Effect of Newly Developed Ball Burnishing Tool on Surface Roughness of AA6351

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ABSTRACT
Ball burnishing is a technique of surface enhancement that can provide residual compressive stresses on the surface to improve surface roughness, hardness and wear resistance of the material. The ball burnishing tool developed can be used on conventional lathe machine. It is observed that tool is giving satisfactory results to improve surface finish of AA6351. By using the designed tool Surface finish of 0.069 micrometer is achieved. Depth of penetration proved to be the predominant parameter among the parameters used.

Keywords
Burnishing, Surface finish, burnishing tool

1. INTRODUCTION
In the present machine age, technological advancement has been possible due to the increased knowledge and constant improvement of the surface structures. The need of finished and hard surface was realized, as greater strength and bearing loads were demanded. The functional performance of a machined component not only depends upon surface finish but also on fatigue strength, load bearing capacity, friction, wear resistance and residual compressive stress induced on the surface of the component.[1] Conventional surface finishing methods like grinding, honing, lapping especially depends upon chip removal to attain desired surface finish, these machining chips may cause further abrasion and geometrical tolerance problem, especially if conducted by unskilled operators. Accordingly burnishing process offers an attractive post machining alternative due to its chip less and relatively simple operations. It not only improves surface finish of the material, but also improves surface hardness, fatigue strength, corrosion resistance and wear resistance by inducing residual compressive stresses on the surface of the material.[1,2,5]

2. LITERATURE REVIEW
Fang-Jung Shiou et al used Taguchi L18 Orthogonal array technique and ANOVA to investigate the surface roughness value. Best on their results,the Vickers hardness scale of the tested specimen was improved from about 338 to 480 after ball-burnishing process. The hardened layer thickness was about 30 µm. By applying the optimal burnishing parameters for plane burnishing to the surface finish of the freeform surface mold cavity, the surface roughness improvement of the injection part on plane surface was about 62.9% and that on freeform surface was about 77.8%.[2]**N.S.M. EL-Tayeb et al** worked on Prediction of Burnishing Surface Integrity using Radial Basis Function. They used artificial neural network (ANN) and radial basic function (RBF) techniques to predict value of surface roughness. Artificial neural networks are computing elements, which are based on the structure and function of the biological neurons. These networks have nodes or neurons, which are described by difference or differential equations.The nodes are interconnected layer-wise or intra-connected among themselves. Each node in the successive layer receives the inner product of synaptic weights with the outputs of the nodes in the previous layer when the vectors are binary or bipolar, hard-limiting non-linearity is used. When the vectors are analog, a squashed function is used. [6]

FathiGharbi worked on aluminum 1050A rolled sheet for improvement of ductility by a newly designed ball burnishing tool device. It was found that the burnished surface had 48% improvement in ductility as compared with unburnished specimen. When the specimen is burnished with burnishing conditions of 200 N, 400 rpm, and 0.1 mm/rev. In this optimum case, the yield strength, ultimate tensile strength, energy, and percent elongation at fracture for aluminum 1050A were 108.2 MPa, 125.16 MPa, 21.01 J, and 12.94%, respectively. [4]

Adel Mahmood Hassan studied the effect of ball and roller burnishing on the surface roughness and hardness of some nonferrous metal. It was seen that the surface hardness of a material is increased with increase in burnishing force and number of burnishing tool passes. [1]

AysusSagbasworked on analysis and optimization of surface roughness in the ball burnishing process using response surface methodology and desirability function. Based on his work it was predicted that the surface roughness reduces with increasing burnishing force and no. of tool passes.[5]

3. BALL BURNISHING TOOL
Ball burnishing tool is designed for conventional lathe machine. This tool is stiff ball burnishing tool. Instead of measuring force, we have measured depth of penetration using dial gauge.

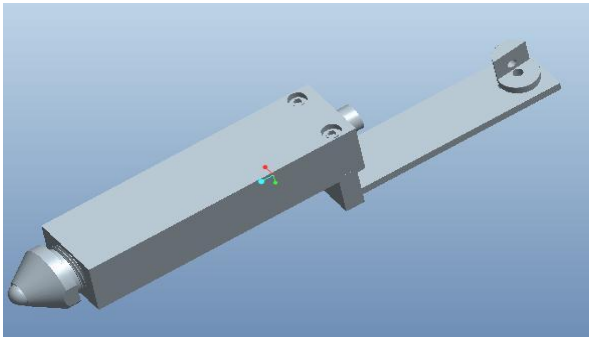

Fig. 1 Ball Burnishing Tool

4. MATERIAL SELECTION

The experimental work is carried out to investigate the effect of process parameter of ball burnishing on surface roughnessof AA6351 alloy. This is mostwidely used alloy in wide variety of general applications in small scale industry as well as large scale industries. The aluminum alloy is widely used in aerospace and space shuttle with high quality and good service life. Aluminum is chosen as its weight to strength ratio is high and can be further improved by using burnishing process.

The composition and mechanical properties of material are given in Table 1 and Table 2 respectively.

Table 1: Composition of work material

Element	Cu	Mg	Mn	Si	Fe	Al
Weight ,%	0.1	0.4-1.2	0.4-1.0	0.6-1.3	0.6	Remainder

Table 2 Material Properties of work material

Density, g/cc	Tensile Strength, Mpa	Yield Strength, Mpa	Hardness, HB	Modulus of Elasticity , GPa	Poisson's ratio
2.6-2.8	250	150	95	70-80	0.033

5. EXPERIMENTATION

5.1 Process Parameter Selection

The factors and their levels are shown in table spindle feed, speed & depth of penetration and number of passes are adopted as factors which vary during experiments. The values of the factors are decided based on trial and error method.

