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Investigations on Effect of Different Ball Burnishing Conditions on Surface Roughness Using Response Surface Methodology

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ABSTRACT

Burnishing is becoming popular post-machining surface finishing technique due to its excellent features. The use of high finish and hard, ball or roller on pre-machined surface with pressure smooths out protrusions to fill the valleys and thus, resulting in lower surface roughness. In present work, ball burnishing has been carried out on free cutting brass in different burnishing conditions such as dry (Plain Burnishing, PB), lubricated (LB) and with abrasives (Abrasive Assisted Burnishing, AAB) to establish the relationship between surface roughness and the four process parameters like burnishing force, burnishing feed, burnishing speed and number of passes. The effect of using lubricants and abrasive particles is compared over PB. Design of Experiments based on Response Surface Methodology (RSM) is adopted to develop the mathematical models of second order for each above said conditions. Analysis of Variance (ANOVA) is carried out to study the effect of burnishing parameters on response and to check the adequacy of the models developed. The results showed significant reduction in the surface roughness with all cases. Surface roughness of level 0.1043 μm can be achieved from the burnishing of the turned surface having roughness level of 2.7838 μm.

INTRODUCTION

Machined surfaces inherently consist of peaks and valleys produced by the tools and other factors such as vibrations in the machine structure, wear and process parameters. Therefore, to finish the machined surfaces the common practice is to use abrasive-based finishing methods like grinding, superfinishing, honing etc. Nowadays, post-machining finishing methods like burnishing works based on cold working principle are employed to achieve the better surface roughness along with other added advantages such as increase in microhardness, wear resistance, fatigue strength, corrosion resistance etc.[1][2] [3]. The ball burnishing process uses a ball as a deformer, which can be pressed against the machined surface during burnishing. When applied load is more than the yield strength of the material, plastic deformation takes place resulting in filling up of peaks in valleys. This plastic deformation mechanism during burnishing depends upon the mobility of dislocations and their interaction. In general, dislocations are initiated when shear strength on material reaches its critical value and further resistance offered by the material for the dislocation growth due to dislocation intersections results in plastic deformation. Burnishing process is easy to carry out in conventional machines using cheaper tools.

The works on burnishing process is undertaken by many researchers concentrating various objectives. Burnishing process employed on non-ferrous materials like brass and aluminum [1] show that an improvement in reduction of surface roughness up to 0.1 μm and 60% improvement in microhardness is possible. It is also recommended that ball diameter of 10 mm is better than 15mm and 6mm ball diameters to improve surface roughness. The effect initial conditions of the turned surfaces were also studied [4] and shown that the final responses in burnishing process are largely depends upon initial surface condition of machined surfaces. Shot peened workpiece further subjected to burnishing process to improve further their surface properties [3]. It was reported that fatigue strength at the surface increased by 65% for shot peened and burnished workpiece, whereas only shot peened components shown 54% improvement in fatigue strength. Improvement in wear resistance of ferrous [5] and non-ferrous metals are presented [6]. An investigation carried out on roller burnishing process on St-37 under lubricated conditions presented optimum conditions to achieve better surface roughness and stated that surface roughness decreases from 4.5 Ra to 0.5 Ra [7]. The out-of-roundness and change in the workpiece diameter during burnishing process are studied on five different types of materials [8]. The results show that the depth of penetration and time of burnishing are important parameters which controls microhardness. Also it is reported that, as initial surface hardness of the material decreases, the out-of-roundness increases and workpiece diameter increases with increase in the burnishing speed. The studies on effect of roller contact width and roller burnishing orientations [9] on aluminum 6061 indicated that 46% reduction in friction co-efficient can be achieved. Application of RSM based design of experiments was reported [10] to study the influence of ball burnishing parameters on ASSAB XW 5 tool steel in vertical milling machine. It is concluded that ball material tungsten carbide (WC) with grease as lubricant have better effect on surface roughness.

