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EFFECT OF BALL BURNISHING PARAMETERS ON SURFACE ROUGHNESS USING SURFACE ROUGHNESS METHODOLOGY

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Abstract
Burnishing, a plastic deformation process, can be used to finish surfaces by plastic deformation of surface irregularities. A simple inexpensive and newly designed bal-burnishing tool, with interchangeable adapter for using different ball diameters, was used throughout the experimental work. In present paper reports on the optimization of the surface finish produced by ball burnishing process, using the surface response (RMS) methodology. A second order mathematical model correlating four predominant process parameters, viz, burnishing force, speed, ball diameter and number of tool pass, with the surface roughness parameter has been obtained. The model can be used in selecting the optimum process parameters for obtaining a desired control surface finish.

Key Words: Ball Burnishing, Surface Finish, Response Surface Methodology

1. INTRODUCTION

Burnishing is a very simple and effective method for improvement in surface finish and can be carried out using existing machines, such as a lathe. There are many finishing processes used to produce surfaces with high quality textures. These processes could be classified into chip removal processes, such as grinding and chip less processes, such as burnishing.

Burnishing is considered as a cold working process. The surface of the material is compressed by the application of a hard and highly polished too (ball). The process of burnishing can be applied to soft and ductile as well as very hard metals. Compressive action by the burnishing tool causes a slight plastic flow of the surface metal to a depth of a few micrometers (Figure 1). Due to the localized cold plastic deformation by burnishing a residual compressive stress will be left at the surface of the metallic component. (Figure 2) This process improves surface finish, fatigue resistance, wear and corrosion resistance of surfaces.

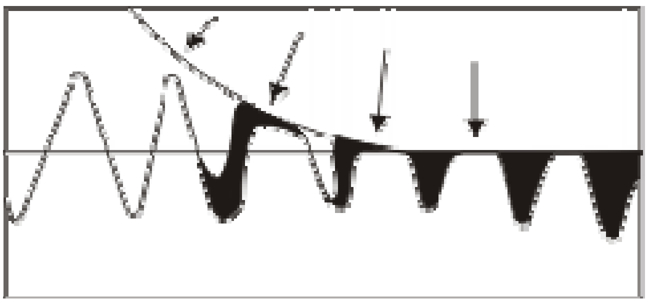

Figure 1: Burnishing process.

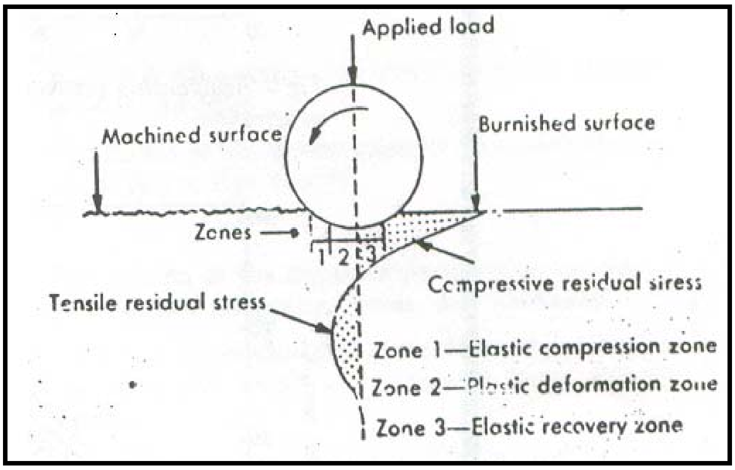

Figure 2: Schematic representation of a residual stress distribution.

Work on burnishing process has been investigated by various researchers on lathes2-6 and on milling machine for wide range of materials like, mild steel1-6 and non-ferrous alloys.

Pande [6] & N. H. Loh et al [1, 2] carried out extensive studies on the surface roughness of burnished components. The literature survey reveals that considerable attention is paid towards studying the influence of various process parameters on the characteristics of surface produced by normal burnishing process [1-6]. Also Pande [4], B.Kotiveerachari [5], shown that surface roughness is governed by interaction between ball force, feed and frequency.

Although a fair amount of burnishing work has been conducted, there is a need to select optimum process parameters to secure a desired controlled surface finish. This paper sets out to optimize the burnishing process by designing further experiments based on response surface methodology (RSM) with central composite rotable design. Based on reference [7], four predominant parameters were studied: burnishing force, speed, ball diameter and number of tool pass.

2. EXPERIMENTAL WORK

The experimental work is conducted on a simple Lathe machine. The main advantage of using such a machine is its flexibility. It enables the machining and burnishing operations to be accomplished easily in a sequential order. Any change in the burnishing conditions (such as speed, force, ball diameters, and number of tool passes) can be easily adjusted. Figure 3 shows the experimental setup.

