DESIGN AND ANALYSIS OF LEAF SPRING SUSPENSION SYSTEM USING HIGH CARBON STEEL AND ALUMINUM SIX SERIES ALLOYS

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Abstract - *The automotive suspension system is the one of the important unit in automotive design, especially leaf spring design. It absorbs payload and road load to give the comfort ride to a passengers in the vehicle. In the present trend peoples are interested to buy a vehicle with good mileage for this reason the automobile industry show an interest to reduce the weight of an vehicle components. The weight of vehicle and mileage are inversely proportional as the weight increases the mileage decreases . In the leaf spring the friction between the leaves of spring is one of the problem the friction between the leaves causes the wearing of the leaves and this leads to a breakdown of leaves. The objective of this Work is to compare the deformation, strain energy, weight of the model of leaf spring with low carbon steel into various Aluminium alloy series (6061 and 6063).Design modeling is done using Creo parametric 3.0 and analysis is carried out by using ANSYS 18.0 software.*

Key Words: Leaf spring, Suspension system, Automotive,   Friction.

1. INTRODUCTION

Leaf spring is a suspension system for vehicles that has been used as far back as medieval times. They were originally called carriage or laminated springs. Its system has been tried and true, primarily used on almost all vehicles up to the 1970's and still today on trucks and vans that haul heavy loads.

The spring leaf is made up of an arc-shape, slender piece of steel that is stacked with the same material in smaller sizes and bolted together creating a reinforced bow-like item. It is then attached to the rear axle and the chassis providing support to any additional weight that is added to a vehicle, preventing the axle from buckling in and snapping from the pressure of an extreme amount of weight that it was not originally designed to carry.

Leaf springs are used in vehicles such as heavy commercial vehicle like truck, dumpers, rails etc. When compare the leaf spring over the helical spring the advantage of leaf spring over the helical spring is that ends of spring may be guided along a definite path so as to act as a structural member in addition to shock absorbing device. The springs are used to absorb energy during the loading condition and then release it, then strain energy of material becomes a major parameter in designing the spring where as in the coil spring load transfer to single point.

A leaf spring is directly attached to the frame or chassis of the vehicle. The leaf spring having the eyes at both the ends one end is directly attached to the frame of the vehicle while other end attached to shackle (Swinging arm). Due to bounces on the road surfaces the spring get compress at that time shackle makes the leaf spring to expand and thus makes for smoother springiness. The design of leaf spring involves it is flat thin and adaptable bit of spring steel or composite material that oppose bending. The basic principle of leaf

spring design and assembly are moderately simple the number of leaves in an spring is relies on the weight conveying limit of a vehicle most heavy duty vehicle today use two pairs of leaf spring per axle. The leaf spring placed perpendicularly to support the weight of vehicle. The spring comprises of a number of plates with a rectangular cross section called as leaves. The leaves are in increasing length. The leaf having maximum length called as master leaf, the other leaves are known graduated leaves.

METHODOLOGY

Modelling a leaf spring assembly as per TATA ACE SPECIFICATIONS using Creo Parametric 3.0

Calculating the values obtained theoretically using stress and strain formula.

Applying the selected material such as High Strength Steel and Aluminum 6 series Alloy.

Applying the specific boundary conditions for the Leaf spring analysis.

Observing the results obtained and comparing the deformation , stress and strain variables within the given materials.

2.MATERIAL PROPERTIES
HIGH CARBON STEEL
Poisson's Ratio = 0.290
Tensile Yield strength = 370 Mpa Tensile Ultimate Strength = 440 Mpa Young's Modulus = 205 Gpa

Al 6061
Poisson's Ratio = 0.33
Tensile Yield Strength = 310 Mpa Tensile Yield Strength = 276 Mpa Young's Modulus = 70 GPa

AL 6063
Density (lb / cu. in.) - 0.097 Specific Gravity -   2.7
Melting Point (Deg F) -   1150
Modulus of Elasticity Tension - 10
Modulus of Elasticity Torsion - 3

VALIDATION

Dimensions of "TATA ACE" commercial goods vehicle is taken for validation and dimensions are as follows.