In addition to this, modifications in the burnishing process also reported in literature. The laser alloying process with slide burnishing [11] reported that multiple-path laser alloying treatment produces tensile stress of the range 500 Mpa and compressive stress after alloying and burnishing found to be -400 MPa. Internal ball burnishing was studied [12] on aluminum Al 2014 material. Combined burnishing and electrochemical process was demonstrated proved that burnishing process is having more advantage compared with other processes like electrochemical finishing, pulsed electro chemical finishing etc. [13]. Thermally sprayed coatings of DP6000 steel sheets are further treated with burnishing to decrease drawing ratio to 10 MPa [14]. Centerless burnishing structure similar to centerless grinding process has been developed to finish shaft of 41Cr4 steel [15]. Although fair amount of work is being done in burnishing, in current study an attempt is made to use abrasive particles and to study its effect on surface roughness along with other two conditions of burnishing namely dry and lubricated burnishing forms. The application of abrasive particles during the burnishing process may increase the surface finish and microhardness and is established in conventional finishing operations and works related to this is not been documented or published with best knowledge of the author. Hence the current work is attempt to study the effects of abrasive particles in burnishing process.

MATERIALS AND BURNISHING TOOL

i) Workpiece material

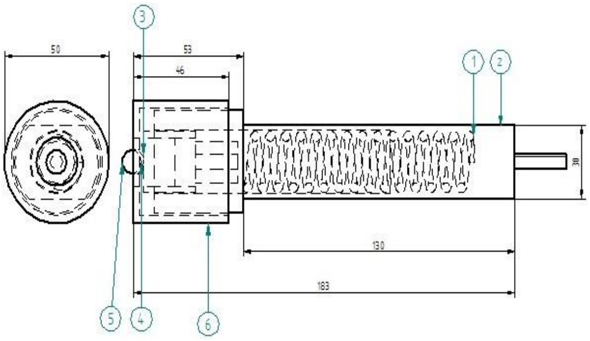
The workpiece material used in present work is free cutting Brass. This material is selected because of its extensive use in the industry. The table 1. Shows chemical composition of the workpiece (by weight percent) and mechanical properties. The material was received in wrought condition from the local supplier in ϕ 20 mm and 1-meter length. The same material was used as workpiece for burnishing without any treatment. The rod was first cut into 1 feet length from the initial length and further 9 samples were prepared with 25 mm as sampling length by making a small grove. One sample was kept as reference for turning and remaining eight samples were subjected for burnishing. The purpose of making grove is only to differential between sample made.

ii) Burnishing tool

The burnishing tool used in the current study is designed to use in a conventional lathe and is as shown in Fig.1. The ball used was carbon chromium ball, used in ball bearing, having surface finish of 0.12 μm and hardness of 165 HRC. The tool has spring inside and deflection of this spring is correlated with force to measure the same during burnishing process. The spring was measured for its stiffness after each case of burnishing condition experiments to make sure that it is working within the safe limits. Fig. 2 shows the graph of load, N Vs. deflection, mm of the spring.

TABLE 1. Chemical composition (% bys weight) and important mechanical properties of free cutting brass, IS 319-2007 Gr.1

Cu	Pb	Fe	Sn	Ni	Si	Mn	Al, P & S	Zn
55.574	3.050	0.308	0.172	0.048	0.08	0.019	0.003	Remd.
Yield stress, N/mm^2						278.191		
Tensile strength, N/mm^2						495.605		



Parts: 1. Spring 2. Lower casing 3. Ball holding casing 4. Carbide supporter for ball 5. ball 6. Upper casing

