SURVIVAL OF THE FITTEST? NOT QUITE...

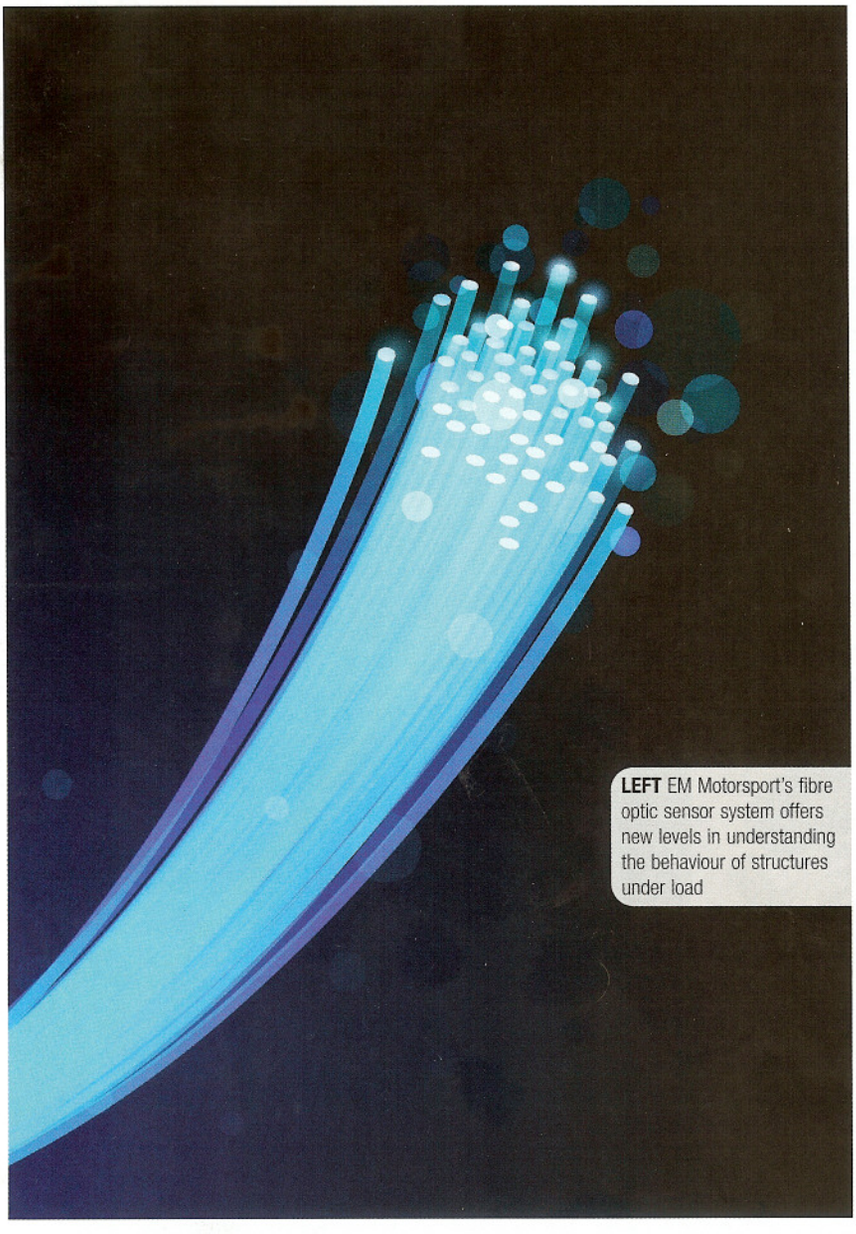
Chris Pickering runs through the shortlist of contenders for the Most Innovative Motorsport Product of the Year accolade, to be presented at next month's Race Tech World Motorsport Symposium

IT'S BEEN said that motor racing comes down to the survival of the fittest. Very often, however, survival of the cleverest is more accurate. With pole positions and race wins frequently clinched by fractions of a second any opportunity to engineer a competitive advantage can be decisive, whether it takes the form of a new component on the car, a new development tool or improvements to the manufacturing process.

