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Technical aspects and guidelines for building an application to control and manage vehicle fuel consumption remotely

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Abstract

Today there is a considerable number of programs that remotely monitor vehicle movements. As such we can mention EogleEye, AVL Fox, easy TRACK, Almaks Security System, GPS Plus, Trimble, Oris, Navirec, Fleet management etc. [9]. Mainly these softwares process the data received from GPS and various sensors placed on it and based on them determine the movement of the vehicle, recording at any moment the position, the speed, the route they travel to reach the destination and many options of other important reports for a business, so generally this is a remote control that is done while the vehicle is moving. An important aspect of this remote control of vehicles is the monitoring of vehicle fuel consumption, which has been little addressed in the literature. This article is dedicated to this aspect.

The problem of fuel consumption is quite important, especially for entities that deal with intermodal transport, but also domestic transport. The specificity of this paper lies in finding the formal parameters that determine the fuel consumption graph, and this is made possible through the Excel application program, using approximations of the dependence of the voltage of the probe (sensor) placed in the vehicle's tank on the amount of fuel happened in it. The Excel program determines the coefficients of this dependence.[10]

Keywords: application, vehicle fuel consumption, remote monitoring

1. TECHNICAL ASPECT

In advance, to build such an application, some basic conditions would have to be met. There are several important hardware components that will make it possible to determine the position of the vehicle wherever it is located, namely a GPS and an antenna (receiver of signals from satellites) as in fig.1. Also, a module (firmware) would be needed in which a SIM card with GPRS service (internet in any position) provided by any telecommunication company is placed.

Fig.1. Components of the FM1100 module

2. MEASURING ELEMENT OR SENSOR

A necessary condition for any kind of process control is to be able to measure certain of its variables. It is therefore very important to choose measuring elements that will ensure an accurate and reliable measurement.

Measuring elements constitute the main source of information in the control system and are often referred to as information elements.

The elements used for these purposes are called sensors or measuring elements - transmitters. Measuring elements - transmitters mainly consist of two parts:

- The sensitive element (sensor) and
- Element of the transmitting part (transmitter).

Depending on the type of transmitter, the output from the measuring element can be a standard pneumatic signal, a current signal, a voltage signal or a digital signal.

Whereas the sensitive element or sensor depends on the physical size which is measured, the working conditions in which it works, etc.

Researching about sensors, we found that for measuring the level of any aggregate state of matter, two methods are mainly used:

- Level detection method and
- Continuous measurement method

Level sensors or detectors determine critical level values, such as minimum and maximum level values. Sensors that work on this principle are used to indicate the alarm signal in the case of filling or emptying the tank, but this type of sensor is not the object of interest for the case of our study, which includes sensors that work according to continuous measurement methods:

- Pear popping sensors,
- Conductive sensors,
- Sensors based on the principle of floating or submersion,
- Vibrating sensors in the form of a fork (spoon) and
- Rod-shaped vibrating sensors.

Also, the fact that the sensor is open or closed, depending on the fact whether we are dealing with a closed or open tank, etc., has an impact on the selection of the sensor. Taking this quality into consideration, we come to the following group of sensors that provide level measurement methods and techniques:

- Hydraulic sensors,
- Pop-up sensors,
- Capacitive sensors,
- Resistive level sensors and
- Ultrasonic sensors

And our choice related to measuring the level of fuel in the tank would be a choice in the set of sensors noted above.

The choice of sensor is also determined by other static and dynamic characteristics which are considered in the study.

3. STATIC AND DYNAMIC CHARACTERISTICS OF SENSORS

Each of the sensor types has static and dynamic characteristics where:

- The static characteristics should be as little as possible subject to the influence of environmental conditions in such a way that the equipment maintains the quality of work for which it is intended.

- The dynamic characteristic should have as few dynamic parameters (time constants) as possible in relation to the dynamic parameters of the management object in which the measurement is made.

Static characteristics include, among others, measurement range, measurement area or space, sensitivity, precision, accuracy, etc.