Figure 1 Ball burnishing tool assembly

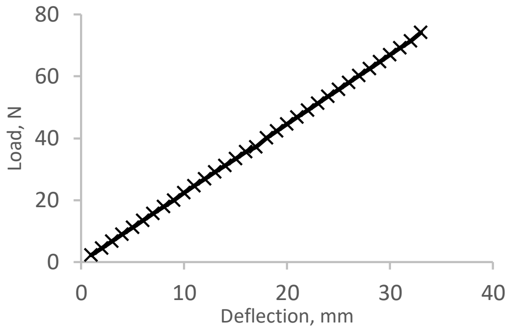


Figure 2 Spring deflection, mm vs. load, N

EXPERIMENTATION

The experimentation runs are planned according to RSM technique. Accordingly, 31 set of experiments were conducted for PB, LB and AAB conditions. The brass rod was first turned in CNC Turning center from ϕ 20mm to ϕ 18 mm. at similar cutting conditions (speed 750 rpm, feed 0.15 mm/rev, depth of cut 0.5 mm) so as to achieve a uniform surface roughness in all samples. The turned samples were than burnished in All Geared Lathe Unitech MTT636. During PB, the ball was cleaned with alcohol after every experiment in order to avoid foreign particles. The lubricant used here is kerosene for LB and in third case i.e. AAB, a fine silicon carbide abrasive paste supplied by Carborondum Universal limited, is applied on workpiece surface as a thin layer manually and burnishing is carried out. Kerosene was selected as the lubricant in the LB condition based on the authors previous studies and also based on the literature[1]. The surface roughness was measured using FORMSURF 50, (made: Taylor Harbson) and the initial surface roughness of the turned samples were found to be in the range of 2.4838 Ra(μm)- 2.7578 Ra(μm).

TABLE 2. Parameters and their coded values for all cases of burnishing

Variable designation	Burnishing parameters	Levels in coded form				
		+2	+1	0	-1	-2
X1	Burnishing force, N (kgf)	245 (25)	196 (20)	147 (15)	98 (10)	49 (5)
X2	Burnishing speed, rpm	910	735	560	385	215
X3	Burnishing feed, mm/rev	0.207	0.163	0.119	0.076	0.03
X4	Number of passes	5	4	3	2	1
Ball diameter		10 mm				

TABLE 3. Experimental Runs and results for all cases of burnishing

Run order	Burnishing force, N		Burnishing speed, rpm		Burnishing feed, mm/rpm		Number of passes		Surface roughness, Ra(µm) in PB	Surface roughness, Ra(µm)in LB	Surface roughness, Ra(µm) in AAB
	Actual	*Coded*	*Actual*	*Coded*	*Actual*	*Coded*	*Actual*	*coded*			
1	98	-1	735	1	0.1630	1	4	1	0.9989	0.2932	0.8675
2	98	-1	385	-1	0.1630	1	4	1	0.9580	0.7231	1.3361
3	147	0	910	2	0.1195	0	3	0	0.3293	0.1493	0.6452
4	147	0	560	0	0.1195	0	3	0	0.3680	0.4556	0.3270
5	97	-1	735	1	0.0760	-1	2	-1	0.8892	0.3182	0.3136
6	97	-1	385	-1	0.0760	-1	4	1	0.3553	0.6382	1.0190
7	147	0	560	0	0.1195	0	3	0	0.8437	0.2052	0.3321
8	245	2	560	0	0.1195	0	3	0	0.1702	1.1774	2.7864
9	97	-1	385	-1	0.1630	1	2	-1	0.9467	0.4130	0.7447
10	196	1	385	-1	0.0760	-1	4	1	0.8018	0.8532	0.5786
11	147	0	560	0	0.1195	0	3	0	0.1676	0.8090	0.3624
12	147	0	210	-2	0.1195	0	3	0	0.2526	0.1285	0.4027
13	147	0	560	0	0.1195	0	3	0	0.1700	0.4018	0.3358
14	196	1	735	1	0.0760	-1	2	-1	0.3221	0.1423	0.2416
15	147	0	560	0	0.1195	0	1	-2	0.7044	0.4084	0.4712
16	147	0	560	0	0.1195	0	3	0	0.3665	0.2273	0.3412
17	147	0	560	0	0.03245	-2	3	0	0.1043	0.7679	2.0393
18	196	1	735	1	0.1630	1	4	1	0.3215	1.2412	2.2681
19	147	0	560	0	0.19665	2	3	0	0.1919	0.3962	0.3166
20	196	1	385	-1	0.1630	1	4	1	0.1644	1.8182	0.5002
21	97	-1	385	-1	0.0760	-1	2	-1	0.1961	0.7662	0.2423
22	147	0	560	0	0.1195	0	3	0	0.2223	0.4421	0.3649
23	147	0	560	0	0.1195	0	3	0	0.1952	0.4159	0.3365
24	196	1	385	-1	0.1630	1	2	-1	0.3318	0.5278	0.1985
25	196	1	385	-1	0.0760	-1	2	-1	0.2810	1.3088	0.2419
26	196	1	735	1	0.1630	1	2	-1	0.2410	1.2262	0.6480
27	97	-1	735	1	0.1630	1	2	-1	0.8743	0.6881	0.1654
28	196	1	735	1	0.0760	-1	4	1	0.4012	0.9797	0.1610
29	147	0	560	0	0.1195	0	5	2	0.2129	0.2052	0.3743
30	49	-2	560	0	0.1195	0	3	0	1.5545	1.0642	0.1837
31	97	-1	735	1	0.0760	-1	4	1	0.2512	0.3279	0.2133

