ANALYSIS OF SYSTEMS FOR CONTROL OF ENERGY EFFICIENCY OF MOBILE MACHINES

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Abstract: The systems for control of energy efficiency of mobile machines suggested on the marked and widespread in practice are analyzed. The based possible variants are generalized as a tendency for their development and using. It is necessary that the systems for control of energy efficiency are based of moment fuel consumption by direct measuring. That gives establishment for realization of different variants of systems for control of energy efficiency.

Key words: FUEL CONSUMPTION, ENERGY EFFICIENCY, MOBILE MACHINES, COMPUTER SYSTEMS

1. Introduction

Different systems for control of the energy efficiency of mobile machines with internal – combustion engine are widespread in practice. The interest to these systems is considerable. That is mean, that problem of energy efficiency and the concrete problems of fuel consumption are more topical. Because of that the earth reserves of petroleum are the limited, the consumption of fuel will increase and along with this, it is expected, the fuel prices will increase during the next years.

The increase interest of the companies, for the possibility to control of the energy efficiency of mobile machines in combination with development of computer information and communication technologies, creates conditions for using of sensors for measuring fuel consumption and obtaining of considerable information for control and optimal management of mobile machines. With their development the computer electronic and communication technologies became more reliable, cheap, package – model which allows their mass using in automobile industry for control and management according to different schemes in modern motor – service stations. The approach, based of different private methods for modelling the machine operation and their aggregates through electronic systems, gives enormous possibilities. On this stage this approach do not based on enaugh exact models and input data. Very often graphic and tabular data for analysis, assessment and management on the base of insufficient correct initial information are suggested.

Computer systems as part of the systems for monitoring the energy efficiency have a significant role in the realization of this approach. Through the hardware and software part of the systems direct base is created for perceiving and forming of an opinion about the results from the activity and the usage of the vehicle.

It can be assumed at this stage, that the systems for monitoring the energy efficiency register different initial values, but a higher efficiency in their usage can only be obtained if they are based on measuring the fuel consumption.

2. Results and discussion

According to the way of measuring of the consumed fuel there are two methods of controlling the energy efficiency – indirect and direct method.

The Indirect method is generally based on measuring the time that the nozzles for fuel injection of the modern engines stay open. It has however a few disadvantages, the main of which is connected with the accuracy of measurement. This method has an unacceptable for the practice error. At the same time it does not provide the opportunity to make an evaluation of the technical condition of elements of the system, as it is influenced by some other indirect indexes, on which it is grounded.

The Direct method for measuring the fuel consumed by the engine has started to gain popularity, especially over the last 5-10 years.

The main problems of this method are connected with the sensor and to be more specific - with its price, reliability, resource and accuracy. At the moment different systems are searched for and offered, which are based on different types of sensors for fuel consumption and which may be rated as acceptable for the practice [3,5].

Important elements of the systems for control the fuel consumption are the control systems of the sensor for the fuel consumption and of the electronic systems for registration, calculation and presentation of the results from the measurement in an easily understandable form. With the spread of the modern information and communication technologies, the electronic systems have become highly reliable, small-sized and comparatively cheap, the possibilities for using them in mobile means of transport have increased considerably and they have started to be built in mobile machines.

Computer systems for monitoring and information, based on indirect methods are already permanently present in the automobiles, tractors, agricultural and road construction machines, etc. At this stage, their role is mainly considered as systems for monitoring and control of the machines as a whole, and of their separate units. It can be assumed, that their usage in their capacity of systems for improving the energy efficiency is still at an initial stage and is far from being exhausted. For example, regardless of the fact that in the modern automobiles, tractors, harvesters and other there are inbuilt board computers, which give information about the fuel economy of the machine, these data are not used by the companies for accounting of the consumed fuel or for effective management of the machine. The reason is that as a sensor for fuel consumption in the indirect methods are mainly used elements from the feeding system, by measuring the duration of the time during which fuel is injected in the cylinders and the quantity of the fuel fed/consumed is determined on this basis. This method is based on indirect indicators, which depend on a number of variable factors and as a result of this the error can become very serious. Most often, when registering the fuel consumption of the engine using this method, it is indicated that the error is about 25%. What is positive about the indirect methods is that all the elements of the system are manufactured and built in by the factory. The existing factory systems, which are built in the mobile machines, provide real time information only on the screen of the board computer. This information is most often visual, which limits the possibility for a more thorough analysis of the transformation of the data, the time and their juxtaposing, including other derivative values and on this basis – the possibility for its fast and effective perception and the undertaking of respective actions connected with the management of the processes. Most often it does not allow the formation of a database archive and subsequent processing according to the needs of the specialists and of the owners for the performing of an appropriate analysis.

