



Putting engines through their paces

Measuring pressure in tough conditions

FPT Motorenforschung AG is based in the Swiss town of Arbon and develops engines destined for the vehicles and machinery of CNH Industrial's Powertrain segment. Some 220 staff work on site to create new FPT products for commercial vehicles, construction equipment and agricultural machinery and for use in industrial and marine applications. The engines are put through their paces on a total of 30 test benches. To measure their efficiency, FPT Motorenforschung uses tools such as the Series M5 pressure transmitters from KELLER AG – the Swiss specialist for pressure sensors.

« The engines that we develop and test in our factory meet the most stringent quality requirements in terms of materials, emissions and efficiency. This means that, when we examine the engines on our test benches, we have to consider all the variables that influence how well they work. So we need precise measuring equipment that delivers precise, reliable readings even in the specific conditions to be found inside the engine, which can sometimes vary considerably and be extremely tough. »

Rainer Linsenmeyer, Head of Test Engineering /
Electronic Measurement at FPT Motorenforschung AG

The M5 – a design that incorporates technical research requirements

FPT Motorenforschung's development work focuses primarily on reducing exhaust emissions and achieving a high power density, low fuel consumption, a long service life and maximum reliability. An engine's efficiency depends largely on the extent to which the flow of air into the combustion chamber and that of the exhaust gases back out again are unimpeded. The pressure here will be under 10 bar. The main priority is to get extremely accurate and highly dynamic measurements using absolute sensors. KELLER AG developed its M5 series



to meet these specific engine testing requirements and several of these devices are used at various places on the engine during tests. To obtain a reliable analysis of pressure conditions and losses, it is important to take measurements as close as possible to the individual cylinders on the inlet side. The varying geometry of the intake manifold poses an additional challenge as it means that each cylinder is supplied with a different amount of air, something that has to be avoided as much as possible. On the outlet side, too, the combustion gases in the individual cylinders can cause unwanted interactions between pressure surges or pulses. The pressure sensors measure these processes on the inlet and outlet sides locally and with a high level of phase fidelity.

When testing engines, it is important for the sensors not to be sensitive to structure-borne noise as the sounds and vibrations from the engine cannot be allowed to interfere with the measurements. The measuring slot should

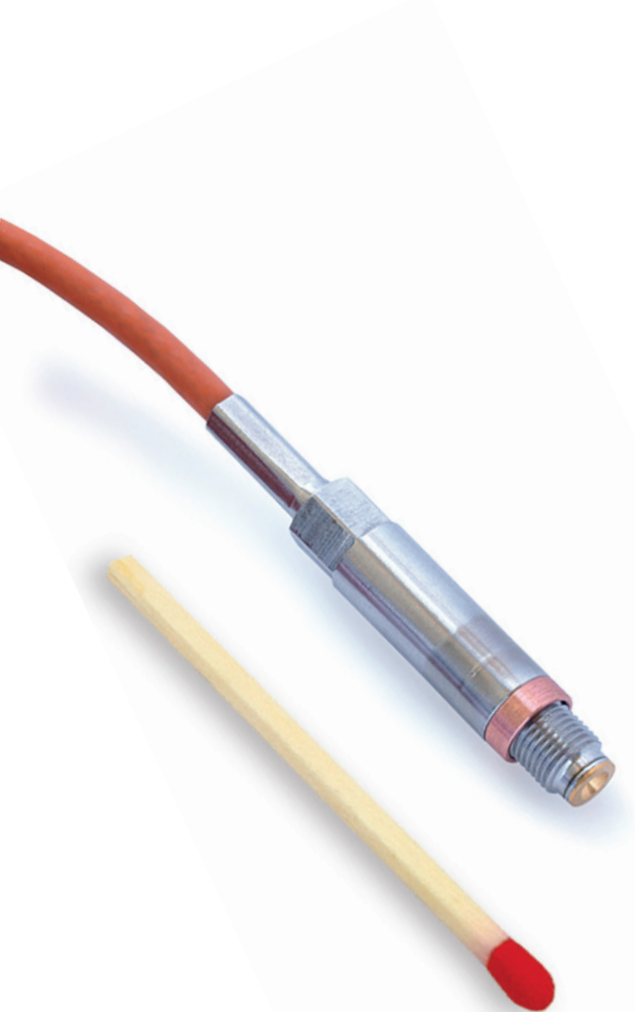
be sealable with a plug once measurements have been taken and should be as resistant as possible to air flows. This application can also lead to compensating currents of up to 40 A being generated by the engine battery – these must not be allowed to influence the sensor. These requirements were met in full when the M5 sensor was developed. Other characteristics of the pressure transmitter also give it an edge in this specific field of use:

no bonding wires are needed in the vicinity of the medium, while there are also no connectors between the sensor and the electronic system. This removes any additional contact resistances and sources of faults. The cable gland is hermetically sealed (IP67) to minimise external influences on the cable. Most of the electronic system is fitted externally, enabling it to be positioned in a noise-free area.

The M5 series – ultra-fast miniature pressure transducers

The pressure sensors in the M5 HB series deliver extremely fast and precise measurements to an accuracy of 0,1 %FS up to 180 °C. The pressure connection to the M5 fine thread is designed for both static and dynamic measurements such as pressure pulses. Their miniature size makes these sensors ideal for local measurements.

The sensor's main attributes are its very low dead volume and its good venting capability. It uses a rear-side technology without a transfer medium that also helps to minimise the attenuation of the measurement signal. No sealants, adhesives or capillaries are needed either.



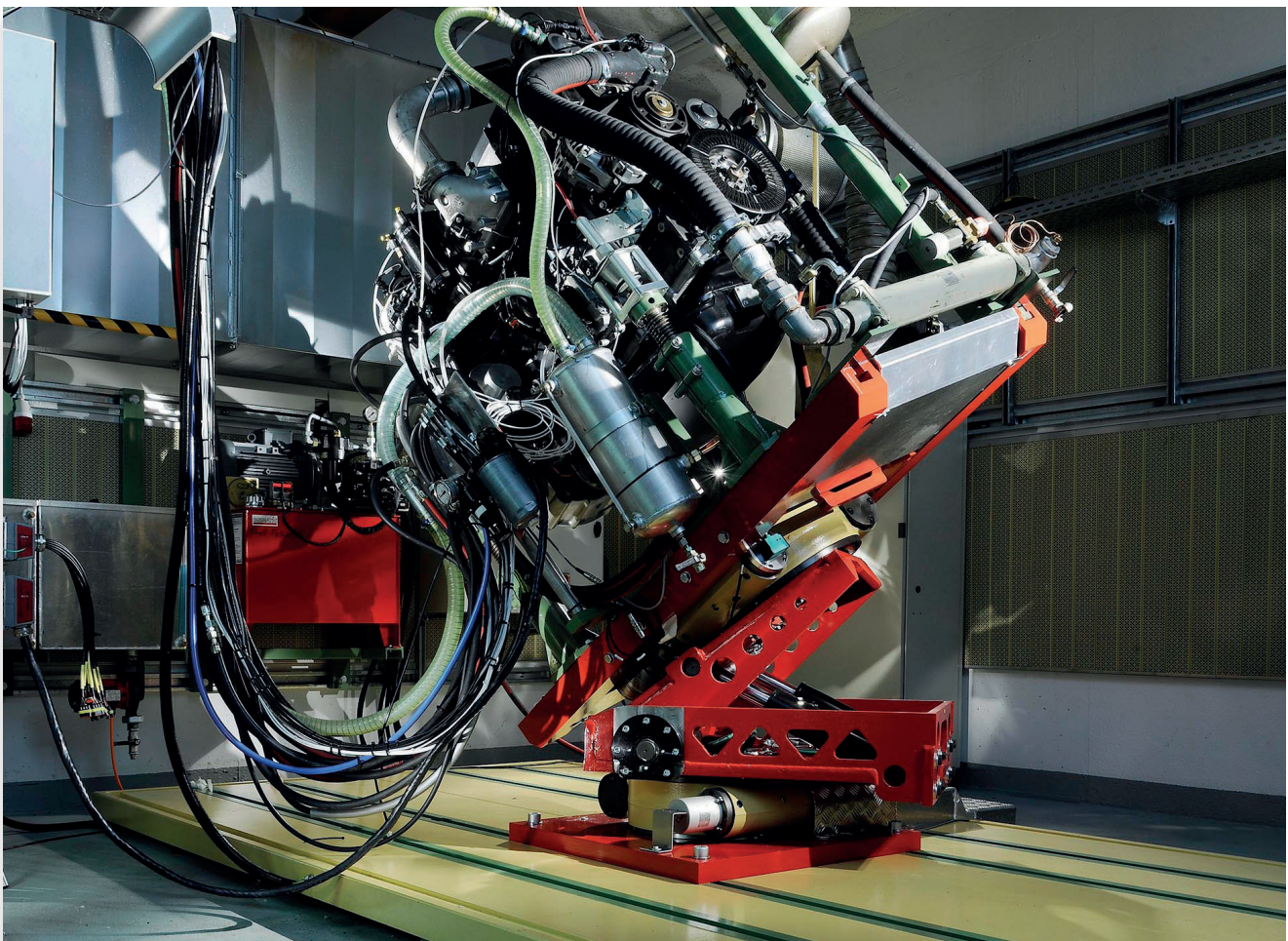
To prevent any unnecessary impact on flow conditions, the process connection should be as short as possible and, in terms of handling, able to be installed easily even in narrow tubes. The sensor is thus also very lightweight and able to withstand rapid acceleration.

