CAE ANALYSIS ON WEIGHT OPTIMIZATION IN STEERING KNUCKLE USING ALUMINIUM ALLOY

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Abstract: In recent years, the research have been focused on the optimization of vehicle especially trends in reducing the weight of various components of a vehicle for better performance is growing wide to reduce the weight is based on reducing weight of steering knuckle. Reducing weight can decrease the safety of vehicle and the parts tend to fail quickly ,though increasing the weight of components could decrease performance as it consumes more fuel due to more weight .The Optimised weight must be chosen and has to be manufactured . The study for optimisation of knuckle is majorly divided int two phases , the first is modeling and primary analysis and the second phase is reducing mass by removing the mass in regions are induced stresses are minimum The silicon carbide reinforced Aluminium 7075 is used for the preparation of a composite using the magnesum powder. The ANSYS workbench was used to conduct a static structural study of the steering knuckle of Al-10% SiC-1% wt Mg. Compared with results of the Cast iron steering knuckle, which were made from the hybrid MMC with improved construction, the real case loading cases operating under dynamic conditions .The change in material brings a lot of change in the weight of the part. This research focuses on weight optimization using the Aluminum Grade 7075 & analysis considered with Aluminium 6061 T achieved better performance in reducing weight upto 2700 kg/m^3 during the analysis and increase the fuel and steering effeciency.

Keywords: Steering Knuckle, Weight Optimization, Ansys, Aluminum 7075, Al 6061 T

Introduction

Weight is consistently a fundamental model while planning any vehicle segment. The directing knuckle is a fundamental part of the vehicle that is associated with the front wheel with the assistance of a suspension framework and case [1]. The essential capacity of directing knuckle is to change over straight movement of the bind pole to the rakish movement of stub hub. To configuration controlling knuckle following necessities should be fulfilled; it ought to be sufficient, light in weight and firm during its administration [2]. It is a moving undertaking to accomplish security norms and outflow principles (BS-VI) for light- obligation vehicles with our exhibition prerequisites. On the off chance that the planner just focuses on security, it makes the framework massive. Outflow guidelines are disregarded as the gigantic framework causes more fuel utilization [3]. Every part influences the other and henceforth has a heading on a various frameworks and sub frameworks. Guiding upstanding is one of the foremost parts of the suspension arrangement of a vehicle. The fundamental point behind the investigation of plan and examination of controlling upstanding is to what significance of controlling upstanding in auto framework. Fundamental plan and capacity of directing upstanding relies upon kind of suspension framework [4]. Extra factors like brake caliper utilized, mounting of tie pole additionally impacts upstanding plan. Front suspensions additionally need to permit the front wheels to turn. The upstanding interfaces the control arms of vehicle to the center. Wheel center point interfaces the upstanding to the wheels, permitting the vehicle to move. The uprights additionally interface with the directing arm (in front wheels), permitting vehicle to guide [5]. The center point is fitted inside upstanding is associated with the wheels. The upstanding stays fixed while the center pivots alongside the wheels. This is finished by setting a direction between the center and upstanding. The directing upstanding is then fixed from two focuses with bolts to keep it upstanding with the control arms. Weight decrease has become significant issue in vehicle fabricating industry. Weight decrease will give critical effect on fuel proficiency, endeavors to decrease outflows and in this way, save environment [6]. Weight can be reduced by means of a few strategy for technological upgrades, like advances in materials, examination techniques, manufacture cycles and improvement strategies, and so forth Producers lessen vehicle loads that bring about decreased energy utilization [7]. A decrease in the weight of suspension segments brings about better vehicle's dealing with execution. Consequently, plan advancement ought to be implemented to acquire least weight with greatest or then again achievable execution under constant conditions. In the plan improvement of the upstanding, weight ought to be minimized while configuration factors like strength, distortion and toughness ought to be satisfied with segment prerequisite [8].

The study focusing on streamlining of guiding knuckle focusing on diminishing load as target work with required strength and firmness. In car suspension, a directing knuckle is that part which contains the wheel center or axle, and joins to the suspension segments. It is differently called a guiding knuckle, shaft, upstanding or center point, too. The haggle get together append to the center point or axle of the knuckle where the wheel turns while being held in a steady plane of movement by the knuckle/suspension get together. Directing knuckle associates guiding framework, suspension framework and stopping mechanism to the body [9]. The directing knuckle contributes a critical load to the complete load of a vehicle. Expanding the productivity of a vehicle without trading off the exhibitions is the significant test looked by the makers. This paper presents a successful advancement of guiding knuckle utilized in a vehicle with the essential goal of limiting weight using Aluminium 6061 T material [10]. The investigation on enhancement of knuckle is partitioned into two stages, the primary stage includes making of a PC helped configuration model of the first guiding knuckle and do limited component examination on the knuckle by assessing the heaps, which are following up on the segment. In the subsequent stage, plan streamlining of the model of guiding knuckle is completed, and abundance material is taken out at the locale where prompted pressure is immaterial as gotten in limited component investigation expecting standard limit and stacking conditions.

