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ANALYSIS AND OPTIMIZATION OF LEAF SPRING MATERIALS IN CAD SOFTWARE

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ABSTRACT

The objective is to analyze the different types of composite material and load carrying capacity, stress stiffness and weight savings of composite leaf spring with that of steel leaf spring. The dimensions of conventional leaf spring are used to design in Solid works of composite multi-leaf spring assign material for analysis. Static analysis of a 3D model of conventional leaf spring is also performed using ANSYS 14.5 and compared with experimental results. Design and run the 16 experiment with the combination of load and material which gives output responses in terms of stress, deflection, and weight. Optimize the responses of 16 combinations by grey relation analysis for the better input parameter against output responses.

Introduction

Leaf spring is a simple form of spring, purposed for the suspension in wheeled vehicles. It was originally called as laminated or carriage spring. It is also one of the oldest forms of springing, dating back to medieval times. The advantage of leaf spring over helical spring is that the ends of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device. According to the studies made a material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material for a leaf spring [2]. The leaf springs are more affected due to fatigue loads, as they are a part of the unsprung mass of the automobile. Performance measures of any leaf springs are its stiffness and fatigue life. Leaf spring serves to locate, damping as well as springing function. Sometimes referred to as a semi-elliptical spring or cart spring, it takes the form of a slender arc-shaped length of spring steel of rectangular cross-section. The center of the arc delivers location for the axle, while tie holes called eyes are provided at either end for attaching to the vehicle body. For heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. A leaf spring mounts directly at one end, either be attached directly to the frame at both ends, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness [1].

A combination of two or more materials that results in better properties

than those of the individual components used alone can be defined as Composite material. As compared to metallic alloys, every material retains its separate chemical, physical, and mechanical properties.

Problem and Objective

Due to Composite leaf having lesser stress, lesser weight, higher stiffness, higher deflection, greater strength many of researchers have suggested that Composite materials are the best replacement for steel leaf spring. The conventional steel leaf spring has some problems which are listed as follow:

- Also, the comparative study can be done by changing various dimensions parameters with a variety of material in leaf springs.
- Reduction of stress and deflection should not optimize by any researcher
- Material with its load could not be optimizing in past literature.

Based on the problems and past research gap analysis objective of work are focused on comparing the load carrying capacity, stresses, deflection and weight savings of composite leaf spring with that of steel leaf spring. The paying attention to composite materials by replacing steel with conventional leaf springs of a suspension system to reduce stresses, deflection is followed some objective;

- Select the vehicle leaf spring to calculate its dimension and its effective load.
- Design the leaf spring in CAD software with assembling which provides the requisite dimension to the body structure as well as to bear the load in actual condition.
- Design the input parameters for analysis in ANSYS tool. As per the design with selected parameters perform the analysis and record the responses.
- Optimize the responses with suitable multi-objective technique.

Method and Material

Leaf spring design has been made in solid work with assembling design and it will be analysed in ANSYS software for result obtain in terms of stress and maximum deflection the material used is SUP9 E-glass, Carbon Fiber and Graphite fiber are spring material with close to identical compositions and chemistry with steel used in current scenario. They are deep hardening steels and are quenched in oil.

Modeling of leaf spring is done SOLIDWORKS 14.0, with the help of sketch tool two-dimensional view of master leaf spring is made. Sketch can be extruded and it will convert into solid master leaf spring, extruded part of master leaf spring are converted into three-dimensional view is shown in fig 1.

Fig 1 Assemble of leaf spring

Design Analysis Process

Based on parameter analysis design has to be made as shown in table 1, in this analysis design maximum load has to vary with 25kg load up to four level and use of four material are vary with respect to load. By a combination of load and material, this analysis design has to be made.

Table 1 Design of analysis

S. No.	L (N)	M
1	5625	SUP 9
2	5625	E glass
3	5625	Carbon Epoxy
4	5625	Graphite Epoxy
5	5600	SUP 9
6	5600	E glass
7	5600	Carbon Epoxy
8	5600	Graphite Epoxy
9	5575	SUP 9
10	5575	E glass
11	5575	Carbon Epoxy
12	5575	Graphite Epoxy
13	5550	SUP 9
14	5550	E glass
15	5550	Carbon Epoxy
16	5550	Graphite Epoxy

On basis of parameters calculation leaf spring are designed in SOLID WORKS by design and meshing involves division of the entire of the model into small pieces called elements. Stress and displacement of steel are run and found their maximum stress and maximum deflection is shown from fig 2 with respect to load. Similarly, all conditions are tested and the result is shown in Fig 3 and fig 4.

