

To Study the Failure Mode and Effective Analysis of Trailing Arm Weldment

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ABSTRACT: In this project, the study is relates to vehicle suspension systems for mounting ground-engaging wheels to a vehicle frame and, more particularly, to the axle support means for securing a wheel-carrying axle to a vehicle. Vehicle suspension structures are well-known in the art. The suspension system comprises a trailing arm having a leading portion pivotally coupled to the vehicle frame. An axle is typically welded to a bracket which is, in turn, secured to the trailing arm of the vehicle suspension structure. The weldment securing the axle to the bracket is usually made at the midpoint of the side where vertical bending moment stresses are neutral. These areas are areas of high torsional loading which results from brake torque, vehicle roll and diagonal axle walk. The welding at the midpoint of the axle typically introduces a point of weakness where axle failure may initiate. Therefore to study the failure mode of a trailing arm weldment, static analysis and fatigue analysis will be done using ANSYS V14 and the results obtained will be discussed in details.

KEYWORDS: Vehicle suspension structures(VSH), trailing arm, weldment , fatigue analysis.

I.INTRDUCTION

When carried to the extreme, today's emphasis on automobile mass reduction has significant implications for vehicle ride and suspension design. We therefore review traditional automobile suspension systems and offer comments on the special considerations of suspension systems of extremely low-mass passenger cars. and the actual suspension system often falls short of the ideal in a variety of ways. [1]

In this project, a study is carried out on trailing arm weldment to know failure modes and its life cycle. A trailing arm is part of an automobile's suspension. It is normally located forward of the rear axle and connects the axle to the car chassis. It is a relatively large piece of the suspension that supports the coil springs. When driving down a bumpy road, the trailing arm moves up and down to smooth the ride. [2]

II.GEOMETRIC MODELING OF TRAILING ARM

A trailing arm is a simple mechanical design is often used in the rear suspension of rear wheel drive vehicles and some of them are inexpensive used in front drive vehicles also. In this kind of suspension, trailing arm is connected to the rear axle and to the unibody frame. This controls the motion of the rear axle relative to the vehicle frame through pivot joints on both

ends of the arm, on which a twist beam will be connected., the arm simply guides and limits up and down motion of the axle relative to the vehicle frame, through a limiting arc shaped path. The coil spring of the rear suspension absorbs upward force when the axle moves, while the shock absorbers dampen downward motion when the spring rebounds. In this project the customized and integrated trailing arm with tubular cross section has been used with a reasonably simple weldment as a cost reduction. In this project the trailing arm weldment of Reva Ev is designed to withstand the bump load and an motor weight.

The design of trailing arm weldment with tubular cross section of 30mm X 30mm X 2.5mm, Axle support plate of 127 mm X 115mm X 6mm, gussets 205mm X 37.5mmX2.5, Hollow bush dia 51mm X 4.25mm with other gusset members forms the trailing arm structure. The trailing arm is designed to allow the twist beam to move up and down using the axle support plate to cushion and limit the movement with the suspension bracket. The dimensional requirements are critical, as it implies that the designed structure should be very rigid and capable of withstanding the forces generated due to bump loads