DESIGN OF EXPERIMENTS

Experiments are designed using factorial design method based on response surface methodology proposed by box and hunter [16]. This technique is useful especially when the curvature was observed in the relationship between parameters and responses. The four parameters under consideration were burnishing force (N), burnishing speed (rpm), burnishing feed (mm/rev) and number of passes of the tool over the sample. Each parameter is defined in three levels, i.e. -1,0, +1 to design the experimental runs. MINITAB software tool is used to generate experimental plan and for the analysis of the results. The parameters in coded unit and experimental plan is shown in table 2 & 3 and is similar for all three mentioned conditions.

The second order mathematical models were developed based on this technique which correlates four parameters such as burnishing force, burnishing speed, burnishing feed and number of passes with surface roughness.

RESULTS AND DISCUSSIONS

i) Results of Plain Burnishing (PB)

In this section, the results of PB are presented. The surface roughness of turned surface reduced to 0.1061 µm during burnishing showing 96% improvement. The optimized parameters are as follows; burnishing force 147 N, burnishing speed 560 rpm, burnishing feed 0.0325 mm/rev and 3 number of passes.

The regression equation for surface roughness in terms of process parameters can be given as follows (Eq. 1.);

$$\begin{aligned} &Surface\ roughness, Ra(\mu\text{m}) = 0.22 - 0.1204x_1 + 0.00204x_2 + 19.02x_3 - 0.275x_4 + 0.00583x_1^2 \\ &-17.3x_3^2 + 0.0448x_4^2 - 0.814x_1x_3 + 0.0107x_1x_4 - 0.00160x_2x_3 - 0.000313x_2x_4 - 0.10x_3x_4 \end{aligned} \quad (1)$$

ii) Main effects of parameters in PB

Figure 3 shows main effect of parameters on surface roughness in PB condition. It is evident from figure that the effect of force is significant than other parameters to control surface roughness. When force increases, the surface roughness decreases first, reaching minimum value and then it starts increase with force. The results are similar to the observations made in the study by [1]. This is attributed to over work hardening of surface due to higher forces. When deformation reaches to maximum level the chattering of the tool may take place and results in poor surface finish.

The increase in speed slightly increases surface roughness within the range of levels selected in current work. The surface roughness increases with increase in burnishing feed first, but upon further increase in the feed rate decreases the surface roughness. This is because of the less time available for the ball to deform the peaks in adjacent valleys and also due to larger distance between irregularities. When number of passes increases the surface roughness decreases first and then starts to increase with number of passes. This is because of repeated deformation which is causing chattering of the ball surface to deteriorate surface finish.

