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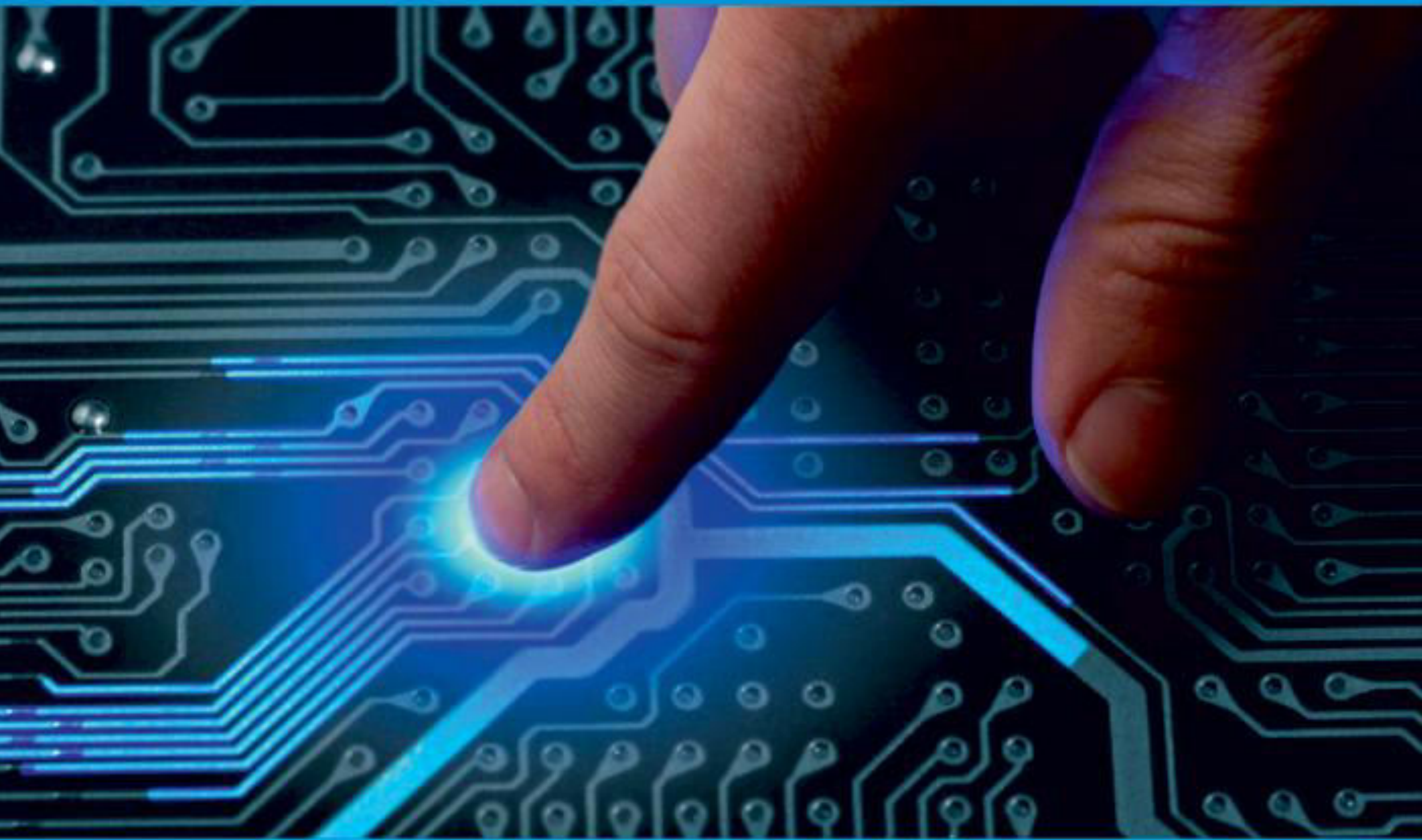

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Survey towards Analysis and Topology Optimization of Tow Hitch

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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

In [1] “Design& Analysis of Rigid Tow Bar for Recovery of Damaged Underground Mining Truck” by Hemanth Kumar C, Sandeep. H. J, Shanmukha. M. Nadiger.In this work author is going to design and analysis of rigid tow bar for recovery damage. Earlier underground mining trucks weighed about 30-40 tons. As the time passed by weight of the underground mining trucks increased due to increase in operational capacity. Therefore the increased weight (50-60 tons) of today's underground mining trucks has introduced a tow bar failure problem encountered during field recovery operations. This problem is due to insufficient strength of the tow bar system currently used in the mining field. In this study design and analysis of a tow bar for recovering the disabled underground mining truck by a recovery vehicle from the mine field to the workshop or garage is carried out using commercially available software packages such as