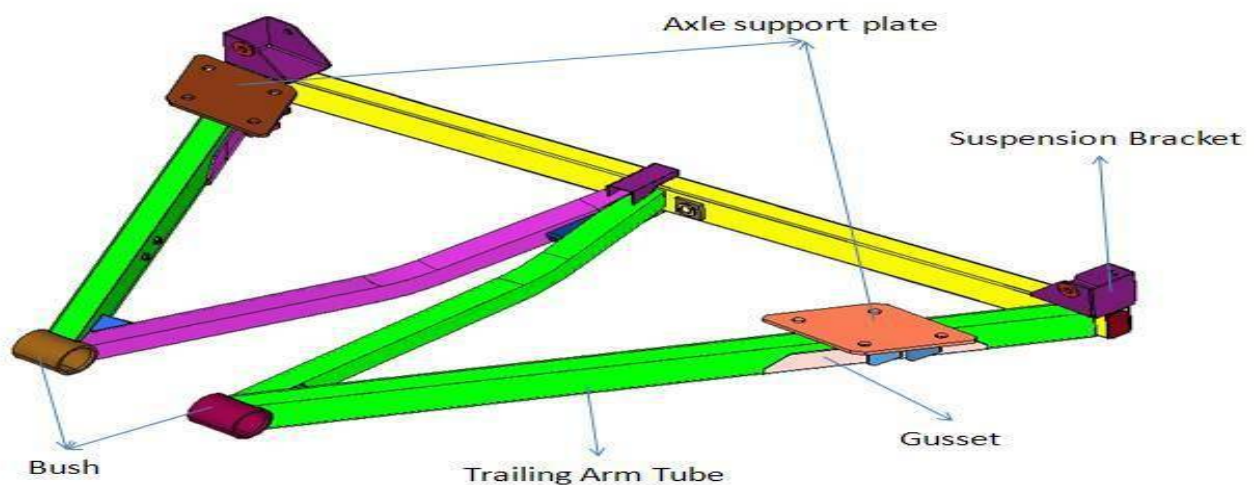


Fig1: Generic View of Trailing Arm Weldment

III.METHODOLOGY FOLLOWED

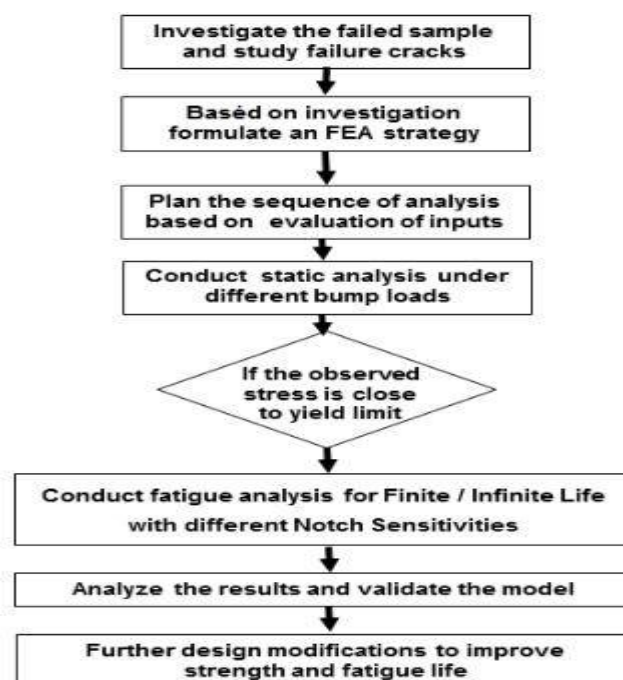


Fig.2: Block diagram of methodology followed

IV.HOW TO RUN THE ANALYSIS

1. Carry out static analysis and study the results with respect to Yield Strength under different bump loads of 2G, 3G & 4G.
2. If the stress levels are near the Yield Strength, carry out fatigue analysis and calculate cycles to failure under the following conditions:
 - a) Using Notch Sensitivity Factor of 1.25
 - b) Using Notch Sensitivity Factor of 1.5
 - c) Using Notch Sensitivity Factor of 1.75
3. If the fatigue life <1000 cycles, modify the design as per suggestions and re-run fatigue analysis as above for Notch Sensitivities of 1.25, 1.5 & 1.75
4. Finalize the modification which meets infinite life criteria of > 1,000,000 cycles

V.LOAD CONDINATIONS



Fig3:load consideration

Reaction at rear side = 698 kg

Reaction on each wheel = $698 / 2 = 349$ Kg

Case 1: Bump load 2G = $349 \times 2 \times 9.81 = 6847.38$ N

Case 2: Bump load 3G = $349 \times 3 \times 9.81 = 10271.07$ N

Case 3: Bump Load 4G = $349 \times 4 \times 9.81 = 13694.76$ N

Static Structural Analysis has been carried out for bump loads of 2G, 3G & 4G

VI.STATIC STRUCTURAL ANALYSIS FOR BUMP LOAD OF 2G 3G AND 4G

The max stress location from the analysis corresponds to the crack initiation point in front crack .The comparison is shown

below **Stress observed at the end of the weld**

- This stress is occurring as a result of relative twisting of the axle support plate and tube, due to upward bending.

