From metal to plastics in transmissions and driveline

**DuPont™ Vespel® parts:** low friction, lightweight and durable metal replacement

Talk to almost any automotive engineer involved in transmission and driveline development and they’ll be looking for answers to these questions:

- How do I save weight without compromising part performance?
- How do I improve performance while reducing fuel consumption?
- How do I minimize friction losses between moving parts?
- How do I reduce cost?

For many applications, the answer is to replace metals with high performance plastics and composites.

*CTI Mag* interviewed J. Ruterbusch, Global Transportation Segment Manager for Vespel® and Kalrez® Parts business at DuPont Performance Polymers, to find out how the company is collaborating with auto engineers to provide solutions to the latest materials challenges in transmission and driveline.
CTI Mag: What trends do you see in automotive drivelines?

J. Ruterbusch: For several years now there has been a tremendous push in the industry to reduce vehicle weight and this trend continues. OEMs are equating dollars to every kilogram of weight shaved off the vehicle, and they talk in terms of taking 10% off the chassis, 15% off the engine, and a very significant 20% off transmission and driveline. So if you are an automotive design engineer working on a big weight reduction program, the best way to achieve that is to replace metals by plastics and composites.

Much of the transition from metals to plastics has already taken place in engines via intake manifolds, cam covers and other significant parts. But when we look between the engine and the wheels we still see a lot of metal and few composites. That has been the drive for DuPont to work with OEMs to develop components that replace metals and provide cost — and most importantly — weight savings. We are turning the corner in this area. With the use of computer simulation and the evidence from commercial successes we have demonstrated how well polymers work in many applications where metal was heavily involved.

A key mega-trend we are seeing is the shift away from purely manual transmissions to automated transmissions. This includes affordable, low cost, lightweight continuously variable transmissions (CVTs) as well as multi-speed dual clutch designs.

In addition, regardless of transmission design, engineers want to improve efficiency by reducing friction — that’s another mega-trend. Globally we’re seeing significant effort and funding for projects where reducing friction and frictional losses are now a key objective.

Low friction DuPont™ Vespel® material performs reliably with or without lubrication in conditions that can cause severe wear to metals, and destroy many other plastics. It is at the top of the polymer pyramid with its high load and high-speed capabilities (high PV limits). Vespel® parts enable new design solutions such as higher shaft speeds and loads. They can replace metal thrust bearings to reduce overall size and weight, or enable the use of lighter weight metals. For example, due to its excellent wear properties against aluminum, using a Vespel® part may eliminate the need for heavier steel inserts or sleeves.

CTI Mag: Can you give examples of applications where plastics can provide advantages over metals?

J. Ruterbusch: One of our customers, looking for a material with excellent wear resistance for a transmission fork application, was convinced that only a move from aluminum to bronze would give the wear and friction characteristics needed. But bronze is very heavy. We provided the solution using Zytech HTN high performance polyamide with two Vespel® wear pads which have proven to be significantly more resistant to wear than bronze.

Almost any new transmission design project can be an opportunity to replace metal. For example, a major Asian transmission producer replaced metal needle bearings in a CVT transmission with Vespel® thrust washers. These are significantly thinner than the metal needle bearings and one-third the weight, allowing the Tier supplier to reduce the overall size and weight of the CVT unit.

A European transmission producer also gained weight and space savings, as well as maintenance-free advantages by designing with Vespel® parts. The company installed highly abrasion-resistant low friction Vespel® SP sealing rings in its CVT.

In the engine section, Vespel® valve bushings have replaced metal components in an exhaust gas recirculation (EGR) system used in four and six cylinder stratified-charged petrol engines, thanks to the advantages of Vespel®: stiffness, tensile strength, and resistance to friction, wear and hot exhaust gases at temperatures up to 220°C. The bushings position and guide the cylindrical operating rods of EGR slip-in valves, supporting their smooth operation during millions of openings and closings. And a leading global supplier of innovative turbocharging systems chose Vespel® bushings to improve the reliability and durability of its pneumatic actuators used in turbocharger applications.

CTI Mag: Where do you see the greatest contribution of plastics?

J. Ruterbusch: There is enormous potential for polymers in automatic transmissions and drivelines. Wherever engineers need to take out weight and cost and reduce component size while sealing fluids, resisting wear, friction and loads, and withstanding chemical attack at low and high temperatures — DuPont have the products to do that.

For example, Vespel® material has a density ranging from 1.35 to 1.77, depending on grade, compared with steel at about 8.0, making weight reductions of up to 80%, and cost savings of 30 – 50% possible. It also has a much lower coefficient of friction, enabling unlubricated operation, downsizing, low friction, a wider operating window, plus high electrical and thermal insulation, unlike metals. As a result, DuPont already has many commercial and developmental applications across the driveline sector.

