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ANALYSIS OF INTERNAL COMBUSTION ENGINE SELECTED TEMPERATURE SENSORS DIAGNOSTIC TESTS AND ASSESSMENT OF THEIR TECHNICAL STATE

Kałaczyński T.[*], Łukasiewicz M.[**], Liss M. [***], Mazurkiewicz A. [****], Kozłowski R[*****]

Abstract: *Temperature sensors in a vehicle are an indispensable element. They are responsible for transmitting information to the engine controller about the temperature of the engine itself or other components affecting engine operation, ecology related to the emission of toxic exhaust compounds and driving comfort. The paper presents an issue concerning the methodology of analyzing the technical state of internal combustion engines selected temperature sensors*

Keywords: Sensor temperature, Technical state, Internal combustion engine.

1. Introduction

For many years, vehicle technology, sensors and actuators have been developed. Every day we use vehicles for efficient movement. Each vehicle is equipped with sensors. The newer the cars, the more sensors and measurement systems we notice. Currently, the cars we use include e.g. vehicles: with combustion engines, with electric motors and hybrids. Temperature sensors are used in each of these vehicles (Kałaczyński T. et al, 2018).. The information from these sensors is essential for the proper operation of the vehicle. Thanks to them, a number of situations related to, among others, the temperature of operating fluids, the temperature of exhaust gases or even the external temperature of the vehicle are performed. There are many types of temperature sensors. Each has different characteristics and scope of work.

Due to the wide range of applications, temperature sensors are perfect for motor vehicles. Their simplicity of construction and low complexity speaks for their use. For many years, temperature measurement technologies have been refined, but the laws of physics on which this measurement is based cannot be changed. The sensor, like any other element in the car, has the right to damage. Appropriate analysis and

* Tomasz Kałaczyński, PhD.: Faculty of Mechanical Engineering, Bydgoszcz University of Science and Technology, Al. prof. S. Kaliskiego 7, Bydgoszcz; PL, kalaczynskit@pbs.edu.pl.

** Marcin Łukasiewicz, PhD.: Faculty of Mechanical Engineering, Bydgoszcz University of Science and Technology, Al. prof. S. Kaliskiego 7, Bydgoszcz; PL, mlukas@pbs.edu.pl.

*** Michał Liss, PhD.: Faculty of Mechanical Engineering, Bydgoszcz University of Science and Technology, Al. prof. S. Kaliskiego 7, Bydgoszcz; PL, michal.liss@pbs.edu.pl

**** Adam Mazurkiewicz, Assoc. Prof.: Faculty of Mechanical Engineering, Bydgoszcz University of Science and Technology, Al. prof. S. Kaliskiego 7, Bydgoszcz; PL,adam.mazurkiewicz@pbs.edu.pl

***** Rafał Kozłowski, Ing.: Faculty of Mechanical Engineering, Bydgoszcz University of Science and Technology, Al. prof. S. Kaliskiego 7, Bydgoszcz; PL, rafkoz003@pbs.edu.pl

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interpretation of measurements allows you to diagnose the correct operation of the sensors (Żółtowski B. et al. , 2013).

When the sensor is damaged, the following symptoms may occur: uneven engine idling, increased idle speed, problems with starting the engine, stalling of the vehicle when moving off, increased fuel consumption, exceeding or failing to reach the operating temperature on the engine temperature needle, abrupt changes in the position of the needle engine temperature, the indicator light comes on. Possible damage to the sensor: internal short circuit, wire short circuit, wire insulation abrasion, wire breakage, mechanical damage to the sensor cube, mechanical damage to the connector, broken sensor pin, tarnished sensor pin.

Information about sensor damage can be deduced from the above symptoms. To find out if the temperature sensor is damaged, connect the diagnostic device to the OBD diagnostic connector in the vehicle (Łukasiewicz M. et al, 2014). Then confirm the fault by reading the faults. It is important to verify the correct operation of temperature sensors due to their impact on the thermal management of internal combustion engines and, at the same time, on operational and reliability parameters.

2. Methods

Electrical and electronic temperature sensors are used in vehicles to check the temperature of, among others: Coolant, Intake air and charged air, Exhaust gas, Fuel, External temperature.

The change in resistance in the temperature sensor is determined by expanding the non-linear function into a power series presented by the formula:

$$R_t = R_0 \cdot [1 + \alpha \cdot (t - t_0) + \beta \cdot (t - t_0)^2 + \gamma \cdot (t - t_0)^3 + \cdots] \quad (1)$$

Where:R_t – sensor resistance at temperature *t*, R_0 – Sensor resistance at reference temperature (assume 0°C), $\alpha, \beta, \gamma, \ldots$ – factors determined.

For the purposes of the work, a test stand was developed and built, equipped with elements ensuring work safety at the stand, executive and measuring elements are shown in Figure 1. There are among others: temperature controller, 2 temperature sensors used in motor vehicles, LM35 temperature sensor, universal multimeter, microprocessor system - Arduino UNO, liquid crystal display, front and rear cover and connecting cables.

