Formula SAE Suspension Design

Mechanical Engineering

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Abstract

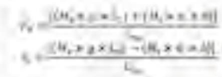
The Senior Design Formula SAE team is designing the suspension system for Bulldog Racing. The team designed the suspension system around the existing frame Bulldog Racing manufactured for competition. We are using a pushrod system in the rear of the vehicle with a standalone shock mounted between the a-arms for the front suspension. Longer A-arms were manufactured by the Senior Design team to help achieve the correct camber of the vehicle, as well as create a stronger base for the vehicle. The shocks have new Eibach coil overs with a greater spring rate to help keep the frame off the ground. The uprights are designed to distribute the forces evenly across the members into the a-arms and shocks. They are manufactured out of solid 6061 aluminum to keep them lightweight and robust. The size of the uprights help set the roll center of the vehicle by setting the a-arms at different angles.

A-arms

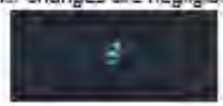
The team chose a lower a-arm length to create a track width of approximately 50 inches. This value was chosen as a starting point so that we can fix a variable in our calculations. If this value did not suffice after calculating other variables, the initial track width would then change. The team was fortunate enough that their initial track width prediction was sufficient in helping calculate other variables such as ride height and the instant center and roll center of the vehicle. After ride height was calculated, and the uprights where, the upper A-arms could be designed to reflect a desired camber and caster. A desired angle for both camber and caster where then implemented into our SolidWorks model, creating the required length for the upper A-arms. The team decided to have a camber of two degrees, and a caster of 1 degree.

Calculations - FEA

To design an effective and stable suspension it is imperative to understand its behavior in any given situation. Using the location of the center of gravity in relation to the contact patches of the tires (L1 and L2) the forces involved can be estimated(Fo and Fi). Initial calculation are done without suspension deflection. Using this free body diagram an equation can be derived as shown below:



MATLAB is used to to calculate the force until a critical point is reached. In this case it is when the lateral force exceeds the friction on the inside front tire. These forces are then plugged into another and the deflection of the suspension is calculate. When the suspension deflects the relative location of the cg changes (L1 and L2 change). These changes translate to a change in forces and the process begins again. This is repeated until the change between iterations is less than 1%. At this point it is assumed that any other changes are negligible.



Suspension components

Our main objective was utilizing our existing frame in the design and planning of a suspension system. After brainstorming possible suspension designs and orientations we proceeded forward with a traditional double wishbone suspension. The next design challenge was the orientation of the damper and coilover assembly. We are currently using Koni's MKII mono tube racing damper, which is well known for its precision adjustment and simplicity and in addition Eibach coilover springs which are extensively engineered and used through out racing in F1, WRC and NASCAR for their high quality spring-steel. The combination of the two components allows us to adjust ride height as well as compensate for forces occurring during a race. For the front suspension we are utilizing the common mounting orientation that can be seen on most vehicles, as the damper is mounted between the lower a-arm and frame at an angle. This allows us to retain space within the frame for the driver and other components as well as provide sturdy mounting locations.

Due to the addition of the half shafts a different mounting configuration is needed for the rear. The rear pushrod-style suspension system has been designed to transfer the same input forces to the pushrods into the shocks by the use of an isosceles triangle shaped rocker. In order to minimize the forces transferred into component mounts and frame members, the pushrod-rocker-shock system is designed to be coplanar.

uprights

Uprights are an integral portion of the suspension system. Their most important job is to connect the wheel to the suspension system and allow the wheel to spin. Other secondary functions are providing mounting locations for break calipers and steering components.

With so many critical components attached it is important to properly analyze the design. 6061 Aluminum was the material of choice to reduce weight without compromising strength. Fatigue analysis was also carried out on the uprights. Under track conditions the uprights will experience several loading and unloading cycles. The car is intended to be used for testing after competition so all components were designed for infinite life.

Sponsors/Conclusion

This project has been a challenging, yet rewarding experience for the team. Each member has gain experience in design, fabricating, and testing for the suspension system. Every component has been modeled and simulations have been run to ensure functionality and durability of the system. The team has worked hard to overcome design challenges and adhere to the rules and standards set forth by SAE International.

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