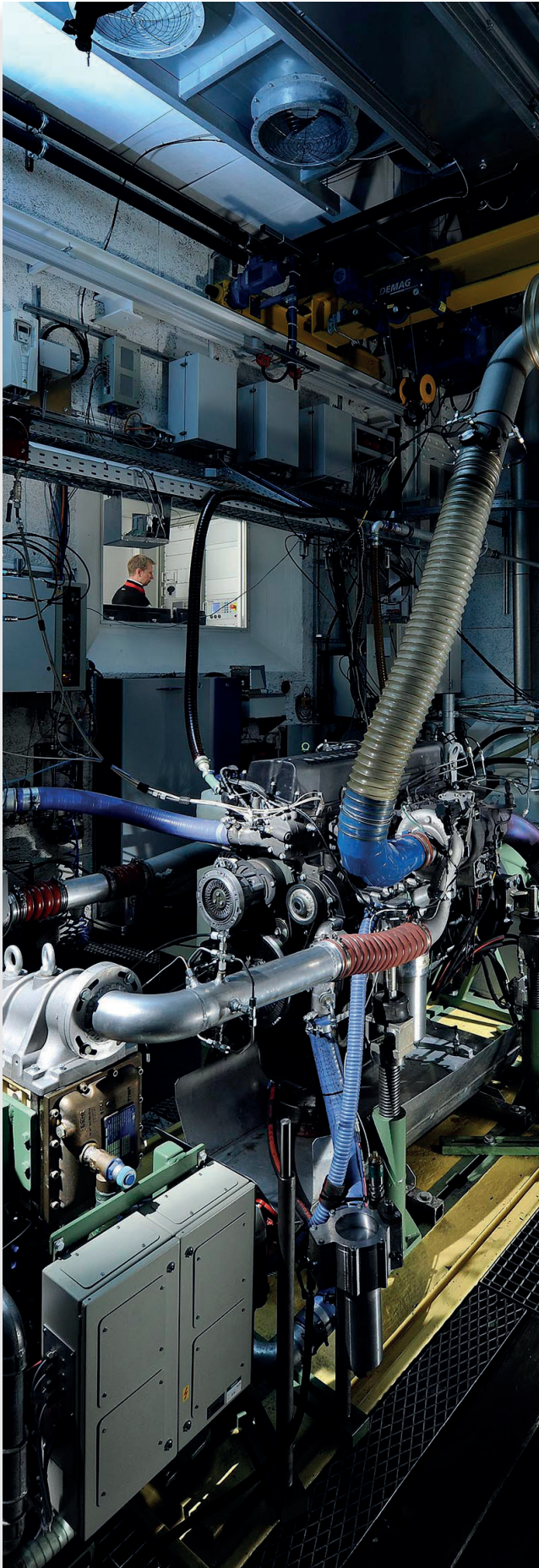
The M5 series is available with or without an electronic system. The KELLER AG team's top priority when developing its electronic system was signal fidelity up to the limit frequency of 50 kHz. The M5 HB pressure transmitters (i.e. with an electronic system) were optimised in line with FPT Motorenforschung AG's technical specifications and have been in use for over two years now.

