In conversation with... Mike Mowins president, The Phillips Screw Company

An in-depth conversation on lightweighting and fastener development with Mike Mowins is never to be missed. Executive Editor Phil Matten caught up with him at Barton Coldform (UK) Ltd, an Optimas company and the most recent licensee for Phillips MORTORQ® SUPER spiral drive system.

Where do you see the car industry in its lightweighting development and where is it going?

"You need to look at the lead innovators in any industry, in automotive that means high-end racing or performance – Formula 1, McLaren, Bentley and others. These are the harbingers of what will lead change going forward. We're seeing more and more integration of lightweight materials – magnesium, carbon-fibre reinforced plastics – and more attention paid to the initial design phase of the joint.

Automotive has driven surrounding industries to address lightweighting. The fastener industry is having to develop superior thread forming opportunities in materials, combining with better drive systems that are lighter weight and stronger at the same time, delivering far more robust joints that are more easily serviced. We saw that start some years ago with the move from standard bolted joints to thread forming fasteners in engine blocks – eliminating nuts and washers and forming the thread directly into the block.

Phillips has been one of the leaders in presenting ideas at conferences like the Global Lightweight Automotive Manufacturing series.

What we see is a process that starts with the question: 'We've got a joint, can we put it together and never take it apart?' If so then adhesives are a great solution. But, if you are ever going to have to repair, service or do anything else that requires it being disassembled, you need a threaded joint. Then the equation becomes, how do you optimise that threaded joint to be easily assembled, not stop the line with tool changes, and take as much weight as possible out of the entire assembly? The most effective answer is to look at lightweighting the entire assembly not just the components of that assembly.

You have a material that has to be thick because you need a counterbore to house your capscrew. If you can make the capscrew X percent shorter you can make your material X percent thinner and save not only the weight from the capscrew but also all of that material spread over the entire structure. We see a lot of that in seat applications, where we are able to shorten the bolt holding the seat in place. That gives the opportunity to reduce the height of the seat track. A millimetre and a half out of a half metre seat track, multiplied by four tracks, and you've taken a significant amount of cold rolled steel out of the vehicle weight.

Look at the whole assembly, instead of being focused on the part of the assembly for which you are responsible, and you have adopted a much more synergistic approach to lightweighting. To do that, you have to be involved very early in the design phase to help the design engineer explore the different options that provide a more efficient lightweight assembly."

You need to look at the lead innovators in any industry, in automotive that means high-end racing or performance – Formula 1, McLaren, Bentley and others

> “The fastener industry is having to develop superior thread forming opportunities in materials, combining with better drive systems that are lighter weight and stronger at the same time, delivering far more robust joints that are more easily serviced.”

So what level of awareness innately exists within the automotive industry?

“There is always the problem of inertia: ‘We’ve always done it this way, we’re always going to do it this way’ but the industry as a whole is moving.

Go from old school to ‘body in white’: Now you have a different set of parameters and now progress is easier to achieve because you have a wholesale change going on.

Start going to ‘body in black’: Now you are going from aluminium to composite. Then it is easier again because you have a sea change as opposed to divert a river.

The mental transition becomes: ‘Gee I’ve got to think new on this because I’ve got a whole new set of material properties involved’.”

For performance sports cars, or luxury sedans, the automotive industry has the price mark to adopt advanced materials – in fact they become a marketing advantage. A medium sized, high volume sedan, though, is still fundamentally manufactured in steel. So what happens here?

“It’s interesting when you look at the history. In North America the Saturn was the first plastic car, beyond the Corvette. Now you are looking at more and more bolt-on plastic pieces, replacing aluminium pieces, replacing sheet steel pieces.

Look at the standard, high-volume sedan and there are economic inhibitors but a significant element of the progress now comes from new talent entering engineering. As some of the old guard engineers retire out of assembly the baton is passed to new engineers coming up from a very different tradition and from a very different educational environment. They are more attuned to CAD than 2D and more amenable to saying ‘OK, if I just change this in the CAD how does that affect the whole structure?’ They are more willing to be outside of the norm with a solution than historically because they don’t have the same ownership as their predecessor.”

What about the crossover and feed through from aerospace?

“We’re seeing more and more crossover and feed through from aerospace but also the converse. The aerospace industry is always concerned about weight. Every kilo taken out of the airframe is a saving of 30 tonnes of kerosene a year.[1]

There are certain technologies coming over from the aerospace world. With more aluminium body in the car world, which has to be assembled and disassembled, 100 degree flush heads have replaced 90 degree flush heads because that’s what aerospace has lived with forever.

