Testing of Optimize Mahindra Tractor Steering Arm using FEA and Strain Gauge Technique

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Abstract: The current off-highway vehicle market demands low value and lightweight weight elements to satisfy the requirement of a value effective vehicle with fuel economical. This in turn offers the increase to more effective use of materials for vehicle components which may cut back the weight with increased utility of the car for varied applications. In tractor business, several casting parts continually suffer dynamic load with less frequency and really high amplitude which can cause the potential danger. Thanks to brittle behavior of the material, such components will break suddenly with no apparent caution. The steering mechanism is needed to control the direction of motion of the Mahindra tractor. This can be done through a series of links to convert the rotation of the wheel into an amendment of the angle of the axis of the steering wheels. Another operation of the steering mechanism is to supply directional stability. Once the operator turns the wheel, the motion is transmitted through the steering shaft to tire angular motion of the pitman arm, through a group of gears. The angular movement of the pitman arm is transmitted to the steering arm through the drag link and tie rods. Steering arms square measure keyed to the several kingpins that square measure integral a part of the stub shaft on that wheels square measure mounted. The movement of the steering arm affects the angular movement of the front wheel. For weight optimization of tractor Steering arm topology optimization module use. Three-dimensional CAD model is intended using CATIA V5R20. Finite part Analysis (FEA) software ANSYS Version nineteen.0 is used to work out the total deformation and equivalent stresses. . Experimental investigations are going to be done by strain gauge technique and UTM. Conclusion and future scope are going to be suggested.

Keyword: Design optimization, Steering Arm, Strain gauge, UTM.

I. INTRODUCTION

The steering system is needed to regulate the direction of motion of the vehicle. This can be done through a series of links that convert the rotation of the hand wheel into modification of the angle of the axis of the steering wheels. The steering lever link is an integral part of a tractor mechanism it facilitates the conversion of movement given at the wheel to angular motion at the road. Steering lever link is mounted on the rigid beam shaft connected to 1 of the wheels of the tractor and it's positioned by means of kingpin. The motion of the vehicle being steered has to become straight ahead once the force on the hand wheel is removed. Once the operator turns the steering wheel, the motion is transmitted through the steering shaft to the angular motion of the pitman arm, through a collection of gears. The angular movement of the pitman arm is more transmitted to the steering arm through the drag link and tie rods. Steering arms area unit keyed to the various kingpins that area unit integral a part of the stub shaft on that wheels area unit mounted. The movement of the steering arm affects the angular movement of the front wheels. In another style, rather than one pitman arm and drag link, 2 pitman arms and drag links are unit used and also the use of a rod is avoided to attach each steering arm. The Pitman arm may be a steering element in an automobile or truck. As a linkage hooked up to the steering box (see recirculating ball) sector shaft, it converts the angular motion of the world shaft into the linear motion required to steer the wheels. The arm is supported by the world shaft and supports the drag link or centre link with a ball joint. It transmits the motion it receives from the steering box into the drag (or centre) link, inflicting it to maneuver left or right to show the wheels within the applicable direction. The nonworker arm is hooked up between the other facet of the center link from the Pitman arm and also the vehicle's frame to carry the center or drag link at the right height. A worn ball joint will cause play within the steering, and should intensify over time. Rigid bodies have wide ranging applications across fields together with molecular dynamics, robotics, machine assembly, human motion, and special effects for video games and films. In several applications, the main focus is on mechanics or inverse mechanics, and dynamic behavior is of secondary or restricted interest with solely a number of instances of certain contact and collision, e.g. consider manipulating a robotic arm in an exceedingly controlled surroundings. Multi body simulation consists of analyzing the dynamic behavior of a system of interconnected bodies composed of versatile and/or rigid elements. The bodies could also be strained with relation to one another via a kinematic ally admissible set of constraints modelled as joints. These systems will represent an Associate in Nursing automobile, a craft as an assemblage of rigid and flexible components, a mechanism with manipulator arms, and so on. In such cases, the elements could endure large rotation, large displacements.

