Design of Suspension Trailing ARM Using Finite Element Analysis & Experimentation Method

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Abstract - : *The Suspension system is the most important system in vehicle for balancing of vehicle and driver comfort. The number of studies had done on suspension system from past few years. This study describes the analysis of cause of the failure of a suspension system trailing arm geometry installed in the rear of an All-Terrain Vehicle. Thus, the topic is focused on designing and analyzing of suspension system in vehicle for driver comfort with providing optimum performance. The trailing arm suspension system is used in auto rickshaw. It is play important role in suspension system. This trailing arm fails suddenly without any sign of failure and this case is a dangerous as well as disturbing factor for driver. We have studies to change design of trailing arm for resolve the problem. Design of the present trailing arm has been improved and from obtained result we can say that design modified and within safety limit.*

Key Words: **Trailing Arm, Modelling, Stress & Fatigue Analysis, Design modification, Experimentation method.**

1. INTRODUCTION

In many countries bus, cars as well as three wheeled vehicles are a public transport vehicles, but three wheeler is common transport vehicle in India with a maximum speed of about 14 m/s [1]. This vehicle is commonly known as an Auto-rickshaw. Especially these vehicles are used in Asian countries as public transport. The total weight of the vehicle is around 1025 kg including the driver and four passengers [4]. It front wheel of auto rickshaw attached to linkage suspension attached to the steering column and two rear wheels attached to corresponding trailing arms that are pivoted to the frame.
The trailing arm connected between the wheel spindle/hub and chassis. Trailing arm placed longitudinally along the driving direction and mounted on suspension sub frame or body on both the sides.

1.1 Problem Definition

The trailing arm has to subjected forces in all direction because of that the possibility of bending and torsional stress increased. If only vertical and lateral forces acting on trailing arm then no camber and toe change. Trailing arm is subjected to high torsional and bending stresses. It allows the wheel to move up and down only. The overall study of suspension trailing arm for minimize the failure of trailing arm during operation. wheeler.

1.2 Methodology

As these all references says that the failure occurs in rear suspension trailing arm will be find out by study the exact failure parameter of trailing arm by different test . The failure of trailing arm we can reduce by improving the failure parameter. The failure parameter is improved by changing design of suspension system arm, so it will help to you improve life of suspension trailing arm and reducing the accidents and reducing weight of three wheeler.

1.3 Design Tool

The various tool available in market for development in market. We have done 3D modelling of suspension trailing arm by using CATIA software. The use of solid modeling techniques allows us the computerization of many difficult engineering calculations that are carried out as a part of the design process. Simulation, planning, and verification of processes of the components of the suspension are some of the tasks that will be performed in CATIA. Also ANSYS software will be used to perform an engineering analysis of the stresses acting on component to resolve the state of stress and failure on the device.

2. MODELING AND ANALYSIS OF TRAILING ARM

The CATIA software is used for modeling of geometry. The measurements of main part of trailing arm have been made in order to create a three dimensional geometry. Initially the 3D drawing of Trailing Arm is done by CATIA according to dimension specified. Then, the model has been imported to ANSYS software and giving fixed support as per operation.

The trailing arm design by standard dimension.

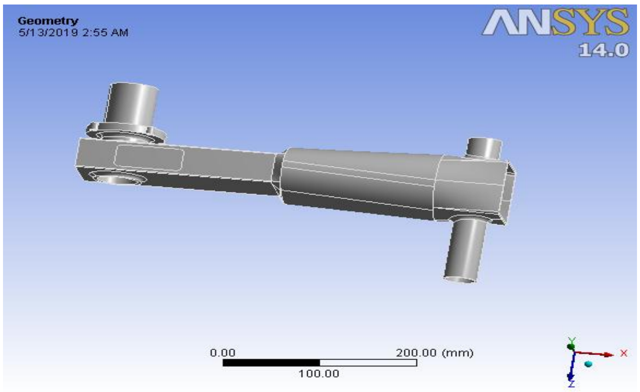


Fig -1: 3D Model

2.1. Material

According to chemical composition analysis by OES [7], the trailing arm was manufactured using an EN 18D steel alloy, EN 18D steel alloy properties:

- Young's modulus (E)= 190Gpa
- Yield stress=565Mpa
- Ultimate tensile strength=887MPa
- Density=7.85g/cm3
- Poisson's ratio=0.29

2.2 Meshing Generation

Meshing is important to convert from infinite element to finite element because of that we can divide all geometry in small element. There are two convergence studies, h-convergence study and p-convergence study h-Convergence study is done by increasing number of elements which can be done by making mesh size finer, and it is important to maintain continuity in meshing and element check should be done for aspect ratio, warping angle, skew ratio and others8. p- Convergence study is done by increasing number of nodes.

Meshing of a given model will be done depending on geometry of the model, it is better to have more degrees of freedom hence more number of elements so that results obtained will be closure to analytical results.

