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COMPUTER CONTROL AND MEASURING SYSTEM OF HWZ-3 ENGINE DYNAMOMETER

Summary

This article presents a project that contributed to the computerization of the obsolete measurement and control cabinet SPS-1, which is part of a test stand designed to determine the parameters of the engine in wheeled tractors. The test stand is located in the Department of Energy Systems Engineering at the University of Life Sciences in Poznań. Arduino platform was used as a built-in system, which enabled the exchange of information between the computer and the measurement and control cabinet along with the readout of analogue meter readings and the control of the engine dynamometer brake load. In order to clearly display measured parameters, proprietary applications were developed in the .NET environment, which in real time presents the results and graphs the speed characteristics of the engine. The implementation was carried out without violating the design of the test station.
***Key words**: modernization of the engine dynamometer HWZ-3, power take-off dynamometer, external characteristics of the wheeled tractor engine, built-in systems based on the Arduino platform*

KOMPUTEROWY SYSTEM KONTROLNO-POMIAROWY HAMOWNI SILNIKOWEJ HWZ-3

Streszczenie

Niniejszy artykuł przedstawia projekt, który przyczynił się do skomputeryzowania przestarzałej szafy pomiarowo-sterującej SPS-1, wchodzącej w skład stanowiska badawczego przeznaczonego do wyznaczania parametrów silnika w ciągnikach kołowych. Stanowisko badawcze znajduje się w Zakładzie Inżynierii Systemów Energetycznych Uniwersytetu Przyrodniczego w Poznaniu. Jako system wbudowany wykorzystano platformę Arduino, która umożliwiła wymianę informacji pomiędzy komputerem a szafą pomiarowo-sterującą wraz z odczytem wskazań analogowych mierników i sterowaniem obciążeniem hamulca hamowni silnikowej. W celu przejrzystego zobrazowania mierzonych parametrów opracowano autorską aplikacje w środowisku .NET, która w czasie rzeczywistym prezentuje wyniki oraz wykreśla charakterystykę prędkościową silnika. Implementacja została przeprowadzona bez naruszania konstrukcji stacji badawczej.
***Słowa kluczowe**: modernizacja hamowni silnikowej HWZ-3, hamownia wału odbioru mocy, charakterystyka zewnętrzna silnika ciągnika kołowego, systemy wbudowane oparte o platformę Arduino*

1. Introduction

In the 1980s, test stands designed to determine the basic parameters of the engine's operation were produced by Rolnicze Spółdzielnie Produkcyjno-Usługowe (Agricultural Cooperatives), located in Raszyn near Warsaw. Engine dynamometers, consisting of a measurement and control cabinet and a hydraulic brake, were intended for plants involved in the development of new engine construction, repair and testing of engine accessories. [1]
Engine dynamometers were and are still used to measure the torque transmitted to the crankshaft. The engine power is calculated using the torque value and crankshaft speed tested. The test results are significantly influenced by atmospheric conditions, such as: ambient temperature, air humidity, or atmospheric pressure fluctuations. It is assumed that as the temperature changes by 5 Celsius degrees, the power decreases by 1%. The currently obtained results of measurement tests have been normalized and are adjusted for normal parameters acc. DIN 70020. [2] The purpose of testing at test stands is to check the parameters achieved by the engine, including torque, power and their characteristics depending on the speed of rotation. During the measurements, it is possible to adjust and interfere with the engine parameters, adjust the ignition system or power supply for better performance. [3]

Determining the engine parameters for wheeled tractors is difficult due to the large mass and diameter of the drive wheels and chassis dynamometers may not always be used for that purpose. To determine the engine's operating parameters, P.t.o. type dynamometers are used in such machines; they allow direct connection to the power take-off. These types of dynamometers are quite limited and only allow to measure the power, torque and course of the characteristics of parameters in the function of the rotational speed of the crankshaft. P.t.o. dynamometers are not able to graph engine performance characteristics and measure its performance. [4]

2. Test stand

The Department of Energy Systems Engineering of the University of Life Sciences in Poznań is equipped with a test stand that allows determination of engine work parame-

ters for wheeled tractors. The stand consists of a hydraulic engine dynamometer HWZ-3 (Fig. 1) and a measurement and control cabinet SPS-1 (Fig. 2). It was produced by Rolnicza Spółdzielnia Produkcyjno-Usługowa in 1984.

