International Journal For Technological Research In Engineering
Volume 3, Issue 9, May-2016 ISSN (Online): 2347 - 4718

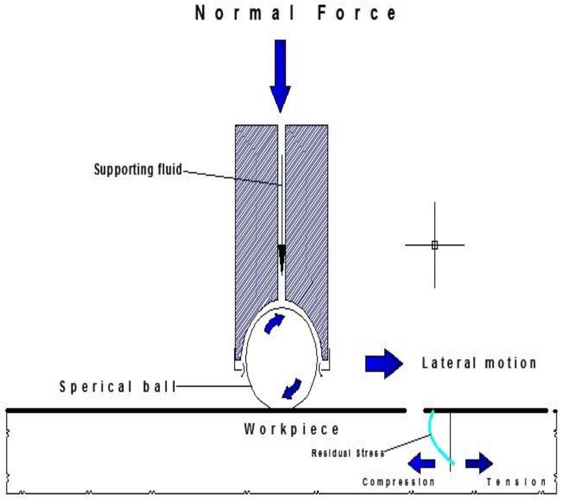
PARAMETRIC OPTIMIZATION OF ROLLER BURNISHING FOR EN19 BY USING FULL FACTORIAL DESIGN

Jay Patel[1], Falgun Patel[2]
[1]ME-Student, [2]Professor Department of Mechanical Engineering, S.P.B. Patel Engineering College, Gujarat, India

Abstract: Burnishing is a chip less finishing method which employs a rolling tool pressed against the work piece for achieving plastic deformation of the surface layer. Roller burnishing process is largely considered in industrial cases in order to restructure surface characteristic. Roller burnishing process is employed on EN19 work piece for current study. In the present work the effect of burnishing parameter like speed, Interference, feed and the number of passes is going to be examined on the surface quality and its wearing characteristics of EN19. For this experimental work, it has been used full factorial design and utilizes grey relational analysis for optimization process.
KEYWORDS: Burnishing, EN19 steel, Roller Burnishing Tool, Surface Roughness, Surface Hardness, Microstructure, DOE, Full factorial Design

I. INTRODUCTION

Technological revolution in the recent years increased in the expectation from the manufacturing industry. The expected service life of the components has taken a long-leap, without increasing the production cost. So the engineers had to come up with improvised and versatile manufacturing processes that address these expectations. The service behaviour and life of the components depend mostly on the surface properties. For this reason, significant attention has been paid to the post-machining operations, because the conventional machining processes like turning, milling etc produce surfaces with inherent irregularities and imperfections. So there is need for a surface finishing operation that nullifies these irregularities and also improves other surface properties like hardness, corrosion resistance, wear resistance and fatigue life. These properties can be increased by utilizing surface plastic deformation (SPD) process, which does not involve material removal, but improves the surface properties by deforming the surface plastically, under compressive loads. Under this external load, the surface of the component is subjected to cold working. One such SPD process that has gained increasing acceptability in the manufacturing industry is burnishing. In 1996, Lambda Technologies developed and patented 'Low Plasticity Burnishing (LPBTM)' which differed slightly from the conventional burnishing[2]. It makes use of very minimal amount of plastic deformation or cold working, to create the residual stresses, which improve the surface properties like fatigue life and corrosion resistance. LPBTM uses a constant volume hydrostatic tool design as shown in figure 1.3, which is patented by Lambda Technologies, to float the ball continuously during the operation, irrespective of the applied force. This eliminates the dragging of the ball and damaging the surface, which is bound to happen in conventional burnishing, if not performed by taking enough care and precautions.



II. METHODOLOGY

2.1 Bright centerless OD roller burnishing machine

Specification Of machine

Min.& Max. Rolling Diameter of the part - 6mm to 40 mm
Maximum plunge rolling length of the part – 40mm
Maximum Rolling Head stroke -65mm
Maximum working pressure – 40/60bars
Rolling force adjustable up to -2000kgf
Main motor power(geared Motor)-3 hp
Hydraulic Power motor – 1 HP

Control system(PLC)-Fanuc make
Variable Speed drive – Inverter drive
Coolant pump motor- 0.25 HP
Overall dimension -900(L) *1100(B)*1650(H)
Net weight-1000kg(Approx.)
Input voltage :440 V AC, 3 Phace, 50 : 220 V AC , 1 phase,50Hz

2.2 Selection of Work-Piece Material

Nowadays, automobile industry has been growing at fast rate which require high tensile strength, and impact for the components. EN19 steel material is suitable for heat treated parts where high tensile and impact are required. For motorsport applications an engine will need to run at speeds beyond the limits of the standard crank. Inevitably this means a steel crank for greater strength and reduced weight. However a steel crank, most commonly available in EN40B material, is a very expensive proposition which is especially for the club level competitor. The solution is to use cranks produced from EN19 which is strong enough and light enough. EN19 generally used for axle shafts gears, connecting rods, studs bolts, propeller shaft joint.

