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TESTING OF INTERNAL COMBUSTION ENGINES OF MOTORCYCLES WITH THE USE OF THERMAL IMAGING METHODS

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Abstract

The internal combustion engine should be rated for the thermal loads that come from different sources. Thermal analysis is important both for design purposes and for evaluating the conditions of its use. Very good results are obtained by a combination of non-invasive measurement techniques, such as research using infrared thermal imaging techniques [3, 11]. The purpose of the study was to determine the engine thermal load by evaluating the average temperature on the outside surface of the engine at many of its points for two selected motorcycle engines with similar displacement capacities.

For many reasons, such as ecology, durability, engine strength and thermal performance when heating and cooling are critical. To accomplish this task, a thermographic technique for indirect evaluation has been used, thus creating the possibility of measuring the temperature in a dynamic manner. These are accurate measurements and most importantly do not interfere with the construction of the object under investigation. The engine was tested during operation according to external and load characteristics. As a result of the work, graphs of temperature curves of heating and cooling of the tested engines were compiled. The article presents a methodology for measuring the temperature fields of outer surface engines. The collected material will be used in the future for studying the equable load on the cylinders, and as accurately as possible determine the conditions of movement such as power, revolutions, flow rates, temperatures and pressures.

Keywords: *combustion engine, thermal analysis, thermography, thermal research of motorcycles*

1. Introduction

Heat engines are machines whose task is to convert heat to mechanical work. The heat in the heat engines is largely caused by combustion, although the operation of the thermal engines is also possible and when the heat is supplied in a different way. Comparing the engine operating cycles should be taken into consideration per cycle, or any whole number of cycles [2, 4]. In addition, a more important than the total number of cycles is the case of equable charging of the cylinders. The engine's thermal load is ambiguous. It involves such quantities as temperature, heat flux, temperature gradient.

In general terms, the heat load can be defined as the heat flow under the given engine conditions:

$$Q = WB_0\xi, \tag{1}$$

where:
W – calorific value of the fuel,
B_0 – fuel consumption per unit of time,
ξ – coefficient of heat emission in the engine combustion chamber [7, 8, 10].

The heat generated in the combustion process partially penetrates into the walls of the elements surrounding the combustion chamber and then into the cooling system. The defined heat load referenced to one cylinder is the averaged general reference. It does not give information about the actual heat load of the individual components. Local loads depend on the size, which are characterized by heat exchange element surface and the penetration of heat to the element.

Essential parameters are therefore the temperature conduction, the course of the combustion process, the exhaust gas velocity around the walls of the chamber or the shape of the chamber and the piston [12]. The parameters that describe the heat exchange in the combustion chamber are the temperature of the medium and the heat transfer coefficient on the surfaces of the walls that limit the space of the combustion chamber. They are variable during the engine cycle, and are also heterogeneous in each combustion space. Therefore, it is difficult to find universal rules describing the temperature and heat transfer coefficient for many engines as well as individual elements. Measurement tools are also needed to measure the temperature of these components in dynamic engine settings without mechanical interference and the installation of complex measuring instruments including sensors and thermocouples. Non-invasive measurements show the use of thermal imaging cameras. Thermovision bases its action on the phenomenon of electromagnetic radiation that passes through elements whose temperature is above absolute zero.

2. Purpose and execution of research

This article describes the research aimed at the initial thermal analysis of two selected motorcycle engines with similar stroke volumes. Research will be used in the future to assess the evenly loading of cylinders, and to show the gradient of the heating of individual parts from the cylinder to the exhaust pipe of vehicles. The measurements included the distribution of temperature on the individual parts of the motorcycle, varying in cylinder configuration, number of cylinders and engine power. Motorcycles used in the study was the Yamaha FZ6-N with a displacement of 600 cm3 produced in 2004 and the Honda Transalp 650V with a capacity of 650 cm3 produced in 2006. The research was done using a JENOPTIK VarioCAM thermal imaging camera with a measuring range of -40°C to 1200°C, emissivity factor was adopted for brushed cast iron ε=0,90 and a sensitivity of 0.08°C for 30°C [9, 14, 15].

