STUDY ON SURFACE FINISH AND MICRO HARDNESS USING VARIABLE TOOLS IN THE BURNISHING PROCESS

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Abstract

Burnishing is a low cost and environmentally friendly cold forming finishing process, wherein tool flattens the peaks. It has unique advantages such as improvement in surface finish and micro hardness at an economic cost. Associated with the burnishing process, is the flow of material into the adjacent valleys, which is being studied and reported in this paper along with the material removal analysis. Fine material removal may take place in burnishing, due to breaking of the tips.

In this study, spindle speed and feed were the input variables, along with variable tools like ball, roller and combined burnishing ones; while, surface roughness as well as surface micro hardness were the response parameters. The material used during trials was En-8. Some specimens were hard chrome plated after grinding and burnishing and the results obtained are illustrated in the paper. The findings show that spindle speed and feed have considerable effect on the response parameters. Scientifically we can use this process against traditional grinding process; since, it saves time, improves surface hardness, surface finish and reduces wastes in-terms of wear and tear of the grinding wheel as well as material.

Key words: Roller and ball burnishing, material removal, micro hardness, chrome plating.

I. INTRODUCTION

The grinding process is widely used in industries for finishing the components. In addition to grinding, most of the times other processes like hardening, burnishing, buffing or lapping are desired to meet the intended customer specifications. In parts such as piston rods, axles, valve seats and pumps, the surface hardness needs to be higher than its mating parts and its surface finish needs to be superior. In the present paper, a case study on grinding and burnishing is presented.

A. Grinding:

Grinding process is widely used in industries for finishing the components. In addition to grinding, most of the times other processes like burnishing, buffing, lapping and improvement in surface treatments like hardening, coating etc., are desired to meet the intended customer specifications. In parts such as piston rods, axles, valve seats and pumps, the surface hardness needs to be higher than its mating parts and its surface finish needs to be superior. In the present paper, a methodical experimental study on burnishing is presented supplemented with study on using different tools.

B. Cylindrical Grinding:

For any surface coating process, the preliminary requirement is finishing of the work-piece. The cylindrical grinding process is normally used this purpose. Centre-less grinding is a good option, but it is limited to small diameters and continuous lengths without step-grindings. In the cylindrical grinding process, we use an abrasive wheel on the cylindrical grinding machine or a lathe. Cylindrical grinding is suited for internal and external diameters in shafts, pistons etc. The controlling parameters here are speed, feed and depth of cut and the measurable are surface finish values.

C. Burnishing:

External burnishing can employ either ball or roller but an internal surface required roller burnishing. Roller burnishing tool consists of a series of tapered highly polished and hardened rolls positioned in slots within a retaining cage. The tool is adjustable within work-piece to develop a pressure that exceeds yield point of the work material. Practically any metal with hardness upto 40 HR_c can be easily burnished. Harder materials require still harder toll material viz. carbide, ceramic or diamond though ductility and malleability renders the material easy to burnish. The figures 1-3 illustrate basics of the burnishing process, the surface patterns before and after finish and the tooling used along with the testing equipment used for surface roughness and micro hardness. It is mainly used in pistons, shafts and valves to improve their mechanical properties and surface finish; mainly in automotive and machinery applications including farming tools, tractors etc.

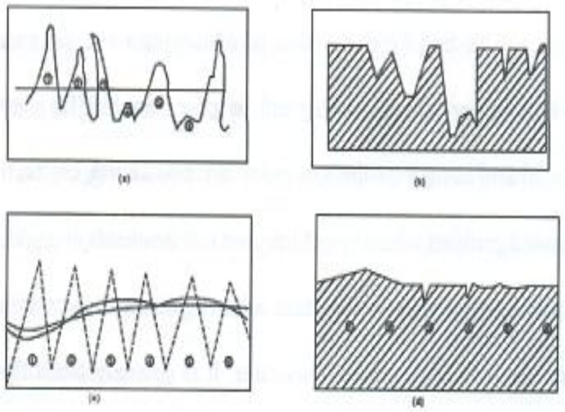

Fig.1 (a) and (c): Un-burnished surfaces, (b) and (d): Burnished surfaces showing simultaneous fluing and flaking [1,2].