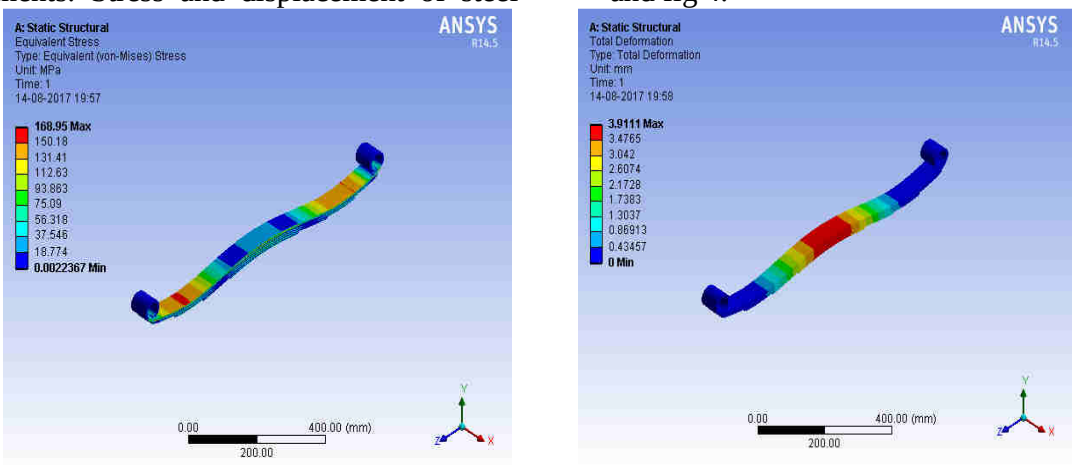

Fig 2 stress and deflection at 5625 N

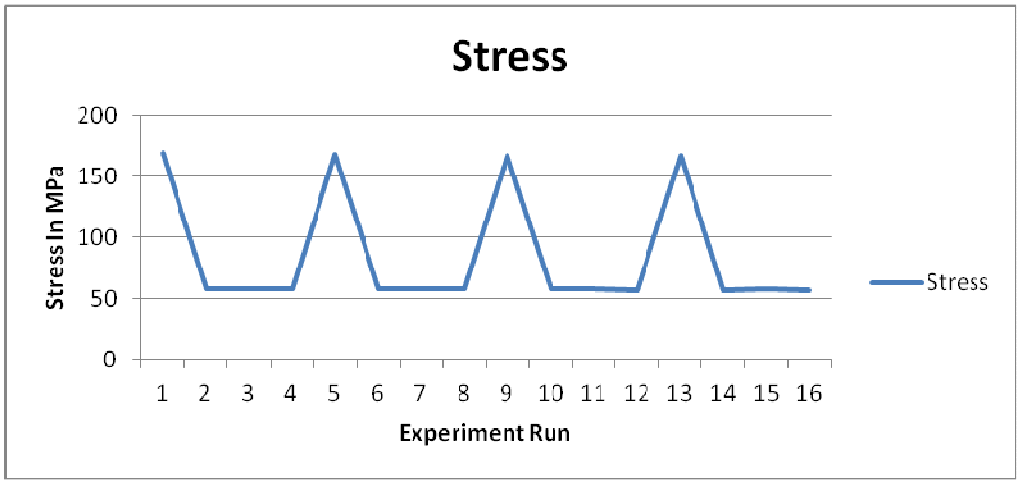

Fig 3 Stress responses from Experiment run

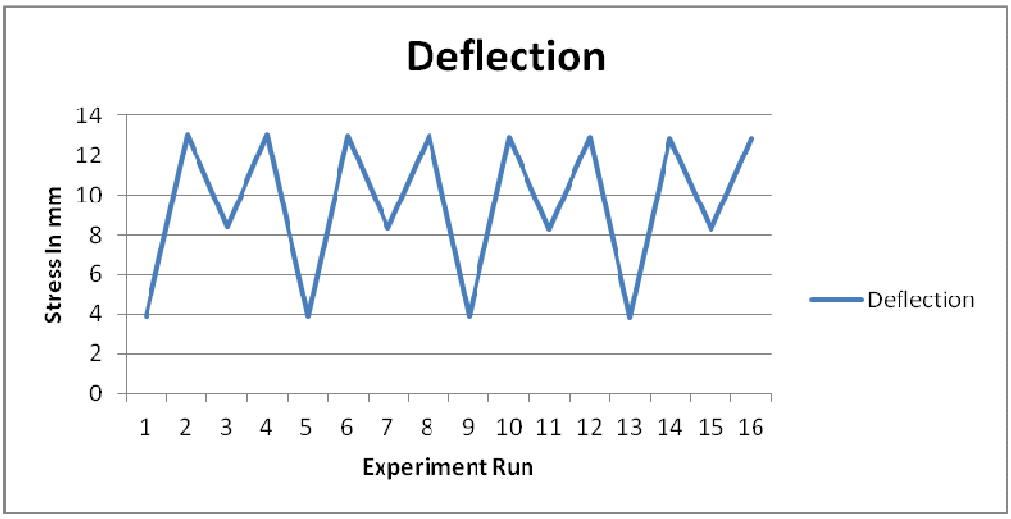

Fig 4 Deflection responses from Experiment run

Optimization

Grey Relational Analysis (GRA) is an impacting capacity method in grey system theory that analyses uncertain and information between one main factor and all the other factors in a given system. In this section, the use of orthogonal array with the grey relational analysis and methodology for multi-response optimization is discussed [4]. The optimization of the process was performed in the following steps:

- Normalising the experimental results of MRR and TWR for all experimental run.
- Calculating the Grey Relational Coefficient (GRC).
- Calculating the Grey Relational Grade (GRG) by averaging the GRCs.
- Selecting the optimal levels of process parameters.

