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Senior Design: FSAE Cooling

The 2020-2021 FSAE Cooling team has completely redesigned and rebuilt the 2019-2020 system. Utilizing as many of the same pieces as possible, the new cooling system is more modular and effective while remaining simple and inexpensive. The 2020-2021 design offers several improvements: greatly increased heat capacity and heat dissipation, compact and flexible mounting solutions, and a streamlined modular construction.

Early in the design process, heat transfer analysis showed that the 2019-2020 team's radiator was concerningly small. By a combination of estimates from the current and previous team, the small radiator would just barely manage to dissipate enough heat to prevent overheating. This left no factor of safety to account for incorrect estimates, high ambient temperatures, or other unforeseen circumstances. A Yamaha Raptor ATV radiator found in stock in the FSAE workshop, about double the size, was selected as the replacement. An appropriately sized fan also found in the workshop has been mounted directly to the radiator to ensure sufficient airflow. The radiator/fan unit resides directly behind the driver, mounted under the rearmost firewall. It pulls air from the underside of the car.

The cooling system utilizes several sensors. The previous design used two thermocouples and an inline flow sensor. The 2020-2021 design has deleted one of these thermocouples but now makes use of the motor and motor controller internal temperature sensors. The external sensors were mounted on a plate, plumbed in series with a pump. The plate consolidates all but two of the cooling components to a single mounting solution, u-bolted to the interior of the rear chassis just ahead of the rear left suspension pickup points.

The reservoir is a new addition to the 2020-2021 cooling system. The previous year's design lacked an easily accessible fill port and had a very low heat capacity with an estimated fluid capacity of under 1L. The new reservoir was purpose-built for this project. It uses common PVC plumbing fixtures and a short section of clear 3" PVC pipe for an inexpensive niche design. This raises the total fluid capacity of the system to over 2L and provides an easily accessible fill port at the highest point in the system.

These components are connected with a series of flexible clear PVC tubing and quick disconnect fittings to the motor and motor controller. While there has not yet been an opportunity to test the assembled cooling system with a constant heat load from the motor and motor controller, a test was conducted with a high starting temperature and no load.

The cooling system was tested outside of the dyno room by filling it with hot tap water at about 40C and letting it run for 10 minutes until the water reached room temperature which was around 24C. It was found to be very successful in this test and was able to drop the coolant temperature by over 5 degrees in under 40 seconds. It was also found to dissipate an average of 62.8 W/°C above ambient and around 1067.8W when subjected to a ΔT of 15°C.

Overall, the cooling system is complete outside of dyno testing. All other goals have been met: delivering a finished modular cooling system ready to plug-and-play, increasing cooling and heat capacity, and finishing under budget. All of the design work and purchasing was completed in the fall semester, allowing the system to be assembled in only a few weeks at the onset of the spring semester. The system currently awaits installation in either the dyno room or car, and the cooling budget has $0.04 remaining.