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1 *Marine vessel engine*
2 *On-line monitoring hardware*

MULTIPARAMETER OIL ON-LINE MONITORING SYSTEM

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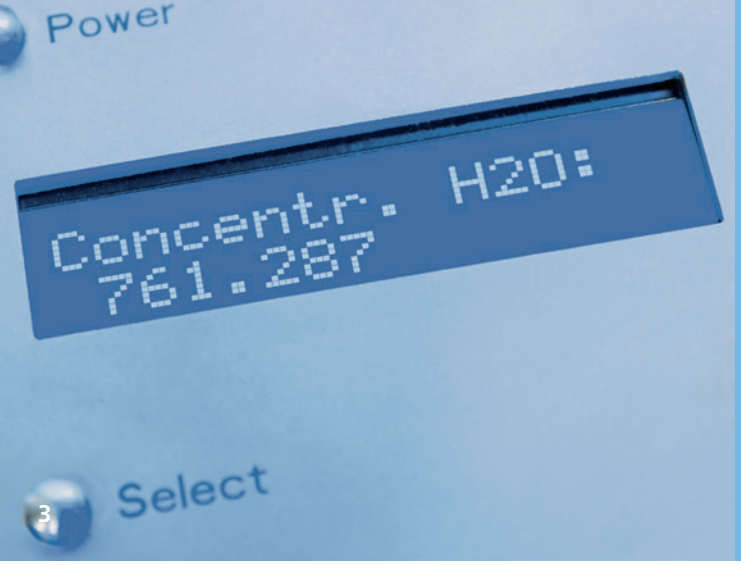
Fraunhofer IMM developed a measuring device for on-line monitoring of lubrication oils in engines, gears and hydraulic systems. Lubrication oils play an important role for a large number of applications and its proper condition often is essential for reliable operation. Complementary to spot measurements that are regularly performed in specialized laboratories for oil analysis, on-line monitoring serves for several additional benefits:

- On-site information available
- In time information available
- Trend analysis possible

Parameter	Specifications
Quantity/Accuracy	■ Water content: 100-5000 +/-100 ppm ■ Oxidation: 0-1 +/- 0.05 A/cm ■ TBN: 0-20 +/- 1 mg KOH/g
Dimensions (HxWxL) [mm]	107x150x88
Weight [kg]	1.8
Fluidic connection	Swagelok push-on connector SS-PB6-TA6, on both sides of sensor housing, flow direction freely selectable
Control	Operation via external PC (calibration, data storage) or internal display (no data storage), calibration by user possible
Accessories	■ Power supply ErP 7.5V, 2.67A, cable length: 1.2 m ■ USB-cable, length: 2 m ■ USB-stick with software MULTIcheck, version: 1.0 ■ Manual, version 2.0

Table 1: Sensor specifications



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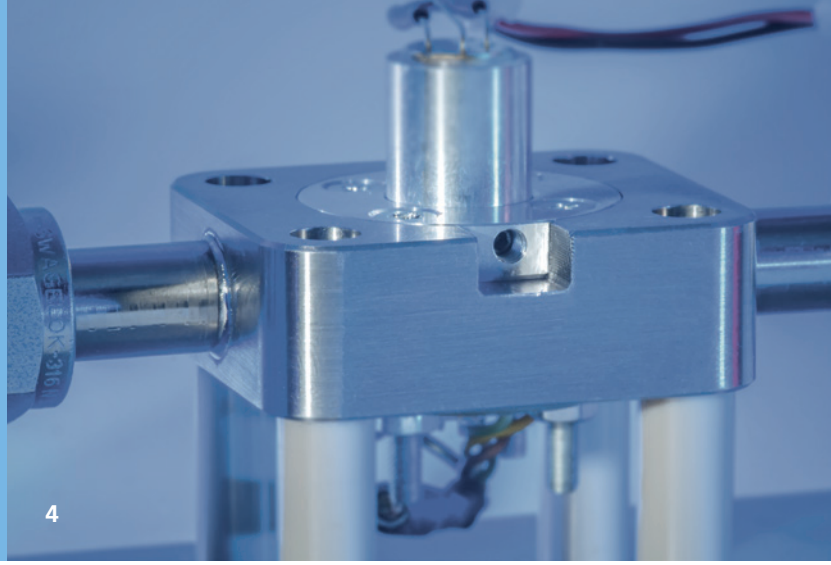

