УДК 62-1/-9:62-7

BADIDA Miroslav, Dr.h.c. prof. Ing., PhD.
DZURO Tibor, Ing.
FRANKO Štefan, Ing., PhD.
Technical Univerzity of Košice, Faculty of Mechanical Engineering, Department of Process and Environmental Engineering, Park Komenského 5, 042 00 Košice, Slovak Republic

UTILIZATION INFRARED THERMOGRAPHY IN THE AUTOMOTIVE INDUSTRY TO DETERMINE FAULTS BY USING THERMAL CAMERA FLUKE Ti10

The contribution deals with the problem the use of thermovision in the automotive industry to fault diagnosis. Thermovision shows the decomposition of temperature field to surface of the body in the infrared region spectrum that the human eye to see, and are therefore currently thermovision is considered a very useful tool for predictive maintenance. The main ways to benefit from thermovision in the automotive industry for example motor control, ignition and set the air-fuel ratio, check cooling systems, thermostats, coolers, catalytic converters, brakes and tires, checking climate control.

Keywords: *thermovision, automotive industry, measurement, thermal camera, software*

1. INTRODUCTION

Currently, cars older than 10 years show a larger degree of mechanical damage, especially engine components, which in a larger scale leads to a failure of the engine parts, whether external or internal [1, 2]. This stems mainly from the heat, friction and compression stress of these parts. We have worked with gasoline internal combustion engine to solve the problem, which showed signs of poor compression, poor performance, incomplete combustion and increased emissions. [4] We tried to make a diagnosis [12, 8] without dismantling the internal combustion engine components such as cylinder head, cylinder head cover, exhaust heat shield and engine intake and exhaust manifold [6, 16, 22, 23]

2. THE TEST SEQUENCE

Prior to each thermal imaging, detailed mapping of surroundings conditions and location of thermal imaging measurements takes place. There has been an external air pressure, wind speed, relative humidity and ambient temperature. [7, 23] The object of measurement, given the state it was in, did not present any signs of surface moisture and due to its location in the engine compartment, there were no significant effect of wind, which at the time of the thermal imaging test amounted to 4 $km.h^{-1}$.

The subject of thermal imaging measuring has been a gasoline combustion engine type Z5-DE DOHC 16V Mazda production, made in 1998 (Fig. 3). With the help of thermal camera Fluke Ti10 (Fig. 4) measurements were conducted in a continuous sequence, in 14 minutes time frame at a image frequency of 10 seconds per one infrared image [5, 13]. Thus we provided detailed mapping of the heat areas of engine block, cylinder head and exhaust manifold (Fig. 1) for identifying troubled parts of the internal combustion engine. Testing took place at ambient temperature of 17 °C.

Measurement was carried out on the premises of the Technical University of Košice (Park Komenského No. 8) (Fig. 2).

The above mentioned internal combustion engine was completely cooled at the beginning of the test, so any thermal changes could be mapped without affecting the surrounding objects which could create reflective radiation on the surface of the measured object and also to avoid error concealment during the heat transition from already heated parts of the internal combustion engine.

Engine block

Cylinder head

Exhaust manifold

Fig. 1 View of realized parts of a passenger car [3]

Fig. 2 Map of grounds of the Technic University with highlighted measurement point

Fig. 3 Mazda 323F [3]

A problem area was mostly the cylinder head and exhaust manifold, on which we have focused in the measurements. After starting the internal combustion engine, detailed records of engine surface temperature, ambient temperature in the vicinity of the combustion engine were conducted and the emphasis was put on the absence of any objects in close proximity, which could adversely affect the thermal imaging photography of the subject.

Following (Fig. No. 4) describes part of Fluke Ti10, which was used in the practice of thermal imaging measurements. [3]

Fluke Ti10 is the perfect device that will strengthen the arsenal of funds for repairs and maintenance. Due to the fact that it has been designed for use in harsh operating conditions, this is a powerful, fully radiometric imagers are ideal as a means for finding problems. [3]

There has been created a sequence of 84 termovision frames from the start of the engine to its full heating and opening of the second cooling circuit. At the moment when the second cooling circuit began to cool with a fan on the radiator coolant, thermal imaging measurements have been completed and the results stored on the storage medium, later processed using Smart View software (Fig. 5). [8, 14, 15]

Fluke Smart View software is part of the Fluke Ti10. This powerful software is a modular suite of tools that annotates, views, edits and analyzes IR images. It also creates in a few simple steps to report fully customizable and professional-looking. [3]

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Fig. 4 Thermal camera Fluke Ti10 [4]

3. EVALUATION OF THERMAL IMAGING MEASUREMENT

As authorized service personnel expected, engine showed signs of damage or defects during the test drive, whose diagnosis would mean dismantling the engine and even that would not ensure the accuracy of diagnosis only by visual assessment or assessment by measuring instrumentation from car service equipment. Time-consuming service diagnostics thus turned into a matter of several minutes.

