International Journal of Engineering, Science and Mathematics
Vol. 6 Issue 8, December 2017 (Special Issue)
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Optimum Material Evaluation for ManufacturingL-Angle of 3-Wheeler

C. V. Gopinath*
ChitturiTejaswi**

Abstract

In the present scenario of automobile sector, auto rickshaws (3-wheelers) are the most sought after public transport among the urban and rural poor in India. Majority of people depend on these vehicles after public transport systems like Road Transport Corporation. Among these 3-wheelers, 7-seaters are the most popular and a lot of developments are seen in the past few years. MLR Motors Pvt Ltd, Hyderabad is a 3- wheeler manufacturer which is trying to mark its presence in the market. "TEJA" The vehicle manufactured by the company has a seating capacity of seven persons including the driver. The vehicle has a worm and roller type steering gear mechanism unlike other conventional auto rickshaws fitted with handle bars. Manufacturing of an auto rickshaw involves assemblies of several major components. L-Angle of the auto rickshaw is one such major component. It connects the floor and front panel and plays a vital role in design and development of the vehicle.

The project work deals with modeling and analysis of the L-angle, subjected to structural loads. The analysis is carried out to optimize the L-angle by analyzing the behavior of the L-Angle for varying thicknesses, different materials and modifications in design. The modeling of L-angle is first carried out in CATIA V5 R18 using Part Drawing and Surface Modeling module. The analysis is done using ANSYS 11.0 by importing the solid model from CATIA in IGES format. During the static and modal analysis the model is subjected to various loads, the results are derived and the optimized L-angle is proposed.

Keywords:

Surface Modeling;

StaticAnalysis;

Optimization;

Automotive Design;

Author correspondence:

Dr.C.V.Gopinath,
Principal,
Baba Institute of Technology and Sciences, Visakhapatnam, India

1. Introduction

*Principal, BITS, Visakhapatnam, INDIA

**M.Tech Student,Dept.of Mechanical Engineering, BITS, Visakhapatnam, INDIA

Auto rickshaws are one of the chief modes of transport in many Asian countries. In India, these vehicles are mainly used as taxis. Since there is heavy congestion on the roads of India, the small size and narrow body of this three wheeled vehicle is perfectly suited to navigate the roads. These vehicles are usually powered by a two or four stroke petrol engine.

India is the fourth largest commercial vehicle market worldwide. However in spite of such credentials, the commercial vehicles segment has probably grown at the most sedate pace since the de licensing of Indian auto industry in 1991. However, post-2006 the industry showed a sudden surge in demand. Presently, commercial vehicles account for more than 60% of the total freight movement in the country. Increasing economic activity, especially the infrastructure, construction and mining activities, has been the principal growth drivers.

In a developing country such as India, three–wheelers are preferred as low-cost means of transport in cities and towns. Auto rickshaws are one of the chief modes of transport for middle-class, lower-middle class, and low-class income group people for their daily commuting as well as commercial purposes in urban and rural areas hence these vehicles are mainly used as taxis.

An auto rickshaw is generally characterized by a sheet-metal body or open frame resting on three wheels, a canvas roof with drop-down sides, a small cabin in the front of the vehicle for the driver (sometimes called an *auto-wallah*), and seating space for up to three passengers in the rear. They are generally fitted with an air-cooled scooter version of a two-stroke engine, with handlebar controls instead of a steering wheel. Many auto rickshaws follow the original design of the Piaggio Ape C, from 1956, which was originally based on the Vespa. Auto rickshaws are light duty vehicles. Typical mileage for an Indian-made auto rickshaw is around 35 kilometres per litre of petrol (about 2.9 L per 100 km, Auto rickshaws have a top-speed of around 50 km/h (about 31 mph) and a cruising speed of around 35 km/h (22 mph), much slower than the Automobiles they share the road with. The triangular form of the auto also makes maneuvering easy, with the front single wheel negotiating the available gap, and the rear two wheels forcing a larger space. The following are some of the 3-wheeler Autos of different companies in India.

