Low Cost Sensing Device for Fuel Detection in Ships

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***Abstract*—In the present work the development of a new, low-cost, sensing device for remote, online detection of the type and quality of fuels used in ships, is presented. In specific, the main concept of this device is the on-line measurement of fuel density that is used by the ship (bunker diesel or fuels). Since the density of diesel is within the range from 0.890 gr/cm^3 up to 0.930 gr/cm^3, whereas fuel oil presents density values from 0.955 gr/cm^3 up to 1.005 gr/cm^3, the use of sensors and the suitable electronic platform, are essential. The experimental measurements have shown that this sensing device can detect the density with very high accuracy, providing with the possibility to detect the fuel type and to estimate the amount of sulfur (S), since for a given fuel the density increases linearly with the amount of sulfur.**

Keywords—Sensing Devices; Ship Fuel Detection.

I. INTRODUCTION

Ships can use two different type of fuels: diesel or fuel oil. Due to the fact that the first one causes lower environmental pollution compared to the second one, ships are obliged to use diesel when they are near coasts (usually less than 50-100 miles depending on national legislation); otherwise they can use fuel oil since it has extremely lower price than that of diesel. It is obvious, that the management of shipping companies want to know in real time the type of fuel that their ships use [1], [2] in conjunction with the coordinates of the ship.

The continuous breakthroughs in technology and the availability of cheap microprocessors, have increased interest in sensor mechanisms or acquiring measurement platforms and in specific for digital devices that are suitable for connection to computer systems. Today, there are plenty integrated systems for online fuel detection in ships, however their cost varies from 10000€ up to 26000€ [2].

In order to contribute to the direction of designing and developing a low-cost fuel detection system, the present work was carried out. It focused on developing a sensing device that could not only detect online the type of fuels in ships, but it could monitor the quality of the fuels, as well. The result of this work is presented in the following section and it is based on extracting information on the quality of the fuel (sulfur incorporations), by measuring its density.

II. THE SENSOR DEVICE

In order to develop a low-cost sensing system able to detect online the type and quality of fuels used in ships, the physical properties of diesel and fuel oil, were exploited. It was found that the most suitable property is the fuel's density. In the case of diesel, the density is 0.890 gr/cm^3 and increases linearly with the increase of the concentration of sulfur from 1.50% to 4.5%, whereas the respective values for fuel oil are 0.955 gr/cm^3 up to 1.005 gr/cm^3 [4]. Consequently, by monitoring the fuel's density (only one kind of measurement), we could detect the type of the fuel and monitor its quality, at the same time.

Although manual density sampling and measurement in the case of liquids is a very simple process, the requirement of online measurement, bears a remarkable amount of difficulties. The measuring system was constructed around a sensing device, which is presented in Fig.1, and it is in parallel with the pipeline of fuels. This sensing device uses a distance sensor in order to measure the height, from top to the bottom of the illustrated densitometer. Its value corresponds to a defined density according to the following relation [5]:

$$h = \frac{B}{S\rho_o g} \qquad (1)$$

where B is the weight of the densitometer, S the average surface of the submerged in the fuel part of the densitometer, ρ_o the fuel density and g the gravity acceleration.

This system, also uses thermocouples (it could be any kind of thermometer) in order to measure fuel's temperature, since its density is a function of its temperature, and it must be

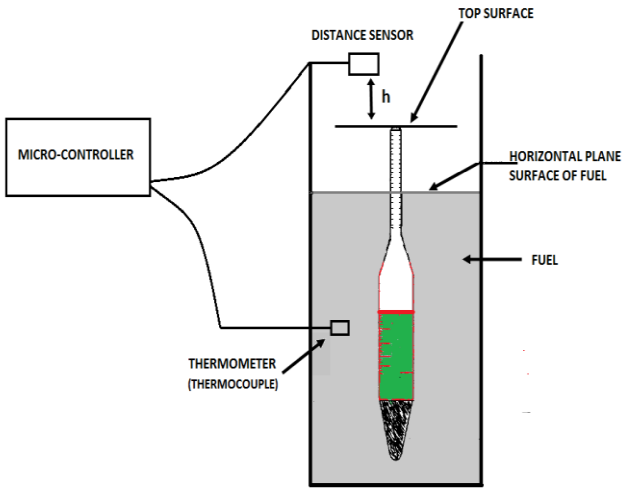

Fig. 1. The sensing device

considered in all calculations, especially in the case of significant temperature variations. According to equation (1), in the case of diesel which demonstrates a lower value of density, *h* is higher compared to that of fuel oil, where *h* gets lower values. It is noted that the distance sensor is an optical sensor, while it could also be an ultrasound one. It is connected to a "collecting" microcontroller, and the measurement data are transmitted wirelessly to *Laros Networks*, which is a new innovative, reliable and low-cost platform for data acquisition and evaluation. This platform provides online complete diagnosis, prognosis and early warnings of the ship's status to the administration headquarters.

Taking into account (1) the sensor device is calibrated, in order to read the type and the quality of fuels, in a remote computer far away from the ship. The experimental results have shown that this sensing device detects the type of the fuel with high accuracy. Also it was found that the estimation of concentration of sulfur (S) was very close to the real values; thus resulting with a sensing device able to detect the type and the quality of the fuel, with one kind of measurement.

Since the whole system was constructed by extremely low cost materials and components, the total cost was limited by the connection to the Laros wireless network. In any case it was significantly lower (at least one order of magnitude) than that of the other systems available in the international market.

III. Conclusions

In this brief, a new, low-cost sensing device-system was designed and developed. This system was able to detect on-line the type of the fuel used in a ship, as well as, its concentration in sulfur. This device was constructed, based on the idea that the density of diesel is within the range from 0.890 gr/cm^3 up to 0.930 gr/cm^3, whereas fuel oil presents density values from 0.955 gr/cm^3 up to 1.005 gr/cm^3 and for the given type of fuel the variation is due to sulfur concentration. The whole device is connected to *Laros wireless network*, which is a platform suitable for transmitting the ship's fuel-status, in real-time, to the administration headquarters.

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