In the evaluation, we focused mainly on the image of fully warm engine, on which were clearly visible deficiencies. It was mainly a thermal anomaly in exhaust pipe area on 4. cylinder (Fig. 6). Due to the fact that the engine in the emission test showed increased emissions and noise from the exhaust pipe, we concluded that the problem is just the fourth cylinder on the basis of exhaust pipe infrared images, which showed a lower temperature compared to the other three pipelines under the heat shield (Fig. 7).

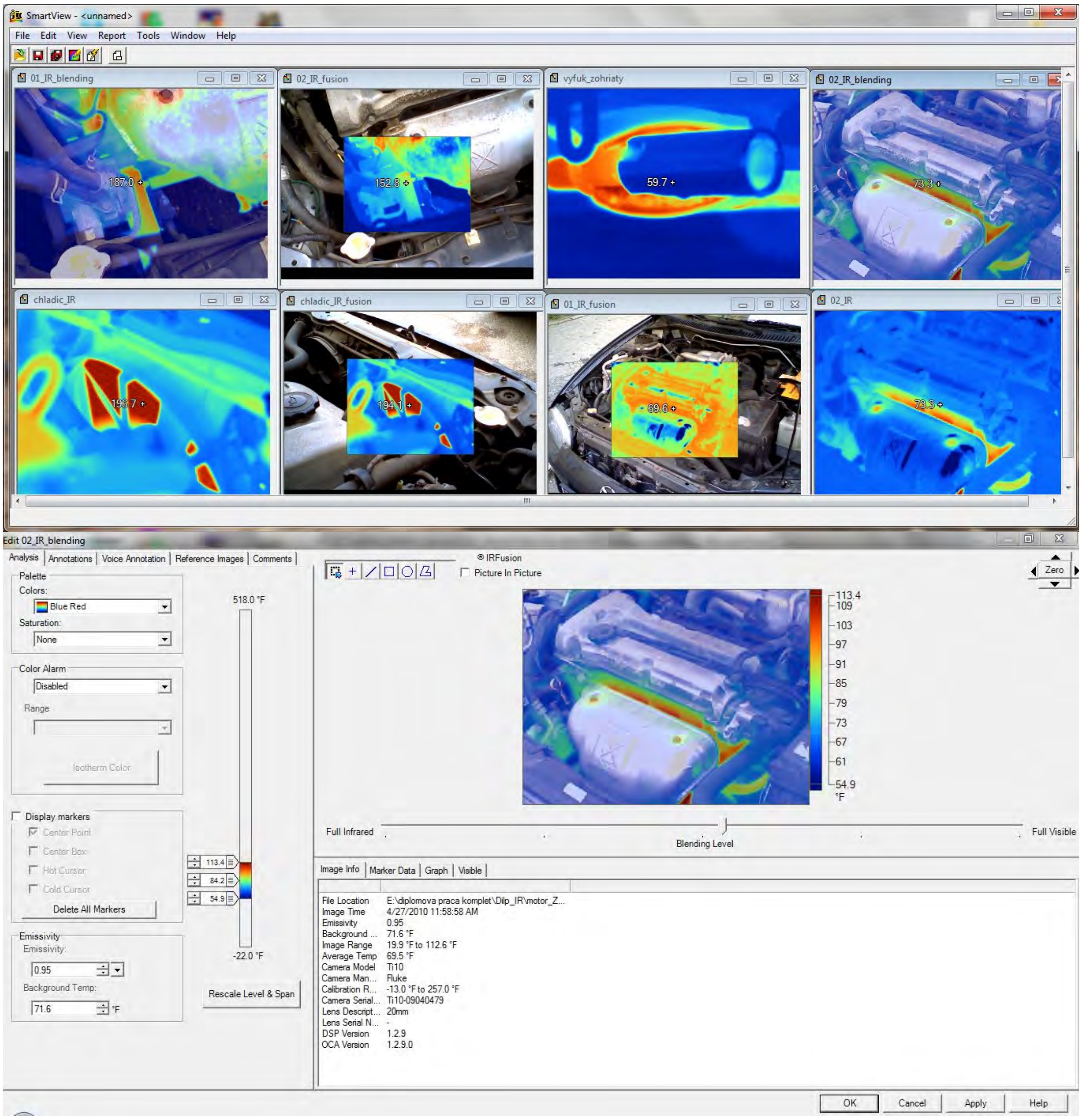

Fig. 5 Smart View software [3]

Fig. 6 Visible light image [3]

