Ever wondered how a carbon-fibre propshaft helps to improve engine performance? Well, wonder no longer...

Diet Poke

Words and photos Carlin Gerbich

At some point, race technology filters down to road car development. Fly-by-wire throttles, hydraulically-actuated valvetrains, active differentials, turbos and composites have cutting-edge motorsport to thank for much of their research and development.

One of the biggest revolutions in race-to-road technology has been the advent of carbon fibre, but in fact carbon fibre's been around for ages. Thomas Edison discovered and patented it to use as filaments in incandescent lighting in the late 1800s, but it wasn't until the 1981 that it made a first major appearance in motorsport with the arrival of the John Barnard-designed MacLaren MP4/1 in 1981. This car was the first to feature a chassis made entirely of carbon-fibre composites which, with the DFV Cosworth engine, handed MacLaren a handy power-to-weight ratio. Made from 10 carbon-fibre parts instead of 50 aluminium ones, the only worry was how well it would withstand impact — as all F1 cars are now made of the stuff, these days it's hard to see why this is an issue.

Ever since, the use of carbon fibre in competition and road cars has blossomed, and it's not just the supercars of the rich that feature composite technology. Car manufacturers have long used fibreglass and carbon fibre to replace heftier metals in chassis design. Lotus used GRP to form the monocoque chassis of the gorgeous Elan, while the Corvette — one of the best-looking non-Japanese cars, if you don't look at the rear — has a GRP body.

The biggest barriers to using carbon fibre and Kevlar is the trouble some people seem to have accepting that something so light can be so strong.

So how does carbon fibre help everyday motoring? Well, saving weight is key to improving power-to-weight ratios — just consider the extra effort that would be required of the everyday motorist in moving heavier car and the impact on fuel bills. »


The carbon-fibre filaments are wrapped around bobbins such as th

It can't be all about weight saving, can it?

Essentially, yes. But there are many reasons you may want to save weight, and many ways of doing it. To improve the power-to-weight ratio by reducing sprung weight you could take everything out of the boot, glovebox and footwells, and use lightweight interior bits. If you can live without it, stripping out the interior trim will improve things too.

Even before you start looking at the engine?

Yes. But even then, there are things you can do to make the most of the power you've already got. Cars lose power through the transmission; some 4WD lose as much as 24 percent of engine power by the time this filters through to the wheels. All mechanical systems suffer from friction, and as power is fed from the flywheel to the clutch, through the clutch to the gearbox, and from the gearbox to the wheels, some of it is transformed into heat and noise. Then tyres can be the biggest power-suckers, sometimes accounting for more than half power loss.

There's only one way to accurately measure the amount of loss and that's to remove the engine and test the flywheel on a correctly calibrated engine dyno, then replace it and test the car on an accurate rolling road. Subtract the latter figure from the former.

How can you reduce these losses?

The answer's simple, but in practice it's difficult. You need to reduce friction and drag in the driveline. Lightweight flywheels reduce rotational inertia on the engine, but there's only so much you can do to the gearbox before it gets ludicrously expensive. One of the best solutions is a lightweight carbon-fibre propshaft.

COMPOSITES: A POTTED HISTORY

Ever since man discovered he could make his shelters stronger by using straw to reinforce them, composites have been used in one form or another.

Modern composites are used everywhere, but their use in aviation and the automotive industry has its roots in the 1940s when a shortage of aluminium pushed engineers to develop an airframe for the Supermarine Spitfire using a newly developed material called Gordon Aerolite.

Developed by British company Duxford Aero Research (which later became Ciba-Geigy and is now owned by Swiss-based Huntsman Advanced Materials), Gordon Aerolite was made from linen impregnated with a phenolic resin. The development model met structural requirements and was a potential alternative, but the feared aluminium shortage never happened and the composite airframe never flew.

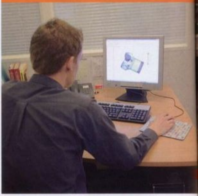
Following the war, fibre and resin technology boomed. Glass fibre appeared in the 1950s and was soon being used in aircraft, boats and cars; while carbon, Kevlar and other fibres were developed to cater for the heavier demands of the automotive and aeronautical industry.

CARBON FIBRE: HOW IS IT MADE?

Each carbon strand is similar to graphite and is formed by heating and oxidising an organic polymer called Polyacrylonitrile; a raw material also used in rubber production. The process separates a chain of carbon atoms that align side-by-side and form narrow sheets which eventually form filaments. Carbon-fibre filaments can also be formed by using pitch or rayon, but this is considered inferior.