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Leaf span	860mm
Free Camber	90mm
Width of all leaves	60mm
Thickness of the spring	8mm
Weight of leaf spring	10.26Kg
Total Number of full leaves (including master leave)	3
Maximum Load given of spring	4169 N
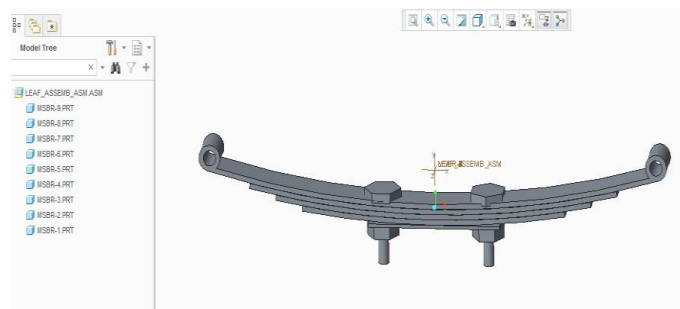
Equivalent stress (also called von Mises stress) is often used in design work because it allows any arbitrary three-dimensional stress state to be represented as a single positive stress value. Equivalent
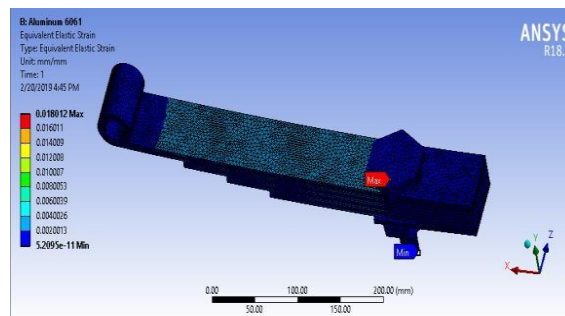
Equivalent Stress:

A total of 4168 N of static force has been applied on both the ends of the leaf spring, which results in 2084 N of force per end of the leaf. The maximum equivalent stress for the Al 6061 can be observed as 1277 MPa. The condition of the designed leaf spring is meant to be safe as most of the part of the leaf spring observes minimum stress which is equivalent to zero MPa. The above image concludes that only limited part of the leaf spring is subjected to maximum stress of 1277 MPa while majority of the leaf spring stays under the fatigue level. As observed during the simulation, an increase in load of 30% of the given load, also keeps the leaf spring without damage.
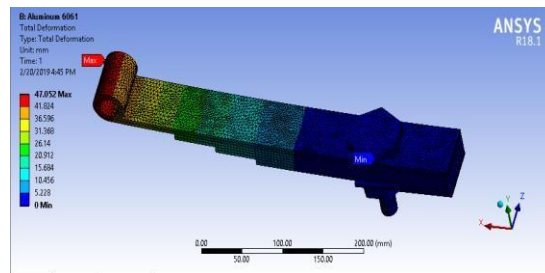
Equivalent Strain

The maximum equivalent strain for the Al 6061 can be observed as 0.018012 . The condition of the designed leaf spring is meant to be safe as most of the part of the leaf spring observes minimum strain which is equivalent to zero MPa. The above image concludes that only limited part of the leaf spring is subjected to maximum strain of 0.018012 while majority of the leaf spring stays under the fatigue level.

Total Deformation:

A total of 2084 N of static force has been applied on each of the end of the leaf spring. The maximum deformation for the Al 6061 can be observed as 47 mm . The condition of the designed leaf spring is meant to be safe as most of the part of the leaf spring observes minimum stress which is equivalent to zero mm. The above image concludes that only limited part of the leaf spring is subjected to maximum deformation of 47 mm while majority of the leaf spring stays under the fatigue level. As observed during the simulation, an increase in load of 30-40 % of the given load, also keeps the leaf spring without damage.

ANALYSIS OF AL 6063:

Equivalent stress:
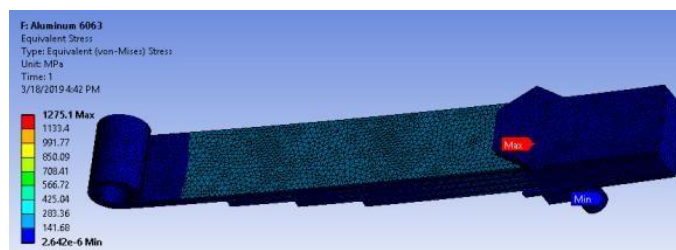
A total of 4168 N of static force has been applied on both the ends of the leaf spring , which results in 2084 N of force per end of the leaf. The maximum equivalent stress for the Al 6063 can be observed as 1275 MPa . The condition of the designed leaf spring is meant to be safe as most of the part of the leaf spring observes minimum stress which is equivalent to zero MPa. The above image concludes that only limited part of the leaf spring is subjected to maximum stress of 1275 MPa while majority of the leaf spring stays under the
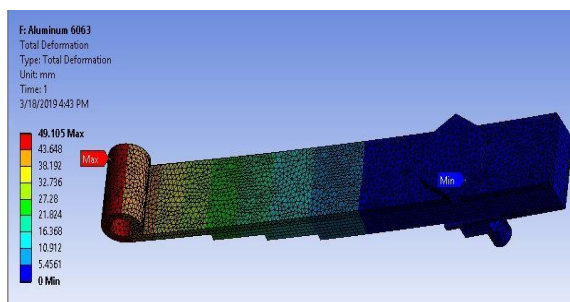
fatigue level. As observed during the simulation, an increase in load of 30% of the given load, also keeps the leaf spring without damage.
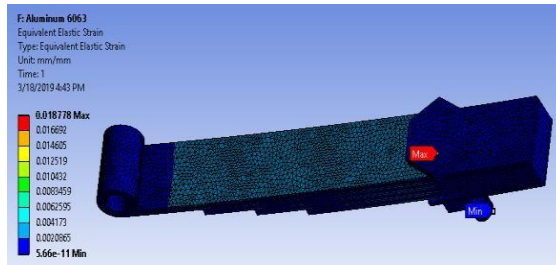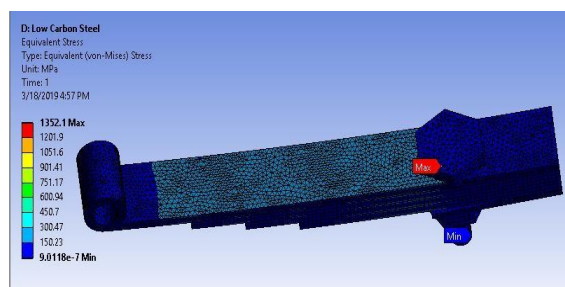
Equivalent Strain

