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Analysis of Trailing Arm for Weight Optimization using FEA

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Abstract: ***An auto rickshaw is a three wheeled motor vehicle with one front steering wheel. Auto rickshaws are most commonly found in developing countries as they are a very cheap form of transportation due to low price, low maintenance cost, and low operation costs. Trailing arm mechanical system that is usually used because the rear suspension in three wheeler car rickshaws offers a straight forward configuration. Trailing arm is important component of suspension system as the suspensions control the movement of the wheels and thus keeping the vehicle on the road. Finite Element Analysis (FEA) is the most powerful technique for strength calculations of the structures working under known load and boundary conditions. FEA approach is applied for the optimization. 3D model of a trailing arm is drawn in CATIA V5R20, and ANSYS is be used for numerical solutions. Finally ANSYS results are validated through experimental results. Overall 8% weight reduction is achieved keeping system safe.***

Keywords: trailing arm; optimization; FEA; ANSYS

1. Introduction

1.1 Trailing Arm

A trailing arm is part of an automobiles suspension. It is located in front of the rear axle and it connects the axle to the car's and rickshaw's chassis. The arm will move up and down when driving on a bumpy road to make it a smooth ride.

A trailing-arm suspension is an automobile suspension design in which one or more arms (or "links") are connected between (and perpendicular to and forward of) the axle and the chassis. Trailing-arm designs in live axle setups often use just two or three links and a Panhard rod to locate the wheel laterally. A trailing arm design can also be used in an independent suspension arrangement. Each wheel hub is located only by a large, roughly triangular arm that pivots at one point, ahead of the wheel. Seen from the side, this arm is roughly parallel to the ground, with the angle changing based on road irregularities. A twist-beam rear suspension is very similar except that the arms are connected by a beam, used to locate the wheels and which twists and has an anti-roll effect.

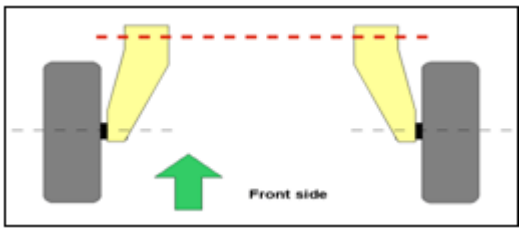

Figure 1: Trailing arm rear suspension of cars

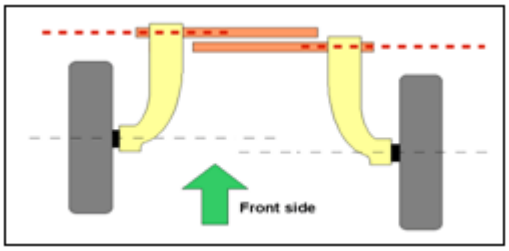

Figure 2: Rear suspension of Renault

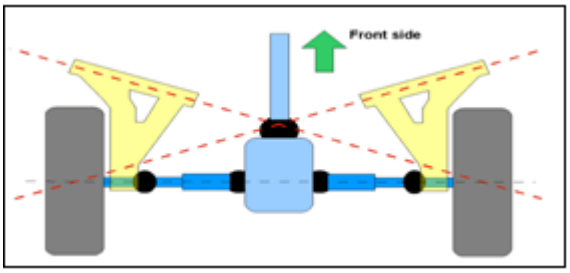

Figure 3: Semi-trailing arm suspension

Trailing arm at rear axle of auto rickshaw:

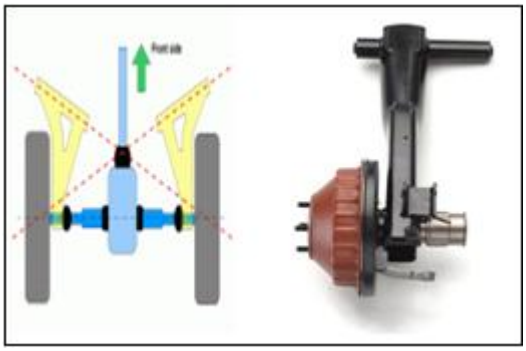

Figure 4: Trailing arm mounting

2. Literature Review

This chapter literature review of dissertation work includes study of design and analysis of trailing arm. Also study the various optimization techniques. For the finite element based

optimization purpose the study of suitable software for optimization of weight will carry out by referring different books and earlier research works published in reputed journals.

Following is a list of researchers who has worked in this area of trailing arm and optimization. The combination with the following literature research on the latest use of alternate materials is expected to make the investigation as complete as possible.

