MEASUREMENTS OF OPERATING PARAMETERS FOR TRACTORS IN FOREST NURSERIES CARRIED OUT USING THE GPS SYSTEM[1]

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Abstract. The work presents the methodology of a measuring system for a tractor working in selected forest nurseries. The measuring system monitors the tractor's position using the GPS and acquires data from installed sensors. Obtained data will make it possible to specify in a precise way the annual use of the tractor and machines, to carry out an analysis of working time, driving style, tractor working speeds and fuel consumption while working with individual machines, skids of tractor drive wheels, tractor engine utilisation level. Obtained data will allow precise determination of machinery operation costs.

Key words: monitoring, the GPS, forest nursery

Introduction

Considering the planned increase of woodiness to 30% of Poland's total area and the need to deliver planting material for restocking and afforestation after natural disasters, it will be necessary to produce considerable amounts of planting material. So far, the organisation of work in forest nurseries has had random character, often without economic calculation. Subject literature on machinery operation in forest nurseries lacks in-depth information concerning the impact of work organisation, machinery utilisation, soil conditions, and machine operating parameters on the productivity of units and nursery production costs.

Machinery operating costs have considerable impact on nursery production costs, and thus on production profitability. In the agriculture of western countries the share of mechanisation costs in direct production costs reaches up to 40% (25-30% on average), depending on plant production trend, while in our country this share is within 30-70% [Karwowski 1998]. There are no analyses of this sort for forest nurseries. Thus, an important issue in the aspect of technology is to get to know the current level of expenditures incurred in the process of technological equipment operation in Polish forest nurseries [Słowiński, Walczyk 2000]. The purpose of this work is to present the methodology of research for the employed GPS system, which measures operating parameters of tractors working in forest nurseries.

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Methodology

In 2010, the chosen 5 forest nurseries were provided with a GPS monitoring system extended with an interface of inputs to measure operating parameters of a tractor with machinery.

The research covered permanent open forest nurseries in:

- Kłaj, Niepołomice forest division,
- Jodłówka, Brzesko forest division,
- Starachowice forest division near Lubień,
- Nowy Folwark, Kłobuck forest division,
- Kały, Turawa forest division.

Monitoring period is 2 years (2010-2011). Nurseries well equipped with machines were selected for the research. Monitoring service is provided by ELTE GPS seated in Krakow [http://elte.systemygps.com.pl].

The heart of the monitoring system is the vehicle on-board computer, installed permanently in the tractor. It is responsible for gathering information from the GPS receiver (position, speed and time) and sensors connected to devices monitored via vehicle memory - the so-called "black box". In this way the equipment records the distance covered by the tractor along with duration of stops, speeds reached, and the data received from sensors working in the system (e.g. recording of fuel level in the tank, etc.). Data saved in the "black box" is systematically transmitted to the base, and in this way the user (e.g. nursery forester) may follow the current position of its tractor and to carry out analyses and settlements for the tractor and drivers on completed tasks and working time. Information from the device memory is transmitted via GSM network to the service provider's servers. With the help of the operator's panel, the user is able to follow his tractor live using an internet browser (Fig. 1). Archival information is kept in a server for several months. It is possible to view history. In the discussed system the data is drawn from the company server. It may be browsed and analysed using a Microsoft Access spreadsheet. Information on tractor position and data from installed sensors is given in individual columns, and successive measurement time values in individual lines.

Depending on its provider, the service is executed using a WWW application, or it is necessary to install an application in the client's computer. Data recorded by a GPS computer allows analysis divided into specific events, including: runs, stops, start-ups of accessories, etc.

Vehicle on-board GPS computer consists of the following functional modules:

- GPS signal receiver module - this module, working with a GPS antenna, is responsible for receiving satellite signals, which allow determining tractor position with accuracy up to ca. 10 m, its movement direction and speed, and exact time. It is made in the form of a replaceable, individually functioning electronic OEM board.
- GSM/GPRS module as a module for data transmission from the vehicle on-board GPS computer to the server - an industrial modem with an antenna is used here. It is characterised by higher operating parameters adapted to the conditions in which it works (that is higher humidity and temperature differences in tractor cabs). It is provided with the most recent technologies developed by a leading mobile phone manufacturer. It is a

module with the potential of an industrial modem for telemetry, made in form of an independent, functionally replaceable electronic OEM board.

– "Black box" module - data is saved in records with programmable recording step (ranging from 1 to 255 seconds or every preset unit of distance covered by tractor). In the tests carried out, the recording takes place every second. The capacity of the "black box" is 100,000 records. Vehicle on-board GPS computer may be programmed so that e.g. every 1 minute it transmits current vehicle position to the server and, additionally, on selected days at preset hour it automatically transmits the whole "black box" content and then deletes from its own memory. It is also possible to set "black box" reading at certain memory filling level, or to define a criterion, which when met will initiate reading (e.g. entry into a specified area, arrival to the base). At any moment the user is able to read out data from "black box" on demand.
– Logic inputs module - this module allows controlling 7 logic signals (that is on/off type) in the vehicle, in which the on-board GPS computer is installed. Each of the inputs may be configured as either an information or an alarm input. Information inputs only save the state of a sensor installed in a given vehicle in the "black box" memory, while alarm inputs are those, whose sensor state change additionally initiates transmission of an alarm signal to the server. These inputs were not used during the research.