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CATIA (V5R19), HYPERMESH (13), and NASTRAN (R9). They are compare result obtained from software with the analytical results to validate the design and conclude that newly designed tow bar system is capable of towing the new heavy underground mining trucks.Analytical calculation for each component of tow bar assembly has been carried out with minimum Factor of Safety of 2.5 Finite Element analysis for each component of tow bar assembly is carried out which the result as for tow bar Maximum stress obtained for the tensile load of 23 tons is 64 MPa which is well within the yield strength of Material. For bracket Maximum stress obtained for the tensile load of 11.541 tons is 161.645 MPa which is well within the yield strength of material and for tow bar assembly Maximum stress obtained for the tensile load of 23 tons is 158.876 MPa which is well within the yield strength of material.

[2] "Fatigue Analysis of a Fire Truck Drop Tow Hitch for an O1 Category Water Pump Trailer" by Cosmin Roszkos, JozefBocko, TomášKula.In this paper author presents static and fatigue analyses of a fire truck drop tow hitch for an O1 category water pump trailer. In total 4 geometry variants with different features have been analysed using the FEM. They calculate loading forces based on two different weights: the weight of the water pump trailer (the only trailer meant to be towed by the fire truck) and the category O1 gross trailer weight. For this two different calculation methods were used: a calculation method recommended by the standard and a calculation method based on the physical breaking tests performed on the fire truck. The results of the performed analyses show the structural differences of the 4 geometry variants. From this study author conclude that the additional stiffening elements added to the base design have decreased the maximum deformation values, but the maximum stress and strain values have been raised especially in areas where stress concentrators are present.Analysis result of this study shows that the maximum stress and strain values appeared in welded areas. Although oval root geometry shapes were used to imitate real welds, singularity points have appeared in the areas, where the stress is higher. The used root geometries did not remove the singularity points. Stress concentrators however were highlighted by these high values. The obtained results differ from the actual behaviour of the designs due to: singularity points, various residual stresses that arose due to manufacturing reasons, like welding, tightening of screws and so on. These are only a few reasons, why an experiment is required to validate the results.

[3] "Finite element analyses of mini combinedharvester chassis and hitch" by Abdulkarim K.O., Abdulrahman K.O., Ahmed I.I., Abdulkareem S., Adebisi J.A., HarmantoD.In this study FEA analysis is carried out for mini combined harvester chassis and hinge. The perennial problems associated with harvesting of agricultural products in sub-Sahara Africa are notunconnected with financial limitations of the farmers. The design of low cost mini combine harvester was aimed at ameliorating the challenges of agricultural products harvest in Nigeria. The need for cost effectiveness, affordability, durability and efficiency of the designs necessitated detail analysis of the design to achieve the above objectives. Solid works Finite Element Analysis (FEA) software was employed in carrying out both static and fatigue analysis of a low-cost mini combine harvester chassis and hitch design. The results were compared and contrasted, with appreciable improvements on available existing data. The stresses, displacements and strains on the chassis were significantly low with factors of safety of 2.48 and 2.80 for chassis and hitch respectively.From static analysis of the chassis they conclude that maximum displacement of 3.6mm and a factor of safety of 2.48. The fatigue analysis gave a damage percentage of 0.1 and maximum load factor of 1.52 ×106 when subjected to maximum load. The hitch gave amaximum displacement of 1.53 × 10-2 mm and a factor of safety of 2.8 when subjected to maximum load. FEA simulation software (Solid Works 2014) have clearly demonstrated that it is a viable tool in analysing models as it showed areas of possible failures that needed additional strengthening mechanism to prevent imminent failure. Author state that the analysis was successful on account of better results obtained when compared to previous work. The analysis also showed that it is possible to design for manufacture, chassis of a multipurpose low-cost combine harvester that will make useof locally sourced materials like the square hollow pipe.