A wide range of potential uses in engine research

FPT Motorenforschung uses M5 sensors with electronic systems on all of its engine test benches. The company takes measurements inside components such as oil, fuel and water pumps, injector lines, intercoolers, heat exchangers and intake and exhaust ducts. Logging the pressure conditions enables any fluctuations, peaks or other generally unusual pressure phenomena to be detected. The engineers can then use these values as a basis for reworking the design, further optimising the components and parameters of the ECU (the control unit).

The data obtained makes it easier to extrapolate the dynamic conditions inside the engines. For instance, a pressure loss of 1 Pa at a volume flow of 1 m³/s – typical values for the intake air volumes of large HGV engines – translates into 1 W of lost performance. In practice, this





means that a 50 mbar fall in pressure results in a flow loss of as much as 5 kW. Consequently, this value must be kept as low as possible to make the engine more efficient.

M5 sensors can also be used in the return pipes in injectors. Because of how they are designed, injectors generate a return flow through leaking and cooling. The pressure conditions in these pipes are also measured and optimised, with the pressure range being from 1 to 5 bar. Oil pressure is a further critical factor in engine efficiency. Whereas it is usually too low in engines running at low speeds, it tends to be too high at high speeds.

« As far as measuring oil pressure was concerned, it was particularly important to find a sensor that was small enough. This is because smaller sensors have less of an impact on the actual flow conditions. Also, there is often very little space to install them with this kind of application, meaning that a standard sensor was never going to be an option. The M5 sensor ticks all the boxes. One particular benefit is the fact that, after testing is complete, the openings for the sensors can be sealed using a simple M5 plug almost as if nothing had changed. This means that any modifications to the system won't distort the results of other tests. We're delighted that, in the M5 sensor, we've found a reliable measuring instrument that can be put to a wide range of uses on our test benches. We've enjoyed an extremely constructive partnership with KELLER AG for many years now. As well as offering good value for money, they are a reliable and expert port of call if we have any technical problems. With KELLER's production based in Switzerland, their quality is as you would expect and we never have to wait long for deliveries. »

Rainer Linsenmeyer, Head of Test Engineering /
Electronic Measurement at FPT Motorenforschung AG





FPT Motorenforschung AG is one of the seven research and development centres of FPT Industrial, the brand of CNH Industrial group dedicated to the design, production and sale of powertrains. FPT Motorenforschung AG is involved in the most important and pioneering projects of CNH Industrial's powertrain segment, with a focus on further improving already existing and developing fundamentally new technologies. FPT Motorenforschung has been designing and manufacturing engines to the highest quality standards in Arbon since 1982. As well as engines, the company also develops its own testing technology. When choosing a solution for its pressure measurements, FPT was looking for short delivery channels and good service alongside high product quality and compliance with technical specifications. The company had already enjoyed many years of positive experiences with KELLER AG and had found a partner whose products, like FPT's, were also made in Switzerland: "We've been using KELLER's X series for our static and dynamic measurements for a few years now. Our successful partnership reflects the benefits of having a user and developer on each other's doorstep and the high degree of reliability that the experts and KELLER's products both share," says Linsenmeyer.

KELLER AG has over 40 years' experience in producing piezoresistive measurement technology and has been developing customised pressure sensors for all manner of different applications ever since it was founded. A further bonus is the company's great flexibility, which enables requests from customers to be met accordingly. "Having a close working relationship with our customers is very important to us. They provide us with some productive suggestions for improvements and some valuable experience from actually seeing the applications in use. Of course, it's particularly nice if they're based nearby like FPT Motorenforschung. It means that our experts can see the situation for themselves up close and get involved themselves if there are any technical problems," explains Bernhard Vetterli, Head of Development at KELLER AG für Druckmesstechnik.

