Solar Cup Boat Design

Information for rookies

BIG note: The information in the Tech manual is worth reading.
Important reference info

• Weight and Drag are the enemy
• The propeller handbook by Gerr is a good ref.
• Good parts sources
  – Rex marine -- KTA
  – Glen – I Marine
  – Minnie's yacht surplus
  – Ev-parts
  – Cloud electric
How Much Power?

- 400lb boat including driver running 5.8 mph requires around 1 hp of mechanical power
- Horsepower required = Weight(Speed)$^3$/70472
- Max power per the rules is 11.2 hp
- Sprint races use max power
  - 24 VOLTS x 350 AMPS = 8400 WATTS/W/HP = 11.2
- The big trick – Find a motor configuration that can do both- suggest reading AVEOX motion control primer by David Palombo
Propellers: Does size matter

• Minimum size for control is 5 inch Diameter
• Any size works
  – RPM and propeller diameter determine the max HP output.
    • The smaller the Diameter the more RPM required
  – Propeller pitch relates to the required speed but not directly due to the slip in the fluid coupling
    • A smaller diameter prop would have less pitch
  – Typical pitches used for solar boats 9-15 in/rev
Required RPM to transfer power to the water at different prop diameter

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Slip calculations

• From calculations and measured data we estimate the RPM to be around 1600-1800rpm for sprint speeds and around 500-700 for the endurance.
• Our propeller has a pitch of 15 inches per revolution so at 1600-1800 rpm the theoretical speed in a solid would be =15 in/rev* 1600-1800 rev/min* 60min/hr /63360 in/mile = 22 - 25.5 MPH sprint
• The endurance rate would be = 15*500-600*60/63360 = 7.1 -8.5 MPH
• The actual measure speed for the sprint is between 15 – 16 MPH
• The endurance is 5.5 -6.5 mph
• Why don’t we go as fast as the theoretical based on a solid?
• Water is not a solid. The difference is known as propeller slip. The drag from the boat is as much of a factor as the fluidity of the water. The more horsepower required to move the boat the more slip the prop has.
• Slip can be calculated as
• (Calculated speed – actual)/calculate= sprint slip = around 31- 37%
• Endurance = around 21-23%
Solar cup Propeller photos
Power transmission

• Motors
  – Considerations
    • No load current – how much power is used to do nothing
    • Efficiency
      – Terminal resistance
    • RPM at 24 volts at sprint and endurance power levels

• Required reading
  – AVEOX.COM  motion control primer by David Palombo @ www.aveox.com/technical/dc.html
Matching Motor and Propeller

• Direct drive
  – Motor shaft connects to propeller shaft directly
    • Very hard to match must find the optimum prop.
    • Motor must have ability to support shaft thrust

• Transmission coupled
  – Motor/propellers can be matched by selecting the best gear ratio

• Required reading the Propeller handbook by Dave Gerr. Available at Amazon .com for around $20
Photos of Solar cup boat drives
Rudders

- To small, and you can’t steer
- To big, will slow you down
- Rule of thumb: The rudder area should be 50% of the propeller disk area minimum.
- See propeller photos & rudders
Batteries consumable power
2/3 endurance requirement

Diehard 51
Old Yellowtop
New Yellowtop
Solar panels

• Per the rules 320 watts of panels are allowed
• The solar panel supplies around 1/3 of the endurance power required
• Weight of the panels is important
  – At 6mph with the boat weight @400lbs 2.2watts per pound is used to propel the weight.
  – A solar panel array @ 80 pounds uses 160 watts
  – Keep this in mind when looking
Instrumentation

- On the boat Volt meters and amp meters are required
- Measure only the consumable power
- Solar power is variable and endless. Measuring it is pointless. (it will determine your speed)
- Power management can not be done without instrumentation
Floatation

- Inflatable floatation has proven to be the best choice
- Kayak floatation bladders work great and fit the hull shape
- Foam works but requires more work
- Some teams have used sparklets bottles
- Provide flotation for things that sink.