness. Mezlini [10] revealed that, the ideal incentive for burnishing power relies upon the flexible properties of treated material and surface roughness acquired from past machining process.

3.2. Effect of Burnishing Speed Parameter on Surface Roughness

The relations between burnishing speed and surface roughness are shown in Figure 6 and Figure 7. Figure 6 shows the effect of burnishing speed on surface roughness at constant feed rate of 0.088 mm/rev, under different burnishing forces. While Figure 7 shows this effect at constant force of 136N and at different feed rates. It can be noticed that, the increasing of speed decreases the surface roughness for the force 64N, but for the forces 136N and 200N surface roughness first decreased with the increase of speed up to a speed of 48.24 m/min. then slightly increased for further increasing of speed. The rate of increasing with a force of 200N is higher than that with the force of 136N. This may partially, be due to the self-excited vibration (chatter), which is usually existed at high speeds with high forces.

Figure 6 likewise demonstrates that, at low speeds the surface roughness is ideal at a force of 200N, while the most exceedingly awful one was acquired with a power of 64N. This can be described to the way that, at low speeds the deformation action of the ball is high which weakens the surface roughness. For this situation, high force is required to press the pinnacles of the burnished surface. Nevertheless, at high speeds the turnaround was valid. Likewise, Figure 6 demonstrates that, the minimum surface roughness was obtained at a speed of 48.24 m/min. what's more, burnishing force of =136N at 0.088 mm/rev. feed rate.

A similar outcome was acquired when utilizing the power 136N yet with a lower slope. While with burnishing force of 200N, the burnished surface roughness is reduced as the speed increment. It very well may be seen from the figure additionally that, the scope of variety of surface roughness for various velocities at the powers 136 and 200N is least than that of single ball burnishing. Additionally, at low speed of 8.4 m/min., the surface roughness for the force 200N is more prominent than different forces and this might be expected to overhardning caused for the workpiece surface under the action of this force.

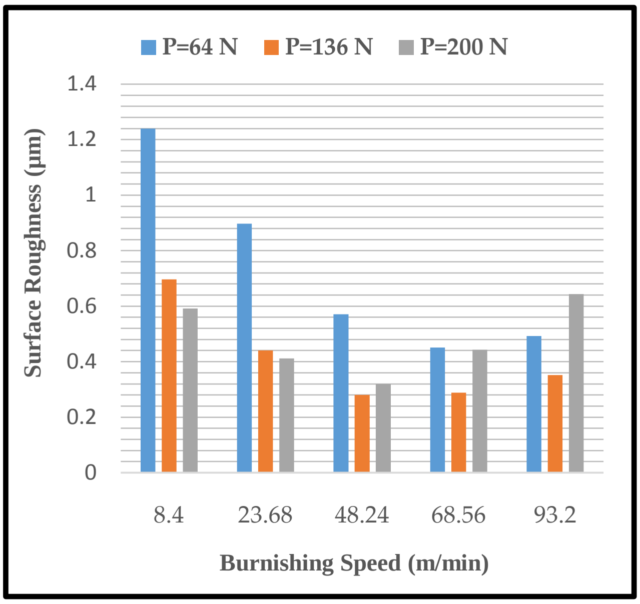


Figure 6. Effect of burnishing speed on surface roughness at 0.088 mm/rev. feed rate

Impact of burnishing speed on surface roughness at different feeds under constant burnishing force (136N) is shown in Figure 7. The surface roughness decreases with the increase of burnishing speed until 48.24 m/min. speed and then slightly increases with the burnishing speed. If there should arise an occurrence of the ball burnishing, the surface roughness diminishes with the expansion of burnishing rate until 48.24 m/min. speed and after that somewhat increments with the burnishing speed as appeared in Figure 7.

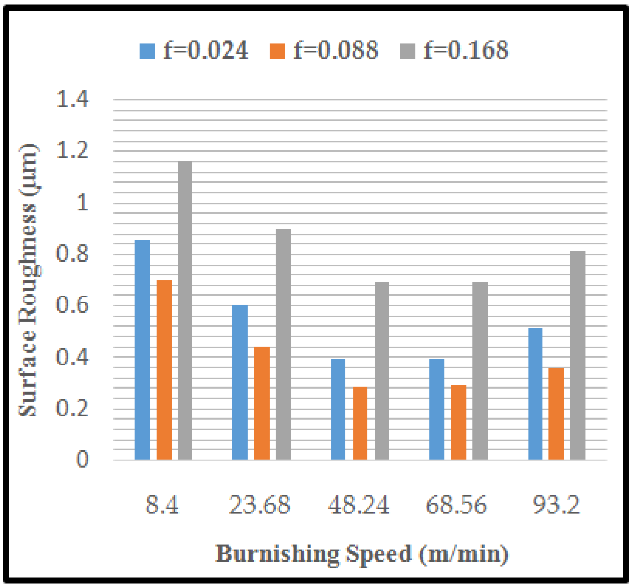


Figure 7. Effect of burnishing speed on surface roughness at 136N burnishing force

The disintegration of surface roughness with the expansion of rates is authentic as the ball burnishing guided the example with no authorization for elastic deformation. This may make the framework fall in chatter with the expansion of paces. At high speeds, there is likewise a lubricant misfortune because of lacking time for it to infiltrate between the ball and the burnished surface, which is fundamental for ball burnishing [11]. When all is said in done for single burnishing, the base surface roughness can be accomplished utilizing 0.088 mm/rev. feed, and at a roughness rate of 48.24 m/min.