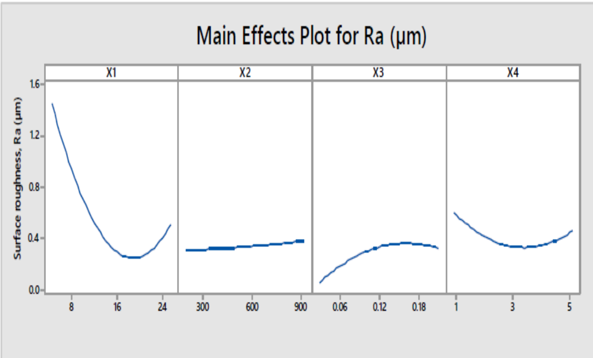


Figure 3 Main effects of parameters in PB

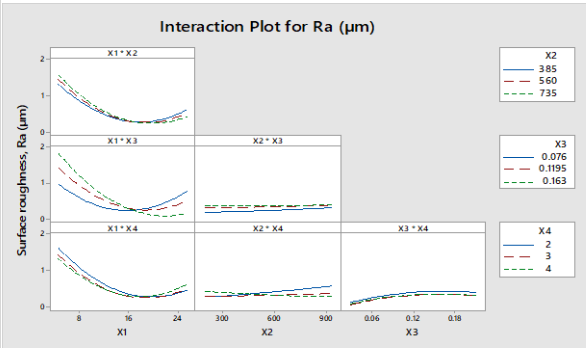


Figure 4 Interaction effects of parameters in PB

iii) Interaction effects of parameters in PB

The interaction effects between the various parameters in PB process is shown fig. 4. The speed of 735 rpm at 147 N (20 kgf) results in better surface roughness. The same effect is observed in case of 385 rpm and 560 rpm speeds. It is observed that for all speed levels, increase in force above 196 N decreases surface roughness. Hence, force of within 196 N is favorable for all the levels of speeds. The interaction between force and feed seems to be effective from the graph. The feed rate of 0.163 mm/rev is found to be effective to decrease surface roughness at higher forces. Whereas the other feed rates deteriorate roughness above 197 N. Similar trend is observed in case of interaction between force and number of passes. The lower number of passes resulting in better roughness above the force level of 197 N. The other interaction effects are not significant as the trend is almost parallel.

iv) ANOVA results for PB

The analysis of variance result is given in the table 4. As the F-value of the regression is greater than the standard F-ratio at 95% significance level, it is concluded that the model developed here is adequate.

TABLE 4. ANOVA for PB

Source	DF	Adj. SS	Adj. MS	F-ratio	Std. F Value
Regression;					
First order term	4	1.33340	0.33335	5.74	4.53
Second order term	10	1.35575	0.2853	4.91	4.06
Lack-of-Fit	10	0.68185	0.06819	1.17	4.06
Pure Error	6	0.34833	0.05806		
Total	30	3.71934			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.253745	72.30%	48.07%	0.00%

v) Results and discussions on LB

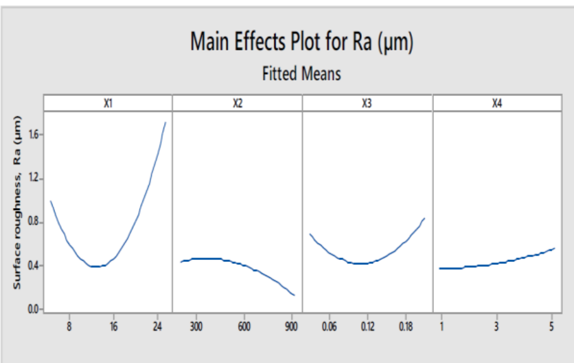
The experiments are conducted in presence of kerosene as a lubricant. The lubricant is applied continuously during burnishing process in the form of droplets. The surface roughness is reduced to 0.1285 µm compared to turned surface, showing 93% improvement. Optimized parameters to get lower surface roughness are burnishing force of 147 N, burnishing speed of 210 rpm, burnishing feed of 0.1195 mm/rev and 3 number of passes. The reduction in the surface roughness is less than dry burnishing case.

