Weight Optimization of Tow hitch by using FEM and UTM

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ABSTRACT

This Paper is focusing on the weight optimization of the tow hitch. Every manufacturer is focusing on the reduce the weight of their end product and to optimized the design. He is basically wants to reduce the raw materials cost that means product should be made within smallest possible material. As we know weight reduction part can't be easily obtained without doing any detailed analysis on the product. So in this project we did, Experiment analysis of existing tow hitch that is tow bar to determine the stress and deformation. Based on the results obtained, later topology optimization is to be carried out for the best optimized model. Aim of the optimized model is to save the material which is a now a days main focus of manufacturer. Also to reduce the cost as well as sustaining existing boundary condition. We have manufactured optimized model by using topology optimization technique. Manufactured new optimized model is compared with existing model of tow hitch and analyzed in the ANSYS software. So the main aim of our project is to optimize the existing tow hitch in order that the weights are reduced but without affecting the strengths of the model. Firstly, The 3D model was drawn with the assistance of CATIA V5 software package. The static analysis in ANSYS was done to determine deformation, stress and optimized model by topology optimization was carried out with the assistance of ANSYS 19.The experimental testing was done at that point the comparative study was done between analytical & experimental results at that point result & conclusions were drawn

Keyword : - *Tow Hitch, Optimization, ANSYS 19*

1. INTRODUCTION

A tow hitch, also referred as tow bar/tractor hitch or bracket is a device which can be mainly used to established a well connections in between the towing vehicle and a trailer. Same role can be performed by the drop tow hitch but only the difference is in this case is nothing but the ball mount is well located more lower than that for the towing vehicle's tow hitch receiver. Whereas the drop tow hitches should fulfil the strict criteria as they are representing the linkage between two moving vehicles and safety concern must come here. It concern with moving vehicles that means load which is going to applied on it is a cyclic and not the uniform. It is dangerous to deal with continue applying loads as we know it develops some deformation after number of cycles. This occurs as the increasing cycle declines the stress and deformation which is within limit so it leads to cause small small plastic deformations within the component. Which consequently results into the failure of the component as that's why the whole assembly. For better understanding of our topic we will see some predesigned towing, mounting objects used in automobile vehicles, agricultural industries also some are used for military purpose that means in hilly and not so common road for the vehicles

1.1 Trailer Hitch System

Use of the trailer hitch is for improving the speed and safety of attached trailer to a tow vehicle The hitch might including the shank that can be attached to the trailer through a ball hitch. A receiver can be given on the tow vehicle in such a way that the attachment between the trailer and the tow vehicle will be completed by introducing a shank of vehicle into the receiver while tow vehicle is coming back to the trailer. shank extends within the receiver. A For facilitating the aligning of the shank with the receiver we can used a funnel shaped guide member . Shank & Receiver can be worked well with the friction reducing rollers to give the better results In addition to this we can used the provision of height adjustment and the visual guidance system which will be facilitating for the connection between trailer and the tow.

1.2 Weight-distributing hitch

A weight-distributing hitch is commonly referred as a "load levelling" hitch as it distribute the load between tow and towing object. Mainly used for distributing the part of the trailer's hitch from the towing vehicles rear axle to front axle, this set up of hitch is mounted on the tow vehicle which is using the spring bars and the chains under tension. Hopping and swaying of the trailer can be reduced by this weight distributing hitch. We know that hopping of the trailer can gives the jerk to tow vehicle. Swaying of the trailer is referred as fish tailing sometimes. It becomes more dangerous and fatal at the very high speeds. In market most of the manufacturers offering max trailer capacity as 2300kg to the 230 kg of tongue weight deprived of utilizing weight distributing. For accepting the weight distributing hitches tow vehicles provides the square receiver sockets frequently.

Fig. 1.4 Weight-distributing tow hitch [10]

2. LITERATURE REVIEW

[1] Hemanth K. and et al went for the styling and analysis of rigid tow bar to recovering from damage. He studied on the mining trucks which are used for underground mining, Problem was that initially the load that was carried by the these trucks were around 30-35 tons ,but in some of the earlier decades their capacity was increased up to 50-55 tons. Due to which breaking of the tow bars happened as it didn't have sufficient strength and stiffness. Author developed design and did analysis of the tow bar of mining truck resulted in increasing its stiffness and strengths so it can carry increased weight for mining purpose. Finally concluded that the new designed tow bar was helpful for that mining trucks with required factor of safety and the required life. and all results were came well within the defined limits as per the problem.

