

The International Journal of Motorsport Technology

Racecar engineering™

August 2007 • Vol17 No08 • www.racecar-engineering.com • UK £4.99 • US \$9.99



ADRIAN NEWEY INTERVIEW

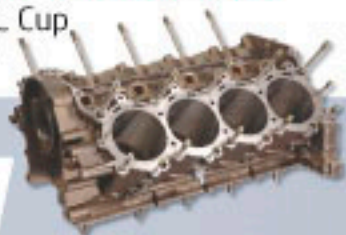
Talking with Formula 1's
most successful designer

LE MANS PAGE 28 24 HOURS

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HOW AN UNLIKELY
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Performance coatings

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Chemical generation

Great claims are made by manufacturers about surface coating techniques, but do they really work in practice? *Racecar* investigates

There are those who would have you believe that just about every surface on a modern racecar has some sort of technical coating on it. There are others who regard the coatings firms as 'snake oil salesmen'. If you are not a chemist or full-time materials engineer the wide range of coatings and applications are hard to fathom. The big question though is can spraying bits of your car with a thin layer of some chemical or other really make it go any quicker, or last longer?

BY SAM COLLINS

The theory is fairly simple - that surface coatings can alter, enhance or improve a material or component's properties, but what exactly they do depends very much on what coating is applied. And there is a baffling range of coatings now on the market, many of them advertised under exciting-sounding brand names, even though many purport to achieve the same objectives.

Coatings firms make some very bold claims regarding their products, and certainly some

of them seem hard to believe, though it seems some coatings really do work, and to the exacting standards of Formula 1 too, where almost every team uses some kind of coating technology. Though reluctant to reveal exact details and clients, a number of firms proudly tell tales of how coating technology has benefited teams in motorsport's premier categories. But with the

secrecy surrounding much of their work, coatings firms have previously failed to verify their products in independent tests, while customers have remained tight lipped, afraid of losing any unfair advantage.

But now Ben Shaughnessy, technical director of AltoPerformance, has decided to come clean. His motorcycle racing team has been using the Oerlikon

COATINGS ARE NOT LIMITED TO REDUCING FRICTION

Balzers range of Balinit coatings on its engine internals and, for the first time, has allowed *Racecar Engineering* access to its findings. Its first tentative step was to coat some titanium valves for an MV Augusta racing engine, in the hope that it might improve the performance of the engine and reduce wear on the valve stems. Whilst the engine's performance did not improve noticeably, there were also no problems with valve wear. It was enough to convince Shaughnessy to try a more extensive coating programme on another of the team's bikes - a parallel twin Laverda 750.

Two engines were built - a control engine and a second, identical engine to gauge the performance gain. Dr Andy Bloyce, technical manager of Oerlikon Balzers, was consulted and he recommended initially coating the camshafts and tappets with a diamond-like carbon (DLC) coating.

While DLC coatings are amongst the most widely used of all in the industry, there are many different coatings that fit

under the DLC bracket and all have slightly different properties and abilities. Wading through all the brand names can be particularly difficult, so time spent researching the different products will be time well spent.

Here though, we're interested in how DLCs work, so we'll let Bloyce explain: 'The low friction of various carbon-based coatings is attributed to the transfer of

DIAMOND-LIKE CARBON (DLC) COATINGS ARE AMONGST THE MOST WIDELY USED

some of the carbon from part to part, this material transforming into what is essentially graphite. The atomic planes of graphite shear easily, resulting in lower friction on a surface.'

Pretty much all carbon-based coatings use these material properties to this end though, as you might expect, there are a wide number of variations on the theme. Some coatings are not pure DLCs, as they have metal-based additives which give slightly different properties, so again it is worth researching

exactly what coating to apply to which parts. Most coating firms will advise on this, and also on how each specific product can benefit the engine.

On the aforementioned racing bike engine, dyno tests suggested the coatings seem to have worked - significant power gains were observed, as well as a reduction in oil and water temperature. 'On a recent

warm race weekend, where we normally fit a large radiator, much lower water temperatures were recorded,' explains Shaughnessy, and he attributes this to friction reduction

in the engine gained from the coatings. 'The next step will be to coat some gearbox components and the gudgeon pins to see if they can further reduce the temperatures and make the gearbox slicker to shift.'

