Experimental Study of Effect of Shot Peening Parameter on the Performance of Shot Peening Process

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Abstract— Fatigue failure is a result of a crack initiation and propagation, in consequence of a cyclical load. In aeronautical components as landing gear the fatigue strength is an important parameter to be considered in manufacturing of it, as well as the corrosion and wear resistance. The major applications of the shot peening are related to improvement and restoration of properties and reliability of machine elements by increasing their surface hardness, tensile strength, surface finish, impact strength, fatigue strength etc. The improvement of properties depends on the intensity of shot peening process. The intensity can be varied by regulating the size of shot, the hardness of shot, the speed at which was fired, the length of time, the distance of nozzle from the surface and the work exposed to the shot. Basically there are so many input and response variables discussed in the previous works but the availability and cost are the important factors considered in this work for the variables. The shot peening was carried out on the EN9 component with the fixed diameter shots and then the changed parameters and properties were discussed with the help of different tools like DoE and optimization were carried out in Response Surface Methodology in MINITAB14, ANOVA and Regression for checking the model for adequacy of the different factors, Response optimizer gave the final optimized combinations of the input variables to get the maximum benefit of responses. From the experimentation it is found that out of three input parameters velocity of peening was observed as most significant factor. The important and primary response parameter arc height gave the significant set of input parameters with their appropriate levels.

Key words: Performance of Shot Peening Process, Shot Peening Parameter

I. INTRODUCTION

Engineering components and structures are regularly subjected to alternating loads, which made them prone to fatigue failures. It is well known fact that almost all fatigue cracks form at surface due to variety of surface stress concentration features, including grain boundaries, machining marks, surface breaking inclusions. Fatigue performance of metallic parts depends on three factors: Metallurgical, surface geometry and residual stress. Performance can also been affected by damages during process manufacturing or in service. Shot peening is a cold working process improving the mechanical properties such as fatigue, stress corrosion cracking, and so on. Shot peening has potentially positive and sometimes negative effects on all these factors. Creation of compressive residual stress, work hardening, surface roughness and tribological properties modification, delay of micro grain propagation in service. Numerous investigations in the past have shown that shot peening can improve the fatigue performance of structural materials such as steels and aluminium alloys. Therefore in shot peening different parameters used and that are controlled depending upon experimentation made by different experimentation techniques. There are no of shot peening input parameters are used such as Shot nature, shot size, shot hardness, Almen intensity, shot angle, coverage, distance between blower and work piece, nozzle diameter, shot material, type of shot peening machine, material of specimen, density of shots, composition of shots, peening medium, pressure of compressed air.

The control of residual stress is crucial in ensuring the integrity of engineering components and shot peening can be used to good effect to introduce the beneficial compressive residual stress levels required. Therefore to have good results from shot peening the ideal conditions required for the performance of controlled shot peening.

II. THE PERFORMANCE OF THE SHOT PEENING IS MEASURED BY ARC HEIGHT AND ALMEN INTENSITY

The efficiency and the performance of the shot peening is important to get calculated to set the parameters for the different manufacturing processes. The following are the components of the process of the shot peening performance evaluation. (D.B.Magar & Dr.N.G.Phafat 2016)

A. Arc Height

Zero the Almen gage using the flat side of the calibration block. Place the Almen strip on the gage firmly seated on the four support balls with the non-peened side touching the indicator stem. The new reading on the indicator is the arc height. Record this value in a table and on the graph for saturation curve. Do not re-use an Almen strip. A new strip must be used for each data point of the saturation curve. Repeat the above process using increasingly longer exposure times.

B. Almen Strip

It is a metallic strip which is precisely manufactured under the controlled environmental conditions. There are three types of the Almen Strips

- 'N' = .032" for low intensity
- 'A' = .051" for medium intensity (range 6A to 24A)
- 'C' = .094" for high intensity

C. Almen Intensity

The shot peening intensity is defined as the arc height of an Almen test strip measured at coverage of 98 % by using an almen gauge. An almen strip after shot peening gets a curvature the n that strip is measured by an Almen gauge following are the Almen gauge and the procedure of Almen Intensity measurement.

III. EXPERIMENTATION

After performing the shot peening on the components the Surface Hardness Depending upon the same information the following table has been prepared. For the same DoE was carried out by RSM by considering Standoff Distance, Time of Peening and Velocity of peening as input parameters with the specific levels.