3.3. Effect of Burnishing Feed Rate Parameter on Roundness Error

Out-of-roundness of circular and cylindrical parts can greatly affect assembly accuracy [12]. Roundness error assumes an essential role in the efficiency of any mechanical part. This error could be because of avoidance of the workpiece, because of the forces created amid cutting. This might be likewise because of off base situating or misalignment of the workpiece amid machining. One of the goals of this examination is to consider the impact of the utilized burnishing tool and burnishing parameters on enhancement the machined surface roundness.

Figure 8 demonstrates the impact of feed on the burnished surface roundness error for burnishing strategies. Figure 8 appears that the increase of feed from 0.024 to 0.088mm/rev, diminishes the roundness error. Subsequently further increment of feed above 0.088 mm/rev. increases roundness error. This can be clarified by the way that, at low feeds the twisting activity of the ball is gathered because of its little hub development that may cause shear of subsurface layer prompting crumbling of roundness error. Increasing of roundness error past the feeds above 0.088 mm/rev is expected due of the increase of pivotal separation moved by the instrument amid shining procedure. In this way, for single ball burnishing it is desirable over abstain from burnishing at low feeds and in as well as at very high feeds.

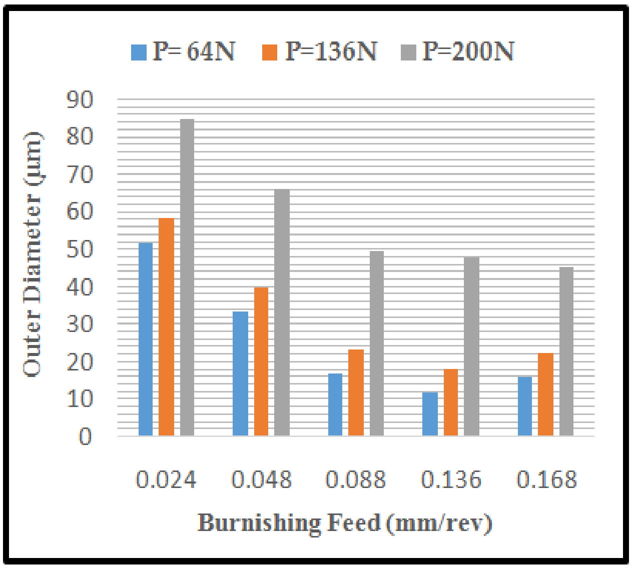


Figure 8. Effect of burnishing feed on roundness error at 48.24m/min burnishing speed

Be that as it may, the feed rate limit at which the roundness error starts to increment expanded from 0.088mm/rev. to 0.136 mm/rev. as appeared in Figure 8. The same figure also shows that the roundness error for the ball burnishing supports the workpiece preventing its deflection under the acting forces, which is the main cause of roundness error. The increase of force from 64N to 136N decreases roundness error. This is due to compressing more asperities on the burnished surface with the force of 136N. Further increase of the force to 200N increases roundness error because shear failure occurred for subsurface layer under the action of this force, which in turn increases roundness error. This lead the manufacturer to give more attention for the value of burnishing force as it affects the result of burnishing process.

3.4. Effect of Burnishing Speed Parameter on Roundness Error

Impact of burnishing speed on roundness error is appeared in Figure 9, and Figure 10. Figure 9 was plotted to contemplate the cooperation between speed and force, while Figure 11 for the connection between speed and feed. For the ball burnishing, the expansion of speed diminish roundness error for all of burnishing forces levels. Figure 9 demonstrates that at low force of 64N, the expansion of speed expanded roundness error for the ball burnishing. Figure 10 additionally demonstrates the best aftereffect of roundness was acquired with the ball burnishing by utilizing burnishing force of 136.

Figure 10 demonstrates the impact of burnishing speed at different feed rates. As appeared in the figure for all feeds esteems, roundness error is diminished as the speed increased with the exception of ball burnishing at feed of 0.168mmm/rev. For this situation the expansion of speed above 48.24 m/min. expanded roundness error. This might be because of, the increase of developed material in front of the ball, prompting inordinate vibration which decay the roundness error.