These friction-reducing components can give reliability boosts too, as Bloyce reveals: 'A racecar using coated gearbox parts managed to finish the race with only the coating supplying lubrication after the 'box lost all its oil,' he claims. 'The coating they were using is slightly porous

and had absorbed a small amount of the oil. That absorbed oil and the reduced friction our coating gave meant the transmission lasted an extra half lap - enough for the car to finish the race.'

TEMPERATURE CONTROL

Coatings are not limited to reducing friction either, they have a wide range of applications from heat control to wear resistance. British firm Zircotec is one who offers a range of ceramic-based coatings aimed specifically at temperature control.

These ceramic coatings are said to allow teams to control or reduce heat in critical areas, by what it refers to as thermal barriers. This can also give a performance gain, as Andy McCabe of Zircotec revealed: 'When the so-called periscope exhausts became standard fitment on Formula 1 cars, it became clear to the teams very quickly that the wing, bodywork and some rear suspension parts would have to be shielded from the very hot exhaust gasses. Teams use a number of methods to achieve this, from metal and even gold film to ceramic coatings like ours. One team using our coating even found an aerodynamic gain by using the

THE COATING PROCESS

Racecar explored the surface coating procedure using a Formula Vee exhaust system coated in Zircotec, a ceramic thermal barrier coating

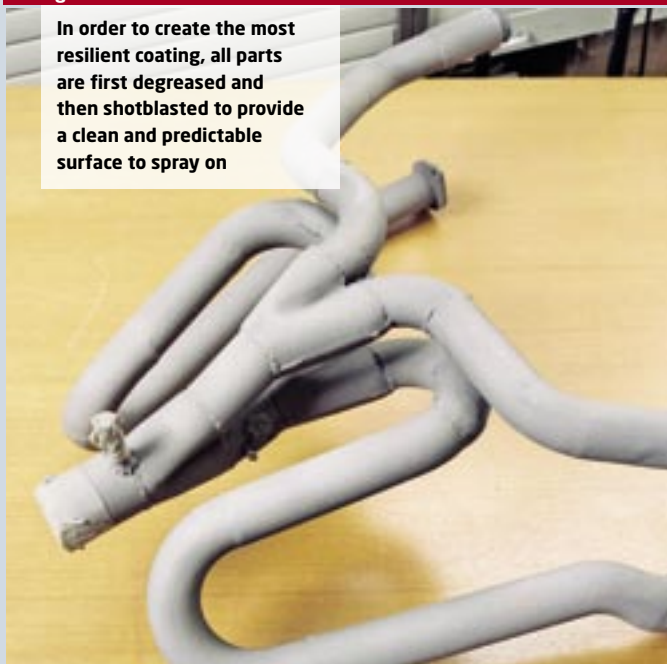
Figure 1

Soiled parts such as this are not a problem for the coating process as everything must be carefully cleaned first



Figure 2

In order to create the most resilient coating, all parts are first degreased and then shotblasted to provide a clean and predictable surface to spray on



CASE STUDY - COATING RODS AND PISTONS

↘ Austrian-based, high-end drivetrain manufacturer Pankl uses coatings on some of its connecting rods as a design feature. 'Coatings are very specific regarding where you place them and what exactly you use,' reveals Pankl's Stefan Leitner. 'If you look at the small end on some of our rods you will see a coating, and this is because there is some movement between bush and small end which could cause fretting. It's important to prevent that from happening and one way of achieving that is using the coating. On the small end we have in common use about three different coatings, dependent on the base material, bush material and other parameters, then you can look at the other end and apply something on the big end applying coatings on the thrust face.'

Leitner went on to reveal that on the gudgeon pin it is quite common to use a DLC coating, while on piston skirts polymers like Zylan are common. 'In some ways this could reduce friction, but in fact it's aim is not really to do that, rather it gives you a kind of safety if something is not really perfect in the piston. We often phosphate the entire piston and, depending on the environment, there are a wealth of processes you can do to increase durability.'

