FINDING THE FORMULA FOR SUCCESS

From the friction materials formulated in the laboratory, through to the manufacturing process and even the packaging, Ferodo is adapting to a range of challenges facing the brake industry. By **Chris Pickering**

IMAGINE for one surreal, terrifying moment that your hands have become the brake pads on an LMGT3 car. I know it's a stretch but bear with me.

You're flying down the Mulsanne Straight at 175 mph. Approaching the first chicane, the mustard-coloured walls of the Auberge flash past on the left-hand side, and the marker boards loom into view. The brake disc is spinning away at 400 deg C and 1,150 rpm. Your job is to grab that super-heated blur and squeeze it as hard as you can.

As the pressure builds, the temperature soars to 750 deg C, causing the discs to glow cherry red. And then you repeat this routine for every corner on every lap for the next 12 hours or more.

In some respects, this is a gross oversimplification of the brake pads' role. There's feel, modulation, ABS engagement, wear rates, fade resistance and a whole host of other factors to consider. But the bottom line is that these seemingly simple blocks of resin have to endure one of the most inhospitable environments on the car. When they work well, they can potentially offer a race-winning advantage; when they don't, you could find yourself limping back to the pits or wedged into the barriers.

The race to develop better brake pads never ends, explains Ferodo Racing's general manager Sergio Bonfanti: "Things have changed hugely in the last 30 years. It's not enough just to know about the brakes anymore, you need to understand the dynamics of the entire vehicle. And the pace of development is such that if we stop developing, someone will overtake us. It's not a sprint, it's a continuous marathon."

LMGT3 is now effectively the top step of international GT racing. Over the past decade or so, the cars have evolved into highly sophisticated racing machines, but they still have to cater to a mixture of pro and amateur drivers. Under the World Endurance Championship rules, each car must have at least one Bronze driver and another Bronze or Silver driver in its three-person crew. At the other end of the scale, you might have a multiple Le Mans winner or a former IndyCar driver taking the wheel.

The wider GT3 ecosystem also encompasses numerous different events, ranging from short sprint races and regional championships to the blue ribband 24-hour events like Le Mans and Daytona. Similarly, the level of engineering experience ranges from small independent outfits to full works teams.

"The SRO events are still the highest level of GT racing, because you can have fully Pro driver line-ups. In the WEC, you must have a mixture of drivers, which means that you can't generally set the car up at its very limit," comments Bonfanti. "You also have a big difference in the teams. GT3 tends to be very customer-driven, so they're generally focusing on how the driver wants the car to behave. Some are starting to take a more data-driven approach, where the engineers will look at the data and then decide what changes will make the car quicker and the driver has to adapt."

Maximising stability

Ferodo consults with the teams, looking at information like slip ratios, G-G graphs and brake efficiency graphs, to advise on potential setups. Where available, infrared temperature readings are said to be extremely helpful too.

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BELOW Ferodo's R&D team has catalogued the behaviour of all the friction materials it has tested. Engineers can now pick from a library of around 200 different materials

grip of the asphalt might change. Therefore, you need to adjust the way you tune the brakes to maximise the performance of the of the car," notes Bonfanti.

Braking is never an entirely linear event. Although brake pad manufacturers go to great lengths to ensure consistent behaviour across all conditions, the reality is that the pads heat up during the course of a braking event and this tends to result in a rising curve, with increased stopping power as the vehicle slows down. (It's the same effect that typically causes road car brakes to grab slightly as the car comes to a rest.)

Critical stages

Conversely, the level of aerodynamic downforce bleeds off at lower speeds (although this is not as big a factor in GT racing as it can be in single-seaters). Professional drivers tend to be better at adapting to these changes throughout the braking zone and optimising the deceleration.

"We've done a lot of work on maximising the stability of the friction material. The flatter the curve, the easier the brakes are to modulate, which makes it easier for less experienced drivers to brake without ABS intervention," explains Bonfanti. "One of the most critical stages is the combined braking – where you're still braking but starting to turn-in. ABS intervention during that phase tends to make the car understeer, which then means it takes longer for the driver to get back on the throttle."

Ultimately, he points out, the limiting factor will always be the grip of the tyre. A very high coefficient of friction between the disc and the pad won't offer any advantage if the tyre can't make use of it.

That's particularly true on ABS-equipped cars (such as modern GT3 machines) where a more aggressive material can trigger the system prematurely. Again, Pro drivers are generally better at holding the car close to this threshold without breaching it, so they can typically exploit a higher level of friction. Bonfanti says that the aim is always to run with as ▶

> *"Even a relatively minimalist pad has in the region of 15 ingredients, all of which interact with each other"*

BELOW A more data-driven approach is starting to be seen in the GT3 ranks. This is the Akkodis Lexus in action

much friction as the car and the tyre can make use of, but lower friction pads are also available for less experienced drivers who find that they are struggling.

Changing requirements

Ferodo's R&D operation, based in the Derbyshire town of Chapel-en-le-Frith, is headed up by its technical manager, Edward Little. He points out that the development approach has changed dramatically behind the scenes too.