Literature Review:

Mehrdad Zoroufi et al. studies the steering knuckle during its working cycle, that undergoes various time loads. The exhaustion tension behavior would have a significant effect on the properties of knuckling yet when constructing a knuckle joint, it should be of the utmost importance. This paper is intended to evaluate the lifetime of fatigue and the fatigue efficiency of the steering knuckles made of three different materials using various production techniques [1].

Pugazhenthi et al. In this paper analyzing the optimization of the efficiency of a car system of knuckle joints and its conduct under conditions of bump and brake loading [2]. In order to achieve the given goal reliability the probabilistic concept problem involves reducing the weight of a variable that is exposed to stress, distortion and frequency limitations [3]. Mahesh P. Sharma et al. The static steering knuckle analysis was studied. Knuckle design that accommodates dual calliper attachments to increase the braking ability and reduce a vehicle's interrupting width. A static study was conducted in ANSYS WORKBENCH by restricting the knuckle, using loads of a braking torque to mount the calliper and the longitudinal tract reaction [4]. S. Vijayarangan et al. uses the distinctive material for improving the knuckle as the standard material. They use MMCs because they can potentially satisfy the necessary requirements of the automotive industry, contrasting and conventional materials. Control knuckle of replacement substance Al-10 wt percent Basic inspection Using ANSYS, Tic was executed during analysis. The inspection shows the most intense anguish and avoidance in the lifetime of the local knuckle strut [5]. The results were obtained from numerical exams and tests using particulate enforced MMCs for the checking of sparing with a weight of approximately 55% when comparison and the SG iron currently used [6]

The hub and upright mounting are a dynamic mechanism to be studied [7]. Drive and upright are stressed during loading all their lives. In the course of action, hub and rectangular mount is subjected, because of the bump and cornering mechanism, to tiredness, angle force, braking power, bump, impact loads and a mixture of all forces while being shocked by extreme vibration in the hub and straight off the road[8]. In these conditions it is therefore important to examine the distribution of tension stress, fatigue and vibrational characteristics of the hub and the upright condition [9].

In the last few years, most analysis is conducted using finite element methods (FEM). Several researchers carried out various analyses using separate FEA methods on the hub and rectangular assemblage. A systematic literature review of research performed on the hub and up-right mounting, emphasizing architecture, structure analysi, tiredness prediction, and structural optimisation through the combination of the hub with CAD/CAE systems and upright mounting, with an emphasis on analytical technology, is the primary objective of this paper.

The Finite Element Model in HyperWorks was designed by Kulkarni and Tambe [10]. The RADIOSS solver solved the model. To reduce the amount of material to use and to set geometric parameters as design variables, OptiStruct solver was used for topological optimisation. The weight of the existing steering knuckle was lowered to 53.33%. The maximum stress and displacement were approximately 2.8 to 3 below the allowable safety range and yield factor

Razak et al [11] performed a lightweight and streamlined steering knuckle concept study with aluminum alloy 6061-t5 (yield strength 276 mPa). The result of their improving physical and mechanical properties and light-weight nature is that alumina 6061-t5 alloy is the right material for the part. The weight of the original knuckle was decreased by 45.8 percent, although the required resistance was attained. In order to improve the dynamics of a vehicle, Dyapa and Shenoy[12] performed modal analysis using unleashed mass. They concluded that the upright steel would certainly replace aluminum without compromising the durability of the vehicles. Similar research was conducted in Gill and new designs were proposed using adapter plates, which fulfill all the design criteria, keeping tension well below the material yield. Pressure machining was used to manufacture aluminum through 7075-t6. The study provided the current concept as a substitute for traditional upright design. Zoroufi conducted an experimental study of material fatigue load. The forged stain, cast aluminum, and cast iron is used as knuckles in three separate production methods [13]. A 50 KN closed-loop uniaxial servohydraulic test system with computer control and hydraulic wedge handling was conducted for the monotonous and cyclic specimen samples. Tensile measurements and monotonous deformation curves have shown a 37% and 57% ultimate tensile strength of aluminum cast and cast iron relative to hardened stainless steel respectively [14,15]. The aluminum cast and cast iron elongation percentage was 24% and 48%, respectively. Forged steel. The overlapping curve from SWT to life in cycle