[2] Cosmin R. and et al studied the analysis for the fireplace truck drop tow hitch which is mainly used as an O1 category pump trailer. FEM analyses the different features with 4 geometry variants. Author had done the calculations of the loading forces ,supporting 2 different weights with two separate methods. And concluded that the extra for addition of stiffening elements was done for the bottom design of the component. And had decreased the highest deformation values. These analysing results showed that the stress and strain values are at its greatest value at welding and the screw points. This was the reason we required an experimentation results to validate our research.

[3] Abdulkarim K.O. and et al performed FEA for the mini harvester, chassis and hinge for this paper. This study was basically done for agricultural problem which was faced by farmers in Africa. For that farmers affordable

equipment's should be given as they were facing the financial problems always so aim was to made the equipment with featuring affordable, durabale and efficient. Results were calculated that is to calculate factor of safety, life of the components and also the various analysis done on the component. Author stated that he had done successful analysis with desired results in comparison with the previous one. And also it was made possible to design and manufacture the affordable, optimize and durable component. Also the tools used that means software came out as powerful and useful .

[4] Henry K. and T. Szostak investigated regarding the trailer towing. Under the stability factor K, repeatable, sensitive and the easily determining of handling the parameters to quantify the combined vehicles stability that is steady state. Author had put forward an approach of using k for quantifying a maximum towing hitch's requirement that were imposed on the towing vehicle. They also further studied on the Ackermann steering angle. The Author concluded that the vehicle claimed to be oversteering when our stability factor K is negative as the less steering angle is needed than that for neutral steering . Vehicle exhibiting the nominal under the steering features, this occurs when the value of K is positive the vehicle exhibits the nominal under steering characteristic.

3. Objective

3.1 Objective

- Experimental analysis and topology optimization of actual hitch of vehicle.
- Development on structural design and weight reduction of tow hitch by the use of optimization
- Finite Element Analysis on the actual hitch of vehicle
- To develop a new model of the tow hitch by topology optimization
- To calculate the equivalent stress on component, total deformation of component, and then the weight of optimized hitch model.
- To perform experimental testing of new optimized hitch model on UTM.
- Experimental testing and then correlating results.

3.2 Methodology

- Modelling of actual hitch (or tow bar) in CATIA software.
- Analysis in ANSYS to determine deformation, stress and optimized model by topology optimization.
- Experimental analysis to determine experimentally deformation, stress.
- Validation of results by experimental and numerical method.
- Manufacturing of new optimized model obtained by topology optimization

CATIA MODEL **Drafting**

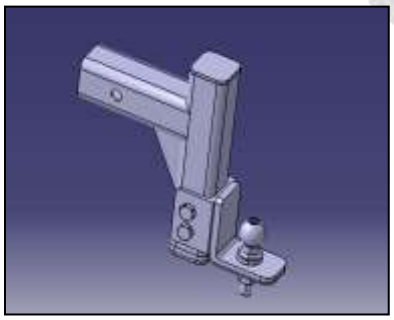


Fig 2 Catia Design of tractor hitch

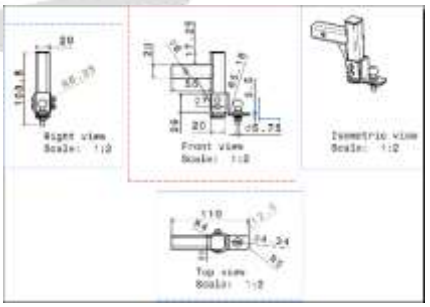


Fig 3 Drafting Of tractor hitch

FEA ANALYSIS OF TRACTOR HITCH IN ANSYS

Material Selection – **Structural Steel**

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modulus and Pois...	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.6667E+11	Pa
11	Shear Modulus	7.6923E+10	Pa