Bajaj Auto rickshaw –This model is most commonly used in India

Piaggio Ape–This is the most commonly used commercial 3-wheeler model of piaggio motors

MLR Motors passenger and cargo vehicles

As the 3-wheeler automotives are of both passenger carrying and load carriers they undergo heavy loading and even over-loading at times which transmissively effects in the deformation or sometimes the failure of body structure components .This project focuses on one such component which plays a key role in holding the shape and contour of vehicle by providing reinforcement to the front panel and floor namely "L-ANGLE" .The case undertaken is that L-Angle is failing due to sustained structural loads.

1.1 Description of the L-Angle

L-Angle is a major component in the design of the 3-wheeler auto rickshaw. Its primary function is to provide reinforcement to the 3 piece front panel of the vehicle. It acts as the molded bracket to the floor of the vehicle. The strength of the L-Angle is vital for the design of the front panel and the floor as it connects the two components. The failure of the L-Angle would mean the front panel and the floor are no longer connected and the vehicle would lose its load carrying capability along with the front panel being opened up losing its aerodynamic shape.

L-Angle

Fig.1 Captured Image showing location of L-Angle of 3-wheeler Passenger vehicle

2.Literature Review

In the year 1942 a research paper was published by Dr. J.Ratzersdorfer in the journal named Air-craft engineering and Aero-space technology about placing the rectangular plate stiffeners to avoid buckling of simply supported beams under compressive stress.

In the year 1973 a technique was proposed by Prof. Susumu Teramoto and Tetsuro Kawasaki to Mitsubishi motors regarding maintaining the Fatigue strength of welded tubular joints with various stiffeners in off shore structures.

In the year 2006 a journal was published by B.W.Schafer and A.Sarawit [1] the faculty of Hopkins University in placing complex edge stiffeners for thin-walled members to withstand the stress.

In the year 2009 a technical paper was published by Tian Ran Lin , Peter o'shea, Chris the faculty of Queens land University to reduce the magnetic resonance imaging coil vibration by placing rib-stiffeners.

3.Failure Analysis of the L-Angle

The manufacture of the Auto rickshaw involves the assemblies of several major components. L-angle is one such major component which provides reinforcement to the front panel and acts as molded bracket to the floor of the 3-wheeler 7-seater auto rickshaw. It is reinforced to the 3-piece front panel by means of spot welding and to the floor by means of bolts. The overall length of the L-Angle is 1383.5mm with thickness of 2.5mm. A total of 9 holes, at prefixed distances are provided for the bolting of the L-angle to the floor of the vehicle. The diameter of each bolt is 9mm. The material used for the manufacturing of the L-Angle is carbon steel DD (Deep Drawing) as per IS-513.

The problem being, permanent deformation and failure of the L-Angle with the existing part that is in service has been observed over a period of time. Hence forth the L-Angle has to be redesigned in order to overcome this problem.

4. Design and Analysis

The existing design of the L-Angle is modified by placing stiffners(beads) at equal spacing to develop the modified design which enhances the stress distribution. The modeling of the L-Angle is carried out using the modeling software CATIA V5 R18.The solid model is created using surface design and part design modules in CATIA. Later it is analyzed in ANSYS version 11.0, considering the structural loads. The analysis is carried out for the L-Angle for varying thicknesses, different materials and modification in design. Elastic Shell 63 element is considered in the analysis. The analysis is first carried out for the existing L-Angle model to find out stress levels at static conditions and at maximum loads. Modified L-Angle is also explored for the induced stresses. Further the investigation is carried out for higher loads, to find out the maximum load carrying capacity within the permissible stress of the material considered.

Material used for manufacturing of existing as well as modified L-Angle is Carbon Steel DD, as per IS 513 The material properties of carbon steel and the other materials considered for analysis are taken from the following Table1.

Table No. 1 Mechanical Properties of Different Materials

Material	Yielding Strength (MPa)	Ultimate Strength (MPa)	Young's Modulus (MPa)	Density (tonne/ $m^{3)}$	Poisson's Ratio
Low Carbon Steel (DD)	215	390	2.1x10^5	7.89x10^9	0.30
Cast Iron	85	220	1.2x10^5	7.20x10^9	0.28
Wrought Iron	210	320	1.9x10^5	7.75x10^9	0.30

4.1 Loading Considerations considered for Static Analysis

1. Unladed weight of the vehicle

Kerb weightwhich is the total weight of a vehicle with standard equipment, all necessary operating consumables (e.g. motor oil and coolant), and full tank of fuel, while not loaded with passengers.

