International Journal of Automotive Technology, Vol. 21, No. 1, pp. 1−11 (2020)
DOI 10.1007/s12239−020−0001−3

pISSN 1229−9138/ eISSN 1976−3832

ULTRASONIC-ASSISTED MEASUREMENT AND EFFECT OF NATURAL METHANE GAS

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(Received 4 March 2019; Revised 23 April 2019; Accepted 25 April 2019)

ABSTRACT−This work is an experimental research to investigate the gas fuel (CH_4) characteristics necessary for natural gas vehicles based on ultrasonic-assisted measurement using two different ultrasonic sensors. This paper offers the technical methods including energy transfer process, ultrasonic propagation, sensitivity, amplitude signal, and relationship of CH_4 density and ultrasonic signal. The experiment is composed of a constant volume chamber (CVC), two different sensors (AUS and HSUS), and gas fuel (methane). The experimental conditions are set by 1 ~ 4 bar of initial pressure, 7 Hz of pulse rate, 53.7 kHz of resonant frequency, and 0.45 ~ 0.85 m of measurement distance in natural gas space. As a result, HSUS is measured by 0.92 V of the height, 4 cm of main width, 12.7 cm of full width, and 42.8º of slope angle. The important thing is to highly increase the height and slope angle of HSUS model comparing with AUS model. Consequently, this experiment is shown that ultrasonic signal is gradually diminished as distances increases, the amplitude is improved as initial pressure increases, and ultrasonic sensor capable of transferring longitudinal wave is significantly affected by distance difference in CH_4 gas space.

KEY WORDS : Natural gas vehicle (NGV), Air ultrasonic sensor (AUS), High sensitivity ultrasonic sensor (HSUS), Vehicle storage tank, Constant volume chamber (CVC), Gas measurement, Matching layer

1. INTRODUCTION

Ultrasound transducer using the longitudinal wave is one of the most important sensors to analyze and measure the object such as distance, flow, density, and many applications. In the past five decades, the ultrasonic sensor has been used to measure the targeted objects including liquid, solid, plastic, epoxy, and gas (Setiabudi *et al*., 2018). The measurement using an ultrasonic sensor is significantly utilized to transfer the acoustic energy via a matching layer in liquid and solid areas. With regards to energy transfer of ultrasonic wave, the efficiency is remarkably higher in high-density than low-density of all of the materials (Fomenko *et al*., 2018). Because the particle constituents in an object are increased by a compressive force, the transmission energy loss is reduced. Moreover, the effect of energy transfer is increased due to high-density accumulated by a compressive force (Werner, 2018). The necessity of ultrasonic measurement is because of combining a lot of control technologies along with machine parts. In order to measure the natural gas including the main methane (CH_4), the structure of ultrasonic sensor needs to improve the matching layer (Larsson *et al*., 2015), case design, epoxy, and stress-strain characteristics due to requiring a safety (Fang *et al*., 2016). The conventional method of ultrasonic measurement is a distance (Arfi *et al*., 2016), level (He *et al*., 2014), density (Metwally *et al*., 2016), sensing, flow, reflection (Zakaria *et al*., 2017), and fault detection and it is included all of measuring types to use the applications.

Nowadays, in natural gas industry, the ultrasonic technology is applied to measure the pure gas events in order to obtain the internal gas characteristics (Kim *et al*., 2019). Ultrasonic measurement is known for a promising technology in many research areas. With regards to the vehicle storage tanks capable of storing the natural gas (CH_4), the gas fuel level is using a pressure sensor technology (Bates *et al*., 2014). The gas fuel scale measured by a pressure sensor is regarded as the gas fuel quantity through the equation, i.e., 4 ~ 20 mA, 1 ~ 5 V, RS-232, and RS-485 (Zhang and Tan, 2012). However, it is not accurate to measure the pure gas fuel and the error rate of gas fuel level is higher. To put it another way, the pure gas fuel inside CVC is significantly affected by ambient temperature and the fuel level can be raised by high-temperature fuel level due to expanding the volume expansion. Moreover. In low-temperature, it changes to have a relation of inverse proportion in comparison to the high-temperature. In order to accurately measure the gas fuel level, quantity, and so on, ultrasonic gas fuel measurement technology using a piezoelectric ceramic (PZT) has continuously conducted to study the insertion methods in many research groups including USA, UK,

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