

Combustion analysis via the spark plug bore

In close cooperation with Bosch and AVL, Piezocryst Advanced Sensorics has developed a novel spark plug series with integrated pressure measurement function for engine design and quality control. The partners have contributed their respective know-how to this cooperative venture (ignition from Bosch, application from AVL and sensor from Piezocryst). Special priority was given to the achievement of a high-quality pressure signal without the need for an additional bore in the engine. For this, completely new design approaches were pursued in order to solve the problems of extreme miniaturization.

For decades, the measurement of combustion chamber pressure has been regarded as the best means for the analysis and development of combustion processes. For relevant and precise measurements, the measuring equipment must not have any influence on the combustion. To achieve this, time-consuming and expensive indicating bores are needed in the engine, into which conventional combustion chamber pressure sensors are inserted. Another possible solution is measurement via the spark plug bore, but here there is the challenge of fitting an ignition function comparable with series spark plugs as well as a high-quality measurement function into a confined space. Sometimes even with M14 spark plugs compromises in both functions have been necessary up to now, for smaller types only solutions with restricted application have existed to date. Now, with the newly-developed spark plug generation it is possible to carry out highly-precise cylinder pressure measurements via the spark plug bore without influencing the mixture ignition.

The new spark plugs are available with M10 and M12 mounting thread as well as in various lengths with spark plug heat ratings of 07, 3, 5 and 7. The integrated pressure sensor has a sensitivity of 12 pC/bar and its thermodynamic behavior is comparable with good, conventionally-fitted sensors.

Longevity and service

From the very beginning, longevity, product quality and service-friendliness were given absolute priority. The sintered-in platinum electrode ensures outstanding stability as well as an extremely low deviation of the heat rating in mass production. Similarly, the platinum-sheathed earth electrodes (some with copper cores) were designed for long service life. In vehicle tests, distances of up to 30,000 km were covered without impairment of the ignition and pressure measurement functions. Thanks to the modular layout of the measuring spark plug, it is possible for the user to replace individual components where often in the past the complete replacement of a sensor was necessary. Thus the new product line contributes significantly to reducing the costs of combustion analysis.

Ignition function

In order to create sufficient space for the pressure measuring function, the ceramic insulator had to be greatly reduced in size in the vicinity of the spark plug shell. Thus the wall thickness of the ceramic part and the ignition pin cross-section are only 40% of the standard dimensions of M10 spark plugs.

As a result, the optimization of the insulator geometry in simulations and tests as well as the use of a particularly shock-resistant ceramic material ensured



Figure 1: Novel pressure measuring spark plugs. Easily recognizable by the round membrane in the immediate vicinity of the electrode.

the achievement of reliable operation in excess of 30 kV; in addition, the voltage requirement was reduced by approx. 30% compared with standard spark plugs thanks to the very thin electrodes. Thus, despite the severe geometric restrictions, it was possible to develop an insulator that ensured sustained ignition of the mixture even with supercharged engines.

Pressure measurement function

Miniaturization without loss of quality

was also the top priority for the integration of the pressure measurement function. Thus the membrane was integrated

laterally in the spark plug housing instead of at the front end in order to achieve sufficient membrane area for high sensitivities and good thermodynamic behavior. By taking advantage of the so-called longitudinal effect, the piezoelectric measuring elements arranged behind it could be of extremely flat design. Due to the high thermal loading, the measuring elements were made of particularly temperature-resistant gallium phosphate monocrystals. This material has already been used in other combustion chamber pressure sensors and thanks to its high sensitivity enables a good signal-to-noise ratio.

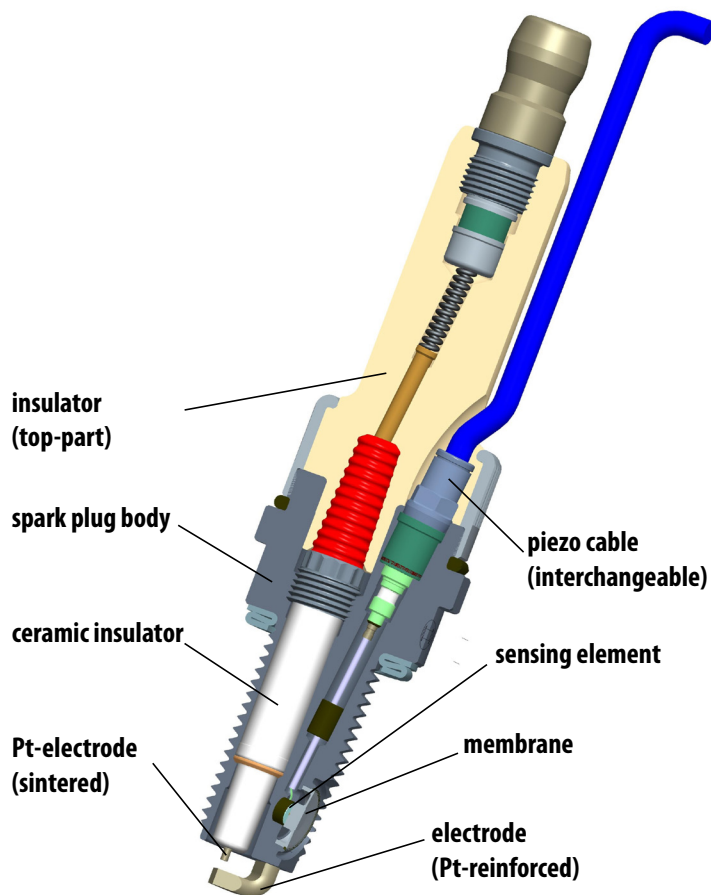


Figure 2: Schematic layout consisting of the insulator top, piezo cable and insulator modules together as well as the spark plug housing with integrated pressure measurement function.

Summary

The innovative measuring spark plugs set a new standard in engine development and quality control regarding signal quality, ignition function and reliability. They enable the implementation of fast, reliable and highly accurate cylinder pressure measurements without additional outlay.