- Permissible Yield Stress for Butt and Fillet Welds = $0.60 \sim 0.66 S_y$ (Reference-page 352 Table 2 of Mechanical Engineering Design by Joseph Edward Shigley)
- Permissible Stress for Gusset = $(0.60) 0.66 \times 280 = (168) 184 \text{ Mpa}$
- The observed stress of 121.9 MPa is lesser than the allowable stress if 184 Mpa

Static structural analysis for bump load 3G

- Permissible Yield Stress for Butt and Fillet Welds = $0.60 \sim 0.66 S_y$ (Reference-page 352 Table 2 of Mechanical Engineering Design by Joseph Edward Shigley)
- Permissible Stress for Gusset = $(0.60) 0.66 \times 280 = (168) 184 \text{ Mpa}$
- The observed stress of 183.5 MPa is almost equal to yield limit of 184 Mpa.
- This indicates potential fatigue failure. Hence fatigue analysis needs to be carried out

Static structural analysis for bump load 4G

- Permissible Yield Stress for Butt and Fillet Welds = $0.60 \sim 0.66 S_y$ (Reference-page 352 Table 2 of Mechanical Engineering Design by Joseph Edward Shigley)
- Permissible Stress for Gusset = $(0.60) 0.66 \times 280 = (168) 184 \text{ Mpa}$
- The observed stress of 251.7 MPa is higher than the allowable stress of 184 Mpa.
- This indicates static failure at a single application of 4G load

