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Experimental Analysis and Topology Optimization of Tow Hitch

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ABSTRACT: Experimental analysis of existing tow hitch (or tow bar) is performed to determine stress and deformation. Later topology optimization is to be carried out for best optimized model leads to saving of material, cost as well as sustaining existing boundary condition. Manufacturing of new optimized model is compared with existing and analyzed in ANSYS software. So, the main aim of our project is to optimize the existing tow hitch in order that the weights are reduced. The 3D model was drawn with the assistance of CATIA V5 software package. The static analysis was carried out with the assistance of ANSYS 19 software package. The experimental testing was done at that time the comparative study was done between the Analytical & experimental results and at that time the result & conclusion was drawn.

KEYWORDS: Manufacturing; Tow bar, reducing weight, design technique, fabrication ..

I. INTRODUCTION

A tow hitch (or tow bar) is a device used to provide a connection between a towing vehicle and a trailer. A drop tow hitch fulfils the same role, but in this case the ball mount is located considerably lower than the towing vehicle's tow hitch receiver. Drop tow hitches must meet strict criteria because they represent a linkage between two moving vehicles and therefore, they are safety relevant. The load applied to a drop tow hitch is cyclic and not static. The repetition of a static load is dangerous, because as the number of load cycles increase, the allowed stress and strain levels decline. Stress values which are located below the yield stress value of the used materials can also lead to small plastic deformations, which in turn may cause the failure of the part or assembly.

The fatigue analysis of welded structures can be analysed by using different concepts: stress, strain or fracture mechanics. These linear-elastic principals require the weld geometry to be designed with a reference radius, in order to calculate the stress values and see if they fall below the permitted values. The most preferred approach for different kind of welded constructions is the notch stress approach. When designing parts for automobile vehicles, other aspects need to be considered as well. The drop tow hitch transmits energy to the vehicle's occupants through the vehicle's chassis therefore energy absorption should be taken into consideration as well when designing such a product. In real situations however, there will always be a degree of uncertainty caused by unknown material properties, stress analysis errors, possible fabrication flaws, etc. In order to make the design as safe as possible, in this case a safety factor of 1.2-1.4 is desired.

A tow hitch (or tow bar) is a device attached to the chassis of a vehicle for towing, or a towbar to an aircraft nose gear. It can take the form of a tow ball to allow swivelling and articulation of a trailer, or a tow pin, or a tow hook with a trailer loop, often used for large or agricultural vehicles where slack in the pivot pin allows similar movements. Another category is the towing pintle used on military vehicles worldwide.

II. RELATED WORK

A) Trailer Hitch System

A trailer hitch system for improving the speed and safety of attaching the trailer to a tow vehicle. The hitch may include a shank that may be attached to the trailer through a ball hitch. A receiver may be provided on the tow vehicle such that attachment of the trailer to the tow vehicle may be accomplished by introducing the shank into

the receiver when the tow vehicle is backed to the trailer. A funnel shaped guide member may be provided to facilitate aligning the shank with the receiver. Also, friction reducing rollers may be used with the shank or the receiver. Moreover, a height adjustment and visual guidance system may be included to facilitate connecting the trailer to the tow vehicle. The shank includes a stop in a fixed position for limiting the depth the shank extends within the receiver.

Fixed-drawbar hitches are typically built as one piece, have an integrated hole for the trailer ball, and are generally not compatible with aftermarket hitch accessories. Fixed-drawbar-type hitches have integrated ball mounts. The ball mount must match the SAE hitch class. The ballmount for a receiver-type hitch is a square bar that fits into a receiver attached to the vehicle. Removable ball mounts are offered with varying rise or drop to accommodate variations in the height of the vehicle and trailer to provide for level towing.