Conversely, Boeing and Airbus face massive back orders for single aisle airframes, so they need to go from 28 aircraft a month and start knocking on the door of 48 and then 60 aircraft a month. That means adopting automotive – and hey, now we’ve got moving assembly lines in the aerospace world that you never had before.

It is an interesting cross-pollination. Aerospace’s quest for quality at no incremental cost is coming over to the automotive side. Automotive PPAP early qualification is moving over to aerospace.”

How about other sectors, for example rail or other wheeled vehicles?

“We see the truck sector move to new innovations because they are driven by the same fuel economy requirements – the lighter the cab, the engine, the transaxle, the more efficient getting cargo from A to B. There’s a lot going on at PACCAR Inc, KENWORTH, Peterbilt Motor Company, these kind of guys. Unity of design, lighter weight materials, all aimed at better optimised performance.

A great example of unity of design is Rolls Royce. Everything that comes out now is 100 degree flush head, MORTORQ® recess parts. All the truss heads coming off the Paccar assembly line have a PHILLIPS SQUARE-DRIV® combination drive. That means multi-tool, multi-drive, multi-service capability in a lightweight package platform. You win efficiency savings in assembly that follow through into the aftermarket.

→

[1] https://www.lufthansagroup.com/fileadmin/downloads/en/LH-fuel-efficiency-0612.pdf

The ability to service an external MORTORQ SUPER with a hex or 12 point socket in an emergency is a huge advantage. On the assembly line you have the efficiency of the optimal drive system paired in the aftermarket with the ability to do pretty well anything necessary to get it fixed.

In the industrial world, we're now seeing the integration of optimised 3D technology into the design process driving more and more innovation. Instead of drawing in a 2D complex it can be pulled together from different places and integrated in the 3D modelling.

That means more flexibility. Occasionally you hit the issue of someone experienced in CAD but lacking shop floor knowledge. Then you get a design that is not easily capable of being manufactured but these things work themselves out and it's part of the learning curve."

All the truss heads coming off the Paccar truck assembly line have a PHILLIPS SQUARE-DRIV® combination drive

So as automotive OEMs inevitably face a law of diminishing returns in terms of lightweighting where does MORTORQ® fit in?

"We talked about the process of lightweighting decisions. Don't need to take it apart – glue it, friction stir weld, minimise addition of material. Got to open it, got to repair it, but still need to make it as light as I can but robust enough to be repairable? That's where MORTORQ comes into its own.

It has really proven its worth in the aerospace industry where we've taken large amounts of weight out of floorboard fasteners, which are the highest volume per airframe. The robust capability of damage tolerance in that particular system has lent itself very well to overhaul of the airframe in a much shorter time period.

We take that same philosophy and translate it into an automotive fastener as we did with Chrysler on their seats and we were able to minimise the seat track height, optimise the fastener driveability and yet serviceability is still straightforward."

Where do you think Barton Coldform can score with MORTORQ?

"Barton's ability to marry a couple of technologies to develop a thread forming fastener that can be driven at higher torque is extremely potent. In an application where the fastener is going to be torqued to yield, tool life is going to erode rapidly unless you have a very robust fastener. Either you create a system that has a higher limit than the yield of the fastener material, which is what we've done with the external MORTORQ SUPER, or you start having line outages on a too frequent basis for it to be cost-effective.

One study we've looked at with Barton Coldform suggests that by changing the fastener design they could take 25% of the weight out. On a high volume annual usage that is a massive saving."

What next – different materials for the fasteners?

"You hear a lot about the austempered Grade 14.9 bolts that are around now. We've been in that arena for a long-time with high strength titanium and high strength Inconel in the aerospace industry.

Yes, you can use fewer fasteners of a small diameter but the cost of that fastener goes up dramatically. Use ten fasteners at a dollar a piece to replace twenty at a quarter apiece and are you really getting a benefit?

You also risk compromising ductility for strength – and that becomes a real trade off forcing you to relook at the whole design. Take a 14.9 bolt and tighten it to the yield and you get face embedment and thread deformation because you are threading an ultra hard material into a cast steel or aluminium. So then you add a helicoil thread so you don't strip out the block. All kind of design parameters start beginning to add up. What looked like it was going to be a fairly linear trade off suddenly becomes multidimensional and really impacts overall cost.

My feeling is, when we look at dealing with high strength materials in automotive, you are almost at the point of diminishing returns.

"In an application where the fastener is going to be torqued to yield, tool life is going to erode rapidly unless you have a very robust fastener."

Powertrains are changing and a lot faster than was previously anticipated. What does that imply?

