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ANALYSIS OF THE DIAGNOSTIC POTENTIAL THERMOVISION RESEARCH IN THE TECHNICAL CONDITION ASSESSMENT OF SPARK IGNITION ENGINES INJECTORS

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ABSTRACT

The paper presents an analysis of the possibilities of implementing thermographic tests in the process of assessing the technical condition of spark-ignition internal combustion engines. Presented method is an innovative approach to diagnosing the condition of injectors used in spark-ignition internal combustion engines. Presented non-installation method of assessment injectors technical state uses measurements of accompanying processes such as heat generation by their working elements. The use of thermovision cameras allows direct verification of the injectors state. The work is a continuation of the implementation of thermovision tests in the assessment of the technical condition of internal combustion engines implemented by the authors.

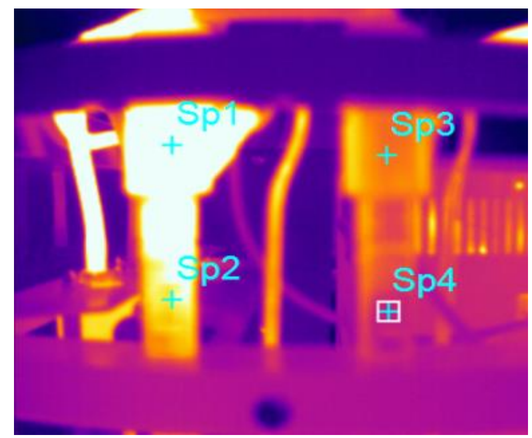
PLAN OF WORK

Introduction

Methods

Results

Conclusions



INTRODUCTION

An important element of the fuel supply systems used in spark-ignition internal combustion engines responsible for controlling the quality of fuel supplied to the cylinders are injectors. Attention should be paid to the problem of diagnostic susceptibility of working elements used in fuel supply systems for internal combustion engines. The process of assessing the technical condition of injectors consists mainly of disassembly and verification of injectors at measuring stations. It is a time-consuming method and requires specialized equipment. Therefore, there is a need to propose an innovative method of assessing the technical condition of injectors that would allow non-invasive assessment of the condition of injectors in spark-ignition engines.

INTRODUCTION

Research carried out in the field of implementing thermal imaging tests for assessing the technical condition of internal combustion engines by the research team being the authors of this publication clearly indicates that thermal imaging tests are a good non-dismantling method for assessing the technical condition of technical objects. This method uses a special type of television that records the heat emitted by objects in its field of vision, more precisely - the emission of infrared radiation. By measuring the infrared radiation emitted by a given body, we measure its temperature (Łukasiewicz M. et al, 2018). The diagnostic potential of thermovision tests should be assessed in assessing the condition of the spark-ignition internal combustion engine injectors.

METHODS

Analysis of the scope of use of injectors in fuel supply systems used in spark-ignition internal combustion engines indicates that the most used injectors are electromagnetic injectors. Verification of the principle of operation of electromagnetic injectors, which depends directly on the control currents, indicates the need for correct response of the injector components to the setpoints (Heiko P. 2016). Damaged injectors generate incorrect work of internal combustion engines with spark ignition which adversely affect the achievement of the required values of operating parameters and the environment (Ligaj B. et al, 2016).

The paper presents the implementation of the injector condition assessment procedure based on thermovision measurements. Stand tests were carried out at the stand for verification and cleaning of electromagnetic injectors LUNCH INJECTIOR CLEANER & TEST shown in Figure 1. This position enables verifications at which time duty cycle, the injector coil begins to work, the way fuel atomization, test to overflow, leak test and conduct ultrasonic cleaning of injectors.

METHODS

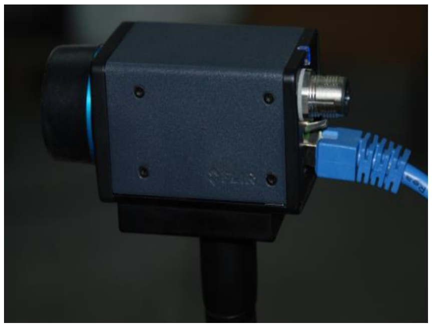


Fig. 1: Test stand

The test stand was equipped with petrol injectors from a Nissan X-trail vehicle used in 2500 cc engines, while the test stand was equipped with a FLIR AX5 camera for continuous thermal imaging measurements.