Fig..4 Material properties of SS

Geometry

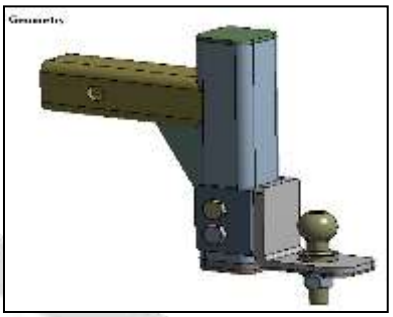
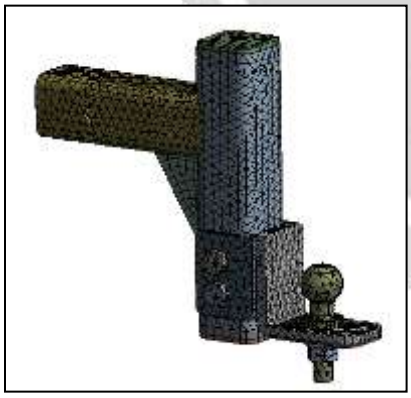


Fig. 5 Geometry of tractor hitch

MESH

Meshing is the most important aspect of FEA. ANSYS Meshing is what :general-purposed, an intelligent based, an automated approach with high-performance desired product results . It gives us the results with the most appropriate meshing for accurate, efficient Multidisciplinary solutions. A mesh is so power full tool which is well used in a many kind of specific analysis as we can initiate the result generation with a just single mouse click for a required parts in a model in a single go



Details of "Body Sizing" - Sizing	
Scope	
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Suppressed	No
Type	Element Size
Element Size	3.0 mm

Fig. 6 Meshing of tractor hitch

Boundary Condition

A boundary condition for the model is that the setting of a notable value for a displacement or an associated load. For a specific node you'll set either the load or the displacement however not each. The main sorts of loading offered in FEA include force, pressure and temperature. These will be applied to points, surfaces, edges, nodes and components or remotely offset from a feature.

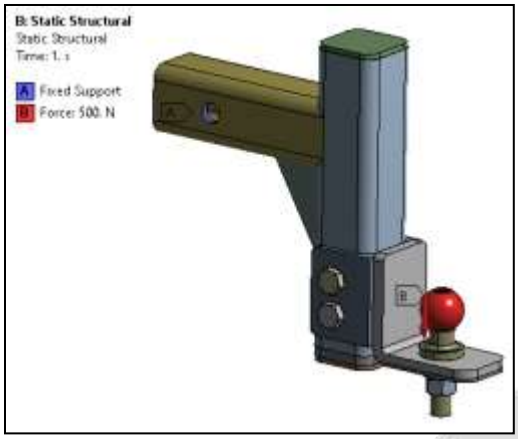


Fig. 7 boundary condition of disc brake

In present research tractor hitch is used to determine the yield strength of material under different load namely 500 N, 1000 N and 1500N.

Results

Total deformation

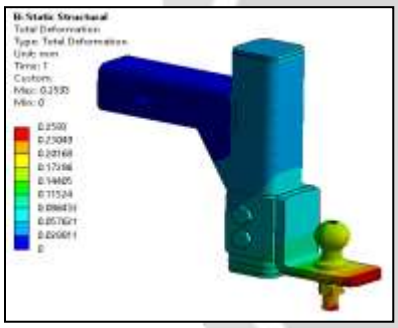


Fig. 8 Total deformation of tractor hitch under static condition

Tabular Data

	Steps	Time [s]	X [N]	Y [N]	Z [N]
1	1	0.	0.	0.	0.
2	1	1.	0.	-500.	0.
3	2	2.	= 0.	-1000.	= 0.
4	3	3.	= 0.	-1500.	= 0.
*					

Fig.9.Tabular data of applied load

In present 3 load step of force as 500, 1000, 1500 N is applied. It is observed that yield occurs are 656 MPa.so, steel of 850 grade material be selected to sustain load at extreme condition.

