

Less is More – the Caterham 160 Story

The Caterham 160 has been receiving a lot of attention in the press recently, and many will have seen it feature on the Top Gear track, where it was highly praised by James May, despite being eclipsed in pure performance terms by the 620R. While its 3 cylinder 80 bhp engine may not offer the outright performance of other Sevens, this entry level model has been received with great acclaim as a great, yet affordable, driver's car. The design of the 160 was undertaken by Caterham's In-house R&D facility, known as Caterham Technology and Innovation (CTI). In early February, Members were invited for a tour of the facility, and to learn more about this car's genesis. **Michael Calvert** reports, with photographs by Mark Gilbert and the author.



The approach to CTI's facility is a curious one; you wind your way through rural Norfolk past the pig farms and sugar beet mounds to end up on the outskirts of the market town of Hingham at a Business Park. It is here that you enter the far more high-tech world of Caterham Technology and Innovation which rubs shoulders with the likes of a farm outlet shop.

CTI had invited 50 lucky members to tour its facility, and to learn more about one of CTI's most recent projects for Caterham Cars, the development of the entry-level Caterham 160. Unlike last summer's Club tour of the Caterham F1 factory, the terrible winter did its best to ensure that there could be no repeat of the row upon row of Caterham lined up

in the car park. Still, three 7s and a 21 braved the downpours to prove that we still have still some hardy members in our midst.

Attendees mingling in reception took the opportunity to examine a number of interesting exhibits on display, including a Caterham branded Team Lotus F1 car (apparently the personal property of Mike Gascoyne), a cut-away Caterham 160 chassis revealing many of the developments that we would learn more about during the visit and a range of other models and mock-ups of projects which CTI have been involved in, spanning automotive, marine and aeronautical domains.

Once assembled, attendees were taken upstairs for coffee and biscuits, and to be briefed on the morning's activities. CTI had

assembled a group of senior engineering and design staff who had given up their Saturdays to be our hosts – Scott Thompson (Business Development Manager), Chris Dunster (Head of Vehicle Engineering), Paul Birch (Head of Powertrain and Electronics), David Minter (Chief Engineer, Vehicle Development) and Ralph Sandford (Chief Engineer, Control Systems). David Minter's face seemed familiar to a number of those present although it was not immediately apparent where from. It soon transpired that David had previously been chief engineer at Lotus, where amongst other projects he was responsible for the Elise S1 and S2 and had featured heavily in the 1996 TV documentary "Lotus Elise – the Inside Story". One of David's first projects



The 160 promises an affordable entry point to the Caterham experience. However, would existing owners be convinced that a 3 cylinder engine is worthy of the Caterham name?

when based at Dartford was to develop the Duratec R400 and bring it to production. With Caterham staff of this calibre as our guides, we were clearly in for an illuminating tour.

With introductions over, the attendees were split into two groups – one would start with a tour of the facilities, while the other would attend a talk on the development of the 160, before the roles were reversed. What follows is (at a very high level) a summary of the development work which ultimately lead to the completion of the Suzuki-powered Caterham 160.

The initial brief to CTI for the car which was ultimately to become the 160 was for a model to replace the Caterham Classic as the entry level to Seven ownership. Over the years, Caterham has used the Classic moniker on a range of different specification cars, ranging from 1600 Ford X-Flow, through 1600 Vauxhall and most latterly the 1.4 Rover K series. In each case, the Classic has represented a pared back, entry-level specification car, with the emphasis on driver enjoyment rather than out-and-out ultimate performance.

In essence, the target for this new car was to offer a light weight, low power yet engaging first step on the Caterham ownership ladder, and the designers were set an aggressive price point to hit for the project to be given the go-ahead.