- Kerb weight of the vehicle under consideration= 435 Kg

Gross weight which is the maximum allowable total mass of a road vehicle when loaded - i.e. including the weight of the vehicle itself plus fuel, passenger weight.

- Gross weight of the vehicle under consideration= 855 Kg

2. Loads influenced by Front panel includes front panel weight, weight of on- board equipment, glass pane weight etc.

The total load considered on the L-Angle for static analysis= 8KN

4.2 Idealization of L-Angle

The L-Angle is of complex shape, and cannot be idealized in 1D or 2D modeling. The 3D solid modeling of the L-Angle is idealized (Fig.2) in CATIA *surfaceand part design* modules. The analysis is performed on the L-Angle considering different materials.

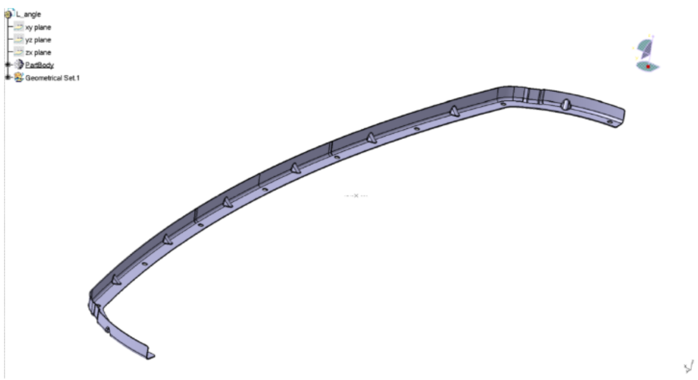

Fig.2 Solid Model of the L-Angle

4.3 Meshing

Meshing generation refers to the generation of nodal coordinates and elements. It also includes the automatic numbering of nodes and elements based on a minimal amount of supply data. The two types of meshing available in ANSYS are free mesh and mapped mesh. Free mesh has no restrictions in terms of element shapes, and has no specified pattern applied to it. While in mapped meshing it is restricted in terms of the element shape, contains pattern of mesh. Mapped mesh needs to build the geometry as series of regular volumes/ areas.

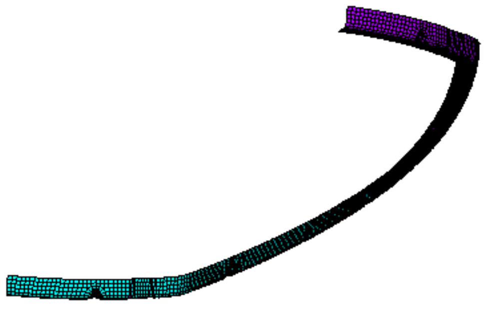

Fig 3 Meshing Model of L-Angle

Present L-Angle can be meshed either by free mesh or map mesh as it is of regular shape. The above figure shows the meshing finite element model of a L-Angle.

4.4 Boundary Conditions considered for Static Analysis

The L-Angle is constrained at the locations where it is spot welded to the front panel and bolted to the floor of the vehicle. All Degrees of Freedom (DOF's) are arrested at these locations for the static analysis of the L-Angle. i.eF_x=0, F_y=0, F_z=0, M_x=0, M_y=0, M_z=0 at these locations.

