

# Engineering the future of wheels

In Blackstone Tek, South Africa boasts the world leader in carbon fibre technology for motorcycle wheels. The company's unparalleled investment in process equipment and its unique manufacturing patent make the BST brand the choice for bike racers, aftermarket customisations of almost every superbike and, increasingly, for elite new models from motorcycle OEMs. *Peter Middleton* takes a tour of the company's North Riding facility.

**B**lackstone Tek set out to create a motorcycle wheel that, while meeting all of the standard requirements, was lighter and stronger than anything else on the market. Bike magazines report that changing to carbon fibre wheels is the biggest performance improvement that you can make to a bike for that money. "You don't need to modify the engine, or change it or adapt it to a new fuel or anything else – you simply replace the wheels with our carbon fibre ones," says Terry Annecke, operations and marketing director.

The gain is described as a virtual 10 HP (7,3 kW) – significant (3-4%) when you consider that superbike power is in the 200 HP range. "You don't really change the power, but you change the dynamics of the bike so that it feels more powerful," she points out. The lighter wheels are easier to manoeuvre

and result in less rider fatigue.

The key advantage of carbon fibre wheels, however, is on the inertial side – the weight is all shifted towards the hub in the centre. The spokes are hollow and the rim is very light. By removing weight from the outside of the wheel, you significantly reduce the inertia, which makes it much easier to spin the wheel. "We are interested in where the power is going, into driving the wheel or into the performance of the bike," adds Annecke. "With carbon fibre

magnesium racing wheel cannot withstand ordinary road use and race track wheels will not last more than two seasons," Annecke claims. Also, carbon fibre will outperform magnesium of the same weight because magnesium still has circumferential weight distribution.

"The limiting design factor for carbon fibre is impact," says Craig Goodrum, BST's technical manager. In order to achieve the required impact strength for carbon fibre wheels, the compressive strength is significantly higher than that required by standards and that of competitive materials. "Our wheels outperform our competitors. They are lighter, stronger and have longer life. Because we can engineer with the material, we can get our spokes and rims much lighter without compromising strength in any way," he adds.

The strength comes from the orientation of the fibre, so different strengths can be designed into the different parts of the wheel by optimising the placement and orientation of every carbon fibre layer. The initial engineering for this task was done using extensive finite element analysis. Every piece of carbon fibre used on a BST wheel has an exact orientation and an exact strengthening purpose. "It's all about the fibre lines," says Annecke, "We make up the wheels using layers of multidirectional and unidirectional pre-impregnated fibre materials of different weights to achieve optimal strength for the amount of material used. That is what you call composite engineering."

Key to the company's success, however, is its unique and patented production cycle. "Our process enables us to produce volumes of identical wheels according to an identical process. We are managing to make perfect



*Craig Goodrum, BST's technical manager and Terry Annecke, operations and marketing director.*



*Moulds are placed into vacuum bags for 30 minutes, twice or three times during the layout process to compress/debulk the carbon fibre layers.*

wheels, you are able to get better acceleration, better handling and later braking."

The handling is also improved due to the reduced gyroscopic effect associated with lower inertia – hence the better handling. You are able to manoeuvre the bike into and out of corners a lot more easily because lower moments of inertia result in lower gyroscopic coupling forces.

Carbon fibre is a very stable material – very light but very strong – and presents no shelf life problems. "Our competitors are forced to use aluminium or magnesium to reduce the wheels' weight, but both of these options carry way too much risk for us. A



*Unidirectional carbon fabric – fanning out from the spokes to join onto the rim – is being laid onto woven fabric layers underneath.*



*Wheels fresh out of the autoclave already have a very high quality finish.*

wheels in volume,” claims Annecke. “The GP standard is a run-out of less than 0,1 mm out-of-true and all our wheels are better than that.”