Pankl uses a range of coatings on its engine components for a number of different applications



coating on the lower element of the rear wing. The ridges left by a heatproof film reduced the efficiency of the wing, whereas the thinner coating did not cause the same problem and gave a slight increase in downforce.'

Ceramic coatings can also

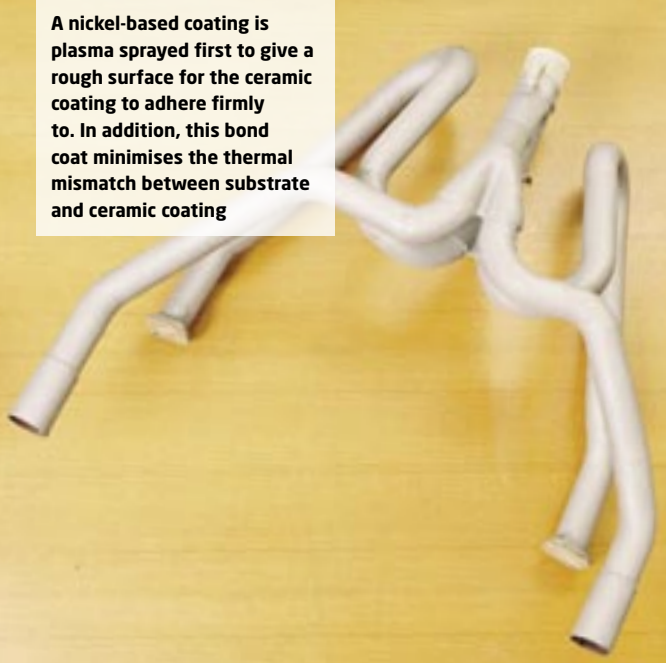
be applied to components like exhaust systems to allow designers to bring the bodywork closer to the hot parts - something that is key in an environment where tight packaging is required or where composites are used (some resins

can melt at surprisingly low temperatures). Coatings like the Zircotec range work by stopping heat radiating from the surface of the material. In the context of an exhaust system, this keeps the heat contained inside the pipes which, in turn, has a beneficial

effect on back pressure. This, it is claimed, may give an increase in power. Certainly when *Racecar Engineering* tried out Zircotec's Thermohold coating on a Formula Vee exhaust system, we found it reduced under-body temperatures significantly. ↘

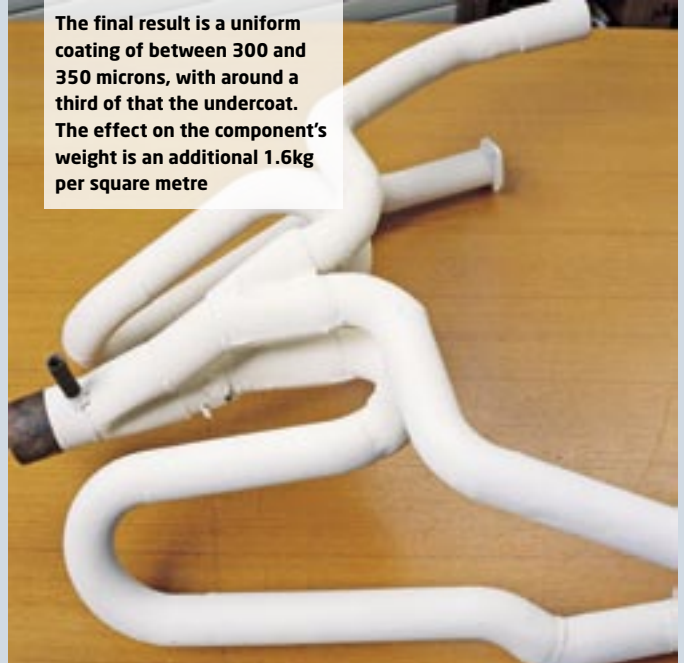
↘ **Figure 3**

A nickel-based coating is plasma sprayed first to give a rough surface for the ceramic coating to adhere firmly to. In addition, this bond coat minimises the thermal mismatch between substrate and ceramic coating




