Solar Car Tire Changer

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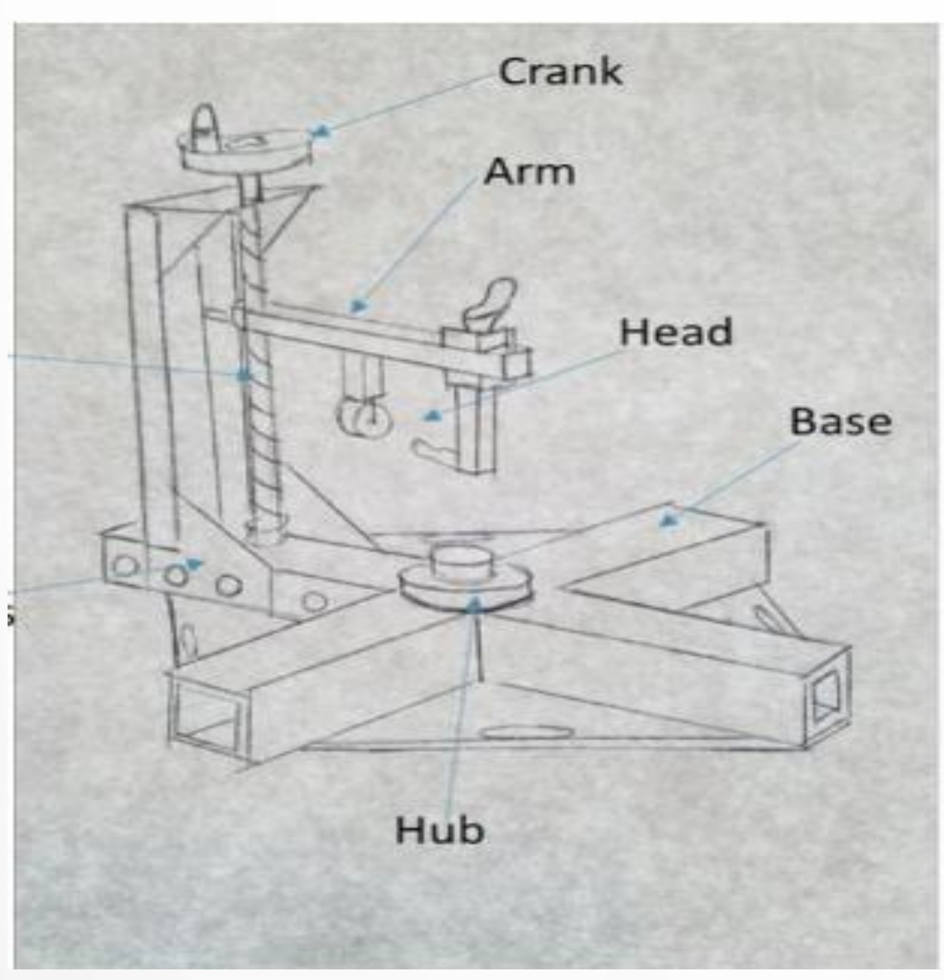
Problem Description and Background

Team 13 had a main objective of designing a tire changer for the University of Kentucky Solar Car Team for their upcoming competition. A major goal of the project was a portable, ergonomic model that could be used in the chase vehicle while the solar car continued its venture. This limited how large the design could be and the options for moving parts. Along with these physical constraints there was a budget of 300 dollars.

The current approach is to stop the solar car and support vehicles to allow the wheel to be changed along with replacing the tire. Since the main goal of the race is to finish as quickly as possible, this is time wasted not moving. Furthermore, the time it takes the car to decelerate to stop along with the time to accelerate back up to speed ads up and could cost the team a win. The support vehicles have to stay within a certain distance of the solar car so the solar car cannot simply leave while the tire is being replaced.