II.   LITERATURE REVIEW

The kinematic models of planetary stuff set and directing stuff are set up, in light of the examination of the transmission instrument of point superposition with Active Front Steering framework (AFS). A regulator of variable guiding proportion for Active Front Steering framework is planned, and virtual street tests are made in Car Maker driver vehicle-street reenactment climate. The consequences of recreation tests approve the regulator execution and the benefit of variable controlling proportion work, likewise show that the driving solace is improved at low speed particularly, because of the Active Front Steering framework adjusts the guiding proportion as per the driving circumstance [1].

A various leveled streamlining method for the ideal union of a twofold pivot guiding component utilized in truck with dynamic burdens is introduced. A multibody model of twofold hub guiding instrument is introduced to portray the leaf spring impact. The impacts of dynamic loads, the movement impedance of guiding linkage came about because of the flexible twisting of leaf spring, and the impacts of wheel slip points and the position errors of wheel speed turn focuses are concentrated methodically. A progressive enhancement technique dependent on track falling philosophy is proposed to characterize the plan factors of twofold pivot guiding instrument into four levels. A twofold hub guiding system for a rock solid truck is used to show the legitimacy of the proposed strategy. The recreation results demonstrate that the progressive improvement methodology is powerful and hearty. What's more, thus, it will certainly be generally utilized in designing [2].

Guiding framework is utilized to guide the front wheels because of driver contributions to request to give by and large directional control of the vehicle. In this manner, Steering framework assumes vital part in vehicle dealing with qualities. Pitman arm assumes a vital part in guiding framework as it sends the directing development to the wheel. The Pitman arm is a linkage joined to the area shaft of the controlling box and track bar that changes over the rakish movement of the area shaft into the direct movement expected to guide the wheels. The Pitman arm is upheld by the area shaft and supports the drag connection or focus interface with a rotating conjunction. It sends the movement it gets from the controlling box into the drag (or focus) connect, making it move left or right to turn the wheels the fitting way. Execution study is done trailed by static underlying examination and enhancement to limit the heaviness of the pitman arm and subsequently decreasing the material expense. Upgraded model is then checked by actual testing [3].

The thesis reports the plan project for the controlling framework and suspension of the 2005 Formula SAE-A racer vehicle made at the University of Southern Queensland. The paper incorporates a survey of current car directing and suspension frameworks followed by the audit of Formula SAE-A limitations and plan necessities. An intensive examination of 2004 USQ racer vehicle has been remembered for request to build up the spaces of plan adjustments followed by the real plan with every one of the specialized details required [4].

Venture work present inflexible multi body dynamic examination approach in plan. The use of this technique work on plan interaction and give right outcome. For the contextual investigation here work of configuration done on Ackerman directing instrument for tipper. In this initially as indicated by Ackerman conditions essential calculation is plan and afterward enhance it for static stacking, modular examination and afterward for dynamic powers created on guiding linkages while turning utilizing Rigid Dynamics apparatus in Ansys. The outcomes procured from inflexible body dynamic examination are utilized for testing singular parts and if vital, remedial moves are made in plan to support that heap. Results shows unbending elements approach for configuration lessens time for streamlining, recreation and give the opportunity to make a most restorative move. Unbending elements approach is utilized in present day plan procedures for different spaces [5].

The controlling methodology and directing execution are combined with one another. Along these lines, how to consider the impact of the guiding methodology on the directing execution and further develop the framework's general exhibition is important to the controlling framework. This work brings the guiding methodology into the investigation of the controlling framework, and consolidates the elements model with the actual model to explore the exhibition of directing feel, directing affectability and guiding methodology. In view of the unique model of the vehicle and directing framework, the exchange elements of controlling feel, guiding affectability and directing strength are determined. Also, the regular recurrence is gotten by joining of plan of analyses (DOE) plan technique and reaction surface strategy. Then, at that point the improvement numerical model of the controlling framework is set up and the multi-target advancement is done by molecule swarm streamlining (PSO) calculation and non-ruled arranging hereditary calculation II (NSGA-II) separately. The streamlining results show that the controlling framework enhanced by NSGA-II calculation can more readily stay away from the reverberation with the motor out of gear condition, and further develop the framework's general exhibitions [6]