In order to tow safely the correct combination of vehicle and trailer must be combined with correct loading horizontally and vertically on the tow ball. Advice should be taken (see references) to avoid problems. Outside North America, the vehicle mounting for the tow ball is called the tow bracket. The mounting points for all recent passenger vehicles are defined by the vehicle manufacturer and the tow-bracket manufacturer must use these mount points and prove the efficacy of their bracket for each vehicle by a full rig-based fatigue test.



Fig (a) Receiver Type Trailer Hitch

B) Truck variants

The far side mounting allows for the item (trailer, etc.) being towed to be further away from the opposite side of the road (oncoming traffic, etc.). Caution must be taken when using the bumper of a pickup truck for towing rather than using a frame mounted receiver hitch, as the bumper does not provide for as much strength and therefore is generally used to tow lighter loads. Weight ratings for both bumper-mounted and frame-mounted receiver hitches can be found on bumper of pickup trucks (for bumper-mounted tow balls) and on the receiver hitch (for frame-mounted receiver hitches). These are used for agriculture, industry and large recreational trailers. Front trailer hitches are also widely used on pickup trucks and full size SUVs for multiple purpose. A front-mounted hitch can accommodate additional truck equipment such as front mount bike carriers, fishing / hunting gear, winches, step plates, snow plows and more. It also allows a driver to temporarily maneuver a trailer with better visibility into any convenient place. Front trailer hitches are mounted directly to the frame of a vehicle to ensure a reliable connection. Front hitches are typically equipped with standard size receiver tubes to accommodate a variety of hitch mount equipment.



Fig(b) A trailer coupled onto a ball-type tow hitch Fig (c) A tow hook mounted on the rear of a vehicle

C) Trailer tow hitch

A car can be equipped with a trailer tow hitch with a removable tow ball

Weight-distributing hitch

A weight-distributing hitch is a "load levelling" hitch. It is a hitch setup mounted on the tow vehicle that uses spring bars and chains under tension to distribute part of the trailer's hitch weight from the towing vehicle's rear axle to the towing vehicle's front axle and to the trailer's axle(s). It can help reduce trailer sway and hop. Trailer hop can jerk the tow vehicle. Trailer sway is sometimes called "fish tailing". At high speeds, trailer sway can become dangerous. Most vehicle manufacturers will only allow a maximum trailer capacity of 5,000 pounds (2,300 kg) and 500 pounds (230 kg) of tongue weight without using a weight-distributing hitch. Tow vehicles often have square receiver sockets to accept weight distributing hitches.



Fig. (d)Weight-distributing hitch

Pintle hook and lunette ring

A lunette ring is a type of trailer hitch that works in combination with a pintle hook on the tow vehicle. A pintle hook and lunette ring makes a more secure coupling, desirable on rough terrain, compared to ball-type trailer hitches. It is commonly seen in towing applications in agriculture, industry and the military.

The clearance between the lunette and pintle allows for more relative motion between the trailer and tow vehicle than a ball coupling does. A disadvantage of that is the "slam" transmitted into the towing vehicle with each push/pull load reversal. This becomes a tradeoff between a more secure coupling and a more comfortable towing experience.

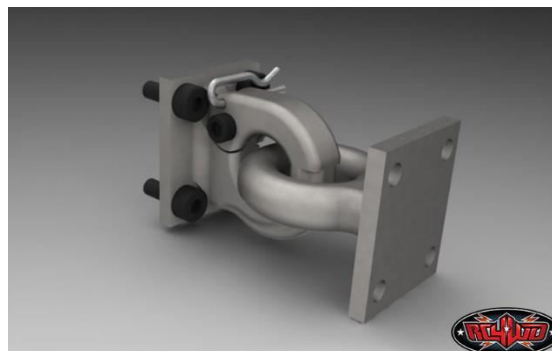


Fig.(e)Pintle hook and lunette ring

III. MODELLING METHODOLOGY

CAD DESIGN

Computer-aided design (CAD) is the use of computers to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations

CAD is used as follows:

1. To produce detailed engineering designs through 3-D and 2-D drawings of the physical components of manufactured products.

