TO: Dr. Trevas

FROM: SAE Baja Team

CLASS: ME476C

ASSIGNMENT: Team Memo- Individual Analysis

DATE: October 4th, 2020

Brian:

Being a member of the chassis sub-team, there are many different analyses that need to be completed to ensure the functionality and the safety of the frame. I have chosen to run an overall resting Finite Element Analysis (FEA) of the frame, to ensure that the weight of the vehicle itself will not cause the frame to fail. This will provide a good starting point for other analyses, allowing us to use this prior to visualizing other scenarios necessary for competition. Though the frame was designed on SolidWorks, to ensure the variety and consistency of products from the various analyses, I will be using Autodesk's Fusion360 to run the FEA on the frame, importing the part file from SolidWorks. This will provide an initial idea of what the frame can endure in testing, and a good starting point for other analyses.

Jacob:

As a member of the front-end sub-team I chose to design and evaluate the lower control arm for the double wish bone design which we will be implementing. In order to evaluate this component, I chose to use Finite Element Analysis within SolidWorks. This is a great way to visualize and quantify forces acting on the control arm. Results from the analysis provide areas of failure that may need to be improved such as tube size or material selection. The control arms on the Baja car experience most of the force of the front-end and this will be an ideal way to minimize a failure which could result in a major setback within the competition.

Logan:

To help improve the strength and reliability of the rear suspension, I will be focusing on the rear knuckles. These are critical points where the control arm(s), axles, and wheel hubs all connect, so the knuckles should be stong enough to withstand ant the forces that the rear suspension may encounter. I will perform a finite element analysis (FEA) on the knuckles using SolidWorks, testing a variety of appropriate load conditions. I will also be testing various metals to see which material has the ideal strength to weight ratio. Along with optimizing the knuckles, I will also be selecting an appropriate roller bearing to use and adapting the knuckle design to fit them. Once both aspects are finalized, I will run a final FEA on the knuckle/bearing assembly and develop a final factor of safety rating for each load condition.

Tanner:

To further validate the front-end suspension design, I chose to evaluate the upper A-arm under various load cases. Because of the implementation of an upper shock mount, the upper A-arm will experience more force than in previous years' Bajas in which the shock was mounted to the lower control arm.

Therefore, I will perform Finite Element Analysis (FEA) using Fusion 360's simulation features. The load cases applied to the FEA analysis will mimic the real-world driving scenarios to which the Baja vehicle will be subjected. The two primary questions to answer with the analysis are as follows: what wall thickness and diameter 4130 chromoly tubing should be used in the A-arm construction, and what if any structural features are necessary to stiffen the shock mounting point to the A-arm. The three primary attributes that will be analyzed to answer the questions will be factor of safety of the A-arm design, maximum stresses experienced and locations of max stress, and greatest deformation and locations of max deflection

Connor:

In order to ensure a safe and reliable drivetrain the rear and front half shafts must be analyzed. The amount of strain the half shafts can take will be determined by calculating values based on the thickness of the wall of the shaft and the diameter of the shaft, this will allow for an optimal selection ensuring a light weight and robust design. The maximum angle of the u joints must also be determined and relayed to the rear end team. This will help them determine how much travel the rear suspension can allow while still transmitting power. Different designs for half shafts have been made and some will be 3D printed in order to visualize how they will fit or if they could be simplified or improved. Finally, a prototype rear half shaft will be machined and fitted to the previous car number 52. This will be a proof of concept reassuring that the u joint half shaft design is a viable option.

Bailey:

This year, the front and rear end teams have decided to use coil over suspension on all 4 corners of the vehicle. We are currently talking to several different companies about getting a custom setup to perform the best for our vehicle. Having correct spring and shock rates are crucial to building a competitive vehicle for the Baja competition. The spring will absorb impacts from the ground to keep the car under control, and the shocks will dissipate the energy created from the compression of the spring. If the vehicle is underdamped, the vehicle will be difficult to control over rough terrain, and if overdamped, the suspension will not absorb the road imperfections correctly. By taking into account the weight that each wheel will be seeing, and the terrain that we are aiming to perform on, a programmable equation/software can be used to find the optimal spring and shock rate. This way, we can easily adjust the equation based on the weight at each corner of the vehicle, and tune the suspension so it can absorb impacts controllably.