“Requirements”

CTI initially examined a wide range of power plant options for this new model, before settling on Suzuki. At first glance, this may not have been the most obvious choice, but when considered more closely, the Suzuki arrangement makes complete sense. They were able to offer Caterham off the shelf components including engine, gearbox, prop-shaft and rear axle which were already designed for a front engine, rear wheel drive configuration, which is a fairly uncommon setup these days. In addition, Suzuki’s three cylinder, 660cc turbocharged engine had been designed from the outset to deliver a sporting

character – for example, it revs to 7,500 rpm in its original application, even before any of the recalibration work which CTI would perform to optimise it for the Seven. What is more, it is incredibly light – the bare engine weighs in at around 60kg, and the gearbox (dry) is a mere 16kg. Scott Thompson quipped that after his first visit to Japan to investigate engine supply, he had considered bringing one back as hand luggage, and I think he was only half joking...

There were some additional “soft” benefits to Caterham from a tie-up with Suzuki too. Firstly, the Japanese company was extremely supportive of them in this development programme. Although in absolute terms, the value of business with Caterham would represent little more than a “drop in the ocean” compared to its main sales, Suzuki saw the project as an opportunity to imbue its car division with some sporting reputation, at a time when it was its motorbike division getting most of the motorsport attention – that “Powered by Suzuki” co-branding certainly seems to open some doors... Secondly, Caterham relished the opportunity to work with a power plant which is well known, understood and developed in

the Japanese market, yet relatively unfamiliar to European customers. The Suzuki 660cc engine had been developed to power a range of Suzuki vehicles which comply with the strict Japanese Kei car (“light automobile”) regulations. In the Japanese home territory, adherence to these rules provides a range of tax and insurance advantages, as well as an exemption from the requirement to certify that adequate parking is available for the vehicle. Of course, this all counts for nothing outside Japan, so could CTI really engineer a Seven, with the driver appeal that we have come to expect, from such a diminutive engine?

The 160 project was kicked off at a launch meeting held in Japan in December 2012. The team was set tight timescales for the development programme, which it achieved with ease since a mere seven months after this launch, Mr Suzuki took to the stage to unveil the demonstrator on Suzuki’s stand at the Frankfurt motor show.

Although to the outsider it may seem that dropping a new power plant and transmission into an existing chassis should be a simple process, the demands of the modern marketplace, and a desire to engineer specific driver characteristics into this car meant that a significant amount of work would be called for from the CTI team. In addition, the cost objectives for the car were only likely to be achieved if the number of components needing to be modified or made bespoke were able to be kept to a minimum.

“Development project definition”

At the start of the project, extensive simulation work was undertaken to model the seemingly endless number of variables which would contribute to the character of the car. Gear ratios, torque curves, tyre sizes and a whole raft of vehicle dynamics aspects were modelled to provide the engineers with the best possible starting point for the car’s design. The choice of optimum gearing was a particular area of focus – options for gear and differential ratios and tyre sizes resulted in quite different



The 160 re-introduces the simple and lightweight live axle setup, not seen on new cars since the early 2000s.

outcomes in terms of performance, maximum speed, acceleration and the like. To further complicate matters, the team had to find a setup that would suit two states of engine tune as for regulatory reasons, the Japanese market would receive a car with a reduced power output of 64PS, while the rest of the world would receive the 80PS version.

Cost also had to be a constant focus in the project. Bespoke parts and component modifications would increase the end price of the vehicle significantly. The final specification car called for a unique differential ratio from Suzuki, married to the tyres which the team felt provided the best combination of performance attributes. Caterham Car's initial brief had been for a car that you could slide around at low speed, so over-tyreing it was to be avoided at all costs. A range of options was considered, with skinny 155/65 Avon ZT5 tyres being the ones selected, above others which potentially offered a higher grip levels, but which "let go" in a less progressive way. The result, we are told, is a car which a driver can slide around on the throttle at 30 mph should he so wish, with the loss of adhesion taking place in a progressive and predictable way.

With this quest to minimise the number of bespoke parts used, I was surprised to hear that Caterham had decided to design and build its own ECU to drive the 160's electrical systems. However, the need to ensure homologation for European and Asian markets, while retaining the Seven's sporting character without any noticeable lag from the turbo apparently made this the most appropriate choice. And although this is an entry level model, high tech concepts such as a "fly by wire" throttle needed to be incorporated to meet the requirements of a responsive, yet emissions friendly engine.