Safety Factor

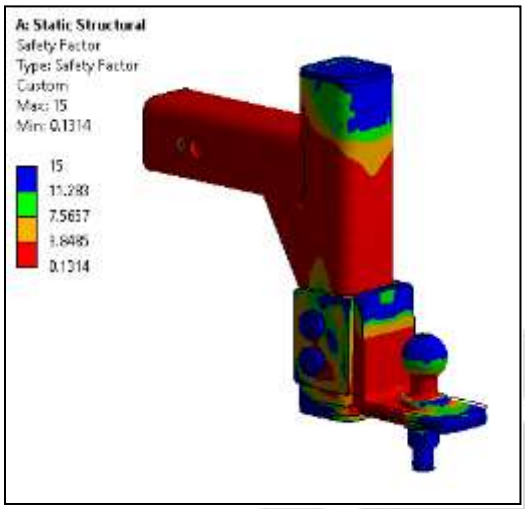


Fig. 10 Safety factor of tractor hitch under static condition

TOPOLOGY OPTIMIZATION

Topology optimization may be a mathematical approach that optimizes material layout within a given design area, for a given set of loads and boundary conditions such that the resulting layout meets a prescribed set of performance targets.

Fig. 11 Details of boundary conditions for topology optimization

In boundary condition of topology optimization exclusion region are boundary condition applied in static structural analysis these are excluded.

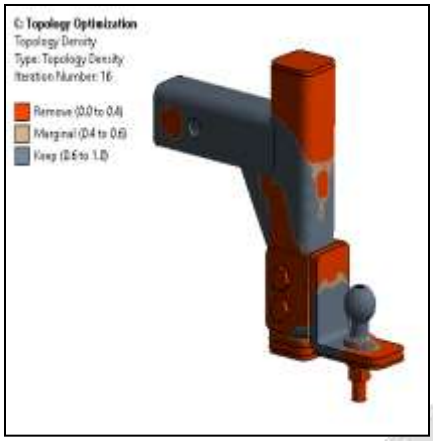


Fig. 12 Topology optimization results

FEA ANALYSIS OF OPTIMIZED TRACTOR HITCH IN ANSYS

Geometry

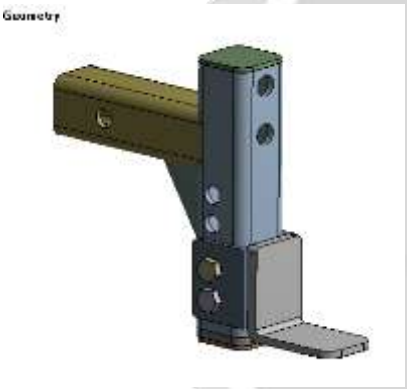
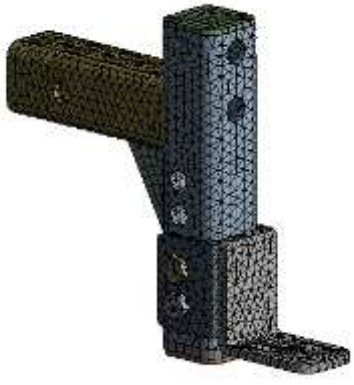


Fig. 13 Geometry of optimized tractor hitch

MESH



Details of "Body Sizing" - Sizing	
Scope	
Scoping Method	Geometry Selection
Geometry	14 Bodies
Definition	
Suppressed	No
Type	Element Size
Element Size	3.0 mm

