Experimental Study of Roller Burnishing Process on Al 6061 Material Using Rsm

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Abstract--- Burnishing is a cold working process in which plastic deformation occurs by applying a pressure through a very hard and smooth ball or roller on metallic surfaces. It is a finishing and strengthening process. Improvements in surface finish and surface hardness is major concern in industries for achieving competitive advantage. Roller burnishing is a cold working process which produces a fine surface finish by the planetary rotation of hardened roils over a bored or turned metal surface.[1] The quality of burnishing machined parts is significantly affected by various parameters used in the process. The aim of present work is to study the four important process parameters of the roller burnishing process such as burnishing speed, feed, burnishing force and number of passes are consider. Their influence on surface roughness of the test specimens are study. The response surface methodology is applied for design of experiments. Response Surface method is used to examine the relationship between one or more response variables and a set of quantitative experimental variables or factors. These methods are often employed after identified the important controllable factors and to find the factor selection that optimizes the response.

Keyword: - Roller Burnishig, Surface Finish, Turning, RSM.

I. INTRODUCTION

Surface finish is important factor of today's manufacturing market. It is vital to avoid friction losses, good corrosion resistant property and high fatigue life. Additional manufacturing cost is required for post surface finishing operation of conventional machining operation as they leaves surface irregularities. Burnishing is a cold working process. In the burnishing process, the pressure imparted by the hard roller or ball on the softer work piece which exceed the yield point of work piece and plastic deformation takes place. [2] All machined surfaces consist of a series of peaks and valleys of irregular height and spacing. Due to this plastic deformation material from the peaks displace into the valleys by means of the cold work pressure. There is no problem of chip formation in the burnishing process. Surface with good finish, tough, work hardened, wear and corrosion resistant is obtained by burnishing process. [3]

II. EXPERIMENTAL DETAIL

A. *Material of Work piece*

In this current research paper, an effort is being made to understand the improvement in the surface finish of burnished surfaces along with the influence of the process parameters in "Al 6061" using single roller hard carbide tool. The chemical composition of work piece is shown in Table 1.

Al	Mg	Si	Fe	Cu	Zn	Mn	Cr
Bala nce	0.8-1.2	0.4-0.8	Max 0.7	0.18-0.40	Max. 0.25	Max.0 .18	0.04-0.35

Table 1 Chemical Composition of Al 6061

B. *Tool and machine Detail*

In present work single roller hard carbide tool is used for the burnishing operation. This tool of 30 – 30 mm shank is purchased from the Microtech tool company. Fig.1 shows the tool used for study. CNC lathe machine is used for the burnishing operation. The Jyoti CNC DX 150 machine is shown in Fig.2

Fig. 1: Burnishing Tool

Fig. 2: CNC Machine

III. PARAMETER SELECTION

Four machining parametersburnishing speed (rpm), feed (mm/min), burnishing force and number of passesare considered as input parameters. Based on Literature Review and studying the range available in CNC lathe machine, Range of four parameters is selected by large numbers of experiment and expert survey which is shown in Table 2.

Table 2 Parameters and their Range

PARAMETERS	RANGE
Speed (rpm)	100 - 500
Feed (mm/rev)	0.06- 0.30
Force(kgf)	5 - 25
No. Of Pass	1 - 5

IV. METHODOLOGY

A. *Response Surface Methodology Using Minitab 15*

Response Surface Methodology is combination of mathematical and statistical technique used to develop the mathematical model for analysis and optimization. Response surface methodology is very useful and modern technique for the prediction and optimization of machining performances. In the present study, the surface roughness and hardness of aluminium 6061 material part machined byroller burnishing process has been studied and also process parameters have been optimized by RSM. Response surface methodology (RSM) is a collection of statistical and mathematical techniques useful for developing, improving, and optimizing processes. The most extensive applications of RSM are in the particular situations where several input variable potentially influence some performance measure or quality characteristic of the process. This performance measure or quality characteristic is called the response. The input variables are sometimes called independent variables. The field of response surface methodology consists of the experimental strategy for exploring the space of the process or independent variables. Also, with the help of response surface methodology, optimization can be done for finding the values of the process variables that produce desirable values of the response. [4]

B. *Parameters and Their Level*

Table 3.Parameters and Their Level

Sr. No.		Control factor	Level				
1	X1	speed (rpm)	100	200	300	400	500
2	X2	feed (rev/min)	0.06	0.12	0.18	0.24	0.30
3	X3	burnishing force (kgf)	5	10	15	20	25
4	X4	number of pass	1	2	3	4	5

C. *DOE Matrix using Minitab 15*

DOE matrixes for four process parameters having five levels are generated using Minitab 15. This will give 31 sets of experiment shown in Table 4. The value obtained after experiment of roughness is also shown in Table.