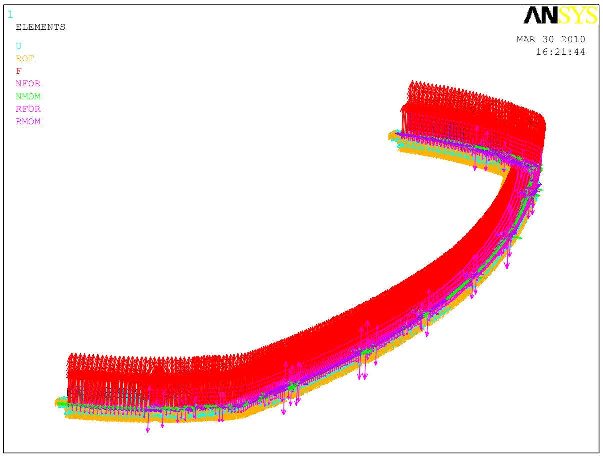

Fig.4 Model of L-angle with applied Boundary conditions and Loads

4.5 Stress Contours in ANSYS software

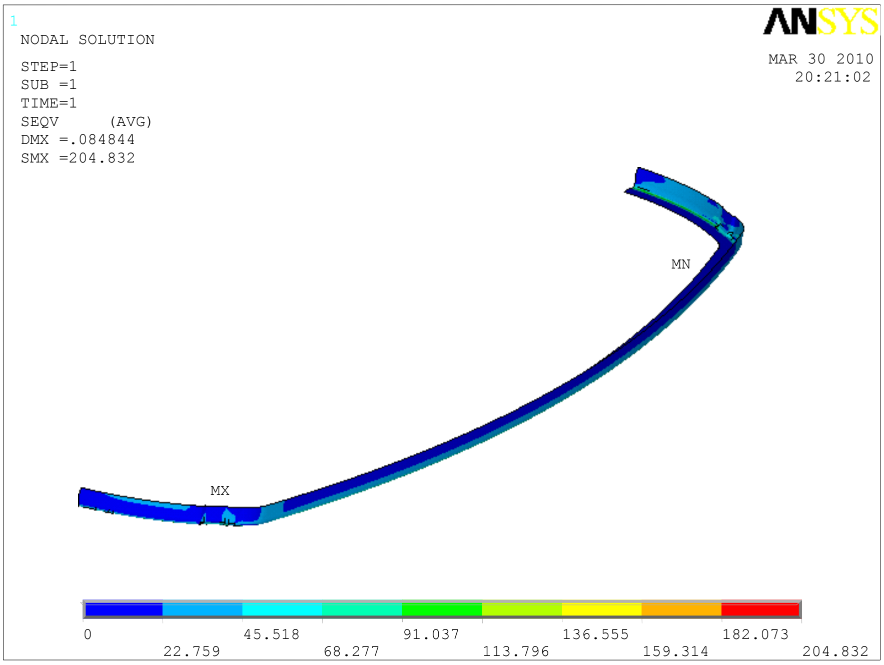

Fig.5 a)Existing Model

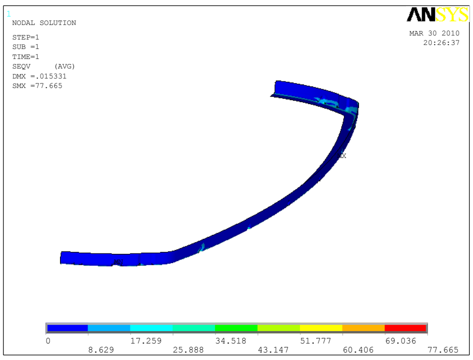

Fig.6 b) Modified Model

5.Results and Conclusion

The generated finite element model of L-Angle is analyzed in ANSYS software for the given loading and boundary conditions. The static analysis is performed on the L-Angle. The modification done to the L-Angle, with addition of stiffeners is analyzed for different thicknesses and different materials and it has been observed that strength has increased considerably. The modified L-Angle of 2.5mm thickness of Carbon steel-DD(as per IS-513) material with stiffeners is observed to be a much efficient design as it can retain up to 175% of its original load. Results of the analysis are discussed in the succeeding sections.

5.1 Static Analysis

Basic aim of static analysis is to find out the stress and deflections of structure under static loading conditions. L-Angle is analyzed for 3 different materials with varying thicknesses. In this analysis different stress values are observed, and some stresses are found to be within the limit (yield strength of the material) which is the basic criterion for the static analysis.

