1996031

International Conference on Shot Peening and Blast Cleaning

COMPUTERISED CORRELATION OF RESULTS OF SHOT PEENING TESTS

Lavit Rawtani
Lecturer in Computer Science and Engineering
Maulana Azad College of Technology
Bhopal, India

ABSTRACT

The major cause of failure of machine components subjected to alternating stresses and vibration, is fitigue. The fatigue life is known to improve significantly by shot peening, the experiments for which consist of two stages. In the first stage a large number of components or test pieces are subjected to different levels of shot peening. The second stage consists of performing fatigue tests on shot pened specimen. A large volume of data is generated in the form of tables, giving the figigue life values for corresponding shot size, velocity of shots, duration of shot peening etc. Since the number of parameters in shot-peening and fatigue response can be large, there is a need to condense the large volume of test data. In the present paper this is achieved by using multiple linear regression analysis. A computer programme is developed which can give a mathematical relationship between fatigue life and the various parameters such as shot size, shot speed, time duration of shot peening etc. The experimental results reported by Sanderson and Slingsby for fatigue tests conducted on shot peened helical coil springs are used as example for illustration.

1. INTRODUCTION

Modern automobile valve springs are subjected to high levels of stresses to achieve economy. In order to increase their life and reliability R & D efforts are continuously taking place in several areas such as material selection, wire production technology, stress relieving treatments, shot peening process applied etc. The valve springs operate under dynamic conditions resulting in high alternating stresses. The fatigue strength is the crucial criteria under such conditions. The fatigue strength of springs is increased by inducing ihitial compressive stresses in the surface layers by suitable peening treatment. The inside surface of the coil has the greatest torsional stresses and it is this srea where shot peening is particularly needed.

For helical springs made of same material, using same production technology and subjected to same stress relieving treatment, the fatigue life depends on the extent of shot peening carried out. It is, therefore, necessary to establish optimum shot peening process. There are several parameters in shot peening such as size of shots, speed wirh which the shots hit the spcimens, the time duration for which shot peening is carried out etc. In order to optimise the shot peening process, experiments are conducted for several different vlues for each of these parameters. If there are m different parameters and n different values are tried for each of these parameters, there will be N = n sets fof observtions. For example if experiments are conducted for six different shot sizes, six different speeds and six different time durations, the lobservation table will consist of 6 x 6 x 6 = 216 sets of observations. The table will thus have four columns (Fatigue life, shot size, speed, duration) and 216 rows.

When fatigue life is required to be found for any given set of values of parameters, the large observation table has to be referred to. Further if the given values of parameters are in between the values of parameters for which the experiments had been conducted, then interpolation must be carried out. This is quite cumbersome. It would be much better if the entire table is converted in the form of a single mathematical equation expressing the value of fatigue life as a function of the values of different parameters. Multiple regression analysis is one such tool through which such an equation can be obtained. The technique is converted into a computer programme and applied to the results of lexperiments carried out by Sanderson and Slingsby (1981) for fatigue life tests on helical coil springs.

2. EXPERIMENTAL RESULTS

Helical coil springs made of 3.86 mm diameter wire of oil hardened and tempered chrome-vanadium alloy are used. The mean coil diameter is 38.1 mm, pitch of coils 17.78 mm and having 5.75 coils in the spring (2). 'Cut Wire' type of shots are used. These are made by cutting high tensile steel wire into pallets of length equal to diameter and then forming nearly spherical shape shots. Four different shot sizes are used (0.813, 0.711, 0.559 and 0.406 mm). Shot peening is carried out in Wheel abrator using four different speeds (3500, 2500, 2000 and 1500 rpm). Four different time durations of shot peening are employed (5, 10, 20,and 40 minutes).

The fatigue testing on lhelical springs is carried out in a resonant frequency test ring. Due to vibration near natural frequency, a low forcing signal causes large amplitude and high alternating stresses, resulting in fatigue failure at relatively low number of cycles (typically 200, 000 at 310 Hz). For each set of values of shot size, speed and duration, eleven springs were shot peened and fatigue tested. Since we are interested in the probable minimum life values, the eleven values of fatigue life obtained for eleven specimens are arranged in ascending order and the highest five values are ignored. The medium and the five lowest values are used to obtain normal distribution and standard deviation. Fatigue life values used are the values of (Median - 3x standard deviation). The observation thus obtained are given in Table.