The measurements were started from the conditioning of the motorcycles until the ambient temperature was reached by all tested parts of the vehicle. The first test was to measure the outside temperature of the engine from the moment the engine was switched on until the temperature stabilized and then the temperature was measured during cooling.

In Fig. 1 and 2 were presented thermal images with two different filters Iron and Rainbow, which were analysed in the program IRBIS Pro. The pictures were shown the heating process for the first motorcycle tested as Honda Transalp 650 V. The warmest places on the given thermal image have been identified, which show the most heat-stressed elements, which were the elements surrounding the combustion chamber as the outlet valves. Temperatures are from an ambient temperature range of almost 26°C up to 419°C.

Then the heating and cooling time curves for both motorcycles were determined. Photos of the thermal imaging camera were fixed with sampling every 30 seconds until the temperature stabilized. This condition occurred respectively after 15 minutes for the 98 HP Yamaha motorcycles and after about 12 minutes for Honda Transalp working in a V-Twin 55HP. Time curves are used to determine changes in heat loads and boundary conditions as a function of time in transient analysis.

Variable shapes of temperature lines were obtained (Fig. 3); they were typical for heating and cooling processes. At first, a relatively rapid rise in temperature followed by stable cooling at ambient temperature is observed. Between these two phases, there was a classic collapse of the curve, associated with the increase, followed by a sharp drop in value [1, 2]. The drop in temperature was due to the stop of the circuit and other cooling, fan shutdowns, and zeroth law of thermodynamics. This moment is dangerous because of the durability of the engine parts. With this knowledge at the design stage, the engine should be adequately protected against degradation. The following examples are included thermal images (Fig. 4 and 5) of heating and cooling Yamaha motorcycle. The overall process of cooling to ambient temperature for motorcycles was about 6 hours.

