Society of Automotive Engineers (SAE) Baja Collegiate Competition: Front-Suspension

NAU NORTHERN ARIZONA UNIVERSITY

Office of Undergraduate Research and Creative Activity

Zac Biehl

Jared Bonds

Dylan Wisniewski

Department of Mechanical Engineering, Northern Arizona University, Flagstaff, AZ 86011

Link To Website

Abstract / Project Description

The 2023 Society of Automotive (SAE) Baja Capstone front-suspension sub-team at Northern Arizona University (NAU) has developed a front-end suspension design for an off-road vehicle. Throughout the year, the team has also collaborated with the rear-suspension and drivetrain sub-teams to develop a functioning, competitive vehicle. The NAU team will compete against 99 other universities in Washougal, Washington from May 31 - June 3. At this competition there will be various events including a tech inspection, brake test, acceleration of the vehicle, maneuverability through a rigorous track, hill climb through different obstacles, and lastly a 4-hour endurance event. In order to complete all events and place competitively against all other schools, the front-suspension team has proposed a functional design that can perform at a high level while remaining light-weight. This design incorporates an upper j-arm and a lower a-arm, which allows the shock to be mounted behind the CV axle and steering components. This also lets the shock mount to the lower control arm, resulting in a lower center of gravity. Additionally, the vehicle will incorporate a full-time 4-wheel drive (4WD) system, which complies with the newly mandated SAE rules.

Customer Needs & Engineering Requirements

Customer Needs:

- Meet all Design Requirements
- Meet all Safety Requirements
- 4WD Compatible
- Low Cost
- Manufacture Capability
- Competitive in Events
- Improve Previous Design

Engineering Requirements:

- Reduce Weight
- Improve Suspension Travel
- Reduce Material Usage
- Increase Durability
- Drivetrain Compatibility
- Minimize Production Time
- Increase Steering Angle

Figure 1: SAE Baja Oregon Endurance Race

Figure 3: SAE Baja Oregon Rock Climb

Figure 2: SAE Baja Oregon Hill Climb

Design

Lotus Shark Suspension Software

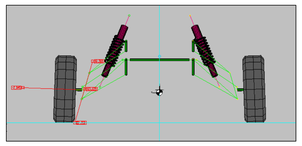

Figure 4: Shark Simulation V2 "Front View"

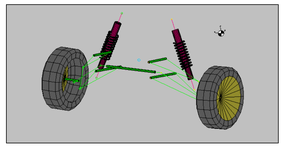

Figure 5: Shark Simulation V2 "Isometric View"

Calculations

Press Fit Verification:

Contact surface interference pressure, P :

$$P = \frac{\delta}{\frac{d}{E_o}\left(\frac{d_o^2 + d^2}{d_o^2 + d^2} + v_o\right) + \frac{d}{E_i}\left(\frac{d^2 + d_i^2}{d^2 - d_i^2} - v_i\right)}$$

Frictional force, F:

$F = \rho * A * \mu$

Torque Required to Slip:

$T_f = F * \mu * r$

Front Hub Stress Analysis

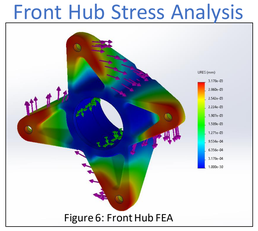

Figure 6: Front Hub FEA

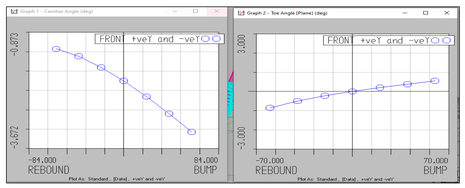

Figure 7: Shark Simulation V2 Angle Graphs

Manufacturing

Figure 8: Front Hub Fabrication

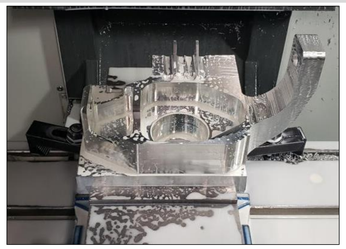

Figure 9: Front Knuckle in CNC Mill

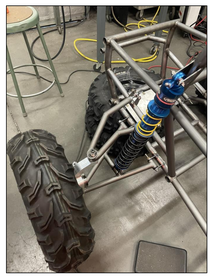

Figure 10: Welding of Suspension Tabs

Figure 11: Completion of Suspension Arms

CAD (SolidWorks)