The measurement range is the difference between the highest and lowest value of the physical quantity that can be measured at a given calibration of the measuring element (sensor). Meanwhile, the lowest value corresponds to the output from the transmitter of the value of 0.2 bar (if the transmitter is a pneumatic one), and 4 mA (if the transmitter is electronic), and the highest value corresponds to the output signal of 1 bar and 20 mA.

The measuring range represents the maximum measuring range within which a given transmitter can be calibrated.

Considering the elements mentioned above such as the sensitivity, the accuracy of the measurement of the given size and the measuring precision of the instrument, the selection of the sensor takes on a special importance, so this was done from the array of capacitive sensors.

The capacitive sensor chosen for this experiment, to measure the fuel level in the vehicle tank, makes very precise capacitive measurements.

Therefore, the selection has fallen on the sensor type DUT-E 485, fig. 2., which is designed for measuring the fuel level in the tanks of all types of vehicles, as well as in the tanks of fixed installations.

This sensor was used because it proved to have enough data to perform the functions that were necessary to achieve the desired effect.

The probe length of this sensor can be easily adapted to all types of tanks allowing the possibility of use in any type of vehicle.

The probe is built from the highest quality aluminum alloy in combination with polypropylene elements and a highly fuel-resistant rubber material that ensures safe work and high resistance to the corrosive actions of the fuel or the substance being measured.

This sensor gives very precise results, not being affected by fuel temperature changes, changes in fuel in the tank during driving, difficult terrain or defects in the air shock absorbers in cases of driving on slopes.

The DUT-E 485 sensor can be used as part of a fuel monitoring system or to replace a vehicle's standard fuel gauge.

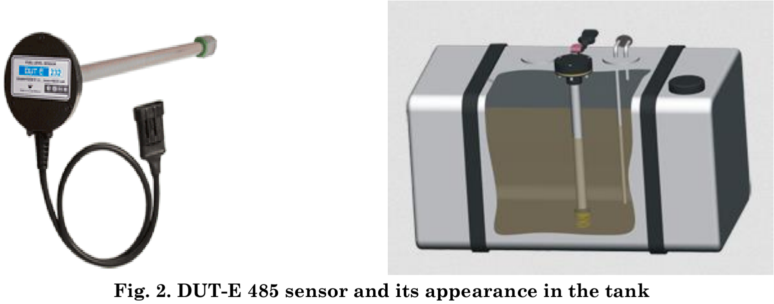

Fig. 2. DUT-E 485 sensor and its appearance in the tank

The sensors must be mounted in the tank of the vehicle, as in fig. 3.

Fig. 3. Procedures for fitting the sensor to the tank

There is a technical procedure that must be followed to place the probe with the sensors in the fuel tank, thus creating the technical environment that will produce the required information.

Then the GPS is configured through a special procedure, it is connected or installed in the vehicle and an element of this process is the configuration of the connection via the Internet with the Server where the data will be sent (via GPRS) and processed. Also, the probe should be installed (connected) to the sensor in the respective vehicle.

4. EXPERIMENTATION

The idea of this experiment is to determine the dependence that exists between the voltage of the probe placed in the tank of the car and the amount of fuel that is in the tank of the vehicle. So, the experiment will determine the coefficients of this dependence. And exactly the experiment takes place as follows:

After the hardware base is secured and the assembly is done correctly, the vehicle tank is tested.

This presupposes the preliminary emptying of the tank and the measurement of the voltage through a universal measuring instrument which we put in the DCV position up to 20 [V].

This voltage measurement is made between the grounding point (ground) of the vehicle and the point where an output from the GPS module and an output of the probe placed in the tank are connected. After connecting the instrument, we wait a minute until the parameters stabilize, then activate the ignition of the vehicle, read the voltage on the instrument and simultaneously read the time at the moment of measurement to note these values in table 1.