"It used to be that the development was led by our work back in the lab. We had a pretty good idea what would make a good friction material – generally speaking, you wanted as much friction as possible with a slightly rising profile and the appropriate wear. We'd go to Sergio and his colleagues at the track and say, 'We think this will work, please try it'. Now, it's largely the other way around – the track team will identify the characteristics that they need and then ask us if we can provide them."

Around a decade ago, Ferodo's R&D team began a lengthy process of cataloguing the behaviour of all the friction materials that it had tested. This ongoing initiative has now built up a library of around 200 different materials, which the engineers can pick from, while others continue to be added.

The development process doesn't always follow a linear path where older materials are replaced by those which are newer and fundamentally better. Changes to the characteristics of the cars can cause older materials to be reassessed for new requirements.

ABOVE & TOP The company's meticulous approach to cataloguing, building up an invaluable library of materials, is reflected in a change of naming strategy. The TL180 and TL163 materials, aimed at the front and rear axles of GT cars respectively, were the 180th and 163rd materials tested

The adoption of ABS is a particularly significant example, Little explains: "Now that GT cars are running ABS, the outright level of friction isn't always that important. It's about how the ABS comes in and out, reducing the amount of intervention both at the beginning of the braking event and at the end.

"Two of our best rear brake materials at the moment are compounds that we originally abandoned after testing. The friction wasn't very high and they wore quite heavily in the dynamometer tests, where the machine pushes harder to compensate for the lack of friction. But when we started to understand the importance of ABS behaviour in the vehicle dynamics at the entry to the corner, we went back and realised that the friction curve was almost completely flat and they're probably the best rear brake materials in the GT racing market at the moment."

In another example, a material that performed well below expectations in the company's original tests ▶

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LEFT Matmut Évolution is capitalising on Ferodo's work with pads for GT racing, running twin Toyota GR Supra GT4 Evos in the GT4 European Series

RIGHT The 2024 season is young but Ferodo has already enjoyed 24-hour endurance success, with the Eastalent Racing Team's Audi R8 LMS GT3 EVO triumphing in the Hankook 24H Dubai

for a front brake application later proved to be a race-winning compound on the rear.

There's a lot of science behind brake pad formulation, but also a considerable degree of experimentation. Even a relatively minimalist competition pad has somewhere in the region of 15 different ingredients, all of which interact with each other, making it difficult to predict the exact behaviour of a material based on its constituent parts. Instead, the focus is on cataloguing the behaviour of the complete compound.

"You can use your judgement as a formulator to steer the material in what you think will be the right direction. Perhaps four times out of five that doesn't work, but the fifth might give us something that represents an improvement for a particular application – even if it's not the one we originally had in mind," comments Little.

Predictive software

Ferodo has had some success with data-driven predictive software. However, Little notes that it requires a huge amount of experimental data to spot the correlations: "You might end up with 30 different compounds that you need to test in order to fill up that experimental space. Even carrying out all the testing internally, it costs us something like €2,000 to run each test, so we now take a slightly different approach, evaluating the key components one at a time."

This cataloguing approach has even changed the naming strategy for the products. It used to be that the Ferodo engineers used their own internal development codes, with the successful materials given a separate tradename when they were released to the market, such as DS3000 or DSUNO. Now, the products are marketed under their development

codes. For instance, the TL180 and TL163 materials – aimed at the front and rear axles of GT cars respectively – were the 180th and 163rd materials tested.

"We sometimes release prototype materials for customers to test and it just got confusing if a customer had tested something that was identified by a TL number at the beginning of the year and then it's found under a different name when they come back to buy it during the season," comments Little.

Going green

Changes to brake pad materials aren't just prompted by shifting vehicle requirements. Environmental regulations are shaking up brake formulations in the road car world. The use of copper, which is potentially toxic if it accumulates in the environment, will be banned in road car brake pads in the US from next year. It's possible that motorsport could decide to mirror these regulations. Likewise, the Euro 7 emissions regulations are set to introduce brake particulate limits from 2030, which may also influence trends in motorsport.

"All manufacturers in motorsport can contribute to reducing the sport's environmental impact," comments Bonfanti. "From our side, we're already trying to consume less energy during manufacturing and use less packaging, and we're looking into other ways to make the products greener."

Electrification is another major trend in the wider industry, although it's hard to predict exactly what impact this will have on brake pad formulation, Little explains: "Electric and hybrid powertrains can influence things like the mass and the centre of gravity on the vehicle, but aside from that there's no fundamental reason why it should change things. A few years ago, we did the pads for the Jaguar I-Pace eTrophy, which was Formula E's support series at the time, and we used exactly the same pads on the rear of that car as we would for an IC-engined GT racer."

There are synergies to existing design challenges too. He notes that consistency across a wide range of temperatures is very important for brake-by-wire applications, much like it is for ABS.

Whatever challenges the future poses, Ferodo is sure to find something in its ever-growing catalogue of materials to fit the bill. RT

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