[4] "Development of maximum allowable hitch load boundaries for trailer towing" by Richard H. Klein Henry T. SzostakThis study is regarding trailer towing. It has been shown in car/trailer handling studies that a sensitive, repeatable, and easily determined handling parameter for quantifying combined vehicle directional steady-state stability is the under steer/overseer gradient, or stability factor, K. The importance of this parameter was also recognized in the analytical study of and in where the first known attempt to establish a trailer towing performance safety standard was made. The latter employed maneuvers determining the limit influence of K rather than quantifying it. In this study they, have suggested an approach for using K to quantify a maximum hitch load requirement imposed on the tow vehicle by the trailer, compared full scale results to analytical stability boundaries , and suggested recommendations for a maximum stability criterion and test proceduresIn terms of the tow car alone, all passenger cars are designed to be under steering at all lateral acceleration levels. Depending on the tires, suspension, weight distribution, etc., this under steer may be a constant over the range of cornering g's or may exhibit increased under steer at higher g cornering. This latter characteristic results in a decreasing turn rate as forward speed is increased. However, when towing a trailer, it has been well established that the opposite occurs; consequently, we must specify the conditions for the minimum acceptable under steer level. In this work tow vehicle wheelbase, divided by the radius of turn, R, is called the

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Ackermann steer angle, and the stability factor is a speed variation weighting. The Ackermann angle is the steer angle required when turn radius is independent of speed. From this study author conclude that when K is negative, the vehicle is said to be over steering, since less steer angle is needed than for neutral steer. When K is positive the vehicle exhibits the nominal under steering characteristic.

[5] “Dynamic simulation of aerial towed decoy systembased on tension recurrence algorithm” by Ma Dongli, Wang Shaoqi, Yang Muqing , Dong Yongpan.This study is carried out to determine the dynamic simulation of aerial towed decoy based on recurrence algorithm. First they built Kinetic equations based on spinor where the cable is discretized into a number of rigid segments while the decoy is modeled as a rigid body hinged on the cable. Then tension recurrence algorithm is developed to improve computational efficiency, which makes it possible to predict the dynamic response of aerial towed decoy system rapidly and accurately, and thenthe efficiency and validity of this algorithm are verified by comparison with Kane’s function and further validated by wind tunnel tests.Simulation results shows that the distance between the towing point and the decoy’s centre of gravity is suggested to be 5%–20% of the length of decoy body to ensure the stability of system. In up-risen maneuver process, the value of angular velocity is recommended to be less than 0.10 rad/s to protect the cable from the aircraft exhaust jet. During the turning movement of aircraft, the cable’s extent of stretching outwards is proportional to the aircraft’s angular velocity. Meanwhile, the decoy, aircraft and missile form a triangle, which promotes the decoy’s performance.From the study they conclude that the tension gradually increases along the length of cablefrom the decoy to aircraft. The maximum tension increases with flight speed and decreases with altitude while tension at the towing point almost remains unchanged at different flight speeds and altitudes.

[6] “Forward and inverse problems in towed cable hydrodynamics” by Nick Polydorides, EskildStorteig, William LionheartResearchers do the study on forward and inverse problem in towed cable hydrodynamics. This paper addresses the problem of reconstructing the velocities of the ocean currents impinging on a towed streamer cable during an offshore seismic survey. In this study author considers a two-dimensional model describing the motion of a flexible, inextensible cable in the presence of hydrodynamic drag forces in an incompressible fluid. In the first part the forward model is introduced and then solved to yield the cable’s velocity, curvature and tension in the knowledge of the towing vessel motion and the hydrodynamic loads applied. In sequence, author formulate the inverse problem of inferring the ocean current velocities from discrete samples of the cable’s shape and tension and show that this is rank deficient and ill-posed. In approaching the inverse problem a numerically stable algorithm is adopted based on generalized Tikhonov regularization, in the context of robust differentiation of discrete noisy signals. In this study they present regularization in inverse problem theory and robust methodology for reconstructing the ocean velocities and predict the corresponding angle of attack. From the simulation result they conclude thatthe noise robustness of the proposed method under the optimal regularization through the calibration of the involved parameter.The results indicate that adequate spatial resolution is realistically feasible despite the noise content in the measurements when smooth velocity profiles are sought.

[7] “Modeling and validation of hitch loading effectson tractor yaw dynamics” by Paul Pearson, David M. Bevly