2.4 Full factorial method

Design of experiment:

Ranges of process parameter

Parameter	unit	Level-1	Level-2	Level-3
Speed (S)	RPM	10	16	20
Pressure	Mm/rev	10	15	20
No. Of passes		1	2	3

Experimental Readings

Sr. No.	Speed (m/min)	Pressure (Bar)	No. of passes	Ra	Hardness RC
1	10	10	1	0.79	35
2	10	10	2	0.71	36
3	10	10	3	0.68	37
4	10	15	1	0.77	36
5	10	15	2	0.69	37
6	10	15	3	0.67	38
7	10	20	1	0.74	38
8	10	20	2	0.68	39
9	10	20	3	0.66	39
10	16	10	1	0.88	34
11	16	10	2	0.82	35
12	16	10	3	0.81	37
13	16	15	1	0.78	35
14	16	15	2	0.76	36
15	16	15	3	0.71	36
16	16	20	1	0.76	38
17	16	20	2	0.71	39
18	16	20	3	0.69	40
19	20	10	1	0.90	32
20	20	10	2	0.86	33
21	20	10	3	0.83	35
22	20	15	1	0.79	34
23	20	15	2	0.78	35
24	20	15	3	0.73	35
25	20	20	1	0.77	37
26	20	20	2	0.76	37
27	20	20	3	0.74	38

2.5 Main Effects Plot for means of surface roughness

The main effects plot for S/N ratio of surface roughness versus Speed, Feed rate and No. of passes are shown in fig.4.2,

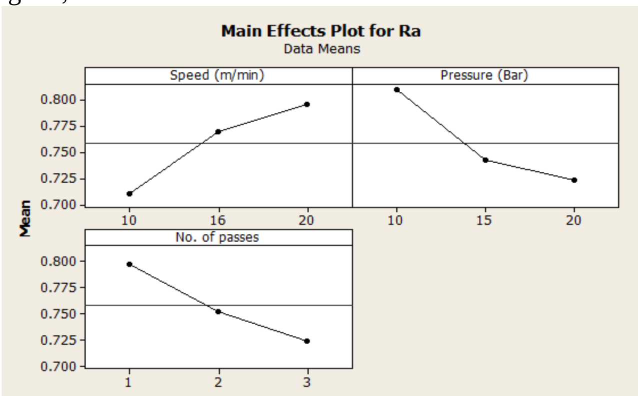


Figure 4.2- Effect of control factor on surface roughness

Table 4.2 Response Table for Means

Level	Speed(m/min)	Pressure(Bar)	No. of passes
1	0.7100	0.8089	0.7978
2	0.7689	0.7422	0.7522
3	0.7956	0.7233	0.7244
Delta	0.0856	0.0856	0.0733
Rank	2	1	3

which is generate from the value experiment of surface roughness as per table in minitab-16 statistical software is useful to find out optimum parameter value for response variable. Fig.4.2 shows that lower surface roughness will meet at Speed 10 m/min, pressure and No. of passes 3. The graph generate by use of minitab-16 statistical software for surface roughness is shown in fig.4.2. From the fig.4.2, it has been conclude that the optimum combination of each process parameter for lower surface roughness is meeting lower Speed[A1], higher Pressure[B3] and higher No. of passes[C3]. The effect of burnishing speed on average roughness can be assessed form figure 4.2, the figure clearly show the average surface roughness is reduced slightly with an increase in burnishing speed. This reduction is expected to be due the stability of the RB tool which is much better at high speeds within the selected range. However, an increase in burnishing speed deteriorates the surface roughness as a result to the over hardening and consequent flaking of the surface layers. Burnishing pressure is one of many important burnishing parameters that can greatly affect On burnishing process characteristics. Figure 5.3 shows, the average surface roughness also reduced as the burnishing pressure is raised, reaching to a minimum value of 64.1 RC at burnishing pressure lower level among three (medium burnishing). Further increase in burnishing pressure can lead to an increase in average roughness. So it is recognized to be better to select processing in this higher burnishing pressure, which is believed to be related to high deforming action of the tool, and more regular metal flow produced a smoother surface.

