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Rear upright developed for a Formula Student racing car

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Abstract

The primary function of the uprights installed in the racing car is to ensure the connection between the A-arm and the wheels. It plays a significant role in increasing the performance and improving the ride properties of the car. The CAD model of the upright was designed taking into consideration the geometry of the chassis and the loads it will be exposed to. The analysis of the component and its topological examination were carried out in the mechanical module of the ANSYS program.

Keywords: upright, simulations, CAD design

1. Introduction

Uprights are the components of a Formula Student vehicle which connect the A-arm to the wheels. The bearing assembly inside them is where the wheel hub rotates. In the case of the rear upright, both the rear axle and the tripod transmit motion to the wheel hub through the tripod profile located in the rear wheel hub. Apart from the A-arms, the wheel-based rods are also connected to the lower bracket and the caliper mount is also mounted on the upright. A lot of different loads affect the components. The components are subjected to a wide variety of loads, with the main stresses being the tensile and compressive forces coming from the direction of the wheel. These forces are transmitted to the A-arms through the connection point of the brackets of the upright. Additional loads occur at the brake caliper attachment due to the radial torsional load during braking and the pure compressive load resulting from the constant preload of the wheel-based rods. After defining the loads precisely, the upright needs to be designed, taking the manufacturing technology into account. Furthermore, attention must be paid the assembly feasibility during the design. The component needs to be assembled multiple times during testing and racing, where it is advantages for the team to be able to assemble the vehicle efficiently and quickly. [1;2]

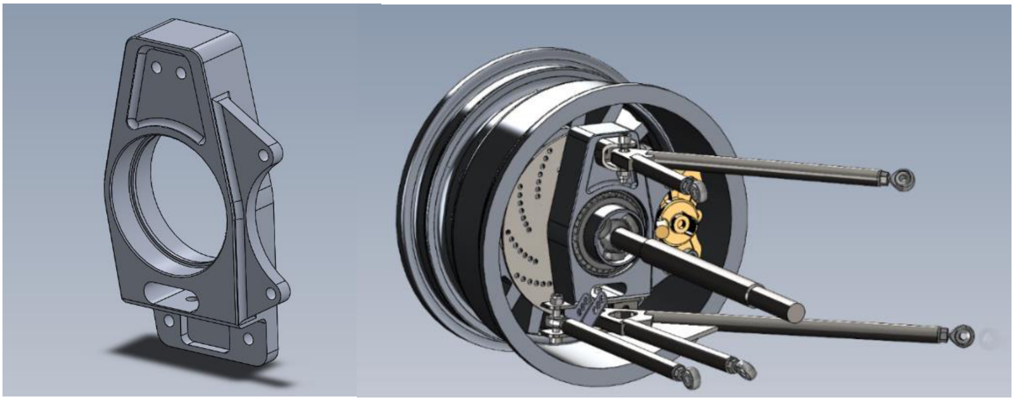

Figure 1. Upright geometry

2. Material and method

During the process of creating the CAD model of the upright, we aimed for a logical, structured design. The development processes defined the steps of designing the model, providing dimensions to facilitate subsequent modifications. In addition to a robust design, we tried to achieve the lowest possible weight.

The upright was designed for the first Formula one race car of the Óbuda University Racing team. We aimed for simplicity and ease of manufacture and assembly. We aimed to use it as a basis for the development of future uprights.

The first step in the design process is to draw up a plan of the model and determine the bearing bore of the hub. The design involves determining the location of tapered roller bearing manufactured by RVC with an inner diameter of 63.5 mm and an outer diameter of 94.458 mm. In the case of a double-sided bearing arrangement, the inner bearing halves are mounted in the trunnion mount and are fitted with a P7 tolerance. The bearings are in O arrangement, which allows the tapered rollers to support a wide range of loads.

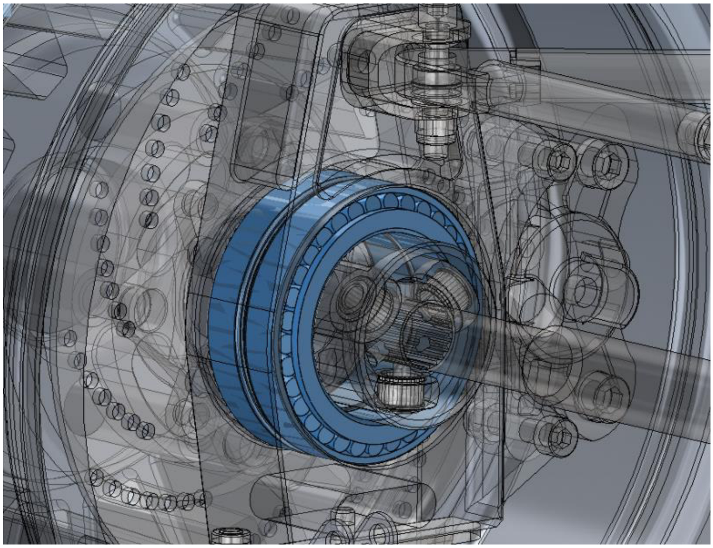

Figure 2. Upright bearing

The second step is to determine the design of the upper part. The geometry of the chassis determines the chassis spacing of the vehicle, so the linkage of the swing arms must be positioned accurately on the upright. When designing, it was important to ensure that the linkage of the swing arms was perpendicular. In this case, the upper connection surface is closer to the chassis than the lower one. The other side of the connection was milled 26 mm deep to reduce weight.