Figure 2 (a) Ball Burnishing tool (b) Roller burnishing tool (c) Combined burnishing tool

Figure 3 (a) Burnishing tool in action (b) Surface roughness measurement (c) Micro-hardness measurement

Brittle materials like CI have also been burnished because they can withstand compressive force though the mechanism may be different in the burnishing of such materials. The effectiveness also is low. Burnishing allowance depends generally on the size and ductility of work so does the final result. A low carbon steel or 40 to 50 diameter can be given a burnishing allowance of 0.01 to 0.02 mm and can be expected to produce a fine surface finish, in the range of 0.1 to 0.2 μR_a; while, a harder and smaller size will need correspondingly lower burnishing allowance and result in higher Ra values.

The beneficial effects from the cold working associated with burnishing could be most of these:

- Improved surface finish.
- Work-hardening which may eliminate heat-treatment.
- Plateaued surface with higher load bearing capacity.
- Improved corrosion resistance, axial alignment

Relative to ball burnishing, roller burnishing produces superior finish due to the absence of feed marks. However in ball burnishing due to point contact the localized stresses are more which produce higher micro-hardness, residual stress with better reduction of surface blemishes.

There are several other finishing and coating processes commonly used in industries. A list of some of these are illustrated in the Table 1.

FINISHING PROCESSES	
Grinding	Using grinding wheels on a grinding machine
Polishing	By using brushes and soft wheels
Lapping	Using laps and a lapping compound
Honing	Using a honing mandrel & lubricant on honing machine
Burnishing	Involves rubbing by a burnishing tool on lathe
Buffing	Involves use of a soft wheel embedded with abrasives
COATING PROCESSES	
Inorganic	Porcelain enameling, Ceramic coatings & Anodizing
Organic	Paints (brush, air & electro-spraying), enamels, powder coatings
Metallic	Electro-plating, dipping, immersion, diffusion, galvanizing, vaporizing & metalizing
Conversion Coatings	By chemical reaction on a surface to form compounds like chromates, phosphates & oxides.

Table 1. Finishing and Coating processes

II EFFECT OF VARIATION IN RPM ON SURFACE ROUGHNESS

In this phase experiments were conducted on ball, roller and combined burnishing tool on En 8 specimen to analyze the effect of variation in rpm on surface roughness. Surface roughness and micro-hardness were the main response variables and the process parameter under consideration was the spindle speed. The material under consideration was En 8, which is a commonly used industrial standard [10]. Figure 4 illustrates the effect of spindle speed and feed on surface roughness. The roller burnished samples gave better surface finish values, followed by combined action tool and ball burnishing tool. In both the cases, i.e., variation of spindle speed as well as feed rate; it was experimentally found that the surface finish values were better while using roller burnishing tool and it gave best results. The optimum surface finish being equal to 0.21 μR_a, observed at the spindle speed value of 550 RPM; whereas, using feed rate as 0.1 mm/rev, the best surface roughness value observed was 0.28 μR_a.

III EFFECT OF VARIATION IN RPM ON SURFACE HARDNESS

In this phase experiments were conducted on ball, roller and combined burnishing tool on En 8 specimens to analyze the effect of variation in rpm on surface hardness. The increase in burnishing force will increase plastic deformation, as the penetration of the ball or roller is increased, it leads to an increase in internal compressive residual stress, which in turn causes a considerable increase in the surface micro hardness. Figure 5 illustrates the variations in spindle speed and feed on surface micro hardness graphically. In micro-hardness studies, the combined tool gave marginally better results in terms of higher surface hardness followed by ball burnishing and roller burnishing tools. The surface micro-hardness decreased with an increase in spindle speed and feed rates. There was a practical limit beyond which it was not possible to vary the surface hardness due to work hardening. Figure 5 represents micro hardness effect for spindle speed and feed rate. The micro hardness decreased in case of combined burnishing with increase in rpm. Experimental evidences illustrate that the micro hardness of En 8 was high (= 77 H_v) when burnishing with combined tool at a minimum spindle speed value of 325 rpm. Similar conditions were observed at the minimum feed rate value (0.1 mm/rev), at which the surface micro hardness noted was = 78 (H_v).

