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AN INVESTIGATION OF MULTI-ROLLER BURNISHING PROCESS ON MILD STEEL AND COPPER METAL

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ABSTRACT

Burnishing is a chipless machining process. It produces smooth finishing both on round and flat surfaces. It easily produces work hardened surface by plastic deformation of surface irregularities. The burnishing is carried out by pressing a freely rotating hardened ball or roller against a rotating or flat or stationery work piece. The surface roughness is produced by the planetary rotation of ball / roller. The resulting cold working process produce smooth surface roughness, induces compressive strength, resist wear, corrosion resistance and improves fatigue life of the work part. The ball burnishing improves circularity of the work pieces. The burnishing process also improves surface hardness on the work piece surface considerably. Various spindle speeds, feed and depth of penetration are used to perform the experiments. High spindle speed and feed for the same depth of penetration produced lower value in surface roughness. The surface hardness on the surface was also increased by increasing depth of penetration for given spindle rotation and feed. The surface hardness can be increased to certain value, however, there is a limitation.

Key words: *Depth of penetration, Multi-Roller burnishing, Surface roughness, Surface hardness, Burning process.*

INTRODUCTION

There are many finishing processes used to produce surfaces with high quality textures. These processes could be classified into chip removal process, such as grinding, turning and milling etc. and chip less processes, such as burnishing [1-3]. Finishing of surfaces on round and flat surfaces has been improving due to the introduction of newer technologies. This is a cold working process which can produce a smooth surface and hardness over the surface on cylindrical and flat part by the planetary rotation of hardened balls / rollers. Burnishing increases the surface hardness of the work piece in which, in turn, improves the wear resistance, [4-7], increases corrosion resistance [6-7] improves tensile strength [7], maintains dimensional accuracy and improves fatigue strength by inducing compressive residual stresses in the surface of the work piece. Rajaselkaraih and Vaidyanathan also compared burnishing with grinding and found that burnishing provided better surface smoothness [7-8]. The process was carried out by pressing hardened and smooth balls or rollers to external surfaces subjected to external forces. The burnishing tool is fed into an appropriate direction according to the work piece surface. In this experiment, cylindrical rollers rotating horizontally were pressed in to mild steel and copper. The burnishing parameters considered are burnishing speed, feed and depth of penetration. The paper presents an experimental study based on roller burnishing process to find the optimum values of a range of burnishing parameters for mild steel and copper work pieces. A typical burnishing process is shown in the Figure 1.

EXPERIMENTAL DETAILS

Multi-Roller Burnishing Tool

A multi - roller burnishing tool have hardened rollers fitted in housing and rotate freely in a horizontal axis. The burnishing tool is shown in the Figure 2, which can rotate in the vertical direction only. There

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are eight rollers altogether on the tool and each project by 1mm from the housing surface. The roller burnishing tool should clear the width of the work piece so as to avoid foreign material enter between tool and work piece. The roller burnishing pressure requirement depends on number of factors like ductility and tensile strength of the material, surface roughness before and after roller burnishing, and diameter and shape of the rolls.

Benefits of Roller/Ball Burnishing [10]

Burnishing imparts a high finish to any machinable metal. Surfaces that are bored , reamed or turned up to 3 micron Ra or more can be finished to 0.05 to 0.20 micron in one pass at feed rates of 150 to 3000 mm per min. Burnishing replaces grinding, honing, lapping and other expensive secondary operations: which eliminates extra parts handling and additional machines. Parts size can be changed as little as 0.002 mm in one pass in a matter of seconds. Tool marks are rolled out. Grain structure is condensed, refined and compacted surface is smoother, harder and longer wearing than ground or honed surfaces. Rolling action greatly reduces surface porosity, pits and scratches which could hold reactive surfaces or contaminates. As a result the corrosion resistance of burnished surface is higher than the open surfaces produced by grinding or honing. Due to plastic deformation, residual compressive stresses are induced in the surface. The compressive stresses greatly increase the strength properties and fatigue life of the part. The burnishing can be used on most of the machine tools already installed in the shop, like screw machines, turret lathes, centre lathes, drill presses or the most sophisticated N.C. machines. Thousands of parts can be finished with little or no burnishing tool wear. Setting up of the burnishing tool takes less than a minute. Unskilled operators can produce close tolerance. The power requirement for burnishing are very low due to the small amount of torque generated. Interchangeable parts of roller burnishing tools keep inventory low.

Work Piece Materials and Other Measuring Equipments

Two types of material, mild steel and copper were used as work piece which are commonly available in the market. The initial surface roughness and surface hardness are shown in the Table 1. The work pieces are bought as square bar having size as 50 x 50 x 1000 mm and cut to 100 mm length. The square bars are skin machined to remove black coloration and sizes and parallelism kept uniform, in order to obtain uniform depth of penetration. The final size was 45x 45 x 100. The vertical milling machine PBM –VS 300 was selected for use in multi-roller burnishing process. This machine is having fixed spindle speeds and feed rates. The spindle speed of 607, 958 and 1541 was selected and used. The operating parameters are shown in the Table 2. The surface roughness was measured using Mitutoyo make surf test SJ-301 tester and micro hardness was measured using HMV -2000 hardness tester.