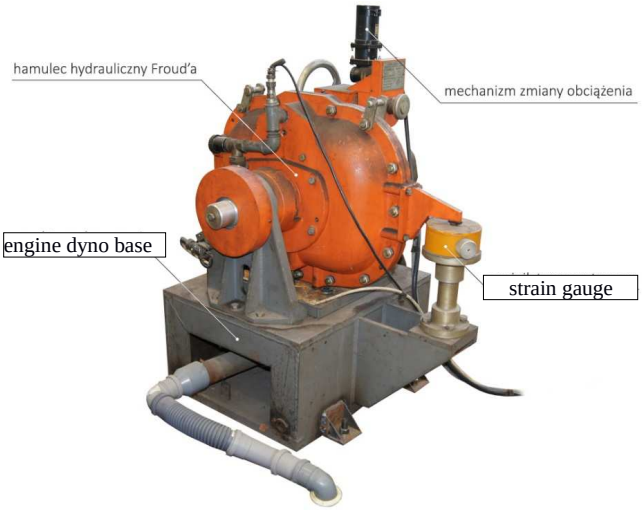

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Fig. 1. HWZ-3 engine dynamometer
Rys. 1. Hamownia silnikowa HWZ-3

Source: own studies / Źródło: opracowanie własne

Fig. 2. SPS-1 measuring and control cabinet for HWZ-3 engine dynamometer: a) view of measuring modules, b) interior view of cabinet
Rys. 2. Szafa pomiarowo-sterująca SPS-1 hamowni silnikowej HWZ-3: a) widok modułów pomiarowych, b) widok wnętrza szafy

HWZ-3 brake uses the system by means of which the value of wasted power on the brake can be read. The whole stand is also equipped with a signaling and blocking system that controls the correct operation of the engine. HWZ-3 brake uses hydraulic dynamometric brakes, operating on the principle of braking operation of a rotating water jet, which converts the engine's power into heat [5].

The SPS-1 measurement and control cabinet, which supports the HWZ-3 hydraulic brake, consists of five separate modules. The first of them plays an informative role and with the help of control lamps it indicates that the safe ranges of such parameters have been exceeded: too high engine speed, too high pressure of brake cooling liquid, too high engine coolant temperature, too high engine oil temperature. In addition, it is also responsible for signaling too low pressure of engine oil or brake fluid. The next three modules are equipped with analog meters, which are responsible for measuring the voltage in the DC circuits. The last module is responsible for the supply of individual cabinet circuits - access to fuses.

Unfortunately, over 30-year-old construction, based on simple semiconductor measurement systems, does not allow archiving results to digital form. The placed analog meters in the measurement and control cabinet enable only a momentary reading of indications during measurements. The test stand is not able to graph the engine speed characteristics. [6]

3. Communication interface

The mutual exchange of information between the computer and the SPS-1 measurement and control cabinet requires implementation of the appropriate interface. The flow of information scheme is shown in Fig. 3.

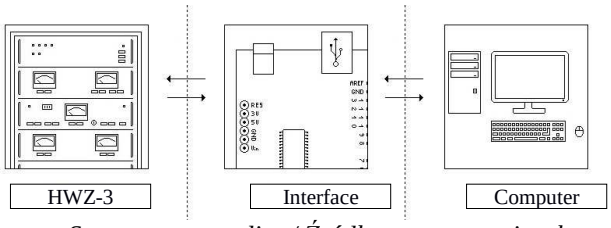

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Fig. 3. Information flow between the interface, computer and SPS-1 measurement and control cabinet
Rys. 3. Przepływ informacji pomiędzy interfejsem, komputerem i szafą pomiarowo-sterującą SPS-1

The Atmega 328P microcontroller placed on the Arduino UNO R3 development board was used as a communication interface enabling readout of analogue indicator states together with the control of the brake load of the HWZ-3 engine dynamometer. Price and ease of use are its main advantages. The Arduino platform communicates with the computer via the serial port (USB cable), and with the SPS-1 cabinet using analogue inputs. [7] The diagram of the discussed connections is presented in Fig. 4.

