Design and Optimization of FS Vehicle Upright
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Abstract:
Wheel upright is one of important component of vehicle which connects the steering, suspension and brake to chassis and to the road of vehicle. It undergoes different loading in different conditions. In this project we are going to design and fabricate a FSAE wheel upright, which is of low cost and at the same time it’s strength should be comparably equal to the normal conventional wheel upright found in the cars. So initially the location of ball joint and stub axle have been fixed and many iterations of CAD modal of knuckle was prepared in Solid works and the best among them was selected with the help of static analysis done using Ansys Workbench by comparing the strength and the weight of the component by assigning different materials. We have designed the wheel upright in a way that the roll center position of the suspension geometry have been fixed by doing the various iteration so that the distance between the upper and the lower ball joint tend to be minimum, by this way the material cost and the machining cost of the Steering Knuckle have been vastly reduced which is our primary motive and at the same time the strength of the component withstands the worst-case scenario. Static analysis was done by constraining the knuckle ball joints and applying loads of braking torque on caliper mounting, vertical load acting longitudinal to the tire and also the lateral load which will be generated during cornering of the vehicle due to centrifugal force. After finalizing the design, the wheel upright was manufactured using CNC VMC machining process and the fabricated wheel upright was assembled in the vehicle and tested in real time for the worst case in the test track.

Keywords: Wheel Upright, suspension, FSAE car.

I. INTRODUCTION

Wheel Upright is that part which contains the wheel hub or spindle, and attaches to the suspension components. The wheel and tire assembly attach to the hub or spindle of the upright where the tire/wheel rotates while being held in a stable plane of motion by the upright/suspension assembly. Wheel Uprights 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 a non-drive suspension, the Upright usually has a wheel hub onto which the brake rotor attaches. The wheel/tire assembly then attaches to the supplied lug studs, and the whole assembly rotates freely on the shaft of the spindle. In a drive suspension, the Upright has no spindle, but rather has a hub into which is affixed the bearings and shaft of the drive mechanism. The end of the drive mechanism would then have the necessary mounting studs for the wheel/tire and/or brake assembly. Therefore, the wheel assembly would rotate as the drive shaft dictates. It would not turn freely by itself, but only if the shaft was disengaged from the transaxle or differential. A driven suspension as described may also be steerable. This is often called a drive/steer arrangement.

II. PROBLEM IDENTIFICATION

The Wheel Upright of an FSAE vehicle will undergo huge loads and have found to be one of the fragile parts of the vehicle. The main problem is the huge stress produced in the steering arm part due to the fatigue load. The CNC fabrication of the Steering Knuckle as a single component is also very high as we have to get a rectangular block for the required design which will be of huge cost and also the machining cost of the component will also be high.

III. SCOPE OF THE PROJECT

In the common car the Wheel Upright is made as a single part as it is done in a casting process. But while fabricating a FSAE wheel upright the casting process will result in a huge waste of amount so we are designing, analyzing and fabricating a knuckle which is divided into two parts and made by the VMC (Vertical Milling Machine) using the CNC Milling and Drilling Process.

IV. LITERATURE SURVEY

1. Rajkumar Roy et. al. (2008) focus on recent approaches to automating the manual optimization process and the challenges that it presents to the engineering community. The study identifies scalability as the major challenge for design optimization techniques. GAs is the most popular algorithmic optimization approach. Large-scale optimization will require more research in topology design, computational power and Efficient optimization Algorithm.

2. S. Vijayaranganet.al. (2013) uses the different material than regular material for optimization of steering knuckle. They use Metal Matrix Composites (MMCs) as it has potential to meet demanded design requirements of the automotive industry, compared with conventional materials. Structural analysis of steering knuckle made of alternate material Al-10 wt% TiC was performed using commercial code ANSYS. It is found from the analysis;the knuckle strut region has maximum stress and deflection during its life time. The results obtained from numerical analysis and experimental testing using particulate reinforced MMCs for steering knuckle with a weight saving about 55% when compare with currently used SG.

3. Prof. R. L. Jhala et. al. (2009) assesses fatigue life and compares fatigue performance of steering knuckles made from...
three materials of different manufacturing processes. These your paper up in sections so you can now proceed to a two- column section for the body of your paper. include forged steel, cast aluminium, and cast-iron knuckles. Finite element models of the steering knuckles were also analyzed to obtain stress distributions in each component. Based on the results of component testing and finite element analysis, fatigue behaviors of the three materials and manufacturing processes are then compared. They conclude that forged steel knuckle exhibits superior fatigue behavior, compared to the cast iron and cast aluminum knuckles.

