"PARAMETRIC OPTIMIZATION OF ROLLER BURNISHING PROCESS FOR SURFACE ROUGHNESS AND SURFACE HARDNESS"

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ABSTRACT

Now a days, manufacturing industry expected more service life of the components without increasing the production cost. This led to development improvised and versatile manufacturing processes that address these expectations. The service behavior 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. **Burnishing** is one of the surface finishing process, which does not involve material removal, but improves the surface properties by deforming the surface plastically. Here SS410 steel is used for making shafts with good surface finish and hardness by the roller burnishing process. The present study aims to achieve high performance of roller burnishing machine, experiments is carry out to find effect of input parameter on output performance parameter. The experimental data will be optimizing by full factorial methodology, and conclude optimal set of parameter by Response surface methodology or Regression analysis.

Keywords: *Surface roughness, Hardness, Grey Relational Analysis.*

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1 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 behavior 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. Burnishing is a surface modification process which produces a very smooth surface finish cylindrical surface. The tool may consist of one or more ball or roller. This process does not involve the removal of material from the work pieces.

All machined or other processed metal surfaces consist of a series of peaks and valleys which constitute the surface irregularities. The force applied by the burnishing tool forces the material from the peaks to flow into the valleys. This reduces the height of the peaks and depth of the valleys, thereby reducing the surface roughness.

Quality of surface is an important factor to decide the performance of a manufactured product. Surface quality affect product performance like assembly fit, aesthetic appeal that a potential customer might have for the product. A surface is defined as the exterior boundary of an object with its surroundings, which may be any other object, a fluid or space or combination of these. The surface encloses the object's bulk mechanical and physical properties. A surface is what we touch, when we held a manufactured object. Normally dimensions of the object are specified in its drawing relating the various surfaces to each other. These nominal surfaces, representing the intended surface contour of the manufactured part, are defined by line in the drawing (machine). The nominal surfaces of the object are represented by perfect straight lines, perfect circles, round holes, absolute perpendicularity and straightness. A variety of processes are used to make the designed parts. In totality the manufacturing result is wide variations in surface characteristics. It is important to know the technology of surface generation. Only then the root causes of deviations can be determined and fixed to get the good results. [1].

Burnishing process is considered as a cold working process, because the surface of the work piece is subjected to severe stress due to the planetary motion between the tool & work piece and the pressure applied by the tool. When this stress exceeds the yield strength of the material, it results in the plastic flow of the material from the peaks of the surface irregularities into the valleys, thereby reducing the surface roughness [2].

2. DESIGN OF EXPERIMENT

Design of experiments was developed in the early 1920s by Sir Ronald Fisher at the Rothamsted Agriculture field Research Station in London, England. His initial experiments were concerned with determining the effect of various fertilizers on different plots of land. The final condition of the crop was not only dependent on the fertilizer but also on the number of other factors (such as underlying soil condition, moisture content of the soil, etc.) of each of the respective plots. Fishers used DOE which could differentiate the effect of fertilizer and the effect of other factors. Since that time the DOE has been widely accepted in agricultural as well as Engineering Science. Design of experiments has become an important methodology that maximizes the knowledge gained from experimental data by using a smart positioning of points in the space. This methodology provides a strong tool to design and analyze experiments; it eliminates redundant observations and reduces the time and resources to make experiments. We have used full factorial design, if the numbers of levels and numbers of factors known then the possible design L is

$$L=M^n \quad \dots (1)$$

Where, M = number of levels for each factor, and n = number of factors.

3. BURNISHING PROCESS

		
Fig 1. Before burnishing of SS410	**Fig 2. Burnishing process on SS410**	**Fig 3. After burnishing of SS410**

The design of input parameter is selected by full factorial method because here we chose 3 factor and 3 level which given 27 result and which is covered all possibility and give best result .The burnishing process is done 27 stainless steel 410 surface. The input parameter and level are given in below table. The size of work piece is 60mm X 28mm dia.

Table 1: Variable Input parameters for Burnishing process

Factors	Level 1	Level 2	Level 3
Speed	50	100	150
Pressure	25	35	45
No of passes	1	2	3

4. TEST RESULTS

After the coating process, Hardness is measured by Brinell hardness tester, and the surface roughness is measured by surface roughness tester.

Table 2: Testing Result

No.	Speed [RPM]	Pressure [Bar]	No. of passes	Hardness [BHN]	Surface Roughness µm
1	50	25	1	264	0.495
2	50	25	2	283	0.437
3	50	25	3	292	0.348
4	50	35	1	267	0.355
5	50	35	2	281	0.331
6	50	35	3	298	0.178
7	50	45	1	277	0.343
8	50	45	2	293	0.309
9	50	45	3	302	0.145
10	100	25	1	230	0.368
11	100	25	2	243	0.455
12	100	25	3	249	0.344
13	100	35	1	266	0.355
14	100	35	2	279	0.441
15	100	35	3	287	0.318
16	100	45	1	269	0.407
17	100	45	2	291	0.343
18	100	45	3	298	0.265
19	150	25	1	228	0.455
20	150	25	2	240	0.509
21	150	25	3	241	0.430
22	150	35	1	260	0.452
23	150	35	2	265	0.497
24	150	35	3	284	0.407
25	150	45	1	261	0.545
26	150	45	2	269	0.437
27	150	45	3	290	0.343

5. ANOVA ANALYSIS

Table 3: ANOVA %contribution

Parameters	**Hardness** *%contribution*	**Roughness** *%contribution*
Speed	23.20%	32.55%
Pressure	40.34%	12.76%
No of passes	22.51%	31.55%
Error	13.93%	23.12%