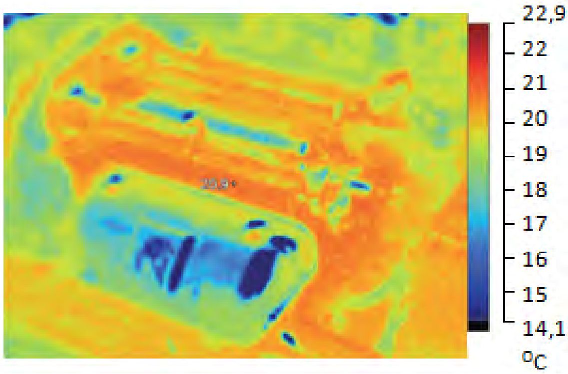

Fig. 7 IR-fusion.IS2 [3]

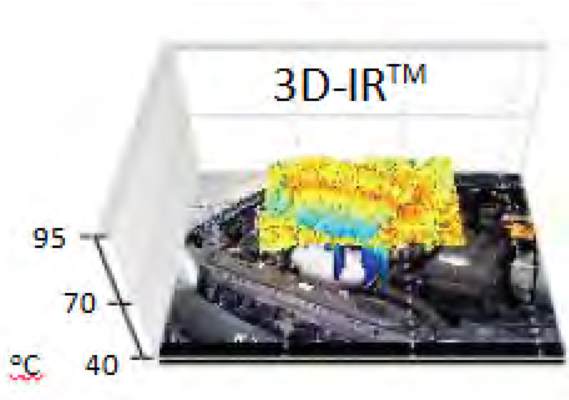

Fig. 8 Graph [3]

Fig. 9 IR-Image [3]

In table 1 shows the color display of the potential danger places.

Tab. 1

Colorful display of potential danger places

Color	**Surface moisture**	**Assessment**
Green	0...64 %	not critical
Yellow-orange	65...80 %	potentially critical
Red	> 80 %	critical

Heat values were compared and reported in the table 2 and 3 for the needs of authorized service.

Tab. 2

Main Image Markers

Name	**Average Temperature**	**Emissivity**	**Background**
Center point	67,5 °C	0.95	17 °C

Tab. 3

Image Info

	IR-fusion.IS2
Background Temperature	17 °C
Emissivity	0.95
Average Temperature	67,5 °C
Image Range	10 °C - 105 °C
Camera Model	Ti10
Camera Serial Number	Ti10-09040479
Lens Description	20 mm
OCA Version	1.2.9.0

Manufacturer	Fluke
DSP Version	1.2.9
Lens Serial Number	-
Image Time	17/4/2010 12:17:19
Calibration Range	-25.0 °C - 125.0 °C

There have been two options for cooler pipe on 4. cylinder - a bad fuel injector, or bad fuel ignition. Therefore, testing of the ramp injections took place through injection nozzles and its seals because of the possible fuel leaks, or due to clogging of injection nozzles. Problem was not confirmed at this point. The next step was to test the engine compression without combustion process and engine oil analysis for the presence of fuel. Compression was standard, as specified by the manufacturer of internal combustion engine, but the oil showed a small representation of unburned gasoline. This test was done by a authorized service. [4]

The last option of an error was electric ignition system. As the automotive ignition system is designed differently from normal electrical systems, it is difficult to diagnose the problem by thermo vision. Therefore, the diagnostics using an electrical measuring instruments took place. Ignition wires and resistance values were diagnosed, which had to satisfy the manufacturer values for one meter length. This test was successfull.

Subsequently, the test moved to diagnose spark plugs and distributor. The problem arised in this area, because the primary and secondary winding of distribution coil was off the manufacturer's specified values, resulting in a poor running engine and low power, but the problem that caused the bad combustion process on the 4th cylinder was the head of the distributor with damaged pin for power supply to the ignition cable and spark plug. After replacing these parts and reset of the engine control unit, this error did not repeat, and the engine has not only improved performance, but also emission rates and combustion temperatures. [5, 9, 11]

4. CONCLUSION

Thermovision is widely used modern method used in the diagnosis, but also the development of monitoring and management of production processes, which is based on sensing and imaging of temperature fields. Therefore, the world's leading manufacturers of thermal-vision techniques are developed and used increasingly sophisticated and sophisticated systems intended for the area of thermal diagnostics. More recently precisely these efforts thanks technical level and its availability was subject to rapid development of this technology.

As can be seen on the results and measurement process, thermal imaging is of great importance in the diagnosis of machinery faults without the need to shut down or disassemble such a device. There are no increased costs caused by replacing seals that need to be changed during disassembly. Infrared photography is a good way for rapid diagnosis and determination of defects and contributes not only to the correct estimation of an error, but also to further smooth operation of equipment.