2. To create conceptual design, product layout, strength and dynamic analysis of assembly and the manufacturing processes themselves.
3. To prepare environmental impact reports, in which computer-aided designs are used in photographs to produce a rendering of the appearance when the new structures are built.

The advantages of CAD include: the ability to producing very accurate designs; drawings can be created in 2D or 3D and rotated; other computer programmes can be linked to the design software. With manual drafting, you must determine the scale of a view before you start drawing. This scale compares the size of the actual object to the size of the model drawn on paper. With CAD, you first decide what units of measurement you will use, and then draw your model at 1:1 scale, should one of the main benefits of CAD. When you draft manually, you first select a sheet, which usually includes a pre-printed border and title block. Then you determine the location for views' plans, elevations, sections, and details. Finally, you start to draw. With CAD, you first draw your design, or model, in a working environment called model space. You can then create a layout for that model in an environment called paper space.

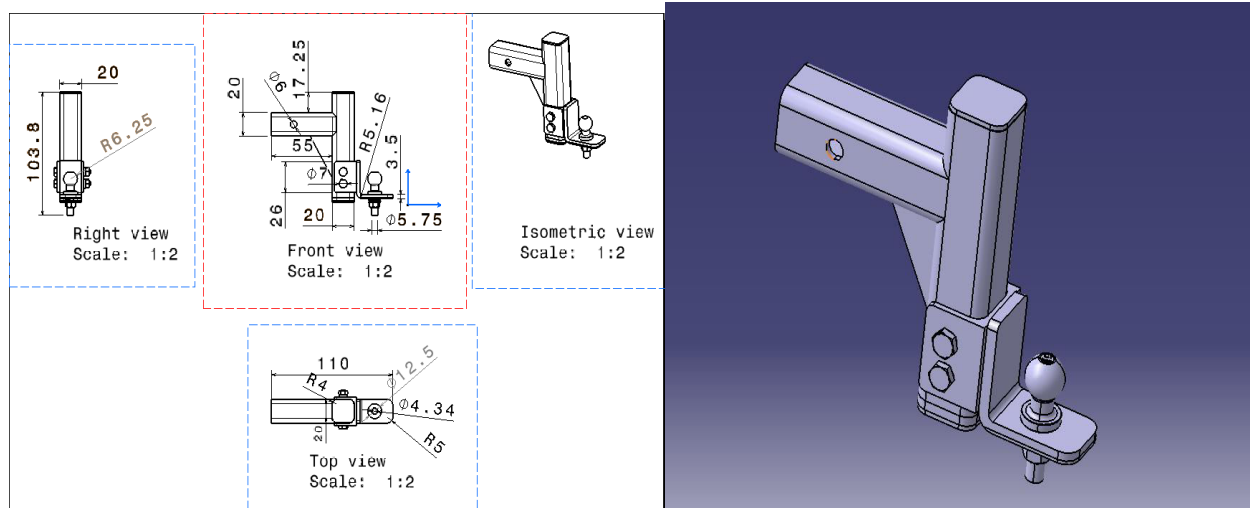


Fig (f) CATIA and drafting of tractor hitch

IV. EXPERIMENTAL ANALYSIS

The finite element method (FEM), is a numerical method for solving problems of engineering and mathematical physics. Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transfer and electromagnetic potential. The analytical solution of these problems generally require the solution to boundary value problems for partial differential equations. The finite element method formulation of the problem results in a system of algebraic equations. The method yields approximate values of the unknowns at discrete number of points over the domain. To solve the problem, it subdivides a large problem into smaller, simpler parts that are called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. FEM then uses variation from the calculus of variations to approximate a solution by minimizing an associated error function. Studying or analyzing a phenomenon with FEM is often referred to as finite element analysis (FEA).

BASIC CONCEPTS:

The subdivision of a whole domain into simpler parts has several advantages:

- Accurate representation of complex geometry
- Inclusion of dissimilar material properties
- Easy representation of the total solution
- Capture of local effects.