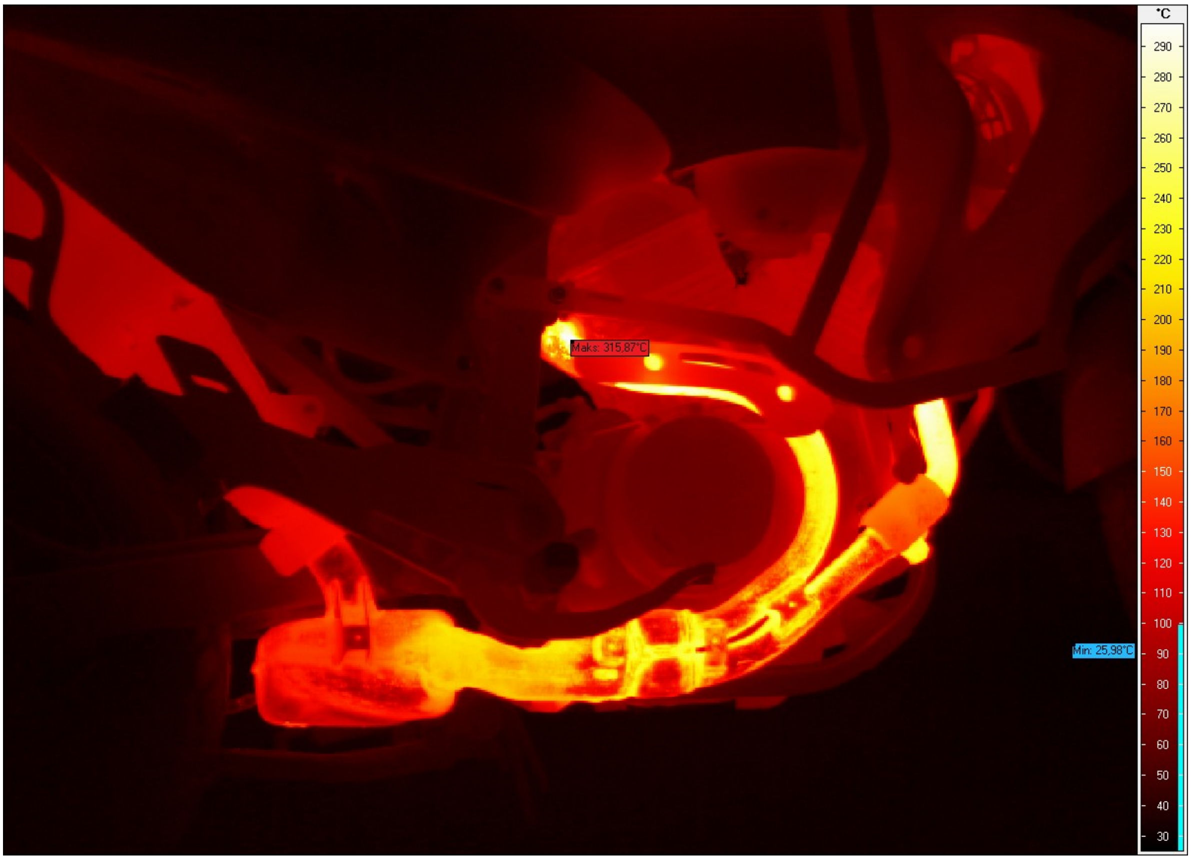

Fig. 1. Heating process for Honda Transalp 650 V with Iron filter in twelve minutes

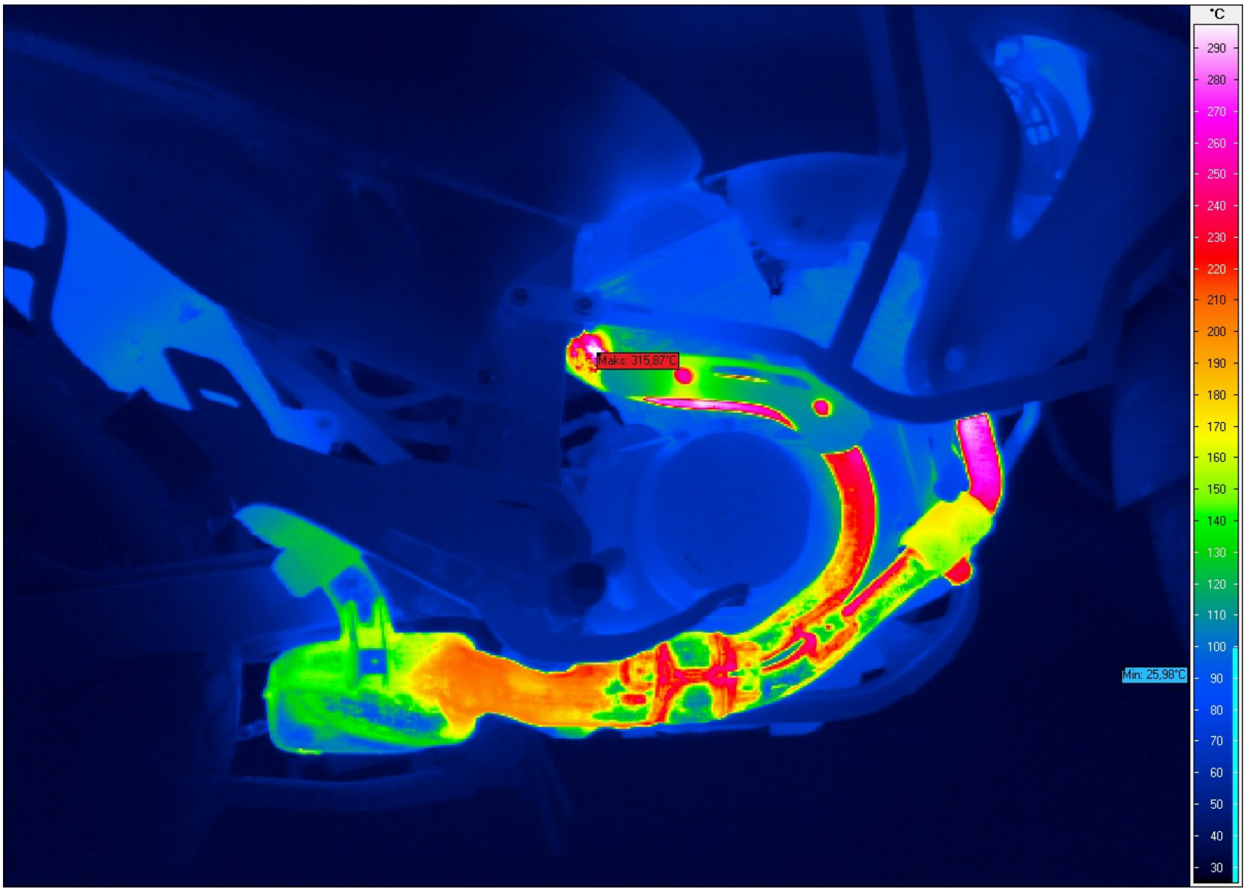

Fig. 2. Heating process for Honda Transalp 650 V with Rainbow filter in twelve minutes