Computer systems for monitoring and information, based on direct methods for measuring the fuel consumption, can be combined in two main groups.

In the first one what is observed is the level of the fuel in the tank. On Fig. 1 is shown the general look of the structure of the system. A disadvantage of this system is that it does not provide the necessary accuracy in measuring the fuel consumption and this
limits the possibilities of the system or its effective usage. For example, these systems do not allow an evaluation of the efficiency of the driving of the machine by the driver, i.e. the momentary fuel consumption cannot be registered, the technical condition of separate elements and aggregates cannot be evaluated and with that the advantages of the preventive diagnostics cannot be used. It does not allow to create diagrams for measuring the regime of the machine as a whole and to evaluate their effective usage, etc.

specialized computer control systems for energy efficiency can be seen. These systems are based on the direct measurement of fuel consumption.

Another important moment in the organization of the system is the transfer of the information from the mobile electronic unit to the customer.

Generally, three practical schemes for the realization of this process are possible.

**Fig. 1.** General view of a system for measuring fuel consumption by data for the fuel level in the tank where: 1 – electronic block; 2 – ignition key; 3 – engine; 4 – computer and software; 5 – tank; 6 – speedometer.

But in combination with other systems they can provide useful information such as time and volume of the refuel.

The **second one** uses one or two sensors for fuel consumption, located between the tank and the engine, which allows the consumption of fuel and the time for its consumption to be measured for a short period of time and on the basis of this data to calculate different derivative values, allowing a wide range of indicators for evaluation of the energy efficiency to be covered, information about the fuel remaining in the tank, etc [7,8].

Fig. 2 shows a basic scheme of a system for the momentary fuel consumption. These types of systems do not have the disadvantages of the direct measuring whereas they provide the opportunity for receiving information about the previous one and have a wider scope for application. Especially important and useful for the control and evaluation of the energy efficiency of the machines is the possibility, through subsequent processing of the incoming signals by respective special methods, to obtain information in tabular and/or graphic form, which can allow a versatile evaluation of the effective usage of the machine. Especially useful is the graphic form of the information, which allows comparing very fast and easily different types of processes and modes of operation of the machine as a whole and of its separate aggregates.

In reality these considerable perspectives are possible in the presence of respective specialized methods and appropriate software, which can realize and present them. The interest of the users in obtaining comprehensive, fast and easily comprehensible information is huge, due to which the market offers systems, which provide information that is diverse in form and volume.

In conclusion it can be summed up that despite the problems, a sustained trend for development and usage / incorporation of

The **first one** provides the usage of information in current conditions in the mobile device. This makes the driver the main user of this information. In this case, however only a minor part of the potential of the information received, is used.

The **second scheme** envisages the retaining of information and its periodical capture and use in stationary conditions by experts and other users [8]. In particular, this is work with the system with stored/archived data. In this case, variations are possible where the driver does not have access to the information in real time and cannot follow certain information on the monitor during the working process, which is the more favorable case.

The **third scheme** enables the usage of data in real time and storage in an archive in stationary conditions by experts [9]. In this way the positive elements of the previous three systems are being united. Using this scheme is possible due to the application of the latest developments in information and communication technologies.

Of particular importance are such technologies as GPS, GPRS etc. In this case there are also possibilities, where the access to information may or not may be available to the driver with its advantages and disadvantages. This scheme can provide additional information for the position of the machine from a satellite navigation system, which creates conditions for improving the control of the energy efficiency of the machine.

Depending on the user and its characteristics, such as the number of machines, working conditions, sufficient information and others, there are different possible variations, all of which are applicable in reality. This conclusion is confirmed by the practice, which requires the market to offer different versions of control systems for energy efficiency.

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Without exaggerating, we can assume that in the coming years these technologies will become part of our daily activities. This gives us the grounds to pay more attention to their application in vehicles and more precisely - to improve their energy efficiency.