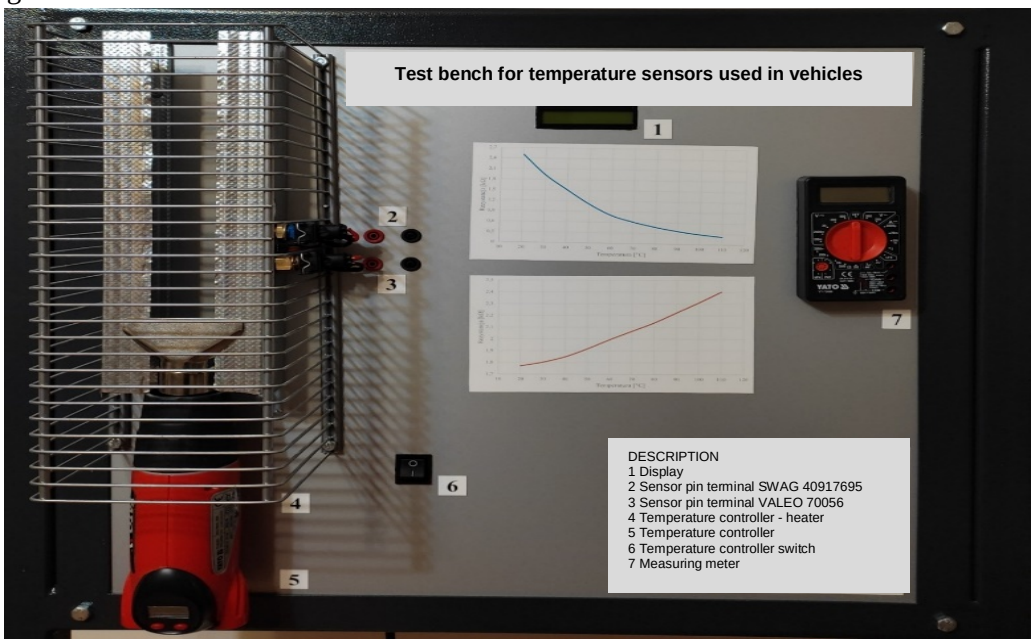
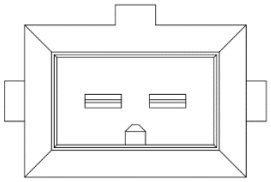
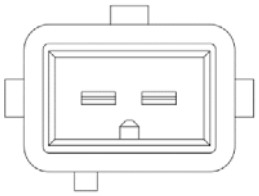


Fig. 1: Test bench.

Resistance temperature sensors were used for the tests to measure the temperature of the coolant in the engine cooling system. Such sensors are located in the small circuit of the cooling system. One of them is a VALEO PTC thermoresistance sensor. The second NTC thermistor is a SWAG sensor. Both of them are 2-pin sensors without power. The parameters of the sensors are shown in Table 1.

Tab.1. Characteristics of sensors used for research (Schneehage G. et al. , 2018).

Parameters	Sensor 1	Sensor 2
Mark	SWAG	VALEO
Model	40917695	700056
Numbers of pins	2	2
Colour	blue	brown
Wrench size [mm]	19	19
Thread dimension [mm]	M12	M14
Thread pitch [mm]	1,5	1,5
Switching on temperature [°C]	20	-
Sensor type	NTC	PTC
Mounting method	screw-in	screw-in
Weight [kg]	0,028	0,04
View of the connector		

The microprocessor system shown in Figure 2 was used to test the temperature sensors used in motor vehicles. For this purpose, the Arduino UNO R3 board was used. It has enough inputs and outputs for this project. Only analog connections were used. The measuring element, i.e. the LM35 temperature sensor, was connected to the board. In order to stabilize the results given by the sensor, a 100nF capacitor was used. The executive element was also connected, in this case the HD44780 LCD display via the I2C display converter.