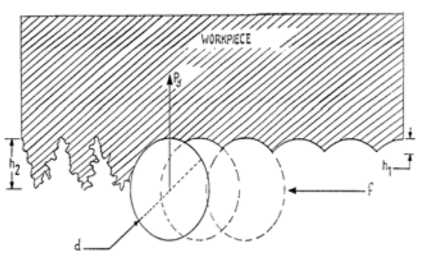

Figure1: Schematic diagram of burnishing process

Figure 2: Multi-roller burnishing tool

Table 1: Initial surface roughness and surface hardness.

Material	Surface Roughness (Ra) µm	Hardness (HRB)
Copper	0.20	16
Mild steel	0.10	57

Table 2: Burnishing Conditions

Spindle Speed (RPM)	Feed (mm / min)	Depth of Penetration (mm)
607	95	0.05
958	130	0.10
1541	200	0.15

RESULTS AND DISCUSSIONS

Surface Roughness

The surface finish affects wear resistant, load bearing capacity and corrosion resistance of the surface of the component. During the burnishing process the tool compresses the outer surface layer by the polished hardened tool (ball or roller) so that it reduces the surface roughness [9]. The mild steel is comparatively a soft material due to the presence of low carbon, the penetration of rollers become easy and increase the smoothness on the surface. The irregularities caused by other machining process were eased out and lower surface roughness was obtained. The Table 3 shows the results obtained for mild steel and copper. It was found from the results that increasing the spindle speeds, depth of penetration and feed rate, lower surface roughness values were obtained. More depth of penetration eased out the peaks and valleys. This is shown in the Figures 3 and 4.

Table 3: Cutting parameters and their results of surface roughness and micro-hardness.

Spindle speed (rpm)	Feed Rate (mm / min.)	Depth of penetration in mm	Surface Roughness Ra (µm) Mild Steel	Micro Hardness (HRB) Mild Steel	Surface Roughness Ra (µm) Copper	Micro Hardness (HRB) Copper
607	95	0.05	0.09	58	0.26	16.77
958	95	0.05	0.09	64	0.15	18.76
1541	95	0.05	0.08	69	0.14	20.19
607	130	0.05	0.10	66	0.25	19.04
958	130	0.05	0.07	70	0.20	23.06
1541	130	0.05	0.08	71	0.12	25.95
607	200	0.05	0.10	62	0.15	22.33
958	200	0.05	0.08	69	0.20	24.00
1541	200	0.05	0.07	72	0.18	27.47
607	95	0.10	0.08	62	0.23	19.03
958	95	0.10	0.07	68	0.14	21.43
1541	95	0.10	0.05	70	0.12	25.50
607	130	0.10	0.10	70	0.13	21.28
958	130	0.10	0.07	72	0.11	25.29
1541	130	0.10	0.10	75	0.10	29.13
607	200	0.10	0.10	73	0.11	26.93
958	200	0.10	0.09	75	0.13	29.21
1541	200	0.10	0.07	76	0.12	30.28
607	95	0.15	0.08	73	0.17	29.04
958	95	0.15	0.06	75	0.15	31.93

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1541	95	0.15	0.04	77	0.14	33.13
607	130	0.15	0.08	71	0.12	27.32
958	130	0.15	0.06	73	0.10	28.43
1541	130	0.15	0.07	75	0.09	30.17
607	200	0.15	0.09	75	0.10	30.00
958	200	0.15	0.08	78	0.09	32.31
1541	200	0.15	0.06	80	0.08	35.96

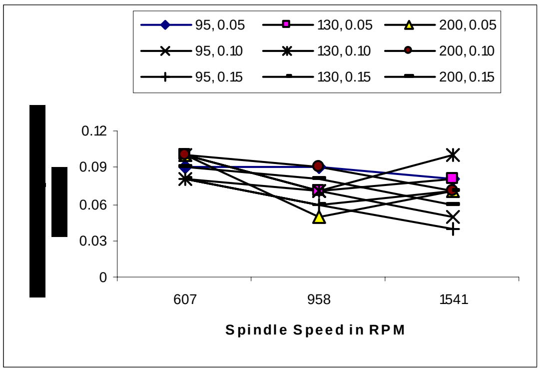

Figure 3: Spindle Rotation Vs Surface Roughness

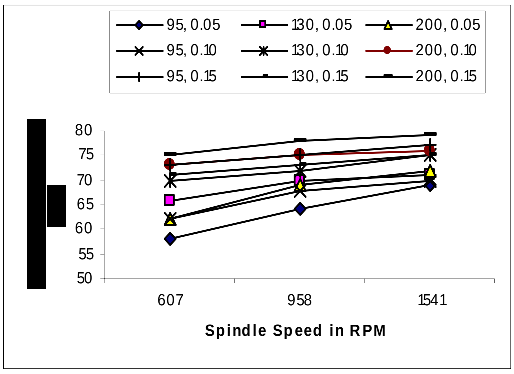

Figure 4: Spindle Rotation Vs Micro Hardness for Mild steel.