3. REGRESSION ANALYSIS

Consider a variable X_1 whose value is a function of several independent variable X_2, X_3 ..... X_m. Experiment is conducted in which X_2, X_3 ..... X_m are assigned some prescribed values and the value of X_1 is measured. The experiment is repeated n times for different values assigned to independent variables. The observation table thus consists of n x m matrix as shown.

	X_1	X_2	X_m
1			
2			
.			
.			
.			
n			

On the basis of these observations it is possible to write a linear regression relation connecting X_1 with X_2, X_3 .... X_m of the form.

$X_1 = b_1 + b_2 X_2 + b_3 X_3 \ldots\ldots + b_m X_m$

The values of coefficients b_1, b_2 ..... b_m can be obtained as follows

$\{b\} = [A] \{c\}$

where {b} is a vector of coefficients b_1, b_2 .... b_m. {c} is a vector of elements c_1,c_2 ...... c_m and [A] is a (n x m) matrix. The elements of vector {c} are obtained as :

$C_1 = \Sigma X_{K,1}$

$C = \Sigma X_{K1} \quad X_{Ki} \qquad i = 2 \text{ to } m$

The elements of matrix [A] are defned as

$a_{11} = n$

$a_{ii} = \Sigma x_{Ki} \qquad i = 2 \text{ to } m$

$aij = \Sigma x_{Ki} X_{Kj} \qquad j = 2 \text{ to } m, i = 1 \text{ to } m$

In all the above equations summition is for k going from 1 to n.

The above equations are represented as a computer programme and applied to 64 x 4 matrix of observation table of shot peening data.

The computations give the following relation :

$X_1 = b_1 + b_2 X_2 + b_3 X_3 + b_4 X_4$

X_1 = Fatigue life in Median - 3 x standard deviation

X_2 = Shot size (mm)

X_3 = Wheel speed (rpm)

X_4 = Peening time (minutes)

The values of coefficients come out to be

$b = 6.81$, $b = 0.157$, $b = 0.98 \times 10^{-4}$, $b = 0.018$

Table : Fatigue Life Values of Shot Peened Helical Springs

Fatigue Life Median - 3 x standard deviation X_1	Shot size mm X_2	Wheel Speed rpm X_3	Peening time minutes X_4
7.220 7.403 7.782 7.759	0.813	3500	5 10 20 40
6.588 7.273 7.854 8.027	0.813	2500	5 10 20 40
6.717 7.269 7.699 7.717	0.813	2000	5 10 20 40
7.238 7.326 7.578 7.614	0.813	1650	5 10 20 40
7.409 7.348 7.590 7.575	0.711	3500	5 10 20 40
6.459 7.486 8.025 7.836	0.711	2500	5 10 20 40
7.551 7.898 7.747 7.924	0.711	2000	5 10 20 40
6.864 7.568 7.744 7.967	0.711	1650	5 10 20 40

Fatigue Life Median - 3 x standard deviation X_1	Shot size mm X_2	Wheel Speed rpm X_3	Peening time minutes X_4
7.668 7.868 7.967 7.900	0.559	3500	5 10 20 40
7.277 7.627 7.916 7.952	0.559	2500	5 10 20 40
7.034 7.469 7.818 7.918	0.559	2000	5 10 20 40
7.134 7.247 7.323 7.329	0.559	1650	5 10 20 40
7.131 7.323 7.489 7.658	0.406	3500	5 10 20 40
7.171 7.435 7.714 8.014	0.406	2500	5 10 20 40
6.801 7.292 7.728 7.862	0.406	2000	5 10 20 40
6.469 6.968 7.491 7.510	0.406	1650	5 10 20 40

4. CONCLUDING REMARKS

The shot peening observations carried out on helical springs give fatigue life values for different values of peening parameters like shot size, speed with which shots strike the spring and the peening time. The large number of data has been converted into single linear mathematical formula using multiple linear regression analysis. The computer programme developed has been applied to existing experimental observations as illustration.

5. REFERENCE

Sanderson, A.M. and Slingsby, R.G. 1981. Improved Method of Shot-peening Control Examines Variables in Production Process ICSP - 1 : 159-166.