

Acquisition system for improving energy efficiency in trawler vessels

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Abstract- A remote data measurement and acquisition system has been developed to study the energy consumption of fishing trawler vessels, with the purpose to improve their efficiency. The system consists on a sensor network distributed along the vessel to monitor fuel consumption, navigation and fishing parameters. The data is acquired and stored by an embedded and robust system, which deals with the different protocols and interfaces of the sensors. The collected data is compressed and packaged in order to be sent via a GPRS modem to a land station, where data is analyzed and processed to study techniques, equipments and materials to improve the energy efficiency.

I. Introduction

Nowadays, fishing is an economical, social and environmental sensitive sector. The main cost of the industry is related to fuel consumption: in Catalonia, Spain, more than 50% of the fishing sales incomes are used for paying the fuel bill. Currently, this local fishing industry consumes about 78,000,000 liters of fuel per year. The continuous increase in fuel prices, in addition with the sales method, decreases the performance of the sector, which needs to improve or modify their fishing methods to reduce fuel consumption.

Trawler vessels usually have very sophisticate navigation and echo sounders equipments to locate fish shoals; the costs of these systems are justified because they help to maximize the fishing, but so far, there are no equipments for controlling a large set of parameters related with the fuel consumption, which finally determines the performance of the fishing.

The main factor that affects the increase of fuel consumption on trawlers can be: the net size and its configuration (which affects trawlers load); the navigation speed and the travel direction in relation with the sea and the wind currents; the type and size of the ship's bulb; the characteristics of the propellers; the engine maintenance, etc. The fishing industry in Catalonia is very interested in understanding how these multiple variables interact with the fuel consumption, with the final purpose to make the appropriate changes in their vessels (navigation, materials, and maintenance) in the right time, to improve the fishing and energy efficiency.

There are different studies that consider vessel's fuel consumption, as is the case of [1], where models of diverse trawler vessels have been tested in laboratory to investigate different propulsion systems, being the main efforts focused on the propulsion and maneuverability, considering the economical advantages. On [2], the energetic efficiency of the rudder is considered, from the point of view of its interaction with the water flow leaving the propeller. There are also solutions, as in [3], where the use of flow meters can assist to reduce fuel consumption by controlling the vessel's speed; and also exists systems to save fuel like magnetic polarizer filters, which are located on fuel pipes before the engine.

Nevertheless, to be able to evaluate systematically and effectively new materials and configurations, the fishing and navigation techniques, and other fishing equipments, it is necessary to follow the evolution of many different variables (fuel consumption, temperatures, position, navigation, net load, etc.) on different scenarios under real conditions. Thus, it is also necessary to have an integral acquisition measurement system which allows a remote monitoring of the trawlers (from a central control base, which is a land station). With the collected information, the central control base can decide which parameters need to be changed (and communicate with the fishing vessel if necessary), or it can test and follow the evolution of different fishing and navigation conditions to detect the better ones. The system has been installed on five trawlers and it is currently being used to monitor these vessels under real conditions.

This work describes a remote acquisition system for measuring and collecting accurate data (navigation, fuel consumption, and fishing parameters) on the Catalonia fishing trawler vessels, on real working conditions. With the collected information and data, different test and analysis have been performed to improve the energy consumption, to study the influence of different navigation and fishing techniques and new materials. In addition, this tool will also help to reduce the environmental impact of this industry, as the consumed fuel is decreased.

The next sections describe the characteristics of the system, as are the sensors and their network, the acquisition system, and the data transmission and reception for the remote monitoring. Last section shows operational results and the conclusions.

II. System Description

To study the energy performance of trawler vessels, a system that measures and stores the different parameters that are involved directly or indirectly with the consumption of the vessel is required. Table 1 shows the selected variables for monitoring different vessel characteristics, divided in three categories: vessel fuel consumption, navigation, and fishing parameters. Also, for each type of sensor, it is shown the type of the output (digital or analog) and the communication protocol for digital ones.

Since the parameters to be measured are inherently located in different parts of the ship, a sensor network was designed to reduce the installation complexity and wiring [4], thus some sensors have digital interfaces. The common interfaces used in ships are NMEA2000 and NMEA0183, but other digital interfaces like RS485 are also suitable to reduce the wiring installation.

The system consist on a sensor network, as shown in Fig. 1, that connects all the transducers with the acquisition system, which meets the hard working conditions requirements that persist inside ships. The system is modular and easy to program, and it manages the different signals and protocols of the sensors used.

The acquisition system stores and sends all the collected data to a centralized land station, where data is reviewed and analyzed by researchers, who study and determine the adequate techniques, materials and equipments that can help to reduce the fuel consumption.

