Investigation of effectiveness of processing parameters on the performance of combined turning and burnishing operations on aluminium alloy

[1]Prafulla Chaudhari, [2]Dr. G.K. Awari, [3]Dr. S.S. Khandare
[1]Assistant Professor, Department of Mechanical Engineering, Priyadarshini College of Engineering, Nagpur (MS) INDIA
[2]Principal, Tulshiramji Gaikwad-Patil College of Engineering and Technology, Nagpur
[2]Ex-Principal, Bapurao Deshmukh College of Engineering, Sewagram

***Abstract* - Burnishing is a cold working process that employs plastic deformation of a suface layer in order to improve surface characteristics such as surface finish and microhardness of the workpiece.. 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 number of passes on final surface texture (roughness and roundness) were demonstrated. Burnishing results showed significant effectiveness of the newly developed burnishing tool in the process. For the aluminium alloys in this investigation, the best results of surface finish and surface hardness with saving in energy were obtained with double ball burnishing. The results of combined turning and double ball burnishing were better than that of performing individually.**

***Index Terms* - Ball burnishing, turning surface roughness, micro hardness.**

I. INTRODUCTION

The surface finish quality and surface hardness of the machined components are 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 figure 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. Plastic flow of the original asperities occurs when the yield point of the work piece material is exceeded; consequently the asperities will be flattened. The improvement of the surface roughness through the burnishing process generally ranged between 40% and 90%. Compressive stresses are also induced in the surface layer, giving several improvements to mechanical properties. Burnishing can improve both the surface strength and roughness. The normal force, the burnishing feed, and speed, original roughness is also expected to exert an important effect.

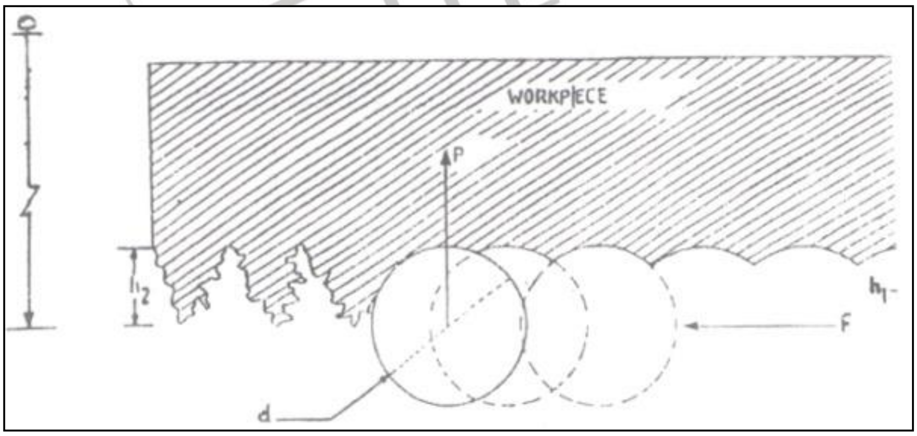

Fig.1 Principle of burnishing process

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, depth of penetration, upon final surface texturewere 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 no of passes on surface roughness and hardness 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 aluminium alloys which is commonly used in shafts, automobiles and aviation parts.

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 Tungsten carbide and have a diameter of 10 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 18.00N/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.

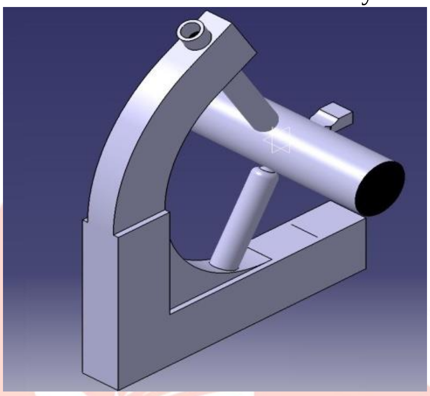

Fig.2 Burnishing Tool

IV. MATERIAL OF THE TEST SPECIMENS

The material used in this study is aluminium alloys 6061. This material was selected due to its Importance in industry. These materials have wide industrial application because of their specialised mechanical properties. The chemical composition is 96%AL, 0.04%Cr and 0.155%Cu, and

Mechanical properties are σu= 310 N/mm2, and BHN= 95.

The specimen configuration is shown below. Turning and burnishing processes were applied to the diameter 30 mm.

The specimen

V. SETUP FOR THE EXPERIMENTATION

The work piece 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 releasing the work piece 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 1 Burnishing parameters and conditions

Burnishing Parameters	Value
Burnishing feed(f) µm/rev.	20, 30, 40, 50
Burnishing speed rpm.	50, 60, 70, 80
No.of passes	1, 2, 3
Depth of penetration	3.0 mm

In this work, produced surface roughness, and surface hardness were carefully measured after burnishing process. The surface finish of the burnished specimens was measured. The experimentation was performed on preturned work piece material on which only burnishing was carried out and combined process of burnishing where turning and burnishing carried out in one setting without releasing the workpiece.

