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Research Paper Engineering

Enhancement of Surface Finish and Surface Hardness of Burnishing Process Using Taguchi Method

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ABSTRACT

Ball burnishing is a cold working finishing process, wherein highly polished and hard balls are pressed against a metallic surface of a flat or cylindrical component. In ball burnishing, initial asperities are compresses and modified. The deformation caused is a function of load applied. Since all machined surface consists of a series of peaks and valleys of irregular height and spacing, the plastic deformation created by ball burnishing is a displacement of the material in the peaks which cold flows under pressure into the valleys. The surface material is progressively compressed, then plasticized as the resultant stresses reach a steady maximum value and finally wiped to a superfine finish. In this paper the Taguchi method is presented for enhancement of surface finish and surface hardness.

Keywords : Taguchi Method, Burnishing, Surface Finish, Surface Hardness

1. INTRODUCTION

Burnishing is a polishing and work hardening of a metallic surface. This process will smooth and harden the surface, creating a finish which will last longer than one that hasn't been burnished. This is a desirable characteristic in clock making and watchmaking since the major determining factor in how long a clock or watch will run is the degree to which the bearings will wear over time. Long-lasting bearing surfaces, like pivots and pivot holes, will greatly increase the length of time that a clock or watch will perform as expected. Although this article is primarily targeting the burnishing process for clocks, the same methods may be applied to watches with the understanding that jewel holes need not, nor can they be, burnished.

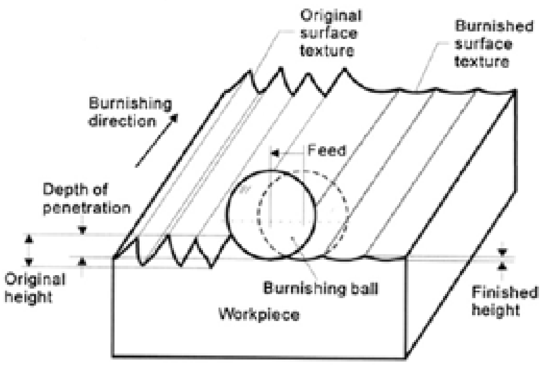

Fig. 1: Schematic diagram of the ball burnishing process

2. THE TAGUCHI SYSTEM OF QUALITY ENGINEERING

Quality engineering is an interdisciplinary science which is concerned with not only producing satisfactory products but also reducing the total loss (manufacturing cost plus quality loss). In contrast to traditional quality assurance, which focuses on on-line quality assurance, the Taguchi system focuses on designing quality into products and processes (i.e., off-line quality control). Quality concerns are addressed at the drafting board as opposed to addressing them on the shop floor i.e. quality should be designed into the product and not inspected into it. The use of statistically designed engineering experiments is the very heart of this method. This helps to identify product and process parameter settings that provide for least variation in product characteristics.

The major steps of implementing the Taguchi method are: (i) to identify the factors/interactions, (ii) to identify the levels of each factor, (iii) to select an appropriate orthogonal array (OA), (iv) to assign the factors/interactions to columns of the OA, (v) to conduct the experiments, (vi) to analyse the data and determine the optimal levels, and (vii) to conduct the confirmation experiment. In data analysis, signal-to-noise (S/N) ratios are used to allow the control of the response as well as to reduce the variability about the response. The (S/N) ratio expresses the scatter around a target value, larger the ratio-smaller the scatter. After performing the statistical analysis of (S/N) ratio, an analysis of variance (ANOVA) has been employed for estimating error variance and for determining the relative importance of various factors.

Table No. 1: Factor and Level Combination for Ball Burnishing Process

Sr. No.	Factor		Level		
			1	2	3
1	A	Force (N)	150	100	50
2	B	Speed (rpm)	1000	630	400
3	C	Feed mm/rev)	0.2	0.1	0.05
4	D	Ball Diameter (mm)	10	8	6

Fig. 2: Experimental Setup

Table No. 2 : L9 Orthogonal Array with Response

Test No.	Factor				Surface Roughness µm		Surface Hardness HRB	
	A	B	C	D	Y_{SR1}	Y_{SR2}	Y_{SH1}	Y_{SH1}
T_1	1	1	1	1	0.28	0.278	25.19	25.00
T_2	1	2	2	2	0.62	0.588	27.90	27.87
T_3	1	3	3	3	0.42	0.409	22.27	22.01
T_4	2	1	2	3	1.21	1.19	26.15	26.09
T_5	2	2	3	1	0.361	0.359	23.00	22.98
T_6	2	3	1	2	1.5	1.49	26.00	25.78
T_7	3	1	3	2	2.21	2.2	25.67	25.07
T_8	3	2	1	3	2.1	1.98	27.43	27.38
T_9	3	3	2	1	0.46	0.44	35.44	35.00