Then we pour the first 20 liters of fuel into the tank and wait 2-3 minutes for the fuel level in the tank to stabilize and again measure the voltage and time with the same procedure, placing these values in the table. We repeat this procedure for every 20 liters poured into the tank until the tank is full, simultaneously filling the table with the measurement data. This is the procedure for checking the fuel tank in the vehicle.

Table 1. The results obtained in the case of vehicle tank validation

#	Voltage Value (V)	Amount of Fuel (L)	#	Voltage Value (V)	Amount of Fuel (L)
1	2.33	10	16	5.53	310
2	2.58	30	17	5.73	330
3	2.81	50	18	5.94	350
4	3.04	70	19	6.15	370
5	3.25	90	20	6.36	390
6	3.47	110	21	6.57	410
7	3.68	130	22	6.78	430
8	3.89	150	23	6.99	450
9	4.1	170	24	7.2	470
10	4.3	190	25	7.41	490
11	4.51	210	26	7.63	510
12	4.72	230	27	7.86	530
13	4.92	250	28	8.09	550
14	5.12	270	29	8.22	560
15	5.33	290	30	...	...

Table 1 defines the specifics of the vehicle, i.e. the dependence of the level of the fuel deposit on the voltage of the probe located in the tank of the vehicle. We put the data of table 1 in the Excel program, which converts the discrete data into a continuous polynomial dependence and determines the coefficients of this dependence fig 4.

Studying the results and approximating the dependence in question with polynomials of the third, fourth, fifth degree, it was concluded that with the polynomial of the fifth degree, the deviation from the real values (taking into account the sum of the squares of the differences) meets the limit of established by us [10].

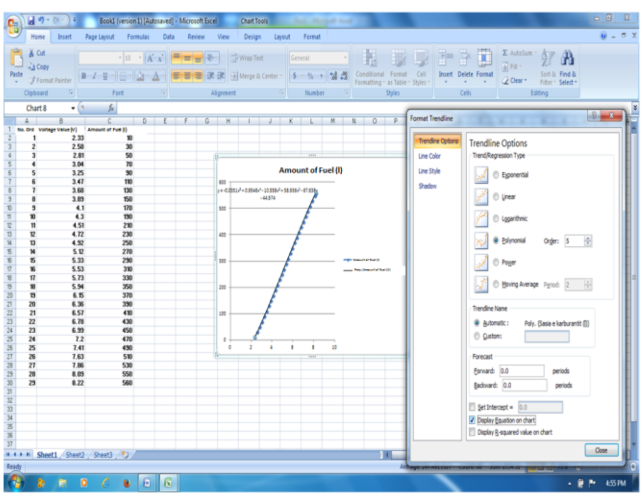

Fig. 4. Polynomial dependence of the values of table 1

The polynomial dependence obtained in this case would be expressed as follows:

y=-0.000000000000000035778901354195x5 + 0.000000000000973659855083592000x4 - 0.000000010759917817579900000000x3 + 0.000060014314679236500000000000x2 - 0.070123329571800200000000000000x - 43.297639681310600000000000000000

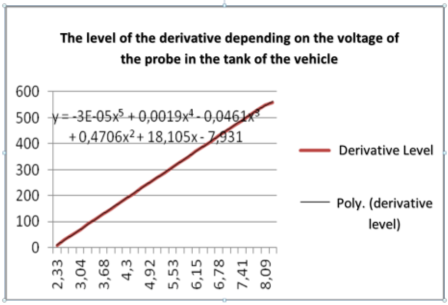

Fig 5. Dependence of the fuel level on the voltage of the probe in the tank of the vehicle

The coefficients a0, a1, a2, a3, a4, a5 as well as the voltage values that are measurable are sent and stored in the server enabling the determination of the fuel level in the vehicle at any moment.

5. DATA PROCESSING

With the help of the sensor probe we are able to collect data that reflects the probe voltage in the vehicle. On the other hand, we have determined in advance the polynomial dependence coefficients between the voltage and the fuel level in the vehicle. With this data, an application is able to check the fuel level at any moment in the vehicle as well as the continuous changes that occur in it. Data via the Internet (GPRS) are sent to the server, in which a My SQL database is implemented.