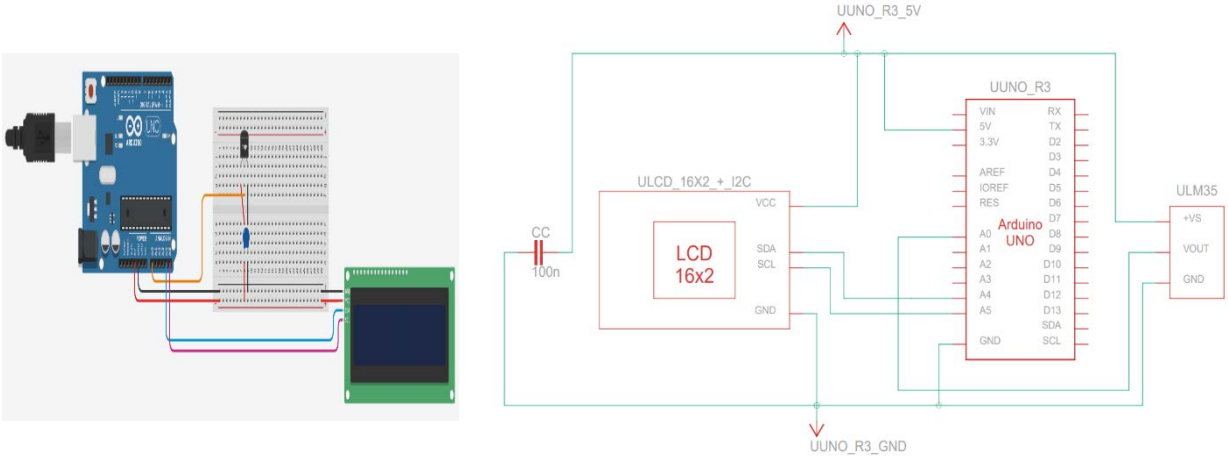


Fig. 2. View of the temperature sensor circuit (Schneehage G. et al. , 2018).

The program is based on the libraries that arduino offers in its application. To build the project, libraries were used that allow the program to use the HD44780 liquid crystal display and the I2C display converter. After using these libraries, you can display information from the LM35 temperature sensor. The display shows the actual temperature in °C.

Electrical components used in the stand for testing temperature sensors used in vehicles: Arduino UNO, printed circuit board with ATmega328 microprocessor, LM35 temperature sensor, 2x16 LCD display

with I2C converter, impulse power supply transformer 230V/9V, YT-82293 temperature controller with adjustable blowing force.

Determination of the performance characteristics of the sensors was made on the basis of resistance measurements for given temperatures of sensors used in motor vehicles. Figure 3 presents the obtained operating characteristics of the SWAG 40917695 and VALEO 700056 sensors.

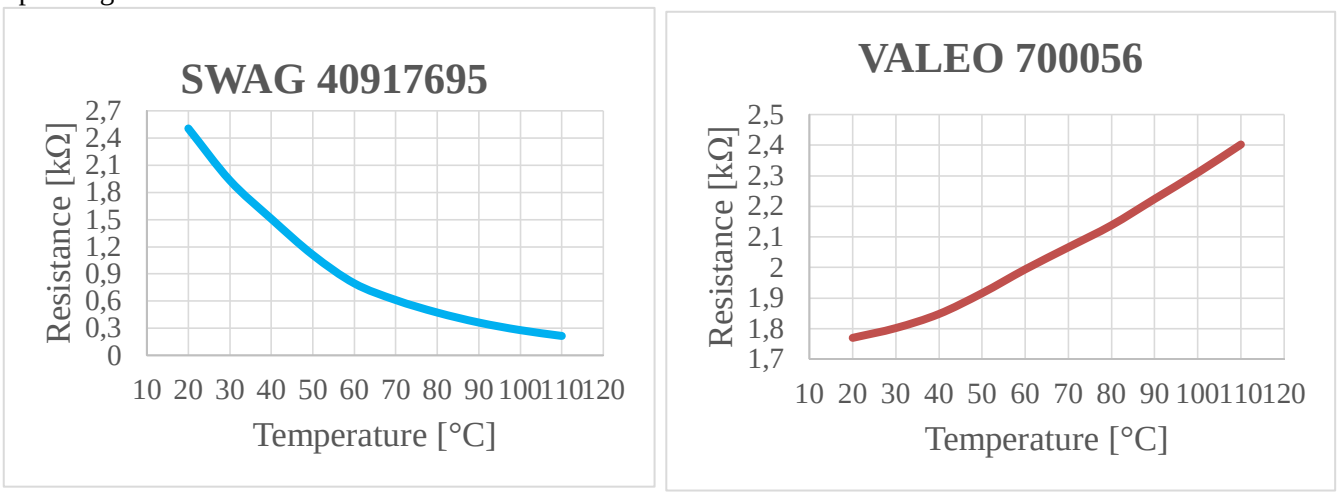


Fig. 3. Characteristics of the sensor.

As the temperature increases, the resistance of the sensor decreases. This action is characterized by the NTC sensor. As the temperature increases, the resistance of the sensor increases. This action is characterized by the PTC sensor.

3. Conclusions

The paper presents the essence of assessment the temperature sensors technical state used in internal combustion engines of motor vehicles. Correct operation of the sensors regulates the characteristics of the engine operation and has a significant impact on the operating parameters and the environment.

The stand for testing temperature sensors used in motor vehicles, developed for the needs of the work, is a technical project. It is designed for laboratory tests on temperature sensors used in motor vehicles to verify their technical condition.

There is a need to carry out further research aimed at verifying the heat balance of internal combustion engines implemented in technical object due to the monitoring of thermal management and their impact on the operation process and reliability.

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