For the past two months we've been inviting nominations for the most ingenious and forward-thinking products of 2012. The shortlist you see here will be put forward to our independent panel of senior motorsport engineers before one will be crowned the Most Innovative New Motorsport Product at the World Motorsport Symposium next month.

As usual we're looking for something that has the potential to redefine its sector of the industry. From the smallest component to the largest assembly, the only constraints are that it must be a commercially available product (rather than a closely guarded team secret) and it must have risen to prominence in the last 12 months or so.

Let the nominations commence...



LEFT EM Motorsport's fibre optic sensor system offers new levels in understanding the behaviour of structures under load

EM Motorsport Bragg Diffraction Sensor

It's fair to assume that William Lawrence Bragg didn't have racing in mind when he discovered the fundamental law of physics that now bears his name. But 100 years on, that's exactly what Oxfordshire-based EM Motorsport is focusing on, using a practical application of his discovery.

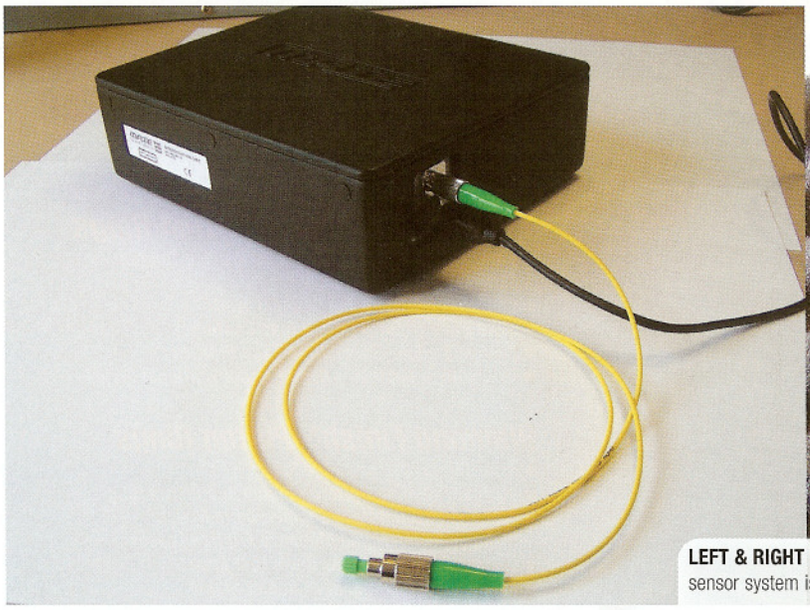
Specifically, the company has harnessed Bragg's discovery to create an extremely sophisticated means of measuring strain and displacement. Think of it as a three-dimensional strain gauge for the 21st century and you won't be far wrong.

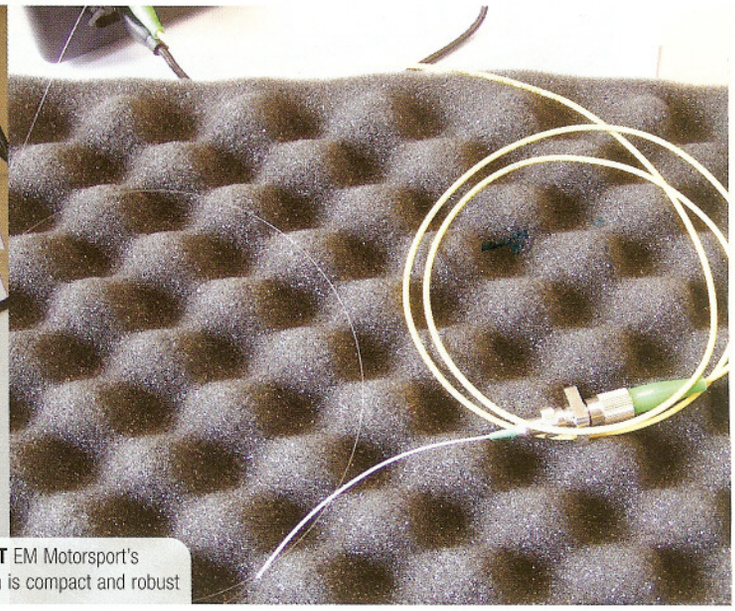
In a nutshell, Bragg's work showed that electromagnetic waves experience the processes of reflection (bouncing back), refraction (changing speed) and/or transmission (going through) *not just*