This paper depicts vigorous directing help force control of electric-power-helped controlling (EPAS) frameworks for an objective guiding wheel force following. The guiding help force control calculation has been created to defeat the significant weakness of the traditional technique for tedious tuning to accomplish the ideal directing feel. A reference guiding wheel force map was planned by post-handling information got from target execution vehicle tests with a profoundly evaluated directing feel for both sinusoidal and progress controlling data sources. Versatile sliding-mode control was embraced to guarantee heartiness against vulnerability in the controlling framework, and the same snapshot of idleness damping coefficient and successful consistence were adjusted to further develop following execution. Powerful consistence assumed a part in remunerating the mistake between the ostensible rack power and the real rack power. The exhibition of the proposed regulator was assessed by directing PC reenactments and an equipment on the up and up reproduction (HILS) under different guiding conditions. Ideal directing wheel force following exhibitions were effectively accomplished by the proposed EPAS control calculation [7].

Ergonomic plan prerequisites are expected to foster ideal vehicle interfaces for the driver. Most of the current particulars think about just anthropometric conditions and emotional assessments of solace. This paper inspects explicit biomechanical angles to work on the current ergonomic prerequisites. Thusly, an examination which included 40 subjects was done to get more information in the field of directing development while driving a vehicle. Five diverse shoulder-elbow joint setups were investigated utilizing a driving test system to discover ideal stance for driving in regard of controlling exactness and directing speed. Thusly, a 20 s accuracy test and a test to evaluate greatest controlling speed over a scope of 90 directing movement have been led. The outcomes show that driving exactness, just as greatest directing speed, are essentially expanded in mid-positions (elbow points of 95 and 120) contrasted with more flexed (70) or broadened (145 and 160) stances. We presume that driver wellbeing can be upgraded by carrying out these information in the auto plan measure in light of the fact that quicker and exceptionally exact directing can be significant during hesitant activities and in mishap circumstances. Moreover, emotional solace rating, broke down with surveys, affirmed trial results [8].

An uprooting and power coupling control plan for dynamic front controlling (AFS) arrangement of vehicle is proposed in this paper. To research the dislodging and power qualities of the AFS arrangement of the vehicle, the models of AFS framework, vehicle, and tire just as the driver model are presented. Then, at that point, considering the nonlinear attributes of the tire power and outside unsettling influence, a

hearty yaw rate control technique is planned by applying a controlling engine to create a functioning guiding point to change the yaw strength of the vehicle. In view of blended H2/H1 control, the framework vigor and yaw rate following execution are implemented by H1 standard limitation and the control exertion is caught through H2 standard. Likewise, in view of the AFS framework, a planetary stuff set and a help engine are both added to understand the street feeling control in this paper to excuse the impact of additional guiding point through a repaying strategy. Assessment of the general framework is cultivated by reproductions and analyses under different driving condition. The recreation and analysis results show the proposed control framework has amazing following execution and street feeling execution, which can further develop the cornering dependability and mobility of vehicle [9].

III. PROBLEM STATEMENT

Now a day's automotive OEM are concentrating on vehicles efficiency and cost effectiveness to reach out with competitors. Pitman arm seems to be an overdesigned part. Hence to achieve cost effectiveness optimization of less critical components is necessary.

IV. OBJECTIVES

- To study and perform static analysis on tractor steering arm under steering load.
- To propose an optimized model which will have better or same performance and reduced weight.
- CAD modelling of tractor steering arm in Catia V5R20 software.
- To perform static structural Analysis of optimized tractor steering arm in ANSYS 19 workbench.
- To perform topology optimization of tractor steering arm for weight optimization.
- Experimental Stain gauge Testing on optimized tractor steering arm on UTM.
- Comparative Analysis between Experimental & Analysis results.

V. EXPERIMENTAL VALIDATION

A Universal Testing Machine (UTM) is used to test both the tensile and compressive strength of materials. Universal Testing Machines are named as such because they can perform many different varieties of tests on an equally diverse range of materials, components, and structures.

Universal Testing Machines can accommodate many kinds of materials, ranging from hard samples, such as metals and concrete, to flexible samples, such as rubber and textiles. This diversity makes the Universal Testing Machine equally applicable to virtually any manufacturing industry.

The UTM is a versatile and valuable piece of testing equipment that can evaluate materials properties such as tensile strength, elasticity, compression, yield strength, elastic and plastic deformation, bend compression, and strain hardening. Different models of Universal Testing Machines have different load capacities, some as low as 5kN and others as high as 2,000kN.