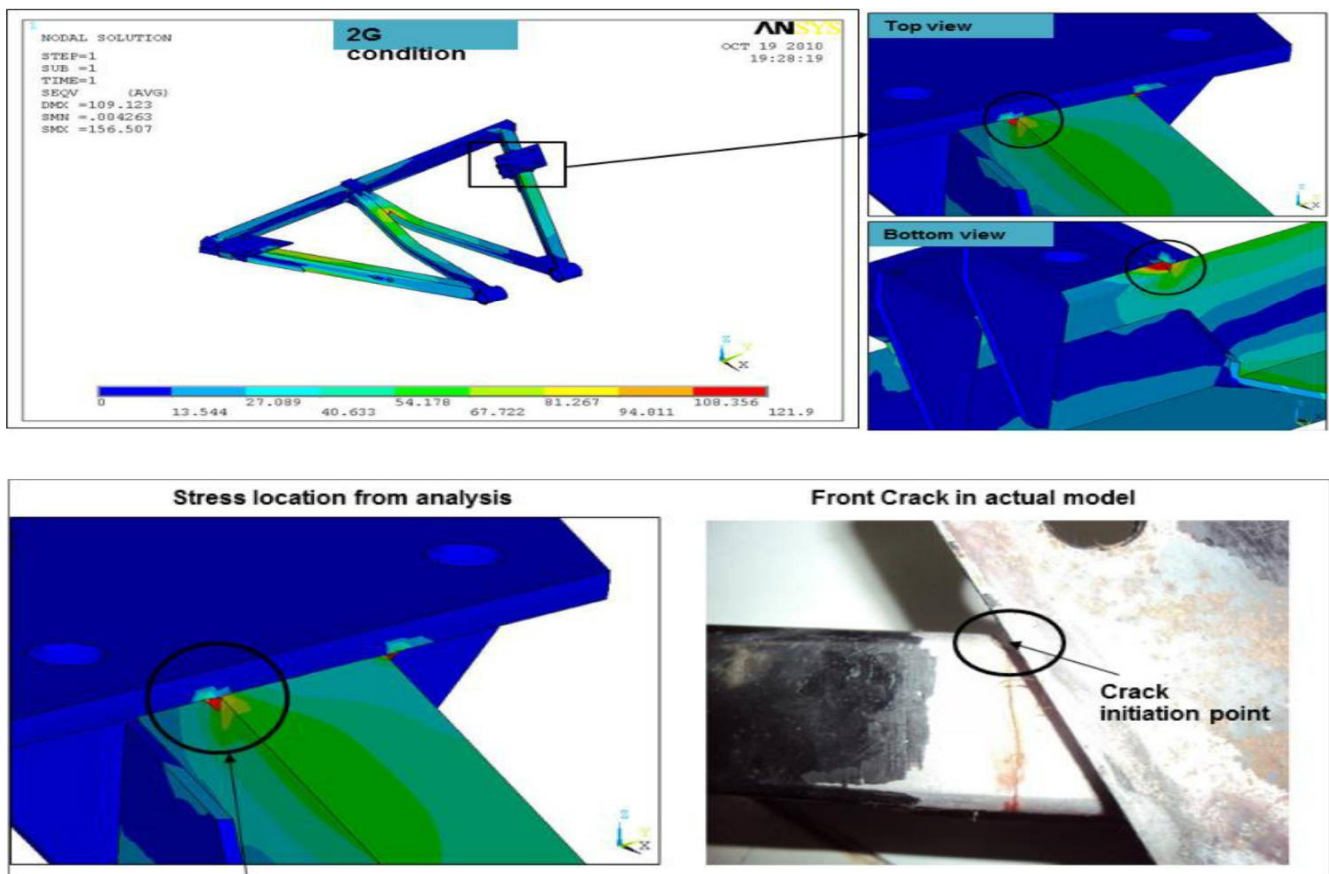


Fig.4 Max Von- Mises Stress = 121.9 MPa

VII.FATIGUE ANALYSIS

- The Fatigue Life requirement is 1,000,000 cycles of cyclic loading.
- Fatigue analysis is carried out for bump loads of 2G, 3G.
- Only the damaging signals resulting out of the above alternating stresses have been taken for the "Cumulative Fatigue Damage".
- The table below shows the Fatigue Strength Reduction Factors for different kind of weld Joints.
- To see the effect of process, strength reduction factors of 1.25, 1.5 and 1.75 have been taken for analysis.

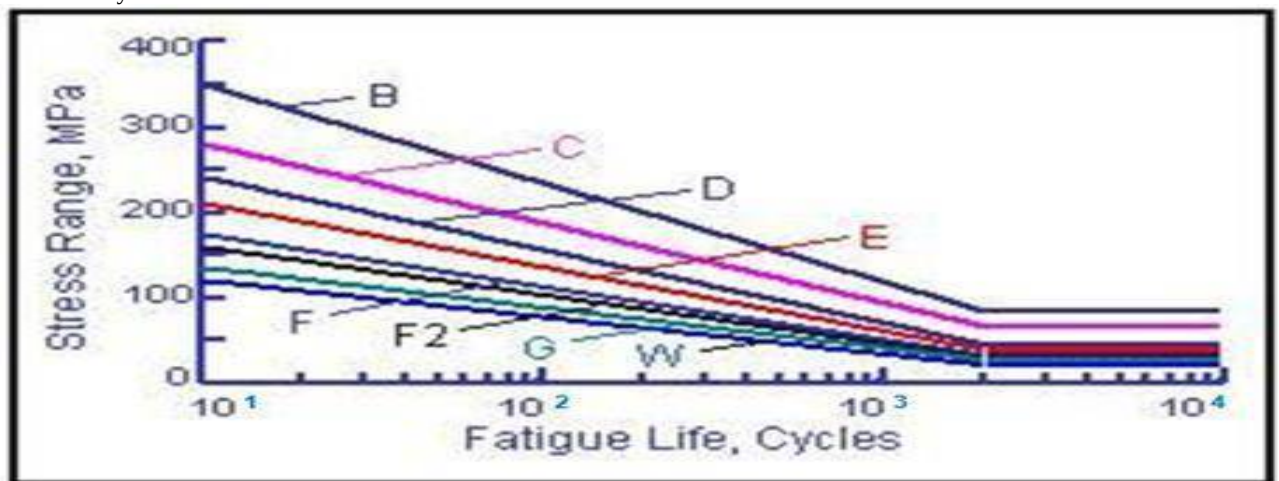


Fig5:SN curve

- SN curve B indicates fatigue life for cold rolled carbon steel. This curve is used for analysis.
- Fatigue analysis is carried out for stress concentration factor (SCF) of 1.25, 1.5 and 1.75

TABLE 1.1

Bump Load	Kf	No. of cycles from analysis (Location – 1)
2G	1.5	269
2G	1.75	68
3G	1.5	10

- The component under study is showing finite life and has to be modified to have an infinite life.
- The Failure follows a sequence – First Failure – Zone 1 Failure Line happens
- first; This is followed by Zone 2~3 Failure Line