REFERENCES

[1] BUGÁR, T.: Experimentálne metódy a technická diagnostika, Košice, SjF TU Košice, 2000

[2] CHUPÁČ, M.- ŠIMKO, M.: Termovízia a jej využitie v praxi. Publisher: EDIS – ŽU, 2007.110 s. ISBN 80-8070-654-8.

[3] DZURO, T.: Diplomová práca. Technická univerzita v Košiciach, Strojnícka fakulta, Katedra environmentalistiky 123 p. Katedra environmentalistiky a riadenia procesov, 2010.

[4] Fluke Ti10 Infrared Camera. Available on the website: http://en-us.fluke.com/products/infrared-cameras/fluke-ti10-infrared-camera.html

[5] FRANKO, S.: Návrh metodiky identifikácie energetických únikov budov pomocou termovízie. Dizertačná práca. Technická univerzita v Košiciach, Strojnícka fakulta, Katedra environmentalistiky 189 p. Department of Environmental Studies, 2012.

[6] KADLEC, K. Available on the website: http://www.vscht.cz/ufmt/kadleck.html

[7] KREIDL, M.: 2005: Měření teploty. Senzory a měřící obvody: vyd. BEN: Praha: ISBN 80-7300-145-4

[8] KUČERA, M., ŠEBOK, M., KUČERA, S.: Spoľahlivosť telekomunikačných zariadení z hľadiska EMC. Nové smery v diagnostike a opravách elektrických strojov a zariadení. Žilina 2006

[9] MICHALÍK, J., ŠIMKO, M., ŠEBOK, M.: Diagnostics of Electric Machines. Zborník z konferencie ELEKTRO 97, Žilina

[10] NOP, D., BRADA Č, A., NOVÁK, L.: Vybrané statě z dopravního inženýrství, Brno, Vysoké učení technické Brno, 1989

[11] NOWICKI, A.N.: Infrared Thermography Handbook, Volume 1: Principles and Practice. 2005, Norman Walker, ISBN 9780903132338. Volume 2: Applications. 2005, BINDT, ISBN 9780903132338

[12] OLESÍK, J.: Využitie termovízie v technickej diagnostike v elektrárňach. Zborník z prednášok 1. medzinárodnej vedeckej a odbornej konferencie, Žilina p. 104 - 9, 1996

[13] RICHARDSON, M., & SCHOLER, R.: (1999, November), "The capabilities of thermal imagers", Fire International, 30-31

[14] ŠEBOK, M., ŠIMKO, M., CHUPÁČ, M.: Measurement of Antenna Systems Transfer Resistances. 4. International Conference on Measurement, Smolenice, 2003, p. 399 - 402, ISBN 80-967402-6-1

[15] ŠIMKO, M. – ŠEBOK, M. – CHUPÁČ, M.: Využitie infračervenej techniky v diagnostike. In: Medzinárodná konferencia TD-2000 DIAGO, Zlín

[16] ŠIMKO, M., CHUPAČ, M.: Aplikačné možnosti termovízie v praxi. časopis ELEKTRO č. 1, s.36 - 40, Česká republika, 2006, ISSN 1210-0889

[17] ŠIMKO, M., MICHÁLIK, J., ŠEBOK, M., PEVNÝ, M.: Thermovision in Medicine Possibilities of Usage. International Scientific Conference Elektro, 1999, ŽU Žilina, p. 129 - 132, ISBN 80-7100-605

[18] SmartView software. Available on the website: http://www.fluke.com/fluke/uken/Products/category.htm?Category=ACC_SOFT&Parent=ACC

[19] SVOBODA, J.: Bezdotykové meranie teplôt - Termovízie. Dni novej techniky, Žilina 1999

[20] SVOBODA, J.: Využívanie infračervenej techniky v procese diagnostického sledovania strojov a zariadení v prediktívnej údržbe. Dni novej techniky, Žilina, 1999

[21] TIPLER, P.: Physics for Scientists and Engineers: Electricity, Magnetism, Light, and Elementary Modern Physics (5th ed.). W. H. Freeman, 2004. ISBN 0-7167- 0810-8.

[22] ÚNMS SR: 2011:Termovízna diagnostika pomáha predísťporuchám zariadení: Available on the website: http://www.unms.sk/?termovizna_diagnostika

[23] ŽIVČÁK J., a kolektív.: Termovízna diagnostika, Vydavateľstvo: TUKE, SjF, 2010, str. 214, ISBN: 9788055305332

ACKNOWLEDGEMENTS

The contribution was prepared in the frame of solving of grant scientific project ***KEGA No. 048TUKE-4/2015****.*