"That's an area where we've been at the forefront with some of the automotive manufacturers. We bring experience from some of the cutting-edge aerospace industry we're dealing with. Look for example at fibre composite, solar powered drones where weight is the ultimate consideration. Now look at an electric vehicle where weight is a much more critical issue because every kilo that can be saved is X amount of kilowatts of battery longevity. That becomes a much more interesting fastening equation. The more you can do with composite-composite joints, as opposed to metal-metal-composite joints, the better. Those are areas we are looking at very closely.

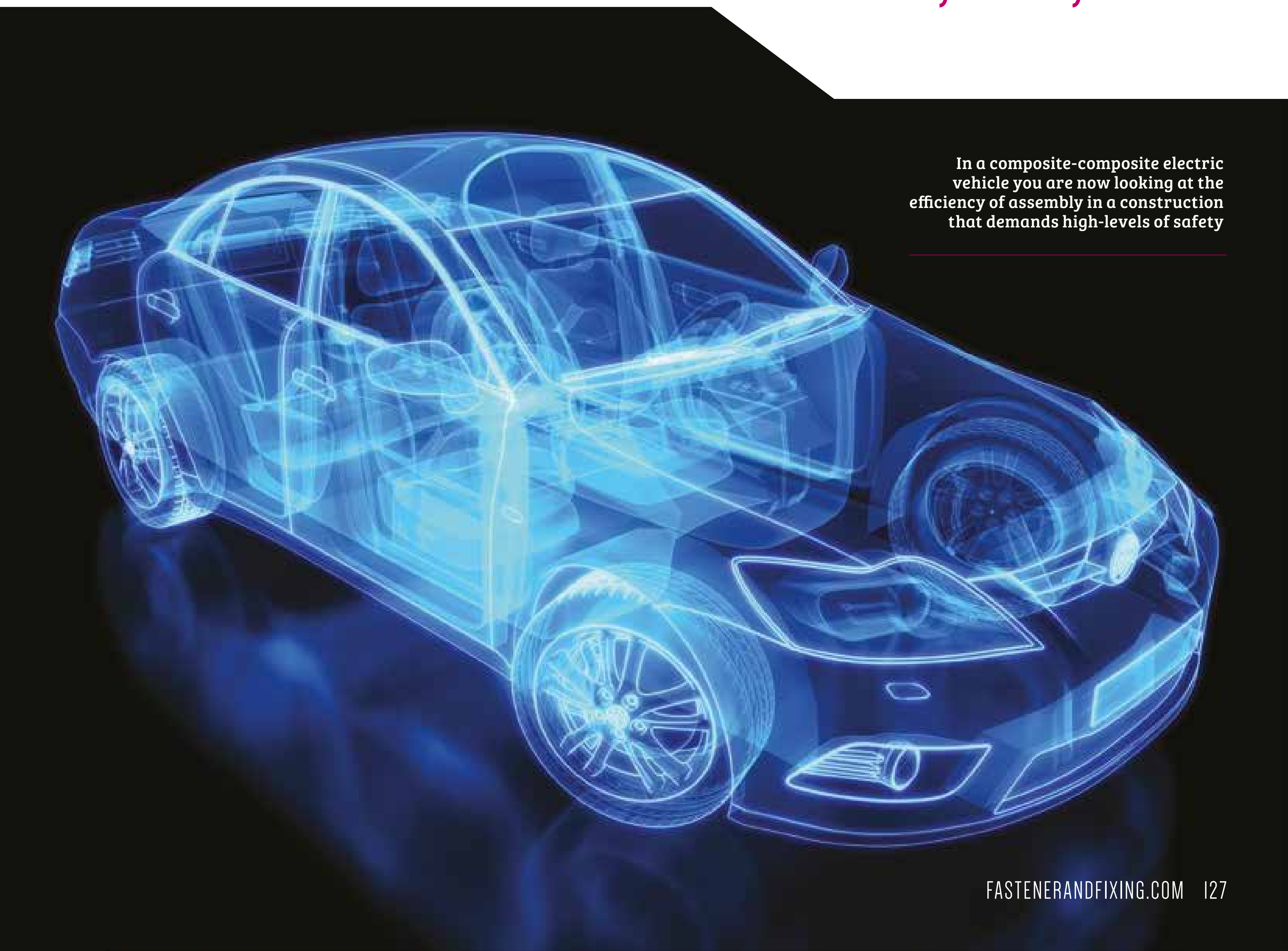
The evolution of fastener drive systems is something that is never really going to stop because you always face another problem to resolve. Maybe you need ultimate torque capability in a tamper resistance design because the vehicle is going into a high theft region – or an electric braking system you don't want accessed because of liability issues.