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

- 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.

Fig. Experimental testing

Fig. Experimental results

- The strain generated as per FEA testing is 533 micron.
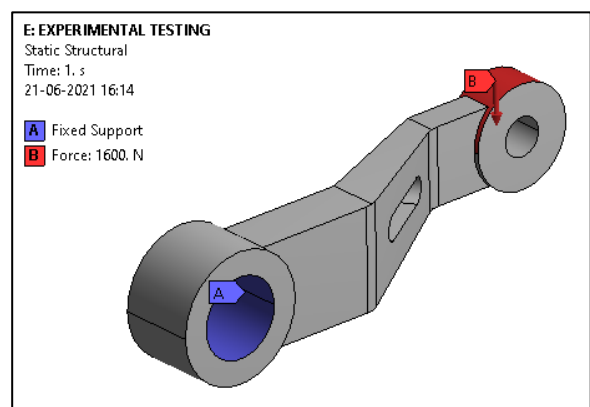
VI.   EXPERIMENTAL TESTING FEA

E: EXPERIMENTAL TESTING
Static Structural
Time: 1, s
21-06-2021 16:14
A Fixed Support
B Force: 1600. N

Fig. Boundary condition for experimental testing
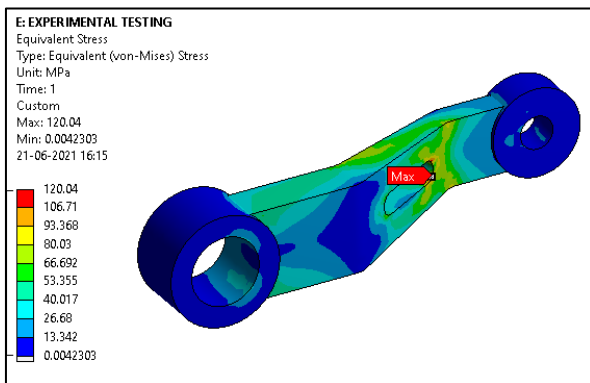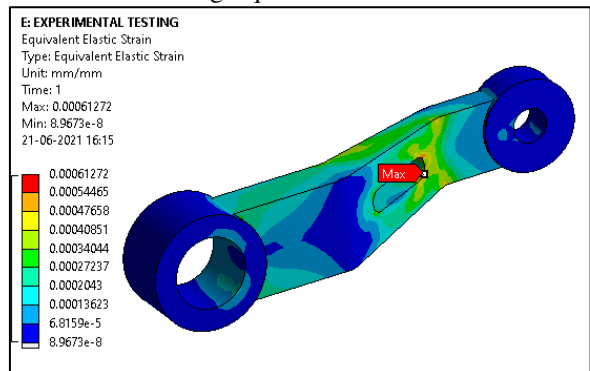
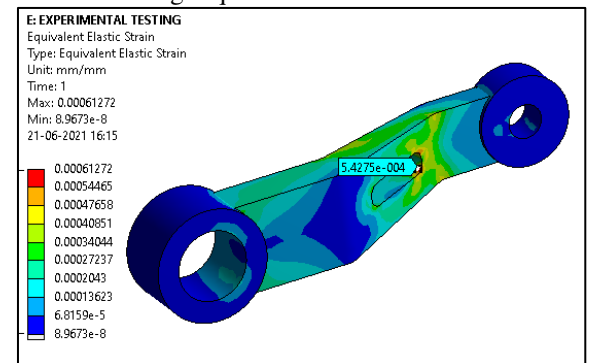Fig. equivalent stress

Fig. Equivalent elastic strain

Fig. Equivalent elastic strain

- The strain value generated in FEA is 542 microns.

VII.   CONCLUSION

- In review paper present research of tractor steering arm static and weight optimization analysis is performed to determine stress and deformation.
- In our case original mass is 1.02 kg but removal of material is to 0.97 kg as per software. But it depends on us to removal of material by proper design and

reanalysis as per existing conditions to sustain boundary condition.
- Weight reduction of around 5 % is observed along with strain measurement of 542 microns and 533 microns by numerical and experimental testing respectively.

VIII.   REFERENCES

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