Front Suspension Design

Problem Description

The current Solar car uses 5-lug aluminum wheels. These wheels have a current lug pattern that requires an adapter to the hub. The current steering knuckle is also an off-the-shelf component which is sub-optimal due to low safety factors, incompatibility with a new suspension design the team is implementing, and needs an additional adapter plate to accommodate both brake calipers. The Aggie Solar Racing team requested a new knuckle and hub assembly to meet safety factor requirements for the race, as well as removing the adapters to simplify maintenance and assembly.

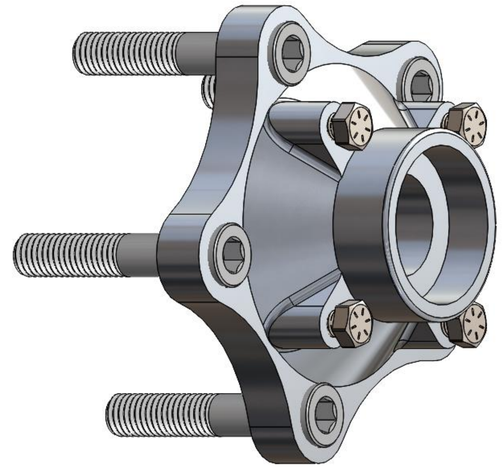
Requirements and Performance

Requirement/ Constraint	Target	Threshold	Actual Performance
Hub Minimum Safety Factor	>1.3	>1.2	4.9
Knuckle minimum Safety Factor	>1.3	>1.2	1.53
Kingpin inclination	5 deg	±1 deg	5.25 deg
Scrub radius	2”	±0.25”	3.5"
5-lug hub	Must be 5x4.5 bolt pattern	N/A	
Hub Nut	10.9 mm thick	10.9 mm thick	

Design Description

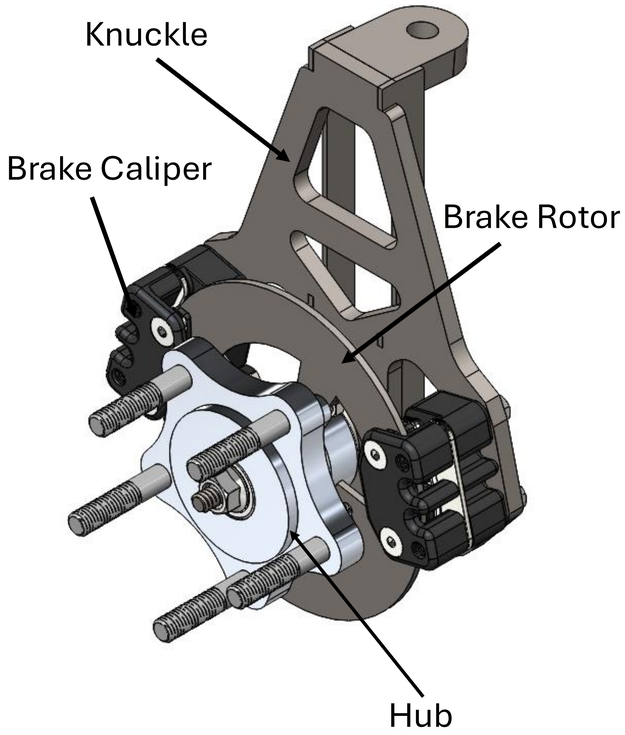
Hub

The hub is fabricated out of 6061-T0. The hub accommodates a 5x4.5" lug pattern eliminating the need for an adapter plate on the original hub design. Typically wheel hubs use press fit studs for the wheel attachment points, however due to the geometry of our rim and hub, there were no available press fit studs that could fit. We decided to go with socket head bolts instead due to their low cost and availability. The bearings for the hub were chosen to have an adequate load rating as well as be similar sizes to the previous hub so that the old hubs can be used as spares.



Knuckle

The knuckle was designed concurrently with the front suspension A-arms. The design changes to the knuckle are that it was made significantly taller than the previous knuckle to accommodate the new suspension geometry that the Aggie Solar Racing team has designed. Another change was the elimination of an adapter plate that was being used previously for the brake calipers. This simplified the assembly considerably, making maintenance easier. The knuckle is primarily made out of A36 cold rolled steel with the exception of the spindle, which is made from 4130 steel due to the higher stresses it endures. The knuckle is mainly constructed out of laser cut sheet stock and simple to machine pieces that are welded together. This manufacturing method kept costs low while providing a strong rigid structure. Since there is less stress near the end of the spindle, the spindle is tapered to help keep weight down as well.



Conclusion

The knuckle and hub met all safety factor requirements well above the target value of 1.3. The king pin inclination requirement was also met. During the process, we learned that outsourcing fabrication is often much faster and worth the extra cost compared to fabricating parts ourselves. We also learned that having a few contingency or backup plans is important just in case things don't go as planned (tolerances incorrect, hardware/materials become unavailable, etc.)

Although the hub is an improvement on the previous design, there are still many improvements that could be made. One improvement is that the material could be changed to one with a higher strength to weight ratio, allowing for the weight of the part to be reduced. Another improvement is reducing the scrub radius of the wheel to meet the target. This could be done by offsetting the calipers into the knuckle more and shortening the spindle. This would also decrease stresses in the spindle, a part of the knuckle with notably high stress points.

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