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Press releases

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Guaranteeing a reliable steering booster requires extreme tests

Many consider aviation and aerospace to be the ultimate high-end area when it comes to technical requirements. This is not always true. While an airplane can fly for hours after takeoff in the same ambient conditions, an automobile is constantly faced with endless disturbance variables for as long as it is in operation-there is no defined operating state. All components of a vehicle have to be designed with this in mind. Particularly for important steering components, which must operate with absolute reliability, quality assurance is of utmost importance. Stringent quality control, involving all of the stresses encountered in the real world, is an indispensable prerequisite for high-quality products.

During their lifetime, automobiles are subjected to an extremely wide variety of requirements. Automakers begin to take this into account as soon as development begins. Driving trials in extreme conditions with heat, dust and off-road tests in the Arizona desert or through ice and snow in Northern Lappland are common. Salt spray fog and tropical humidity are additional threats that automotive components have to face. For drive specialist at ebm-papst of St. Georgen, Germany, this means preventive and in-production tests for the electric motors that are built into vehicles in order to ensure trouble-free function over the entire life of the car or truck. Especially stringent standards apply to the power steering motor, which is exposed on the underbody and is an important safety-related component. Test engineers devised an entire series of "torture" methods to ensure that the products meet these standards.

Mechanical stresses

From the moment its engine is started, a vehicle is subjected to a variety of mechanical forces. These include everything from engine vibrations to vibrations from the road to braking and acceleration forces. Because even today's shock absorbers and suspensions cannot absorb them all, all automotive components need to withstand them. Furthermore, rock impacts, humidity and dirt make life difficult for all components of a car or truck. Only intensive advance tests can guarantee that components will survive field testing of the finished vehicle.

Naturally, the foundation is laid by materials quality control and documented monitoring of manufacturing processes, as only high-quality materials manufactured with process reliability result in high-quality products. Then, all relevant tolerances are tested on the finished product . These basic requirements are followed by more stringent tests, which are based on the real-world conditions under which the product will be used. These test conditions are significantly tougher than any that will be encountered in day-to-day operation. One reason for this is that only a short time is available for testing-years of real-world use must be simulated in mere weeks. Another is to provide a safety margin to cover special stress conditions the user may face.

For individual tests, the motors are screwed onto mounts that correspond to the steering gear flange, ensuring that the heat deformation, heat conduction, condensation etc. are as realistic as possible and reflect the conditions to be faced in the future life of the vehicle. The actual testing process includes trials that are also familiar in the field of mechanical engineering, such as the dynamic strength test on the vibration table, and continuous stress with fixed frequencies at different temperatures.

The torture continues as heat tests simulate the Arizona desert. A temperature stability test extends for 16 hours at a continuous temperature of -40 °C and 96 hours at 130 °C. Hot asphalt during the day and a cold pass at night with below-zero temperatures in front of the hotel-all of this must be withstood by the motor without a hitch. For the thermal shock resistance test, the motor must prove its endurance in electrical function testing in increments of 5 °C from -40 °C to + 120 °C. It is also hot under the engine hood, and splash water means sudden, shock-type cooling. This is simulated by a temperature shock induced with a gush of water (image 1). The drive is heated to 110°C and cooled with a gush of water at 0°C in 3 seconds. To make conditions even more difficult, 3% Arizona dust is added as an abrasive. This is repeated approximately one hundred times. The housing, seals and function must all conform to requirements.

After each and every test, the motor is checked to ensure that its function and electrical system are intact and undamaged. It is not enough for it to work properly-no water may have permeated it, for example, impairing the insulation resistance of the winding. Every mechanical test, therefore, is accompanied or followed by electrical measurements.

