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REMOTE SENSING OF LIQUID LEVELS INSIDE AUTOMOTIVE FLUID-TANKS THROUGH OPTICAL PROCESSES

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ABSTRACT

We report the development of an optical sensor system that can be placed ex-situ of fluid-tanks to monitor the level of fluids through level gauge displays. The sensor system is designed for remote monitoring of operational status of industrial heavy equipment through a low-footprint internet of things (IoT) approach without involving extensive mechanical or electrical overhauling for sensor deployment.

Sequential and non-sequential ray tracing simulation over visible and infrared spectrum were conducted for optical beam propagation through air-fluid, air-glass, and glass-fluid interfaces. Reflection, refraction, and dispersion of light through sight glass materials, fluids, and level indicator backgrounds over visible and infrared spectrum were studied. Effects of optical beam divergence on the sensitivity of the detection system were studied for sourcing of suitable optical emitters and detectors. Experiments were conducted on several types of fluids (e.g., coolant, engine oil, transmission oil) that are typically used in internal combustion engine systems. The fluid reflectance and transmittance over a broader spectral range were measured through an optical spectrometer. Calculated refractive index parameters were used in ray tracing simulation to design the optical path and the wavelength of operation that are specific to fluids and the fluid tank configurations.

Changes in optical propagation in presence or absence of fluid inside the level gauge at the point of interest are monitored by a photodetector of the sensor system. Angle of light incidence, beam divergence angle, location of detector, and detector responsivity were optimized for the types of fluids and the fluid-tank sight glass configurations. The analog output from the photodetector is digitized with electronic circuitry to represent the level of fluids inside fluid-tanks with reference to their safe recommended levels during machine operations. The digitized signal is read through a microcontroller and transmitted to a central hub where multiple fluid level sensors of an industrial system can be monitored remotely through a custom designed user interface. Our low-footprint non-invasive approach of fluid level monitoring allows their deployment on industry installations with minimum interruption of services and without needs of major overhauling.