Emily:

Another important analysis that needs to be executed is the shaft design for the chain drive. In order to be able to determine what shaft diameter to design to, finalizing the chain and sprocket selection was the first critical step to the shaft design analysis. Our team will be using a 420nZ3 chain, with sprockets running a 1.6:1 ratio with related diameters and face widths. After determining how large each sprocket would be, the shaft analysis could begin. The Goodman Equation will be used to determine the shaft diameter with related factors of safety. Initially, a diameter will be approximated with the given torque, material, horsepower, and other characteristics of the system. Inputting that approximated diameter will provide the Goodman factor of safety that will be analyzed to determine if the diameter of each shaft needs to be adjusted. Once the desired diameters are achieved for each shaft, determining the method for mounting the sprockets onto the shafts will need to be executed as well through determining the stresses along different segments of the shaft.

Tyler:

The drive train sub-system has several integral parts to the vehicle's overall performance. One of the most important power transmission systems is the speed reduction box. In general, this box takes an input delivered from the CVT and creates an output directly to the wheels. The reduction is fixed and must have an optimized ratio to generate adequate torque for acceleration while also being able to sustain top speeds to do well in the competition. For my individual analysis I will find the optimum gear geometry to transmit and handle expected loads while reducing moment of inertia as much as possible. To do this I will find extreme load cases, like the tire contacting the ground at max speed and run finite element analysis on a gear train model. This analysis will not only be performed on the gear tooth but the body of the gear, the shaft and the case.

Ryan:

The front-end team on this year’s SAE Baja has chosen to mount the shocks to the upper control arm; which differs from previous years designs. The change in loading scenario means that the new knuckle design must be able to withstand a larger load on the top of the steering knuckle. This is why a new Finite Element Analysis or (FEA) must be done on the component with an emphasis on the larger loading at the top ball joint. Looking at the new steering knuckle design, the part will most likely fail at the connection between the flat back plate and the angled upper mount. For my FEA, I fixed the hole location where the front half shaft would connect to the part. After that, a load was placed with the same diameter of the nut being used to fasten the upper ball joint to see if failure would occur at the joint. This analysis concluded that the nearly 90 degree angled upper mount was too sharp and created to large of a moment at the end of the part. This caused a deflection of a couple millimeters which will throw off our king pin and caster angle. The FEA analysis showed where the part needs to be improved for future designs.

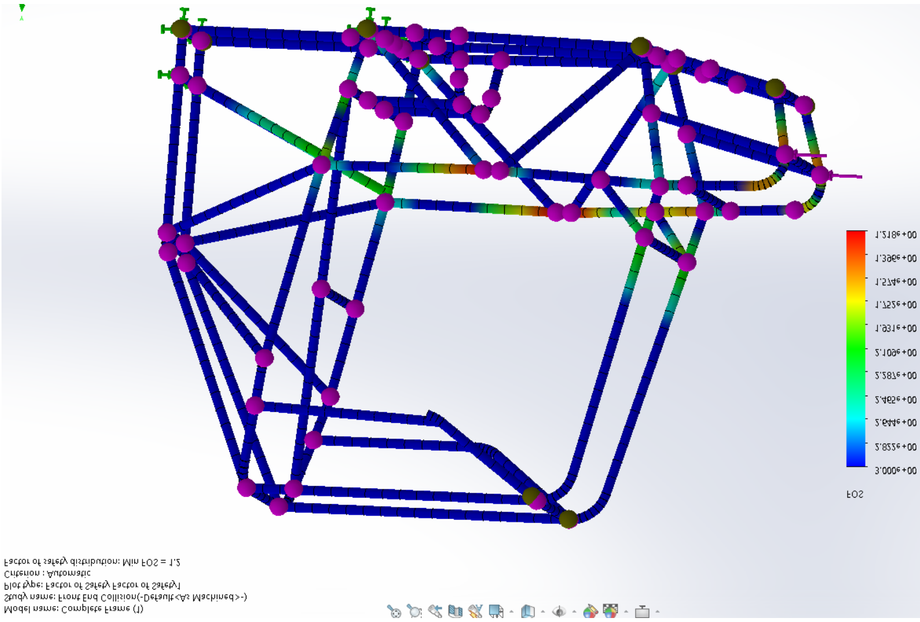
Colton:

The design chosen for the rear end suspension this year relies heavily on an upper control arm to keep the wheel located throughout the suspension cycle. Therefore, for my analysis I want to run 3 different FEA analysis on the upper control arm. This way we can make sure the upper control arm does not deflect too much or yield in anyway. The arm essentially will be experiencing three different loading scenarios during operation. The first is when the suspension bottoms out in the rear, during this loading the back two points are considered to be fixed as well as the shock mounting points. Then there will be a upward load on the knuckle mounts. The second loading case is when the tire takes a lateral hit and because the shocks are mounted using a hiem joint, the shock mounts will not be fixed only the frame mounding locations. Then there will be an axial force on the knuckle mounts. The last loading case on the upper control arm is when the wheel speeds up and there is sudden jerk that stops the wheel. This will put a twisting force at the knuckle. The shock mounts allow for motion here too, therefore the shock mounts will not be fixed and only the frame mounts will be fixed. The prescribed analysis will load the arm with these loading cases and look at the yielding of the material. If the arm does yield more support will be recommended. Then the deflection will be checked to make sure the severity of deflection is not too great to cause issues with the rest of the suspension travel.

Brendan :

The frame has various structural integrity scenarios that need to be analyzed. One scenario could be a front-end collision where the vehicle could slam into another vehicle, or an obstacle such as a rock. This requires that the frame maintains its overall shape, performance and minimize deformations. To simulate this scenario, I ran the frame model into the SolidWorks Static FEA Simulation where I can place a specific load case on the front of the frame. Given a maximum speed of 20 mph and vehicle/passenger weight of 500lbs, I calculated 3000 lbf would be an appropriate analyzation value for FEA. I pinpointed

3000 lbf onto the most forward member on the front-end which is what the frame will most likely see in competition if a front-end collision ever occurs. As shown in the figure below, the frame has a minimum factor of safety of 1.28 at the midpoints of the cockpit (in red) where the collision is occurring. The frame is using 4130 Chromoly Steel Ally as its material selection. This analysis makes room for improvements in the cockpit of the frame for later in the design process. More FEA needs to be done on the frame to solidify performance capabilities which can involve rear-end collisions, T-bone collisions, rollovers, torsion, and bending tests.



Ashley:

In order to identify the weakest members on the frame, the frame team wanted to run a Finite Element Analysis (FEA) for multiple scenarios. For my FEA, I chose to run a drop test simulation on the frame in SolidWorks. This scenario is for a case where the Baja vehicle rolls upside-down while in mid-air, landing on the topmost part of the cage. This simulation will be evaluated for a maximum drop height to identify the displacement of any members and a factor of safety required to ensure that the driver is uninjured in case of a roll-over. Based off this analysis, we can determine any potential failures and make any necessary changes to strengthen the design of the roll cage.

Matthew: As a team member of the frame I was researching for the ergonomic analysis of the frame. By looking at the rule book and the frame we had made in solid works. One can determined the maximum size of an individual that would be allowed to fit into our frame. As it stands now, we meet all the standards in terms of measurements and everyone on the team should be able to fit without issues. However, in terms of comfort the smaller individual in the BAJA team should be recommended. Our overall design does allow anyone as long as they are not over 6’11’’ and 220 lbs. However, the smaller the individual is the more space they will have making it easier to get in and out of the frame as well as overall space when seated.