Based on the initial tests, the test conditions were established:

- ambient temperature 25°C,
- measuring distance 50cm,
- 2.4 ms injection time,
- rotation speed 800 rpm

RESULTS

First, state of the injectors was verified by overflow test. The measurements showed that the injector No. 4 gives much less fuel, which may indicate that it is dirty. The measurement results are shown in Table 1. Then, thermographic measurements were carried out during the operation of the injectors according to the following methodology. The injection system was running for 20 min. During the work, the injector temperature was read every 5 minutes. Readings were taken in three measurement series; the results are presented in Table 2

Tab. 1: *Results of the overflow test*

Test	Injector 1	Injector 2	Injector 3	Injector 4
1	60 ml	62 ml	59 ml	45 ml
2	61 ml	60 ml	61 ml	48 ml

series I						series II						series III					
camera FLIR AX5																	
Time (min)	0	5	10	15	20	Time (min)	0	5	10	15	20	Time (min)	0	5	10	15	20
I	25.6	30.2	31.5	33.8	35.5	I	25.8	30.2	31.8	33.3	35.4	I	25.1	30.1	31.4	33.9	35.7
II	25.4	29.9	31.9	34.0	34.8	II	25.7	29.9	32.2	34.1	34.9	II	25.2	29.8	31.7	34.2	34.9
III	25.5	30.5	32.2	34.5	35.2	III	25.6	30.5	32.6	34.3	35.5	III	25.2	30.6	32.4	34.4	35.3
IV	25.4	32.1	36.4	38.3	45.2	IV	25.9	32.1	36.9	38.7	45.4	IV	24.9	32.5	36.6	38.7	45.6

Tab. 2. Temperature measurement results

RESULTS

The results of thermographic measurements clearly confirm that there is a relationship between damage to the injector and its operating temperature.. After cleaning and overflow test, the injector showed the same parameters as efficient injectors during the first test. The results of the overflow test after cleaning are shown in Table 3.
Then the thermographic tests on the injectors were repeated to verify the temperature of the injector after regeneration, the test results are presented in Table 4.

Tab. 3: *Results of the overflow test*

Test	Injector 1	Injector 2	Injector 3	Injector 4
1	60 ml	62 ml	59 ml	58 ml
2	61 ml	60 ml	61 ml	59 ml

series I						series II						series III					
camera FLIR AX5																	
Time (min)	0	5	10	15	20	Time (min)	0	5	10	15	20	Time (min)	0	5	10	15	20
I	25.3	30.3	31.4	33.7	35.4	I	25.7	30.3	31.7	33.4	35.5	I	25.2	30.3	31.8	33.3	35.6
II	25.5	29.5	31.5	34.1	34.7	II	25.6	29.8	32.3	34.3	34.8	II	25.3	29.7	31.6	34.7	34.8
III	25.2	30.7	32.7	34.6	35.3	III	25.5	30.6	32.8	34.6	35.4	III	25.5	30.5	32.5	34.8	35.4
IV	25.4	30.4	32.4	34.6	35.5	IV	25.9	30.1	32.9	34.7	35.4	IV	24.9	30.4	32.5	34.3	35.4

Tab. 4. *Results of temperature measurements after regeneration*

RESULTS

Analysis of the obtained results allows to determine the accuracy of the measuring device, as well as to verify the dependence of the temperature gradient increase at the measuring points. The test results presented in the tables are measurements at the selected point. Detailed analysis requires propagation of thermal energy flow in the injector based on the analysis of thermographic images. Figure 2 presents selected results of thermovision examinations of injectors. FLIR Tools software was used to analyse thermographic images. The main software dialog window is shown in Figure 3.