Table 3: Levels of factors for design

Factors / Levels	Code	Low(-)	High(+)
Feed Rate (mm/Rev)	A	0.04	0.051
Speed (rpm)	B	850	950
Depth of Penetration(mm)	C	0.50	0.75
No. of tool passes	D	1	2

For each factors, two levels are deliberately chosen and set during experiments according to the DOE.

Table 3 shows the selected design matrix. All these data were utilized for the analysis and evaluation of optimum parameter combination required to achieve desired surface quality within the experimental domain.Experiment was carried out based on experimental design matrix. The experimentation for burnishing operation is done on conventional lathe. The surface roughness measurement is done on surface tester.Table 4 shows selected design matrix based on Taguchi L16 orthogonal array consisting of 16 sets of conditions. All this data is used for conduction of actual experimental work. Experimentation is done on experimental matrix developed by Minitab 15 and results are evaluated for surface roughness for AA6351 Alloy.

Table 4: Design of Matrix and Results

Run	Actual Values				Roughness Value (Ra) (After Burnishing)
	A	B	C	D	
1	0.04	850	0.50	1	0.156
2	0.04	850	0.50	2	0.116
3	0.051	850	0.50	1	0.094
4	0.051	850	0.50	2	0.131
5	0.04	950	0.50	1	0.192
6	0.04	950	0.50	2	0.156
7	0.051	950	0.50	1	0.088
8	0.051	950	0.50	2	0.149
9	0.04	850	0.75	1	0.117
10	0.04	850	0.75	2	0.102
11	0.051	850	0.75	1	0.108
12	0.051	850	0.75	2	0.089
13	0.04	950	0.75	1	0.105
4	0.04	950	0.75	2	0.069
15	0.051	950	0.75	1	120
16	0.051	950	0.75	2	113

The objective of the present work is to investigate the effectof factors that is (A) feed rare (mm/rev), (B) speed (rpm) and (C) depth of penetration (mm) and (D) number of passes for the burnishing on AA6351 alloy.In these investigations "surface roughness"is typically chosen as response variables. The entire experimentation performed on PL lathe machine.

Fig. 2 Experimental Setup

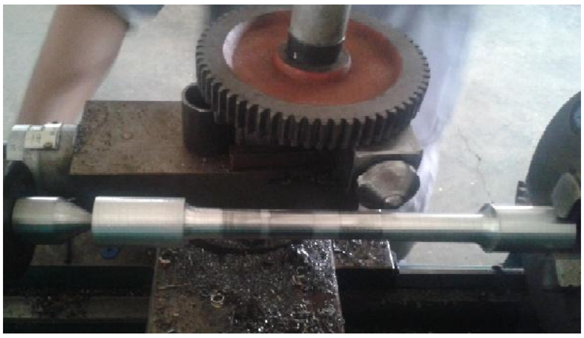

Fig. 3 Burnishing Process

Table 5 Effect of Different Parameters

Factors	SS	DF	MS	F	% P
A (feed rate)	2.280 × 10^{-4}	3	7.6 × 10^{-5}	4.8162	2.522
B(speed)	9.802 × 10^{-5}	3	3.26 × 10^{-5}	2.0659	1.084
C (depth)	8.665× 10^{-3}	3	2.895 × 10^{-3}	183.46	95.862
D (passes)	4.762× 10^{-5}	3	1.578 × 10^{-5}	1	0.526
Total	9.039 × 10^{-3}	12	3.01938 × 10^{-3}		

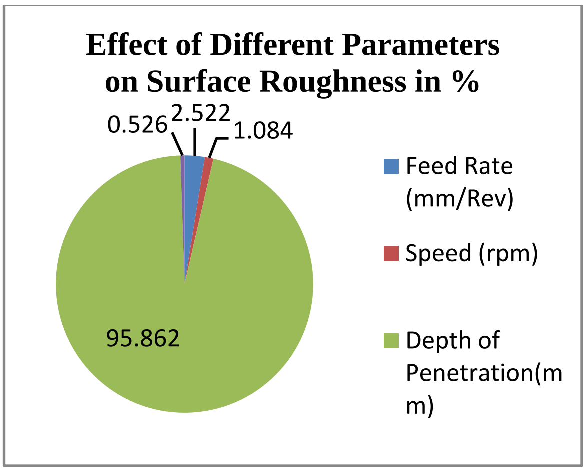

Fig. 4 Effect of Different Parameters on Surface Roughness

6. CONCLUSION AND DISCUSSION

1. The surface roughness value is dependent on burnishing parameters which are studied. Out of four parameters depth of penetration plays major role (95.862) in reducing surface roughness value.

2. The ball burnishing tool developed is effective in reducing surface roughness of the material as low as 0.069 μm.

3. It is also observed that if initial surface roughness is more, we can get better surface finish.

7. FUTURE SCOPE

1. The burnishing operation is successfully carried out on AA6351 Alloy which shows the improved results for surface finish. Still the following work can be carried out to check other properties of alloy.

2. The Simulated model can be generated for ball burnishing process and FEA analysis can be carried out for selected ball burnishing parameters.

3. By changing Tool ball material and ball diameter better surface quality can be achieved.

4. Optimization of parameters can be done to improve surface integrity of material.

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