Eleven cities Solar Boat Challenge

TU Delft students are participating for the fourth time in the world championship solar boat race in Friesland, which begins on 8 July. Expectations are high because the TU Delft students were world champions in 2006 and 2008. In 2010, the solar boat was equipped with hydrofoils for the first time. Unfortunately, the hydrofoils caused the boat to rise so far out of the water at top speed that it tilted and only achieved a third place. The big question is whether this year's new boat is fast enough to beat the competition. This infographic describes the technologies that the TU Delft team hope will help them win the race. For more information, see www.deltalloydsolarboat.nl

Student team

The Delta Lloyd Solar Boat Team consists of twenty students who work together for a year to design and build a racing boat. When the boat was assembled in June, it was not yet known which of two candidates would actually pilot the boat. A condition of the race is that the pilot must weigh at least 70 kg.

A Lightweight hull

The hull is made of carbon fibres to keep weight to a minimum. The deck is made of glass fibre because carbon conducts electricity. The relatively weak hull is reinforced with ribs and beams. Only when the deck is fastened to the hull, a stiff box structure is created. The shape of the hull flares out above the waterline to provide sufficient surface area for the solar cells. The hull (47 kg) has four hoisting eyes to enable the boat to be lifted out of the water. During the course of the Solar Challenge, the boat must be lifted out of the water in some places to pass obstacles.

B Propeller drive

The motor, gearbox and motor controller are supplied as a unit (pod, 3.3 kg) in a streamlined underwater housing. The aluminium motor (maximum output power 4 kW) has been specially modified by the German manufacturer to work with the low battery voltage of 43.2 Vte. The rules require this low voltage because of the wet environment.

C Propeller

The aluminium propeller (diameter 34 cm) is specially designed for the solar-powered boat with hydrofoils. At the most important speed, the propeller achieves a theoretical efficiency of 84%.

2

Pod

Motor including

gearbox and controller.

rotatable hydrofoils

Steering system When the pilot turns the carbon steering wheel, a steering mechanism consisting of a cable and pulleys causes the motor including pod, gearbox and propeller to swivel and change direction. The boat does not have a rudder.

G Batteries

If the solar panels generate more energy than needed to power the motor, the surplus energy can be stored. This energy is used in overcast weather and when the boat needs to reach top speed during the final sprint of the race. The maximum storage capacity is 1 kWh (= 3.6 MJ). The TU Delft solar-powered boat carries 7.1 kg of lithium-ion batteries on board (the maximum permitted weight for this type of battery). The solar panels charge the batter in less than thirty minutes. A special battery management system measures all voltages, currents and temperatures and ensures that the batteries are never overcharged or run down too low. In the event of the batteries catching fire, fire extinguishers are activated automatically.

Fire extinguisher

DIAMAENV

delta llovd

Hydrofoil in 2010

The solar-powered boat was first equipped with hydrofoils in 2010 3. At speeds above 12 km/h the foils generate enough lift to raise the boat out of the water. This reduces resistance and permits a higher speed to be reached at a given rpm. During the race, the hull rose out of the water completely. This meant that the boat was only supported by point 4 of the V-shaped hydrofoil and it became unstable and tilted over. In order to avoid this occurring, the boat had to be kept below its top speed and finished third (average speed 16.7 km/h).

E Improved front hydrofoil 2012

As the boat rises further out of the water, the angled hydrofoils 5 will pierce the water at an increasingly lower level. The shape and angle of the foil is different at lower levels of the foil and thus generates less lift. This means that the hull will remain at a constant height above the water even at higher speeds. A new feature is the

Top speed o**ut hydro**i 25 km/h

Top speed vith hydrofoil

Top speeds

Head Mounted Display

TUDelft

hydrofoil design 2010

8 MPPT controllers

MARIN

Advantage

The battery system consists of 156 individual cells: 13 parallel battery units, each consisting of 12 cells connected in series. Thanks to this innovative arrangement, the TU Delft team expects their 7.1 kg set of batteries to have a greater capacity than the 1 kW assumed in the rules. They hope to use this loophole in the rules to achieve higher speeds than the other teams

D Rear hydrofoil

Originally, the plan was to have a single large rear hydrofoil this year. Due to a lack of time during the hull construction, a decision was taken to once again use the T structure used in 2010 - two foils mounted on each side of the motor pod. The angle of the hydrofoils can be individually adjusted using two actuators 2 at the rear of the pod. If the boat begins to tilt during the race, due to a strong side wind, for example, the boat can be righted by setting the foils at different angles.

On-board computer

Remote control

The pilot uses a walkie-talkie or a cell phone to maintain contact with a vehicle following the boat. In the vehicle, it is possible to monitor and analyse the performance of the boat (e.g. speed, GPS location, operation of the solar cells, remaining battery power) as well as the weather conditions. A computer calculates the speed that will produce optimum results. The pilot wears special glasses (a head-mounted display) that project a data screen into the pilot's field of vision. A special on-board computer controls the actuators of the hydrofoils depending on the measured GPS speed and boat position.

Dank aan Roel Stein (Delft Solar Te illustrations and text: Eric Verdult www.kennisinbeeld.nl (C) 2012

Energy Solar Challenge

The Delft Team is competing in the top class of the Dong Energy Solar Challenge (8 to 14 July 2012). The race follows the route of the legend-ary Dutch ice skating event the "Elfstedentocht" (the Eleven Cities Tour). The route is divided into sections. The boat that achieves the best total winning time was 11 hours and 25 minutes) is the world champion solar-powered boat in 2012.

horizontal section of the foil 6, which is always submerged and is designed to prevent the boat from tilting. The front hydrofoil can rotate around its mounting axis 7 (using two actuators). The angle of inclination can be set beforehand to achieve the optimal lift.

> Solar cells 2,928 triple-junction solar cells

Technical data for the boat

LxWxH

Draught 10 cm

Total weight 135 kg

F Solar panels

Solar panels are the only source of energy permitted on the boats. The maximum power the panels are permitted to generate is 1750 Wp (watt-peak). The deck of the boat is covered with 2928 gallium-arsenide triple-junction solar cells (7.92 m^2) . The cells have an average efficiency of 21.9%. The power generated by the solar cells is passed to the batteries via MPPT electronic controllers 8. These MPPT units ensure that the maximum power is obtained from the solar cells and stored in the batteries.