The maximum equivalent strain for the Al 6063 can be observed as 0.018778 . The condition of the designed leaf spring is meant to be safe as most of the part of the leaf spring observes minimum strain which is equivalent to zero MPa. The above image concludes that only limited part of the leaf spring is subjected to maximum strain of 0.018778 while majority of the leaf spring stays under the fatigue level.

Total deformation

A total of 2084 N of static force has been applied on each of the end of the leaf spring. The maximum deformation for the Al 6063 can be observed as 49 mm . The condition of the designed leaf spring is meant to be safe as most of the part of the leaf spring observes minimum stress which is equivalent to zero mm. The above image concludes that only limited part of the leaf spring is subjected to maximum deformation of 49 mm while majority of the leaf spring stays under the fatigue level. As observed during the simulation, an increase in load of 30-40 % of the given load, also keeps the leaf spring without damage.
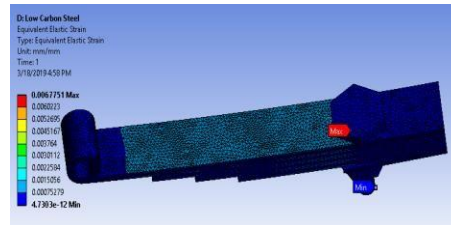
HIGH CARBON STEEL

Equivalent Stress :

A total of 4168 N of static force has been applied on both the ends of the leaf spring , which results in 2084 N of force per end of the leaf. The maximum equivalent stress for the Low Carbon Steel can be observed as 1352 MPa . The condition of the designed leaf spring is meant to be safe as most of the part of the leaf spring observes minimum stress which is equivalent to zero MPa. The above image concludes that only limited part of the leaf spring is subjected to maximum stress of 1352 MPa while majority of the leaf spring
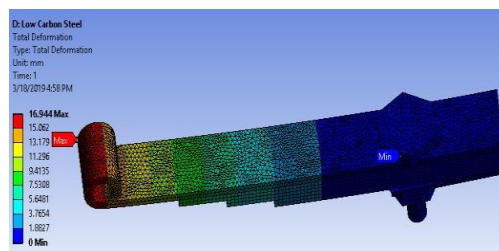
stays under the fatigue level. of the leaf spring is subjected to maximum stress of 1352 MPa while majority of the leaf spring stays under the fatigue level.

Equivalent Strain:

The maximum equivalent strain for the High Carbon Steel can be observed as 0.0067751 . The condition of the designed leaf spring is meant to be safe as most of the part of the leaf spring observes minimum strain which is equivalent to zero . The above image concludes that only limited part of the leaf spring is subjected to maximum strain of 0.0067751 while majority of the leaf spring stays under the fatigue level.

Total deformation:

A total of 2084 N of static force has been applied on each of the end of the leaf spring. The maximum deformation for the High carbon steel can be observed as 17 mm . The condition of the designed leaf spring is meant to be safe as most of the part of the leaf spring observes minimum stress which is equivalent to zero mm. The above image concludes that only limited part of the leaf spring is subjected to maximum deformation of 17 mm while majority of the leaf spring stays under the fatigue level. As observed during the simulation, an increase in load of 30-40 % of the given load, also keeps the leaf spring without damage.

RESULT & DISCUSSION

MATERIAL	EQUIVALENT STRESS (Mpa)	UIVALENT STRAIN	ORMATION (MM)
HIGH CARBON STEEL	1352 Mpa	0.0067751	17 mm
AL 6061	1277 Mpa	0.018012	47 mm
AL 6063	1274 mpa	0.018778	49 mm

CONCLUSION

The work results that the AL 6063 has less stress acting on its surface than the other two materials. So that it can withstand maximum stress up to the permissible limit. so it is said to be a best option in case of stress absorption.

More the strain ratio deformation is more so that the comfort and life of the leaf spring is more than the other two materials. According to the above statement the AL6063 posses' high level of strain rate.

In case of deformation AL 6063 possess high deformation, rate compared to all the three materials. so higher the deformation the level of comfort and cushioning effect for the passengers is more.

From the above points it is evident that AL 6063 is considered to be best material among the three in all safety, comfort, weight reduction ,mileage and prolong working with out fatigue for more years.

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