Researchers do this study for tractor yaw dynamics. This paper develops a yaw dynamic model for a farm tractor with a hitched implement, which can be used to understand the effect oftractor handling characteristics for design applications and for new automated steering control systems. Dynamic equations which use atire-like model to capture the characteristics of the implement are found to adequately describe the tractor implement yaw dynamics. This model is termed the ‘‘3-wheeled” Bicycle Model since it uses an additional wheel to account for the implement forces. The model only includes effects of lateral forces as it neglects differential longitudinal or draft forces between inner and outer sides of the vehicle. Experiments are taken to verify the hitch model using a three-dimensional force dynamometer. This study shows the implement forces are indeed proportional to lateral velocity and that differential draft forces can be neglected as derived in the ‘‘3-wheeled” Bicycle Model. Steady state and dynamic steering data are used for implements at varying depths and speeds to quantify the variation in the hitch loading. The dynamic data is used to form empirical transfer function estimates (ETFEs) of the implements and depths in order to determine the coefficients used in the ‘‘3-wheeled” Bicycle Model. Changes in a single parameter, called the hitch cornering stiffness, can capture the various implement configurations. Finally, a model that includes front wheel drive forces is derived. The experiments result provide a preliminary look into the effect of four-wheel drive traction forces, and show a difference with two-wheel versus four-wheel drive, on the yaw dynamics of a tractor with the hitched implement.

[8] “Headland turning optimisation for agricultural vehicles and those withtowed implements” by Xuyong Tu, Lie Tang.Researchers do this study for optimization of agricultural vehicle and towing implementation. Mobile agricultural field equipment headland turningis a process that should be done in a manner that can maximise the equipment's operational efficiency through minimising the time or travel distance during the turning. This headland turning trajectory optimisation task represents a challenging dynamic nonlinear optimisation problem which is difficult to solve by using traditional indirect numerical methods. In this research, they investigate the possibility of using direct numerical methods to solve such a nonlinear optimisation problem in a restricted parameter neighbourhood with

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constraints. Author going to develope the kinematic models of the tractor and the tractor-implement(s) systems and formulated their headland turning optimisation problems through incorporating their models and the operational constraints. A range of headland turning scenarios from symmetrical bulb turn to fishtail turn and to turns with single and double trailers. In this work with integration of the tractor and trailer models and by implementing the optimisation process with the TOMLAB/SNOPT software tool, results for diverse circumstances of the tractor/trailer headland turning scenarios were generated and illustratedWith the development of computer and DCNLP software tools, direct optimisation methods play an important role in optimisation research. In this study, TOMLAB/SNOPT tool was proved to be an effective solver to plan an optimised headland turning path for a given tractor or tractor-trailer combination and the headland parameters. Headland boundary angle does matter to the solution existence especially when headland width is restricted, and it may affect the result of field coverage path planning once being incorporated into the cost function. The fishtail turn shows advantages on space efficiency. The case study of the hillside headland turning implies that 3D terrain features affect the trajectory generation and shows the capability of the DCNLP method in this regard.

[9] “Does a tow-bar increase the risk of neck injury in rear-end collisions?” by Anne VingaardOlesen,RuneElvik, Camilla Sloth Andersen,Harry S. Lahrmann.In this work, author talk about risk of neck injury in real end collision. The rear part of a modern car has collision zones that are rendered non-operational when the car is equipped with a tow-bar. Past crash tests have shown that a car's acceleration was higher in a car equipped with a tow-bar and also that a dummy placed in a car with a tow-bar had higher peak acceleration in the lower neck area. The main of thisstudy is to investigate the association between the risk of neck injury in drivers and passengers, and the presence ofa registered tow-bar on the struck car in a rear-end collision. They performed merger of police reports, the National Hospital Discharge Registry, and the National Registry of Motor Vehicles in Denmark. From this they identified 9370 drivers and passengers of whom 1519 were diagnosed with neck injury within the first year after the collision. In this study they found a statistically insignificant 5% decrease in the risk of neck injury in the occupants of the struck car when a tow-bar was fitted compared to not fitted (hazard ratio= 0.95; 95% confidence level = 0.85–1.05; p = 0.32). Several other collision and car characteristics and demographic information on the drivers and passengers were evaluated as confounders but were not statistically significant. Author conclude that this studyserve as valuable input for a meta-analysis on the effect of a tow-bar because negative results are necessary in order to avoid publication bias.

III. EXPERIMENTAL METHODOLOGY

A. PROBLEM STATEMENT

The main focus of every manufacturer is to reduce the weight of their products, in other words, to use the smallest possible amount of material. The weight reduction of parts can’t be obtained without detailed analyses, which include the fatigue analysis. Because the main part of the designed drop tow hitch is a welded part, special attention has to be given to the joining areas, where welds are present.On the other hand, due to economic reasons and mass reduction of automotive products is necessary. Weight can be reduced through several types of technological improvements, such as materials, design technique, fabrication processes and optimization, etc. This research aims to contribute to the development of structural design and mass reduction of tow hitch (or tow bar) using topology optimization