As loads, fluid pressures and shaft speeds increase, high performance polymers can help provide new levels of vehicle performance — more power from smaller, lighter components. Vespel® parts excel in auto-
matic and continuously variable transmissions, transfer cases and torque converters because they can help make new designs and concepts possible.

**CTI Mag: How do you convince engineers of the long-term reliability of Vespel®?**

**J. Ruterbusch:** Since its introduction, Vespel® has been the subject of continual development and improvement. Millions of Vespel® transmissions and driveline seals, bearings, thrust washers, bushings and wear pads have been performing well for over 50 years, proving the long-term reliability of the material, not only in automotive, but in applications across all industries.

In automotive, Vespel® thrust washers that replaced metal needle bearings in CVT transmissions manufactured by a major transmission supplier to a big five auto maker became standard equipment some years ago. The significantly thinner and lighter thrust washers enabled the OEM to reduce the overall size and weight of the CVT unit. That’s a standout reliability case history that convinces engineers and designers today of the long-term reliability of Vespel® parts.

For our Vespel® business, giving our customers ‘peace of mind’ is really where the ‘Science of Sealing, Wear and Friction’ provides its value. First, we have the historical material science capabilities of DuPont backing our resin development and selection process. Second, since we are the supplier of Vespel® parts, we have part testing capability in all three regions: Europe, Asia and the Americas. It’s very typical for us to confirm part performance in DuPont laboratories under actual end use conditions as specified by the customer. These test facilities also allow us to optimize design and material selection before the parts are installed in the actual components.

We continuously undertake studies to understand the wear and friction behaviour of polymeric seal rings, used in new generation automatic transmissions, especially to compare wear performance during initial actuation of the transmission, and long term performance.

This type of information is much appreciated by automotive customers who benefit from the DuPont capabilities and experience in evaluating technical solutions to wear and friction challenges in automatic transmissions, and from the comparisons and conclusions drawn from their own in-house or field testing. It also provides evidence supporting the long-term viability of Vespel® polyimide parts in replacement of metals.

Finally we have production capability in all three regions as well. All facilities operate to global quality standards as required by our customers.

**CTI Mag: Can you comment on some product capability highlights of Vespel®?**

**J. Ruterbusch:** I’d highlight the ability of Vespel® parts to operate continuously in temperatures from -196 °C to 349 °C and above, while offering low wear and low friction at high loads and velocities in lubricated or unlubricated environments. Vespel® S parts do not have a melting point and can survive temperature excursions as high as 482 °C. Special Vespel® SCP heat resistant grades can withstand temperature excursions to 650 °C.

The latest Vespel® S grade, for example, exhibits a low coefficient of friction and excellent wear against aluminum. DuPont tests have demonstrated that those Vespel® S parts can

- provide significant improvement in measured torque loss on a transmission shaft
- reduce seal ring leak rates, lowering the parasitic losses associated with the transmission oil pump
- contribute to weight reduction compared to metal.

Vespel® S is commercialized in transmission seal rings offering very low friction, tolerance control over a broad temperature range, and long life.
CTI Mag: What are the advantages of working with DuPont?

J. Ruterbusch: Our customers benefit from the technical application development support services, ranging from concept design to product testing. We work closely with OEMs on computer simulation involving almost the entire driveline including axles, wheels, springs, shock absorbers. We also have in-house capability to run material behaviour projections that allow modeling of dynamic crash events in milliseconds, to meet government crash worthiness requirements, for example.

And I believe it really centers on ‘peace of mind’. As mentioned earlier, we apply our science all the way from material selection to end-use testing. And because we are a global company, we can rely on our global network to support our customers anywhere they need us.

DuPont offers the industry’s broadest range of polymer composites, engineering polymers and elastomers. The automotive industry already uses these products extensively. They include Crastin® PBT thermoplastic polyester resin, Hytrel® thermoplastic polyester elastomer, Kalrez® perfluoroelastomer parts, Rynite® PET thermoplastic polyester resin, Vamac® ethylene acrylic elastomer, Viton® fluoroelastomer, Zytel® high performance polyamide and of course Vespel® parts and shapes.

DuPont polymers are proven in use in manifolds and gaskets, air ducts, turbocharger hoses and resonators, EGR seals, hoses, valves, bushings, thrust washers, to name some. The in-depth and long-term experience in providing the automotive industry with optimal polymer and/or part solutions to meet their specific requirements and regulations – embracing downsizing, light weighting, fuel economy, alternative drive systems and safety – make DuPont an ideal partner to collaborate with.

The charts show that during the first 24 hours, the wear rate (amount of wear by time unit) of the seal ring measured in the axial direction is much higher than that observed from 24 to 100 hours. This phenomenon, often seen in friction applications, enables a better understanding of the relevance of long term testing in evaluating the wear performance of friction parts.

Charts: DuPont.