Figure 6. presents the obtained graph of the dependence of the fuel level in relation to the time of the vehicle's movement, the speed of its movement as well as the state of the vehicle (on, off) through the application used. While GPS gives us data about the position of the vehicle. We associate this position with the moments when we have fuel entering or leaving the tank. So, with this data, we are able to judge at what point of the vehicle's location we have essential changes in the vehicle's fuel level.

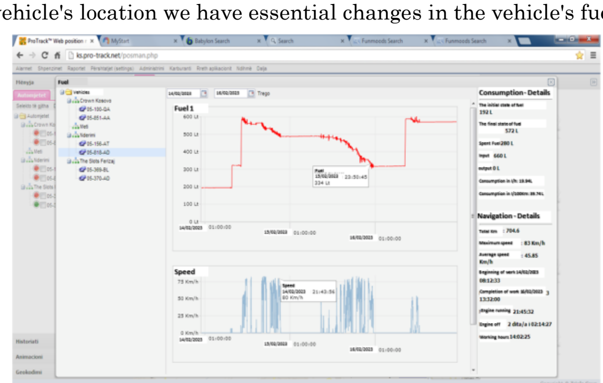

Fig. 6. Chart and analysis of fuel costs for the specified time period for vehicle 05-818-AD

6. ALGORITHM USED

An algorithm was used, fig. 7, which makes it possible to find the fuel consumption at each point of its movement, and to find the points where there are significant fuel changes. To distinguish fuel inputs and outputs in the tank, the difference between two consecutive points on the graph must be greater than the parameter of minimum inputs and outputs of fuel in the tank, since only in this case they are considered inputs or outputs.

Also, the algorithm also verifies the speed of the vehicle movement and in order to record the inputs and outputs of the fuel, the condition that the speed is zero would have to be fulfilled, because only in this case we can have the output or input of the fuel (the vehicle must be stopped for filling or emptying of fuel). Also, this condition allows not to consider as output or input fuel level changes during the vehicle's journey (downhill or vice versa).

Fuel costs are calculated using the formula,

- Initial state + inputs - final state - outputs.

The block diagram or logical algorithm of fuel consumption control based on which the program was written looks like the following:

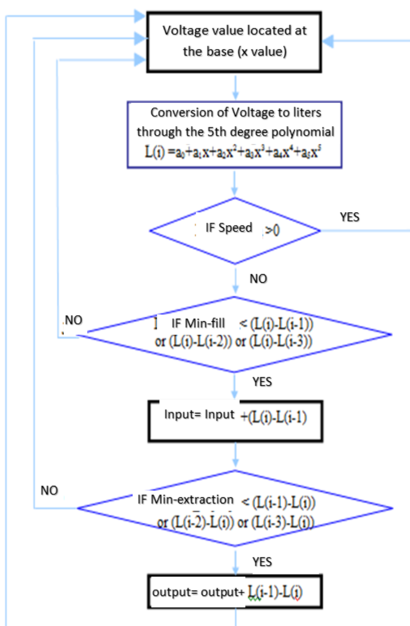

Fig. 7. Algorithm built for control of fuel consumption in the tank

The algorithm described above will only calculate or consider fuel inputs and outputs from the vehicle tank with the default conditions that fuel fluctuations along the vehicle route are not considered inputs or outputs:

1. The speed of movement of the vehicle should be zero, because nobody can empty or fill the tank while moving.

2. The parameter of minimum entrances or exits is laid down as a condition for the case of vehicles that have a reserve of cca 1000 liters, because in such cases even minimal fluctuations along the vehicle's route, as a result of the road configuration, can bring a difference between points of (1-1.5) %, which, expressed in liters, would be 10-15 liters. According to the algorithm, the difference between the reference point L(i), which we look at, and the previous point L(i-1) or even the next previous point L(i-2) or even the next even earlier L (i- 3), must be greater than the minimum amount of fuel input or output in the tank to (not) accept fluctuations as input or output.

