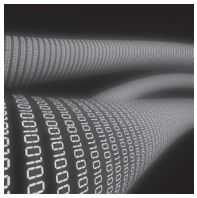

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Influence of satellite equipment control systems on economics of working machines operation using the example of excavators

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ABSTRACT

The paper describes the principle and operating range of currently used satellite monitoring devices of working machines. The paper presents some possibilities of satellite control systems of working machines. We analyzed the impact of satellite monitoring equipment work on the fuel consumption during the operation of excavators.

KEYWORDS: GPS controls, excavator, consumption of fuel

1. Introduction

One of the basic conditions for the selection of working equipment to various types of work is to make full use of ground and technology conditions. Moreover, the economics, reliability, availability, service and spare parts are very important.

In recent years diagnostic systems of working vehicles significantly expanded – caused a substantial increase in reliability. Elements of diagnostic systems are often installed on vehicles. These systems are designed to collect the information on performance of the basic equipment of excavators.

The scope of the built-in diagnostic systems for excavators has been considerably extended. In the equipment manufactured in the 90's the systems control parameters like the temperature of engine coolant, the engine oil temperature and pressure, the fuel level, the level of hydraulic oil dirt and indicators of various kinds of filters. The diagnosis takes now into account a much larger number of measurements [1].

Control parameters of the equipment produced in the 90's allowed only to protect the machine and the basic level was associated with a great machine operator's responsibility, which was somewhat parallel to the job of sensors analyzing. Measurements were not archived and reported hence a coming hardware failure could not be foreseen. In many cases such a situation resulted in the occurrence of major accidents and therefore in restraining it frequently for many days.

Current approaches to the excavator diagnosis are based on measurements of many more indicators such as the fuel consumption, engine load level, as well as the burden of work such as hydraulic excavators. Moreover, in modern devices, all operating parameters are archived and a periodic summary and analysis is possible. The spread of satellite navigation systems also allowed for an almost continuous transmission of data collected in an excavator to service centres. This resulted in the current situation of serious accidents of the equipment equipped with a satellite tracking system, leaving the mechanics of failure to know what to expect and have the information, what kind of spare parts may be needed during the repair.

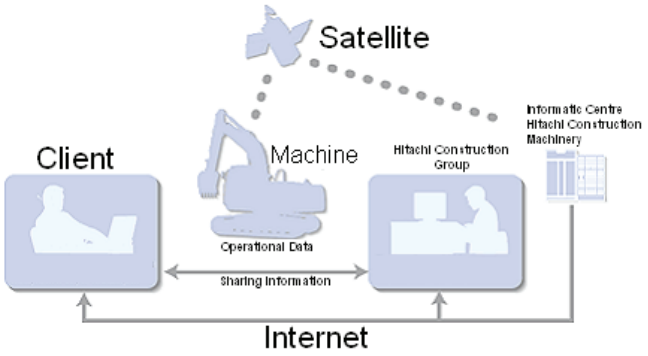

Fig. 1. Schematic representation of the principles of current monitoring systems of the work of diggers. Source: [2]

A schematic representation of the principles of current monitoring systems of the work of diggers is shown in Figure 1.

In addition, current systems used and their combination with wireless data transmission allows identifying quickly important parameters and transferring them to the dispatcher in real time.

KOMATSU excavators used in KOMTRAX allow tracking the following information [3]:

- Map of the location of the fleet
- Location of the machinery
- Driving condition
- Run time
- Remote engine start interlock
- Remote start the engine block at any given time
- A view on the monitor in the cabin
- Use of working equipment
- Hydraulic oil pressure. (excavator)
- Motive force (bulldozer)
- Maintenance intervals
- The maximum cooling liquid temperature
- Operating time of the machine
- The level of fuel in the tank
- Fuel consumption

Current systems beyond the control of satellite monitoring of the operation of the equipment itself also allow their remote immobilisation, which causes that the equipment is better protected against an unauthorized use.