A typical work out of the method involves dividing the domain of the problem into a collection of sub domains, with each sub domain represented by a set of element equations to the original problem, followed by systematically recombining all sets of element equations into a global system of equations for the final calculation. The global system of equations has known solution techniques, and can be calculated from the initial values of the original problem to obtain a numerical answer.

In the first step above, the element equations are simple equations that locally approximate the original complex equations to be studied, where the original equations are often partial differential equations (PDE). To explain the approximation in this process, FEM is commonly introduced as a special case of Galerkin method. The process, in mathematical language, is to construct an integral of the inner product of the residual and the weight functions and set the integral to zero. In simple terms, it is a procedure that minimizes the error of approximation by fitting trial functions into the PDE. The residual is the error caused by the trial functions, and the weight functions are polynomial approximation functions that project the residual. The process eliminates all the spatial derivatives from the PDE, thus approximating the PDE locally with

- A set of algebraic equations for steady state problems,
- A set of ordinary differential equations for transient problems.

These equation sets are the element equations. They are linear if the underlying PDE is linear, and vice versa. Algebraic equation sets that arise in the steady state problems are solved using numerical linear algebra methods, while ordinary differential equation sets that arise in the transient problems are solved by numerical integration using standard techniques such as Euler's method or the Runge-Kutta method.

In next step above, a global system of equations is generated from the element equations through a transformation of coordinates from the sub domains' local nodes to the domain's global nodes. This spatial transformation includes appropriate orientation adjustments as applied in relation to the reference coordinate system. The process is often carried out by FEM software using coordinate data generated from the sub domains.

FEM is best understood from its practical application, known as finite element analysis (FEA). FEA as applied in engineering is a computational tool for performing engineering analysis. It includes the use of mesh generation techniques for dividing a complex problem into small elements, as well as the use of software program coded with FEM algorithm. In applying FEA, the complex problem is usually a physical system with the underlying physics such as the Euler-Bernoulli beam equation, the heat equation, or the Navier-Stokes equations expressed in either PDE or integral equations, while the divided small elements of the complex problem represent different areas in the physical system.

FEA is a good choice for analyzing problems over complicated domains (like cars and oil pipelines), when the domain changes (as during a solid state reaction with a moving boundary), when the desired precision varies over the entire domain, or when the solution lacks smoothness. FEA simulations provide a valuable resource as they remove multiple instances of creation and testing of hard prototypes for various high-fidelity situations. For instance, in a frontal crash simulation it is possible to increase prediction accuracy in "important" areas like the front of the car and reduce it in its rear (thus reducing cost of the simulation). Another example would be in numerical weather prediction, where it is more important to have accurate predictions over developing highly nonlinear phenomena (such as tropical cyclones in the atmosphere, or eddies in the ocean) rather than relatively calm areas.