4.2.3 Main Effects Plot for means of surface hardness

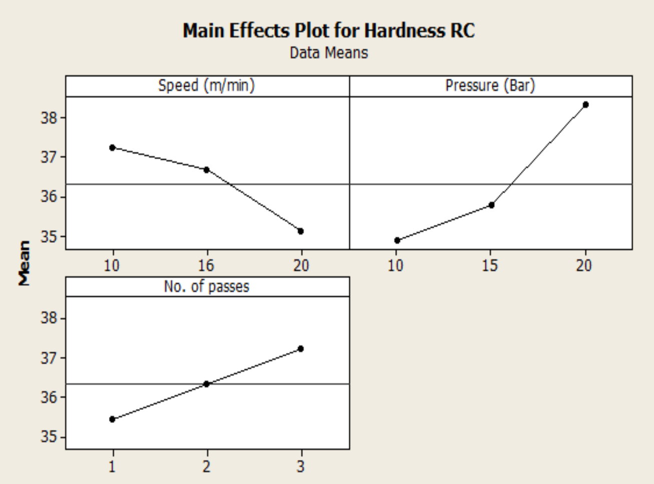


Figure 4.3- Effect of control factor on surface hardness

Table 4.3 Response Table for Means

Level	Speed (m/min)	Pressure (Bar)	No. Of passes
1	37.22	34.89	35.44
2	36.67	35.78	36.33
3	35.11	38.33	37.22
Delta	2.11	3.44	1.78
Rank	2	1	3

Fig.4.3 shows that higher surface hardness will meet at Speed 10 m/min , Pressure 20 bar and No. of passes 3. From the fig.4.3, it has been conclude that the optimum combination of each process parameter for lower surface hardness is meeting at lower Speed[A1], higher Pressure[B3] and higher No. of passes[C3]. Burnishing speed; The effect of burnishing speed doesn't appear to be significant. Figure 5.4 shows the effect of burnishing speed on hardness, when the hardness reaches the maximum value at level one(10 m/min) of burnishing speed. At medium and high burnishing speed the hardness gradually reduced, in this condition the reduction is expected to be related to less amount of cold working imposed to the deformed metal surface, due to rapped deformation rate (high strain rate). Burnishing pressure; The effect of burnishing pressure on the hardness are shown in figure 3.7 hardness reaches the maximum value at burnishing Pressure between level two and three.

Analysis Of Variance (ANOVA)

Analysis of variance (ANOVA) is a statistical model which can be used for find out effect of independent parameter on single dependent parameter and also it can be use full to find out the significant machining parameters and the percentage contribution of each parameter.

MINITAB16 statistical software used to analyze the ANOVA analysis for Surface roughness and surface hardness and their analyzed value is show in ANOVA table. All the terms related to ANOVA table is explained in chapter no.4. This table concludes all information of analysis of variance and case statistics for further interpretation.

According to the analysis done by the MINITAB16 software, if the values of probability are less than 0.05, it indicated that the factors are significant to the response parameters. Comparing the p-value to a commonly used α- level = 0.05, it is found that if the p- value is less than or equal to α, it can be concluded that the effect is significant, otherwise it is not significant.

4.3.1 Analysis of Variance for surface roughness

According to the analysis done by the MINITAB16 software, if the values of probability are less than 0.05, it indicated that the factors are significant to the response parameters. Comparing the p-value to a commonly used α- level = 0.05, it is found that if the p- value is less than or equal to α, it can be concluded that the effect is significant, otherwise it is not significant.

From ANOVA result it is observed that the speed, pressure and no of passes influencing parameter for Surface roughness, while the value of p for speed, pressure and no of passes are 0.000 which is less than 0.05 p value

ANOVA: Ra versus Speed (m/min), Pressure (Bar), No. of passes

Factor	Type	Levels	Values
Speed (m/min)	fixed	3	10, 16, 20
Pressure (Bar)	fixed	3	10, 15, 20
No. of passes	fixed	3	1, 2, 3

Table 4.4: Analysis of Variance for Ra

Source	DF	SS	MS	F	P
Speed (m/min)	2	0.034496	0.017248	28.57	0.000
Pressure (Bar)	2	0.036363	0.018181	30.12	0.000
No. of passes	2	0.024674	0.012337	20.44	0.000
Error	20	0.012074	0.000604		
Total	26	0.107607			

R-Sq = 88.78% R-Sq(adj) = 85.41%

4.3.2 Analysis of variance for surface hardness

From ANOVA result it is observed that all responses are influencing parameter for surface hardness, while the value of p for all process parameter is 0.000, 0.000 and 0.000 which is less than 0.05 p values. So, it is influencing parameter for surface hardness.

