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Investigation of effect of shot peening on fatigue life of composite material

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Abstract - *One of the common cold processes that is used to improve the fatigue life of the metals is shot peening. But, studying the effect of this process on the variation in properties of composite material is still investigated. This work investigates the effect of shot peening experimentally on fiber glass (E type) with epoy resin with volume fraction of 70% & 30 % respectively. The results showed that the best improvement obtained in the fatigue life was at 6 min shot peening time with a percentage of 17 % more than that of without shot peening on glass fiber epoxy resin.*

Key Words: **Composite material , shot peening ,fatigue life, shot peening time (SPT),glass fiber epoxy resin(GFER).**

1.INTRODUCTION

Currently , composite material are being used instead of the conventional material like metal and alloy in aircraft and automotive industries. Mainly the fatigue failure occurs in the cyclic loading region like rotor drive shaft. As composite material has low weight and high strength compared with traditional metal and alloy .Many researchers studied how to improve the mechanical and fatigue properties of the material. One of the methods used to create the compressive residual stresses was the shot peening to obtain surface improvement. This surface compressive residual stress field is highly effective in preventing premature failure under conditions of cyclic loading.[4]

Some researchers studied the effect of shotpeening on the metals , alloys , metal matrix composite materials , but studying the effect of shot peening on polymeric matrix composite materials still very little and insufficient. So this experimentation mainly focuses on the effect of shot peening on the fatigue life of fiber glass epoxy resin composite. Many important studies are done in the past. Ahmed N.Al-Khazraji et al. (2014) in their work have investigated shot peening effect on fatigue life behavior of E-glass reinforcement by 33% volume fraction & unsaturated polyester with aluminum powder by 2.5% volume fraction. The experimental results shows that the improvement in endurance limit was obtained at 2,4 & 6 min of shot peening & 25 % maximum improvement in endurance limit.[1]

Ujjawal Makkar et al. "Analysis of fatigue behavior of glass/carbon fiber epoxy composite" have discussed the test of GFREC & CFREC samples in rotating bending test for stress level of 60% to 70% of ultimate tensile strength. This surface compressive residual stress field is highly effective in preventing premature failure under condition of cyclic loading [3]

The induced residual compressive stress can neutralise a considerable portion of the tensile stress that may act on the surface of the component during service. Thus, consequently the fatigue life and in turn the part life of the component increase.

2. EXPERIMENTAL WORK

The experiment was carried out in 4 stages followed by the expected results.

2.1 Selection of material

Two materials viz. glass fiber epoxy resin & glass fiber with polyster. The glass fiber epoxy resin was selected for experimentation after comparing it with other material-glass fiber with polysterene after testing it for bending .Bending shows that glass fibre epoxy resin had 2.72 KN bending strength.

Table -1: Comparison of 2 Materials for bend test

Material	Breaking load
Glass fiber epoxy resin	2.72 KN
Glass fiber with polyster	1.92 KN

Hence GFER(glass fiber epoxy resin) was subjected to shot peening for varying amount of exposure time. Thus experimental run is done on one un shotpeened rod and 3 shot peened rods.

2.2 Preparation of specimen for testing

The specimen was prepared according to the requirements of fatigue testing machine.

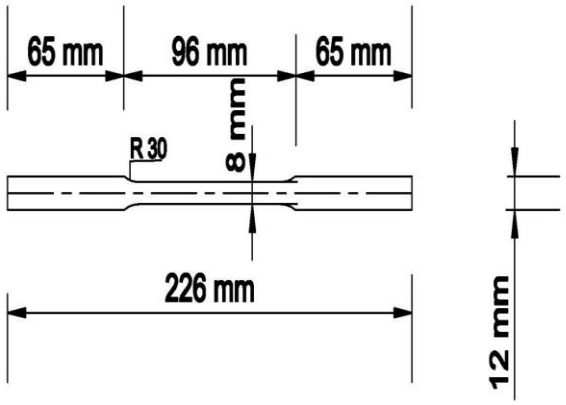


Fig -1: Standard Size Specimen

2.3 Shot peening

Shot peening process is used in this investigation, to study the variation of mechanical properties and fatigue behavior of GFER.

The shot peening is accomplished by machine of M/s. Tejashri Engineers ,Kolhapur.

- Shot mass velocity : 30 kg/sec.
- Shot velocity : 3141 m/sec.
- Shot material : hardened mild steel
- Shot diameter : 1.2 mm to 1.5 mm

Fig -2: Shots

The time used for shot peening (SPT) was three different times of (2, 4 and 6 min) on the prepared specimens. 3 specimens were subjected to shot peening for that respective SPT & were compared with fatigue life of unshot peened specimen.