> *"Fibre optic cables providing hitherto impossible quantities of data"*

when they hit the surface of a material, but also when they travel through. Furthermore, he discovered that all three mechanisms can combine to produce a unique effect when you pass the wave through an array of regularly spaced objects. If the spacing of these objects is comparable to the wavelength of the light, then any changes to the material's properties will have a knock-on effect on how the light is transmitted.

In the 1970s scientists discovered that this allowed them to isolate a particular wavelength of light by periodically modulating the index of refraction inside the core of an optical fibre. Most would be allowed ▶





LEFT & RIGHT EM Motorsport's sensor system is compact and robust

to pass through unimpeded, but light of a specific wavelength would be reflected back, where it could be picked up by a sensor. This type of structure was christened a Bragg Fibre Grating (BFG).

Crucially, anything that changes the array dimensions – for example, strain or expansion due to change in temperature – also changes the wavelength of light returned. This makes BFGs a very sensitive means of measuring temperature and strain: something that's has been known for decades and widely used in heavy industrial applications. But, until now, it's never been made small enough or rugged enough for use in motorsport.

The end result is a collection of fibre optic cables that can be embedded into virtually any composite structure to provide hitherto impossible quantities of data. The potential applications are numerous. Carrying out aerodynamic testing on a new aerofoil section, for example, traditionally employs a handful of strain gauges, but EM Motorsport's system allows up to 80 BFG sensors to be placed on the same part. Each one can be used to infer aerodynamic loads on that point of the surface in real time, as well as long-term flex from the cumulative impact of racing and testing.

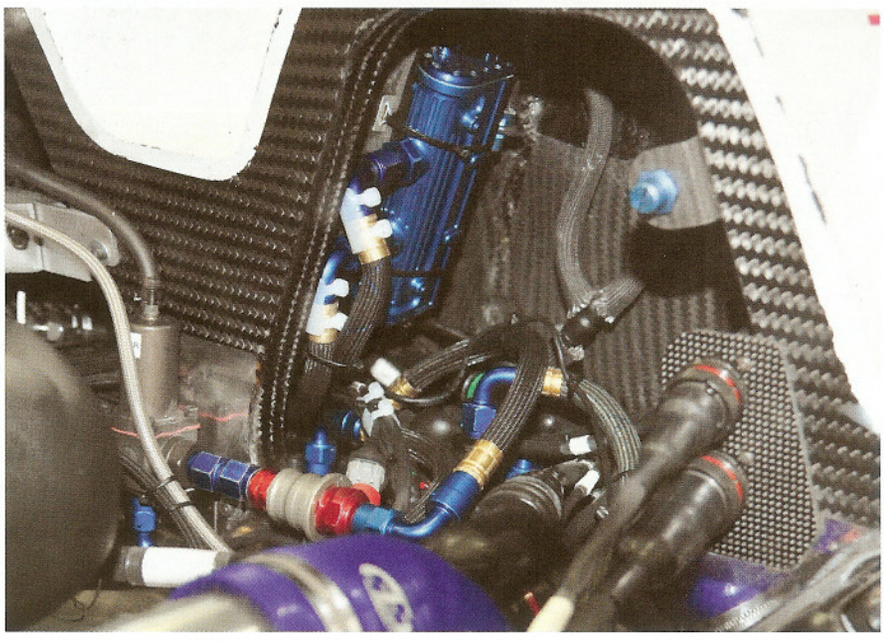
Similarly, a multi-sensor fibre embedded in a helmet or neck restraint would provide a simple and reliable method of determining when the equipment needs replacing or even used to alert medical crews to a potentially serious neck injury.