Run Order	Standoff Distance (cm)	Time of Peening (sec)	Velocity of Peening (m/s)	Surface Hardness (HV1)
1	50	120	60	376
2	40	150	50	365
3	40	150	50	360
4	40	150	50	358
5	30	180	40	324
6	40	150	50	357
7	50	180	40	322
8	30	180	60	417
9	50	120	40	328
10	40	99.546	50	347
11	23.1821	150	50	345
12	40	200.454	50	344
13	50	180	60	400
14	40	150	50	342
15	30	120	60	443
16	40	150	50	335
17	56.8179	150	50	334
18	30	120	40	334
19	40	150	66.8179	457
20	40	150	33.1821	322

Table 1: DoE and Response table

IV. OPTIMIZATION IN RSM GIVES ADEQUACY AND ANOVA FOR SURFACE HARDNESS

Regression model is formulated with the help of Minitab software.

$$Surface\ Hardness = 1.41803 + 0.07040SD + 0.00062VP + 0.00238TP \quad (1)$$

A. Adequacy and ANOVA for Hardness (µH)

1) Adequacy of the Model for µHV1:

The analysis was done using uncoded units

Source	DF	Seq SS	AdjSS	Adj MS	F	P	
Regression	9	28129.8	2819.8	3125.5	21.33	0.000	Significant
Linear	3	23491.0	775.1	258.4	1.76	0.217	Not Significant
Square	3	3527.8	3527.8	1175.9	8.03	0.005	Significant
Interaction	3	1111.0	1111.0	370.3	2.53	0.117	Not Significant
Residual Error	10	1465.2	1465.2	146.5			
Lack-of-Fit	5	786.3	786.3	157.3	1.16	0.438	Not Significant
Pure Error	5	678.8	678.8	135.8			
Total	19	29595.0					

Table 2: Anova Table for Model Of µhv1

Source	**DF**	**Seq SS**	**Adj SS**	**MS**	**F**	**P**	**% of Contribution**
Velocity of Shots(V)	1	26085	2819.8	6521	27.81	0.000	88.14
Standoff (SD)Distance	1	2483	775.1	621	0.34	0.844	8.39
Time of Peening (TP)	1	1035	3527.8	259	0.14	0.967	3.50
Total	19						

Table 3: ANOVA Table for Input Parameters

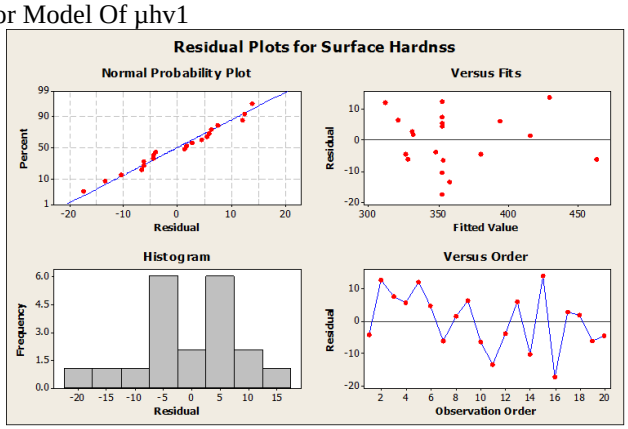

Fig. 1: Residual plot for Surface Hardness

From the coefficiebt table for Surface Hardness it is clear that velocity of peening is a significant factor for the process as it's corresponding P value is 0.000. Similarly the ANOVA table shows the significancy of the parameters for

the various factors like degree of freedom, sequential sum of squares, adjusted sum of squares, adjusted mean squares. Fishers value and P value. From the ANOVA for the I/P parameters shows the percentage contribution in the process. The velocity of the peening is having more significance on the response variable amd it is having 88.14 % contribution. Residual plots for Surface Hardnessexplains the various terms like normal probability plot of the residuals, the relation between resiuals and the fitted values, histograms of the residuals and the comparison of residuals with the order of the data. The normal probability plot shows that there are very few values are scatered from the mean values that means the process is in favour of good results.

V. CONCLUSION

From the above study it was seen that shot peening increases surface hardness which is important to increase resistance to surface cracks. The input parameters selected was crucial for shot peening but velocity of the peening plays an important role in shot peening. the residual plot shows the significance of the input parameters.

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