Kali Charan Rath, Debasish Shee, "Some Aspects of CAE for Modelling and Analysis of Trailing Arm of Auto-Rickshaw", International Journal of Emerging Trends in Engineering and Development Issue 3, Vol.6 (November 2013) ISSN 2249-6149

In this paper, author has performed structural and modal analysis on trailing arm of auto rickshaw. Torque, torsional stiffness, bending stiffness has been calculated. Analysis by assigning suitable material, properties is done in Ansys. Output of analysis results was stress and deformation which were found well within the safe limit.

Mr. Milind M. Gore, Dr. B. P. Ronge ,Prof. N. D. Misal, "A Review Paper On Design And Analysis Of System Of Three Wheeler", International Journal of Application or Innovation in Engineering & Management , Volume 4, Issue 5, May 2015 ISSN 2319 – 4847.

The authors have studied vibrational analysis on three wheeled vehicle (TWV). The vehicle models based on finite element method have become a practical alternative to rigid body models. A wobble instability is one of the major problems of a three wheeled vehicle commonly used in India, and these instabilities are of great interest to industry and academia. In this paper, they have studied this instability using a multi-body dynamic (MBD) model and with experiments conducted on a prototype three wheeled vehicle (TWV) on a test track.

Thomas Gyllendahl, David Tran, "Development of an auto rickshaw vehicle suspension", Thesis for Bachelor of Science in Engineering Technology, Automotive Engineering, Sweden.

A project was started by Lulea University of Technology where a hybrid auto rickshaw concept was developed in collaboration with TVS Motor Company Ltd.; which is an Indian manufacturer of auto rickshaws.a development of the suspension was carried out to analyse if the negative handling characteristics typical for a three wheeled vehicle could be improved in the hybrid auto rickshaw. The goal of this thesis work was to develop a vehicle suspension intended for an auto rickshaw. A variety of different suspension types were investigated and evaluated, suspension types were chosen.

VenkataMangarajuKaranam, AshitavaGhosal, "Studies on wobble mode stability of a three wheeled vehicle, "Studies on wobble mode stability of a three wheeled vehicle", Research and Development, TVS Motor Company Ltd., Hosur, India

A wobble instability is one of the major problems of a three wheeled vehicle commonly used in India, and these instabilities are of great interest to industry and academia. In this paper, we have studied this instability using a multi-body dynamic (MBD) model and with experiments conducted on a prototype three wheeled vehicle (TWV) on a test track. The MBD model of a three wheeled vehicle is developed using the commercial software ADAMS-CAR.

Damtie Enawgew "Strength analysis of three wheeled vehicle's chassis and body frame assembled in Ethiopia" A thesis submitted to school of Mechanical and Industrial Engineering, Ethiopia.

Three-wheeled vehicles are becoming a popular and common means of short distance transport in Ethiopia. It is significant to know the current strength situation of three wheeled vehicle frames to be confident on their load carrying capacity, service and use. They are antiquated, unsafe and highly polluting, so there is substantial room for improvement in this huge market. A new three wheeled vehicle is designed, safer, more modern and easier to manufacture.

Ayman A. Aly, and Farhan A. Salem, "Vehicle Suspension Systems Control: A Review", International Journal Of Control, Automation And Systems Vol.2 No.2 July 2013, ISSN 2165-8277.

In this paper, A quarter-car 2 degree-of-freedom (DOF) system is designed and constructed on the basis of the concept of a four-wheel independent suspension to simulate the actions of an active vehicle suspension system.The purpose of a suspension system is to support the vehicle body and increase ride comfort. The aim of the work described in this paper is to illustrate the application of intelligent technique to the control of a continuously damping automotive suspension system. Jeffrey L. Glass, "Experimental Evaluation of a Trailing-Arm Suspension for Heavy Trucks", Thesis submitted to the Faculty of the Virginia.

This study includes an experimental evaluation of a prototype trailing-arm suspension for heavy trucks. The primary goal of this new suspension is to match or improve the kinematics and dynamic performance of an existing "Z-bar" suspension. Significant reductions in cost, weight, and number of parts are the main reasons for this redesign. The kinematics tests include vertical stiffness, roll stiffness, and roll steer measurements for each suspension.The dynamic testing consists of three input signals commonly used for such tests, namely: a chirp signal input, a step signal input, and a range of pure tone inputs.The test results show that the resonant frequencies of the two primary suspensions differ by an amount that is most likely too small to affect ride dynamics.

AniketThosar, "Design, Analysis and Fabrication of Rear Suspension System for an All Terrain Vehicle", International Journal of Scientific & Engineering Research, Volume 5, Issue 11, November-2014 258 ISSN 2229-5518.