Later, Premraj et al. [16] analyzed geometric model of steering knuckle using Catia v5 as modeling tool and HyperWorks 12 as discertization tool later the analysis was carried out on RADIOSS. Different conditions of load were applied to the steering arm. Free vibration modal analysis was done to find natural frequencies and mode shapes of vibration. From the analysis results of design parameters were compared for SG Iron and MDI knuckle. They concluded natural frequency of MDI steering knuckle is less than SG Iron knuckle. Using topology optimization by Premraj and Palpandi[17] Analysis with the aid of OptiStruct solver was performed in HyperWorks. Two separate loads analysis was conducted and the optimization of the topology by maximum pressure and deformation was analyzed. They reduced their weight to 2.84% of the steering knuckle. The hub and the upright are subject to cyclical load, that leads to cyclic stress and fatigue loss. The fatigue of the hub and upright mounting can also be analyzed for premature disintegration, collapse or fracture. The stresses occur if the material gets so high that stresses and stresses can no longer be supported [18-20]. The estimates of failure were dependent on material strength or yield power only in classic structural analyzes. The study of durability goes further and assesses the loss based on repeated basic or complicated loading

Methodology

The most important stage in optimization is material selection, as plays a vital role in the component not being failed .The material selected must satisfy all the criteria of demand as per requirement. For steering knuckle the material needs to be as lightweight as possible, must withstand the loading criteria over the part.

Table.1 Properties of Material

MATERIAL	YOUNG'S MODULUS	POISSON'S RATIO	DENSITY	ULTIMATE TENSILE STRENGTH
CAST IRON	1.1e+005 Mpa	0.28	7200 kg/m^3	240Mpa
ALUMINIUM 6061T	7.0e+4-8.0e+4 Mpa	0.33	2700 kg/m^3	230 MPa
ALUMINIUM 7075	71.7GPa	0.33	2810 kg/m^3	572MPa

Lighter weight of upright assembly and required stiffness is achieved by optimum design calculations and less complex design. Proper material selection of Al7075 is important factor in reducing the weight of upright component without sacrificing in hardness and strength of component.

ANSYS

Topology optimization is done to reduce the weight of the component without compromising on the structural stability and strength of the component. So the products weight must be optimised .Primarily design of CAD model is done in SOLIDWORLS then the FEA analysis is done in ANSYS .

After the primary analysis is done the cad model is optimised. The places where maximum stress is induced are left without being altered and places where least stresses or negligible stresses are induced are removed .The material is removed until the optimised result is obtained.