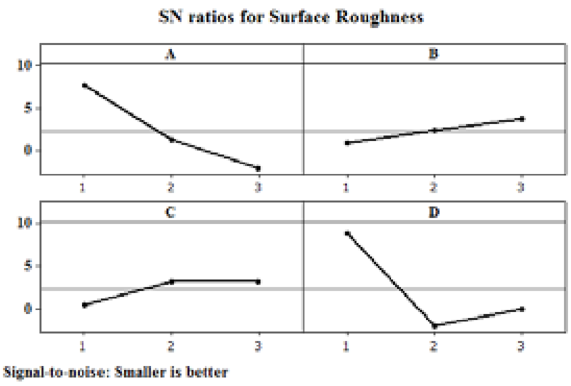

Fig. 3: S/N Ratios for Surface Roughness

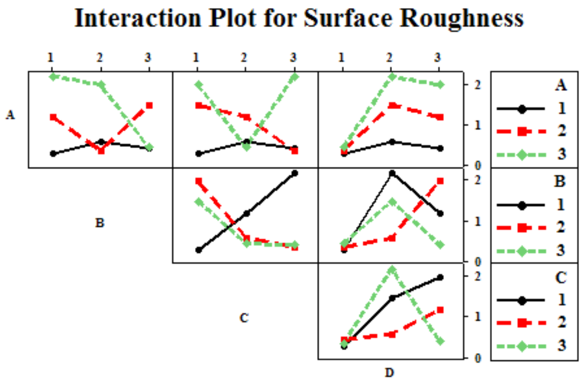

Fig. 4: Interaction Plot for Surface Roughness

Table No. 3: ANOVA Table for Surface Roughness

Factor	DOF	SS	V	F	%p
A	2	3.84	1.924	2092.8	42.2
B	2	0.58	0.292	318.01	6.42
C	2	0.81	0.406	441.7	8.92
D	2	3.85	1.926	2095.07	42.3
e	9	0.01	0.001		
Total	18				100

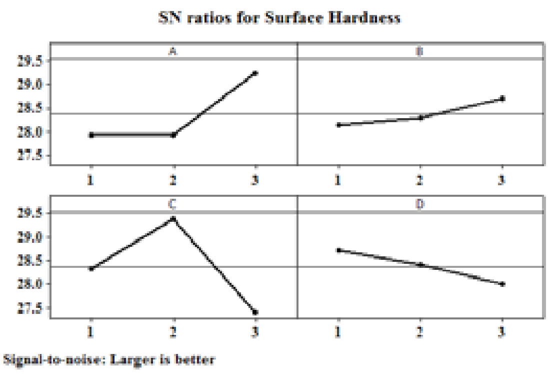

Fig. 5: S/N Ratios for Surface Roughness

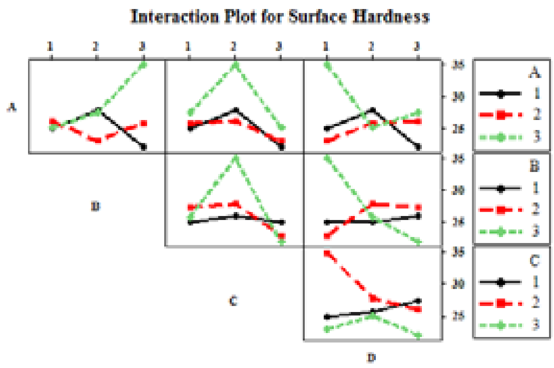

Fig. 6: Interaction Plot for Surface Hardness

Table No. 4: ANOVA Table for Surface Hardness

Factor	DOF	SS	V	F	%p
A	2	74.36	37.18	938.5	32.6
B	2	15.99	7.99	201.9	7.01
C	2	117.8	58.91	1487.2	51.6
D	2	19.50	9.753	246.2	8.55
e	9	0.35	0.04		
Total	18				

CONCLUSIONS

(A) SURFACE ROUGHNESS

(i) Good surface finish is obtained at A3B3C2D1

(ii) Factor A and Factor D plays significant role in obtaining surface finish

(B) SURFACE HARDNESS

(i) Good surface finish is obtained at A1B3C2D1

(ii) Factor A and Factor C plays significant role in obtaining surface hardness.

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