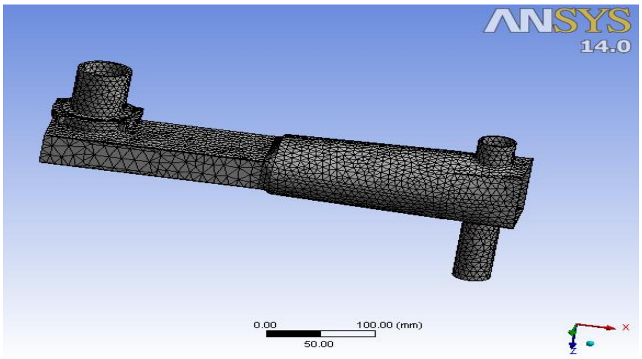


Fig-2 Meshing of Trailing Arm

2.3 Loading and Boundary condition

The gross weight of three wheeler distributes on each wheel, gross weight and weights of persons riding the Auto rickshaw. The full static load located at the centroid of three wheeler., each tire has a share of triple of that full static load, The gross weight of rickshaw is around 1025kg, assuming the weight of passenger is 100kg of each person and Luggage weight add separately 100kg, the total static load will be 1025 kg .The assuming 425 kg kerb weight by data available so, each tire will have a share of 388kg. when the a car has an impact within the motion, control arm subjects to longitudinal load equals nearly to double of its tire share static load as well as horizontal load equals to that longitudinal one but it directs a horizontally along the length of Auto. The fatigue stress and its safety factor have been created in these two forms of numerical analysis, the load on trailing arm is fluctuating and the static load which only includes the weights of AVT, freight and persons.

Calculations for weight distribution on each wheel: According to OES[4]
Gross Weight = Kerb Weight + Passenger weight + Luggage weight
WG = 425+ 500 + 100 Kg
WG = 1025 Kg
From standard
The ratio of weight distribution
Weight acting on each wheel
W = (0.66X WG)/2
= (0.66 X 1025)/2
W =338.25 Kg
So, the reaction force,
P = W X g
= 338 .25X 9.81
P = 3318.23N
P = 3500N Appx.
Assumed condition is of bump, in which the extremity of load is present.
The load considerations are Double Gravity (2g acceleration)
P = 7000 N (taken for Analysis)

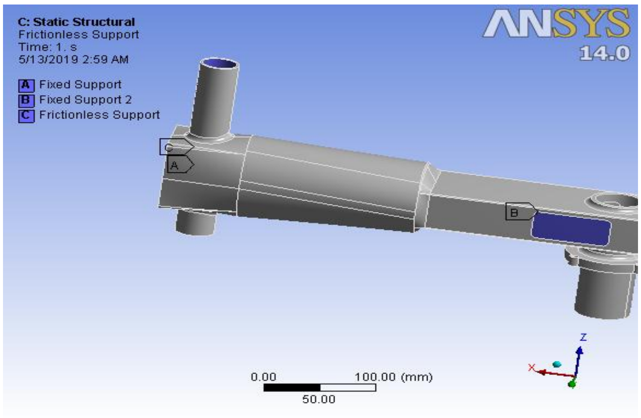


Fig -3: Loading and Boundary condition

3. Result for Original Geometry

From all above loading and boundary condition following results are obtained. According to von mises's theory, a ductile solid will yield when the distortion energy density reaches a critical value for that material.