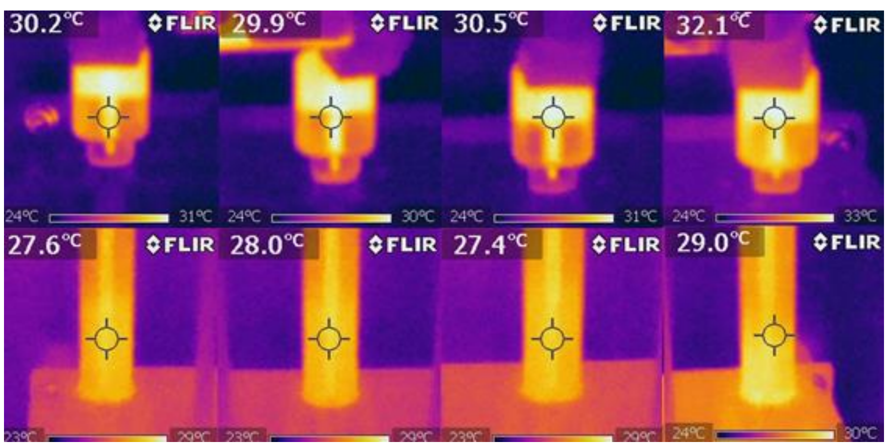


Fig. 2: Selected test results for the thermovision camera

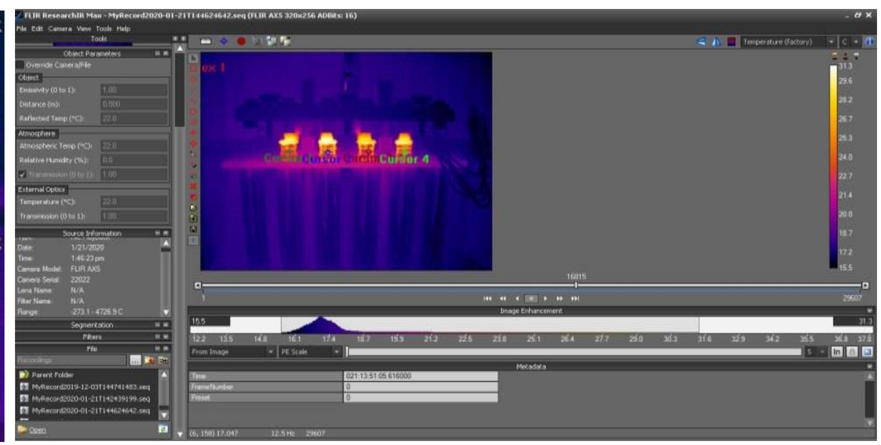


Fig. 3: The main FLIR Tools software dialog box

RESULTS

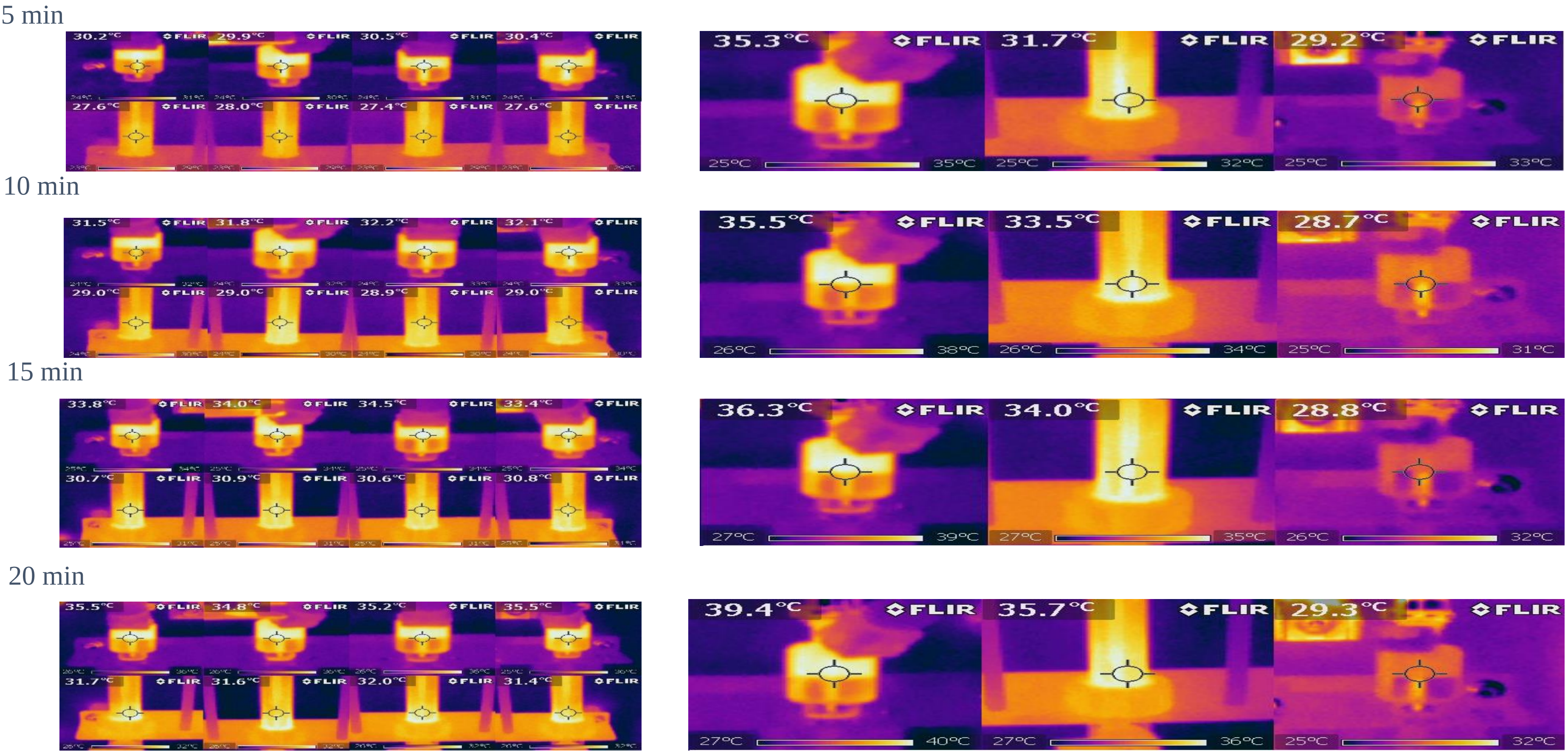


Fig. 4: Selected test results for the thermovision camera

CONCLUSIONS

The paper presents the process of verifying the technical condition of injectors with the use of thermovision tests, which were verified to confirm the results of the tests.

The implementation of thermal imaging tests makes the temperature correlation unambiguous with the change in the technical condition of the injectors being components of internal combustion engines.

The method of thermovision testing is an ideal tool that can be used in an innovative methodology for assessing the technical condition of spark-ignition internal combustion engines.

There is a need to improve thermal imaging tests in the areas of technical object assessment and to develop diagnostic procedures considering the minimum acquisition and validation of measurement data aimed at increasing the operational efficiency and reliability of technical objects.

THANKS FOR YOUR ATENTION

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