

Rotary Racer's Roll

Castle Combe – 2010-06-27

The Rotary Racer Team

Unfortunately not a good race for the Rotary Racer team. During practice, one of the drivers managed to roll the car at the notorious quarry corner. Thankfully the car stood up to the roll very well and the driver was un-harmed.

The Car was RR8e. This was the cars seventh race. The only modifications since the last race was a metal plate near the motor to improve cooling flow and the movement of the GPS aerial to the top of the roll-bar. The car had been checked over by the lads and dads since the previous race at the previous Tuesday's Greenpower session and also while at one of the parents houses on Saturday before the race.

The car was running with a 20:49 (2.45) ratio on the chain drive. The Castle Combe circuit is 2.977Km long and has some slight hill with generally sweeping corners although there are some tight-ish ones as well, but no chicanes. It is a bit bumpy in places. There was a slight wind on the day (18Km/H ?). The software was car18 which included average speed computation and GPS data and lap timing measurements.

What Happened

Gareth, the first driver took the car on a 3 lap test and practice. The middle one of these was with the power levels turned up to full power to test average current draw with the gearing ratio in use. All went fine although he did say the track was a bit bumpy.

The drivers had decided to put in Liam as the next practice driver as he had had no experience on this circuit and to put him out for 3 laps also rather than the two for all the other drivers. We have a policy of trying to get all drivers to do at least one practice lap if the time allows. We try and ensure being close to first into scrutineering to allow us the time to do this.

Liam, who was reasonably experienced (3 races, Dunsfold, Goodwood CC, Goodwood Southern counties), but not with this circuit then took out for practice at the normal power level. He is a steady and calm driver. He had been told to take it steady on his first circuit to get used to the track by James (The team captain), which he duly did. He did one circuit and then on the second had a problem at the sharp, almost hairpin quarry corner. The car rolled at this point while going relatively fast, about 32.5 MPH looking at the data logs. A St John's ambulance man saw the roll and said the car had jumped up as had the driver. The on-board cameras were switched off at the time. From the various accounts of the event, and looking at the track afterwards, we conjecture the following:

- The car was going reasonably fast, but not excessively so, at about 36.9MPH after the downhill section of the track with the wind behind. The car slowed down as it travelled up the hill towards Quarry corner and then started cornering. From the data logs it looks like the driver started to slow the car down further, with the brakes, in the last few seconds and it appears to have rolled while doing between 27.8MPH and 32.5MPH. The car had gone through this section with a previous driver at 36MPH and 37.7MPH previously on the day while on full power. However, this is quite fast for the sharp corner, a good racing line would be needed.
- From a report by Steve King, who was one of the marshals who picked up the car afterwards, and after looking at the track at the end of the day, there is a patch (about 1m x 0.5m) in the tarmac with some rough edges. Around it are with some gouges out of the track. This is followed by a ridge of about 3cm high for about a meter or more long, in the tarmac further to the outside of the corner probably caused by the tarmac being pushed up by full sized cars cornering hard. This is just before the marks on the ground caused by the paint on the foam sides and the roll-bar hitting and in line with the most probable line the car took. It looks like

the car was on a reasonable racing line.

- We think the car was cornering hard and the rear end was sliding a touch when it hit the ridge. We think that this lifted the rear end slightly off the ground, allowing the car to rotate, possibly with the brakes on. When the car dropped down the wheel would have increased sideways friction. We think this gave enough sideways force for the car to topple. Alternatively hitting the ridge may have caused the problem, but the driver did say that the car bumped up and down on the rear end before starting to roll.
- There were no flats on the front tyres suggesting that, although the brakes were on, the front wheels had not locked up.
- We believe the car rolled twice before sliding to a halt. The roll-bar protected the driver admirably and the foam sides probably softened the landing and the friction probably brought the car to a halt relatively quickly.
- The driver was un-harmed by the accident, with just a few very minor bruises. His helmet was untouched apart from slight scratching on the left hand end of the visor.

