Fig.1 Mould for Composite Leaf Spring

2. The Preparation of Matrix (Epoxy): In preparation of the mixture, two solutions were used named epoxy resin and hardener. The ratio is 1:5.Resin hardener blend is blended completely and mixed, till a gel like appearance happen.

Fig.2 Preparation of matrix (Epoxy)

3. Cleaning and Polishing of Mould: To avoid sticking of the composite with resin after curing, the mould is polished with wax.

4. Cutting of Fibers: The material is carbon fiber. The fiber is available with sheet format. With the help of scissor fiber sheet is cut down. The dimensions for cutting lamina are 960 (mm) x 60(mm).

5. Laying of laminas: After the arrangement of gum hardener blend it is connected on the surface of the material with a specific end goal to wet it. The wetting is done similarly by moving hand roller on the fabric surface with the goal that fiber is not separated from the material. Laying of laminas is done to the thickness required of the overlay; there is a need to build a 14 mm thickness cover then 42 laminas be layered up on the grounds that the thickness of every lamina is 0.24 mm.

Fig.3 Laying of the cloth on mould

6. Curing: At last after the way towards laying the laminas to the mould and permitted at room temperature for 72 hrs. After that the part is discharged from the mould precisely without making any harm to the segment.

Fig.4 Mould left for curing

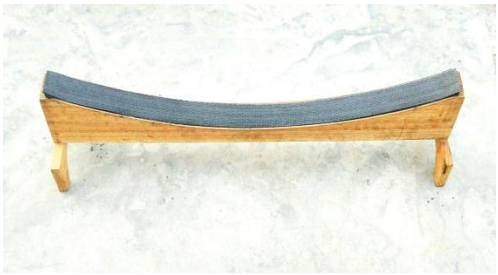

Fig.5 Mould after 72 hour of curing

Fig.6 Finished carbon epoxy composite leaf spring

III. RESULTS AND DISCUSSION

Composite leaf spring is prepared by Hand Layup Technique. It is assumed that composite material will have better mechanical properties and less weight other than steel leaf spring. Static and fatigue test is performed on both composite leaf spring and steel spring.

A. Static Test

The electro-hydraulic leaf spring test rig is used to perform static test on steel spring and composite leaf spring. EN45 steel spring is use in Tata ace mini truck. The mechanical properties of EN45 material are given in Table I.

TABLE I MECHANICAL PROPERTIES OF EN 45 STEEL SPRING

Properties	**Young's Modulus, E (N/mm^2)**	**Poisons Ratio**	**Tensile Strength (MPa)**	**Density (kg/m^3)**
Material EN45	204000	0.30	621	7850

The total weight of Tata ace is 885 kg and Gross vehicle weight of vehicle is 1550 kg .The present steel spring of material EN45 include the 915mm length, 57 mm width, 7 mm thickness. To find the deflection, load apply on the spring is from initial load of 1000 N to final load of 5400N.

In hydraulic test ring, the plunger is move to desired height so that fixture can be fixed. Leaf spring is mounted with help of special fixture. The load is applied at the spring centre and spring deflection is recorded at different loads. Final Deflection values of composite spring is 14% less than steel spring deflection value which means more stiffness in the composite leaf spring. Load deflection curve under different loads shown in fig.7.

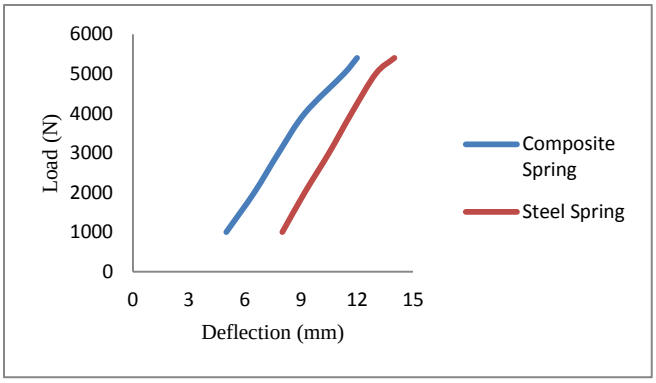

Fig.7 Load deflection curve for steel spring and composite spring.