All Terrain Vehicle (ATV) is defined by ANSI as a vehicle that travels on low pressure tires, which is used to handle any kind of terrain it faces. The paper focuses on design of rear suspension system for an ATV. The paper covers simulation, modeling and analysis of suspension geometry. Suspension is designed such that it provides better handling and better comfort for an ATV.

S.Pathmasharma, J.K.Suresh, P.Viswanathan, R.Subramanian, "Analysis of Passenger Car Suspension System Using Adams", International Journal of Science, Engineering and Technology Research, Volume 2, Issue 5, May 2013, ISSN: 2278 – 7798.

This paper discusses about the analysis of the existing of the suspension system and improved design is suggested for achieving maximum comfort. Passenger vehicle suspension system data from the existing vehicle are collected and a model is created using UG. Automatic dynamics Of Mechanical System (ADAMS) has become an important feature of roadside hardware design and analysis in recent year. Using ADAMS analysis of existing model is carried out to determine the forces acting on components of suspension system.

3. Problem Statement and Objectives

3.1 Problem statement

- To design and optimize the trailing arm used in auto rickshaw.
- On most models, trailing arms can collapse leading to dangerous consequences. There are numerous reports of the arm cracking and collapsing. If this should happen at highway speeds you could lose control of the vehicle.

3.2 Objectives

- To prepare a CAD model from input parameters: sketch, photographs and hand measurements, using 3D Designing software Tool.
- To analyze its real time Boundary conditions and recommend required changes for design optimization.

4. Modelling and Analysis of Trailing Arm

4.1 Trailing arm model

Figure 5: Trailing arm under study

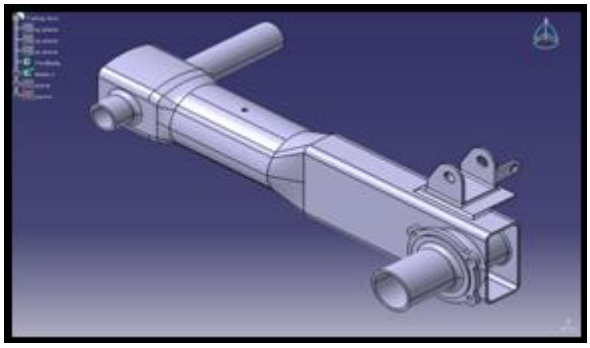

Figure 6: Trailing arm CAD model

4.2 Analysis of trailing arm

Figure 7: Constraints and forces applied on model

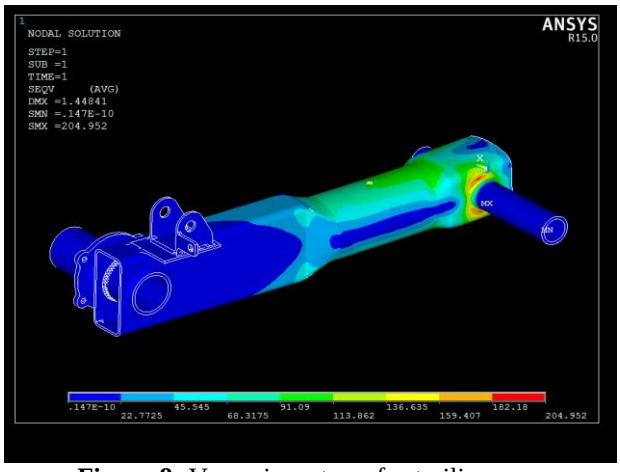

Figure 8: Von-mises stress for trailing arm

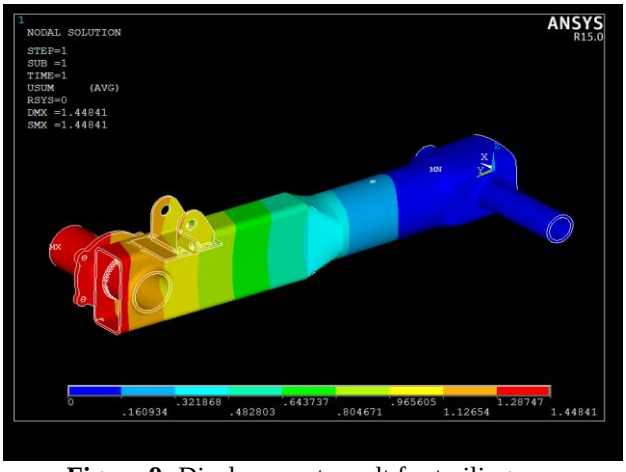

Figure 9: Displacement result for trailing arm

5. Optimization of Trailing Arm

Optimization of the trailing arm is done on the basis of material removal from the base model. The sample result for iteration 1 is shown below and accordingly analysis is done for all iterations and results are summarized in table 1.

