Study of materials used for the thermal protection of the intake system for internal combustion engines

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Abstract. The present paper focuses on calculation of thermal conductivity for a new materials developed by the authors, using the heat flux plate method. This experimental method consists in placing the sample of the new material in a calorimetric chamber and heating from underside. As the heat flux which passes through the sample material is constant and knowing the values of the temperatures for the both sides of sample, the sample material thermal conductivity is determined. Six types of different materials were tested. Based on the experimental data, the values of the thermal conductivity according to the material and the average temperature were calculated and plotted.

1. Why thermal protection for intake manifold of an internal combustion engine?

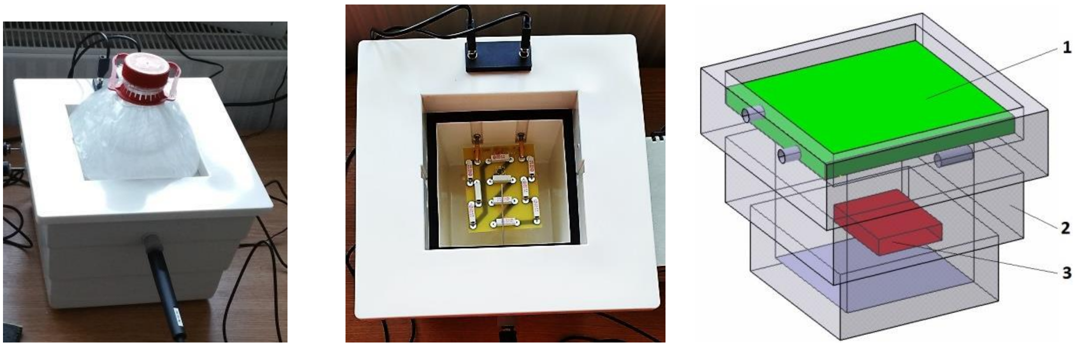
Because of the position in the engine compartment the intake is highly expose to thermal radiations from the cooling radiator, exhaust pipe and other hot parts of the engine which is a disadvantage, the intake air it heated and the result is a lower density, thus containing less oxygen per volume unit than cold air [1]. Recent studies show significant differences in fuel consumption and exhaust emissions depending on the temperature of the intake air [2-4], [6].

The air mass found in cylinders after closing the intake valve is the decisive factor in relation to the mechanical work produced by cyclically burning of the fresh load, with direct influence on the engine torque. That means that the higher the air mass, the higher the engine torque will be. In other words, we can say that, on the intake route, two kinds of losses are recorded: pressure losses or gasodynamic losses caused by the existence of hydraulic resistances on the suction line and heat losses or thermal losses, caused by fluid heating from the suction line walls, which determine the final temperature to be higher than the engine inlet temperature, the temperature increase resulting in density decrease and, hence, affecting the filling [5], [7-9].

One method of reducing thermal losses is to insulate the intake whit a new kind of material. The principal scope is to resource and development a new insulates material from composite, natural and organic materials based from recycling materials. As an additional property, this material must be applied easily by brush or spray on the manifold surface and adhere to it. In order to do that, it is necessary to prove that the new material has insulated properties. The present paper focuses on calculation of thermal conductivity for a new materials developed by the authors, using the heat flux plate method.

2. Basic principle of the method and devices

The single-plate method determines the thermal conductivity λ of a building material sample (Figure 1c-1) of thickness d and surface A by measuring the temperature difference and thermal flux directly. It is important for the measurement that the thermal flux crosses the building material sample homogenously and that no heat disappears by other ways. Whit the calorimetric chamber (Figure 1), this is achieved in particular by the insulating housing.



(a) (b) (c)

Figure 1. Calorimetric chamber
a – general view, b – inside view of electric heated source, c – virtual model: 1 – material sample, 2 – calorimetric chamber wall, 3 – heated source

The chamber is electrically heated on the inside (Figure 1b,c), and ice is placed directly outside the sample (Figure 1a). In the thermal equilibrium, i.e. in stationary condition, in which the temperature is constant over time at every point, the electric power exactly matches the thermal flux, i.e. the inserted electrical energy is equal the thermal energy flowing through the building material sample.
Figure 2 shows a general view of the experimental ensemble containing the following devices: transformer 2-12 V, calorimetric chamber with insulated housing, digital thermometer with 4 inputs and a laptop for data acquisition.