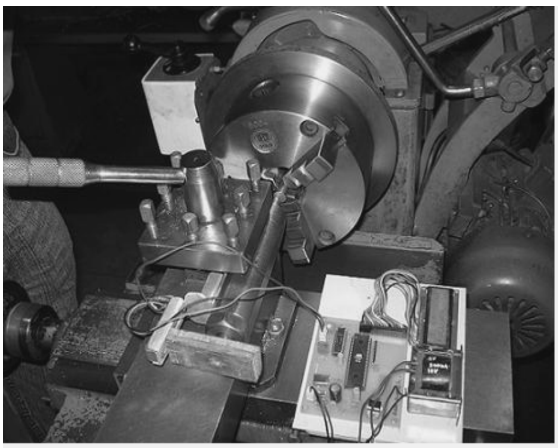

Figure 3: Experimental setup.

The burnishing tool assembly consists basically of a burnishing ball that is held rigidly in the ball holder by means of an adapter and the work piece. For measurement of burnishing force, microprocessor kit is developed as shown in Figure 4.

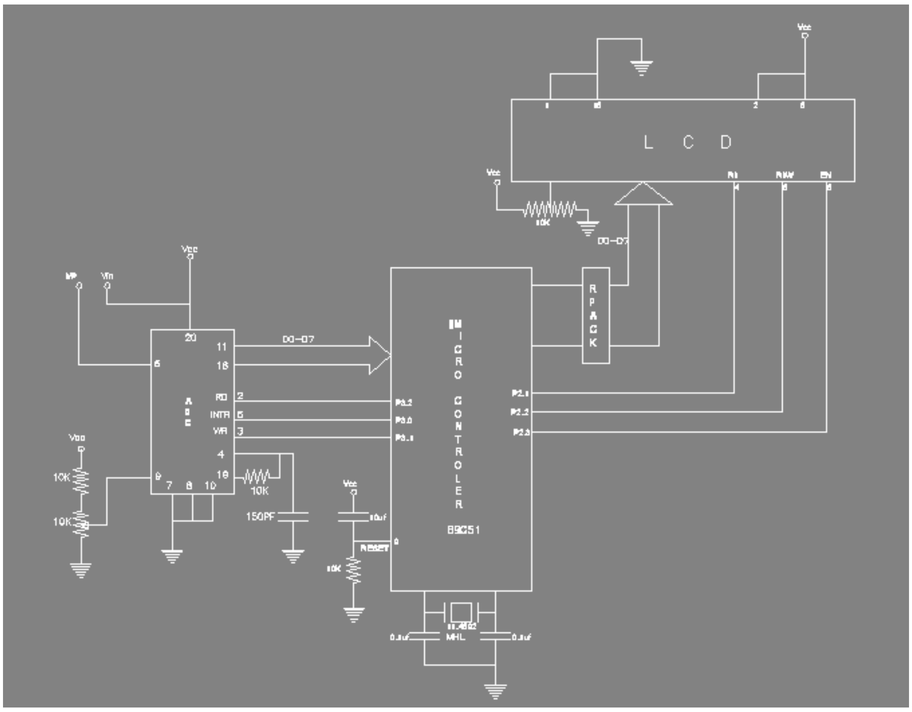

Figure 4: Measurement of force.

The surface roughness (Ra) of each burnished specimen was measured with Hommelwerke, German make surface roughness tester (Figure 5).

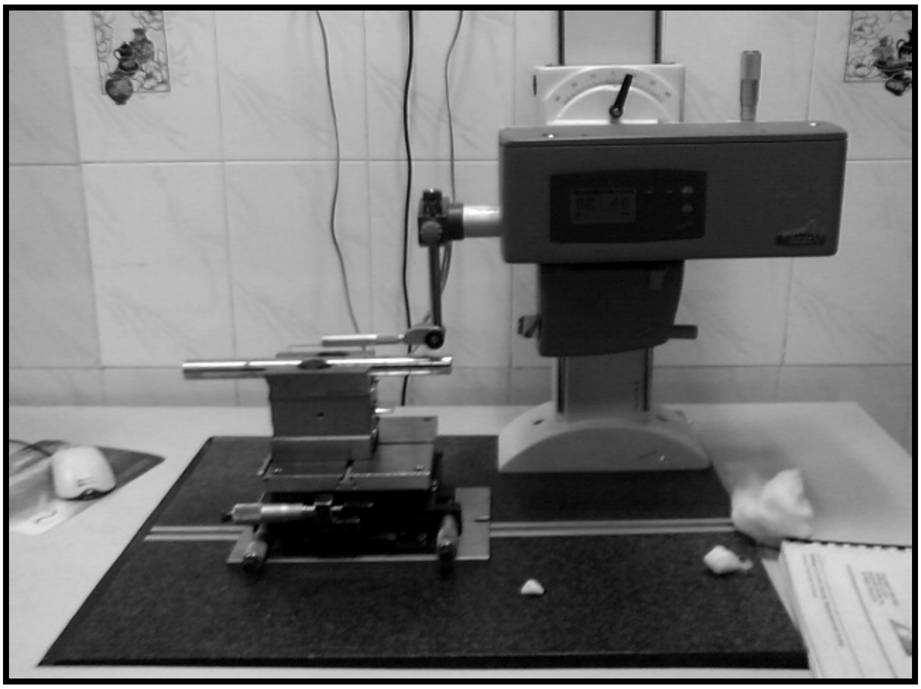

Figure 5: Surface roughness tester.