The regression equation for surface roughness in terms of process parameters can be given as follows (Eq. 2);

$$\begin{aligned} &Surface\ roughness, Ra(\mu m) = 5.11 - 0.342x_1 - 0.00037x_2 - 27.6x_3 - 0.420x_4 + 0.00851x_1^2 - 0.000001x_2^2 \\ &+ 41.3x_3^2 + 0.0093x_4^2 + 0.420x_1x_3 + 0.0236x_1x_4 + 0.0145x_2x_3 - 0.000196x_2x_4 + 1.38x_3x_4 \end{aligned} \quad (2)$$

vi) Main effects of parameters in LB

Figure 5 illustrates the main effects of parameters on surface roughness. In comparison dry and lubricated ball burnishing processes have similar effects for force and number of passes but the effect of feed is opposite in nature. From figure 5 it can be noticed that the force and feed were having significant effect on response than speed and number of passes. The force at level 147 N is having higher effect on roughness, but when force increases beyond 147 N the roughness starts increasing at surface. This may due to application of lubricant. Interestingly, the effect of lubricant is not effective in reducing the roughness at higher forces. Increased burnishing speed results in reduction in the roughness at surface. The increase in feed rate up to 0.12 mm/rev is found to be advantage to reduce the roughness at surface but beyond this the roughness tends to increase. This may be attributed to increase in the distance between burnishing traces at surface and also lack of time available for deformer to cause deformation of irregularities. When number of passes increases the roughness start to increase due to increase in temperature, which may cause chattering of the tool and also materials transformation between tool and workpiece.



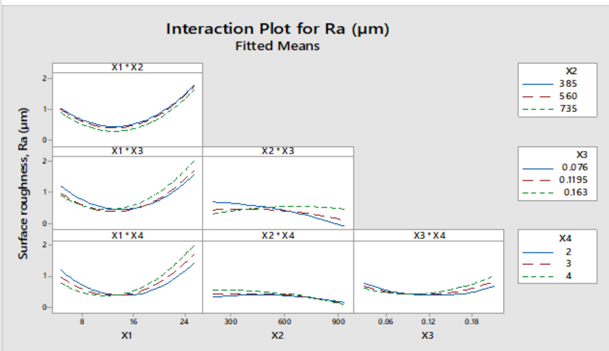


Figure 5 Main effects of parameters in LB

Figure 6 Interaction effects of parameters in LB

vii) Interaction effects of parameters in LB

Figure 6 depicts the interaction effects between the parameters. It is clear from figure that the speed of 735 rpm is producing better surface finish within the force level of 147 N among other speed ranges. The force and feed interaction effect is significant on roughness as seen in figure. The higher feed range of 0.163 mm/rev is seems to better at low force but when force increases low feed becomes effective in reducing the roughness of the surface. Combination of higher feed and low force, the deformation of the peaks is sufficient but when force along feed increases the deformation increases leading to poor surface roughness. Similar trend is observed in the interaction between force and number of passes.

Higher number of passes at lower force levels results in better finish, on the other hand, increase in force and number of passes together increases the roughness. this may be due to increase in plastic deformation which causes increase in temperature of the surface leading formation of bulge or chattering of the tool which are responsible for poor surface finish. At Higher force levels, less number of passes are recommended to reduce the roughness to greater percentage.

The lowest feed rate 0.0760 mm/rev is found to be effective with increasing force during burnishing for higher finish and increases as feed increases at higher force.

For all values of number of passes, increase in speed rate decreases surface roughness. From figure it is evident that increase in feed rate along with number of passes deteriorates surface roughness, whereas lower number of passes are beneficial to increase the surface finish at higher feeds.

viii) ANOVA results for LB

The ANOVA results of the LB is given in table 5. As shown in following table the F-value of regression (linear and interaction terms) is greater than the standard F-ratio at 95% significance level. Hence, it is concluded that the model developed in current case is adequate.

The values of S, R-Sq, R-Sq (adj), R-Sq (Pred.) are given for reference. The value shows that the equation can be used successfully to predict surface roughness values for any parameters.