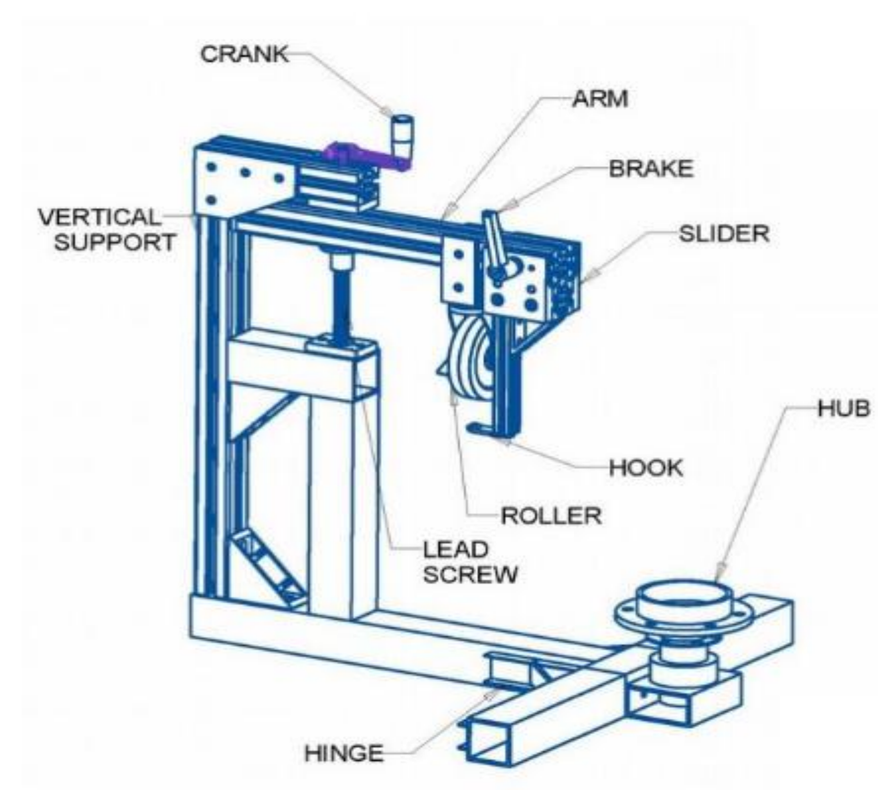
Early Concept



First sketch of complete design

As the team came together for brainstorming it was not long before a design came together. Due to the limited space of a vehicle a crank lowering an arm via a lead screw was the best idea. This also would have ease-of-use benefits due to the transfer of force multiplier from the crank to the arm. The arm would be fitted with two separate, detachable fittings. The roller would be used to press onto the tire to install it while the hook would be slid underneath the lip of the tire to remove it. During both of these processes, the wheel would be placed on the hub to allow the user to rotate the wheel. This design also featured slots along one of the base legs for ability to change the location of the vertical support to account for different sized wheels.

Considerations of Cost



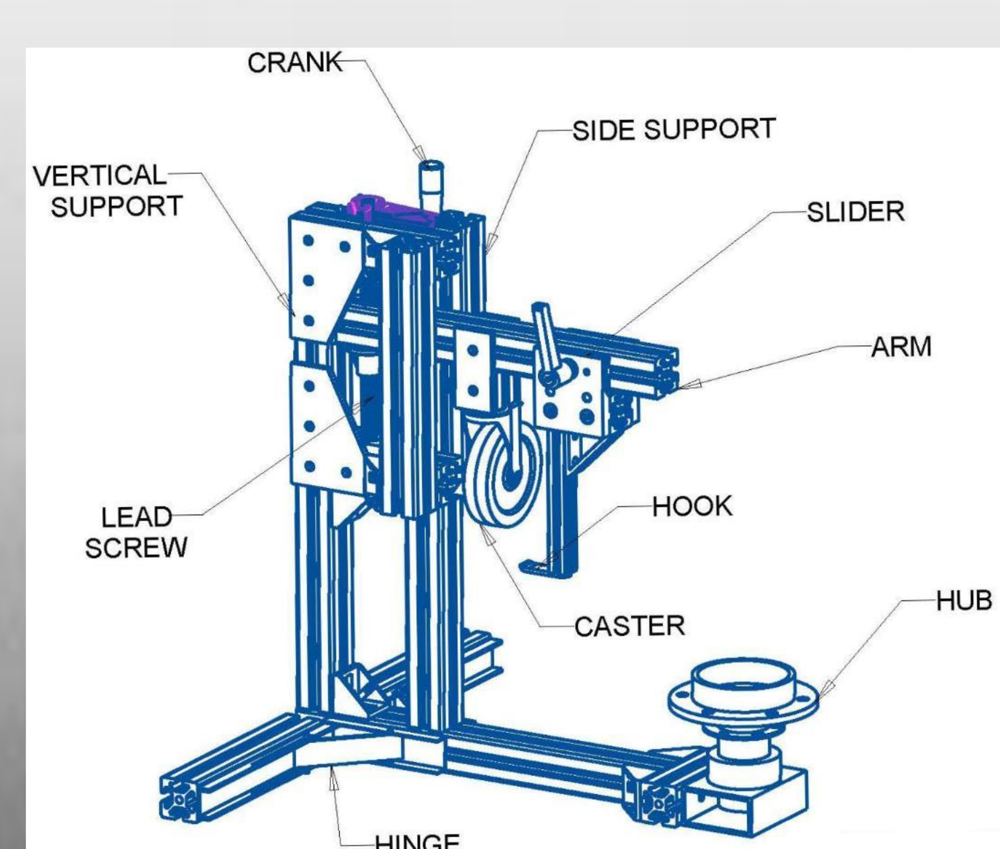
Improved cost efficiency design

As the first design did not meet the cost requirements, new innovations were implemented. The lead screw was one of the most expensive parts in the design and ran almost the full length of the vertical support. Since the arm did not need to lower that far to install the tire it could be shortened considerably to additionally lower the cost. The arm still featured the two fixtures of the previous design but now instead of the vertical support having the ability to slide the hook and roller had a slider on the arm. Convenience was also improved by adding hinges on the legs to allow them to be folded during transport or certain positions in the vehicle.