4. K.H. Chang and P.S. Tang (2001) discuss an integrated design and manufacturing approach that supports the shape optimization. The main contribution of the work is incorporating manufacturing in the design process, where manufacturing cost is considered for design. The design problem must be formulated more realistically by incorporating the manufacturing cost as either the objective function or constrain.

5. Patel Nirala and Mihir Chauhan (2013) carry out the topology optimization of clamp cylinder using CAE tools to reduce weight with the constraints of standard operating condition. The new optimized design of configuration is Proposed FEA of optimized cylinder is also carried out and compared with acceptance criterion. The optimized model is equally strong and light in weight compared to existing model. The topology optimization of the component is carried out and substantial reduction in weight about 70 kg is obtained and also obtained stress and deformation within acceptance criteria modeling is done using HYPERMESH and the necessary boundary conditions and material are imposed on it.

6. A workshop report published by an agency of the United States government (Feb2013) focused on the development in light weighting and the technology gap for light duty vehicle. Also, the set the goal for weight of vehicle for year 2020 to 2050. The target for reduction of weight of LDV chassis and suspension system is 25% by the year 2020.

7. Rajeev Shankuntala Rajendran et. al. (2013) discuss the process of designing a light weight knuckle from scratch. The design space is identified for the knuckle and subsequently a design volume satisfying the packaging requirements is created from it. Using Opti Struct, topology optimization is performed on the design volume to derive the optimal load path required for the major load cases. Hyper morph is used to create the required shape variable and Hyper Study is used as optimizer. The process of using Topology optimization for load path generation& Parametric study using shape optimization, reduces the design iteration and intermediate concept models and there by reduces the design cycle.

V. METHODOLOGY

Initially the literature survey for the Wheel Upright of FSAE vehicle is collected and then the problem statement is formed and then the initial concept of the upright is formed. Then the modeling of the knuckle is started by fixing the ball joints and the stub axle diameter and done with the help of Solid works. Different models of the concepts are generated by using optimization concept and they are analyzed for static structural analysis using Ansys. By comparing the analysis of the generated models, the best among them is selected by taking the strength and weight of the models as a consideration. After the completion of design and analysis the Wheel Upright is manufactured using the best suitable manufacturing process. The best suitable process for manufacturing the Wheel Upright is found to be CNC VMC process. After the manufacturing of the Wheel Upright the part is assembled into the vehicle wheel assembly. After that the testing of the vehicle is done and the tested result of the knuckle is discussed and also the future scope of the steering knuckle is discussed and further studies are done towards it.

VI. DESIGN AND ANALYSIS

The modelling of the Wheel Upright is done using the Solid works software. The basic mounting point of the Wheel Upright is first decided and then using the modelling software the design of the Wheel Upright is designed by modelling one or more different concepts and analyzing them in the Ansys Workbench and the design is finalized.
and then the A arm points in the upright are fixed and the bump load of 3G is applied in up direction on the stub mounting point and the braking torque of 2G is applied in the opposite direction on the brake caliper mounting points and the FOS is found.

Weight of the vehicle (with driver) = 260kg

3G = 6762 N
2G = 4508 N

VII. FABRICATION

After the designing and analyzing the fabrication work of the steering knuckle is held. The upright is fabricated using the CNC VMC (Vertical Milling Center) process. The finalized design was extracted into a STEP file and they are uploaded to the CAM software and the G codes and the M codes are generated and inputted to the machine and the milling operation is held over the square block which will be converted into the Knuckle and Steering Arm.

VIII. TESTING

The testing of the wheel upright id done in a motor sport racing track. The car is allowed to run at its maximum speed of 105 kmph. And allowed to drive over the curbs at a speed of 50 kmph. The wheel upright withstand its loading condition.

IX. CONCLUSION

The design, analysis and the fabrication of the Wheel Upright is done and tested successfully in our colleges FSAE team vehicle and it was very fine without any damage after completion of the event. The Project’s objectives were very clear and we were able to successfully fabricate a Wheel Upright with low cost and huge strength for a FSAE vehicle.

FUTURE SCOPE

In future the design of the steering knuckle is to be studied further and also, we should focus in design and fabricating a knuckle which will be cost efficient than this design and also have high stress. Acknowledgments section goes after that section.

X. REFERENCE


[6].” Race Car Vehicle Dynamics” by William F. Milliken And Douglas Milliken.


Figure 3. Upright FOS = 1.456 [3]

Figure 5. Fabricated part [5]