The conducted analysis, although limited in volume, indicates that the computer control systems for monitoring the energy efficiency should be based on the ability to measure the momentary fuel consumption, which will allow the realization of an operation regime of the system with sufficient accuracy in real time and from stored data. The first is necessary so that specialists can respond at any given moment in order to take control measures within a short period of time since the event has started (for example from 15 seconds to 5 minutes) and the second - to make the necessary processing and presentation of final results in a volume, shape and visualization satisfying the needs of professionals and allowing the quick and accurate evaluation of the effective usage of the machines.

Composition and characteristics of the system:
- flow meter RTG-2 with a portion volume of 40см³ and a maximum real total error below ± 1,5%;
- controller - electronic control and protection block;
- pulse counter located in the driver’s cabin;
- connecting cables - up to 5 m;
- supply voltage 12V, of the accumulator of the machine;
- duration of pulse accumulation by the counter - at least 45 days, depending on engine power and mode of operation.

System for evaluation of the fuel economy of mobile machines IIIOS ‘RTG-2.2_RUTER’ is of a higher class. In addition to the possibilities of the previous system, it allows the hourly consumption of the engine’s fuel to be monitored as well.

It consists of:
- flow meter RTG-2 with a portion volume of 40см³ and a maximum real total error below ± 1,5%;
- controller - electronic control and protection block;
- pulse counter located in the driver’s cabin;
- connecting cables - up to 5 m;
- supply voltage 12V, of the accumulator of the machine;
- work in two modes - real monitoring and continuous accumulation (for professionals);
- registered parameters:
  - in real time – the total quantity of fuel, working hours and hourly fuel consumption;
  - cumulative – the total fuel consumption, total hours of work;
  - duration of pulse accumulation of the counter - at least 45 days, depending on engine power and mode of operation.

Intelligent information and communication system IIIOS ‘RTG-2.3_RUTER’ is used to measure the regime and monitor the location (GPS / GPRS) of mobile and stationary machines, operating on liquid fuels - cars, tractors, trucks, road construction machinery, combines, burners, etc. This results in creating conditions for the rational use of machines and improvement of their energy efficiency (fuel economy).

The analysis of the received information allows:
- to determine the fuel-economic indicators of the machine in real time and and in an archive in hours, days, months and years;
- to evaluate the impact of the driving style of the driver on the fuel-economic indicators of the machine;
- to identify the uncontrolled diversion of liquid fuels;
- to identify uneconomical modes of operation;
- to carry out training of drivers aimed at achieving fuel economy;
- to perform preventive diagnostics and analyze the need for servicing the machine;
- to reveal and analyze routes and assess their necessity and effectiveness.

The system uses computer systems and information and communication links through which information is transmitted. Flow meters are controlled through a controller installed in the machine which accepts the data coming from them. Sensors are used to measure the frequency of internal combustion engines, the speed of motion, fuel consumption etc. The received information is transmitted using a transmitting device through GPRS connection to mobile operator, server and PC with receiving device.

It is processed and archived by specialized software. The parameters to be determined are momentary and average; hourly consumption of fuel Qh, fuel consumption per 100 km Qном, rotation rate of the crankshaft of the engine n, speed V; distance covered S; fuel consumption ΣQ; working time T; time for outage T0, etc.

The system provides information on the following parameters:
- total quantity of fuel consumed for real modes of operation, l;
- momentary and average-hour fuel consumption, l / h;
- momentary and average fuel consumption, l/100km;
- distance covered, km;
- working time, h;
- the location and routes done by the machine;
- the time during which these variables were measured.

The system works in two modes:
- in real time;
- in archive mode - information is stored by time of day, by days, by months and years.

The system comes complete with a program for presenting data from the measurement and visualization of results and a program for professional analysis of the results.

In order to facilitate and enhance the security of operation of the system in operational conditions, additional elements are provided for the automatic restoration of the traditional fuel-feeding system of the engine and the direct feeding of fuel.

This is recommended for special-purpose vehicles - tanks, oversized machines, buses, etc.. Control of the elements providing such possibilities are implemented in the previous two versions. Depending on the scheme for the realization of these possibilities, the prices of the respective options are specified additionally.

3. Conclusion

1. The above provides an analysis of computer control systems for monitoring the energy efficiency of mobile machines offered on the market and distributed in practice. The main options are being summarized as trends in the development and their usage, too.
2. The analysis shows that regardless of the type, the systems for control of the energy efficiency should be based on the momentary fuel consumption, which suggests its direct measurement.

3. The analysis gives ground for further work aimed at the implementation of different control systems for monitoring the energy efficiency and for carrying of appropriate theoretical, experimental and applied research.

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4. Literature

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