Sensor	Parameters	Interfaces
#1	GPS Latitude, Longitude	WeatherStation - NMEA0183 (Bus #1)
	Heading	
	Speed over ground	
	Barometric pressure	
	Air temperature	
	Wind direction and speed	
#2	Pitch/Roll	WaterSpeed sensor - NMEA0183 (Bus #2)
#3	Speed over water	RS485 - address 1 (Bus #3)
#4	Current battery	RS485 - address 2 (Bus #3)
#5	Rpm hydraulic	RS485 - address 3 (Bus #3)
#6	Rpm engine	RS485 - address 4 (Bus #3)
#7	Fuel consumption	RS485 - address 5 (Bus #3)
#8	Load cell #1	RS485 Modbus - address 1 (Bus #4)
#9	Load cell #2	Analog output 4-20mA
#10	Exhaust temperature	Analog output 4-20mA
#11	Exhaust pressure	Analog output 4-20mA
#12	Hydraulic pressure	Analog output 4-20mA
#13	Engine room Temperature	Analog output 4-20mA
#14	Oxigen concentration	Analog output 4-20mA
#15	Engine temperature	Analog output 4-20mA
	Engine room pressure	Analog output 4-20mA

Table 1 Sensors and interfaces used

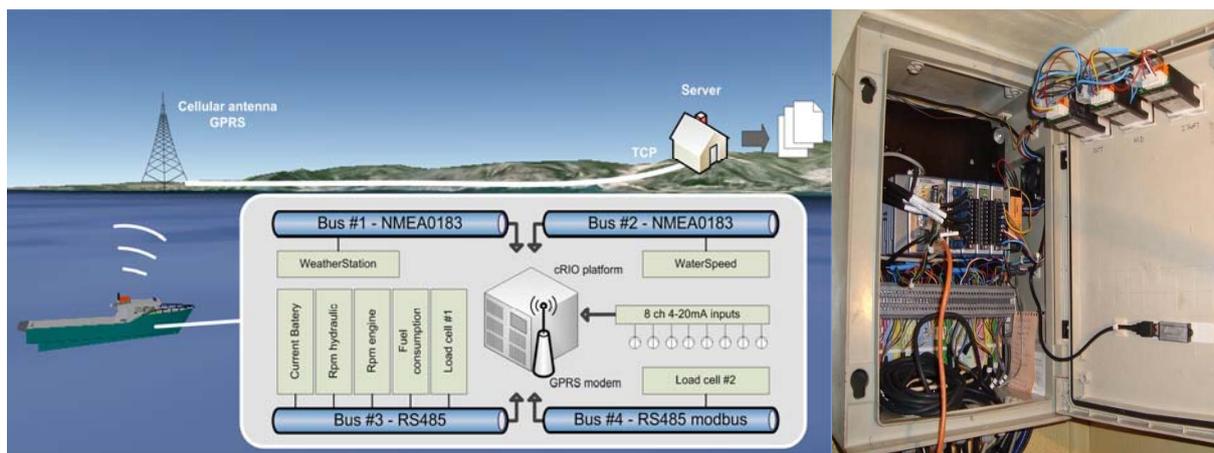


Fig. 1 System structure and acquisition system installed in a trawler vessel

A. Sensor network

One part of the network consists on a set of different digital sensors with the RS422 (NMEA0183) and RS485 interfaces, which allows locating the sensors far away from the acquisition system. These sensors measure the GPS position, the ground and water speed, the pitch and roll, the heading, the wind speed and direction, the engine rpm, the fuel consumption, the battery current, and the strength of both fishing gears.

On the other hand, there is a group of analog current sensors (4 to 20mA) dedicated to measure temperatures (the engine room, the engine and its exhaust), the pressure (the engine room, the hydraulics and the exhaust), and the oxygen concentration in the engines' admission.

B. Acquisition system

The acquisition system that has been chosen for this application is a robust solution for the working conditions in the vessel, and it also offers the possibility to connect the different types of sensors and interfaces. In addition, it facilitates the programming of the different protocols and has powerful processing and storage capabilities.

The platform chosen is the National Instruments CompactRIO. The equipment consists of a RT processor with VxWorks Operating System and a FPGA. Modules of 422/485, and current acquisition (4-20mA) were incorporated in the CompactRIO in order to acquire the signal from the proposed sensors (Table 1).

The FPGA has been programmed with the different communication protocols of the digital sensors. This has the advantage of improving the system performance freeing the processor of high consuming tasks. The protocols programmed were the NMEA0183 [5] and the Modbus, as well as other non-standard protocols in order to acquire from the digital sensors. If data from digital sensors arrive in the right format, the FPGA sends the data to the processor using DMA (Direct Access Memory), which records the data with a time-stamp. The processor also transfers data into files and manage the data transmission to the land station through the GPRS modem.

C. Data transmission

The GRPS communication system transfers the acquired data to the land station. This implementation does not provide a real-time monitoring, but it allows a periodic monitoring every time the vessel has GPRS coverage, which can be in a regular daily basis. Although the GPRS speed is low [6], the system is able to send all queued data before the vessel reaches port, being available for its analysis on the same day.