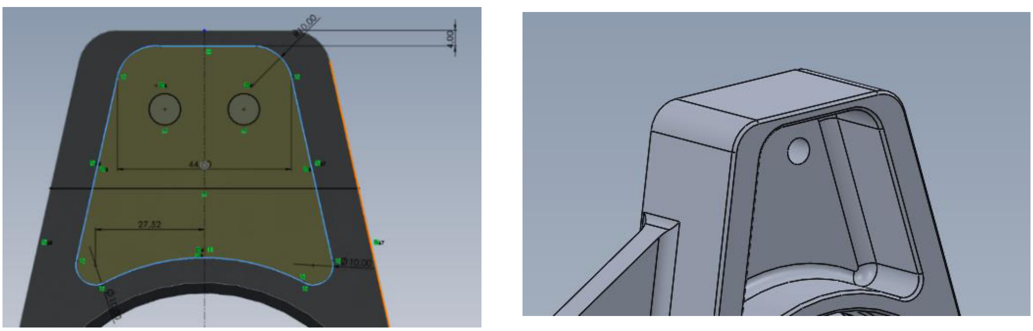

Figure 3. Swing arm connection

The third step was to position and fix the callipers. The exact positioning of the calipers depends on the inside diameter of the 13-inch BMW E21 rim, which is a tight constraint on the positioning of the calipers. Our calipers have a radial layout and are from the Suzuki GSX-R 600 K3, so they have very robust dimensions. They have to 1.5-inch pistons, which gives the vehicle extremely good braking power which was a factor in their selection. The position of the calipers is also influenced by the size of the brake disc, which is maximised at 210 mm diameter. In addition, during the design it is important to ensure that the pads touch the disc in as many places as possible and that the bleed pint can be accessed during assembly. It is advisable to keep the calipers bore spacing as a fixed dimension at the beginning of the design process, so that the two bores do not slip relative to each other during positioning. [3;4]

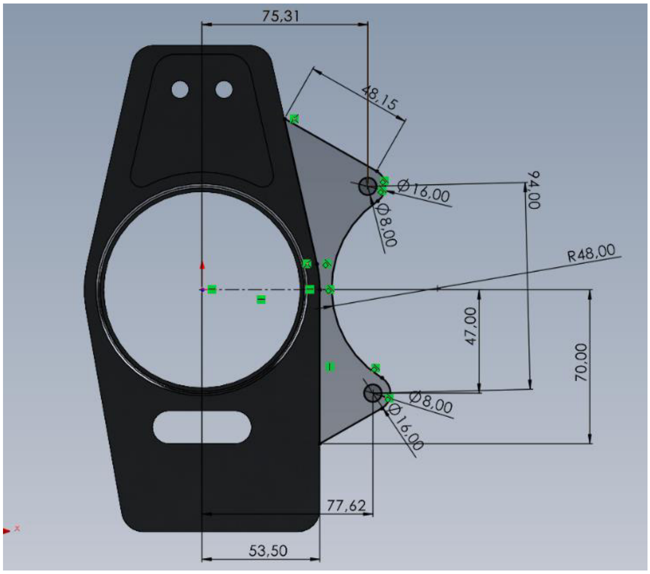

Figure 4. Caliper connection

The fourth step was the design of the lower part, which was also done according to the chassis geometry parameters. The lower connecting bracket is perpendicular similarly to the upper one, but the track bar is also connected to this component. The component is secured horizontally by 2 bolts and positioned and unloaded vertically by one bolt. To ease the mounting, a mounting hole had to be placed to allow room for the wrench to screw in the bracket. [5;6]