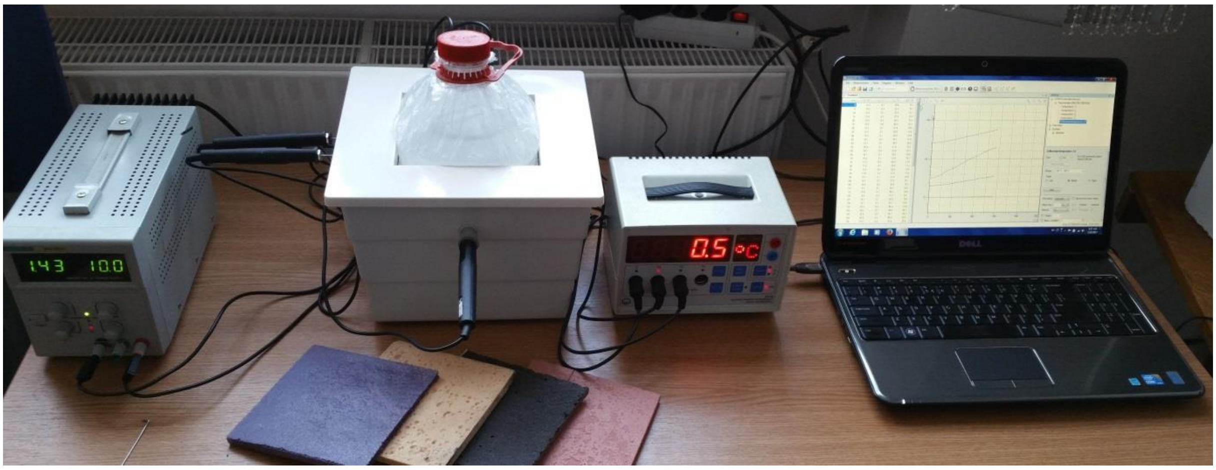


Figure 2. General view of the experimental ensemble

Three NiCr-Ni thermocouple sensors were used for temperatures measurements as follows: T1 – outside sample surface, toward the exterior of the calorimetric chamber, T2 –on the underside, toward the interior of the calorimetric chamber, T3 –inside the calorimetric chamber. The material sample have square surface of $150 \times 150\ mm$ and $10\ mm$ thickness and fit perfectly inside the calorimetric chamber in horizontal position (see Figures 3 and 5).

Figure 3. The way the thermocouples are mounted and the material sample are fitted inside the calorimetric chamber

Six samples of different material were developed for which thermal conductivity was determined.

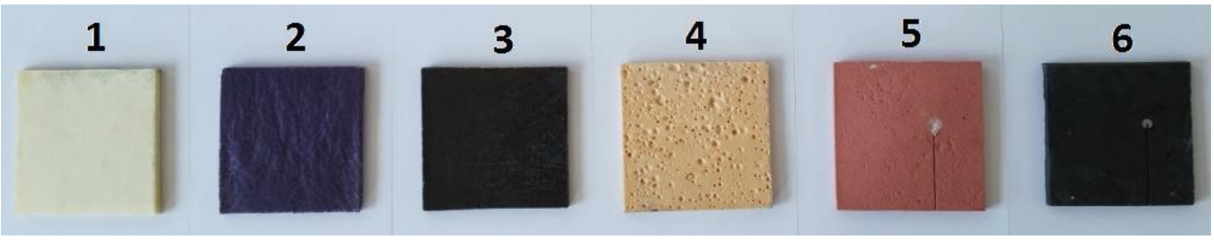


Figure 4. The six samples

Material sample composition – Sample 1

Elements	Silicone	Polyurethane foam	Solvent	Cork	Pigment
Composition %	-	100	-	-	-

Material sample composition - Sample 2

Elements	Cork	Polyurethane foam	Solvent	Pigment
Composition %	8.36	68.82	19.01	3.81

Material sample composition - Sample 3

Elements	Silicone	Polyurethane foam	Solvent	Cork	Pigment
Composition %	11.38	61.20	9.64	5.69	12.09

Material sample composition – Sample 4

Elements	Silicone	Polyurethane foam	Solvent	Pigment
Composition %	21.31	69.26	6.14	3.29

Material sample composition – Sample 5

Elements	Silicone	Polyurethane foam	Solvent	Pigment
Composition %	58,1	37.28	1.73	2.89

Material sample composition – Sample 6

Elements	Silicone	Polyurethane foam	Solvent	Cork	Pigment
Composition %	32.95	21.11	3.42	1.01	2.89

Figure 5. Material samples composition

Experimental data was acquired with the help of Cassy Lab2 software. The interface of this software is presented in Figure 6.