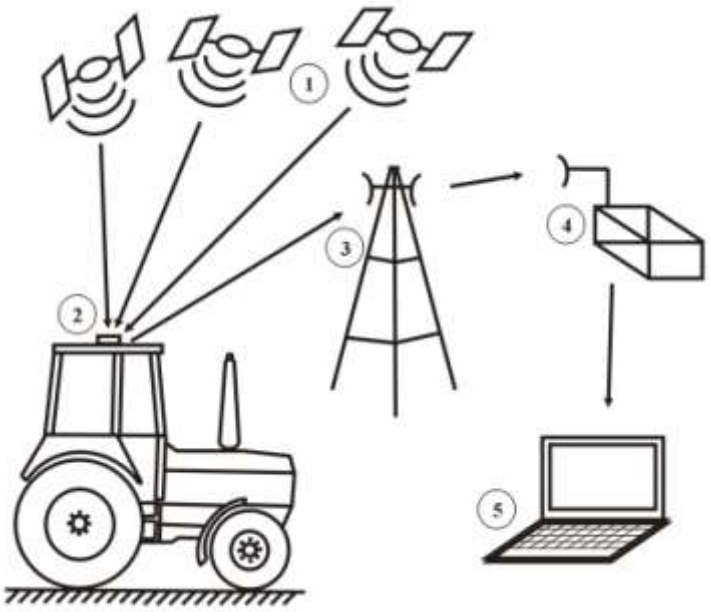

Fig. 1. Diagram showing the functioning of tractor monitoring GPS system: 1 – GPS satellites, 2 – vehicle on-board computer, 3 – GSM base station, 4 – the base, service provider's server, 5 – user's computer

Fig. 2. Vehicle on-board computer (ET-GSM-GPS) with antennas: GSM antenna to the left, GPS antenna to the right

– Analog inputs module - this module allows connecting 4 analog signals with measurement range within 2.5 - 35V, depending on the configuration. Data from these inputs is recorded with 10-bit resolution. Additionally, signals from these inputs may be averaged with a period set in the configuration file sent from the base. The following parameters were measured using these inputs: fuel volume in tractor tank, connection to fuel sensor, engine temperature, and temperature inside and outside tractor cab.
– RS-485 interface module - general-purpose communication interface, which allows connecting to the vehicle on-board GPS computer e.g. the following elements:
  - "OBRAZ" ["IMAGE"] attachment with outputs to 4 cameras used for sending black and white images at resolution 350x250, either on demand or cyclically in an automatic way, not used during the research;
  - fuel tank filler opening sensor, not employed because flowmeters measuring fuel consumption were used;
  - terminal with an alphanumeric display (4x24 characters) and a keyboard (Fig. 3). During the research this module was used to monitor data from sensors in the field and to identify machines working with the tractor. After having attached a machine to the tractor, the driver's task was to select via the terminal the approrpiate machine or operation. This significantly facilitates acquired data analysis.
– Meter inputs module - this module allows connecting to 4 digital (pulse) information signals. During the research, these inputs were used to measure the following:
  - actual distance covered by the tractor, carried out using the John Deere E235734 radar,
  - engine speed, one of the alternator stator winding outputs was used (output marked "W", current frequency at this output is the function of engine speed),
  - tractor drive wheels, inductive proximity detectors and disks mounted on hubs of tractor drive wheels were used,
  - fuel consumption measured using the Aquametro flowmeter, transmitting one pulse at flow reaching 5 cm^3.

– Logging inputs module - these inputs allow connecting 2 readers of the so-called DALLAS tablets. These tablets may identify tractor driver, not used due to low rotation of tractor drivers in forest nurseries.
– UPS module - the vehicle on-board GPS computer is equipped with own battery support for approximately 10 hours of work, which allows uninterrupted equipment operation in case of failure of main power supply from tractor battery (Fig. 4).
– An audio module - this module allows connecting a hands-free set consisting of a microphone and loudspeaker with adjustable volume. With this set it is possible to communicate with the tractor driver via a GSM module installed in the vehicle on-board GPS computer. This module has not been used and it seems dubious to use it during the operation of a tractor which is not properly soundproofed.

Fig. 3. Terminal with an alphanumeric display and a keyboard

Fig. 4. Fitting of the vehicle on-board computer with UPS module - installed permanently in tractor cab

Summary

The employed testing equipment works correctly, measuring selected operating parameters of tractors. There have been no problems with GSM data transmission from black boxes even though nurseries are often located in out-of-the-way areas in forests, far away from any buildings. The GPS antenna connected to the vehicle on-board computer receives signals from satellites at satisfactory quality level; no problems have been observed as regards determining tractor position.

This measuring system gives an opportunity to acquire large base of measurement data with the parameters of tractors operated not only in forest nurseries. In case of conventional measurements, to establish a database of this sort would be expensive and time-consuming. Research costs when using the proposed measuring system with the GPS are lower compared to conventional studies, as in the latter we have to add the costs of travelling to the examined nurseries and the time spent on it.

Bibliography

Karwowski T. 1998: Polska na drodze do Unii Europejskiej. Zespołowe użytkowanie maszyn warunkiem unowocześnienia polskiego rolnictwa. Przegląd Techniki Rolniczej i Leśnej. Nr 1. s. 2-6.

Słowiński K., Walczyk J. 2000. Metody filmowe w badaniach eksploatacyjno-technicznych maszyn szkółkarskich. Inżynieria Rolnicza. Nr 7. s.161-168

Oferta handlowa i parametry urządzeń do monitoringu. [online]. Kraków. Firma Elte GPS sp. z o.o. 2011. [dostęp 15.04.2011]. Dostępny w Internecie: http://elte.systemygps.com.pl/

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