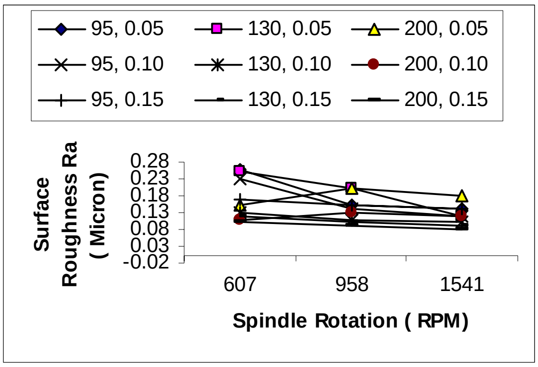

Figure 5: Spindle Rotation Vs Surface Roughness for copper

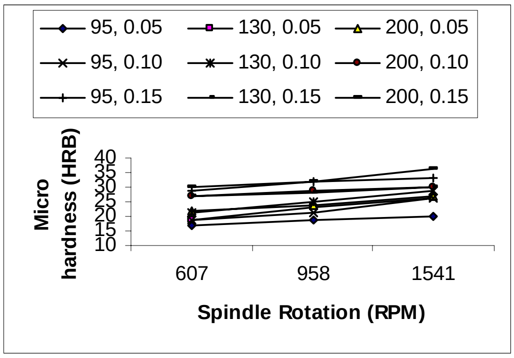

Figure 6: Spindle Rotation Vs Micro-Hardness for copper

Surface Hardness

The micro-hardness of the surface work piece is another important parameter for engineers. The burnishing process can increase the surface hardness. Hongyun et al [11] studied the effect of burnishing parameters on surface micro-hardness by burnishing with cylindrical PCD tools which can be used effectively to increase surface hardness. The surface hardness produced by this process can eliminate heat treatment of mild steel where lower hardness is required for lighter applications. In the same way, the hardness produced on copper can also resist wear and help to have good strength. The surface hardness on the surface can be increased by increasing spindle speeds, feed and depth of penetration. Burnishing operation produced work hardening effect and hence improvement in the surface hardness. The Figures 4 and 6 show the surface hardness for mild steel and copper respectively.

CONCLUSIONS

The following are the conclusions drawn from the experiments conducted. (1) The roller burnishing process increases smoothness and surface hardness on mild steel and copper. With the increase in above qualities, the wear resistance property is improved and therefore roller, burnishing process increases wear resistance due to surface characteristics. (2) By increasing the spindle rotation and depth of penetration, lower surface roughness and surface hardness were obtained. (3) The surface hardness was improved by increasing the depth of penetration. (4) There is also a limitation to increase the depth of penetration. This may produce micro-cracks. (5) Further research can be conducted by having more number of burnishing rollers. The research can also be extended to test fatigue life using various operating parameters.

REFERENCES

[1] Yankee H.W, Manufacturing Processes, 2nd edition, Prentice hall, Englewood Cliffs, NJ, 1979.
[2] Schey J.A, Introduction to Manufacturing Processes, 2nd edition, McGraw Hill, New York, 1987.
[3] Hassan A.M. and .Al-Bsharat A.S, Influence of burnishing process on surface roughness, hardness and micro-hardness of some non-ferrous metals, Wear 199 (1996)1-8.
[4] Fattouh M, .El-Axir M.H. and Surge S.M. Investigation into the burnishing of external cylindrical surfaces of 70/30 Cu-Zn alloy, Wear 127, (1988) 123-137.
[5] Morimoto T, Work hardening and tool surface damage in burnishing, Wear 127, (1988) 149-159.
[6] Murthy.R.Land Kotiveerachari.B, Burnishing of metallic surfaces –a review, Precis. Eng., 3 (1981) 172-179.
[7] Rajasekaraiah R. and Vaidyanathan S, Increasing the wear resistance of steel components by ball burnishing, Wear, 34 (1975) 183-188.
[8] Némat.M and Lyons A.C, An investigation of the surface topography of ball burnished mild steel and aluminum, Intl.J. Adv. Manuf. Technol. (2000) 16: 469-473.
[9] El-Axir.M.H and Ibrahim A.A, Some surface characteristics due t center rest ball burnishing, Journal Materials Processing Technology, 167 (2005) 47-53.
[10] Website of Mech-India engineers Pvt. Ltd, www.mech-india.com. 2005.
[11] Hongyun, Jianying Liu, Lijiang Wang and Qunpeng Zhong, The effect of burnishing parameters on burnishing force and surface micro-hardness, Intl. Journal of Advanced Manufacturing Technology (2006) 28: 707-713.

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