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THERMOGRAPHY – TOOL FOR ASSESSING LIFE OF PRODUCTS

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Abstract: The paper is focused on the usage of thermography to assess the life of products and their failure rate. Thermography was used during routine vehicle technical inspections at the MOT station and focused on exhaust systems of 6 vehicles. For each vehicle tested, thermography identified critical places which, however, did not reduce the effectiveness of the product. The paper details the critical places of 2 cars. Potential damage has been identified in the 2 vehicles, as evidenced by increased values of emitted heat. As the results show, thermography is a suitable tool for identifying the quality reduction in the materials used, thus prolonging the life of the product thanks to early detection of problems.
Keywords: thermography, technical inspection, vehicle, lifetime, product

INTRODUCTION

Thermography is a method of thermal imaging of objects and their temperature field. The infrared radiation is emitted towards the investigated objects and the image is visible thanks to a semiconductor detector that converts the radiation to an electrical signal. Thermography allows a person to observe the distribution of thermal fields that are invisible to the human eye. Depending on the temperature, it is possible to determine critical points as well as to detect mechanical damage. Infrared radiation is located between visible microwave particles of the electromagnetic spectrum. Its primary source is heat or heat radiation. Any object that has a temperature above absolute zero (-273.15 ° C or 0 Kelvin) radiates infrared radiation.

Infrared temperature measurement depends on the infrared radiation emitted by the object. The system's measurement circuit converts the radiation into an electrical signal that conveys information on object's temperature. The thermometric diagram used in the device memory is used to determine the area that emits the heat and heat value. [3]

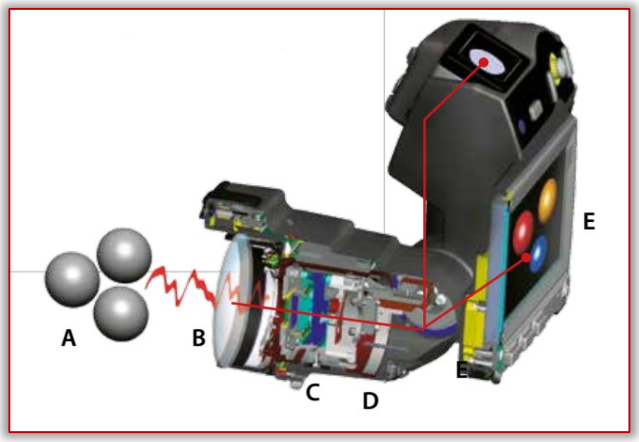

Figure 1. How thermographic camera works [4]

Thermographic works as follows: Infrared energy (A) coming from the object is recorded using the detector (C) of the optics (B), the detector then sends the information to the electronic image sensor (D) for processing. The electronics transform the data from the detector into the image (E), which can be displayed in the viewfinder, on video monitor or LCD screen. [4]

Thermographic solutions for various fields of the automotive industry

- Reconcile thermal behaviour of components with their standard behaviour
- Non-destructive testing allows precise and efficient quality control
- Integration into complex text solutions through interfaces to LabVIEW and MATLAB
- Analysis instruments for fast-rotating objects, such as tires or brakes.

Thermography helps to make defects visible without damaging the device under test on its testing. Therefore, functions of catalysts as well as electric systems of cars and motor assemblies can also be tested with the help of infrared camera systems.

Moreover, defects and deficiencies of multiple products for the automotive industry are only to be detected through temperature changes. Thus, heated seats and window heating can be tried and tested for their functionality by applying infrared camera systems.

THERMOGRAPHY IN PRACTICE

For the purpose of this paper, we used the thermographic camera during regular vehicle technical inspection at MOT stations. The thermographic camera monitored the horizontal exhaust system of selected vehicles. Vehicles were monitored regardless of their production year, mileage, engine power or fuel type. Diagnostics was performed on 6 passenger cars. The individual characteristics of the diagnosed vehicles are to be found in Tables 1-6.

Methodology:

- The motor vehicle was heated to the operating temperature.
- Visual inspection of the exhaust system.

- Exhaust system diagnostics using a thermographic camera.
- Making thermographic records of the evaluated object.
- Evaluation of thermograms using software.
- Specification of critical places.

The diagnostics took approximately 10-15 minutes depending on the exhaust system of the vehicle.

RESULTS OF THERMOGRAPHIC ANALYSIS OF EXHAUST SYSTEMS OF PASSENGER VEHICLES

We evaluated 6 vehicles using thermography. Data on vehicles is outlined in Tables 1-6.

Table 1. Data on vehicles (CITROËN)

Brand	CITROËN	Engine vol.	1868 cm
Model	Berlingo	Torque	125 Nm
Year of production	2002	Power	51 kW
Fuel	Diesel	Acceleration (0-100 km/h)	15,6 s
Engine	1,9	Weight	1125 kg
No. of cylinders	4	Consumption (average)	6,90 l

Table 2. Data on vehicles (SUZUKI)

Brand	SUZUKI	Engine vol.	1242 cm
Model	Swift	Torque	118 Nm
Year of production	2009	Power	69 kW
Fuel	Diesel	Acceleration (0-100 km/h)	12,3 s
Engine	1,2	Weight	1020 kg
No. of cylinders	4	Consumption (average)	5,00 l

Table 3. Data on vehicles (DACIA)

brand	DACIA	Engine vol.	1390 cm
Model	Logan	Torque	112 Nm
Year of production	2007	Power	55 kW
Fuel	Petrol	Acceleration (0-100 km/h)	13,0 s
Engine	1,4	Weight	1050 kg
No. of cylinders	4	Consumption (average)	6,90 l

Table 4. Data on vehicles (VOLKSWAGEN)