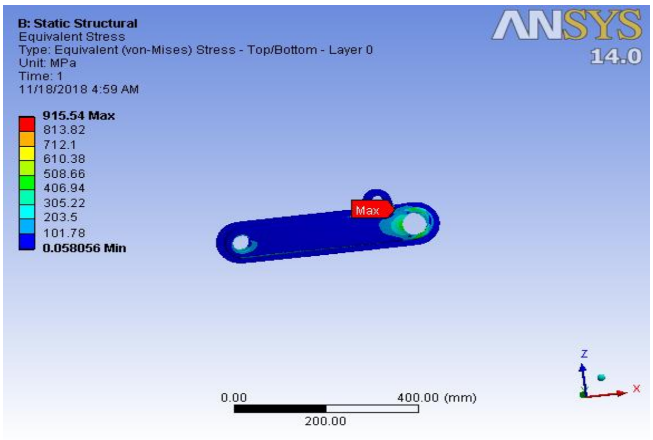


Fig -4: Equivalent Stress

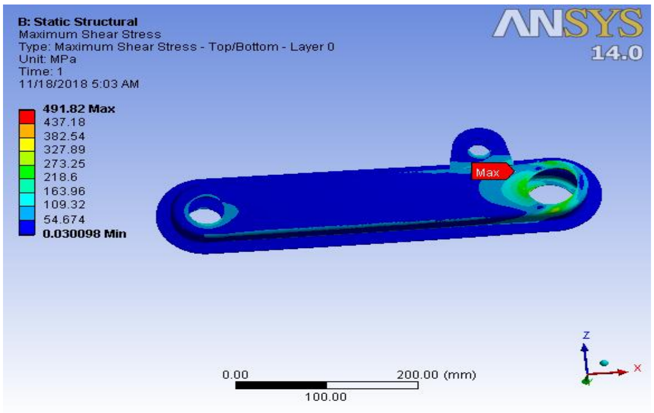


Fig -5: Maximum Shear Stress

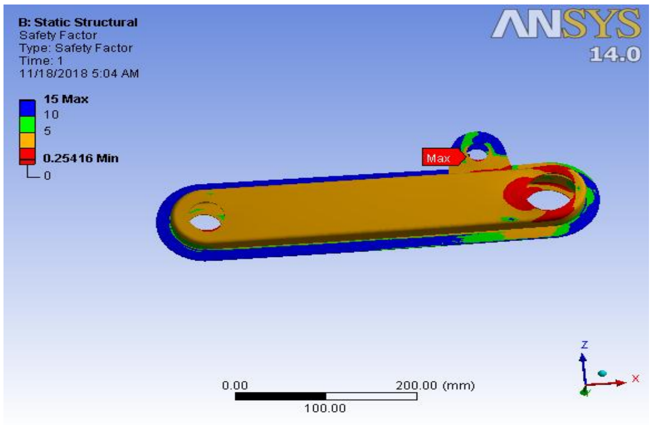


Fig -6: Factor of Safety

It is observed from results, which is obtained from previous design. We came to know that, equivalent von-mises stress goes beyond ultimate tensile strength of the material and hence there is crack initiation in the trailing arm at the specified loading conditions and that crack leads towards the fatigue failure of the trailing arm as the trailing arm is under cyclic loading as per the description given in the problem definition.

4. RESULT FOR MODIFIED TRAILING ARM

We are getting result from modified design as below:

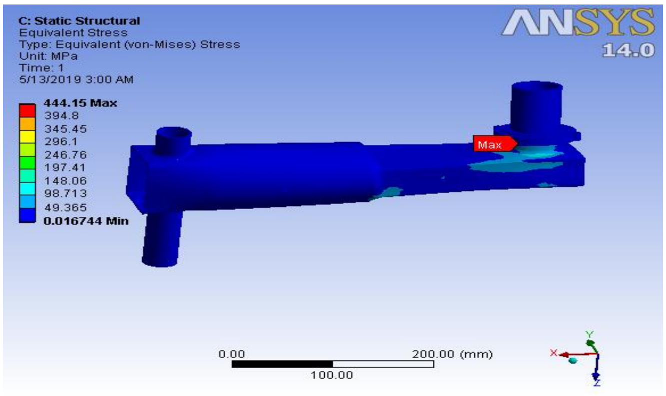


Fig -7: Equivalent Stress

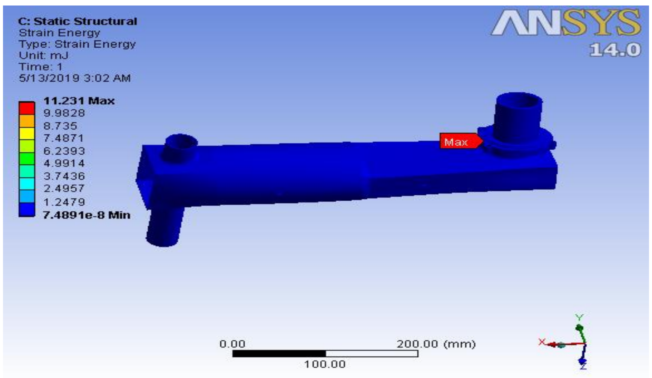


Fig -8: Equivalent Stress

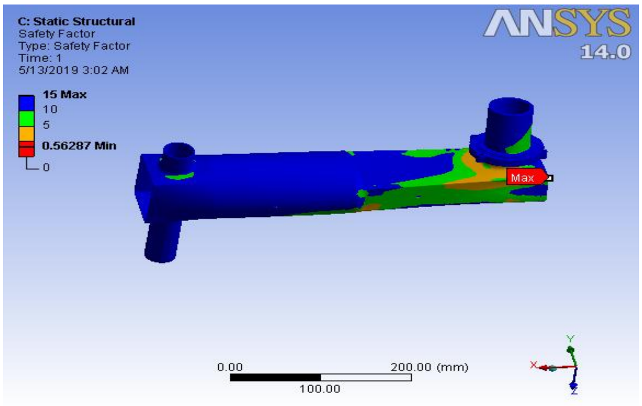


Fig -9: Factor of safety

5. **COMPARISON OF ANALYSIS RESULT**

Sr. No.	Components	BEFORE MODIFICATION	AFTER MODIFICATION
1	Total Deformation	0.8	4.9
2	Equivalent Stress Plot	915.54	444.15
3	Major Principal Stress Plot	875.09	470.92
4	Equivalent Elastic Strain Plot	0.0047	0.0029
5	Max Shear Stress	491.82	79.67
6	Factor Of Safety	0.25	0.56
7	Fatigue life	264.(min)	940.8 cycle/s