B. Fatigue Strength

Fatigue test is important to find the maximum load that a sample can endure for a specified number of cycles. The main reasons of fatigue failure are number of cycle, range of stress and local stress. To find out the fatigue strength, Fatigue test performed on steel spring and composite leaf spring separately. A long time is required to find the fatigue strength of leaf spring.

C. Fatigue Test of Steel Leaf Spring

Hydraulic load test machine is used to know fatigue strength which include stroke of 0-150mm. Fatigue strength of leaf spring must be stand above the 100000 cycle. The leaf spring is placed on to hydraulic load machine. [8][9] After initial starting of machine, cycle of loading and unloading repeat until the end of the test reach. The Hydraulic test rig initial deflection is 60 mm and the initial stress is203 MPa. Final stress of the spring is 110 mm and the stress is 304 MPa. It is investigated that fatigue life of the steel spring was above to 100000 cycles.

D. Fatigue Analysis of Carbon Epoxy Composite Leaf Spring

To find the fatigue strength of carbon epoxy composite leaf spring similar hydraulic test rig machine is used and similar procedure is adopted. Load applied from initial load of 1000 N to 5400 N to find the fatigue strength. Hydraulic test machine set to operate for a deflection of 70mm and 25 strokes/min. The maximum and minimum stress value obtain during cycle of the leaf spring are 77 MPa and 105 MPa. During first 20000 cycles no any crack formation seen in the composite leaf spring. The maximum load apply on the composite leaf spring is 5400 N and time taken is 16 hours. Hydraulic test rig is use to perform fatigue test shown in fig.9.

Fig.8 Fatigue testing of steel spring

Fig.9 Fatigue testing of composite leaf spring

Further, Hwang and Han analytical model is used to know the number of fatigue cycle to failure for the composite leaf spring. Hwang and Han has given a relation $N=\{ B (1-r)\}^{1/c}$, where B and C are the constants , value of B = 10.33 and c = 0.14012, N = no of cycle to failure and r = stress level value which is equal to $\sigma_{max} / \sigma_{\mu}$: σ_{max} = maximum stress and $\sigma_{\mu=}$ ultimate tensile strength.[10]The fatigue life of carbon epoxy composite leaf spring is calculated by applied different stress levels. The results are obtained by analytical bases and plotted on S/N curve. It is analysed that composite based leaf spring withstand more than 100000 cycle under the stress level 0.5. It is estimated that crack formation may be occur only after 100000 cycles.

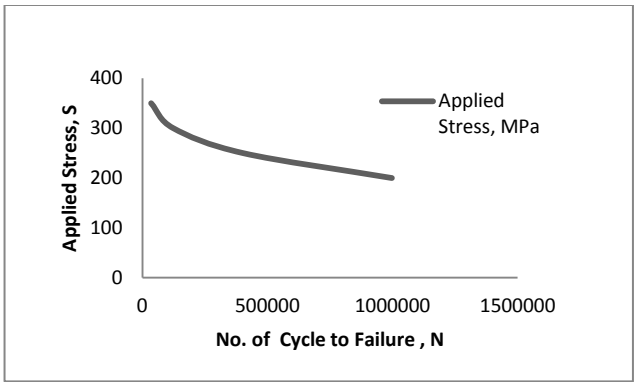

Fig.10 S/N curve for composite leaf spring

IV. CONCLUSION

The carbon epoxy composite based leaf spring is successfully manufactured via hand layup technique. The leaf spring of composite is lighter in weight as compared to conventional steel leaf spring with similar design specification. The carbon epoxy composite based composite leaf spring is found deflection 14% less to the deflection values of existing steel spring values which means increase in stiffness. And fatigue analysis of steel spring and composite spring is carried out. Fatigue life cycle of steel spring and composite leaf spring is more than design value 100000 cycles. It is concluded that carbon epoxy composite leaf spring is an effective replacement for the existing steel spring used in automobile vehicles.

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