TRUCK DIESEL MONITORING SYSTEM

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Abstract. *The cargo transportation in Brazil is predominantly done by road, instead of any other means of transportation. It represented more than 35% of the total amount of money spent on goods transportation on that South American country during 2005. There are several factors that should be taken in consideration in the final cost of this service. We can highlight, for example: poor road quality, cargo robbery, theft of tires, fuel stealing, road accidents, etc. These costs are always reassigned to the final customers. Among that list, one of main factors for increasing transport costs in Brazil is the illicit fuel deviation. In order to reduce this problem, several strategies have been adopted by entrepreneurs; so far none of them could come up with an efficient proposal. This paper presents a new tool to assist preventing the fuel stealing issue. It can detect the tank violation, notifying the company when it happened and how much fuel was diverted. The proposed system is also capable of fuel tank level monitoring as a function of time, storing data and preparing it for post analysis as well. The system goes beyond a theft detection and alarm system; it also provides the telemetry of fuel consumption at each trip moment. This tool can help in reducing costs, not only in cargo carriage business, but also in passengers transport business.*

Keywords*: Fuel stealing; Monitoring system; Embedded system; Automation; Cargo transportation*

1. INTRODUCTION

The fuel diesel theft is an international problem, as the price of this fuel still high it became more and more important to afford ways to reduce fuel loses. The fuel thief use to attack big fuel tank wherever it is, these targets include: fleet vehicles, diesel powered farms irrigation system, construction yards, gas stations and tank truck.

The fuel robber acts in many different ways, the most comm of them are (Krishnamurthi, 2008):

- Siphon fuel withdraws directly by the tank.
- The amount of fuel supplied is less than the fuel amount described in the chit.

Many techniques are used to reduce the damages caused by the illegal fuel deviation, quantity supplied monitoring and fuel consumption profiles are the most used methods in Brazilian companies, those are administrative methods. Unluckily, it does not provide high accurate data in order to certain inform if the fuel were deviated by the tank. Another common technique is the use of mechanical locks, despite a large quantity of lock models offered in the market, the principle of action are the same, block the entrance of the siphon, this technique is not efficient because it only prevent fuel withdrawal through the main access in the tank leaving the rest unprotected as proposed by Rebello (2008) and Mougenot (2007).

It can be seen that any of the techniques used currently are an efficient low costs solution. The administrative solution requires high investments in staffs selection and training, because the people who execute these jobs must be highly reliable. And all different mechanical locks existent in market makes only a little bit more difficult for thieves to extract fuel from tank.

The cargo road transportation segment companies clams for a solution like this, those participated with 4,3% of Brazilian GDP(Gross Domestic Product) in 1999 according to Wanke and Fleury (2006). For these companies fuel cost is about 50% of freight value, and according with research realized by the Quatro Rodas Frota (2009), this segment enough to take damage about 10% under the freight value by the fuel deviation. All theses fuel looses are reassigned by companies to the product shipment what is payed at the end of cycle by final customers.

In this paper we propose a new low cost solution for fuel monitoring that can be used in any automobile. The system operation involves monitoring the fuel tank level during the time automobile stay out of the base and subsequent analysis of data. This make possible observe with a high degree of reliability if happened any fuel casting or deviation.

2. System Description

Targeting understand fuel level tank behavior aiming detect fuel deviation means analyze fuel level as function of time. Many strategies are used to monitor a physical quantity over a time period in mobile systems, as trucks, over all the cheapest solution is to use low-cost data-loggers (Dedrick, 1999). Such data-logging technology could become an even more important tool for data collection in future as proposed by Ross et. al. (1995), it can provide precise measurement of how vehicles are actually driven. In order to monitor the amount of fuel available in the fuel tank, a data-logger was developed using its own fuel level float switch as a sensor. The system developed is presented in Figure 1. At programmable time intervals, a relay disconnects the fuel sensor from the vehicle's measure system, connecting it to the data-logger, so the fuel amount can be measured.