TABLE 5. ANOVA for LB

Source	DF	Adj. SS	Adj. MS	F-ratio	Std. F Value
Regression;					
First order term	4	0.93183	0.23296	5.90	4.53
First order term	10	2.12475	0.212475	5.38	4.06
Error;					
Lack-of-Fit	10	1.92075	0.19207	4.86	4.06
Pure Error	6	0.23668	0.03945		
Total	30	5.21400			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.367205	58.62%	22.42%	0.00%

ix) Results and discussion on AAB

In current work an attempt is made to use abrasive particles in between the burnishing tool and workpiece to find its effect in deformation process. As there is dearth of literature in this field of burnishing and based authors preliminary experimental works the parameters were selected for the experimentation process. In whole experimentation the silicon carbide lapping paste made of fine abrasive particles is applied on workpieces. The results are tabulated in table 3. The lowest roughness value that can be achieved in this case is 0.1610 Ra(μm), which is better than 89% from the turned samples. Though the predicted results were not achieved in terms of roughness using abrasives, there may be chance of increase in microhardness at the surface due to abrasives. The surface of the metal affected by its appearance of aesthetic look because of the use of abrasives. The optimized parameters which are responsible for the above said low roughness value are as follows; burnishing force of 196 N, burnishing speed of 560 rpm, burnishing feed of 0.076 mm/rev and number of passes 4.

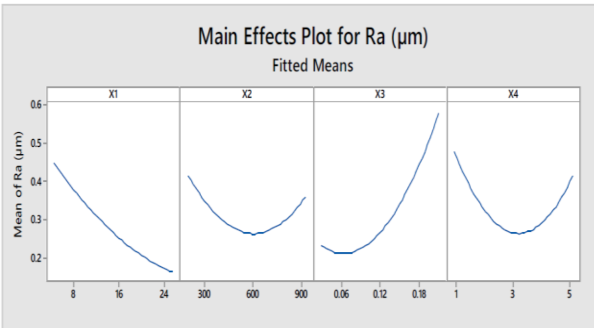
The assumption made here is that the material removal is not involved during burnishing action as it is difficult to find the chips in presence of abrasive materials. Also it is evident form the results of the surface roughness from the table 3 that in every experimental run the roughness value is lesser than the turned sample roughness value. Hence it can be concluded that the use of abrasives was influenced positively in the process of burnishing.

The regression equation (in uncoded units) for surface roughness in terms of process parameters can be given as follows;

$$\begin{aligned} &Surface\ roughness, Ra(\mu m) = 7.49 - 0.429x_1 - 0.00601x_2 - 45.0x_3 - 0.12x_4 + 0.00946x_1^2 + 84.5x_3^2 \\ &- 0.029x_4^2 + 0.000256x_1x_2 + 0.306x_1x_3 + 0.0026x_1x_4 + 0.0191x_2x_3 + 0.000048x_2x_4 + 3.28x_3x_4 \end{aligned} \tag{3}$$

x) Main effects of parameters in AAB

The main effects of the parameters during AAB can be seen from Fig. 7. From figure it noticed that when force increases from 49 N to 245 N the roughness level decreased exponentially at the surface. It is may be due to presence of abrasives which were also involved in the process of deformation. When speed increases up to 600 rpm, roughness value reduced and further increase in speed value decreases the roughness. This is attributed to fact that at lower speed the contact time between ball, abrasives and peaks present in the surface was less causing proper deformation of peaks present at the surface but when speed increases the time for deformation is less and there might be an increase in temperature causing deterioration of the finish at the surface. As seen from the figure the less feed levels are responsible for increase in surface finish of the surface and as feed rate increases the roughness level also increases exponentially. At higher feed rates, as distance between burnishing traces increases, ineffective deformation may result, even though in presence of abrasives. The influence of number of passes observed similar to other conditions of burnishing. The increase in the passes more than 3 causes repeated deformation as a result the roughness deteriorates at surface.



