

Pressure Measurement

Using Optical Technology for Measurement of Exhaust Gas Pressure



Smart in sensing

INTRODUCTION

WIKA Optical Sensing, in collaboration with the Department of Engineering Science, University of Oxford, tested a PT1100 sensor in the exhaust of an internal combustion engine. While the PT1100 sensor had accumulated a large amount of running hours on gas turbine engines, it had not been tested in an internal combustion engine where the pressure and temperature can change rapidly. Furthermore, the WIKA sensor performance was compared with a piezoresistive sensor, which is the standard sensor used in this location.

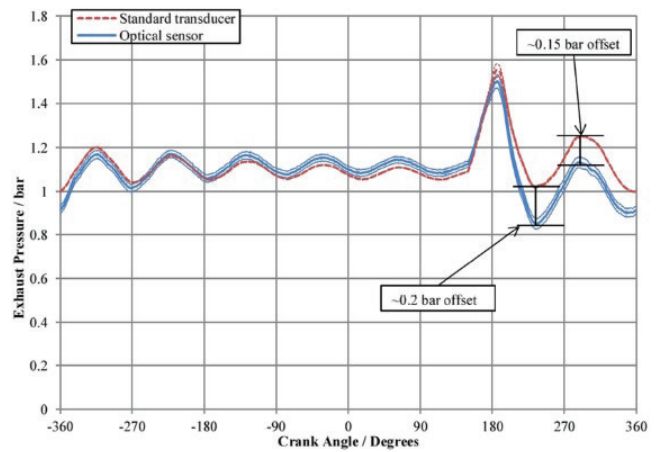
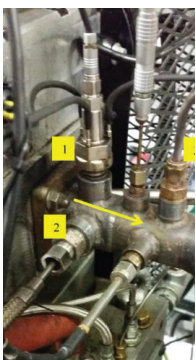


Figure 3 – Test Results (Test Point 1) Change in Static Pressure & Temperature

Background

The environment within the internal combustion engine exhaust is harsh – temperatures in this location can reach 1000°C. Piezoresistive sensors typically operate up to 140°C; therefore, to withstand temperatures in this location it is required that the sensor uses one of two methods to prevent overheating. The sensor may be positioned further from the exhaust, which results in a reduced dynamic response due to attenuation of the signal. Alternatively, the sensor is cooled which can be achieved through a cooling adaptor. The adaptors often experience reliability issues, which in turn cause damage to the sensor and incur further expense due to the additional equipment and subsequent replacements.

There is interest in WIKA sensors for this type of application – firstly, the simplicity of the WIKA system in comparison with piezoresistive sensors is attractive, which does not require specialized cooling mechanisms. Additionally, the WIKA sensor is designed for high temperature environments, with the front face of the sensor being able to withstand 1000°C.



Test

The WIKA PT1100 sensor and a piezoresistive sensor were installed on to a Jaguar Land Rover AJ200D “Ingenium” engine, approximately 2cm downstream from the start of the exhaust manifold – piezoresistive sensor (1), WIKA sensor (2). The engine was run under various test conditions to review sensor performance in different scenarios.

Test Results

The WIKA sensor correlated well with the piezoresistive sensor; the large peak corresponds to the opening of the exhaust valve. Noise present on the piezoresistive sensor does not occur on the WIKA sensor.

Furthermore, there were no detrimental effects on sensor operation from exhaust deposits. At the temperatures seen in this location, contamination build-up will flake off due to the polished nature of the sapphire surface and the mismatch of thermal expansion within the materials.

The difference in readings between the sensors at around 270 Crank Angle Degree (CAD) is believed to be related to a temperature transient at the front of the sensor.

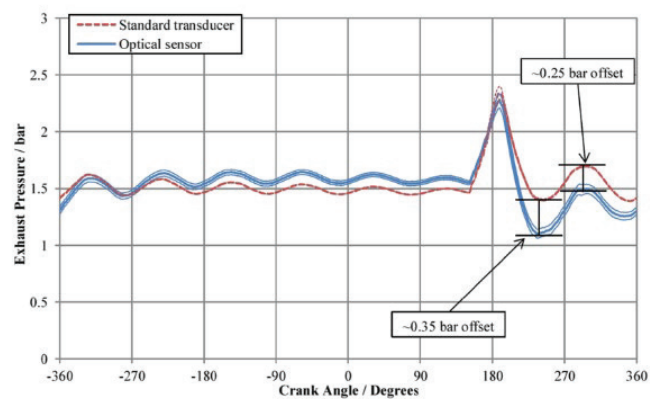


Figure 4 – Test Results (Test Point 2)

Next Steps

There is room for further development of the WIKA sensor in the exhaust location. Alternative shielding of the sensing element could be investigated to reduce the effect of temperature transients. Moreover, there is the possibility to extend the application to a multi-measurand sensor, which would be able to compensate for temperature.

Summary

Initial test results show that the WIKA sensor performance is comparable with the standard piezoresistive sensor. The ability to mount the sensor directly into the exhaust reduces Helmholtz ringing effects seen on the piezoresistive sensor; additionally, the requirement for no additional cooling mechanism is well suited to this type of application where access is limited.



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