2. Analysis of the benefits of the monitoring system of excavator work

The introduction of a range of devices monitoring the excavators working conditions and transmitting these conditions in real time to the dispatcher makes that the operator of such a machine is equipped with a nearly permanent scrutiny of compliance with established standards for loading wheeled, fuel consumption, the work on site, and compliance with working time.

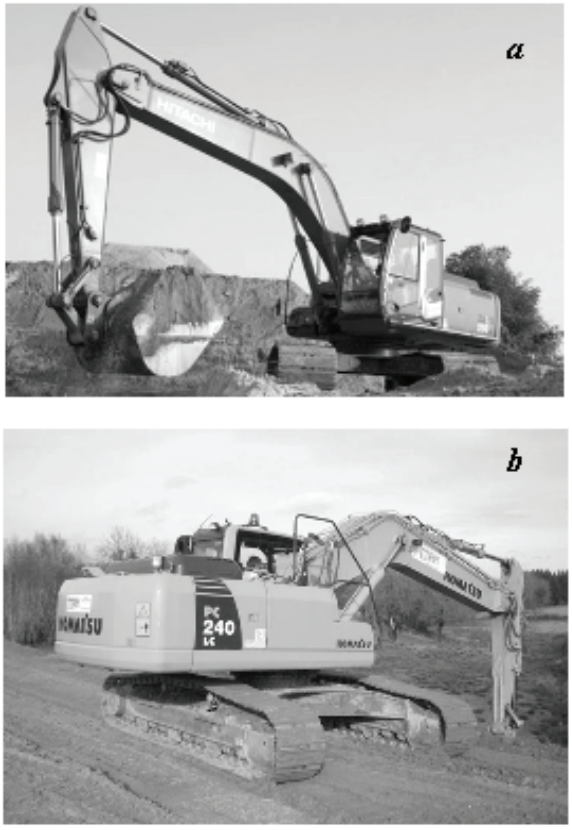

Fig. 2. Analysed excavators: a) Hitachi ZX250LC-3, b) Komatsu 240-8

The analyzed example of Company "X" involved in the implementation of water supply shows economic benefits of the introduction of excavators monitoring systems.

We analyzed two structurally similar – an excavator equipped with a GPS monitoring system and the other without such a system. Both excavators have engines of similar power. Both excavators worked very close –under field conditions within a construction site, and performed there very similar in terms of the load task. Analyzed excavator specifications are summarized in Table 1.

The weekly fuel consumption was analyzed for an

Table 1. Engine specifications of excavators analyzed Analyzed excavators are shown in Figure 2.

	HITACHII ZX 250 LC-3	KOMATSU PC 240-8
engine	Diesel, direct injection, turbocharged, liquid cooled, 4 cylinders, capacity. 5193 cm3	Diesel, direct injection, turbocharged, liquid cooled, 6 cylinders, capacity7961 cm3
power	132 kW (180 hp) at 2100 rpm	134 kW (180 hp) at 2000 rpm

Table 2. Normative fuel consumptions established by the user

	HITACHII ZX 250 LC-3	KOMATSU PC 240-8
Fuel consumption, dm3/h	9	11

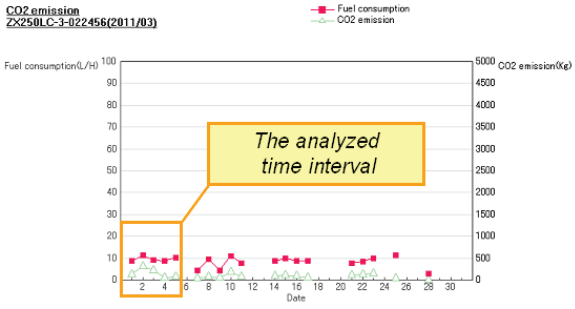

Fig.3. Fuel consumption by Hitachi excavator ZX250LC-3 in March 2011

excavator equipped with a monitoring system (Hitachi ZX250LC-3) and without such a system (Komatsu 240-8).

Operators of both analyzed diggers were not aware about the analysis. Operators knew, in which excavator the monitoring system was installed.