VI. RESULTS AND DISCUSSION OF BURNISHING PARAMETERS ON SURFACE ROUGHNESS

Effect of feed rate: As mentioned before four burnishing feeds were selected for this test. The effect of feed rate (f) was studied with various burnishing speed of 50 rpm, 60 rpm, 70 rpm and 80 rpm and for different number of passes to study the interaction between the two parameters. The relations are plotted as shown in figure 3.

It is observed from the figure that surface roughness increases with increase in tool feed. Also it is observed that surface increases for increase in speed for same set of tool feed.

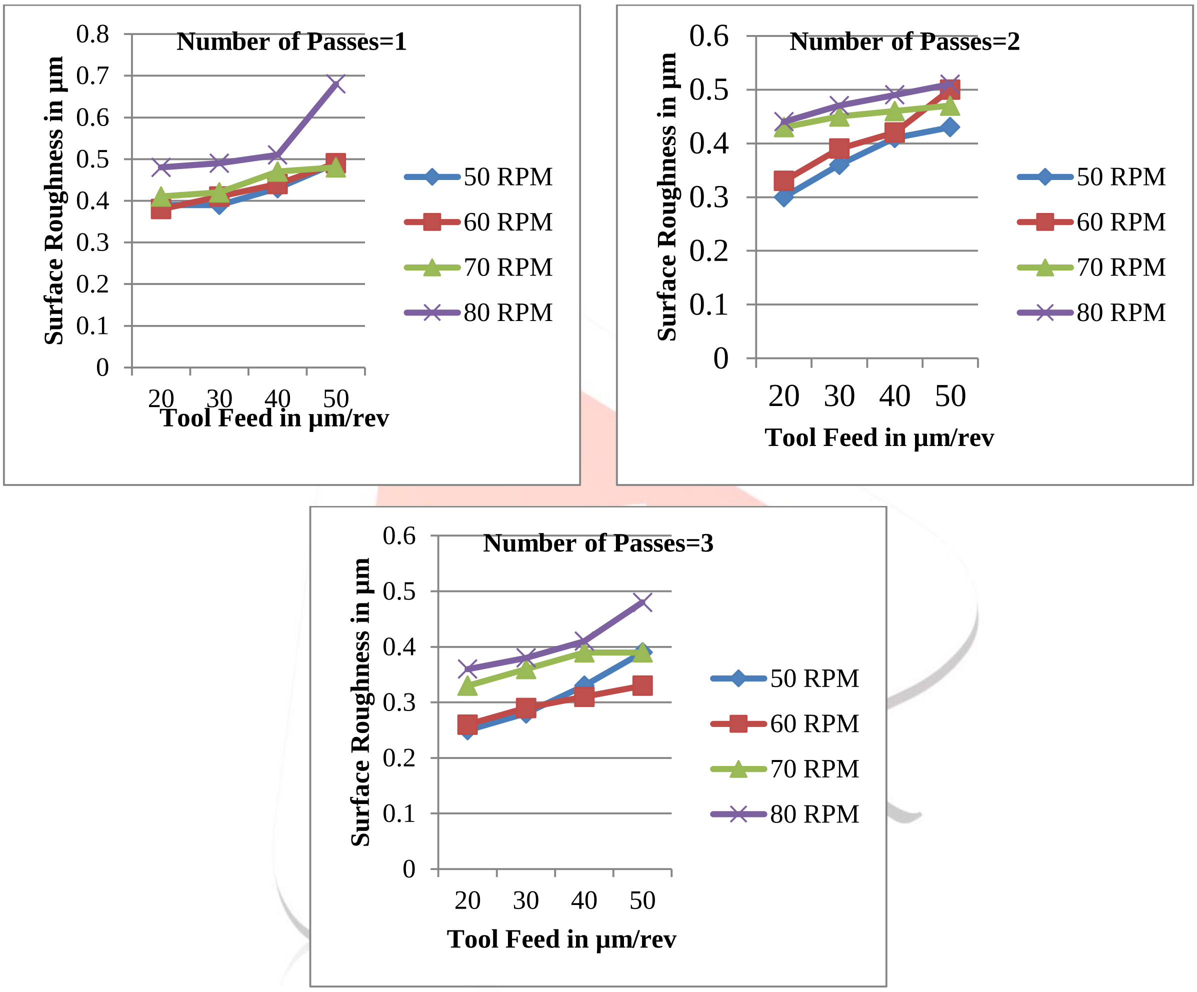

Fig. 3 Effect of burnishing feed on surface roughness for various speed and number of passes

Effect of burnishing speed: As mentioned before four burnishing feeds were selected for this test. The effect of Workpiece speed was studied with various tool feed of 20 µm/rev, 30 µm/rev, 40 µm/rev, 50 µm/rev and for different number of passes to study the interaction between the two parameters. The relations are plotted as shown in figure 4.