↘ **Figure 4**

The final result is a uniform coating of between 300 and 350 microns, with around a third of that the undercoat. The effect on the component's weight is an additional 1.6kg per square metre



CONSIDER COATINGS IN THE DESIGN PHASE OF A PROJECT

Ceramic is not only useful for its thermal properties though, some coatings firms also exploit it for its hardness to protect against corrosion or wear. Keronite is an example of this. Whilst these coatings also have some thermal barrier properties, this is not the primary objective of applying ceramics in this way. Instead, it allows for light metal alloys such as aluminium or magnesium to be used instead of steel, giving them the extra hardness required on a piston crown, for example.

To be most effective, coatings need to be considered in the design phase of a project, and a good working relationship should be established with the coatings supplier to make sure the design is optimal from the beginning. There are limitations, of course – some materials are not suitable for some coating applications (composites, for example, can cause problems with PACVD machines) and there may be some unexpected side effects with certain coatings. If you lower the friction of your engine it will turn more easily, but you need to consider what knock-on effects that might have. 

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METHODS OF COATING

 You could look at applying coatings as being a bit like painting, with preparation, an undercoat and then a range of top coats applied until the desired result is achieved. With paint the desired result might be a nice shade of blue on the bedroom wall, whereas with coatings it could be anything from friction reduction to heat control. As with painting, a surface must be cleaned and prepared properly before any coats are applied, as a poorly cleaned part could lead to the coating failing to stick well to the surface and potentially more serious issues further down the line.

KEEP IT CLEAN

Various bathing, general scrubbing and polishing techniques are used prior to the application of a coating. With some really soiled components what is effectively a dishwasher is used initially.

Instead of a brush, coatings are applied in a number of different ways. DLCs, for example, are often applied using a process known as plasma assisted chemical vapour deposition (PACVD). Once again, Dr Andy Bloyce of Oerlikon-Balzers explains: 'The process involves the reaction of components in a vapour. These components form a solid film on a part when assisted by an electrical discharge. Usually, the gas molecules are separated by electron impact to generate very reactive neutral, radical and ion species. The atoms then react with and 'stick' to other atoms forming the coating.'

PACVD is not the only process, physical vapour deposition (PVD) is also used with some DLC-based coatings. Bloyce: 'The PVD process involves the creation of a vapour species, transport of this species to the surface and condensation of the species onto a substrate, resulting in film formation by nucleation and growth processes.'

Continuing the paint analogy, you usually need an undercoat before a top coat. Carbon-based coatings, for example, are generally not able to support themselves, so require another coat to adhere to. As examples, Oerlikon-Balzers uses a layer of chromium nitride under its Balinit-branded DLC, whereas Zircotec uses a nickel-based coating with its ceramic coatings.

Another method of applying coatings is bathing, which has the advantage of being able to coat otherwise inaccessible areas. Bloyce: 'Plasma electrolytic oxidation (PEO) is a patented immersion process that converts the surface of the aluminium or magnesium substrate into a chemically inert matrix of ceramic oxides. Light metal parts are suspended in a tank of non-toxic electrolyte solution and a pulsed alternating current is passed through the bath, creating a localised plasma discharge on the surface. Tiny sparks are formed and the ceramic layer 'grows' in a very uniform fashion, above and below the surface.'

'Physical vapour deposition processes involve the creation of a vapour phase species, transport of this species to the surface and condensation of the species onto a substrate, resulting in film formation by nucleation and growth processes.'

'Plasma assisted chemical vapour deposition processes involve the reaction of constituents of a vapour phase to form a solid film when assisted by an electrical discharge. Usually the gas molecules are dissociated by electron impact to generate very reactive neutral, radical and ion species. Atoms will then react with and 'stick' to other atoms. Adhesion is obtained by removal of non-reactive surface contaminants by rigorous cleaning and performing the deposition processes in a contamination free vacuum environment.'



A column of ions is created in the centre of the chamber and attracted towards the components, to etch them prior to PVD or PACVD coating

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