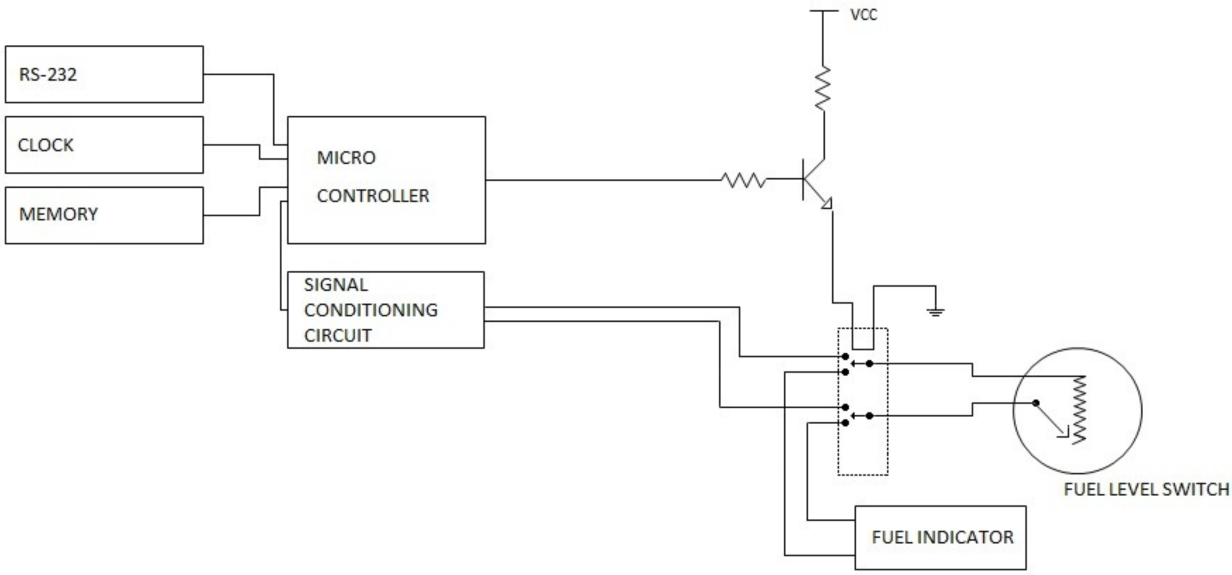

Figure 1. System diagram.

In this data-logger, a PIC microcontroller manages the whole measure system by triggering in the relay in pre-set periods for measurement, scanning and saving the acquired signal. Corresponding measured tank fuel level data are stored by the microcontroller in an EEPROM memory. The time when the measures were taken are also recorded, for what a watch IC (Integrated circuit) was made necessary.

The measure starting and ending commands are made through a RS-232 communication line, as well as all the other system settings (time, measure intervals, among others). In this way, before the vehicle leaves the base, the system is triggered, so that when it returns, data acquired during the trip may be downloaded and analyzed.

When analyzing the data, continuous fuel amount decreasing is supposed to be found. In case that an abrupt decrease appears, that might indicate fuel deviation. In the other hand, sudden increase would be interpreted as refueling. Thus, being the system calibrated for the vehicle's tank – floating switch set, it is possible to determinate the amount of deviated fuel, the amount of fuel supplied, and even estimate average fuel consumption in each road stretch.

3. Results

To evaluate system performance a laboratory test was made. For that, was used an Indebrás ref 001.972.0PR (Indebrás, 2008) floating switch and a 200 liters BEPO´s fuel tank. This floating switch is nothing else than a variable resistor, varying from 0 – 6Ω , empty tank condition, and 178 – 192 Ω, full tank condition.

The tank was full filled with water and while that floating switch resistance where measured at each liter putted in tank. The measurement results are presented in Figure 2.