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The measuring system is based on non-dispersive mid infrared (MIR) absorption spectroscopy. For that, specific bands in the MIR, correlated with molecular vibrations representing a finger-print-like property, are selected by a band pass filter. The absorption of MIR-radiation at that specific wavelength in a medium of thickness d follows the law of Lambert-Beer. The intensity of the transmitted radiation $I(\lambda,d)$, relative to the incoming intensity $I_0(\lambda)$ is the characteristic measure and is correlated to the concentration of a contaminant or a quality parameter in the oil to be monitored. This method is well known from gas measuring technique and is called non-dispersive, since no dispersive optical elements like e.g. gratings are required for splitting up the single wavelengths. Using a non-dispersive technology, allows for making the sensor very cost efficient and compact.

Application fields

A major application of the multi-parameter on-line sensor is the determination of the water content in lubrication oils, especially in combustion engines. The sensor measured data usually shows a good correlation to the laboratory measured data, using FTIR-spectroscopy (Fig. 1).
A further important measure for quality evaluation of lubrication oils is the degree of oxidation, correlated with wear. The oxidation of oils is assigned to the formation of carbonyl-bindings (C=O), which can be monitored in the MIR very well. There is often a strong correlation between oxidation and total acid number (TAN). In this way MIR-spectroscopy allows to address also parameters that principally are not infrared-active.

Especially for two-stroke and four-stroke engines in marine vessels, the determination of the total base number (TBN) is important, since the TBN value is a measure for the alkali content of the corresponding lubrication oils, that is adjusted by additives in the oil. The TBN value is a measure of the ability to neutralize acids that are generated during combustion in the engines. For control of the TBN value MIR spectroscopy offers a good alternative to titration methods, by correlating sulphate (TBN < 20mg KOH/g) and carbonate bands (TBN < 40mg KOH/g) in the fingerprint region of the MIR spectrum with the actual TBN value, for on-line monitoring. Particularly, also small concentrations of the TBN value of < 2mg KOH/g can be addressed by this method.

3 *Integrated display*
4 *Flow through cell*

Technical specifications

The sensor specifications are given in table 1. The sensor performs a simultaneous 4-parameter detection in-line or at-line non-dispersively (no gratings and moving parts required). The sensor is simple, compact and has a robust construction, built up with cost effective components. User specified selection of parameters is possible, if they can be addressed in the MIR spectrum, also with wireless communication for data transmission and diagnosis.

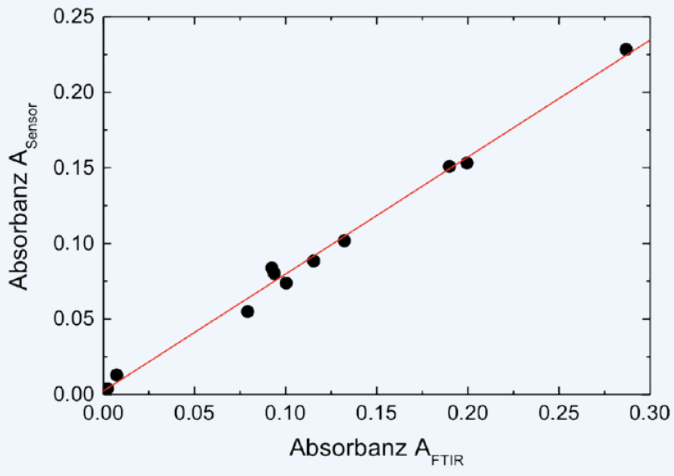

Fig. 1: Sensor measured absorbance compared to laboratory FTIR measured values.