	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

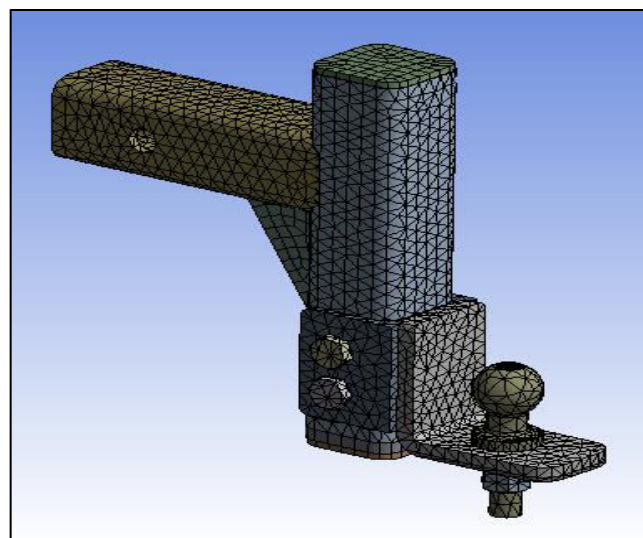
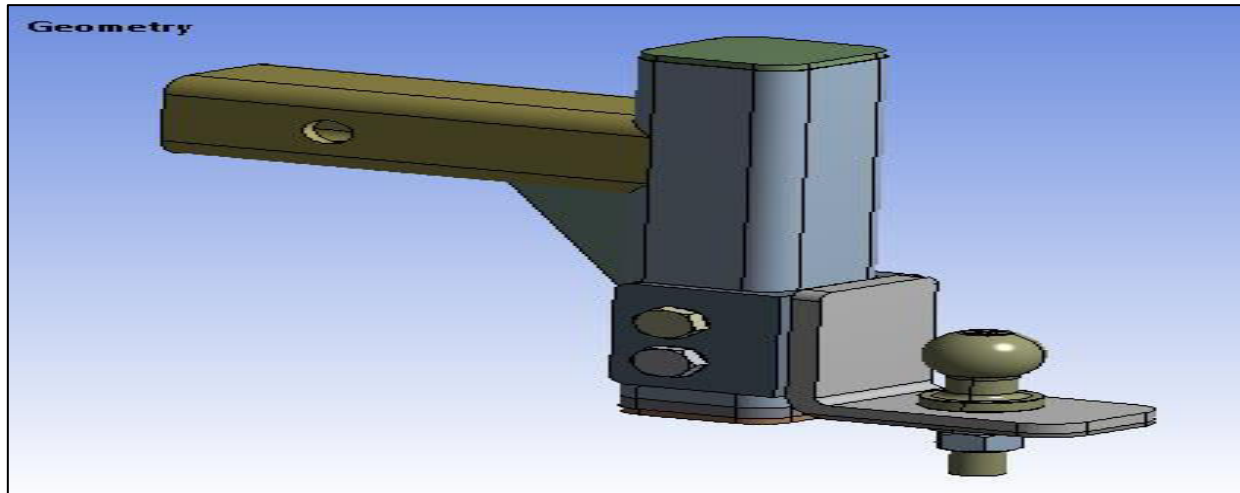


Fig (g) Meshing Of Component

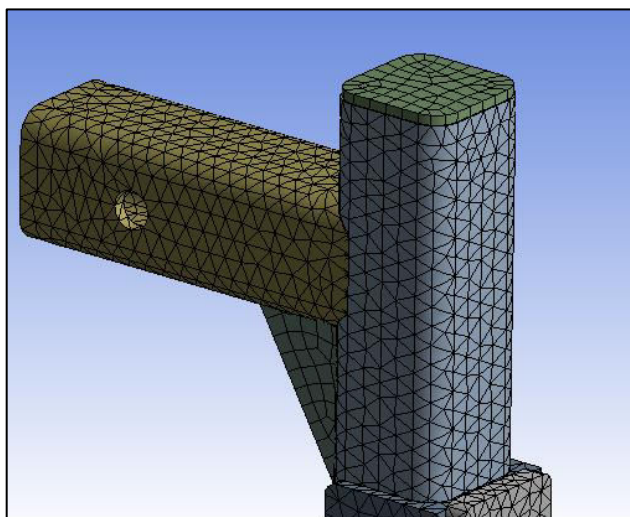
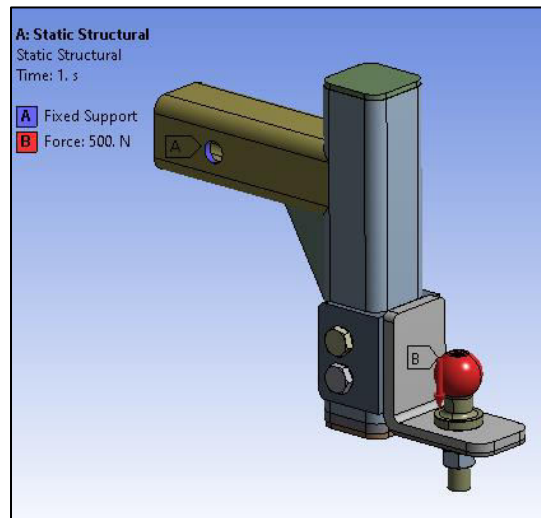


