Society of Automotive Engineers Baja Competition

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Frame Sub-System
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Abstract

Every year, the Society of Automotive Engineers (SAE) holds a collegiate competition in which students are tasked with the design and construction of a single seat, all-terrain vehicle. This vehicle must be capable of traversing rocky terrain at high speeds whilst allowing the driver to maintain full control. This performance is facilitated by the intelligent design of the roll cage structure, driver ergonomics, and integration systems. The designs of theses systems were undertaken by the frame team, with lightweight and efficient subsystem integration in mind. Items such as weight reduction, system compatibility, maximum efficiency, and high service life were prioritized in the design process. The frame was designed as narrow as possible to allow for improved suspension kinematics, at 8” wide at the bottom in the front and 5” wide in the rear. The height of the roll cage was also shorted as much as possible to decrease weight of the frame. Strength was increased using AISI 4130 tubing to increase strength while reducing weight.

Requirements

The SAE governing body provides extensive rules for the design and production of the vehicle, which are evaluated before every competition as a technical inspection. The roll cage and driver safety systems share the main focus of the inspection process, with the following design parameters showing to be most important [1]:

- Minimum primary material dimensions: 1”x.065”
- Minimum secondary material dimensions: 1”x.035”
- Material strength meets or exceeds strength of AISI 1018 steel in primary and secondary minimum dimensions
- Minimum driver clearance of 6” around the head and 3” around the body to roll cage structure
- Cockpit ergonomics design to fit 95th percentile male and 5th percentile female drivers safely

Design

The roll cage and all other systems were designed using Solidworks CAD programs prior to any manufacturing. Force analysis was applied to all aspects of the roll cage to simulate possible competition scenarios including frontal, side, and rollover impacts at speed. Driver ergonomics and safety were paramount in the design stage, with the vehicle designed around the ergonomics of the team drivers. Special attention was also placed on system integration, working with the other teams to ensure the manufacturing process was as efficient as possible.

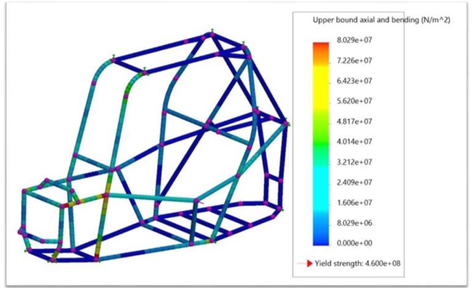

Figure 1: Side Impact Member Load Simulation

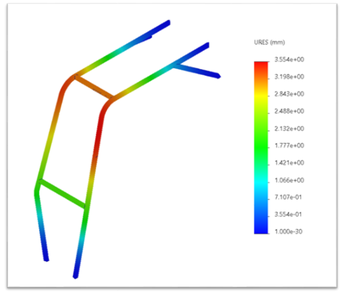

Figure 2: Roll Hoop Overhead Deflection Simulation

Manufacturing

The primary and secondary tubing that comprise the roll cage were all cut, coped, and welded in house. Integration tabs and mounts were laser cut by a sponsor for precise geometry. Composite components such as the seat, skid plate, body panels, and subfloor were provided by a composite company sponsor. In the manufacturing stage, subsystem integration was prioritized.

Figure 3: Vehicle CAD With Panels

Figure 4: Roll Cage With Firewall

Conclusion

The design of the frame must be robust and lightweight to provide adequate driver protection, handling, and maximize the thrust to weight ratio of the vehicle. By following SAE regulations and performing FEA analysis, we are confident that the frame will meet all technical requirements and perform well. By choosing smaller tubing and composite components the weight of the vehicle decreased while maintaining the structural integrity of the frame and other components. In the future, this design should be used as a benchmark for frame integration and design. Improvements could be made in the rear suspension mount positioning to give the rear suspension system clearance as suspension compresses through the travel. More improvements could also be made and in the cockpit area to give the driver more clearance to meet technical requirements.

Figure 5: Rolling Chassis

References

[1] SAE International, “Collegiate Design Series Baja SAE Rules 2024,” 2023.

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