3. PLANNING OF THE EXPERIMENTS

The experimental programme was planed in accordance with the principles of experimental design suggested by Cochran et al [7] using RSM with central composite design was used. Response surface methodology is a collection of mathematical and statistical techniques useful for analyzing problems in which several independent variables (parameters) influence a dependent variable (response-surface roughness), and the goal is to optimize this response.

The experimental programme was planned using a complete 2 [4] factorial design with 7 center and 8 star points at ±2 levels. This involves 31 experimental observations. The scheme of experimentation adopted in the present study is given in Table I and the levels for the variables are given in Table II.

Table I: Coded design matrix.

EXPT. NO.	X1	X2	X3	X4	Surface roughnes $R_{a,}$ μm
1	-1	-1	-1	-1	0.4
2	1	-1	-1	-1	0.5
3	-1	1	-1	-1	0.4
4	1	1	-1	-1	2.3
5	1	-1	1	-1	1.4
6	-1	1	1	-1	0.8
7	1	1	1	-1	4.0
8	-1	-1	1	-1	2.2
9	1	-1	1	1	2.4
10	-1	1	1	1	2.3
11	-1	-1	1	1	2.2
12	1	1	1	1	1.5
13	-1	-1	-1	1	1.3
14	-1	1	-1	1	0.5
15	1	-1	-1	1	1.9
16	1	1	-1	1	0.4
17	-2	0	0	0	1.4
18	2	0	0	0	2.1
19	0	-2	0	0	1.5
20	0	2	0	0	1.2
21	0	0	-2	0	1.4
22	0	0	2	0	2.3
23	0	0	0	-2	1.8
24	0	0	0	2	2.1
25	0	0	0	0	2.3
26	0	0	0	0	2.1
27	0	0	0	0	2.1
28	0	0	0	0	2.1
29	0	0	0	0	1.8
30	0	0	0	0	1.8
31	0	0	0	0	1.7

Table II: Levels in coded form.

Variables Designation	Description	Levels in coded form				
		2	1	0	-1	2
X_1	Burnishing Speed, rpm	540	425	330	260	200
X_2	Ball diameter, mm	10	9	8	7	6
X_3	Burnishing force, N	200	150	100	70	50
X_4	No. Of Tool Passes	5	4	3	2	1

4. MATHEMATICAL MODELING

A polynomial response surface of second order can be represented by

$$Y_u = b_0+\sum_{i=1}^{K} b_i x_i+\sum_{i=1}^{K} b_{ii} x^2_i +\sum_{i=<j} b_{ij} x_i x_j \quad (1)$$

Where Y_u is the response and the x_i (i =1,2, k) are coded levels of k quantitative variables or factors. The coefficients b_0, b_1 etc in Equation 1 were calculated by using Mat Lab by

$$b= (x'x)^{-1}xy \quad (2)$$

Where x is the matrix of independent variables in coded from and y is the column matrix of the observed response.
The adequacy of the model was checked from the Analysis of Variance and postulated by use of the F-test.

The fitted second order model is

$$Y_u = 1.9857X_0 + 0.2121X1-0.0038X_2+ 0.4822X3+ 0.0602X_4 -0.0982X_1^2 -0.1982X_2^2 - 0.0732X_3^2 -0.0482 X_4^2 + 0.2982 X_{12}- 0.0057X_{13} - 0.2228X_{14} + 0.0182 X_{23} - 0.3201X_{24}- 0.0528X_{34} \quad (3)$$

The analysis of Variance table for the model is shown in Table III.

Table III: Analysis of variance.

Source	DF	SS	MS	F	P
Regression Residual Error	14 16	11.2576 6.8443	0.8041 0.4278	1.88	0.11 3
Total	30	18.1019			

S = 0.6364 R-Sq = 62.0% R-Sq(adj) = 32.9%

5. CONCLUSIONS

The following conclusions are drawn from the investigation.

1. The analysis shows that a second order Rot table design can be used to predict the performance characteristics of a burnished surface. The mathematical model developed can be used to correlate the burnishing parameters and their interactions with the response parameters for brass, were proposed which can easily be used in selecting the optimum process parameters for generating the desired controlled surface characteristics.
2. Optimum condition of a surface finish is obtained at speed of 425rpm, ball diameter of 7mm and normal force of 70N and no. of tool pass was 2.
3. The MINITAB output shows the coefficient of determination R^2 labeled as R-sq in percent form. The output also shows the coefficient of R-sq (adj). Both the values can be viewed as reasonably good between the responses Y_i and the fitted value $\hat{y}_i$.

6. ACKNOWLEDGEMENT

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