The carbon-fibre filaments can be further enhanced by more heating to bulk them up (high modulus, for better elasticity) or high-tensile strength. Filaments are then stranded, rated and used as either carbon-fibre threads or tapes, or woven into cloth — the strength of the thread determining the strength and weight of the cloth.

Depending on its final use, the cloth is either pre-impregnated (pre-preg) with curing resin (dry lay-up for autoclave oven curing), or supplied without it (wet lay-up with a two-part resin and cured in a vacuum or press-mould).



"The winding procedure gives the hollow carbon tube its strength by altering the depth of the wind"

Why?

It solves two problems. One, it reduces rotational inertia, making it easier for the engine to transmit power and torque to the wheels. And two, depending on the sort of propshaft it is, it will weigh around 25 percent of the OE steel item, reducing kerb weight

How are they made?

Carbon-fibre filaments are wrapped around a bobbin, after passing through a resin bath. The winding procedure gives the hollow carbon tube its strength by altering the depth and angle of the wind, and different filaments are used to build layers on


Different windings create different strengths


Couplings are individually inspected before fitment


Props are finished with a clear protective layer


The whole process is computer controlled

the bobbin until it's finished. It's a computer-controlled process and most companies guard the process closely.

How does the tube resist twisting, bending and crushing forces?

By the way the filaments are wound. Tighter packed windings — looking from the side, the angle of these would be more vertical and closely packed — help resist crushing, while elongated windings help combat most of the torsional forces experienced by driveshafts and propshafts.

What happens next?

The propshaft is usually finished with a clear protective layer and cured before it's removed from the bobbin, trimmed to length, fitted with its couplings and balanced. The couplings are bonded into place with high-strength resin and pressed into position, then left to cure.

The couplings, produced by leading propshaft producers CTG, are individually inspected and tested before they're fitted to the propshaft.

How can I be sure the propshaft is strong enough?

CTG's tests are extremely rigorous and carried out on the torsional and longitudinal strength of the propshaft. The couplings are tested for strength and walloped with a huge weight along the length of the tube to test impact resistance. Unless your car is producing more than 3500Nm (2500 lb/ft) of torque, there's no need to worry whether a CTG prop is up to the job.

What happens if a carbon propshaft fails?

When steel propshafts let go the steel couplings tend to flail about and rip everything apart, either until the engine

"CTG designs its carbon-fibre propshafts to withstand anything you demand of them"

CTG AT THE HEART

Crompton Technology Group is based in the heart of the British motorsport circles and supplies many F1, WRC and GT teams with lightweight pressure vessels and accumulators.

They also won a contract to supply a critical part for the BAE Typhoon Euro fighter, which it describes as a 'multifunctional composite part, using novel material integration techniques'.

The 800bhp Team ICE Impreza STi8 built by Roger Clark Motorsport (cover car J-Tuner issue 5) is fitted with a Torqline propshaft.

Fit one and you'll want a perspex transmission tunnel

stops spinning or the car stops moving. A loose steel propshaft can spear through the car's transmission tunnel, rip an exhaust apart and even punt the car off the road, if it breaks free of its mounts and spears into the ground.

Carbon fibre is a bit different. Crush testing at ultimate pressures shows that the fibres don't shatter into a million shards of intensely sharp needles. They simply split and if they hit anything, such as the transmission tunnel or anything else, they turn to powder if the shaft still spins.

So they're safe?

Yes. CTG designs its carbon-fibre propshafts to withstand anything you demand of them and if you do manage to exceed them, they're designed to absorb energy better than metals.

How much lighter are they?

CTG's range of Torqline carbon-fibre propshafts are 75 percent lighter than steel, making them far lighter than aluminium and titanium propshafts too.

What are the other benefits?

Better torsional rigidity means multi-part propshafts can be replaced with single tube items, reducing weight further by eliminating additional bearings/couplings. Manufacturing quality controls and tailor-made performance characteristics make for a quality item with F1 and GT development.

It all sounds a bit too good to be true. Are there any downsides to a carbon-fibre propshaft?

Ultimate load testing shows a small deflection in the torsional rigidity of the carbon propshaft over a steel one just before it fails, but it's not enough to adversely affect drive through the transmission, and it's something you'll never notice. Besides, torsional loads are around 3500Nm when this occurs, so far beyond the operational requirements of most cars.

The only bad point — if it could be thought of as such — is the fact you spend so much on a component you never see. Some people make Perspex covers for the transmission tunnel, so that they can peek at it every now and then or show it off to their mates! So or what.

CTG's carbon props are 75% lighter than steel versions