Ultrasonic Helical Sensor for Monitoring Fuel Adulteration and Concentration

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1. INTRODUCTION & OBJECTIVE

This paper presents a novel approach for monitoring fuel adulteration or concentration using an ultrasonic helical waveguide sensor. The longitudinal L(0,1), torsional T(0,1), and flexural F(1,1) wave modes were transmitted and received simultaneously through a stainless steel (SS308) helical waveguide. Here, we used a shear wave transducer with a 45-degree orientation of the waveguide axis, following the pulse-echo concept. We conducted experiments by preparing various fluid samples and altering the blend percentage mixture from 5% to 50%. The combinations included (a) a blend of kerosene and diesel, (b) a blend of kerosene and petrol, (c) a blend of ethanol and diesel, and (d) a blend of ethanol and petrol. Air pollution has emerged as a significant global issue due to the escalating number of automobiles. The contamination of gasoline and diesel fuel further intensifies the problem. Finding fuel quality at the distribution point is critical to prevent fuel adulterations effectively. Monitoring fuel adulteration involves measuring attenuations in the ultrasonic helical waveguide sensor's reflected signal and the velocity of waves. This sensor technique can also detect the $\leq$ 4% adulterations of fuel by re-configuring the helical sensor. Also, the measurement error from the different test samples was discussed based on experimental results. The implementation of this simple technique has the potential to detect fuel adulterations in many petrol bunks/distributor points and manufacturing plants. That helps to reduce air pollution levels effectively, significantly enhance the life span of human beings, and increase the performance of automobile engines or fuel-based vehicles.

Keywords: Ultrasonic, waveguide sensor, helical, detection, fuel adulterations

2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

The estimation of fuel adulterations was conducted by analyzing the behavior of ultrasonic wave propagation in a helical waveguide. The fluid sample consisted of different concentrations of several combinations, namely: (a) petrol and ethanol, (b) petrol and kerosene, (c) diesel and ethanol, and (d) diesel and kerosene. The prepared sample exhibits a variation in fuel concentration, ranging from 5% to 50%, by blending the main fuel with the adulterant fuel by mass. Similarly, we combined the diverse amounts of diesel fuel with varying concentrations of ethanol and kerosene. We conducted the experimental investigation using a 20 ml volume of the produced sample and a waveguide immersion level of 2 mm. We chose the mean coil diameter of the helical sensor to be greater than twice the wavelength (2λ), as stated in a previous study, to mitigate the impact of dispersion effects. Fig. 1(a) illustrates the schematic diagram of the experimental setup and the instruments used. We inserted the waveguide sensor into the glass test tube's test sample (fuel mixtures). This investigation employed a single shear transducer to produce all three wave modes, with a 45-degree alignment between the waveguide axis and the transducer. In this scenario, the helical waveguide facilitates simultaneous transmission and reception of three modes, namely L(0,1), T(0,1), and F(1,1), based on pulse-echo techniques. The obtained A-scan signals of all three wave modes from the air medium are depicted in Fig. 1(b). In the early work, we reported that F(1,1) modes pose better sensitivity as compared to L(0,1) and T(0,1) modes. Therefore, we have chosen F(1,1) mode to monitor the adulteration of petrol and diesel. We identified fuel adulterations by assessing the ultrasonic wave velocity and attenuations of the sensor's received signal from the fuel test sample. In addition, the signals obtained from each test sample were analyzed by comparing them to various concentrations of the identical test sample, considering the signal's amplitude (attenuation).

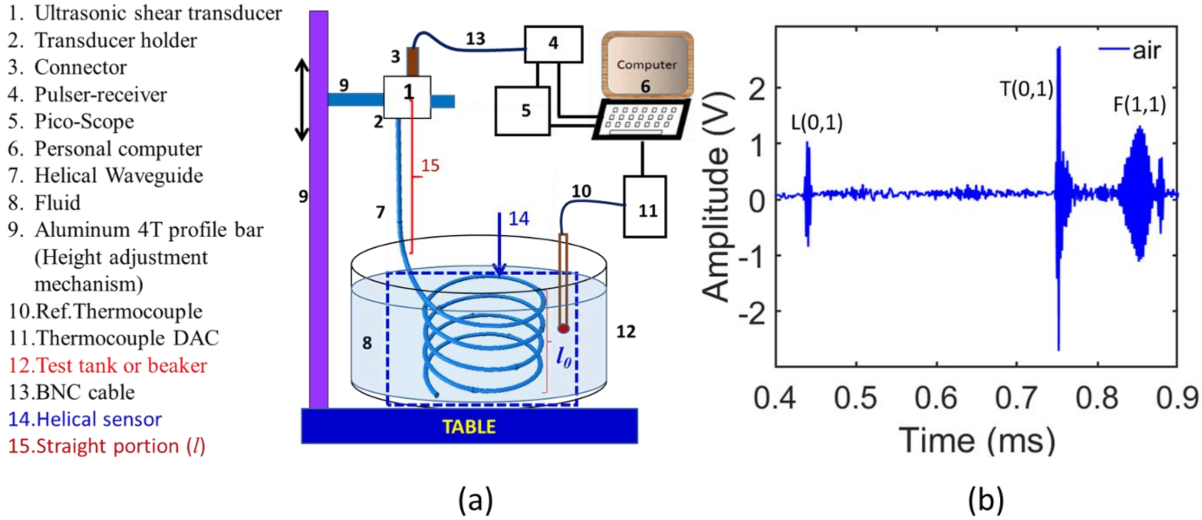

Fig. 1(a) Schematic diagram of the experimental setup and used instrument, (b) Acquired A-scan signal from air medium.

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