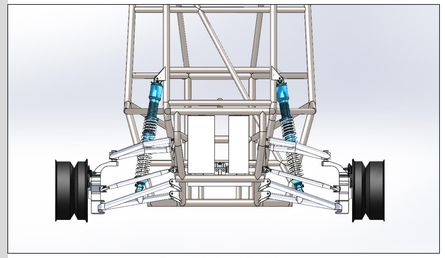

Figure 12: Front End View

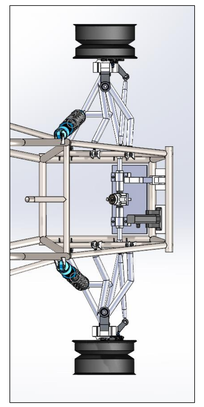

Figure 13: Top View

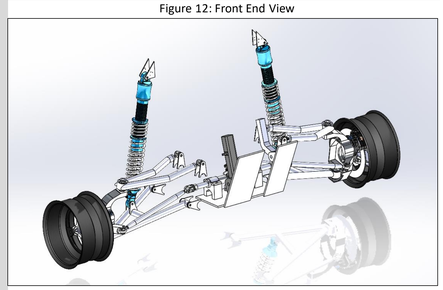

Figure 14: Isometric View

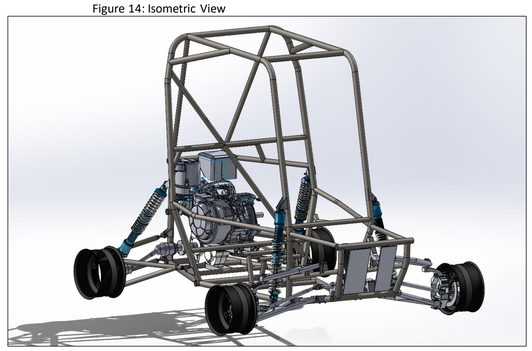

Figure 15: Isometric View (Full Assembly)

Vehicle Images

Figure 16: Front End Suspension Demonstration

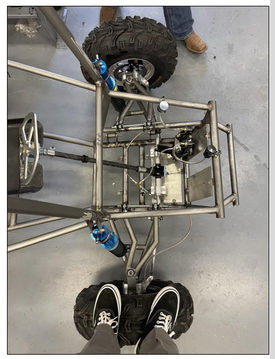

Figure 17: Top View

Testing

Maneuverability:

- **Summary**: This is a competition event that the team will be attempting to re-create to test the overall handling of the vehicle.
- **Procedure:** For this test, the team will set up a cone-course, with turns like those seen in the competition setting. The team will take turns driving to also help determine the fastest drivers around the track.
- **Results:** The results of this will help the team fine tune suspension adjustability such as toe and camber angles to help achieve the best performance possible. The course will also serve as a means of driver training for relevant competition obstacles.
- **Conclusion:** In the end this test will give us the closest simulation to the maneuverability test in the real SAE Competition. The course will consist of several turn styles such as hairpin and switchback style.

Suspension Travel Cycling:

- **Summary:** During this experiment we are going to be utilizing the front suspension components such as the control arms, knuckle, hub, and shocks, to put the suspension through a static travel test.
- **Procedure:** To start we will need to fully assemble the front end and fine tune the steering angles that we desire. Then the group will compress the shocks by standing on the front end to see how the steering angles such as camber and toe. Then the group will lift the front end until max travel and compare the angles to see the overall angle discrepancy.
- **Results:** End results will supply further data if any last-minute adjustments that need to be made within any specific components of the front end set up.
- **Conclusion:** The team aims to compare these tests with the simulations that were run in the Lotus Shark suspension software. With proper adjustment with the heim bearings, the team should be able to achieve similar results to the simulations.

Brake Test/ Mock Tech Inspection:

- **Summary:** This experiment will be to conduct a mock tech inspection as well as a brake test to simulate the inspections we will see at the competition.
- **Procedure:** The team will drive the vehicle into a set of 4 cones with someone watching each wheel specifically. The driver will then slam on the brake to ensure all wheels lock up. Then the group will print out the 2023 Tech inspection sheets and thoroughly inspect the vehicle as they will at the event. This consists of various safety requirements and rule checks.
- **Results:** From the video, the brakes are applied, and the vehicle did come to a stop under its own braking power. In tech inspection the brakes will need to lock on a dirt surface.
- **Conclusion:** From this test the team was able to demonstrate a full braking system that will pass the corresponding test at competition. The team also plans on conducting a thorough tech inspection to mimic the inspection that will be seen at competition. Results can be seen in the spec sheet.

Conclusion

The final design utilizing the upper J-arm and lower A-arm chosen by the front suspension team has proved to meet all engineering and customer requirements by having each characteristic within the design specific to meeting the requirements. During the testing procedures the structural integrity and functionality of design has also proved to be durable for use in competition. It is believed with confidence that the performance of the front suspension system in the 2023 SAE Baja Washington competition will be competitive.

References

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