Mechanical power measurements on drive systems

Tech article

CAEMAX Technology GmbH has developed a new sensor system for making wireless power measurements on mobile equipment. The system synchronously records the speed and the torque acting on the shaft and calculates the power. Because of its modular design, it can be easily integrated into existing systems.

Power measurements are essential to the development and optimization of drive systems. This applies to many areas: The automotive industry is striving to reduce CO_2 emissions from its vehicles. In addition to classic combustion engines, they are also developing electric and hybrid systems. In many branches of industry, electric motors power machines of all kinds. All these components are expected to become even more efficient. The overall efficiency of a drive system is a decisive parameter and can be determined with the aid of power measurements. But it is not always enough to look at overall efficiency – it is often also necessary to know how the power is distributed to individual components. This is the only way to develop intelligent systems that guarantee maximum efficiency in every driving situation.

Mechanical power measurements typically measure the speed and the torque applied to a shaft at a given time. The power is then calculated as:

$$P=2\pi \cdot n \cdot M$$

where n is the rotational speed and M the torque.

Power measurements up to now

There have long been different systems on the market for measuring both speed and torque. If one wants to determine the power with the help of such discrete systems, however, problems arise: the two signals independent of each other must be synchronized afterwards. This is only possible with some effort, which makes the system very error-prone. Mechanical installation is also time-consuming and complex.

Some integrated systems that have been on the market for some time also have limitations that should not be ignored. For example, the shaft to be measured often has to be shortened in order to install the sensor. Another alternative is to replace the shaft completely with a new version equipped with a sensor. With these systems, the original component is not preserved, which inevitably leads to a change in the component behavior. In addition, many systems for measuring the rotation rate require a stator, which must be attached to the chassis, for example. Some systems are not suitable for mobile operation, but only allow stationary measurements, e.g., on the test bench. They are often heavy and mechanical installation is often complex.

New measurement system from CAEMAX

CAEMAX Technology has now developed an integrated measurement system for making wireless mechanical power measurements on drive shafts that solves these problems.

Fig. 1: Half-shell housing on strain gauge equipped shaft with integrated D^x transmitter unit and rotation rate sensor.

The most important innovation is the rotation rate sensor system. This provides correct data independent of lateral accelera-

tions. The fact that the shaft moves up and down irregularly when driving a vehicle, for example, has no influence on the measurement result. An additional stator mechanically connected to a stationary part or to the body is not necessary: the system does not require any additional fixed points.

In addition, the sensor is shock-resistant up to ±10,000 g and can be used for speeds up to ±7,200 rpm. The accuracy achieved is better than 0.5%. This is made possible by the use of a gyroscope based on MEMS technology (Micro Electro-Mechanical Systems). Worm grid structures interlock within this sensor. During rotation they are deflected against each other by the Coriolis force. This changes the capacity between the grids proportionally and the rotation can be measured with very high resolution. The intelligent wiring in the entire sensor system largely eliminates interfering factors. The temperature drift common with these sensors is also compensated over a wide range of -40 °C to +85 °C. This makes the rotation rate measurement very precise. The torque is measured by a sensor on the drive shaft. For this purpose, a strain gauge is applied to the shaft in a bridge circuit. The data from the rotation rate sensor and the strain gauge are sent by the D^x telemetry transmitter to the radio receiver unit, which calculates the power synchronously. By using this system, the original shaft is retained. The power supply is inductive via a stationary inductive current loop. A half-shell housing protects the applied strain gauge sensor and contains all necessary systems. There is no further mechanical intervention on the shaft.

Fig. 2: D^x half-shell housing with integrated power supply.

The construction is mechanically very robust and waterproof to IP 66 and IP 67, making the system particularly suitable for mobile use in all weather. The telemetry operates in either the 868 MHz or 2.4 GHz band. This enables the system to be used worldwide without requiring approval.

The installation of the necessary components is quite effortless. This is where the modular concept of CAEMAX Technology's measurement systems comes into play. Individual components can usually be easily added.

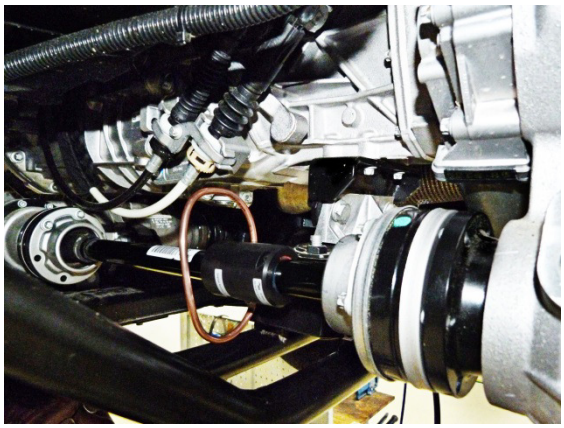

Fig. 3: Installed power measurement system with inductive power supply on the vehicle.

If, for example, a torque measurement system with protective housing, inductive power supply and the D^x telemetry system already exists, the rotation rate sensor can be easily added. Its data is then transmitted synchronously to the torque sensor via the existing system. The receiver unit then calculates the corresponding power value in real time. All data can be output via CAN, Ethernet or analog and processed further

as required – for example, with the imc FAMOS analysis soft-ware, where the recorded data can be ana-lyzed in many different ways. The analysis can be carried out automatically so that the user receives a PDF file with all desired data, for example.

The idea behind the new power measurement system is that it can be used universally. It can be utilized with different shaft diameters and does not have to be newly designed for each individual case. This enables very short times for the preparation of all necessary components. The half-shell housing, as well as the D^x telemetry and the rotation rate sensor built into it, can be easily dismantled and reused later. This results in a high level of investment security.

In addition to the hardware, the company offers support throughout the entire project. This starts with consulting and planning, then continues with the installation and calibration of the necessary components all the way up to competent assistance during operation.

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