In an attempt the find practical effects; a comparative study was done using cylindrical grinding and roller burnishing on En 8 specimens and each of these specimens were further hard chrome plated [11]. As illustrated in figure 6, burnished specimens yield better hardness in both cases.

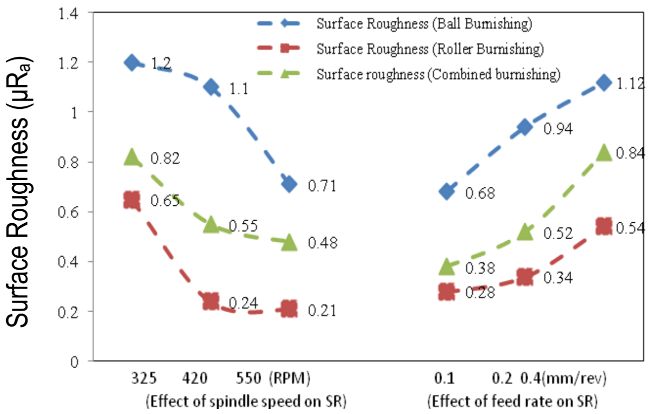

Fig.4 Paramteric effects of spindle speed and tool feed on surface roughness

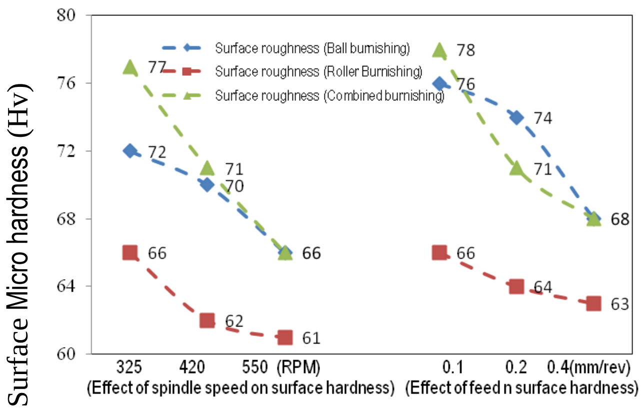

Fig.5 Paramteric effects of spindle speed and tool feed on micro hardness

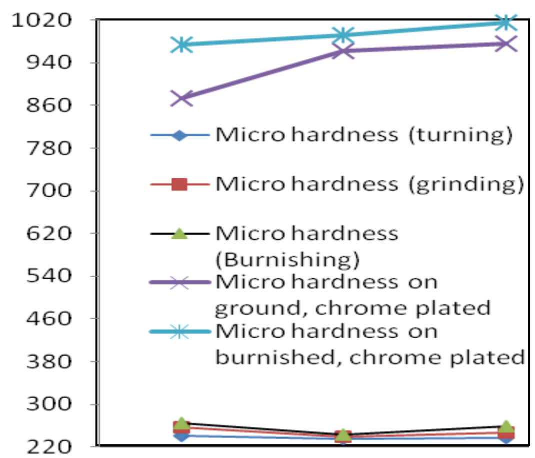

Fig.6 Effect of grinding and burnishing on microhardness before and after hard chrome palting

IV CONCLUSIONS

The investigations into burnished and ground surfaces of En 8 specimens have led to useful results. In situations requiring higher surface hardness and better finishes, burnishing can be used. The added advantage is the shorter tool-setting time and work need not be reset on another machine. Some of the important conclusions within the range of test conditions employed in the exhaustive experimental investigations, and analytical work are as follows:

- Roller burnishing produces superior surface finish with absence of feed marks of the burnishing tool.
- The tool cost of burnishing is 4 to 5 times higher than grinding. For higher engineering applications involving better surface finish and higher surface hardness the cost factor is secondary, due to major benefits involved in it, this could be overlooked, since the setting time is reduced. The burnishing process can be done on the same lathe set-up, unlike changing the machine and re-setting the job in case of grinding.
- Amongst the three types of tools used, roller burnishing tools were found to give optimum results.

In precision engineering applications involving better surface finish and higher surface hardness, burnishing can aid as an economical alternative since the process can be done on the same lathe set-up, unlike changing the machine and re-setting the job in case of grinding.

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