Gill/Hyspeed Ultrasonic Fuel Flow Sensor

If you subscribe to the theory that motorsport can be used to develop technology that will address problems in the mainstream automotive industry, then surely one aspect stands out above all others: efficiency.

Whether you're looking at CO_2 production, dwindling oil supplies or simply the cost of filling the tank, there can be no argument that increased fuel efficiency is the car industry's number one goal. And if ▶

ABOVE & BELOW The Gill Ultrasonic Fuel Flow Sensor (installed in a car, below) offers a glimpse of the future



we're ever going to address that in motorsport then the first thing that's needed is a reliable, secure and truly accurate means of measuring fuel usage under racing conditions.

There have been a few isolated attempts to do this before, such as the British Touring Car Championship's experiments with fuel flow meters in 2003, but these have used mechanical measuring devices with many flaws. Now, however, Gill Sensors, along with Hyspeed, has developed an ultrasonic fuel flow sensor that bypasses these issues.

One of the main challenges was that existing flow meters tend to have been developed for industrial applications. This means they are predominantly set up to measure steady state flow, instead of the rapid transient response which is often of interest to motorsport engineers and sanctioning bodies. They also create a physical obstruction to the flow, leading to a pressure drop.

What makes the Gill/Hyspeed sensor different is that is uses ultrasonic sound waves to measure the fuel flow, rather than a mechanical impellor. It works on the relatively simple premise that sound waves moving with the flow travel faster than those moving against it.

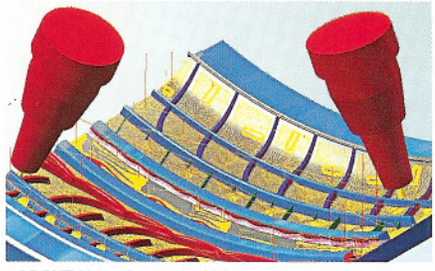
Inside the sensor, placed at opposite ends of a tube, are two ultrasonic transducers that can both transmit and receive pulses. If there is no movement of fluid down the tube then the time taken for the signal to go down and for the reply to come back is precisely the same. However, if there is a flow of liquid then the first pulse gets carried a bit faster when travelling down the tube than the second pulse does on the way back.

Knowing the distance between the two and the time taken means you can work out the velocity. And from that, providing you know the pipe's diameter, the temperature of the liquid and its density, can be calculated the all-important mass flow.

It's a relatively simple concept, but one that's required some fiendishly clever engineering to realise. The electronics required for signal processing and the mechanical design required to ensure robustness and serviceability were all key concerns. Now those challenges have been overcome, however, Gill and Hyspeed are in the hot seat to provide the fuel flow data on which the 2014 rules for Formula One and the Le Mans Prototype categories will depend.

Open Mind hyperMAXX

Open Mind's 5-axis milling package hyperMILL has taken the Formula One world by storm. It's estimated that every single car on the grid now features at least one component produced using the software. And with the release of the hyperMAXX add-on Open Mind has broken new ground.



ABOVE Using hyperMAXX for rough machining

Around 80 per cent of material taken out when machining from billet comes from a series of preliminary rough cuts. These are performed before the tool is changed for the final precision machining operations and they account for a large portion of the total machining time.