In order to compare the fuel consumption of two excavators manufactured by different producers on the basis of data collected during research as well as the information from the literature, the fuel consumption was calculated as deviation from the nominal values defined by the user as the norm[1]. Normative fuel consumptions of two analyzed excavators established by the user are shown in Table 2.

The study was conducted from 1 to 5 March 2011. The information on fuel consumption of the excavator equipped with satellite control system was read from the web site e-Service Owner's Site[1]. Charts showing the fuel consumption in the month of March for the excavator examined are shown in Fig. 3

The Hitachi e-Service Owner's Site information website could also give the information about the time of engine working, while driving excavator, working time, etc. This information is presented in Table 3.

The satellite control system also allowed reading the location of analyzed excavator. Locations of the excavator during tests are shown in Figure 4.

Table 3 shows that in the analysed period of time (1÷5 March 2011) the Hitachi excavator consumed 307 dm^3 of diesel fuel. During this period of time the excavator worked less than 31 hours (including travel time, time of preparatory operations.) This gave an average fuel consumption of 9.9 dm^3 / h.

The second of the analyzed excavators (Komatsu PC 240-8) was not equipped with a satellite control system. For that excavator the average fuel consumption was calculated based on the fuel supplied to the excavator and the number of hours worked. This information is presented in Table 4.

Table 4 shows that in the analysed period of time (1÷5 March 2011) the Komatsu excavator consumed 459.8 dm^3 of diesel fuel. During the analyzed period the excavator worked more than 35 hours (including travel time, time of preparatory operations.) This gave an average fuel consumption of 13.1 dm^3 / h.

Table 3.Works parameter of Hitachi excavator in the analysed period of time

Parameter	date	1	2	3	4	5
Engine ON, h	March 2011	6,00	10,60	9,20	2,30	2,70
Travelling time/Engine-ON Time, %	March 2011	11,50	12,90	13,50	15,40	10,40
Travelling time, h	March 2011	0,70	1,30	1,20	0,30	0,20
Non-operation hours during engin-ON, h	March 2011	3,40	4,40	5,40	1,40	1,20
Fuel consumed, dm3	March 2011	53,00	120,00	85,00	21,00	28,00
Fuel consumption, dm3/h	March 2011	8,70	11,20	9,10	8,80	10,30

Table 4. Parameters of Komatsu excavator work in the analysed period of time

Parameter	date	1	2	3	4	5
Engine ON, h	March 2011	7,00	11,60	9,30	2,50	4,70
Fuel consumed, dm3	March 2011	106	163,6	99,9	32	58,41
Fuel consumption, dm3/h	March 2011	15,10	14,10	10,70	12,80	12,40

3. Conclusion

The work of excavator equipped with a satellite control system was more economical in terms of fuel consumption than of the machine not controlled by satellite. The fuel consumption of the first machine differed from the normative consumption set by the user by + 10%, whereas in the latter case – by + 25%.

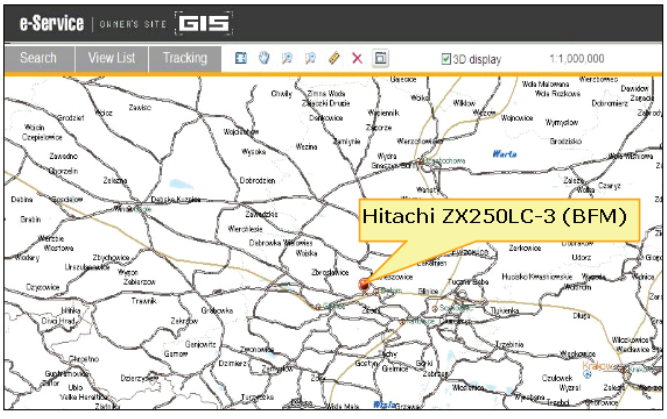

Fig.4. Location Hitachi ZX250LC-3 excavators during the test

The system of satellite equipment monitoring mobilizes operators to use rationally the power of targeted machines.

The satellite monitoring system contributes to increasing so-called culture of equipment service, which translates into its greater reliability and safety.

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