Table No.2 Stress values for varying thicknesses of carbon steel

Sl No.	Thickness of component (mm)	Stress values for Existing component without Stiffners (MPa)	Stress values for Proposed component with Stiffners (Stiffner Thickness=Sheet Thickness) (MPa)
1	1.6	422.11	186.6
2	1.8	348.21	147.71
3	2.0	293.48	119.6
4	2.2	251.60	99.16
5	2.5	204.8	77.2
6	2.8	170.742	62.67

Yielding Stress of Carbon Steel = 215 MPa
Ultimate Stress of Carbon Steel= 390 MPa

Tableno.3 Stress values for varying thicknesses for different materials

Sl no	Material	Stress (MPa) for 1.6mm thickness	Stress (MPa) for 1.8mm thickness	Stress (MPa) for 2.0mm thickness	Stress (MPa) for 2.2mm thickness	Stress (MPa) for 2.5mm thickness	Yielding Stress (MPa)	Ultimate Stress (MPa)	Young's Modulus (MPa)
1	Carbon Steel(DD) As per (IS-513)	**186.6**	147.71	119.6	99.16	**77.24**	**215**	390	2.1x10^5
2	Cast Iron	215.21	188.31	161.41	134.51	89.48	85	220	1.2x10^5
3	Wrought Iron	**188.117**	162.85	136.59	116.32	**77.66**	**210**	320	1.9x10^5

From the above table carbon steel and wrought iron are found to be within the safe limit. The highlighted values indicate the safe stress values.Carbon steel is considered as the material for manufacturing of the existing component. Though wrought iron is a brittle material by its nature, it is observed that wrought iron is retaining the designed stresses to reasonably good extent. However due to the ease of fabrication of carbon steel, it is preferred over wrought iron. As the complete automotive is made with carbon steel , it is proposed to consider carbon steel material for the modified component.

Graphs

The following graphs are plotted for the static analysis

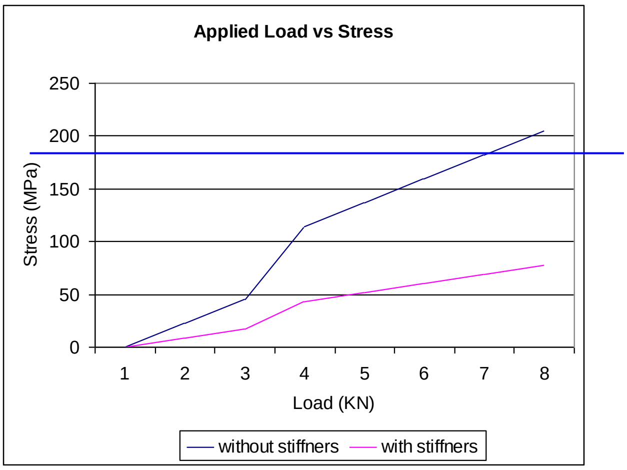

Fig. 7 The Applied Load vs Stress Graph shows the behavior of the L-Angle for 2.5 mm thickness with stiffners (modified design) and 2.5 mm thickness without stiffners(existing design).

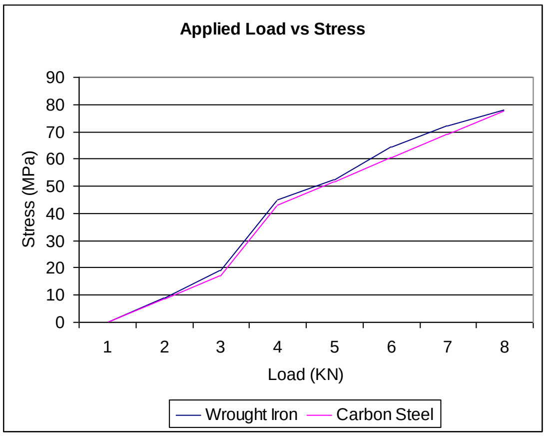

Fig.8 The Applied Load vs Stress Graph shows comparison between carbon steel and wrought iron for different loading conditions.

6. Acknowledgements

The authors are thankful to M.L.R. Motors Private Ltd for permitting and providing the necessary technical data related to the L-Angle and the 3-wheeler to execute this project.

7. References

[1] Journal on "Complex edge stiffeners for thin-walled members to withstand the stress" by B.W.Schafer and A.Sarawit.