Another fundamental decision for the design team related to the rear suspension choice. Having considered the options, the choice was made to hark back to the design of the Seven as it was some forty years ago when Caterham first took over production and use a live axle. An appropriate axle was available from Suzuki (albeit with a bespoke final ratio), but with the Caterham chassis now designed around the more familiar De Dion rear end, there were significant technical obstacles to retrofitting a live axle. The simplest option would have been to weld an A frame mount onto the axle, but such a mounting point would have been very low down and prone to damage, and calculations predicted that there could be problems as when the suspension went through its full articulation, the prop shaft could go beyond an acceptable angle with the gearbox. With the completion of a range of exercises to model the behaviour of different suspension setups, the decision was made to continue a retro theme with the simple, yet effective choice of locating the axle

via a Panhard rod. CTI designed the necessary package of parts and axle modifications to marry the Suzuki axle to the Seven chassis and the basic architecture was complete.

Next came the engine. With Caterham's own ECU finished, it was time to fine-tune the engine setup for the 160. Many months of bench testing were to follow as the team developed the inlet, exhaust and electronics. A new lubrication system and sump were developed which would fit the confines of the engine bay yet maintain oil pressure under the most extreme conditions. First for Caterham was the development of "knock control" which allows the engine to extract the most performance possible from the fuel, while being able to run safely on the different grades available around the world.

The development of these ancillary systems to tune the engine's performance meant that the engine itself was able to be left untouched, reducing cost and maximising the reliability of this tried and tested power plant. And while the CTI staff privately admitted that in an ideal world, a "driver's car" would be naturally aspirated rather than turbocharged, they are clearly proud of the work that they have done to provide responsive power delivery. In fact, Dave Minter said that he very much doubted that anyone who did not know that the car used forced induction would be able to guess that it was turbocharged at all. Throttle response is no doubt helped by the fact that the turbo is actually quite minuscule (it apparently has a turbine blade about the size of the end of your thumb) so is always 'on-speed' which cuts out throttle lag.

With a "sporty" character for the engine developed, the next stage was to pass the necessary steps for the car to be homologated against European and Asian small series regulations. CTI did not elaborate on the no doubt extensive and laborious testing that such regulations entail, but I was interested to learn about the way in which "EU recognised" engine performance is assessed. The engine is tested under set environmental conditions, and under the watchful eye of independent assessors. On the dyno, it has to sit for two minutes at each of the available 250 rpm increments all the way up its rev range, then the same back down again. As someone who winces when his car is on a rolling road for more than the briefest power run, the idea of an engine sitting there for much of the day going slowly up and down through its rev range sounds like pure torture... However, this is the way that repeatable and comparable engine outputs are now conducted across all EU homologated makes. CTI also made the point that such "stable" output readings tend to record significantly lower than the more usual "flash readings" which engine tuners use. I sense the material for a really good pub debate brewing here...

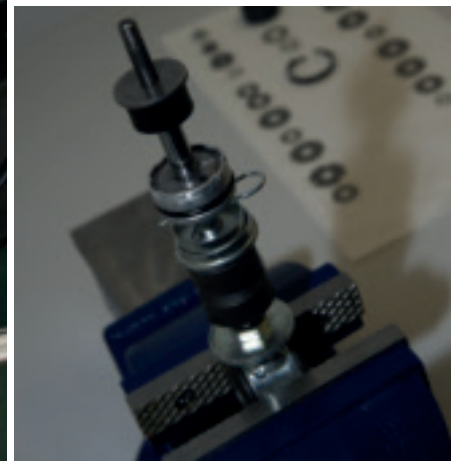
The 160 chassis on display in reception provided a foretaste of the developments that attendees would learn about.