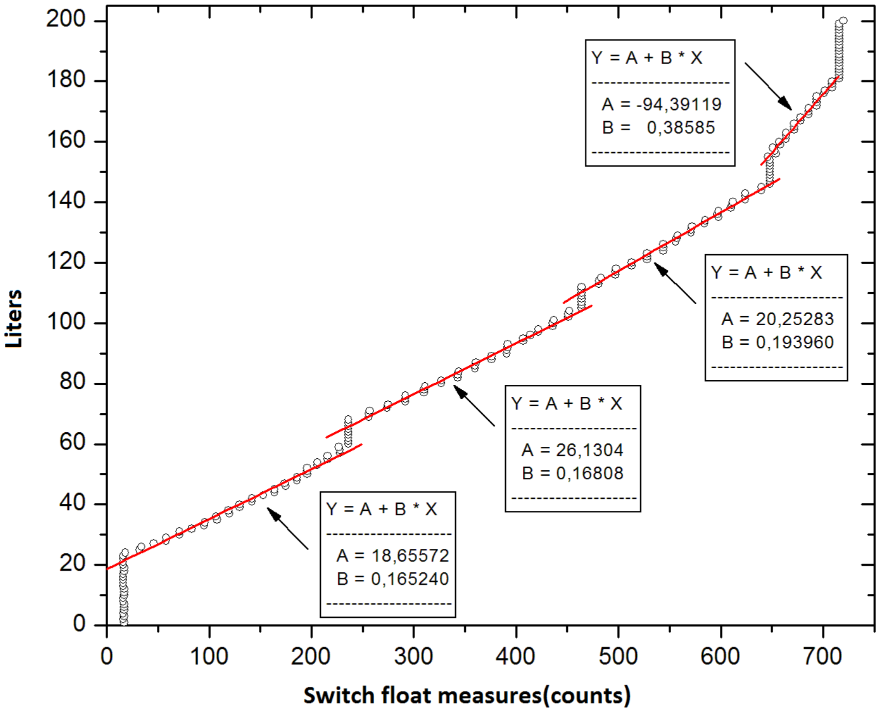

Figure 2. Fuel tank charging profile

Analyzing graph one can see:

- A reserve tank of 24 liters, ie, between zero and 24 liters the floating switch can't sense any change in fuel level.
- A dead zone of 20 liters until tank is completely filled, in this zone the system can't sense any change in fuel level again.
- A filling profile divided into 4 tendencies separated by rises.
- The tendencies evolve by steps.

These features were cleared when the fuel sensor where disassembled for internal structure analyzing, internal image is shown in Figure 3.

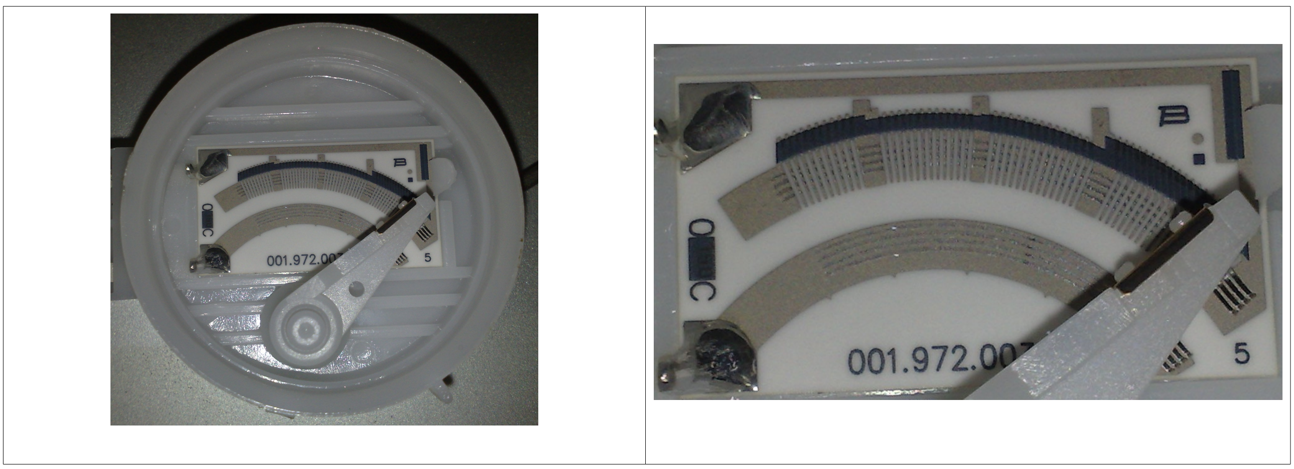

Figure 3. Fuel tank switch internal structure

It was observed that the float switch potentiometer is not continuous, it has several steps, hence the no continuity in the measures. Because of this steps the system resolution was limited in 2 liters, ie, the float switch only allows the visualization of variations in the level of oil more than 2 liters. Other characteristic of the float switch is the existence of three larger steps, they are responsible for the straight where do not happen variations in the measures.