Statistics	
Nodes	39185
Elements	19240

Mass	0.21396 kg

Fig. 14 Meshing of optimized tractor hitch

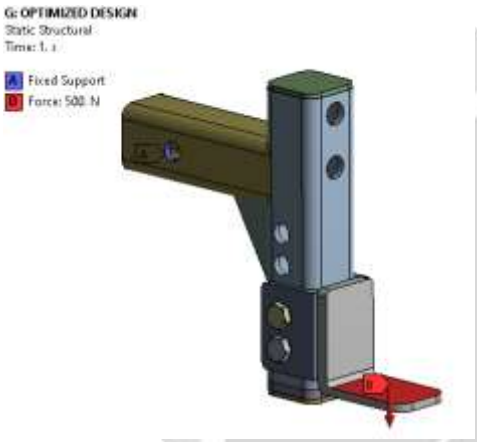


Fig. 15 Details of boundary conditions

Results of new optimized model

Total deformation

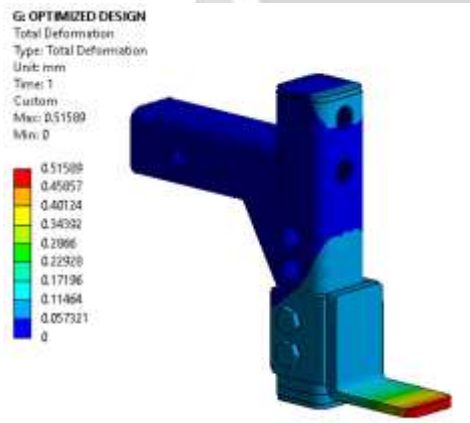


Fig. 16 Total deformation of optimized tractor hitch under static condition

Equivalent stress

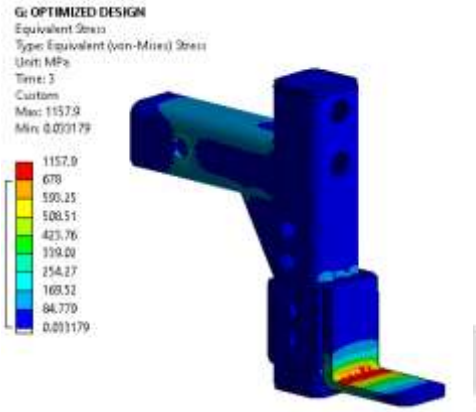


Fig. 17 Equivalent stress **of** optimized tractor hitch under static condition

EXPERIMENTAL SETUP

Specification of UTM

1	Max Capacity	400KN
2	Measuring range	0-400KN
3	Least Count	0.04KN
4	Clearance for Tensile Test	50-700 mm
5	Clearance for Compression Test	0- 700 mm
6	Clearance Between column	500 mm
7	Ram stroke	200 mm
8	Power supply	3 Phase , 440Volts , 50 cycle. A.C
9	Overall dimension of machine (L*W*H)	2100*800*2060
10	Weight	2300Kg

EXPERIMENTAL TESTING FEA

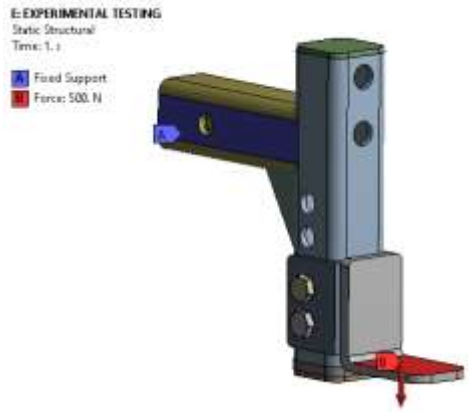
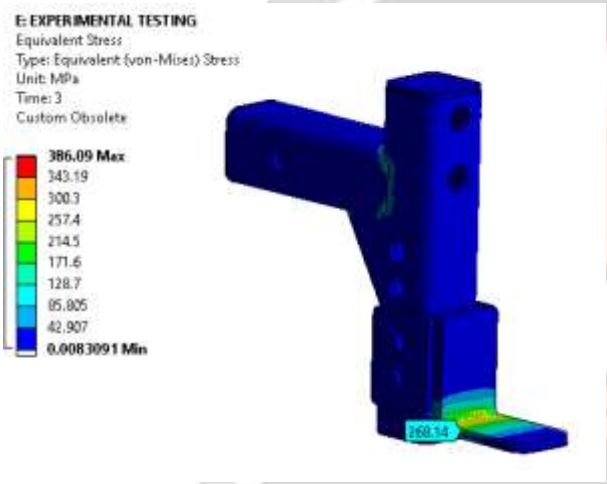
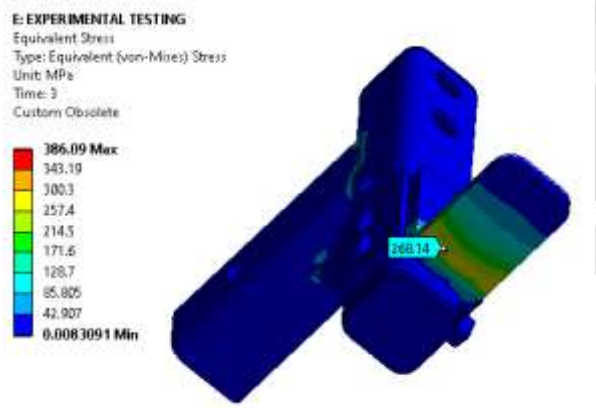