B. OBJECTIVE

Experimental analysis and topology optimization of actual hitch (or tow bar) of vehicle.
Development of structural design and mass reduction of tow hitch using topology optimization
Finite Element Analysis (FEA) of actual hitch of vehicle

C. SCOPE OF WORK

Modeling of actual hitch (or tow bar) in CATIA V5R20 software.In order to accomplish the objective of weight reduction over existing design, finite element analysis method (Topology optimization) is used.
To calculate the equivalent stress, total deformation and then the weight of optimized hitch model.
To perform experimental testing of new optimized hitch model on UTM.
Experimental testing and correlating results

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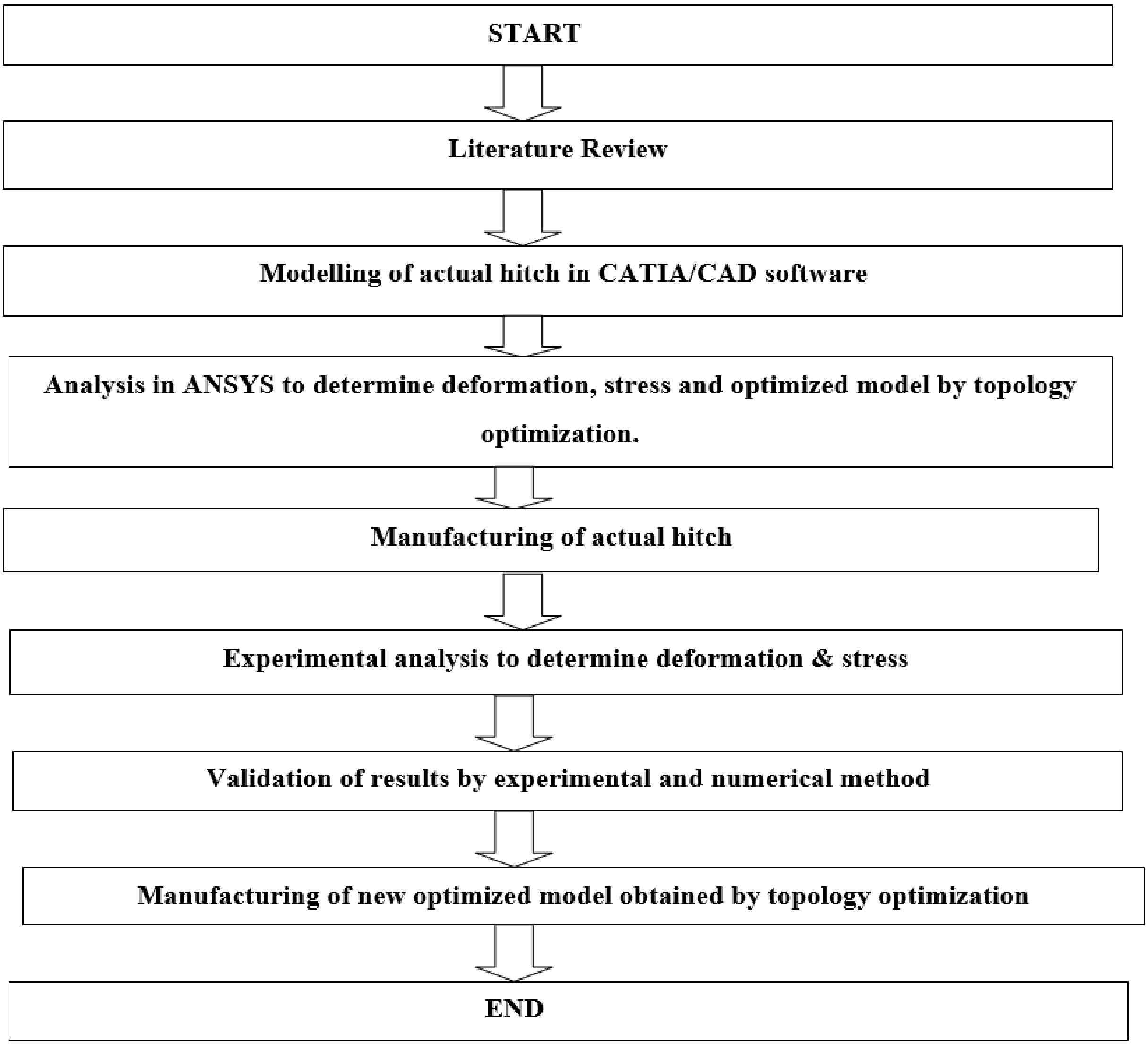

IV. CONCLUSION AND FUTURE WORK

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.

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