With the calibration graphics of the float switch and justified the characteristics of the curve behavior we propose a mathematic model for the curve. Using a linear adjust for the 4 tendencies of the measure, as can be seen in Figure 3, was possible write equations that relate the value measured for the resistance of the float switch with the fuel volume in tank.

Once know the system behavior it were installed in a truck that has two 200 liters tanks interconnected and the initial fuel amount in tank was unknown. Then chosen truck doesn't receive any adaptation on its electrical system nether were chosen by any factor, it was a fleet vehicle as any other, as well as its driver. The system was then started and truck went in a trip. In this test the data logger monitored more than 50 hours of the trunk trip, making one measurement at each 5 minutes, collected data are shown in Figure 4, as blue line. Many factors interferes making collected data very noisily, such as: bad float switch state of quality, road holes and slopes that makes the fuel level oscillate, between others unknown. All these factors together make directly float switch level measurement difficult to be interpreted, so that it was necessary apply a filter to this data, shown as a red line.

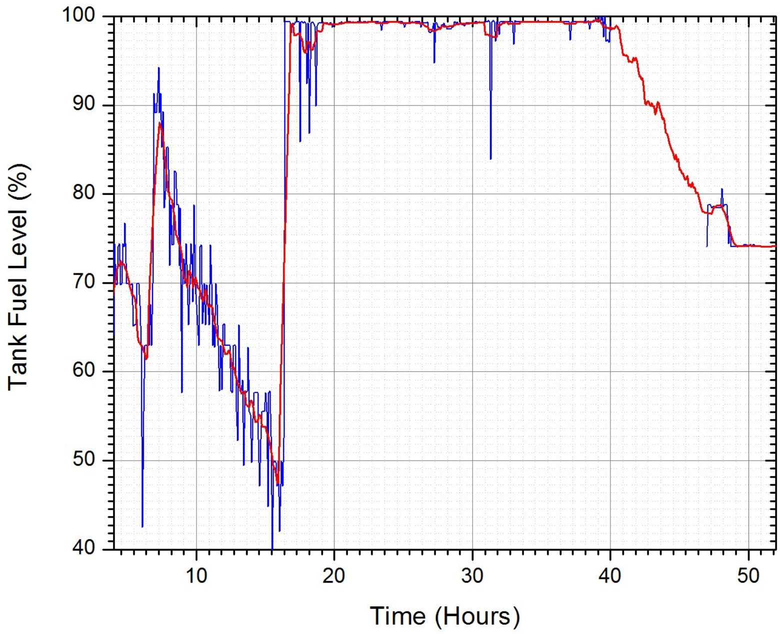

Figure 4. Tank float switch signal in blue and filtered signal in red.

It can be seeing in Figure 4 that when the system starts it measurement routine the tank was filled with around 70% percent of it full volume. The truck had a fuel consumption of 11% of tank fuel in the first 3 hours, then it were recharged with 100 liters, 25% of total tank volume, and went back in 8 hour trip and then fully recharged. The graph region between 17 and 39 hours means that truck remains parked, after that it back to road. Fuel consumption in this two trips are different because in first it were loaded, loaded the truck had a consumption of around 16 liters/hour while unloaded a consumption of around 13 liters/hour. The graphic analyses accords perfectly with trip schedule made by truck driver.

4. CONCLUSION

The system has proven to be a strong tool helping cargo transportation companies detect fuel deviation, and more, helping truck consumption analysis at each moment of the trip. All of it without making any change in truck neither electronic system nor using any expensive sensor.

Tank fuel consumption profile has show to be a very noisily measurement, what makes very difficult to just use fuel level differences as a way of fuel deviation detection, as proposed by Krishnamurthi (2008). A way to get more accurate fuel stolen detection is make a full consumption analysis, using treated data.

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