ANOVA: Hardness (RC) versus Speed (m/min), Pressure (Bar), No. of passes

Factor	Type	Levels	Values
Speed (m/min)	fixed	3	10, 16, 20
Pressure (Bar)	fixed	3	10, 15, 20
No. of passes	fixed	3	1, 2, 3

Table 4.5 Analysis of Variance for Hardness RC

Source	DF	SS	MS	F	P
Speed(m/min)	2	21.556	10778	32.33	0.000
No. of passes	2	14.222	7.111	21.33	0.000
Pressure(Bar)	2	57.556	28.778	86.33	0.000
Error	20	6.667	0.1511		
Total	26	100			

R-Sq = 93.33% R-Sq(adj) = 91.33%

III. CONCLUSION

Experimental investigation on roller burnishing machining of EN19 has been done using Design of experiment. The following conclusions are made.

- From the mean effect plot the optimum parameter settings for surface roughness at, ie. Speed 10 m/min, pressure 20 bar and no of passes is 3.
- It can also observed that all process parameters are more contribute for surface roughness but pressure is the most prominent factor affecting the surface roughness.
- Same thing occurred on hardness for all process parameters.
- The Analysis of Variance resulted that the pressure has major influence on the surface roughness (µm) and hardness (RC). Whereas the speed and no of passes has less effect on surface roughness and surface hardness .
- The objectives such as surface roughness and hardness are optimized using a single objective full factorial method.
- Mechanically modified layer of varied thickness was found to be present at the surface as a consequence of burnishing values of burnishing depth as a function of extent of burnishing (unburnished, 1st, 2nd and 3rd passes). The present study shows that maximum burnishing depth happens to occur in 3rd pass.

REFERENCES

[1] Krishna, R Murali," An Investigation of the Effect of the process parameters on the Material Properties of burnished components" Jawaharlal Nehru Technological University, Hyderabad,2013
[2] J.N. Malleswara Rao et all, "Experimental investigation of the influence of burnishing tool passes on surface roughness and hardness of brass specimens", Indian Journal of Science and Technology, ISSN: 0974- 6846
[3] Types of burnishing tools are being used in the industries "http://www.cogsdill.com/products/burnishing/"
[4] Figure of Types of roller burnishing tools "www.brightbright.com/about_burnishing."
[5] Internal roller burnishing tool "yamasa.com.tr/137/2/6/yamasa/rollerburnishing.aspx"
[6] A.A. Ibrahim et all , "Center rest balls burnishing parameters adaptation of steel components using fuzzy logic" Elsevier
[7] Feng Lei Li et all, "Analytical prediction and experimental verification of surface roughness during the burnishing process", ScienceDirect
[8] Burnishing By David J. LaBounty, CMC FBHI
[9] M.M. El-Khabeery, M.H. El-Axir , "Experimental techniques for studying the effects of milling roller-burnishing parameters on surface integrity" International Journal of Machine Tools & Manufacture
[10] Fang-Jung Shiou, Chih-Cheng Hsu, "Surface finishing of hardened and tempered stainless toolsteel using sequential ball grinding, ball burnishing and ball polishing processes on a machining centre" journal of materials processing technology
[11] Mieczyslaw Korzynskia, et all ,Surface layer characteristics due to slide diamond burnishing with a cylindrical-ended tool, Journal of Materials Processing Technology
[12] Malleswara Rao J. N, et all, "The effect of roller burnishing on surface hardness and surface roughness on mild steel specimens", International Journal Of Applied Engineering Research
[13] Dinesh Kumar,et all , "Improving Surface Finish and Hardness for M.S. Cylinder using Roller Burnishing" , International Journal of Scientific Research Engineering & Technology.
[14] Kiran A Patel, et all, "Comparative Analysis for Surface Roughness of Al Alloy 6061 using MLR and RSM" International Journal of Computer Applications
[15] K Saraswathamma et all, "Optimization of surface roughness in the Roller burnishing process using response surface methodology and desirability function", International conference on Emerging Trends in Mechanical Engineering
[16] F.J. Shiou, C.H. Cheng , "Ultra-precision surface finish of NAK80 mould tool steel using sequential ball burnishing and ball polishing processes" journal of materials processing technology
[17] Aysun Sagbas "Analysis and optimization of surface roughness in the ball burnishing process using response surface methodology and desirabilty function" ScienceDirect
[18] P Ravindra Babu et all, "Optimization of burnishing parameters and determination of select surface characteristics in engineering materials"