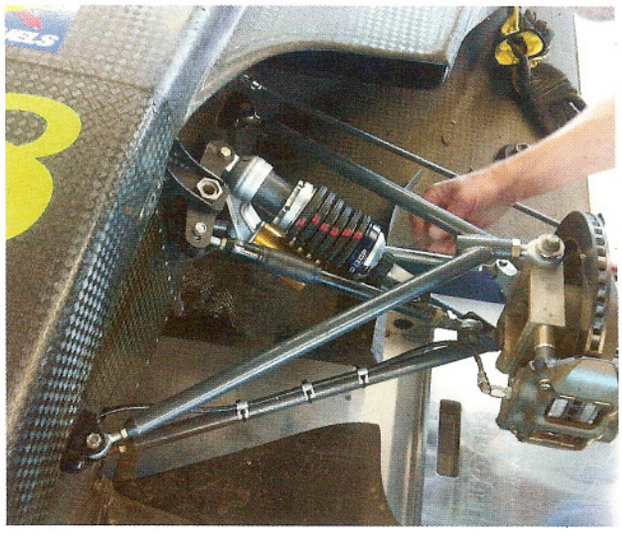
Yet for all the time spent on rough machining it's been somewhat overlooked in the past. Many packages only offer 3-axis machining for these rough cuts, for example, even if they have a 5-axis capability. This results in a lot of flat surfaces, where the tool has been unable to follow complex curvature reserved for the final run.

The beauty of hyperMAXX is not just that it adds these two extra axes, but also that it uses some very clever milling strategies to greatly improve the roughing efficiency. It avoids full cutting, sharp corners and edges in the path, thereby preventing the abrupt changes in direction that can drastically reduce the feed rate.

In total, Open Mind claims a reduction in cycle time of around 50 per cent is possible, along with a 30 to 40 per cent improvement in tool life. With manufacturing time at a premium in motorsport, such improvements are sure to prove popular.

Hyperco Carbon Composite Bellows Springs

In December 2011 Race Tech got its first glimpse of a new spring design that was quite unlike anything we'd seen before. Using a stack of carbon composite discs US suspension specialist Hyperco created a spring system that carries several significant advantages over conventional coil springs. ▶



ABOVE & LEFT Hyperco's Carbon Composite Bellows Spring (installed, above) utilises a stack of carbon composite discs

ABOVE & BELOW The Lazer Lamps LED Driving Lights, used here on a Britcar

The stack is placed concentrically over a damper in the same way as a coil spring. It typically contains around 12 carbon composite discs, but by varying the quantity and orientation of the various base rate discs a Carbon Composite Bellows Spring can be configured to meet very precise requirements for spring rate and deflection.

This provides race engineers with significantly more choices than conventional coil springs, explains the design engineer in charge the project, Mark Campbell: "The great thing about the Carbon Composite Bellows Spring is that it is tuneable for both rate and deflection. The spring rate can be varied simply by altering the total number of elements or their orientation in series or parallel (or combinations of these two), rather than needing to change the entire spring."

Where the Hyperco system really scores is its weight. The company claims the Carbon Composite Bellows Springs work out at around a third of the weight of a steel coil and half the weight of an equivalent titanium unit. Clearly this is a useful weight saving by any standard – particularly where outboard springs (which contribute to the unsprung mass) are used – but it also helps to reduce the inertia of the spring.

Also working in the Carbon Composite Bellows Springs' favour is the fact they greatly reduce the effects of friction and side loads. Unlike a traditional coil spring, which effectively works in torsion, the Hyperco springs gain their deflection by bending the carbon fibre discs. This means the twisting force that's normally experienced at the spring perch is eliminated, and instead all the spring force goes into vertical movement.

Conventional coil springs are also subject to a wave effect as oscillations run along the length of the wire itself. This can affect the way the spring performs, but the Hyperco system minimises (if not eliminates) these effects.

It didn't take long for these advantages to be embraced by the racing industry. Shortly after the Carbon Composite Bellows

Springs' launch in the spring of this year they'd already spread to various categories of sports car racing and NHRA Pro-Stock drag racing. Development is now underway for series ranging from Moto GP to Formula One and the Carbon Composite Bellows Spring looks like it could be shaping up into a true game-changer.