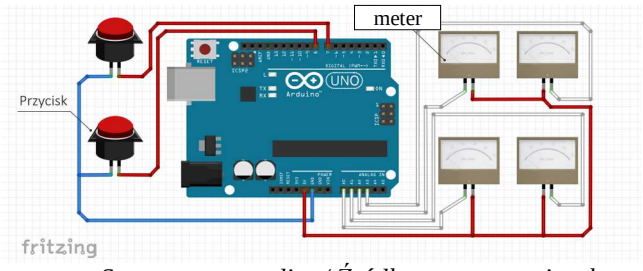

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Fig. 4. Diagram of connections between the Arduino platfrom and SPS-1 measuring and control cabinet
Rys. 4. Schemat połączeń pomiędzy platformą Arduino a szafą pomiarowo-sterującą SPS-1

The implementation of the communication interface connection took place in a non-invasive way, without violating the design and the electronic system of the SPS-1

measurement and control cabinet. For the needs of this communication, special cables have been prepared that allow direct connection to the indicators and buttons for changing the brake load. From the SPS-1 cabinet, four indicator states are read in real time (rotational speed, torque, pressure, temperature). The engine power is calculated by multiplying the speed of rotation and the torque of the tested engine on the hydraulic brake HWZ-3.

4. .NET application

All information obtained via the communication interface and the Arduino UNO R3 r is transferred to the .NET application installed on the computer. The application has been designed with a clear presentation of the data obtained and is easy to use. The application interface is shown in Fig. 5.

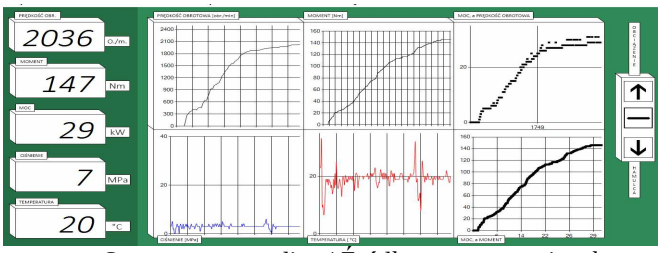

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Fig. 5. Control and measurement system of the HWZ-3 engine dynamometer – inteface
Rys. 5. System Kontrolno-Pomiarowy Hamowni Silnikowej HWZ-3 – interfejs

The states of all indicators, read from the SPS-1 control and measurement cabinet, such as: rotational speed, torque, power (calculated), pressure, temperature, are presented in a clear numerical form on the left, along with their units. In the middle, the status of individual indicators for the currently tested engine is determined. On the X axis, the time is counted, which is 10 reads per second, and on the Y axis the current status of a given indicator is presented. On the right side there are buttons responsible for reducing and increasing the load of the hydraulic brake of HWZ-3. The application also has a security that allows you to restore an accidentally broken connection between the computer and the interface, e.g. accidental removal of the cable from the computer's USB port, without the need to restart the application itself.

5. Summary

The implemented solution increased the accuracy of measurement readings and enabled the archiving of results along with graphing the speed characteristics of the tested wheeled tractor engine. The measurement itself is not fraught with human error in the form of improper reading of the states of individual analogue indicators. The states are graphed on a regular basis in a specially prepared .NET application, which allows analyzing the entire engine test cycle. The analogically mounted analog gauges in the SPS-1 measurement and control cabinet do not allow this because they present only one current measurement status [8].

The entire implementation does not violate the original design of the SPS-1 measurement and control cabinet. In the future, the project may be developed and provide such solutions as: wireless access to the cabinet's resources, comparing the characteristics of earlier research, a database with specific measurements, and many other helpful solutions.

From an economic point of view, thanks to the computerization of the test stand, the time of the entire testing process of the engine has shortened, the amount of fuel consumed per cycle has decreased, and thus also the emission of exhaust gases into the environment has been reduced.

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