In a composite-composite electric vehicle you are now looking at the efficiency of assembly in a construction that demands high-levels of safety. Heavy batteries must be secured not just against the extraordinary forces of collision but also the repetitive g-forces of braking and high-speed cornering. So you need a fastener assembly that will survive the stresses exerted by those heavy loads over a long period and you needed threaded fasteners – because you need service access.

It's a very different set of parameters from a combustion engine vehicle but nevertheless the ultimate joint characteristics are not dissimilar from what you see with a head bolt. You see more sheer stress with battery compartments than tensile stress but you still need the same clamp load to keep it all together."

→

"The more you can do with composite-composite joints, as opposed to metal-metal-composite joints, the better. Those are areas we are looking at very closely."



In a composite-composite electric vehicle you are now looking at the efficiency of assembly in a construction that demands high-levels of safety

Where next for Phillips and for mechanical fasteners generally?

"We've started to go outside our historic comfort zone. It used to be about internal drive systems in the head of the fastener. We've now gone to the external MORTORQ SUPER, which was a significant departure for us.

We're developing a recess in the thread end of the fastener. There is a big demand for that in aerospace. It can't be so large that you deform the thread or you burst the thread when tightening the fastener. Those types of application are more aligned with composite-composite where you have a flush surface on the outside of the bolt.

We're seeing similar requirements in the large head type of fastener designed to be embedded into composite material, which is being used more in automotive but also in boats and other applications. People are realising that when the nut is run onto the stud it imparts torque loads which start twisting the head inside the composite – fracturing fibres and creating weakness. A recess in the thread end prevents rotation within the bonded structure, eliminating a potential failure path. That's already proven to very effective in a number of areas.

We definitely see a trend more to bonded fasteners. When you look at what is being done panel-to-panel, non-rigid to rigid, you are going to see a lot more of these joints – for example a flexible plastic joined to a CFRP panel. We're certainly seeing some interesting things in the aerospace world, which are out and beyond the bounds of what you usually see.

The greater the vehicle longevity the more the balance between insertion and removal of a fastener becomes an issue. Our assertion has always been you need to have better removal than insertion capability – the exact ratio is debatable but you always want your removal torque requirement to be a little bit better than what it took to install it. When the fastener is inserted it is generally in a clean, controlled and well-equipped environment. It's a different story one year, five years, twelve years down the road when its gone through some nasty stuff. An aircraft experiencing temperatures from –40°C to +40°C, even a cooker cycling regular from hot to cold, let alone a car that's gone through sand, salt, snow and car wash.

When you take the joint apart it normally requires 25% to 50% more torque than it took to install it. That's why we have a design philosophy that says better in removal than installation.

Eventually you've got to recycle it these days, and design for recyclability is driving a lot of what is going on in the automotive world now. That has an impact on the complete life-cycle carbon footprint – just by reducing the energy required for disassembly by having fasteners that will allow the separation of different materials."

The external MORTORQ® SUPER

> "It used to be about internal drive systems in the head of the fastener. We've now gone to the external MORTORQ® SUPER..."

What inhibits the development?

"The interesting thing is what the barriers to rapid adoption of innovation are. A lot of industries are held back by a combination of 'Not invented here' with 'Gee, I just don't know'. You run into a lot of companies that fall into the NIH camp, but you also run into a lot that simply have not had the time to think about it.

They are so busy producing the product they don't have time to look at how they should optimise the product so they are tied to technologies that might well stem from the 1950s. Is it safe? Absolutely. Have you proven it's safe? Absolutely. Is it the best solution available to use? No it's not. Can you be somewhere further down the line by a few changes? Yes you can – absolutely.

It's not a lack of the technology – it is a lack of the daring to apply the latest technology – and also a lack of comprehension of the capability of that technology.

You run into two types of engineer in any industry, the glass half full and the glass half empty. Glass half full – it's good enough, I've slaked my thirst. I have a proven system: I am not going to break what doesn't need fixing. Glass half empty: With just a little more technology, a little more daring, I can take this to the top of the glass and have something exceptional.

The buzzword these days is disruptive technology. What needs to be recognised is the level of optimisation and incremental advances that are essential milestones on the road to a disruptive technology. Look at the Boeing 787. Yes, the carbon fibre fuselage is a disruptive technology but there were so many incremental technologies that helped Boeing to get there. Optimising the fastener for lightning strike because now, instead of conductive aluminium it is non-conductive carbon fibre. Optimising the floor fastening system because you've got a CFRP floor going into titanium stringers and it needs to all be a single sided assembly.

When you look at the end result it is actually the sum of a lot of incremental innovation. It is about having an organisation that will embrace the incremental innovations to reach the disruptive innovation.

It's also about a company like ours that every so often succeeds in nudging the process forward. Here's a small step, well that worked well, so here's another, a little bit larger..." +