It is observed from the figure that surface roughness increases with increase in Workpiece speed. Also it is observed that surface increases for increase in tool feed for same set of workpiece speed.

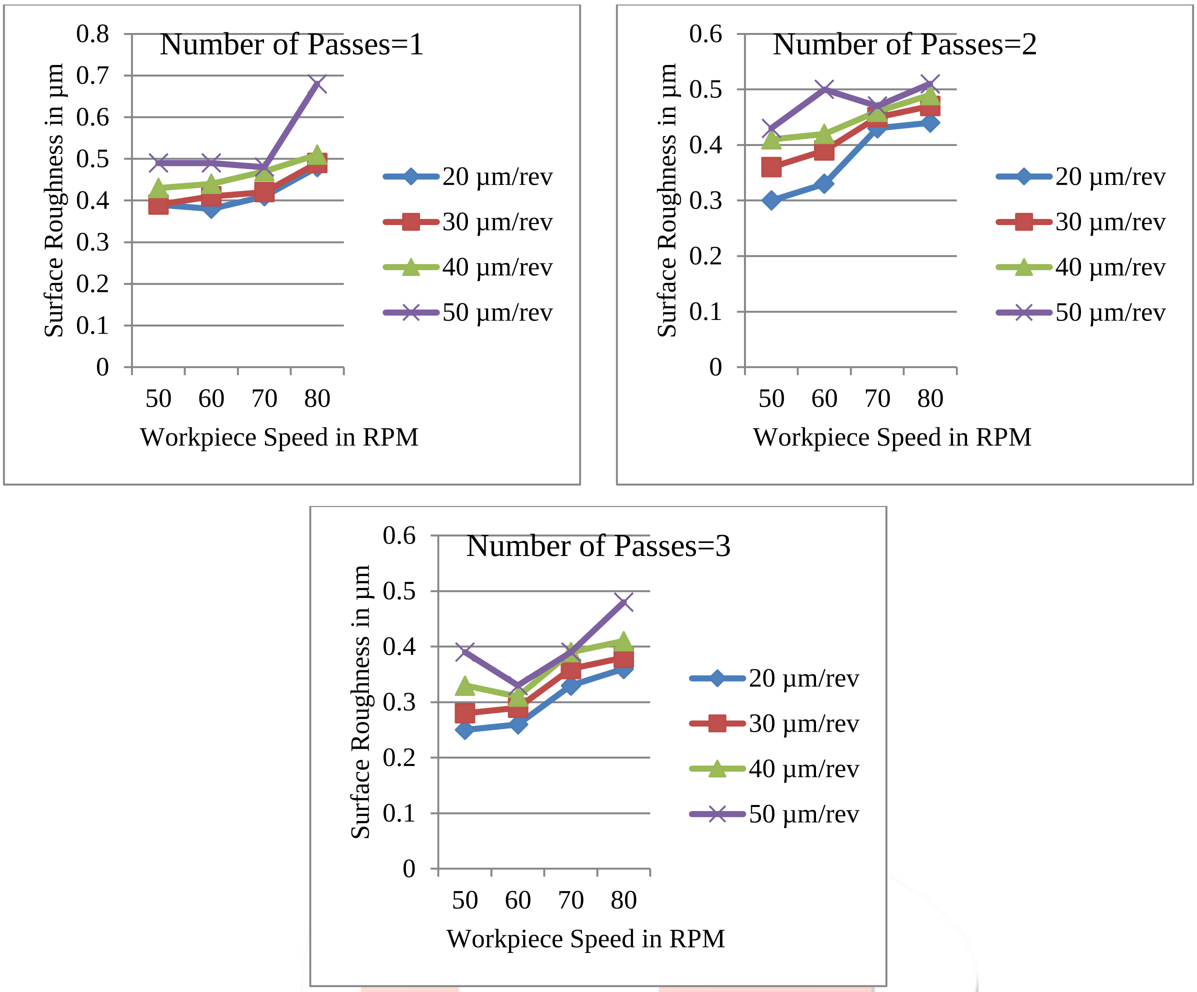

Fig. 4 Effect of workpiece speed on surface roughness for various tool feed and number of passes

Effect of number of passes: Three numbers of passes were selected for this test. The effect of number of passes was studied with various tool feed of 20 µm/rev, 30 µm/rev, 40 µm/rev, 50 µm/rev and for different workpiece speed to study the interaction between the two parameters. The relations are plotted as shown in figure 5.