Lazer Lamps LED Driving Lights

Just 18 months ago, Audi Sport, one of the world's richest and most advanced factory race teams, made a big thing of the fact it was switching to LED headlights for the new R18. Now a small specialist lighting company from the UK is making this technology available to the mainstream.

Lazer Lamps produces a range of LED driving lights and headlamps that have already found favour in endurance racing, rallying and off-road competitions. And while the concept behind them is not unique, they're thought to be the first company to produce an LED design specifically for motorsport use. Previous efforts have usually involved adapting a road car design or a lighting unit originally designed for conventional bulbs, which tends to result in quite a large unit.

Standing at just 72 mm in diameter, the company's LED driving lights are far more powerful than equivalent HID or halogen lamps. The T16 model is rated at 13,800 lumens (lm), while HIDs tend to come in at less than 3,000 lm and halogens around 1,500 lm. Crucially, this doesn't come at the expense of current drain; the Lazer Lamps systems operate at 79 lm/W, which is getting on for twice the efficiency of an HID setup (typically 45 to 55 lm/W) and around four times that of a halogen bulb (15 to 20 lm/W).

You might expect cost to be an issue, but the Lazer Lamps driving lights are sold for around the same price as aftermarket HID units – actually undercutting some of the big-name brand offerings.

Ole Buhl Racing PCM2

Electronic power control modules (PCMs) may have been around for some time now, but the new PCM2 from Ole Buhl Racing (OBR) takes the genre to new levels of sophistication.

The basic premise is quite familiar. In place of the passive bundle of relays, fuses and circuit breakers that were once used to control racecar electrical systems, the PCM2

> *"New levels of sophistication"*

is a fully programmable device, capable of making its own decisions.

A prime example is alternator failure. While an old-fashioned system will simply carry on blindly until the battery voltage drops – at which point it will most likely die completely – an intelligent PCM can sense the failure and begin a phased shut down of non-essential items that will give the driver the best possible chance of limping back to the pits.

All well and good, but what's so special about the PCM2? "It's the way the logic expressions can be written and the way the ▶

RIGHT A multi-tasking operating system is at the heart of the PCM2

conditions can be combined by linking events," explains Ole Buhl, managing director of Ole Buhl Racing. "It's also unique in the way that it uses a multi-tasking operating system. It can undertake several tasks at the same time and it can also work with a varying duty cycle or indeed a varying frequency."

The PCM2 also manages to pack a lot in, despite its remarkably compact dimensions (just 191 x 176 x 36 mm, excluding the Deutsch Autosport connectors). In total there are 48 power output channels, including 14 high power channels and two very high power channels rated to 200 A of inrush current.

All the power outputs are designed for use in harsh environments and include self-recovery features. They are also designed to handle loads with high inrush current as well as motors and all types of resistive and inductive loads. Any of these can be controlled by various types and combinations of inputs, including analogue, digital, CAN and LIN channels.

ATL Reserve Collector System

To appreciate ATL's new Reserve Collector Systems it's perhaps best to consider what happens in a normal racing fuel tank as it approaches the point of running dry. Far from being a simple container in which to store fuel, modern racing fuel tanks use multiple lift pumps to draw fuel from the main tank into a separate volume known as the collector. It's from this collector volume that the engine actually takes its fuel.

The collector tends to be a long, sealed cylinder running vertically inside the tank. Typically, it features two pumps: one at the top of the tube and one at the base. Under normal conditions there is enough fuel coming through from the main tank to keep the collector full (and hence pressurised).