Brand	VOLKSWAGEN	Engine vol.	1390 cm
Model	Polo Classic	Torque	110 Nm
Year of production	1997	Power	44 kW
Fuel	Petrol	Acceleration (0-100 km/h)	15,6 s
Engine	1,4	Weight	945 kg
No. of cylinders	4	Consumption (average)	6,70 l

Table 5. Data on vehicles (KIA)

Brand	KIA	Engine vol.	998 cm
Model	Picanto	Torque	95 Nm
Year of production	2013	Power	51 kW
Fuel	Petrol	Acceleration (0-100 km/h)	14,4 s
Engine	1,0	Weight	905 kg
No. of cylinders	4	Consumption (average)	4,20 l

Table 6. Data on vehicles (CITROËN)

Brand	CITROËN	Engine vol.	1360 cm
Model	Berlingo	Torque	120 Nm
Year of production	2007	Power	55 kW
Fuel	Petrol	Acceleration (0-100 km/h)	14,2 s
Engine	1,4	Weight	1180 kg
No. of cylinders	4	Consumption (average)	6,20 l

Of the listed and evaluated vehicles we focus only on 2 which thanks to thermographics showed thermal loss points caused by the extended corrosion of the exhaust system. The first of these was DACIA Logan. The thermogram showing the critical places is shown in Figure 2 and thermal limits of the marked places are shown in Table 7.

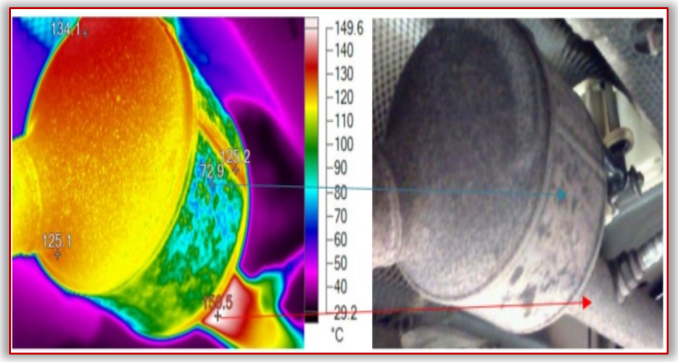

Figure 2. Infrared image of the exhaust system and real shot of the exhaust system

Table 7. Limitations of the marked places

Title	Temperature	Emissions	Environment
Warm	150,5°C	0,92	18,0°C
P0	72,9°C	0,92	18,0°C
P1	134,1°C	0,92	18,0°C
P2	125,1°C	0,92	18,0°C
P3	125,2°C	0,92	18,0°C

This exhaust system shows that corrosion has disturbed the original properties of the material to such an extent that its quality is already reduced. This is manifested by large temperature differences between the individual parts of the exhaust system. Temperatures on the thermogram range from 45 °C to 160 °C. Figure 2 shows the difference between the highest and lowest temperature of the evaluated surface - up to about 90 ° C.

The second assessed vehicle was VOLKSWAGEN Polo Classic. The thermogram showing the critical places is shown in Figure 3 and the thermal limits of the marked places are shown in Table 8.

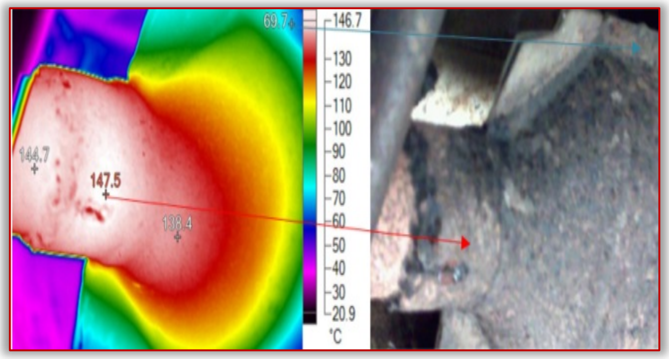

Figure 3. Infrared image of the exhaust system and real shot of the exhaust system

Tab. 8 Limitations of the marked places

Title	Temperature	Emissions	Environment
Warm	147.5°C	0.92	18.0°C
P0	69.7°C	0.92	18.0°C
P1	144.7°C	0.92	18.0°C
P2	138.4°C	0.92	18.0°C

Since the car is 20 years old, it was evident that the individual parts of the exhaust system had been replaced. The replaced parts showed the average temperature of about 48-55 °C. The critical place, which is an original part, is shown in Figure 3, (the part has not been changed since the vehicle left the production). These places showed temperatures up to 177 °C. The reason is advanced corrosion and the evident reduction in the quality of the material due to its aging.

CONCLUSION

The main objective of the paper was to find out if the thermographics is a suitable tool for diagnostics of exhaust systems during vehicle technical inspection, and whether it can be used to estimate the time need for replacement of the exhaust system of vehicles. The time required to replace the exhaust system of a vehicle varies. It may happen that at the time of the vehicle technical inspection, the exhaust system was in a good shape but got damaged after a few days/ months following the inspection. Such a vehicle then does not comply with MOT regulations. The measurements showed that the average temperature of the exhaust system of the assessed vehicles at the operating temperature was about 50 ° C.

Results showed that some parts of the exhaust systems reached temperatures of 150-170 °C. The analysis showed that these values are caused by advanced material aging and visible corrosion. Corrosion was visible by the naked eye, and the thermogram showed that the thickness of the material had diminished so much that the emitted heat reached critical values.

With regard to the results we note that thermodynamic would be an appropriate way to determine products' life cycle stage - in this case the vehicle's exhaust system. Thanks to a timely intervention it is possible to extend the useful life of the vehicle.

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