D. Data reception

The land station that collects the data sent by the vessels has a centralized database, based on a Windows Server with a LabVIEW application [7] [8]. The main tasks of the application are store the data on disk in a orderly form, and to generate tabulated files (excel files with all measurements and timestamp) and “*.kml” files with the routes, which can be viewed with mapping applications. In Fig. 2, position, fuel, temperature and rpm engine data is presented.

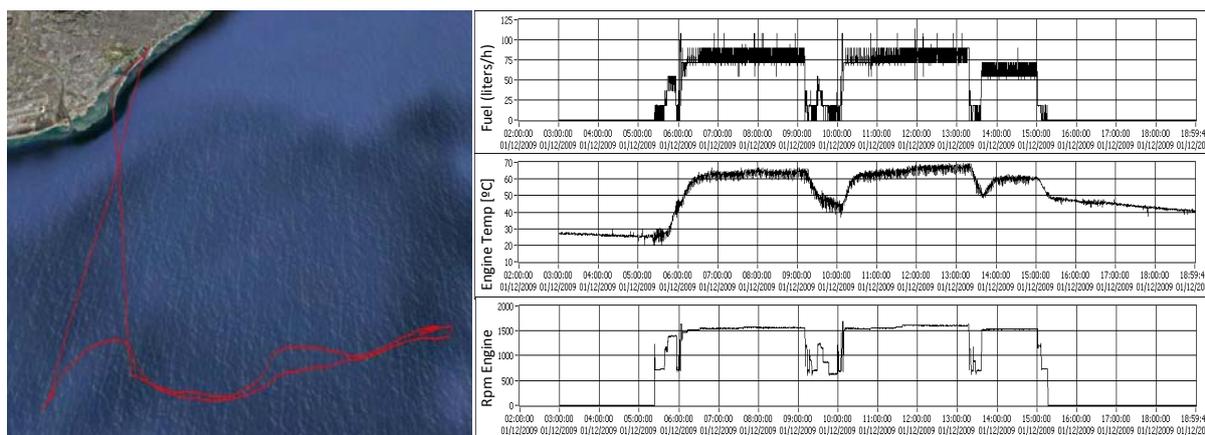


Fig. 2 Position, fuel consumption, temperature and rpm engine data from a trawler vessel

III. Results

The system has been installed on five trawler vessels and different tests have been carried out to study the fuel consumption. Studies show that it is possible to reduce the fuel consumption if some specific technical actions are applied [9]. Specifically, current tests shown that it is possible to reduce up to 29% of energy per day, which is the consequence of reducing 41% of fuel during the trawler fishing activity, and 16% due to an efficient navigation management. This improvement can represent, to a standard Catalonia fishing trawler, a save of up to 18,000 Euro per year, approximately a reduction of 120 tons on CO₂ emissions, as shown in Fig. 3.

IV. Conclusions

A robust and autonomous system for monitoring energy efficiency in trawler vessels has been designed and presented. This system allows monitoring different navigation and fishing parameters related to the energy consumption during their fishing activities.

Successful results were obtained thanks to the remote monitoring using the GPRS communication. This system has shown to be a good solution (technically and economical), also if no real-time data is required, GPRS is an economical solution for data transmission.

This acquisition system is currently in use by different trawlers of Catalonia, and the collected data is being used to study new techniques to reduce the energy consumption of these vessels.

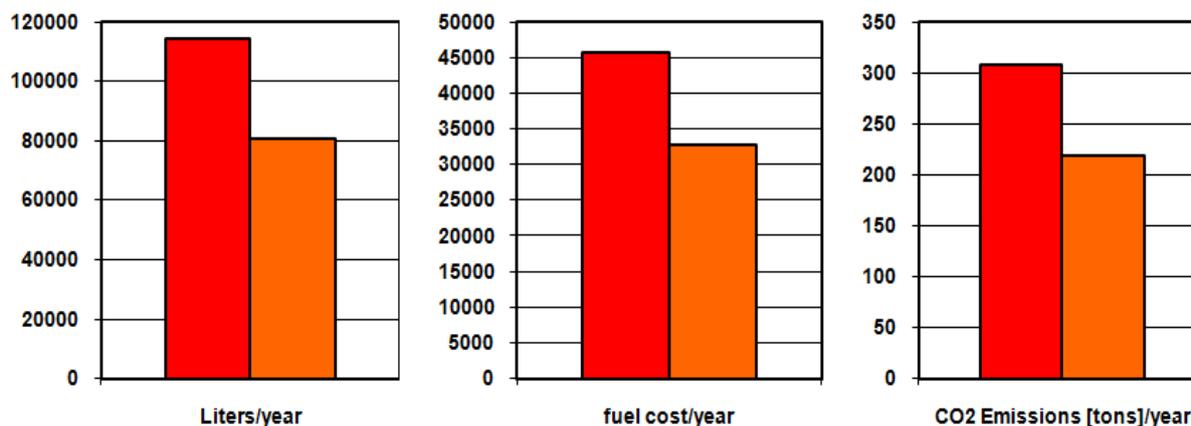


Fig. 3 Results achieved after the different tests made [9]

V. Acknowledgments

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