VIII.FATIGUE ANALYSIS

With Stress Concentration Factor = 1.25

- The Fatigue Life requirement is 1,000,000 cycles of cyclic loading.
- Fatigue analysis is carried out for bump loads of 2G, 3G.
- Only the damaging signals resulting out of the above alternating stresses have been taken for the "Cumulative Fatigue Damage".
- To see the effect of process, strength reduction factor of 1.25 has been taken for analysis

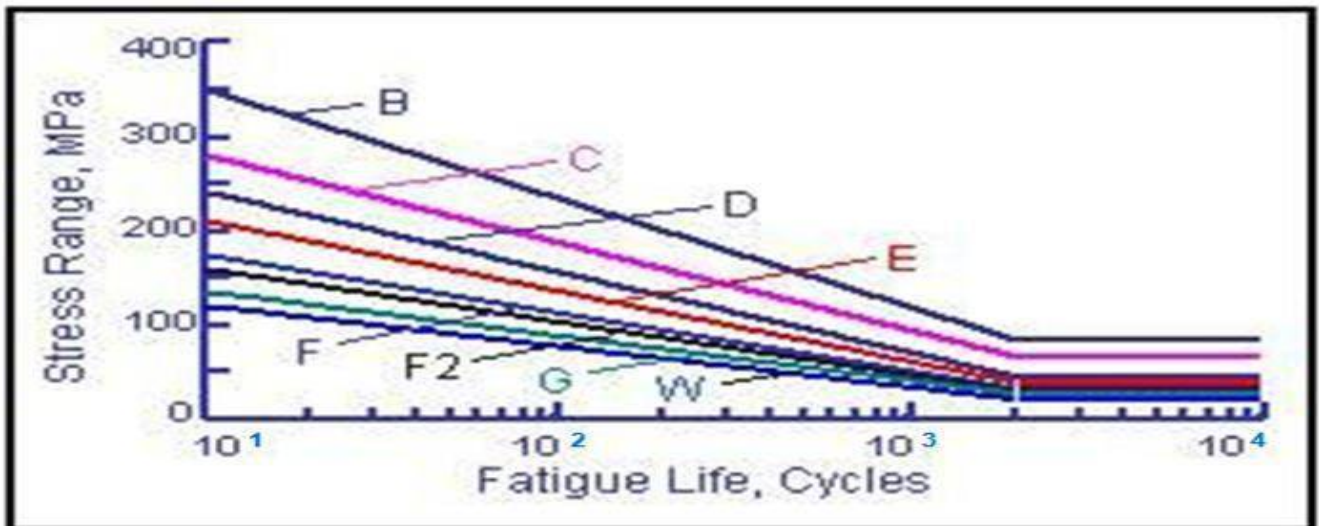


Fig6;SN curve after design modification

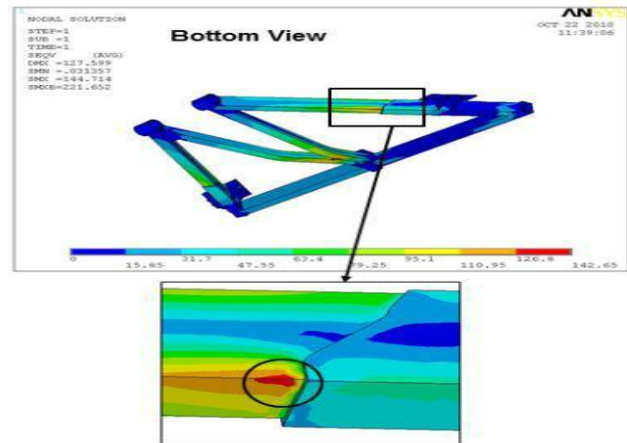
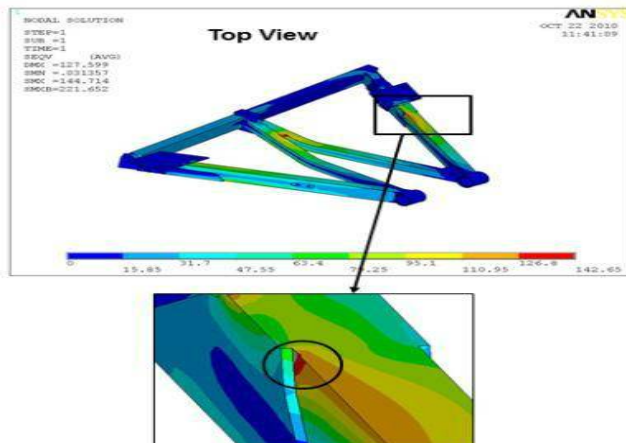
TABLE1.2:

Bump Load	Kf	No. of cycles from analysis (Location – 1)
2G	1.25	893900
3G	1.25	62010

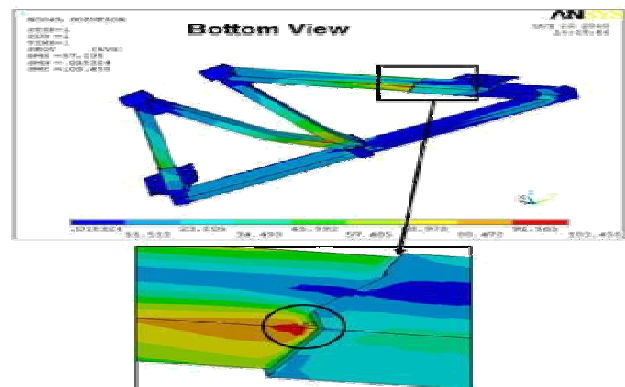
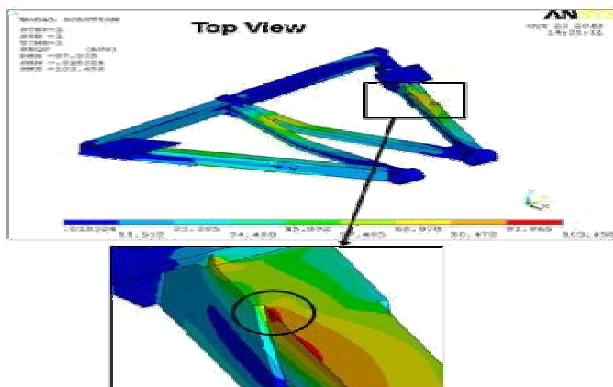
IX.ANALYSIS APPROACH

- Static analysis with bump loads of 2G, 3G and 4G were carried out on the modified model.
- Fatigue analysis was also carried to determine the fatigue life at the weld region of the axle support plate.

- The analysis results are shown in the following slides.

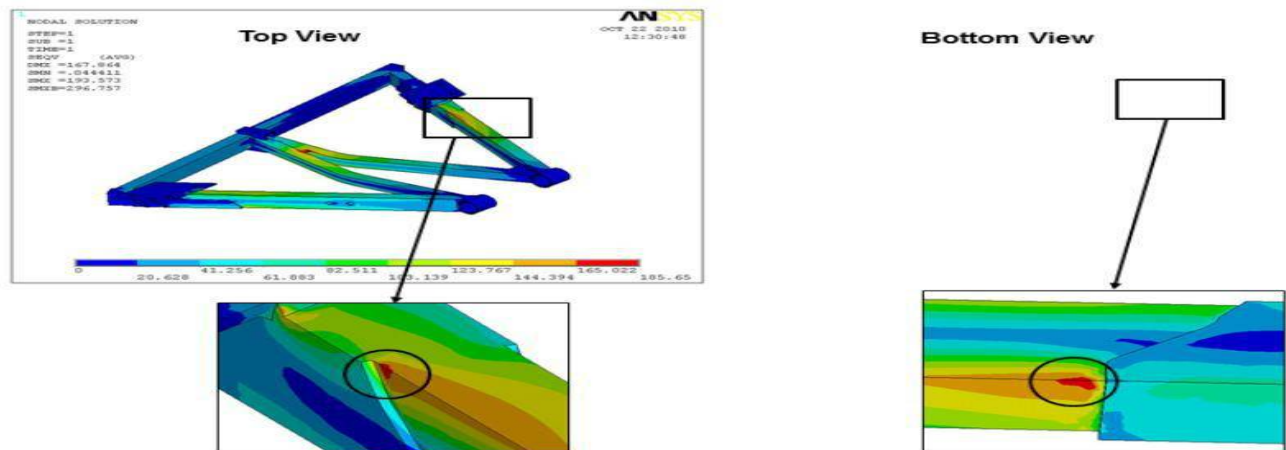


The von-mises stress =103.458mpa(2G)



