Mechanical Report

Solar Cup 2017-2018

Palos Verdes Peninsula High School

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Palos Verdes Peninsula High School
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Introduction

After their last competition in the 2015-2016 season, the 2017-2018 Peninsula Solar Boat Team was alerted to two significant adjustments along with a number of minor changes that would need to be made to maximize their boat's performance and optimize results.

The rudder design was the most detrimental to the team in the past and will be improved for the competition. Steering was also faulty, reflected in the skipper's difficulty in keeping the boat on course even when applying copious amounts of effort. A shorter arm will be placed on the rudder to increase the precision of the boat's steering, thus allowing the boat to sharply turn. The team is learning from their previous errors and is aiming to be among the best teams at the Lake Skinner competition.

Boat Specifications: Center of Gravity

In order for the boat to remain flat on the water, the center of gravity (CG) must be positioned so that the boat doesn't tip forward or backward during the sprint event. This issue occurred last time as the boat's bow lifted upward, increasing the effect of drag on the boat.

The center of gravity is the point where an object could theoretically balance on a pin. This year many of the electrical components have been moved forward and closer together as to decrease weight by removing unnecessary lengths of wire but more importantly, to shift the CG forward. This should lower the bow, allowing the boat to glide through the water more efficiently.

The CG was calculated by grouping the items in the boat to five areas, each about 2.5 feet wide (See Figure 1). The bow is used as the datum. The total weight in each area was calculated and then multiplied by the arm, distance from the datum, to give us the moment of each area.

*Weight * Arm = Moment*

Dividing the sum of the moments by the total weight gives the CG location in reference to the datum.

Total Moment / Total Weight = Center of Gravity Location

The center of gravity is located 96.5" aft of datum (See Figure 2).

Figure 1: Grouping Representation

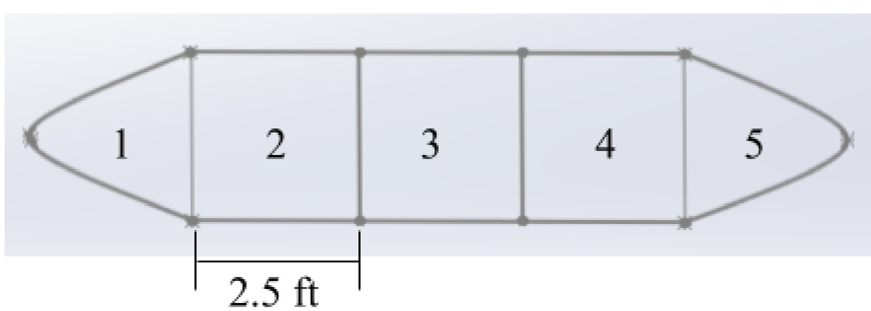


Figure 2: Center of Gravity Calculations

Area	Weight (lb)	Arm (in)	Moment (in-lbs)
Empty Hull	50	96	4800
1	30	28	840
2	3	60	180
3	17	90	1530
4	146	107	15622
5	39	138	5382
Empty Totals	285	---	28354
Skipper	131	90	11790
Loaded Totals	416	---	**40144**
Empty CG: 99.5 inches aft of datum		**Loaded CG: 96.5 inches aft of datum**	

Boat Specifications: Buoyancy

In order to make sure the boat doesn't sink, we must calculate its natural buoyancy. The only items that will float are the boat hull and the skipper, thus they don't need to be included in the buoyancy calculation. All other components inside of the boat need to be considered and compensated for by our canoe floatation bladders.

The weight of the internal components was found by subtracting the weight of the boat hull from the empty weight. This weight ended up being 235 pounds (See Figure 3). The amount of water displaced can then be found by dividing the weight of the internal parts by the weight of a cubic foot of water.

Weight of Internal Components/Weight of a Cubic Foot of Water = Displacement

After adding a safety margin of 20 percent to the displacement calculated, the total safety displacement equaled 4.52 cubic feet of water (See Figure 4). Since the floatation bladders displace a total of 6.42 cubic feet of water, our boat will remain floating on the water's surface.