It is observed from the figure that surface roughness decreases with increase in number of passes. Also it is observed that surface increases for increase in tool feed for same set of number of passes.

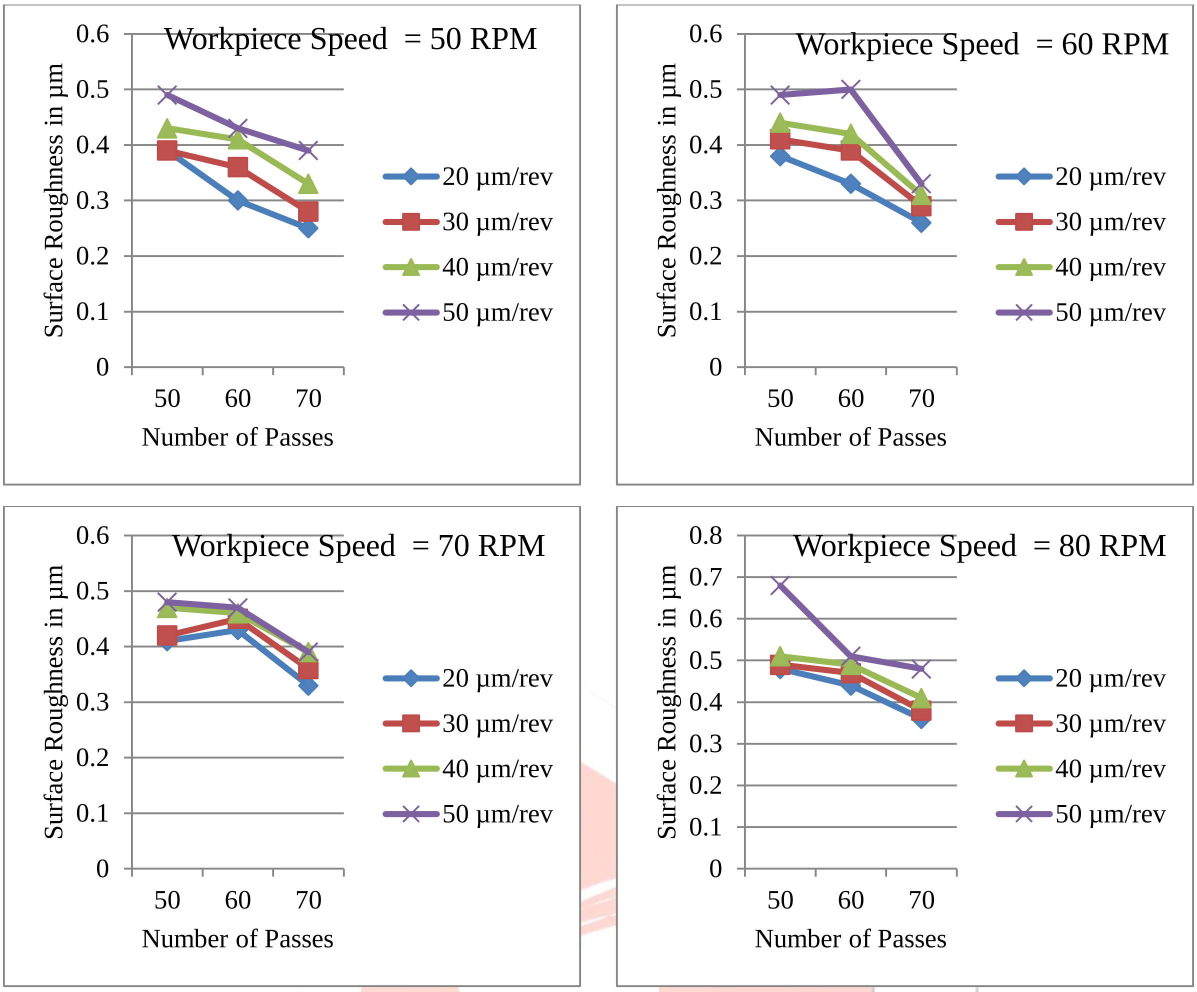

Fig. 6 Effect of Number of passes on surface roughness

VII. Conclusion

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

- Burnishing results showed significant effectiveness of the burnishing tool in the process. The surface roughness of the turned test specimens were improved by burnishing. But when the burnishing process is carried out in setting without releasing the workpiece provides superior results of surface finish.
- For double ball burnishing better surface roughness can be achieved using lower values of machining parameters.
- Thus it is conclude that the combined turning and burnishing process gives better surface texture characteristics.

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