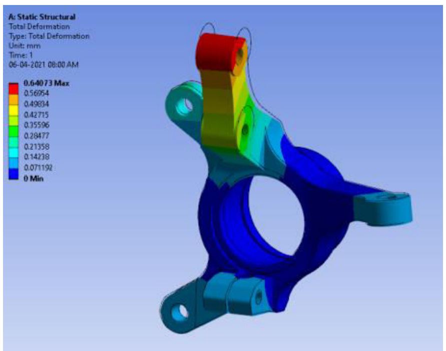

Fig.1 Total Deformation

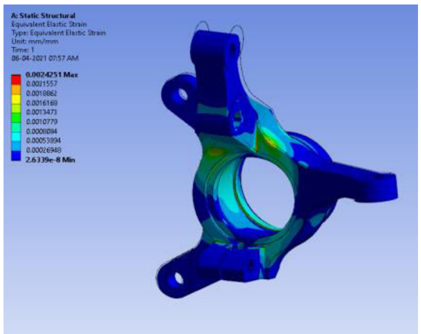

Fig.2 Equivalent Elastic Strain

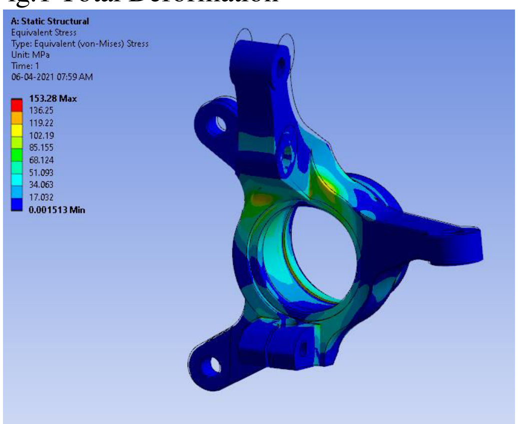

Fig.3 Equivalent Stress (Von-Mises)Stress

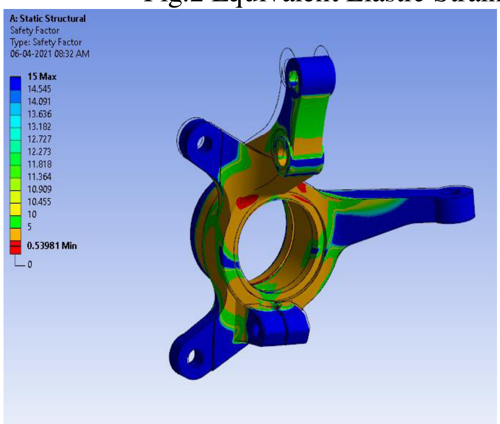

Fig.4 Factor of Saftey

LOADING CONDITIONS

The gross mass (M) is taken to be 1250 kg and mass distribution to be 50:50 i.e each wheel is sharing equal mass.