Figure 3: Weight of Internal Components

Item	Weight (lb)
Skipper	131
Empty Hull	50
Internal Components	**235**
Total Weight of Boat	416

Figure 4: Water Displacement Calculations

	Calculation	Result
Water Displacement by Boat	235 lb/62.43 lb ft^3	3.76 ft^3
Safety Margin (20%)	3.76 ft^3 * 0.2	0.75 ft^3
Total Displacement	3.76 ft^3 + 0.75 ft^3	4.52 ft^3

Propulsion System: Motor

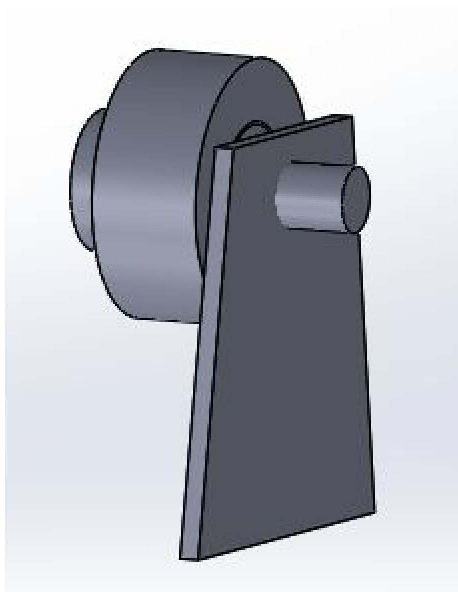
Like last competition, the motor of choice will be the Saietta Engineering (AGNI) B-95R Motor (Figure 5).

Figure 5: AGNI B-95R Motor

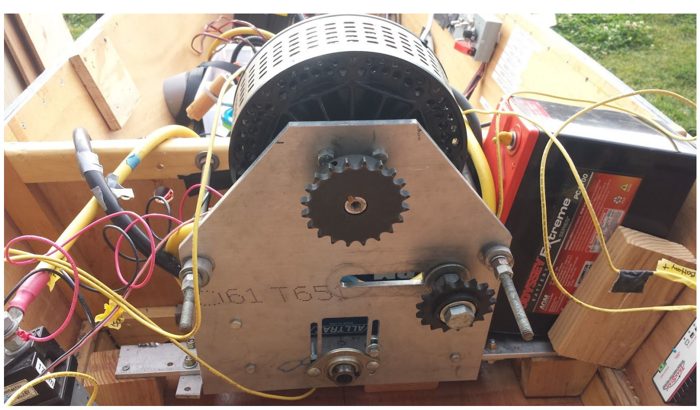
Propulsion System: Motor Mount

Since the same motor will be used, the same motor mount will also be used as it has been shown to be compatible. The motor mount is a hexagonal slab of metal measuring 4” on the top, 5” on the edges, 5.5” on the sides and 10” on the bottom. This year, a third gear will be included on the motor mount in order to ensure that the chain will be tight and will run smoothly over the assembly.

<u>Figure 6: CAD of Motor and Motor Mount</u>



<u>Figure 7: Picture of Motor and Motor Mount with Chain Tightener</u>



Propulsion System: Gears and Sprockets

The boat currently has two configurations available. For the sprint event we use a 10:7 sprocket ratio with 20 teeth at the motor and 14 teeth at the drive shaft. For the endurance event we use a 10:11 sprocket ratio with 20 teeth at the motor and 22 teeth at the drive shaft. As mentioned in the motor mount section of this report, we installed a sprocket between the drive shaft and the motor. We saw it unnecessary to alter our system from the previous years since it worked smoothly.

We created our trapezoidal chain guard out of aluminum. The dimensions of our chain guard is base length of 8”, upper width of 4”, and a height of 10.5” (See Figure 8).

<u>Figure 8: Chain Guard</u>

Propulsion System: Stuffing Box and Shaft Log

The stuffing box (See Figure 9) is an item made out of a cylindrical tube of rubber, a couple of hose clamps, and a plastic cap. Its main function is to seal the opening created to allow the drive shaft to go through the boat. Its inner diameter is 1 ¼”.

The shaft log (See Figure 9) is a PVC pipe used to help the stuffing box prevent water from leaking into the boat and help guide the drive shaft. Its outer diameter is 1 ¼”.

<u>Figure 9: Stuffing Box and Shaft Log Assembly</u>

Propulsion System: Drive Shaft, Thrust Bearing, and Strut

Currently, the drive shaft that will be used in the competition is a ⅝" aluminum rod. This drive shaft has a pin (See Figure 10) that further secures the prop in place.

