Society of Automotive Engineers Baja Competition

Spring 2024

Front End Sub-System

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Abstract

The Baja Collegiate Design competition is an event hosted every year by the Society of Automotive Engineers (SAE). The objective of this event is to develop a four-wheel drive vehicle that meets the thorough requirements of the competition in addition to being competitive against other teams. The front end subsystem team is tasked with the design of the steering, braking, and suspension components on the front of the vehicle. To ensure that the vehicle was competitive, the team undertook months of rigorous design, simulation, and testing to ensure that the vehicle met all requirements outlined by SAE. This was followed by months of manufacturing and field testing.

Requirements

The most important requirements regarding the vehicle are those that are mandated by the technical inspection checklist. Competition rules are heavily covered in the 2024 SAE Baja rules and regulations. These regulations ensure the safety of the driver while also developing a competitive but fair environment. In addition to the regulations outlined by the rulebook, the team also developed its own parameters to improve the vehicle within competition. These regulations helped govern the whole design cycle, from initial suspension geometry formulation to the final interference check. These regulations are as follows:

- Max Vehicle Width = 64”
- Front Ride Height Minimum = 10”
- Scrub Radius = 0”
- Total Wheel Travel = 12”
- Pro-Ackerman = 30% to 60%
- Max Survivable Collision Speed = 20 mph

Methods

The front end of the vehicle employs a variety of materials to ensure that each component was as light as possible while still meeting all design and operational requirements. Before design began, however, the team used Lotus Shark software to generate the suspension geometry of the vehicle. This helps to generate a model of how the front end would articulate and steer. This geometric model was then validated for clearance once components were designed within SolidWorks.

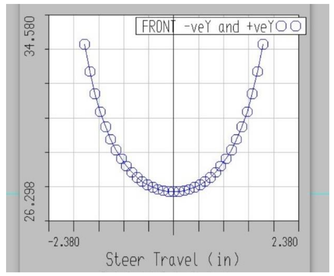

Figure 1: Lotus Steering Simulation

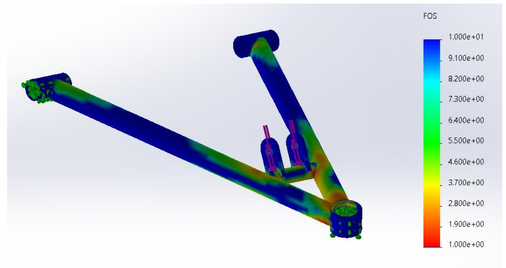

Figure 2: FEA Simulation on Control Arm

Results

The design features in-house manufactured parts including two pairs of 6061 aluminum front knuckles and hubs capable of delivering power from the CV axle. The double A arm design was constructed using 4130 steel tubing with laser cut A36 steel tabs. The rack and pinion system utilizes a steel rack with oil impregnated bronze bushings. Tie rods are constructed using carbon fiber tubing with custom threaded aluminum inserts. Utilizing a variety of materials, the front end performs as intended whilst remaining lightweight. Through meticulous design and research, the front-end team was thrilled to yield a ride height of 14" while being able to utilize 12" of wheel travel. This is compounded with a tight turning radius, meaning that the system is robust, reactive, and maneuverable

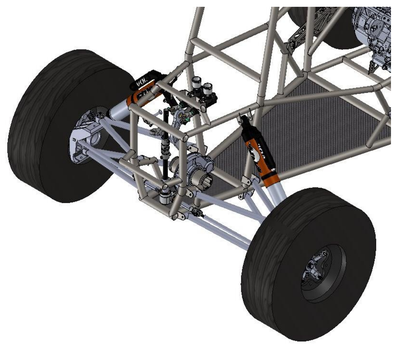

Figure 3: Front End Assembly

Figure 4: Constructed Suspension

Conclusion

This year's front end sub-team has developed a lightweight sub-system with the best off-road capability within recent history at NAU. The design yielded 14” of ground clearance, 12” of vertical wheel travel, and 3.4” of steering rack travel allowing for a maximum wheel angle of 45 degrees with 31% Pro-Ackerman steering orientation. Through constant collaboration with other Baja members, the front end was designed to accommodate the demands of the other sub-systems, allowing for the best suspension, steering, and braking feel possible.

Figure 5: Driving Chassis

References

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Acknowledgements

- Faculty: David Willy and Perry Wood
- Special Thank You: Brennan Pongratz and Hailey Hein