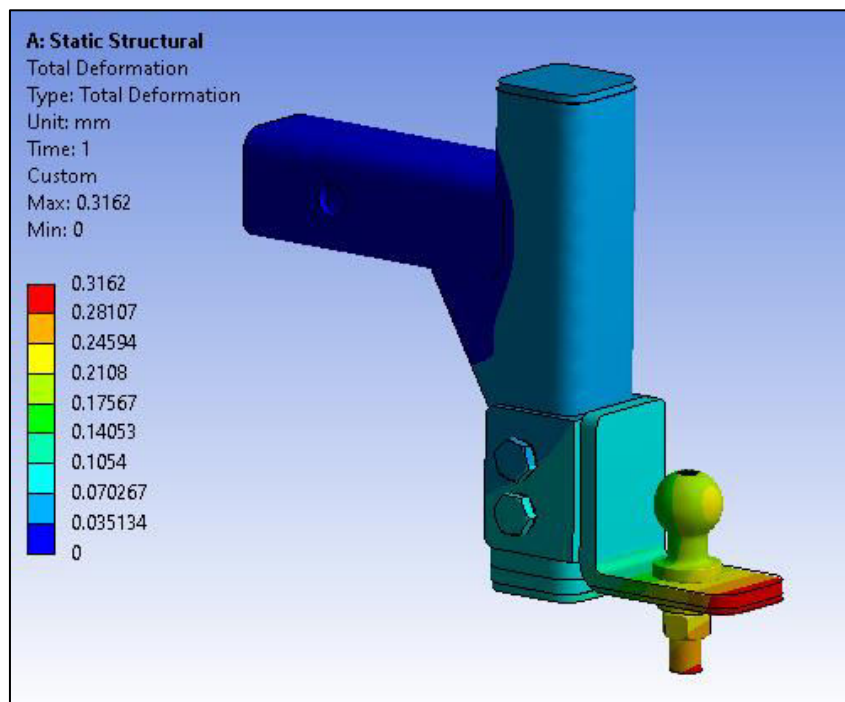
Fig (h) Details of meshing

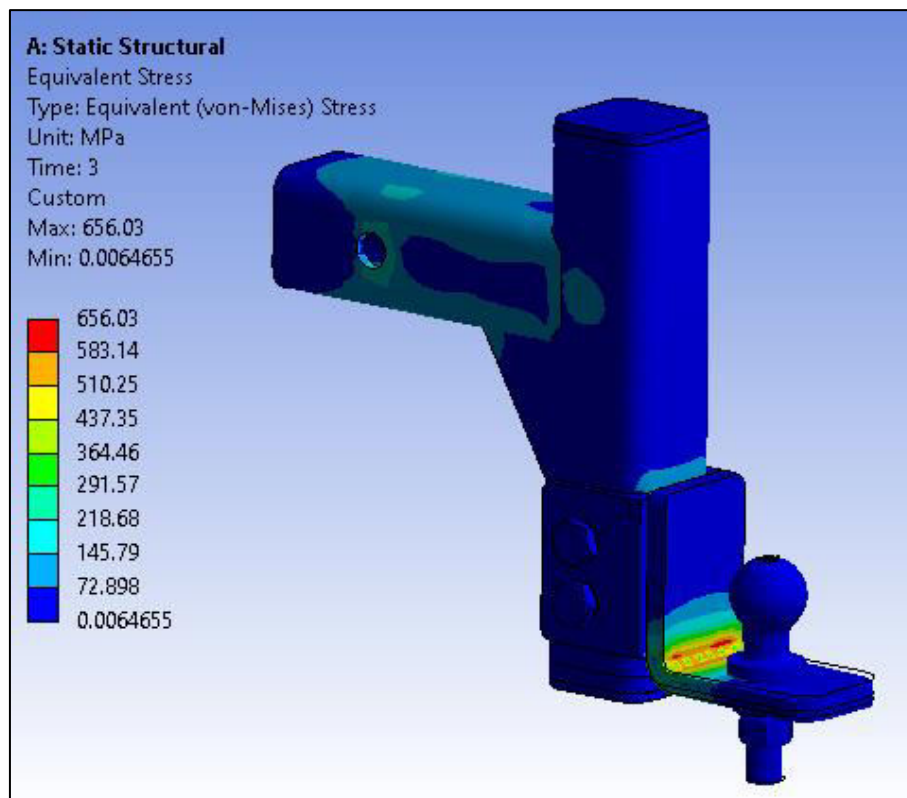
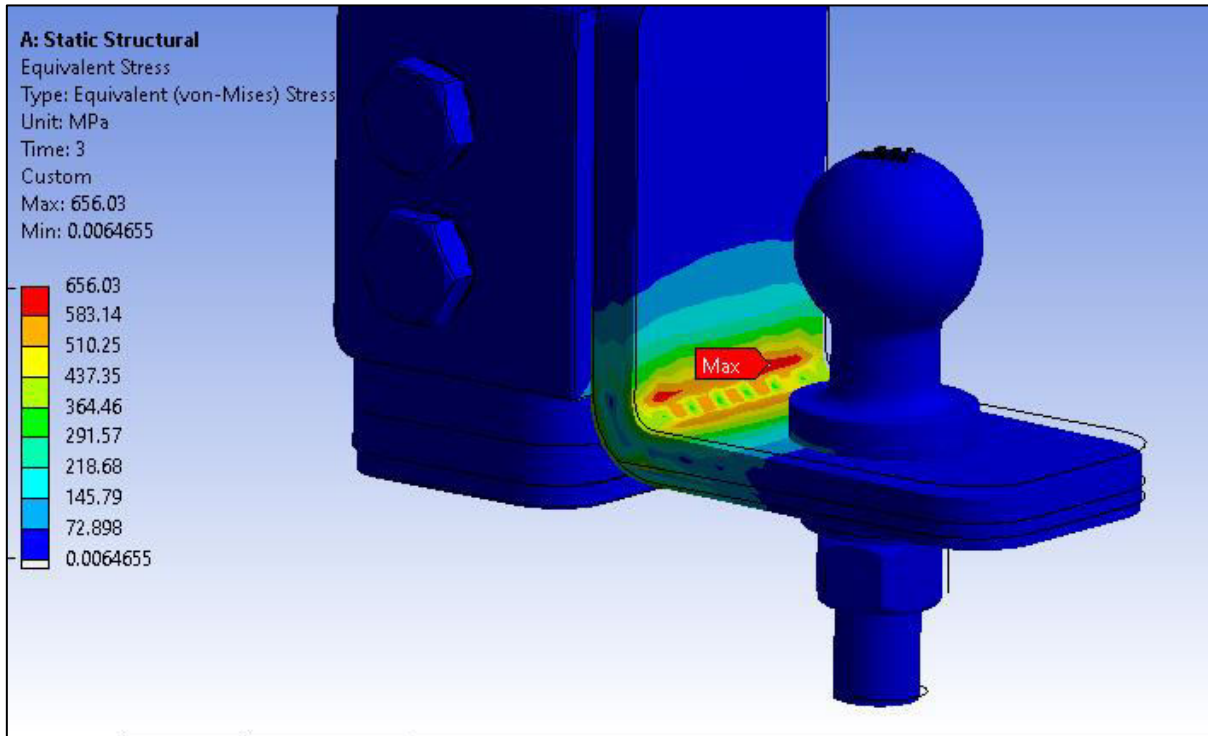
Details of "Body Sizing" - Sizing	
<input type="checkbox"/> Scope	
Scoping Method	Geometry Selection
Geometry	18 Bodies
<input type="checkbox"/> Definition	
Suppressed	No
Type	Element Size
<input type="checkbox"/> Element Size	3.0 mm