Table-1:Structural analysis Result

6. EXPERIMENTATION RESULT

6.1 Compression Test

In compression loading, the material follows elasticity up to certain value of stress. Stress is directly propositional to strain. After elasticity point material behaves plasticity. In compression loading, the fracture of the specimen takes place due to bulging action. The property of a material to bulge under compressive loading is called malleability. In compression test the relationship between stress and strain is similar to that obtained for a tensile loading.

Compression test more critical as compare to tensile test as following

1. Specimen must have larger cross-sectional area to resist any buckling due to bending,
2. The specimen undergoing strain hardening as deformation proceeds, and
3. Cross-section of the specimen increases with deformation.

6.2 Share Test

The most common use of a shear test is to determine the shear strength, which is the maximum shear stress that the material can withstand before failure occurs of a material. When a bolt is used to secure two plates together it will experience a shear forces if the plates themselves experience any forces parallel to their plane that attempt to separate them. If the small fastener fails in shear it may lead to a chain of failures that could lead to the entire destruction of a much larger structure. This is a very important design characteristic of many types of fasteners such as bolts and screws.

Shear tests differ from tension and compression tests in that the forces applied are parallel to the two contact surface, whereas, in tension and compression they are perpendicular to the contact surfaces.

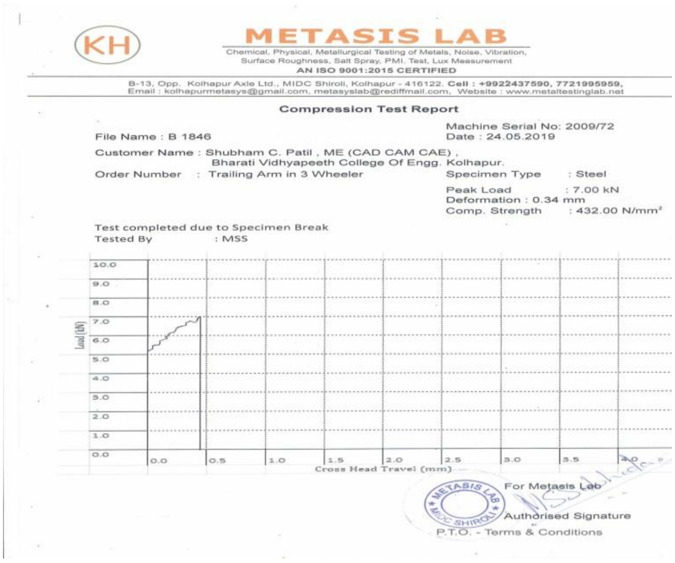
6.3 Testing on Machine

During shear test, we have first place the test attachment on lower table of testing machine and trailing arm inserted in shear test attachment, then apply load and got the shear strength of trailing arm. Figure shows the test set-up on universal testing machine

Fig -10: Fixture of trailing arm

Fig -11: Manufacturing of fixture

Fig -12: Testing of Trailing Arm



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Compression Test Report

Machine Serial No: 2009/72
Date : 24.05.2019

File Name : B 1846

Customer Name : Shubham C. Patil , ME (CAD CAM CAE) ,
Bharati Vidhyapeeth College Of Engg. Kolhapur.

Order Number : Trailing Arm in 3 Wheeler

Specimen Type : Steel

Peak Load : 7.00 kN
Deformation : 0.34 mm
Comp. Strength : 432.00 N/mm²

Test completed due to Specimen Break
Tested By : MSS

For Metasis Lab

Authorised Signature

P.T.O. - Terms & Conditions

Fig -13: Compression Test Report

After Completing Compression Test the Compressive strength of trailing arm was 432.00 N/MM²

It is observed from the results, equivalent von-mises stress goes beyond ultimate tensile strength of the material and hence there is crack obtained because of specified loading and that crack leads towards the fatigue failure of the control arm is under cyclic loading condition. After Completing Shear test the shear strength of trailing arm was 82.00 N/MM²

7. CONCLUSIONS

Modify the design of trailing arm to make safe reliable and durable. We worked on the stress raiser in the previous design of trailing arm and required design modification is done. We got some results which defines the stress distribution, deformation and safety factor. We compare all results before and after modification.

Design of the present trailing arm has been improved and from obtained results we can say that the design of trailing arm is optimized and within safety limit, the component is now have considerably good life. Also experimentation validation of result through finite element analysis was done.

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