Also fundamental to the car's behaviour was the suspension setup. CTI decided to take as their baseline the setup of the R400D, which they regard as a well designed and engineered package. They started with its settings in their simulation tools, but then applied the weight and desired handling characteristics for the 160. I must admit that it was at this point that the technical enthusiasm and expertise of the CTI team began to overwhelm the understanding of your reporter, particularly when concepts which appear counter-intuitive, such as how changes to the front of the car affect how the rear responds were concerned. Dave Minter took us through the almost infinite number of adjustments which can be made to damper behaviour. The team has a long standing relationship with damper supplier Bilstein, and the drawer upon drawer of different size shims which they can use to fine-tune the damping bear testament to the amount of work to get the handling just the way that they like. Again, the team start off with theoretical modelling, but report that ultimately, it can only ever be subjective testing on the road and track which arrives at the final setup.

The CTI team did make a number of statements that many attendees found surprising. For one, Dave Minter said that he

High tech concepts such as a "fly by wire" throttle needed to be incorporated to provide a responsive, yet emissions friendly engine.



prefers to design cars without needing to resort to limited slip differentials, arguing that for all but the most extreme use, a proper suspension setup negates any real benefit from them. Secondly, the team explained how they had engineered the 160 so that it had a fair amount of bump steer designed in (for those unfamiliar with the term, bump steer is a situation where the compression of the suspension results in changes to the steering angle). Most owners I know who have looked to fine-tune their cars have been seeking to eliminate bump steer as far as possible, so the idea of intentionally introducing some seemed strange. However, in the apparent alchemy of suspension setup, the team were aiming for a particular balance between the front and rear of the car; the bump steer aimed to reduce the response at the front of the car, so as to keep the rear axle under control and avoid it going into oversteer too easily. This could have counteracted this by fitting wider tyres, but that would have been against the original design brief. At this point, my brain began to hurt again...

With the suspension setup honed, it was time for the car to undergo extensive road and track testing. CTI has access to a test track at the old RAF Coltishall airbase, which the car lapped repeatedly as part of its endurance testing. The team even went as far as to install their own rubber speed bumps to subject

the test cars to repeated aggressive shocks – probably not the most fun “day in the office” for the test driver. The 160 was also subjected to the dreaded “pavé” testing where a car is constantly driven around a circuit of granite paving stones to represent the most severe road surface and test the durability of the chassis and components such as suspension, dampers and mountings. Apparently, 1,000 miles of pavé puts about as much strain on the car as 100,000 road miles – I wonder what it does to the driver?

All in all, the Club members who attended came away with a far greater appreciation of just some of the aspects of car design which CTI had undertaken to bring the 160 to market. Those who had started with the idea that this was “just” a case of dropping in a new engine and transmission could not help but come away impressed by the amount of work which had gone into the development.

So, had the 160 received significantly more development and testing than other recent Caterham models? We were told that no, this was now the norm. As Caterham designs cars to be sold not only in the fairly liberal UK market, but also into mainland Europe and beyond, it is clear that the investment needed to bring a car to market is many times what it used to be. At the same time, the CTI team conceded that the lower the mass of a car,

the more difficult it can be to get it right - the 160 weighs in at 490kg, so I guess that puts it firmly at the “tricky” end of the scale.

Caterham are clearly proud of what they have achieved with the 160. From what we heard, and from the press acclaim received, this would appear to be well justified. It may not have the outright performance of the typical Seven, but the session helped us to understand how the design process had aimed to deliver a car carefully honed to score highly in terms of driver involvement. With its lower power output and carefully balanced handling, the driver is free to use the main controls – throttle, brakes, and steering - to their full extent, and enjoy a sweet handling package at “real world” speeds.

The project has also allowed Caterham and CTI to prove that they have the development expertise to deliver ambitious projects. With the 160, Caterham Cars has become the first European manufacturer to successfully homologate a small three cylinder Japanese engine. Caterham may be seen by many as a ‘niche’ player, but this project they has shown the ‘Big Boys’ what they can achieve.

We have yet to have the chance to test a Caterham 160, but we hope to bring a full road test of one in a future edition. In the meantime, our sincere thanks go to the team at CTI for having given up their weekend to host an enjoyable and informative Club visit. *LF*