BOUNDARY CONDITIONS



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







Tabular Data					
	Steps	Time [s]	<input checked="" type="checkbox"/> X [N]	<input checked="" type="checkbox"/> Y [N]	<input checked="" type="checkbox"/> 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.
*					

1. In present 3 load step of force as 500, 1000, 1500 n is applied
2. It is observed that yield occurs ar 656 mpa
3. So, steel of 850 grade material be selected to sustain load at extreme condition

V. CONCLUSION

The advantages of the system can be stated as Common, simple design. Affordable components, most pickups come ready to tow. Bumper pull trailers can be towed by cars, vans, SUVs, & pickups (other hitch types require a pickup & bed space). Large tow capacities available, weight distributed over the rear axle. The biggest advantage of an adjustable trailer hitch is that you can adjust the hitch height up or down. The majority of these adjustable hitches use a ball-and-pin method to change the hitch height, and a good trailer hitch requires no additional grease or lubrication to remove the pin and adjust the hitch

Expected Outcomes for system are to determine stress and deformation by performing research static analysis of tractor hitch. Determine safety factor and life for existing boundary condition. Results of experimental testing of tow hitch by using UTM.

REFERENCES

[1] Hemanth Kumar C, Sandeep. H. J, Shanmukha. M. Nadiger “Design & Analysis of Rigid Tow Bar for Recovery of Damaged Underground Mining Truck”, International Journal of Mechanical and Industrial Technology ISSN 2348-7593 (Online) Vol. 3, Issue 1, pp: (248-257), Month: April 2015 - September 2015

[2] Cosmin Roszkos, Jozef Bocko, Tomáš Kula “Fatigue Analysis of a Fire Truck Drop Tow Hitch for an O1 Category Water Pump Trailer”, American Journal of Mechanical Engineering, 2016, Vol. 4, No. 7, 312-319, DOI:10.12691/ajme-4-7-15

[3] Abdulkarim K.O., Abdulrahman K.O., Ahmed I.I., Abdulkareem S., Adebisi J.A., Harmanto D., “Finite element analyses of mini combined harvester chassis and hitch” Journal of Production Engineering Vol. 20 NO.1, <http://doi.org/10.24867/JPE-2017-01-048> JPE (2017) Vol.20 (1)

[4] Richard H. Klein Henry T. Szostak “Development of maximum allowable hitch load boundaries for trailer towing”, Downloaded from SAE International by University of New South Wales, Monday, August 20, 2018 800157

[5] Ma Dongli, Wang Shaoqi, Yang Muqing, Dong Yongpan “Dynamic simulation of aerial towed decoy system based on tension recurrence algorithm”, Chinese Journal of Aeronautics, (2016), 29(6): 1484–1495

[6] Nick Polydorides, Eskild Storteig, William Lionheart “Forward and inverse problems in towed cable hydrodynamics”, Ocean Engineering 35 (2008) 1429–1438

[7] Paul Pearson, David M. Bevely “Modeling and validation of hitch loading effects on tractor yaw dynamics”, Journal of Terramechanics 44 (2007) 439–450



- [8] Xuyong Tu, Lie Tang “Headland turning optimisation for agricultural vehicles and those with towed implements”, Journal of Agriculture and Food Research 1 (2019) 100009
- [9] Anne Vingaard Olesen, Rune Elvik, Camilla Sloth Andersen, Harry S. Lahrmann “Does a tow-bar increase the risk of neck injury in rear-end collisions?”, Journal of Safety Research xxx (2018) xxx–xxx



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