The von-mises stress =142.65mpa(3G)

- Permissible Yield Stress for Butt and Fillet Welds = 0.60 ~ 0.66 Sy (Reference-page 352 Table 2 of Mechanical Engineering Design by Joseph Edward Shigley)
- Permissible Stress for Gusset =(0.60) 0.66 x 280 = (168) 184 Mpa



Von misses stress =185.65mpa

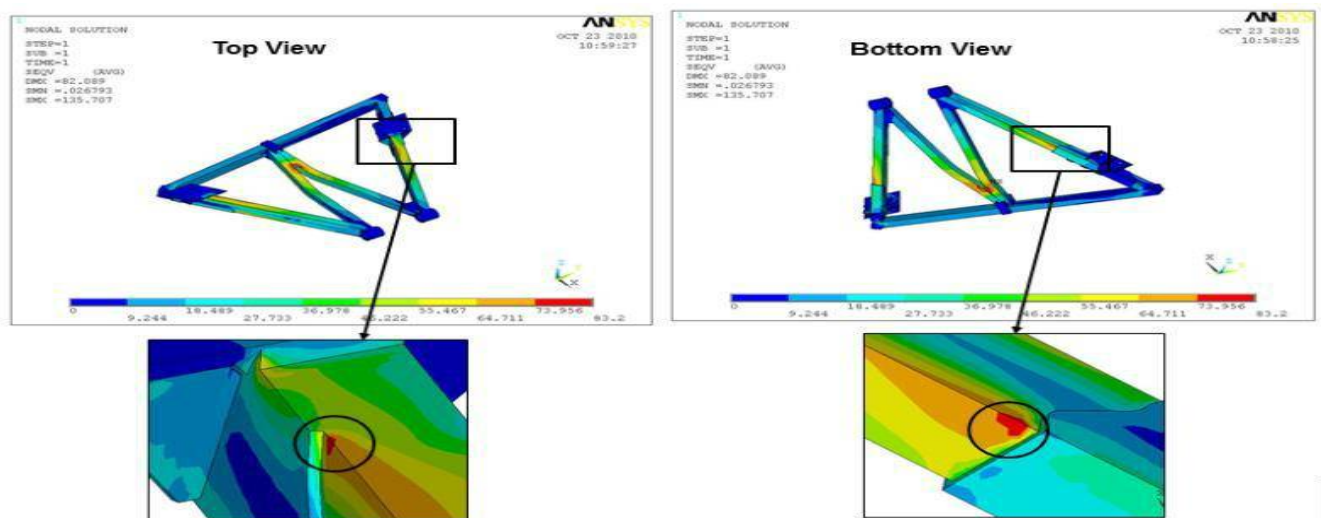
TABLE:2

Sl. No.	Bump Load	Observed Stress (MPa)	Allowable Stress (Mpa)	Remarks
1	2G	103.45	184	Not failing by yielding in 2G bump load condition
2	3G	142.65	184	Not close to allowable stress but has potential for fatigue failure
3	4G	185.65	184	Above allowable stress. Indicates static failure for single application of load

X.DESIGN MODIFICATION OF TRAILING ARM

2 The 2nd design modification increasing the

gusset no



- SN curve B indicates fatigue life for cold rolled carbon steel. This curve is used for analysis.
- Fatigue analysis is carried out for stress concentration factor (SCF) of 1.25, 1.5 and 1.75

TABLE 1.1

Bump Load	K_f	No. of cycles from analysis (Location – 1)
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XI.CONCLUSION

- The fatigue life observed in the modified model is higher than that of the base model.
- However, to reach fatigue life of 1,000,000 cycles additional modifications have to be carried out on the model.
- The Rate Of Improvements are big in comparison to Original (16,000 Kms). This will
- indicate Infinite Life.
- The Modification requires Welding improvement & Extension of Gusset upward –Box
- Further design modification and fouled by analysis is under progressive , will complete with in week

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