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Topic: Analysis and optimization of composite leaf spring using intelligent techniques

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A lot of research work is being done in automotive sector to improve the ride quality of vehicle while reducing the fuel consumption. Scientists are exploring materials which can satisfy maximum demanding characteristics while maintaining the weight of the components or machines to a minimum. We all know that in automotive sector weight is a big constraint in design consideration as weight reduction not only reduces the running cost and but also has a very positive impact on the environment as it reduce the level of pollution. Not only this but the weight reduction if it is done for semi- sprung or un- sprung mass, as in the present work, the ride could be made better. The focus of the present research work is to conduct the different analysis of leaf spring using some advanced materials which are very new to be used for springs. The alternative material used in the present research work is known as Functionally Graded material. This material is being extensively used in aviation sector because of excellent strength to weight ratio and better thermal properties. The biggest advantage of this material is that it can be tailored as per the required mechanical properties. During the analysis of leaf spring it is treated as a beam. The higher order shear deformation theory is used in the present analysis to assess the vibration characteristics, maximum deflection and maximum stress induced in the leaf. The governing equations are derived using variational principal. Then finite element methods

(FEM) is utilised for the complete analysis of the beam and the results are obtained with the help of MATLAB.

Different types of isotropic and FGM material are used during validation and the analysis of leaf spring treating it as a beam. Convergence and validation study are conducted. The isotropic material used for leaf spring analysis is manganese-silicon steel which is readily used for conventional leaf spring. The vibration, bending and finally stress analysis is done and compared with the Functionally Graded materials (FGM) for the same leaf spring geometry. The FGM used for the present analysis is the combination of Manganese Silicon Steel and Ti-6Al-4V. The top surface of the FGM used for leaf spring during the analysis was taken as Manganese Silicon Steel and the bottom surface as Ti-6Al-4V. Different volume fractions are used for the FGM. The material properties are assumed to vary in thickness direction as per the Power law. On comparing the natural frequency for the FGM and isotropic material, no significant variation is recorded for the individual leaf of leaf spring when the volume fraction index is varied up to 0.5.(The constraint which is used for volume fraction as 0.5 is discussed in due course of study , as the deflection of the leaf varies very fast with increase in volume fraction index.). As the assembly for the leaves of leaf spring is same for both isotropic and FGM , it can be predicted very easily that the natural frequency of vibration of the complete leaf spring would not be much affected because the frequency of each leaf using isotropic and FGM , as mentioned above is not varying much with change in material. .As far as the weight of leaf spring is concerned it is calculated that there is around 13% weight reduction when FGM is used. It is also found that the deflection of the material is more when same load is applied to FGM. This is also positive as deflection is more it can absorb more energy and the shock would be less but to have proper ground clearance the volume fraction is not increased beyond 0.5.The analysis of leaf spring is

done with both straight beam consideration and curved beam consideration The variation in frequency, deflection and stress was observed for different values of L/h ratio, volume fraction index for straight beam consideration. For curved beam consideration some other parameters like R/h ratio opening angle etc. are tested for different support conditions like Clamped- Clamped, Simply supported and Fixed Free. It is observed that as the radius of curvature of the beam is increased the natural frequency decreases. Also, the frequency for the FGM material decreases as the volume fraction is increased up to some limit. The weight change was calculated for different values of volume fraction index and significant drop in the weight of the beam is observed as the increase in volume fraction index. After this the bending analysis of FGM is done and compared with Manganese Silicon Steel. The volume fraction proposed for both straight beam consideration and curved beam consideration is found to be 0.5 as mentioned earlier. Now the stress analysis of the leaf spring was done for proposed volume fraction index and it is compared with the stress induced in manganese silicon steel used for leaf spring. The stress distribution is also presented and it is found that the stress little bit increases in FGM but it is much below the yield strength of combining material used for FGM, which is safe. Now with this analysis it is recommended that FGM should be used for leaf spring with volume fraction index 0.5 with the combination of Manganese Silicon Steel and Ti-6Al-4V as the stress is in the safe range and the weight of the leaf spring (considered to be in the category of semi-sprung or un-sprung mass) is reduced which indirectly improves the ride quality.