Temperature cycles are a good way to find potential gremlins. They are a fast-motion simulation of summer and winter use. The motor is taken from a -40 °C environment to one at +120 °C and vice versa. It is stored in each temperature for one hour; this cycle is repeated, without interruption, for four days (image 2). Afterwards, the so-called breakaway torque of the rotor at startup is not allowed to deviate from the reference variable. A dust test and gravel test to simulate rock impact complete the mechanical testing conditions. Since nobody likes a dusty or dirty car, in the real world, it would be time for a car wash with steam jet. This is simulated by a hot water-jet test with a water pressure of approx. 100 bar, followed by immersing the motor, at an operating temperature of 120 °C, into a cold (0 °C) 5% salt water solution.

Chemical stress

Installed in an automobile-particularly in its underbody area-a motor is exposed to the effects of a wide variety of chemicals. No engine compartment is actually sealed 100%. In addition, fluids are often spilled in to the engine compartment during service and maintenance. All components must withstand these stresses. Among the worst stresses are road salt in winter and corrosive gases that attack the contact material. A salt spray test spanning six eight-hour cycles, each followed by one four-hour resting period, simulate the rough life of a car or truck in winter. Dilute gases such as sulfur dioxide, nitrogen oxide and chlorine-the gases the components will normally encounter in the vehicle-attack them for some 21 days at a relative humidity of 75%. Above all, here it is important that the plug contacts do not corrode and that the contact resistance increases by less than 15 %.

Everyone knows Murphy's Law: Anything that can go wrong will go wrong. Specifically in automobiles, a wide variety of chemicals are used that can leak or be spilled. Therefore, at a storage temperature of 80 °C, the test motors are subjected to fluids such as methanol, gasoline, diesel, biodiesel and window washing fluid containing alcohol. Cleaner solvent, ethyl alcohol, desert dust and wheel cleaner are also given a chance to work in at this temperature. Substances with a higher boiling point such as antifreeze, battery acid (37 % sulfuric acid) and brake fluid are allowed to go on the attack at 100 °C. At a blazing hot 125 °C, the testers apply motor and gear oil and hydraulic and automatic transmission fluid as well as commonly used underbody protectants. Sugary and caffeinated soft drinks are also included in this test. The exposure time at each temperature level is 24 hours, after which operation must be possible with no restrictions.

All of these tests have the sole purpose of proving the resilience of the motor's casing and mechanical system. The real primary task, the electrical function test, comes at the end. Since a car or truck must complete a large number of steering movements over its assumed 10 years of service, this test is extremely important-and just as complicated. It accelerates the motor to its setpoint rpm in less than 200 ms, keeps it at this speed for a while, then brakes it to a complete standstill in less than 200 ms. After each 100,000 test cycles, the motor is switched from clockwise to counterclockwise operation and vice versa. Approximately 1.6 million steering movements or 26 million revolutions of the electric motor. In the process, it is subjected to a constant load or tested under changing temperature conditions and speed profiles (image 3).

Quality requirements, such as those placed on a highly exposed car component like a power steering motor, can be met only if quality control is used as a feedback mechanism to cycle information back to production. Therefore, in-production tests are an important part of manufacturing. They simulate users' requirements and thus help to increase customer satisfaction.

Power steering motor

Increasingly, today's technically advanced vehicles are using brushless electric motors-often called BLDC drives-for auxiliary and servo functions. One example of these applications is the innovative steering booster that consists of an electronically commutated BLDC motor and a planetary gear (image 4). This concept expands the conventional, servo-supported steering system by adding a differential gearbox with two inputs: one for manual activation via the steering wheel, and another for the electric motor. The two independent input speeds are converted to one output speed.

When driving at slow speeds, the electric motor is activated such that its speed increases in proportion to how quickly the steering wheel is turned. This achieves the maximum steering angle fast, and the steering movements required at speeds up to 120 km/h are significantly reduced. In contrast, at high speeds, the electric motor works counter to the direction in which the driver turns the wheel. Therefore, the output speed and the steering angle at the gear output are smaller, and the on-center feel is more reliable. In addition, the electronic control enables automatic counter-steering in certain driving situations, such as driver errors. Yaw and lateral acceleration sensors measure the vehicle's driving reactions and stabilizing steering interventions are derived from this information. Because this power steering is active for the entire operation time, the EC motor used must have an especially robust and reliable design.

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