CHAPTER-8
EVALUATION OF COMPOSITE LEAF SPRING

8.1 INTRODUCTION

The performance test results of the composite leaf spring are considered for comparison with the performance results of the steel leaf spring. The objective of this study is to evaluate the applicability of a composite leaf spring in automobiles by considering cost effectiveness and strength. The comparison between multi-leaf steel spring and mono-leaf composite spring is made for the same requirements and loading conditions. The comparison is based on four major aspects such as weight, riding comfort, cost and strength.

8.2 COMPARISON BASED ON WEIGHT

The total weight of composite leaf spring is 4 Kg including the metal eye weight of 1 kg. The weight of a conventional steel leaf spring assembly is around 15 kg. So, around 75% of weight reduction is achieved. Thus, the objective of reducing the unsprung mass is achieved to a larger extent.

8.3 COMPARISON BASED ON RIDING QUALITIES

The weight reduction of unsprung mass of an automobile will reduce the transfer of inertia effects and road shocks to the chassis. The suspension leaf spring contributes around 10-20% of the unsprung mass. The weight of the composite leaf spring is 3.75 times less than steel leaf spring. Hence, the
riding comfort of an automobile is increased due to the replacement of multi-leaf steel spring by mono-leaf composite spring.

8.4 COMPARISON BASED ON COST

The cost estimation of composite leaf spring provides a clear economic viability of the product in comparison to that of a conventional leaf spring.

8.4.1 Cost of Material

Materials constitute nearly 60-70% of the vehicle cost and contribute to the quality and the performance of the vehicle. The different materials considered for the fabrication of composite leaf spring is listed in the Table 8.1.

Table 8.1 Material cost

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity (kg)</th>
<th>Cost (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E - Glass fiber</td>
<td>4.5</td>
<td>522</td>
</tr>
<tr>
<td>Dobeckot – 520F epoxy resin</td>
<td>1.5</td>
<td>684</td>
</tr>
<tr>
<td>Resin hardener</td>
<td>0.22</td>
<td>60</td>
</tr>
</tbody>
</table>

The mould is designed to fabricate two leaf springs at a time. Hence, the quantity and cost listed in Table 8.1 is for two composite leaf springs.

Total cost involved in the materials for two leaf springs = Rs. 1266
Cost involved in the materials for one leaf spring = Rs. 633
8.4.2 Cost of Mould

Cost incurred in the manufacture of a mould is Rs. 1400. This mould can be used at least for 5000 cycles of manufacturing composite leaf springs through filament winding process and this results to manufacture of around 10000 leaf springs. Hence, the cost distribution over 10000 leaf spring costs around Rs. 0.14 per leaf spring.

8.4.3 Machine Hour Rate of Filament Winding Machine

Machine hour rate of filament winding machine is around Rs 140 and time required in the manufacturing two leaf springs is only 30 minutes. Therefore, cost involved in the machine hour rate is Rs 70.

8.4.4 Labour and Miscellaneous Cost

The costs involved in employing skilled labour have to be incorporated in the total cost. In this case, there is no labour involvement, it is assumed that the labour cost and miscellaneous cost in manufacture of two-leaf spring to be around Rs.25.

8.4.5 Cost of Metal Eye

Two metal eyes are manufactured to attach with the composite leaf spring. Hence, the cost involved in the manufacturing of two metal eyes for a composite leaf spring is Rs. 25.
8.4.6 Total Cost

Total cost of a composite leaf spring = Material cost + Mould cost + Machine cost + Metal eye cost + Labour and Miscellaneous cost

= 633.00+0.14+70+12.50+25

= Rs. 740.

8.4.7 Cost of Steel Leaf Spring

The steel leaf spring assembly is available in the market for Rs. 1000. By assuming a profit margin of 25% for the leaf spring the cost of the leaf spring works out to be Rs. 750. Hence, it is seen that the cost of a composite leaf spring is comparable to that of the conventional leaf spring even at the developmental stages. This shows that, if mass production is attempted the cost can be reduced by 20-30% of the cost of a conventional leaf spring.

8.5 STRENGTH COMPARISON

8.5.1 Based on Static Analysis Results

Static test has been conducted on steel and composite leaf springs for the same loading condition. The static test results are listed in Table 8.2 for comparison. The factor of safety available in the composite leaf spring is more than that of steel leaf spring. The deflection characteristics of these two leaf springs are also shown in Fig. 8.1.
Table 8.2 Comparison of static test results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Steel leaf spring</th>
<th>Composite leaf spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum stress</td>
<td>845 MPa</td>
<td>300 MPa</td>
</tr>
<tr>
<td>Spring rate</td>
<td>25 – 28 N/mm</td>
<td>25 – 28 N/mm</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>1300 – 1700 MPa</td>
<td>900 – 1200 MPa</td>
</tr>
<tr>
<td>Yield strength</td>
<td>1170 – 1550 MPa</td>
<td>–</td>
</tr>
<tr>
<td>Safety factor</td>
<td>2.0 – 3.0</td>
<td>3.0 – 4.0</td>
</tr>
</tbody>
</table>

8.5.2 Based on Fatigue Analysis Results

Fatigue life of the multi-leaf steel springs is explained in the diagram for estimating fatigue life cycles of steel leaf springs in SAE manual [47]. The selected steel leaf spring is withstanding less than 10,00,000 cycles only. Where as composite leaf spring, which is designed and fabricated for the
same design requirements is withstanding for more than 10,00,000 cycles under same fatigue testing conditions. The fatigue results are given in Table 8.3.

Table 8.3 Comparison of fatigue test results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Steel leaf spring</th>
<th>Composite leaf spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum stress</td>
<td>845 MPa</td>
<td>300 MPa</td>
</tr>
<tr>
<td>Minimum stress</td>
<td>535 MPa</td>
<td>200 MPa</td>
</tr>
<tr>
<td>Amplitude</td>
<td>50 mm</td>
<td>50 mm</td>
</tr>
<tr>
<td>Cycles to failure</td>
<td>&lt; 10,00,000</td>
<td>10,00,000</td>
</tr>
</tbody>
</table>

8.6 ADVANTAGES OF MONO-LEAF COMPOSITE SPRING OVER MULTI-LEAF STEEL SPRING

➢ High strength to weight ratio

➢ High stiffness to weight ratio.

➢ Weight saving around 75 % for a given load

➢ Reduction in unsprung mass of the automobile will improve the vibration characteristics and hence, the riding qualities of the automobile.

➢ Superior fatigue strength over steel.

➢ Due to high specific strain energy storing capacity, the leaf spring is designed as mono-leaf.
➢ Heat treatment like quenching and tempering is not required.

➢ Cost gets reduced if it manufactured in mass production.

➢ In built damping available is considerably large.

➢ Reduced noise.

➢ Excellent corrosive resistance.

➢ Less maintenance

➢ Better environment properties

➢ Assembly cost is minimum