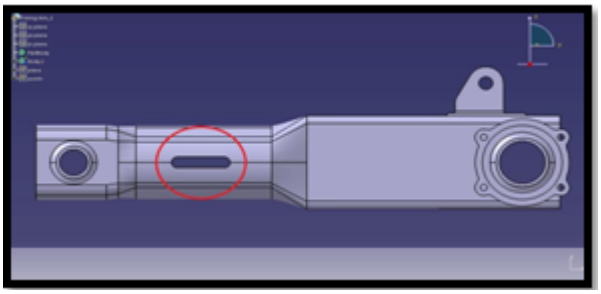

Figure 10: CAD drawing for iteration 1

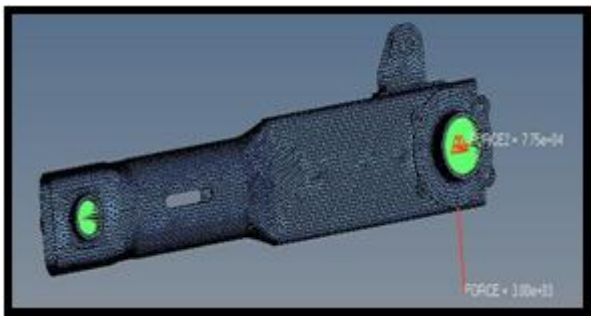

Figure 11: Meshed model of trailing arm of iteration1

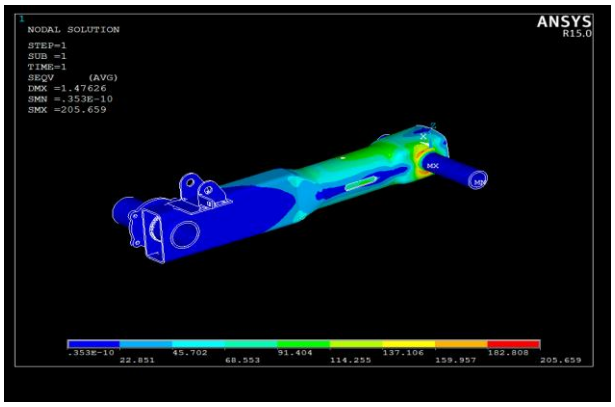

Figure 12: Von-mises stress for trailing arm

Stress value for trailing arm is 205.65 N/mm^2 which is well below the critical value. Hence, design is safe.

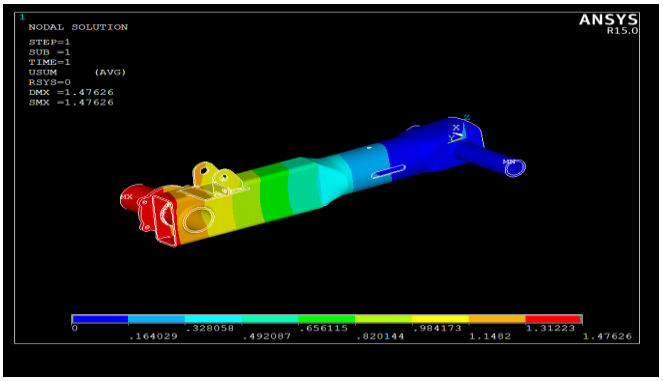

Figure 13: Displacement result for trailing arm

Table 1: Results for Base and iteration models

S. No	Parameter	Max. Stress	Max. Displacement	Mass
1.	Original model	204.95 MPa	1.44 mm	3.037 Kg
2.	Iteration 1	205.65 MPa	1.47 mm	3.018 Kg
3.	Iteration 2	206.57 MPa	1.5 mm	2.978 Kg
4.	Iteration 3	204.89 MPa	1.51 mm	2.97 Kg
5.	Iteration 4	195.46 MPa	1.53 mm	2.8 Kg

% reduction in weight = 3.037 – 2.8/3.037
= 7.8 %

6. Conclusion and Future Scope

6.1Conclusion

- Existing trailing arm shows higher stresses 204.95 MPa, deformation of 1.44 mm and weight of the same is 3.037 kg.
- Modified trailing arm shows the stresses of 195.45 MPa, deformation is 1.53 mm and weight of the same is 2.8 kg.
- The stresses generated in modified model are comparatively low, while deformation is on the higher side but it's within allowable limit. The weight of the modified model is 7.8% less than the existing model.

6.2 Future Scope

- NVH can be performed for further investigation..
- Composite material can be tested as option for alternate material.

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