Necessity of Reliability

After further analysis under recommendation from Senior Engineers, the strength of the arm connection to the vertical support needed to be increased. By adding brackets and side supports the amount of bending and torsional stress that affected the arm and lead screw was mitigated. This design will guaranteed hold up to the stresses of the tire changing process without failure and will be reliable for years to come.

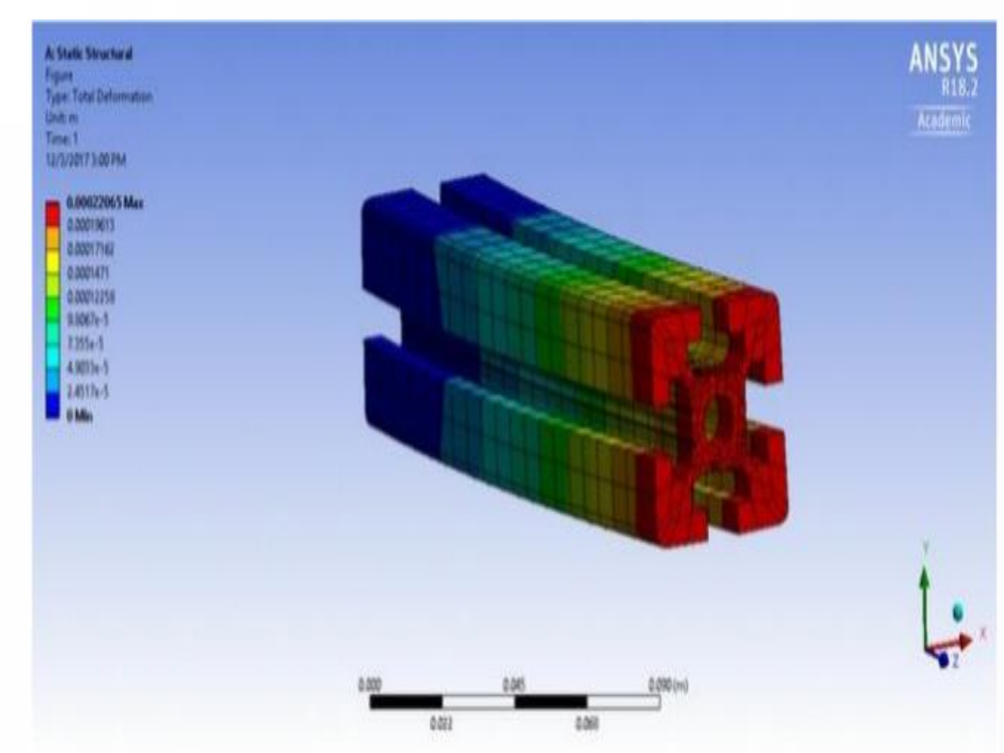
Though this design pushes the limits of the budget, functionality is key in a successful model. A design that meets the budget but fails due to those limitations is just wasted money at any rate.



Final prototype design

ANSYS Analysis

The majority of the stress of changing the tire rests on the arm of the design. As the crank lowers the caster onto the tire the tire pushed against the arm that causes deflection. The material of the arm along with the amount of force placed on it was put into ANSYS program to see how much deflection it would experience. This value needed to be known to ensure that the arm would not fail while changing the tire. Hand calculations were also done to double check the values.



ANSYS model of the arm showing the most serious deflection in red

Testing Plan

To examine for weakness, the base of the tire changer will be a three-legged cross type structure. Since this is the base of the prototype it will be the major provider for stability to the prototype. The testing of the base will be to “rock” the tire changer from different directions to see if there is a side that cannot hold a force applied to it. Failure of this test will occur if the prototype loses stability and tips over or if the components break.

The next component of the design to test will be the Arm for strength and deformation. It will also need to be tested to ensure the arm does not rotate sideways. To test all of this, the same method used to test the support will be applied here. By hanging a weight in increasing increments from 25 to 100lbs from the caster location, the team will be able to see how, if at all, the Arm deforms. This load is less than the planned load and is meant to help see any issues before the machine is taken to full loading during operation.

After individual components are tested, the overall function of the model will be analyzed. The team will change multiple tires and record the times it takes to take the tire off as well as put it on. The tire changer will be used from a variety of positions to ensure the ergonomics of the crank are sound.