The small roundness error also can be achieved by using burnishing speeds between 48.24, and 68.56m/min. with a burnishing feed of 0.088 mm/rev. The surface roughness profile for the example polished with feed rate 0.088 mm/rev., speed of 48.24 m/min., and a force of 136N is shown in Figure 11 preceding polishing in the wake of turning, and in the wake of burnishing. This figure illuminates the viability of the burnishing tool, and furthermore the ability of burnishing in delivering smooth surfaces [13], and modifies the surface integrity [14].

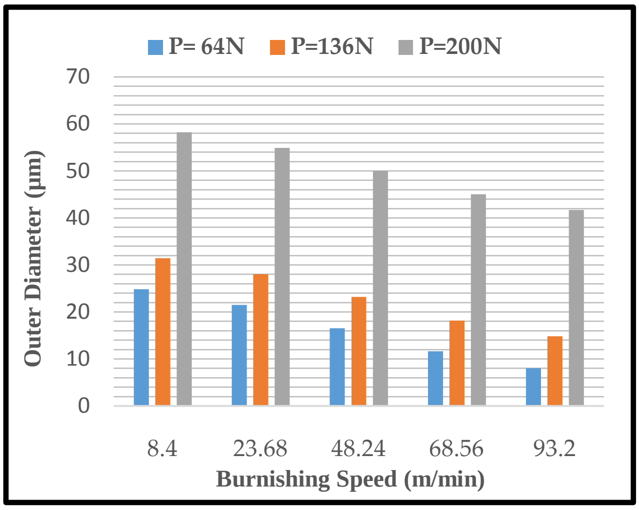


Figure 9. Effect of burnishing speed on roundness error at 0.088mm/rev. feed rate

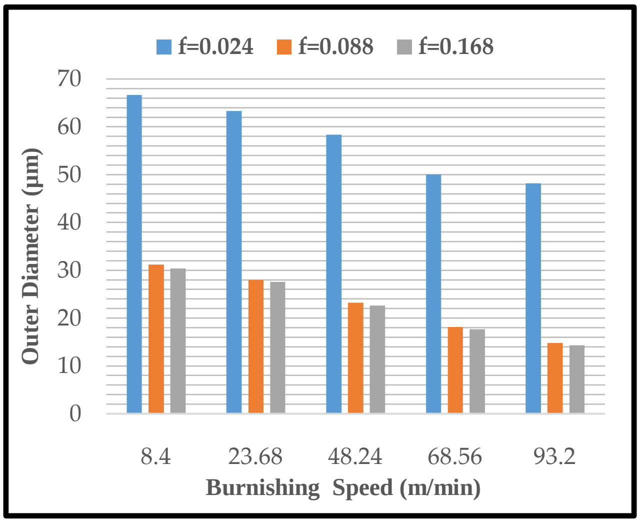
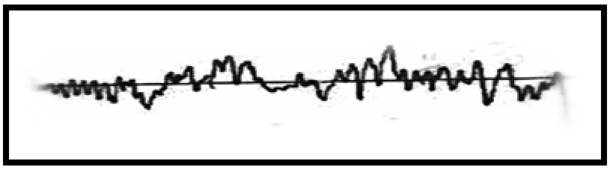
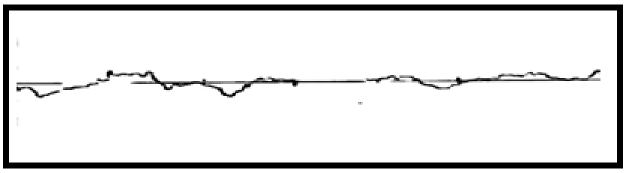


Figure 10. Effect of burnishing speed on roundness error at 136N burnishing force



a. Surface of the workpiece after turning



b. Surface of the workpiece after burnishing

Figure 11. Surface roughness profile before and after burnishing

4. Conclusions

Burnishing tool was displayed in this investigation, which enables single ball burnishing procedure in site in the wake of turning without releasing the workpiece. Effect of burnishing parameters upon definitive roughness surface and roundness was represented. Burnishing outcomes exhibited that, the Burnishing tool has an essential enhancement of the surfaces occurred in view of the method. The surface roughness and roundness error of the turned test specimens were upgraded by burnishing from about Ra = 2.0 to 0.16 µm, and roundness error from about 5.84 to 1.6 µm. For the treated material in this investigation, the perfect impetus for burnishing power that gave best surface roughness and roundness botch was 136N. The base surface roughness was acquired at a feed rate 0.088 mm/rev. in addition, a speed of 48.24 m/min. The little roundness mistake can in like manner be cultivated by using burnishing speeds some place in the scope of 48.24, and 68.56 m/min. with a burnishing feed of 0.088 mm/rev. At last, it is obvious from the abovementioned and every single past assume that the best conditions for burnishing constrained to states of low power, low feed rate, and high speed.

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