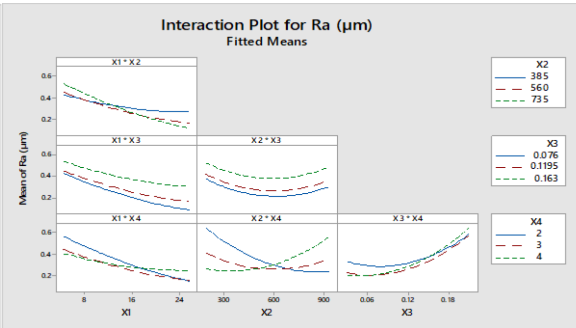


Figure 7 Main effects of parameters in AAB

Figure 8 Interaction effects of parameters in AAB

xi) Interaction effects of parameters in AAB

Figure 8 shows the interaction effects between different parameters on surface roughness during the case of AAB. The interaction between force and speed is having significant effect of surface roughness. Higher values of speeds with higher force are producing better level of roughness at the surface. whereas the speed of the range 385 rpm was found to be less effective causing less improvement in the surface finish at higher forces. At higher force along with higher speed levels, though there is a chance of increase in deformation causing deterioration of surface roughness values, due to the presence of abrasive particles smoothing of peaks was found to be effective.

The effect of force and feed is found to negligible as shown in figure. The low number of passes at higher force levels can increase surface finish. There is a considerable level of interaction between speed and number of passes was observed. Higher number of passes at low force can result into better finish, whereas, lower number of passes are more effective at higher speed ranges. The combination low number of passes and higher speeds, higher number of passes and low speed levels are causing same amount of deformation at the surface to improve the finish. The intermediate effect was seen in the three number of passes. At low speed, these passes are insufficient to cause effective deformation and at higher speed the deformation increases to effect adversely on surface roughness. The effect between feed and speed were seen insignificant on surface roughness.

The roughness level obtained better for all levels of number of passes at lower feed rates but as feed rate increases the all levels of number of passes produces poor surface finish at the surface. This may due to effect of increase in feed rate which is reducing the distance between peaks present at the surface causing less deformation and at higher number of passes the surface roughness due to repeated deformation which is causing material transformation between the tool and workpieces.

xii) ANOVA results for AAB

The ANOVA results for this condition is presented in table 6. It is evident from table that, the F-ratio of regression is greater than the standard F-ratio at 95% significance level, Hence, the developed models said to be adequate.

TABLE 6. ANOVA for AAB

Source	DF	Adj. SS	Adj. MS	F-ratio	Std. F Value
Regression;					
First order term	4	0.281561	0.070390	8.87	4.53
First order term	10	0.230327	0.045224	5.70	4.06
Error;					
Lack-of-Fit	10	0.085355	0.058355	7.6	4.06
Pure Error	6	0.047571	0.007928		
Total	30	0.644813			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0911473	79.39%	61.35%	13.71%

CONCLUSION

Following conclusions can be drawn out of this study;

1. The burnishing tools developed in present work can be used to carry out burnishing process, which is one of the easiest methods to improve surface finish of the components
2. The burnishing tool can be used on conventional lathe tool post thus avoiding additional tool holding requirements
3. There is improvement about 96% of surface roughness in burnished components when compared with turned samples in PB and optimized parameters are burnishing force 147 N, burnishing speed 560 rpm, burnishing feed 0.0325 mm/rev and 3 number of passes.
4. The improvement in surface roughness when kerosene is used as lubricant was 94% with respect turned samples. The optimized parameters levels are; burnishing force of 147 N, burnishing speed of 210 rpm, burnishing feed of 0.1195 mm/rev and 3 number of passes
5. By using abrasives, the turned reference samples roughness value can be decreased up to 0.1610 Ra (μm) and the reduction was 89%. The optimized parameter levels for this low roughness were; burnishing force of 196 N, burnishing speed of 560 rpm, burnishing feed of 0.076 mm/rev and number of passes 4
6. The mathematical models developed in current work at confidence level of 95% can be readily used to predict the surface roughness value for any combination of parameter levels.

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