Build your own racing car

This year, the DUT Racing Team is building a racing car for the thirteenth time that will take part in the Formula Student Electric (FSE). There is a great deal at stake. In 2012, the team from Delft won the official World Championships in Germany, and finished in second place on the Silverstone F1 circuit in the UK. As a result, TU Delft is now top of the FSE world rankings. The Delft racing car will be making its debut in England, followed by appearances in Germany and Austria in August. This infographic shows why the DUT13 is even better than its twelve predecessors.

**Chassis**
The car’s chassis is a self-supporting construction (monocoque), made up of a 2.5-cm thick foam core covered with carbon fibres. The mono¬coque is attached to the base plate and laminated. The wings and the base plate are made from special TeXtreme fibres, into which the resin has already been impregnated. This means that it is better distributed in the fibres, as a result of which less resin is needed.

**Four-wheel drive and skid regulator**
The friction (and therefore the propulsive power) between the tyre and the road is at its maximum at 15% skid (at 100% skid, a wheel rotates twice as quickly as it does when rolling perfectly). A computer – the skid-ratio controller – regulates the number of revolutions of the wheels so that each tyre generates the maximum propulsive power by making optimal use of skid. The yaw rate controller (yaw rate is the velocity at which the car rotates around its vertical axis) ensures that the forces are distributed over the four wheels in such a way that the car is able to take bends as tightly as possible at the highest possible speed (by enabling the outer wheels to rotate more quickly). Four-wheel drive is needed to be able to control the forces on the wheels accurately. Last year, the DUT12 was the first Delft racing car to have four-wheel drive.

**Motors 4 x 26 kW**
Each wheel is propelled by its own electric motor. The advantage of this is that no axes or gears are needed between a central motor and the rear wheels, but the disadvantage is that the heavy motors are located a long way from the car’s centre of gravity, as a result of which the car is less agile (it has a greater yaw inertia).

**Transmission**
The gear box has to fit into the small wheel rim. Two-gear transmission provides the correct transmission (the engine turns fourteen times faster than the wheel) with the help of a standard cog set (1:4) and a planetary system (1:3.5). The large ring wheel remains still, and the four planet wheels are connected to the rim. The engine is not positioned centrally on the wheel, which allows more space for the steering rod.

**Spring damper system**
The spring damper system should preferably be low, in order for there to be a low centre of gravity. As there was not enough room near the front wheel suspension, the system has been placed on the monocoque.

**Composite brake discs**
The aluminium composite brake discs combine high heat capacity with a high level of strength. They are twice as light as the old steel brake discs.
The FSE is not about racing at top speed. In order to win, the car has to be able to handle bends well, and more especially accelerate on the short stretches between the bends. Acceleration is determined by the non-constant friction coefficient, which decreases the more the tyre pushes down onto the road. For maximum acceleration, the mass of the car should therefore be as low as possible. The weight distribution across the tyres should also be equal. Finally, the car’s centre of gravity should be as low as possible. If it is high, the car will tilt, so that the outer tyres will bear a heavier load. This will reduce their maximum grip, and the car will fly off the bend.

**Regenerative breaking**
When the driver brakes, the motors work like an alternator so that some of the braking energy is stored in the batteries. Four-wheel drive is more suitable for this than is two-wheel drive, because it is the front wheels that bear the heaviest load during braking – and these wheels do not have motors if two-wheel drive is used. As a result, the batteries can be smaller than those used last year. The batteries are designed to store at least 25% of the braking energy used.

**Battery packs**
High voltage means low current, and therefore little heat loss. Batteries for electric cars, for example, supply 600 V, but are large and heavy because they have to store a lot of energy. The longest FSE race lasts just thirty minutes. A battery in radio-controlled cars, for example, has the capacity to store large amounts of energy and has a low weight, but supplies just 3.7 volts. For the racing car, 288 separate lithium polymer battery cells are bundled in series (so that the voltages, together, add up) in two battery packs (each of eight modules with eighteen cells). The heavy battery packs, weighing 23 kg each, are positioned as low as possible on the base plate on either side of the driver, as close as possible to the centre of gravity.

**Cooling**
The air-cooled electric motors are normally used in factories to supply power of 3 kW. As a great deal of heat is generated during the race application (of 26 kW), each motor is fitted with an aluminium cover with cooling channels. The cooling water flows through the motors via tubes to two radiators on the sides of the car. The water cooling ensures that the internal temperatures remain below 150°C.

**Electrical system**

- **ECU**
  The electronic control unit processes all the sensor data, and determines the power that goes to each wheel.

- **Low voltage battery**
  This battery provides power to the computer, the motor controllers, and the water pump, among other things.

- **Motor controllers**
  The high voltage from the battery cannot be fed directly to the motors. Four motor controllers convert the high-voltage direct current from the batteries to low-voltage alternating current for the motors.

- **Split box**
  The split box splits up the power from the battery to the motor controllers.

**Dimensions**

- **Wheelbase (axis-axis)**: 153 cm
- **Mass**: 173 kg

**Design philosophy**

- **Driver**
  Every driver gets his own carbon seat, made according to his personal dimensions: he sits in a foam sack, while a two-component resin hardens.

- **Wings**
  This year, the car has two front wings and a rear wing that are supposed to generate a negative lift of 500 N at a speed of 60 km/h. This downforce pushes onto the car, allowing it greater acceleration on bends. A drawback here is that other parts (chassis, rims) have to be made stronger, so the car is 25 kg heavier than without wings. Practical tests should show whether the downforce really is generated. The wings will undoubtedly result in greater air resistance.

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