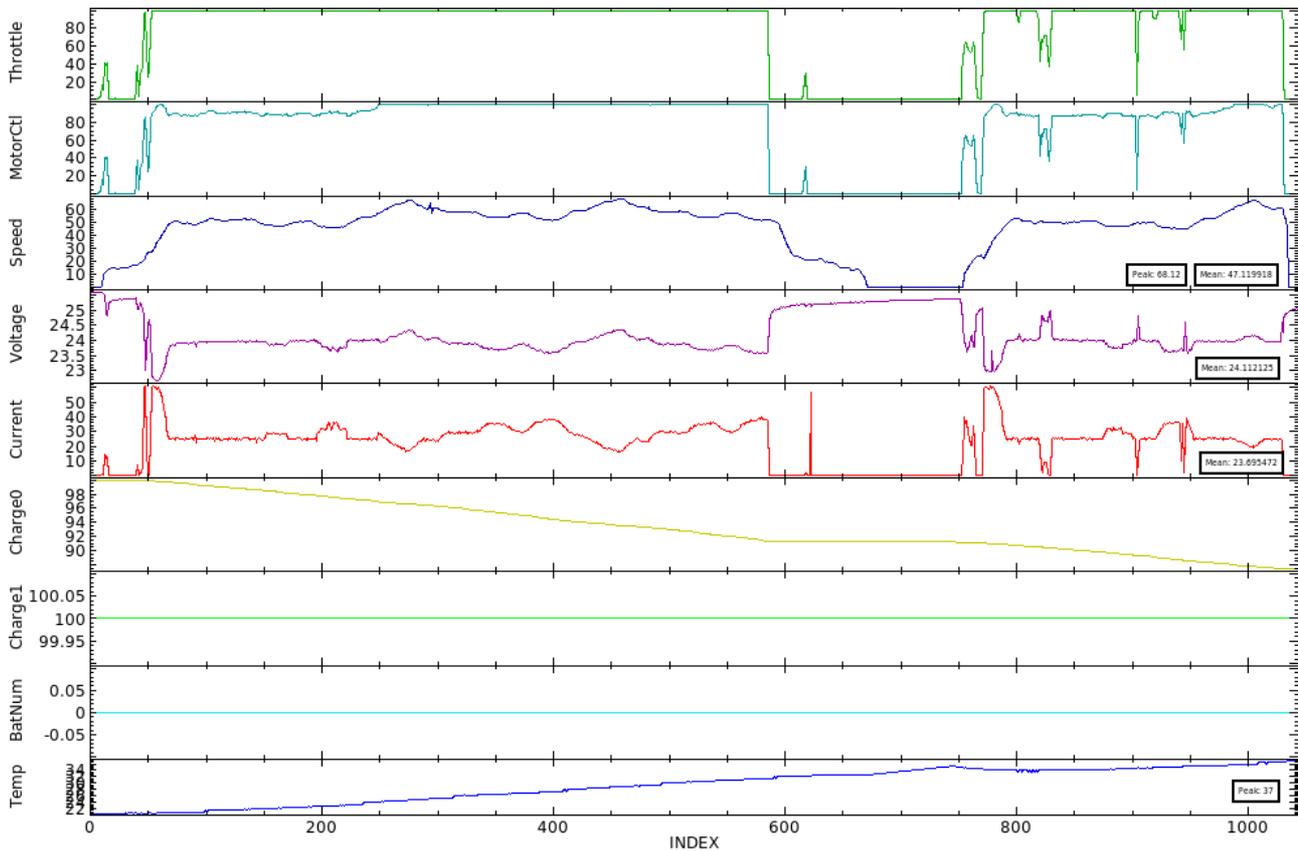


Data Logs

The car was logging data during the practice runs. This includes: Throttle position, Motor power level, Speed, Voltage, Current, GPS position etc. The data for this is at:

http://www.greenpower.beamweb.co.uk/files/RotaryRacer/performance/2010-06-27_CastleCombe

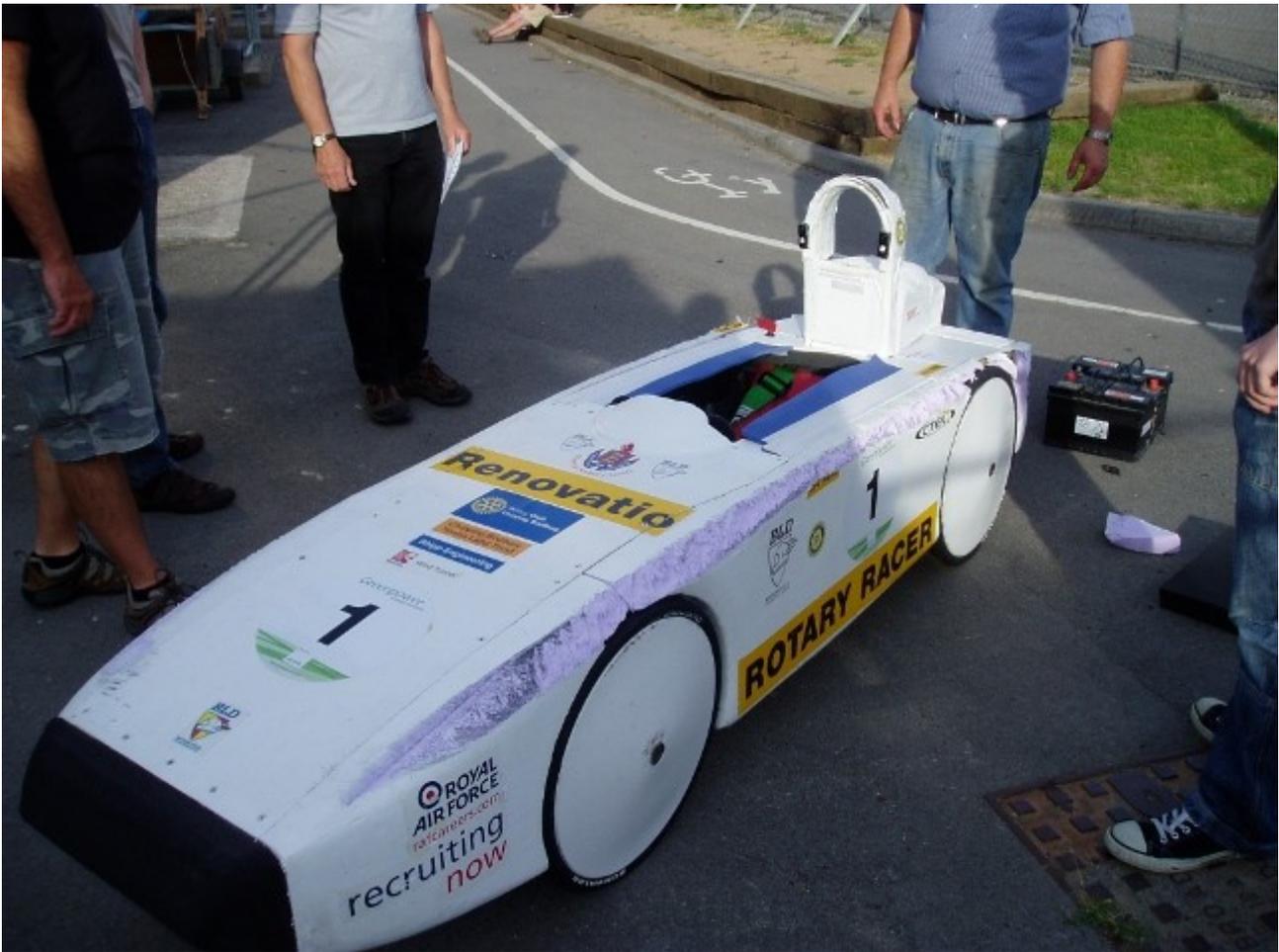
The following plot, shows the core information.