Table 4 Sets of experiments with result

Sr. No.	Speed	Feed	Force	No. of pass	Surface Roughness
1	300	0.18	15	3	1.231
2	400	0.12	20	2	1.326
3	300	0.18	15	3	1.185
4	300	0.18	15	1	0.778
5	400	0.24	10	2	0.568
6	200	0.24	20	2	1.170
7	400	0.24	20	2	1.356
8	200	0.24	20	4	1.171
9	200	0.24	10	2	1.115
10	300	0.18	15	3	0.961
11	400	0.12	20	4	1.227
12	300	0.18	15	3	1.046
13	300	0.18	5	3	1.320
14	500	0.18	15	3	1.184
15	300	0.06	15	3	1.151
16	200	0.12	20	4	1.587
17	400	0.24	10	4	1.252
18	100	0.18	15	3	2.316
19	200	0.12	10	4	2.031
20	300	0.18	15	3	0.923
21	400	0.12	10	4	0.669
22	300	0.30	15	3	0.726
23	200	0.12	20	2	2.082
24	300	0.18	15	3	1.002
25	400	0.12	10	2	0.770
26	300	0.18	15	5	0.798
27	300	0.18	15	3	1.212
28	300	0.18	25	3	1.770
29	200	0.24	10	4	1.535
30	200	0.12	10	2	2.898
31	400	0.24	15	4	2.341

V. ANALYSIS OF VARIANCE

In order to statistically analyze the results, ANOVA was performed. Process variables having p-value<0.05 are considered significant terms for the requisite response characteristics. The insignificant parameters were pooled using backward elimination method. The pooled version of ANOVA for surface roughness (Table 5.4) indicates that speed(X1), feed(X2), force(X3),No. of pass(X4), the interaction terms (X1X2, X1X3, X1X4, X2X3, X2X4, X3X4,) and the quadratic terms (X1, X2, X3, and X4) are significant parameters affecting surface roughness. A statistical inference is also given at the bottom of ANOVA Table 5.

A. *Statistical Inferences*

1. The Model F-value of 73.94 implies the model is significant. There is only a 0.00% chance that a "Model F-Value" of this much magnitude could occur due to noise.

2. The "Lack of Fit F-value" of 1.87 implies the Lack of Fit is not significant relative to the pure error. There is a 22.90% chance that a "Lack of Fit F-value" of this order could occur due to noise. Non-significant lack of fit is good.

3. The “R-Squared" of 0.9544 is in reasonable agreement with the "Adj R-Squared" of 0.9146."

4. Values of "Prob > F" less than 0.0500 indicate model terms are significant. In this case X1, X2,X3,$X1^2$, $X3^2$, X1X2, X1X3, X1X4, X2X3, X2X4, are significant model terms.

Table 5: Pooled ANOVA- Surface Roughness

Source	DF	SS	MS	F	P
Model	14	8.38855	0.59918	73.94	0.000
X1	1	1.67693	1.67693	67.01	0.000
X2	1	0.35819	0.35819	14.31	0.002
X3	1	0.22465	0.22465	8.98	0.009
X4	1	0.01344	0.01344	0.54	0.474
$X1^2$	1	1.06123	1.13100	45.20	0.000
$X2^2$	1	0.00588	0.00046	0.02	0.394
$X3^2$	1	0.66871	0.62319	24.90	0.000
$X4^2$	1	0.04955	0.04955	1.98	0.179
X1X2	1	1.64609	1.64609	65.78	0.000
X1X3	1	1.29960	1.29960	51.93	0.000
X1X4	1	0.36301	0.36301	14.51	0.002
X2X3	1	0.18361	0.18361	7.34	0.015
X2X4	1	0.83357	0.83357	33.31	0.000
X3X4	1	0.00410	0.00410	0.16	0.691
Residual error	16	0.40040	0.02502		
Lack of fit	10	0.30310	0.03031	1.87	0.229
Pure error	6	0.09730	0.01622		
Total	30	8.78895			
R-sq= 95.44% % , R-sq(adj)= 91.46%%					

VI. Effect Of Process Variables On Surface Roughness

The main effect plot is plotted to study the effect of process variables on the surface roughness and is shown in Figures 3. It is clear that from Figure the surface roughness has an improving trend with the increase of spindle speed and feed at the same time it increases with the increase of burnishing force. To obtain the longer discharge time, the machining speed needs to be slowed down. It is seen from Figure 3 that surface roughness increases slightly with increase in the burnishing force values. The higher is the burnishing force, better is the deforming action of roller. This leads to improvisation in surface roughness. It is seen from Figure that passes shows mild tendency to increase with increase in the spindle speed.

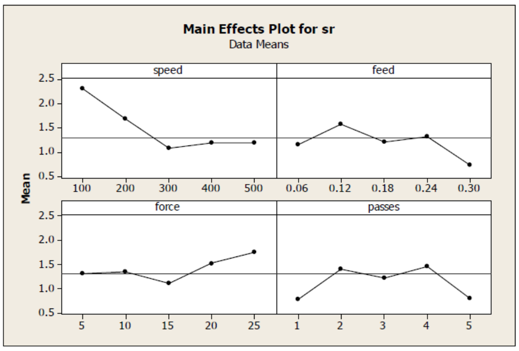

Fig. 3: Main Effect Plots for Surface Roughness

The main effects plot shows that number of passes is insignificant as the slope gradient is very small. From the same figure it is shown that spindle speed is significant with the high gradient of the slope, while feed and force is less significant than spindle speed. However, based on the main effect plot we can conclude that in order to achieve the best surface finish, the spindle speed (300 rpm) and highest value of burnishing force (30) and highest value of feed 0.30 (mm/rev) and no. of pass (5) should be selected.

VII. Conclusion

1. In this research work observed the results the influence of no. of pass, burnishing force, feed and speed on surface roughness, the test was performed and it was seen that the effect of spindle speed is greatest among all the parameters.
2. Surface roughness is increased with increase in speed, best result is obtained with speed 300 rpm (4.712 m/min)
3. Number of passes is insignificant as the slope gradient is very small.
4. Spindle speed is significant with the high gradient of the slope, while feed and force is less significant than spindle speed.
5. based on the main effect plot we can conclude that in order to achieve the best surface finish, the spindle speed (300 rpm) and highest value of burnishing force (30) and highest value of feed 0.30 (mm/rev) and no. of pass (5) should be selected.

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