Fig.18 Optimized geometry imported in ANSYS





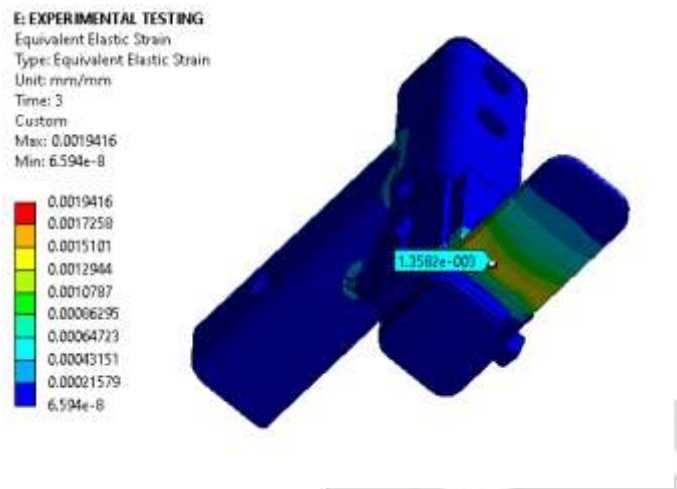


Fig.19 Different views of Experimental testing

Strain is observed around 1358 microns using FEA

Experimental procedure

- Fixture is manufactured according to component designed.
- Single force is applied as per FEA analysis and reanalysis is performed to determine strain by numerical and experimental testing.
- Strain gauge is applied as per FEA results to maximum strained region and during experimental testing force is applied as per numerical analysis to check the strain obtained by numerical and experimental results.
- During strain gage experiment two wires connected to strain gage is connected to micro controller through the data acquisition system and DAQ is connected to laptop. Strain gage value are displayed on laptop using DEWESOFT software.

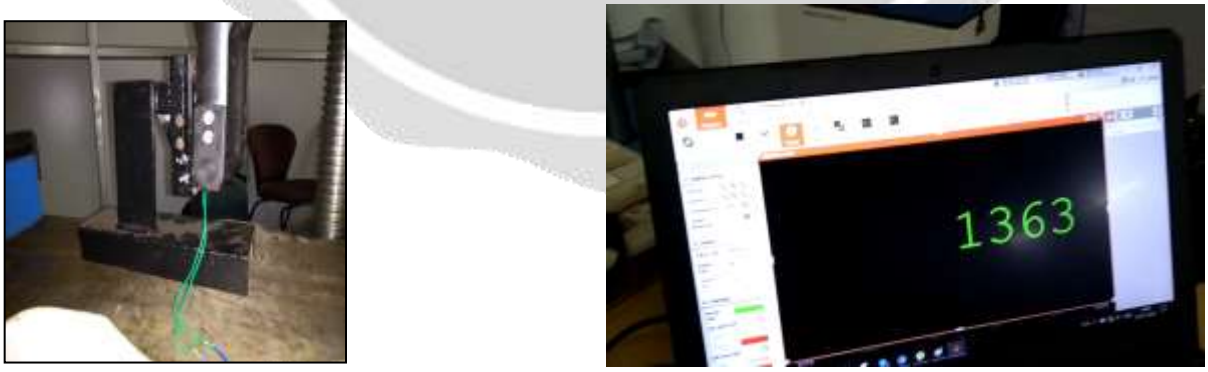


Fig. 20 Snaps of Experimental Testing of Component

4.CONCLUSION

- In present research static analysis of tractor hitch is performed to determine stress and deformation.
- It is observed from results maximum deformation around 0.2593mm so, it is convenient to used 850 steel grade.
- Also, safety of factor and fatigue life is determined for existing boundary condition.
- Weight reduction of around 13.7 % is observed along with strain measurement of 1358 microns and 1363 microns by numerical and experimental testing respectively.

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