6. MAIN EFFECTS PLOT

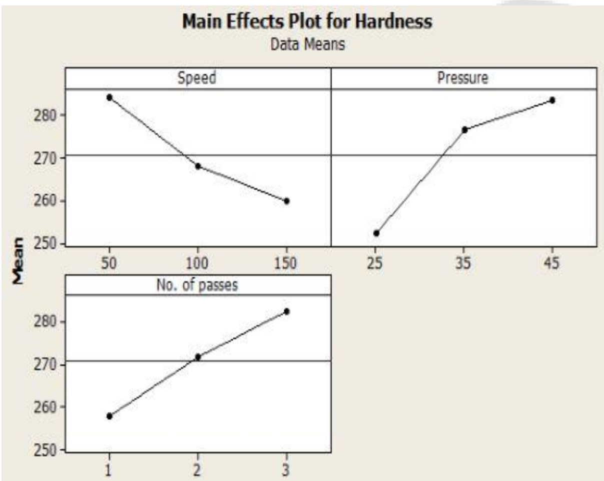

Fig 4: Main effect for hardness

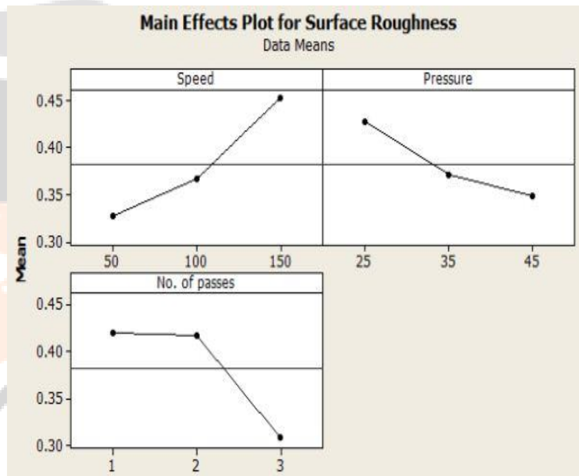

Fig 5: Main effect for roughness

7. GREY RELATIONAL ANALYSIS

In grey relational generation, the normalized data corresponding to Lower-the-Better (LB) Criterion can be expressed as:

$$Xi(k) = \frac{\max yi(k) - yi(k)}{\max yi(k) - \min yi(k)}$$

For Higher-The-Better (Hb) Criterion, The Normalized Data Can Be Expressed As:

$$Xi(k) = \frac{yi(k) - \min yi(k)}{\max yi(k) - \min yi(k)}$$

Where xi (k) is the value after the grey relational generation, min y_i(k) is the smallest value of y_i(k) for the k_{th} response, and max y_i (k) is the largest value of y_i(k) for the k_{th} response. An ideal sequence is x_0 (k) for the responses. However, if there is ''a specific target value'', then the original sequence is normalized using,

$$Xi(k) = 1 - \frac{|yi(k) - OB|}{\max\{\max yi(k) - OB, OB - \min yi\ (k)\}}$$

The purpose of Grey relational grade is to reveal the degrees of relation between the sequences say, [x0 (k) and xi (k), i =1, 2, 3…, n]. The Grey relational coefficient can be calculated using the preprocessed sequences. The Grey relational coefficient is defined as follows

$$\xi i(k) = \frac{min\Delta + \theta max\,\Delta}{\Delta i\ (k) + \theta max\,\Delta};$$

The Grey relational grade γi can be computed as : $yi = \frac{1}{n}\sum_{k=1}^{n} \xi i\ (k)$

Table 4: GRC and GRG and GRG NO.

Experiment no.	Hardness GRC	Surface roughness GRC	GRG	GRG no.
1	0.49333333	0.363636364	0.493333	19
2	0.66071429	0.406504065	0.660714	10
3	0.78723404	0.496277916	0.787234	5
4	0.51388889	0.487804878	0.513889	16
5	0.63793103	0.518134715	0.637931	11
6	0.90243902	0.858369099	0.902439	3
7	0.59677419	0.502512563	0.596774	13
8	0.80434783	0.549450549	0.804348	4
9	1	1	1	1
10	0.33944954	0.472813239	0.33945	26
11	0.38541667	0.392156863	0.385417	23
12	0.41111111	0.501253133	0.411111	22
13	0.50684932	0.487804878	0.506849	17
14	0.61666667	0.403225806	0.616667	12
15	0.71153846	0.536193029	0.711538	8
16	0.52857143	0.432900433	0.528571	14
17	0.77083333	0.502512563	0.770833	6
18	0.90243902	0.625	0.902439	2
19	0.33333333	0.392156863	0.333333	27
20	0.37373737	0.354609929	0.373737	25
21	0.37755102	0.412371134	0.377551	24
22	0.46835443	0.394477318	0.468354	21
23	0.5	0.362318841	0.5	18
24	0.67272727	0.432900433	0.672727	9
25	0.47435897	0.333333333	0.474359	20
26	0.52857143	0.406504065	0.528571	15
27	0.75510204	0.502512563	0.755102	7

8. CONCLUSION

Analysis of hardness shows the percentage contribution of individual parameters in Burnishing Process for Speed is 23.20 %, Pressure of 40.34 % and No of passes of 22.51 % and the error is 13.93 %. Analysis of surface roughness shows the percentage contribution of individual parameters in Burnishing Process for Speed is 32.55 %, Pressure of 12.76 % and No of passes of 31.55 % and the error is 23.12 %. By use of GRA optimization technique the optimal parameter combination is meeting at experiment 9 has the best multiple performance characteristic among 27 experiments, because it has the highest grey relational grade of 1.

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