m= M/4= 312.5 kg

M=M

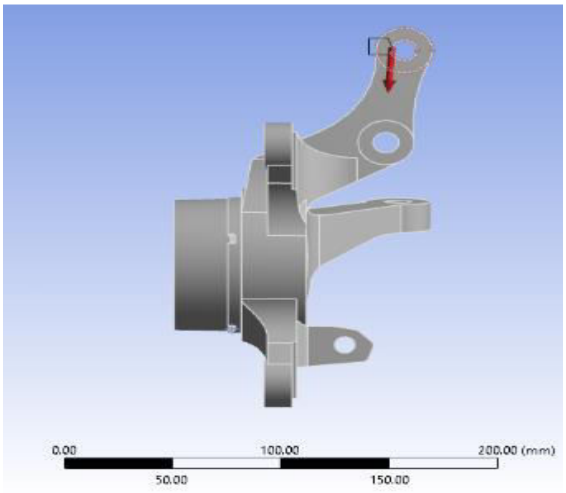

Fig.5 Upper Strut Mount

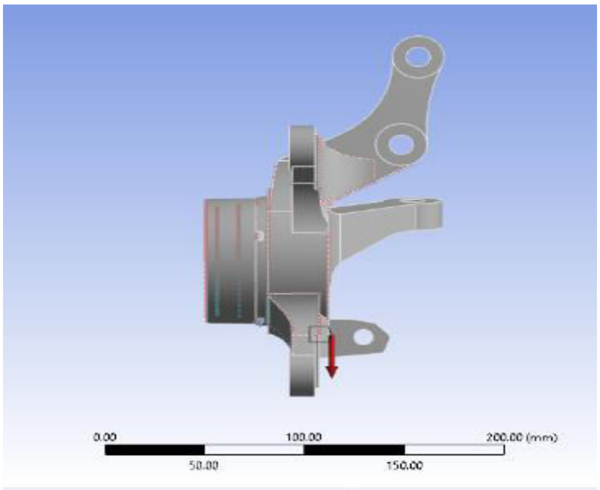

Fig.6 Lower Ball Joint Mount

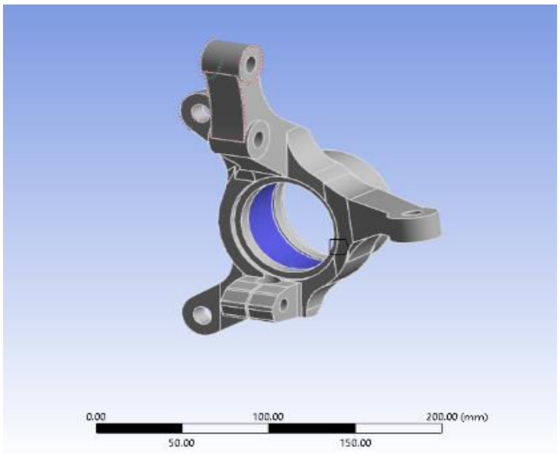

Fig.7 Support Mount

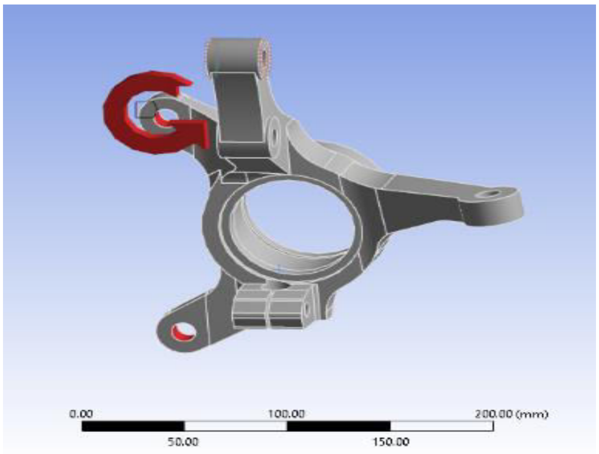

Fig.8 Brake Caliper

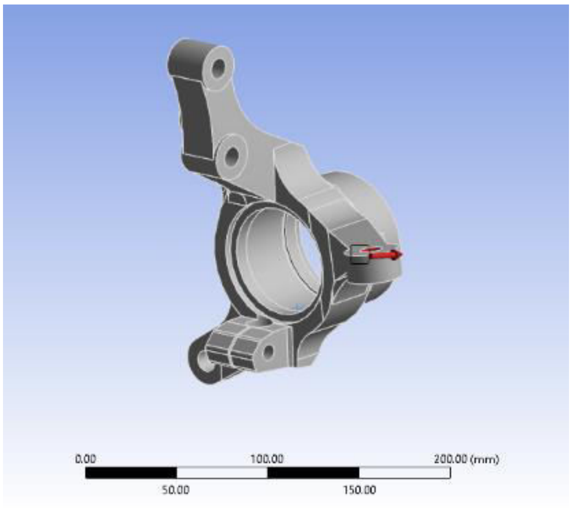

Fig.9 Steering Tie-Rod Mount

The primary model is of material Iron A536 the weight is

2.64 kg .After changing the material to Aluminium Al 7075 the weight of the component is decreased to 0.894kgs.

The model is meshed for analysis the result was

Nodes : 4,75,271

Elements : 2,78,797

After primary analysis the results were

Factor of Safety : 7.51

Maximum equivalent stress : 153.21 Mpa

Total reduction in volume :16%

Total reduction in mass : 1.76 kg (2.64- 0.89)

The steering knuckle on your vehicle is a joint that allows the steering arm to turn the front wheels. The forces exerted on this assembly are of cyclic nature as the steering arm is turned to maneuver the vehicle to the left or to the right and to the centre again. Steering knuckles come in all shapes and sizes. Their designs differ to fit all sorts of applications and suspension types. However, they can be divided into two main types. One comes with a hub and the other comes with a spindle. In this investigation, steering knuckle was used as component for study. Mass or weight reduction is becoming important issue in car manufacturing industry. Weight reduction will give substantial impact to fuel efficiency, efforts to reduce emissions and therefore, save environment. Weight can be reduced through several types of technological improvements, such as advances in materials, design and analysis methods, fabrication processes and optimization techniques. Steering Knuckle is subjected to time varying loads during its service life, leading to fatigue failure. Therefore, its design is an important aspect in the product development cycle.

The steering knuckle accounts for maximum amount of weight of all suspension components, which requires high necessity of weight reduction. Under operating condition is subjected to dynamic forces transmitted from strut and wheel. The weight reduction of steering knuckle is done such that the strength, stiffness and life cycle performance of the steering knuckle are satisfied

Conclusion

Topology optimization can be used to reduce the weight of existing knuckle component by 11% while meeting the strength requirement, with limited design space given with or without change in material properties. Therefore, the overall weight of the vehicle can be reduced by using Aluminium 7075 grade material to achieve savings in raw material costs and consequently processing cost, as well as, improve fuel efficiency and reduce carbon emissions to help sustain the environment.

Therefore, the overall weight of the vehicle can be reduced to achieve savings in costs and materials, as well as, improve fuel efficiency and reduce carbon emissions to sustain the environment.
Shape optimization. All manufacturing enterprises strive to develop the optimized product commonly by reducing the weight while ensuring they produce cost effective products that meet their design functionality and reliability. Structural optimization tools like topology and shape optimization along with manufacturing simulation are becoming attractive tools in product design process. These tools also help to reduce product development time. Shape optimization gives the optimum fillets and the optimum outer dimensions. Objective of this investigation is to reduce weight of steering knuckle of rear driven vehicle having double wishbone type suspension system. This paper focuses of static analysis and shape optimization. Finite element analysis has been used to implement optimization and

maintaining stress and deformation levels and achieving high stiffness. Reduction of weight has been one the critical aspects of any design. It has substantial impact on vehicle performance, fuel efficiency and in turn reduces the emissions.

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