PROTEAN

In-Wheel Motor Durability 3.0

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One of the questions we are asked most often by our customers is about the reliability and durability of our in-wheel motor products. It's an important topic for vehicle manufacturers, whose vehicles are regularly assessed and ranked according to the reliability experienced by their end users worldwide. Electric drivetrains in general have not been in common use for anywhere near as long as their combustion driven counterparts, and therefore have fewer years of experience and development behind them to give existing confidence in their reliability.

The use of in-wheel motors (IWMs) adds to this by dramatically changing the environment in which the product needs to operate. Compared to a conventional central electric drivetrain, being positioned inside the wheel means that IWMs must continue to operate reliably while being subjected to much harsher environmental conditions. An electric motor located on the un-sprung side of the vehicle suspension will experience much higher levels of shock and vibration from potholes and other road surface defects than a central drivetrain located on the sprung chassis. IWMs are also more exposed to environmental factors such as dirt and water, full submersion wading and potentially higher thermal loads due to their close proximity to the vehicle brakes. In addition they are subjected to stresses not seen on a central drivetrain such as lateral cornering loads, cable movement due to suspension travel and potential kerb impacts. For the area in which they are located on the vehicle IWMs are a relatively complex and high cost component, with a significantly higher value than the wheel, brakes or basic suspension components that surround them. End users may readily accept paying to replace a wheel in the event of a moderate kerb impact, but would not be so accepting if they had to replace their wheel motor. This means that IWMs need to exceed the durability of the components that are usually found in this exposed area of the vehicle.

Application of lateral loads to represent cornering forces

It's easy then to see why some customers might be nervous about the reliability of in-wheel motors, and it's natural for them to feel more comfortable applying an existing solution for their powertrain needs rather than a new technology in an extremely challenging environment. IWMs are an exciting proposition though as they can offer a number of substantial benefits to a vehicle manufacturer over a central electric drivetrain, with increases in efficiency and range, improved vehicle dynamics and greater chassis design flexibility allowing class-leading interior space, but none of those things can come at the cost of vehicle reliability. At Protean we firmly believe that IWMs can work reliably and remain durable in the conditions they are exposed to, across a wide range of vehicle types and uses. That belief comes from many years' experience of developing and testing IWMs in extreme conditions, both in lab testing and vehicle testing, on our own and in collaboration with customers all around the world.

Our product is designed to last the lifetime of the vehicle without requiring servicing and as with most products, the journey towards a suitably reliable and durable in-wheel motor starts with a clear set of requirements. For many automotive components, manufacturers can look to recognised industry or vehicle manufacturer standards, most of which have been developed through many years of experience of vehicle use in different climates and road conditions around the world. There are no existing

standards specifically for IWMs, so Protean's approach has been to amalgamate requirements from identified standards in topic areas that are relevant to our product. For example, the IWM is used to drive the vehicle, has low voltage components and is attached to the suspension, so Protean have adopted aspects from existing durability standards on powertrain, electronic equipment and suspension components. The stress factors that impact the reliability of electric drivetrains are often different to those that affect the reliability of combustion engines, and this needs to be taken into account when adopting existing standards. For example, electric drivetrain lifetime is less affected by mechanical wear but more affected by electrical and thermal stresses, so requirements that were originally intended for different components may need to be adapted to account for this.

Shock and vibration testing is conducted at levels between two and four times greater than centralised drivetrains

Simulation tools can be used during the design phases to show whether the proposed design will be resilient to the real world use that the product will be subjected to, while careful testing of materials, component parts and sub-assemblies can be used to further increase confidence early in the development. Real evidence of the product durability begins during lab testing of the complete assembly under conditions that replicate or exceed the expected worldwide environments. Protean's approach to lab testing has been much the same as our approach to the requirements, taking applicable test methods from international industry bodies and vehicle manufacturers and adapting test protocols originally intended for different components to account for the unusual conditions IWMs operate in. We perform around 85 different types of test, each of which may be anywhere from a few hours to many months duration, and for the more unique stresses this has often meant creating our own test equipment in order to apply loads in ways that centralised electric drivetrains are not subject to, for example the application of lateral loads that act on IWM bearings during vehicle cornering. Representing the harsh environment that IWMs must survive in means that tests for aspects such as shock and vibration resistance are conducted at much higher levels than would usually be applied to a centralised drivetrain. Shock testing for resistance to pothole strikes for example is conducted at levels of 100 g, somewhere between two and four times the levels usually applied to components on the sprung body of the vehicle.

After lab testing has proven a level of confidence in the design, durability testing can start at a vehicle level. Full vehicle durability is commonly used by vehicle manufacturers, and is the final checkpoint in proving reliability when introducing a new technology. Protean have completed several sets of full vehicle durability testing, in two wheel drive vehicle configurations on our own demonstrator vehicles and in multiple samples of four wheel drive delivery vehicles with customers. In addition we have completed vehicle winter testing with two customers that we can name, NEVS at Colmis in northern Sweden and Dongfeng Motor Corporation (DFM) at Yakeshi in Inner Mongolia. Both NEVS and DFM were examining the unique vehicle dynamics benefits given by truly independent four wheel drive on snow and ice, and found that IWMs were more than capable of operating reliably in these harsh conditions.

Snow packing around the IWM during winter vehicle testing

Overall then we understand why we are asked so often about the reliability of IWMs. Even with all the many benefits on offer, it's a new technology operating in an extremely

harsh environment and it's natural for customers to want to fully understand how we manage durability before adopting them. Protean constantly strive to improve the reliability of our product, and our experience in comprehensive lab and vehicle testing, both on our own and as part of customer programs, has shown us that wheel motors can meet the reliability and durability required by modern vehicles even in extreme conditions. We look forward to seeing in-wheel motor technology and the benefits they bring in mainstream use on a range of vehicle types.

About the author:

Mark Mcdonell has been working on Testing & Validation at Protean Electric for 13 years.