The grey relational grade was computed by averaging the grey relational coefficient corresponding to each process response as shown in Fig 5. The overall evaluation of the multiple process responses is based on the grey relational grade. As a result, optimization of the complicated multiple objective responses can be converted into optimization of a single grey

relational grade. Optimization of a factor is the level of the highest grey relational grade is observed that is 15 experiments.

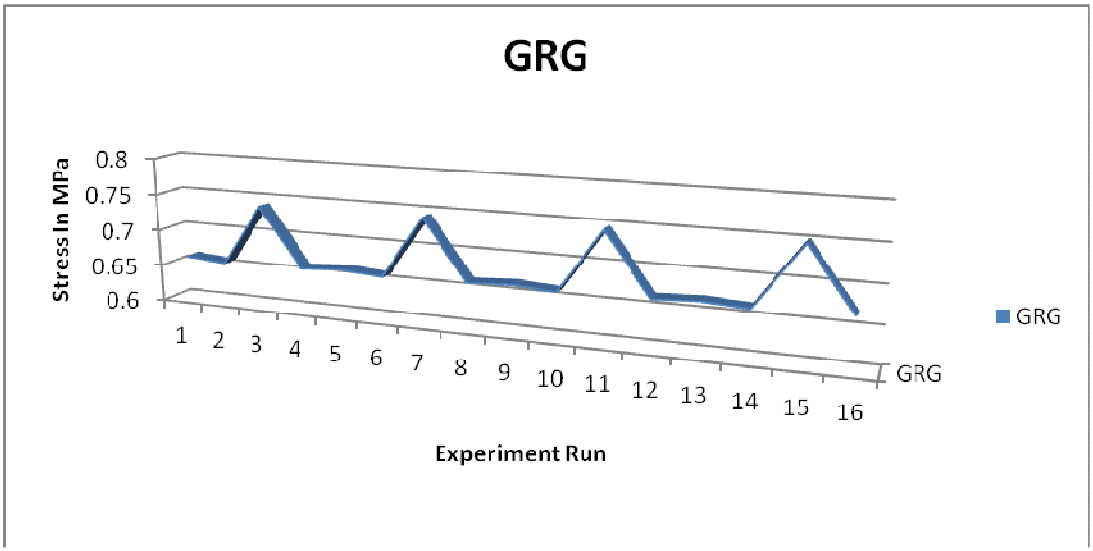

Fig 5 Optimize Result by GRG

Conclusion

As leaf spring contributes a considerable amount of weight to the vehicle and needs to be strong enough, a single composite leaf spring is designed and it is exposed that the resulting design and simulation stresses are much below the strength properties of the material satisfying the maximum stress failure criterion. From the optimization of grey relation analysis observed the minimum stress and deflection simultaneously drawn on Carbon Epoxy material. The work can be extended on chipping resistance which is most efficient in leaf spring to maintain for a long duration in the vehicle.

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