Using some real data to make the above conditions concrete we have: if, for example, the minimum inputs parameter is 25 liters (because we are assuming that rarely anyone fills the 1000-liter tank with less than 25 liters), while we have filled 100 liters, let's say, twice from 50, then these fillings are greater than the minimum filling of 25 liters, so the condition for this filling to be registered as fuel input has been met.

But if we have, for example, 100 liters in the tank and we fill it with another 100 liters, while the base fuel level points are 100, 180, 200, then the first difference (180-100) is 80 liters, so greater than the minimum entries parameter (25), and the condition is met to record this as an entry. The difference between the two following points is (200-180) = 20 liters, in this case the condition that the difference between the two points L(i) and L(i-1) is greater than the minimum input parameter is not met, therefore, even this difference would not be recorded.

But as the algorithm looks further and considers the difference L(i)-L(i-2), which is 200-100=100, then the condition will be met. In this way all continuous inputs will be calculated, even though the difference between two instantaneous points is smaller than the minimum inputs parameter, fig. 8.

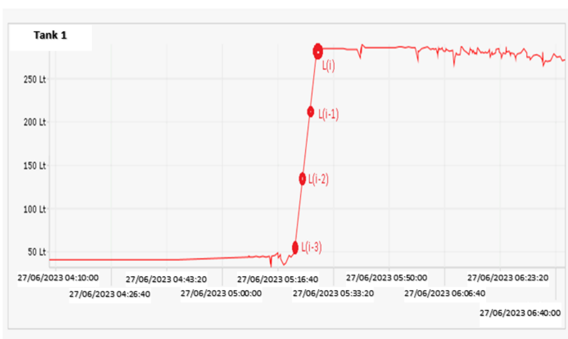

Fig.8

In short, we are presenting only the contents of some tables located in the database on the server, such as, for example, the basic data table about vehicles, which contains: ID, IMEI, registration and all additional data that describe vehicles.

The position in which the vehicle is located is in the next table, which contains the ID, time, coordinates, speed.

Data related to fuel are located in the third table, which contains ID, time, level values of the probe placed in the tank, tank number.

The notes for calculating the data from the probe and converting them to liters are located in the table which contains the ID, the capacity of the tank, the coefficients from the diagram and other parameters.

All these tables and data are connected through the application and, according to the user's need, this data is presented on the screen or monitor.

The device in the vehicle with the data from the satellite calculates the position and speed and through the GPRS service sends them to the server, where the read values of the probe placed in the tank are also sent and all these data are placed in a database.

The database that the application uses has approximately 50 different tables and the connection to a certain vehicle is made through its ID.

BIBLIOGRAPHY

1. GALILEO Impacts on road transport. Michael Schmidt, Liana Giorgi ICCR (AT), Martial Chevreuil, Sarah Pauline Faber Maunsel (UK) Scientific Officer at JRC/IPTS: Panayotis Christidis July 2005
2. Basic Essentials Using GPS, Bruce Grubbs 2005.
3. GPS Basics, James Marie Zogg 2002
4. Understanding Gps and Gps receivers version 3.0 Video Clip.
5. Gps for Mariners, Robert J.Sweet 2006
6. Gordon K. Smyth, 1998 Polynomial Approximation.
7. FM1100 User Manual v1.21 (1).pdf
8. Muhamet Avdyli "Some Results with Economic and Managerial Character when using a Telematics System in the Transportation Process in a Transport Business, European International Journal of Science and Technology Vol. 3 No. January 1, 2014
9. Muhamet Avdyli "Requirements, Hardware and Software Description of Server AVL Triola (AVLT) for Tracking from the Distance and Managing the Transportation Vehicle Float for Passengers and Goods", EUROPEAN ACADEMIC RESEARCH Vol. I, Issue 10/ January 2014
10. Muhamet Avdyli "The use of Intelligent System in transport and concrete benefits when using this system in the context of saving fuel". International Conference on Business, Technology & Innovation Durres, 7-8 November 2014