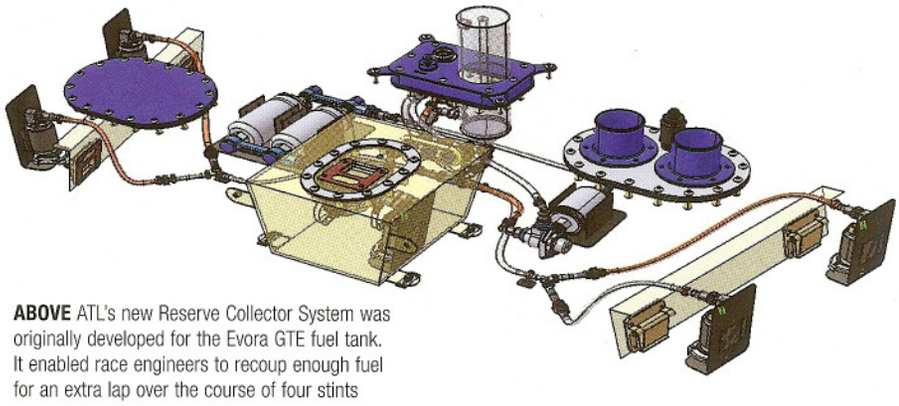
The first sign of the fuel running out is when the upper pump runs dry, at which point the fuel warning is flagged to the driver or the ECU. From this point onwards the lower pump is used to draw the remainder of the fuel.

There are several significant downsides to this approach. Most importantly, as the fuel in the collector is used up there is nothing else to fill the volume and so the collector starts to depressurise. This can cause issues with cavitation in the pumps, particularly when running at high temperatures, which means the race engineers are often very reluctant to delve too deeply into the reserve. Secondly, it means that once the top pump runs dry, you're wholly dependent on the lower pump; if that fails for any reason you lose all fuel supply.

ATL's response is a brilliant piece of lateral thinking. It effectively introduces a second volume into the main fuel tank, which now provides the majority of reserve fuel storage, alongside a much smaller collector.

As before, the main section of the tank pumps fuel into the collector. Once this primary volume runs dry, fuel is pumped in from the reserve tank, maintaining pressure in the collector throughout.

It's only once the reserve volume runs dry and the engine is left to run on the minimal volume remaining in the collector (typically a litre), that the pressure starts to ▶



ABOVE ATL's new Reserve Collector System was originally developed for the Evora GTE fuel tank. It enabled race engineers to recoup enough fuel for an extra lap over the course of four stints

drop. As a result, cavitation is resisted right until the end, allowing teams to run well into the reserve. In the case of the Evora GTE fuel tank that this system was originally developed for, ATL reports the race engineers were able to recoup enough fuel for an extra lap over the course of around four stints.

The benefits don't end there, either. The low fuel alarm can now be triggered when the pumps in the main tank run dry, which removes the need to run an upper and lower pump in the collector. As a result, both can now be placed at the base of the collector, providing a back up supply if one fails.

This new construction also allows fuel technicians to install different size reserve tanks depending on the length of the track. Plus, it opens up the option of producing lower, flatter tanks that would not be possible with a conventional collector design.

Miller's Oils Nanodrive Engine Oils

Miller's Oils scooped this award in 2009 with a ground-breaking formulation of transmission oil, harnessing the immense potential of nano technology. Now the company is back with an engine oil that it hopes will prove equally revolutionary.

This time the nano particles are a relative footnote in the story. What's really significant is the unique approach the company has taken to developing this oil.

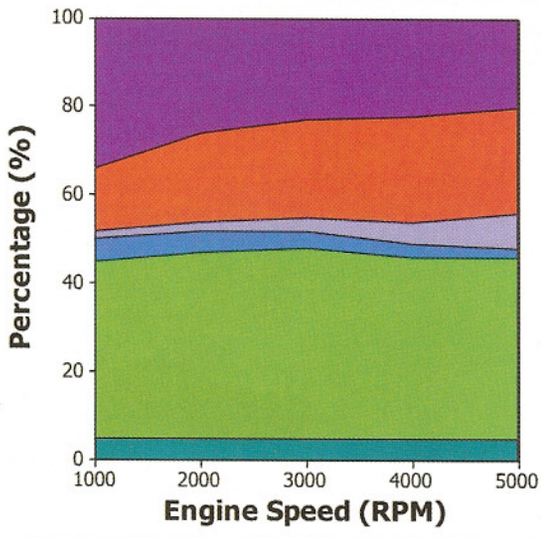
Drawing on research published by Ford, Caterpillar and Ricardo, Miller's Oils set about pinpointing all the different areas of frictional losses in an engine and the various lubrication mechanisms at work in those locations.