After the Incident

Looking at the car after the incident we notice the following:

- The roll-bar was completely intact and fully upright. It had bent “forward” about an inch at the top, the car must have gone backwards for a bit, was bend slightly to one side and had deep scoring on the top edge where it had hit and rubbed the ground. The roll-bar was made of 25.4mm steel tubing, 1.6mm thick. It had a horizontal, welded steel tube brace about 190mm from the top. It was mounted to the cars steel sub-frame at the bottom by welded spigots and with 8mm steel bolts about 150mm up from this. It had an aluminium rear strut going to the rear chassis. This was fastened to the roll-bar with bolted plastic bungs one of which had popped out with the roll-bar going forward.
- The right-hand side rear wheel had bucked badly. We are pretty sure this happened during the roll rather than before. There are no broken spokes and the hubs are intact. The rim is bent. The wheels are quite strong and other than the buckle in the rim look fine. This wheel is the free running, not motor driven, wheel and was the wheel on the inside of the corner.
- The tyres, Schwalbe Durano's, were in good condition. They have done about 500 miles or so, but had no flat spots or other damage. There are some sideways scuff marks on the rear tyres after this race, but they were still fully inflated (about 110 PSI) and generally un-damaged apart from some scuffing.
- The top corners of the cars foam sides are worn away. We think this would have softened the roll and brought the car to a timely stop due to the friction with the road surface.
- The batteries did not move and there were no leaks. The plywood battery leakage box was slightly damaged around one of its holding screws, but otherwise there were no problems here.
- The front steering and brakes suffered no damage and were fully working.
- There are no other noticeable faults or damage to the car.



Car Rolling Angles

Rotary Racer 8e has a relatively low CofG and although not high, a reasonable wheel track for Greenpower cars of 600mm. We measured the rolling angle of the car to test its rolling stability.



The angle at the balance point was 43 degrees. We also measured the weight on the front and rear tyres and tested the sideways tyre friction on tarmac. These were:

Tilt Angle	43 degrees
Weight on front wheels	57Kg
Weight on rear wheels	88Kg

Forward/Rear weight distribution	39:61
Sideways friction force on front wheels	47Kg
Sideways friction force on rear wheels	63Kg

The following are static calculations, dynamic calculations would yield different values.

The sideways force needed to roll the car is thus about: $135\text{Kg} = (145 * \tan(43))$

The car will slide when the force is: 110Kg

Thus the car's static stability is such that it should slide before it rolls with a margin of: 21%

Although these figures are calculated for the static case, and on a different surface to the hairpin corner in question, the results appear to match the conjecture above, that the car was sliding when it hit a bump which caused a dynamically greater sideways force enough to tip it over. Obviously any vehicle sliding sideways and hitting an object with enough force will roll.

Car and Team Improvements to be made

Although we believe this is a one off type of event, that was caused by a number of factors coming together at the wrong time, we intend to perform the following improvements to the car and team procedures.

1. We will replace the 20 inch wheels with 16 inch wheels. This will lower the cars centre of gravity by about 30mm and improve roll stability by about 12%.
2. We will make the dish in the wheels flatter. This will increase the track of the wheels by about 20mm (3%).
3. We will replace the roll-bar with an identical remade one, as it has been used.
4. We will change the rear strut to be able to take both push and pull forces.
5. We will spend more time with the drivers going over the circuits and its corners before races.
6. We intend to take the drivers on a go-kart circuit to better hone their drivers skills.

The above changes will increase the cars tilt angle to about 47 degrees. The cars stability would then be such that it would slide before rolling with a margin of about: 37%.