The production cycle starts in the cutting room. Sheets of pre-impregnated carbon fibre of specific weights and orientations are cut into very specifically shaped and oriented pieces. Each different wheel and each component of each wheel has its own cutting plan, a nested pattern of shapes programmed into the CNC machine to cut each piece to the exact orientation with minimum waste. Every piece that is cut is also printed with a number so that kits of component pieces can be put together. Each kit needs to be cut from three different sheets, two different weights of woven carbon fibre fabric and a unidirectional fabric. Packets of pieces for a particular component – spokes, rims, and outer layer components – are then assembled, labelled and returned to a cold room at -18°C. “Pre-preg material has a working life of around 30 days at room temperature. If you chill them, this can be extended to a year,” explains Goodrum.

The next step on the tour is the clean room: “We train our lay-up specialists from scratch,” says Annecke. “These are not skills you can buy.” Moulds, manufactured in-house from steel tooling, are used as formers. We see a specialist stripping off the backing of pieces of pre-impregnated fabric and pasting them down into position on the mould. “Fikile is taking numbered pieces out of her kit and laying them according to an exactly defined set of process instructions. She is currently laying unidirectional carbon fabric

coming out from the spokes between woven fabric layers underneath, and then fanning them out to join onto the rim,” Annecke explains.

She points to a vacuum-packed mould on the layout table. “Because you need to use multiple layers, it is important to debulk after a number of layers,” she explains. Every station has its own vacuum pressure and moulds are placed into vacuum bags for 30 minutes, twice or three times during the layout process.

The wheels are made in two halves. Then intensifiers – made out of silicon rubber with Shore A hardness of 40 – are inserted into the spoke cavities along with an inside layer of carbon fibre. The two halves are then joined together. “The rims will be created by wrapping layers of carbon fibre of different weights and strengths around the circumference,” Annecke explains.

Then the whole mould is again vacuum wrapped, this time with a temperature-resistant plastic, ready to be placed onto an autoclave at 125°C for four hours under six bars of pressure. This is completed in batches overnight.

Annecke takes us to some wheels recently removed from the autoclave. The market that BST serves demands a class A finish. “Pressure from the autoclave is vital to give you both a perfect surface finish – one without fish eyes, holes or uneven surfaces and a structurally sound product. If a wheel comes out with a surface defect, it could be an indication of an underlying structural defect.”

Each wheel then goes onto a CNC machine, to profile the tyre bead on the rim. The finished weight of the carbon part is around 2,0 kg for the superbike-types.

Blackstone’s expertise is not limited to carbon fibre. It has invested very heavily in the CNC machines required to make the many different styles of hubs for different motorcycles. “We used to outsource the hubs, but we found we could not get the precision required,” says Goodrum. “Now we do the design and manufacture of the hubs.”

Annecke points out the variety of different hubs being machined: Harley-Davidsons for the American aftermarket; a number of Ducati designs; and hubs for the new Norton



*A motorcycle wheel, destined for the UK for use on the new Signature range of Norton motorcycles.*

Signature Series, a UK motorcycle only just released to the market.

We see Norton hubs being assembled to wheels in the assembly bay. An aerospace adhesive is applied between the hub-halves and the carbon fibre wheel. Inserts are glued into position on the inside of holes drilled into the wheel. One side of the hub is bolted on. A spacer is passed right through the centre to hold the two sides perfectly inline and the other side is bolted on. The wheel is then ready for final machining on its own hub to guarantee each one runs true.

Finishing and painting with a clear automotive layer follows and a final pass through an inspection room where every product made gets re-measured and inspected for cosmetic quality. The wheels are then packaged, along with a full set of documentation detailing every aspect of its design and history.

“It’s a complex business and with lots of technological challenges,” says Annecke. “To make perfect wheels, we monitor the process at every single stage.”

The price? Around US\$3 700/R30 000 a pair, less than the magnesium wheels against which they compete and much less than the cost of an alternate performance enhancement.

Perhaps one day, more wheels will be made this way. Goodrum sees advantage in applying the technology to trucks – payload, fuel efficiency, lifecycle and perhaps safety advantages too. With some R&D support, this could also become a niche South African competence. □