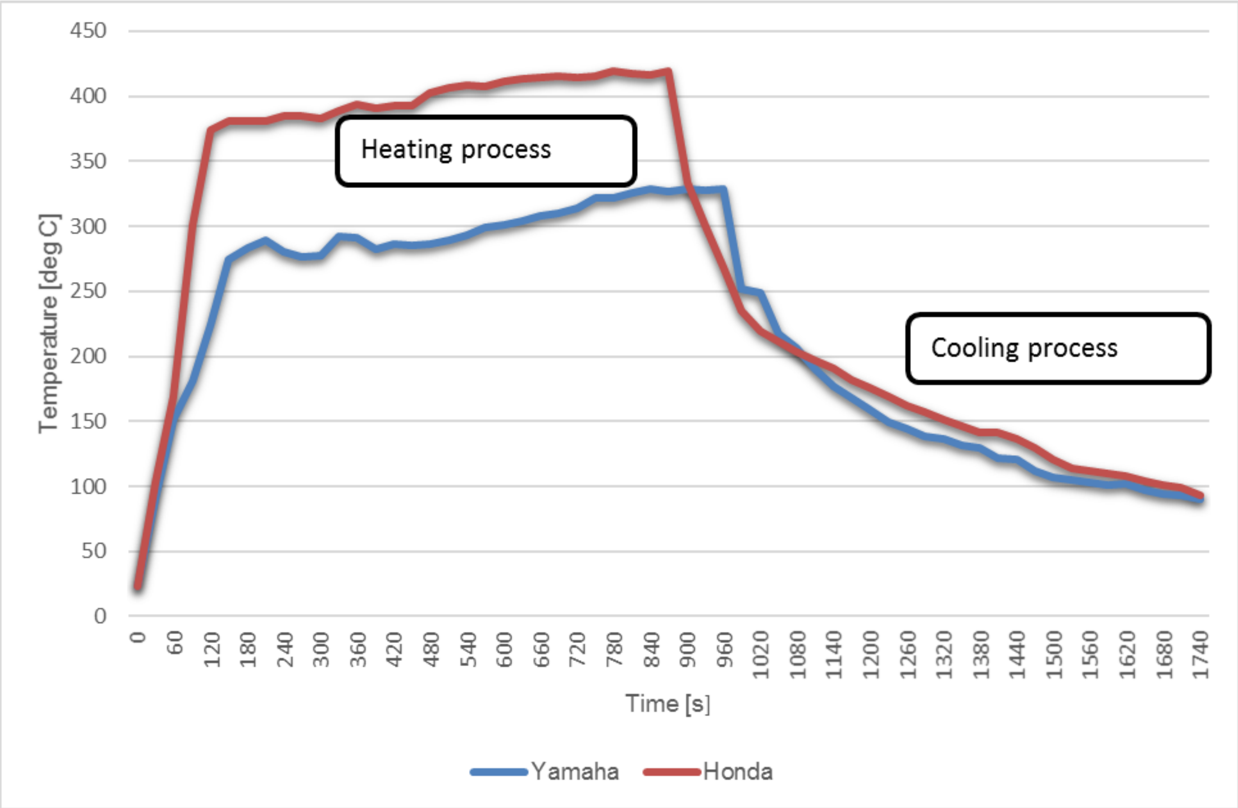

Fig. 3. Heating and cooling process for Honda Transalp 650 V and Yamaha FZ6-N

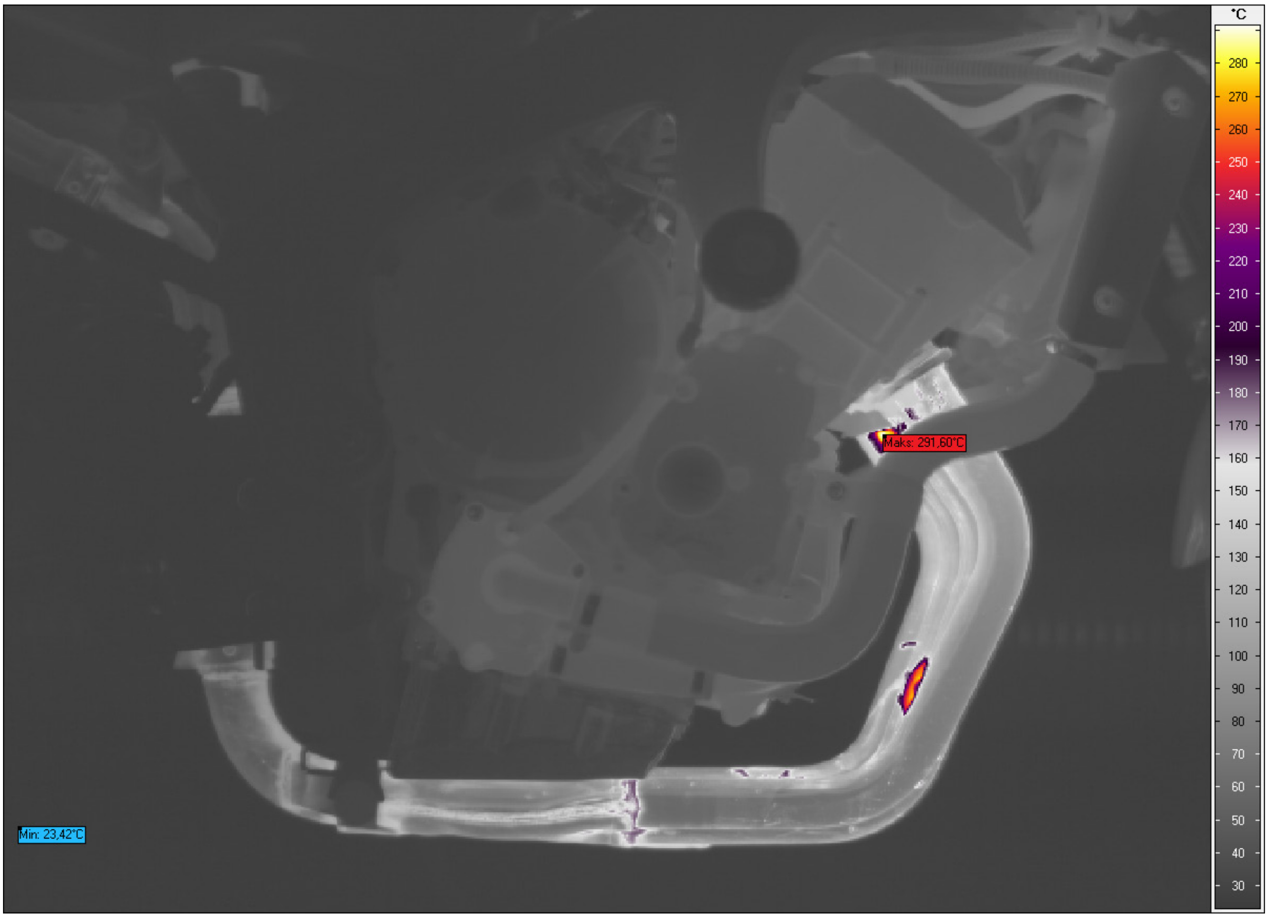

Fig. 4. Heating process for Yamaha FZ6-N in ninth minute of working

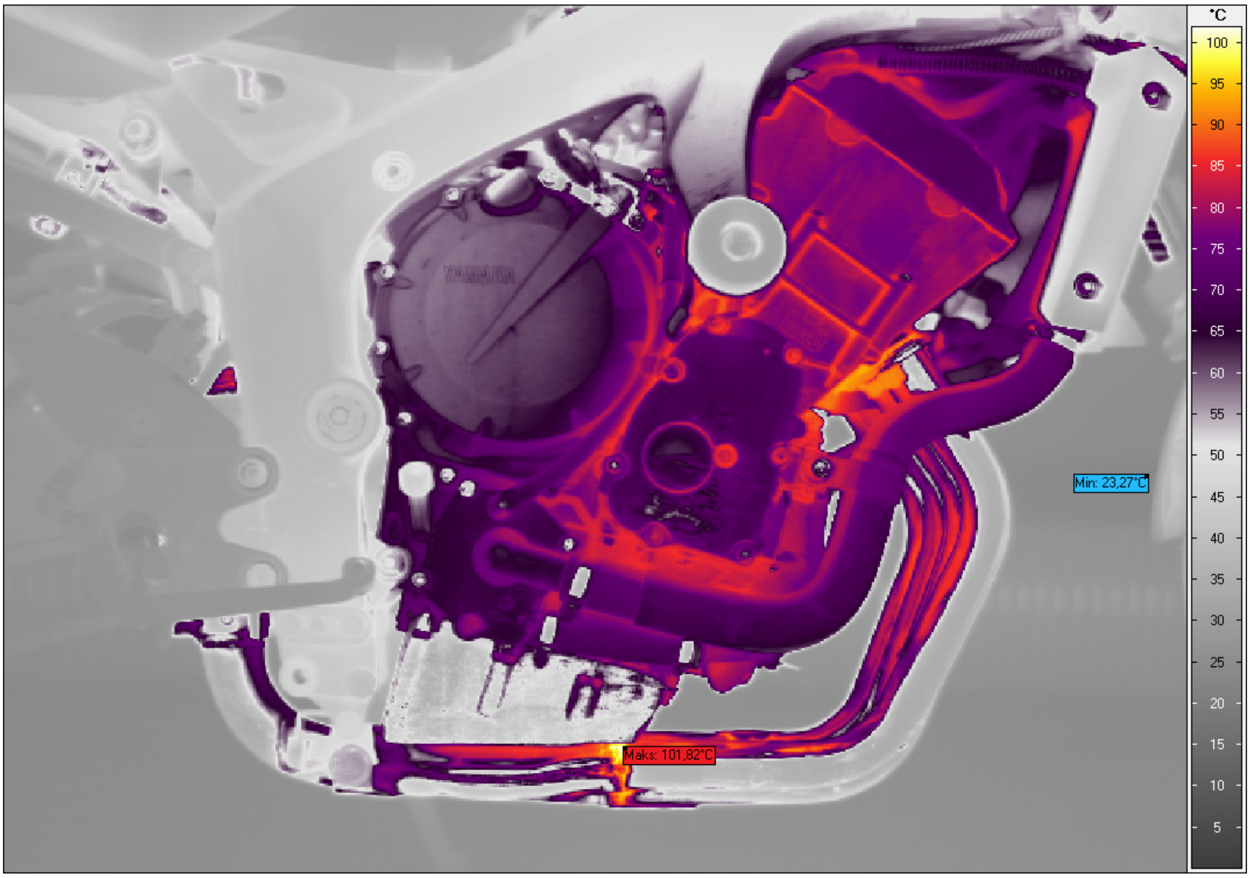

Fig. 5. Colling process for Yamaha FZ6-N in tenth minute

4. Conclusions

Two motorcycles with similar displacement were examined. A thermal imaging camera was used for the study to determine the outside temperature of engine parts and exhaust pipes. The temperature curve for heating and cooling for motorcycles was determined.

The collected material was unambiguously confirmed the heat absorption rate dependence not only on the size of various parts, but also the temperature of adjacent components. Heating strongly depends on the processes occurring in the engine and cooled by ambient influences [10].

The study material will be used in the future for studying the equilibrium load on the cylinders, and as accurately as possible to determine the conditions of movement such as power, revolutions, flow rates, temperatures and pressures.

The study showed only an outline of the thermal loads of motors, not only the heat flux [6], but also the temperature and temperature gradient. An accurate assessment could give a detailed assessment of each case, taking into account mechanical influences, superposition of thermal and mechanical stresses [11, 13]. Thermal phenomena may change the properties of the material, changing the geometrical dimensions, deterioration in tribological properties and destroying components.

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