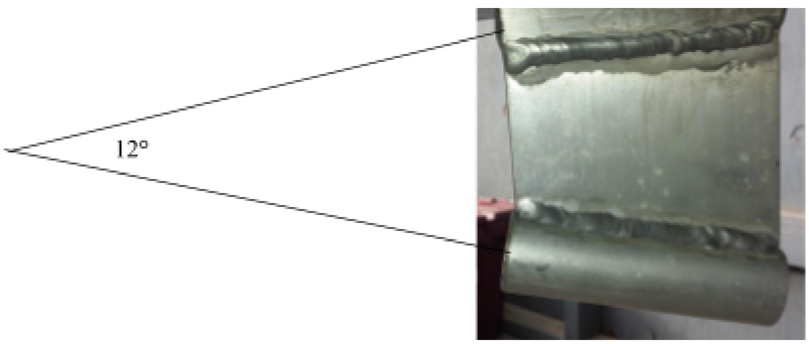
The thrust bearing(See Figure 11), connected to the drive shaft, transfers all the thrust from the prop to the rest of the boat. The inner diameter is ⅝". It has two set screws that are used to secure the drive shaft in place.

The strut is a component that secures the drive shaft in place. It is at an angle of 12° (See Figure 12) and this won't be altered as there are no significant changes in center of gravity or buoyancy. It is located at the very back of the boat and is secured with 4 bolts. However, this year polymer bearings will be used instead of metallic bearings (See Figure 13) for the inside of the strut. This is because polymer bearings use water as lubrication meaning that no other lubrication needs to added. In contrast, the metallic bearings had to be taken out and then lubricated. Its position might also slightly change in order to allow the rudder to be more effective in terms of steering the boat.

Figure 10: Drive Shaft with Pin

<u>Figure 11: Thrust Bearing</u>

<u>Figure 12: Strut</u>



<u>Figure 13: Metallic Bearings for Strut</u>

Propulsion System: Propellor

The propellor churns the water and provides the thrust to move the boat forward. Given our current gear ratio and motor, a three-bladed prop would be the best to use. Theoretically, this also matches up with the torque curve. Also, the prop has a slot (See Figure 14) that hooks on to the pin in the drive shaft.

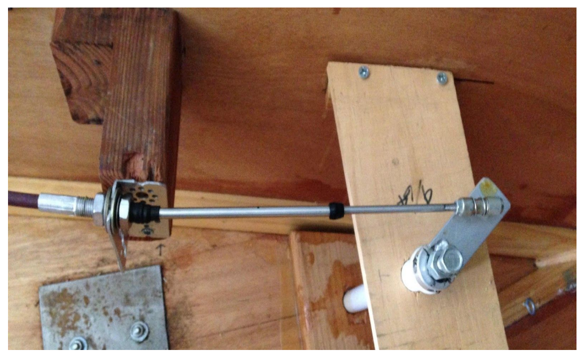
<u>Figure 14: Three-Bladed Propellor</u>

Steering Mechanics: General System

The general system uses a push-pull rod (See Figure 14) to move the rudder through a linkage assembly (See Figure 15). As it was hard for the skippers to steer the boat, several changes will be made. This year, the lever used to move the push-pull rod will be lengthened in order to increase the skipper's mechanical advantage when adjusting their heading. The linkage assembly arm will also be shortened in order to allow for more precise steering and handling, allowing the boat to make sharp turns during the endurance race.

Figure 14: Push-Pull Rod with Lever

Figure 15: Linkage Assembly



Steering Mechanics: Rudder

Like most of the steering system, the rudder has also been changed. It is trapezoidal, made of aluminum, 12” tall, 4” on the top edge, 6” on the bottom edge, and is welded onto a ½” diameter rod of aluminum which is 14 ¼” long (See Figure 16).

Compared to the previous rudder, this is much larger. Since there was so much trouble before in handling the boat, the idea was that the bigger surface area would allow the boat to steer more effectively without having to turn the rudder so much.

Figure 16: Rudder

Conclusion

By fixing the problems with the steering system, adjusting the center of gravity forward, and changing the bearings, the Peninsula Solar Boat team is excited to show what they can do. After learning from mistakes from years prior, the team is willing to compete at a level where they can be the very best among those at Lake Skinner.

Works Cited

Motor Specifications and Source of Picture
http://www.asmokarts.com/index.cfm?pageID=24
Motor Torque Curve
http://www.robotcombat.com/products/images/EMS-AGNI-B-95R_performance.pdf
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Last competition’s report was also used as a reference.