Table -2: Specimen subjected to shot peening.

Specimen	Shot size (mm)	SPT (min)
1	1.2	0
2	1.2	2
3	1.2	4
4	1.2	6

2.4 Fatigue testing

The fatigue testing was carried out on a rotating bending machine. The failure load of glass fiber epoxy resin samples in rotating bending test is discussed for the test at stress of 60 to 70% of ultimate tensile strength.[2]

All the 4 specimens were tested for fatigue on the fatigue testing machine shown in figure 3 & the obtained observations of number of cycles were recorded & compared.

Fig -3: Fatigue testing machine

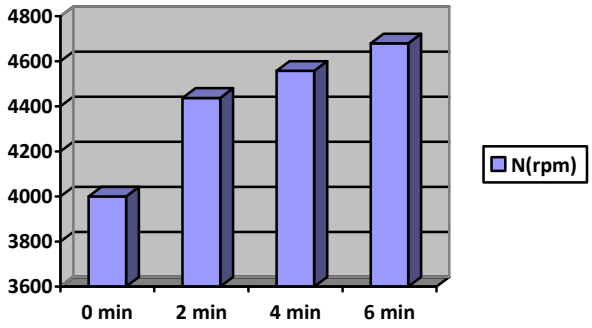
3. OBSERVATIONS & RESULTS

Form the experiment done we found that all the specimen tested for 30 kg load for 0 min,2 min,4 min & 6 min of shotpeening showed life for 4000 rpm(N1), 4438 rpm(N2), 4558 rpm(N3) & 4680 rpm(N4) respectively.

Table -3 : Observation table for N (number of cycles).

Specimen	Load	SPT	N(rpm)
1	30 Kg	0 Min (unshotpeened)	NI = 4000
2	30 Kg	2 Min	N2 = 4438
3	30 Kg	4 Min	N3 = 4558
4	30 Kg	6 Min	N4 = 4680

Chart -1: N(rpm) Vs SPT(minutes)



From the above graph we can see that as the shot peening time increases , the fatigue life cycles for the glass fiber epoxy resin specimen increases accordingly till 6 min.

3.3 Calculations

$$\frac{N2-N1}{N1}=\frac{4438-4000}{4000}=0.1095=10.95\ \%$$

$$\frac{N3-N1}{N1}=\frac{4558-4000}{4000}=0.1395=13.95\ \%$$

$$\frac{N4-N1}{N1}=\frac{4680-4000}{4000}=0.17=17\ \%$$

- Thus N1 , N2 , N3 , N4 are number of cycles for specimens 1 , 2 , 3 & 4 respectively which were subjected to 0 min (unshot peened specimen) , 2 min , 4 min & min of shot peening.

Fig: 4 – Unshotpeened specimen after fatigue

Fig: 5– 6 min shot peened specimen after fatigue

- The fatigue life of 3 shot peened specimens were compared with the un shot peened specimen.
- 2 min shot peened specimens fatigue life had increased by 10.95 %
- 4 min shot peened specimens fatigue life had increased by 13.95 %
- 6 min shot peened specimen showed a maximum increase in fatigue life by 17 %

3. CONCLUSIONS

In the present study emphasis is given on the effect of shot peening on the fatigue life of glass fiber epoxy resin specimen. After analysing the experiment for selected levels of exposure time for shot peening , it was evident that the fatigue life of the selected material had increased .It was seen from the experimentation that the increase in shotpeening time increases the fatigue life accordingly.
Thus it showed a considerable maximum increase in fatigue life of about 17 % for 6 minutes of shot peening of glass fiber epoxy resin specimen.

4. FUTURE SCOPE

In future works it is expected to experimentally investigate the maximum permissible shot peening time(SPT) which gives increase in fatigue life .

The full factorial experiment can be used by selection of other parameters depending on the cost,availability of testing and material & more emphasis can be given on the interactions & their effects on the response under study.

If more factors(say 4) at multiple levels (say 2), full factorial experiment will need 16 experimental runs. This improvement in the fatigue life of glass fiber composite is generally attributed to amount of residual compressive stresses resulted due to shotpeening. However the work hardening effect induced have not been covered in the present work hence the effect of this simultaneous variation

of parameter can be studied in specimens of glass fiber epoxy resin specimen can be carried out as future work

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