SENSORS FOR THE PLASTIC INJECTION MOLDING

Sensorized Future – Sensing of temperature and pressure in harsh environments (SensoFut). The “Sensorized Future” project was funded in the 13th Cornet Call (Collective Research Networking) by the Federal Ministry for Economic Affairs and Energy (BMWi) with the support of the German Federation of Industrial Research Associations (AiF). The aim of a subproject was, among other things, to create a sensorized thin film system which simultaneously picks up both the force and also the temperature distribution at the surface of the mold during the plastic injection molding process.

The challenge

Wear-resistant thin film sensor systems are playing an ever greater role in the most varied applications, especially in the field of real-time acquisition of process data. So also during the plastic injection molding process both the force and also the temperature distribution are of importance to recognize possibly appearing defects during the process.

The solution approach

At the Fraunhofer IST individual thin film sensor modules have been developed which can be fitted very precisely into the mold and measure the force and also the temperature distribution at the surface of the mold simultaneously during the plastic injection molding process. Furthermore the surface of the thin film system shows anti-adhesion properties. So, the component can be removed easily from the mold.
The thin film sensor systems

The thin film sensor system consists of the following functional layers which were deposited on a steel base body:

- the piezoresistive sensor coating (material: DiaForce®, d ~ 6 µm)
- a lithographically structured metal layer (material: chromium, d ~ 250 nm), and
- an insulating and wear-protective layer which at the same time has very good detachment properties with respect to the polymer melt (material: SiCON®, d ~ 3 µm).

In a plasma-assisted chemical vapour deposition process (PACVD) the surfaces to be treated are coated with the piezoresistive and tribologically resistant hydrocarbon coating DiaForce® in a thickness of 6 µm. The sensor coating has a hardness in the region of 24 GPa and a coefficient of friction with respect to steel in the region of 0.17.

A 1.5 µm thick electrical isolation coating consisting of a hydrocarbon layer modified with silicon and oxygen is deposited locally. In a physical vapour deposition (PVD) process a chromium layer 0.25 µm thick is applied to this isolation coating. This layer is then structured by using photolithographic and chemical wet etching technologies with a meander design which is used for temperature measurement. Secondly, it contains conductors which run from the circular electrode structures for force measurement right up to the electrical connection area. The sensor structures must be protected against wear, which is the reason for the deposition of a final 3 µm thick top coating consisting of a further hydrocarbon layer modified with silicon and oxygen.

Test of the sensor modules

The wear resistance of the sensorized thin film systems was investigated in the injection molding unit at the Sirris research institute in Belgium. Here polycarbonate (PC) and acrylonitrile butadiene styrene (ABS) were used as test polymers. In the tests the mold temperature was 60 °C while the melt temperature was 230 °C. The injection phase lasted in each case 1.8 s and a maximum pressure of 1000 bar was held for 3 s and was followed by a cooling phase of 25 s. Several thousand injection molding cycles were carried out with each plastic, after which the sensor surfaces were analyzed. Absolutely no traces of wear could be found.

During the further course of the project, the temperature and also the force curves of the sensor structures were recorded and compared with those of reference sensors, located extremely close to them beneath the surface of the mold.

The advantages

- Measurement of the force and temperature distribution in direct contact with the plastic melt at the surface of the mold
- Low adhesion of the plastic melt due to the used SiCON® film, thus the component can be removed easily from the mold
- Increased wear protection for the plastic injection mold surface

2 Sensor modules with different structure designs.

3 Sensor module integrated into the injection molding line at Sirris in Belgium.