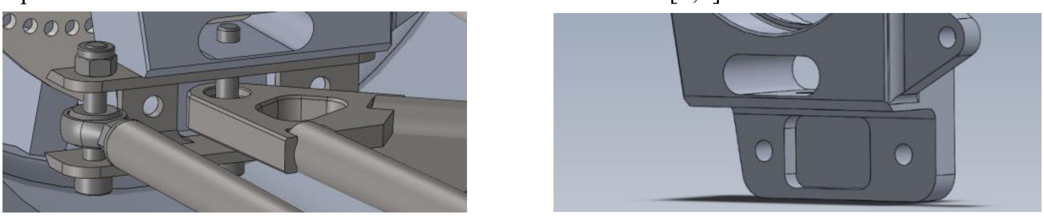

Figure 5. Lower swing arms and track bar connection

3. Simulations

To finalise the design of the component, it is essential to create a finite element simulation. By knowing the different loads effects, we can determine the life cycle, fatigue, which we want to optimize as much as possible during the design phase. These are the torsional loads on the caliper connection due to braking and the push and pull loads on the two swing arms, which will act on the lower and upper anchorage points of the upright. The simulation was carried out in ANSYS Static Structural module, where I was able to adjust both the model mesh and the direction and magnitude of the different loads accordingly. [7]

4. Results

After setting up the appropriate network and boundary conditions, the calculation was performed. The evaluation of the results is shown in Figure 5 and 6.

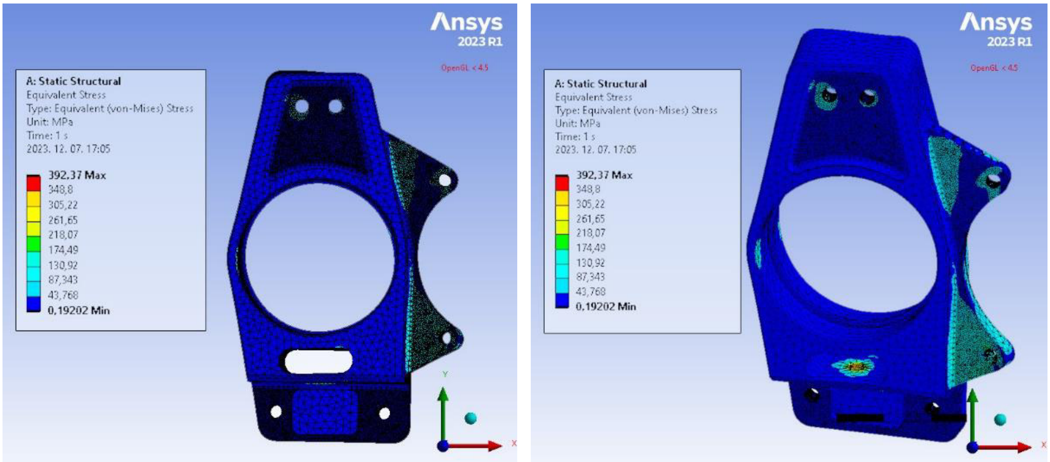

Figure 6. Equivalent Stress

The component can endure all loads in a number of different ways in the majority of the component material. Stress collection points were determined during the tests. This is shown in Figure 6.

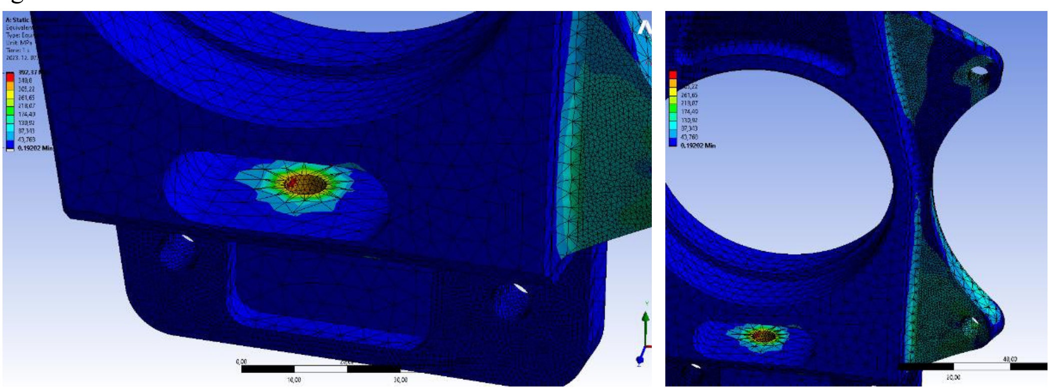

Figure 7. Stress points

The lower swing arm connecting bracket is also secured in the upright by a third vertical bolt, where the maximum stress occurs at the bolt hole. This will be taken into account for the next generation of uprights. There is also a lot of stress at the caliper mounting bracket, which can be reduced by increasing the edge stiffness between the body of the part. [7]

5. Conclusions

The upright of a Formula Student racing car has a very complex geometry due to the many different components attached to it and the function of the component. Designing the correct geometry of the upright depends on many aspects, similarly to those of components found in motorsport. Each component of a vehicle of this type requires custom development by students, so the requirements for a particular component are also determined by the team.

The upright of our first race car will provide the team with a basis to give guidance for the next generation of development in terms of direction and principles. Simulations and tests will provide further information to continue to develop the next component.

6. Literature

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