Some 40 per cent of the frictional losses were found to occur between the piston rings and the bores. Here there is a combination of hydrodynamic lubrication (when the piston is at high speed in the middle of the stroke) and elasto-hydrodynamic (at top and bottom dead centre where the piston is moving slowly and attempting to rock). The former requires a thick oil film of 60 to 70 microns to protect effectively, where nano particles will have very little effect. Conversely, nano particles come into their own in the very thin oil films generated at the extremes of the stroke.

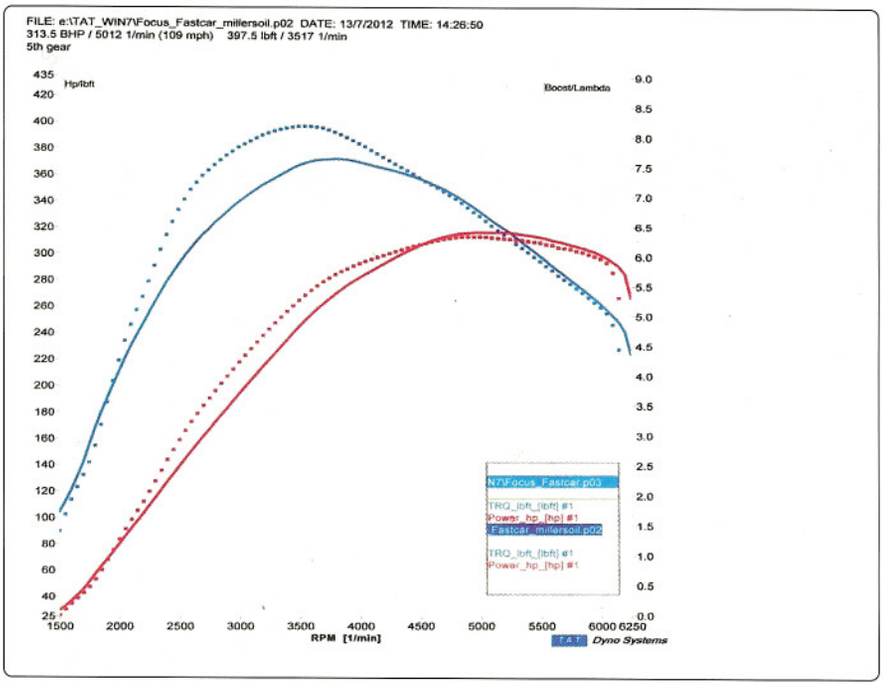
The valvetrain differs again. Here the primary mechanism is boundary lubrication, which requires yet another approach to be treated effectively.

This complicated array of different mechanisms forced the company to develop a totally new oil. Only the nano particles were carried over from the existing range; every other component is new. Friction modifiers of various types were introduced for areas served by hydrodynamic or mixed lubrication, while nano particles were included for elasto-hydrodynamic and boundary lubrication. In like-for-like dyno tests the result has been to shift the power and torque peaks around 250 to 500 rpm lower down the rev range, along with a 5 to 10 per cent increase in total output.

Launched at the beginning of this year, the Miller's Nanodrive range has gone from strength to strength. The company is now in talks with several prominent Formula One and IndyCar teams, along with a major high street retailer in the UK.



LEFT & BELOW Miller's Oils pinpointed the various friction mechanisms at work in the engine (left). The results from a comparative test between its new Nanodrive engine oil and an existing race oil are extremely encouraging



> *"Dyno results showed the power and torque peaks had shifted around 250 to 500 rpm lower down the rev range"*