IOP Conf. Series: Materials Science and Engineering **294** (2018) 012006 doi:10.1088/1757-899X/294/1/012006

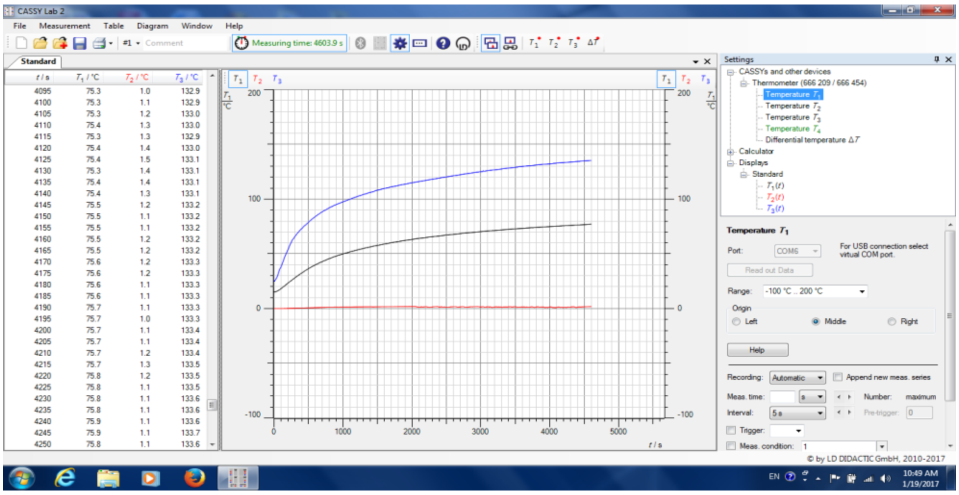


Figure 6. The interface of the CASSY LAB 2 software

The temperature values were taken from 5 to 5 seconds for 4,000 seconds, the time required to stabilize the heat transfer phenomenon.

3. Results and conclusions

Below are the results obtained from the calculations based on the experimental data taken.

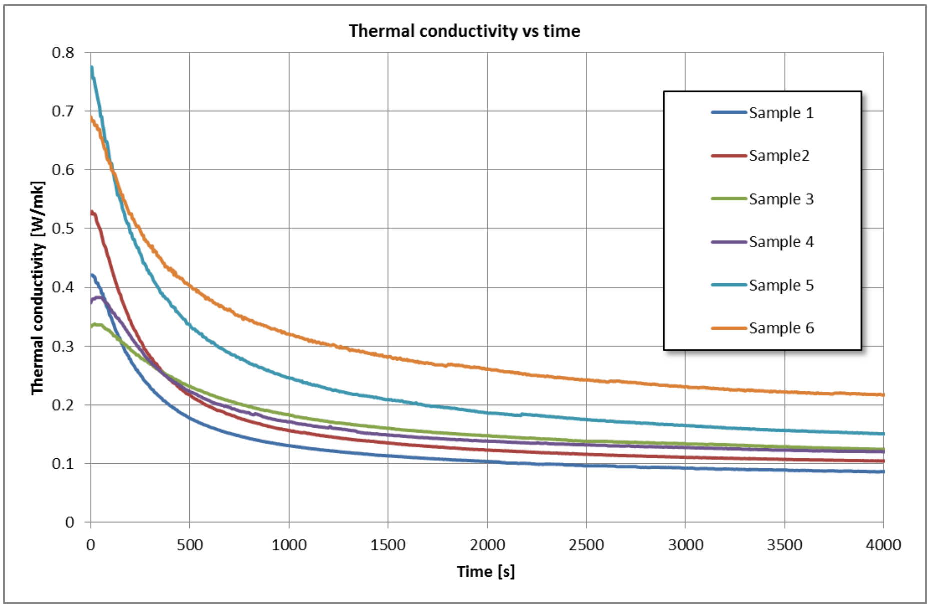


Figure 7. Thermal conductivity vs time, for the six samples

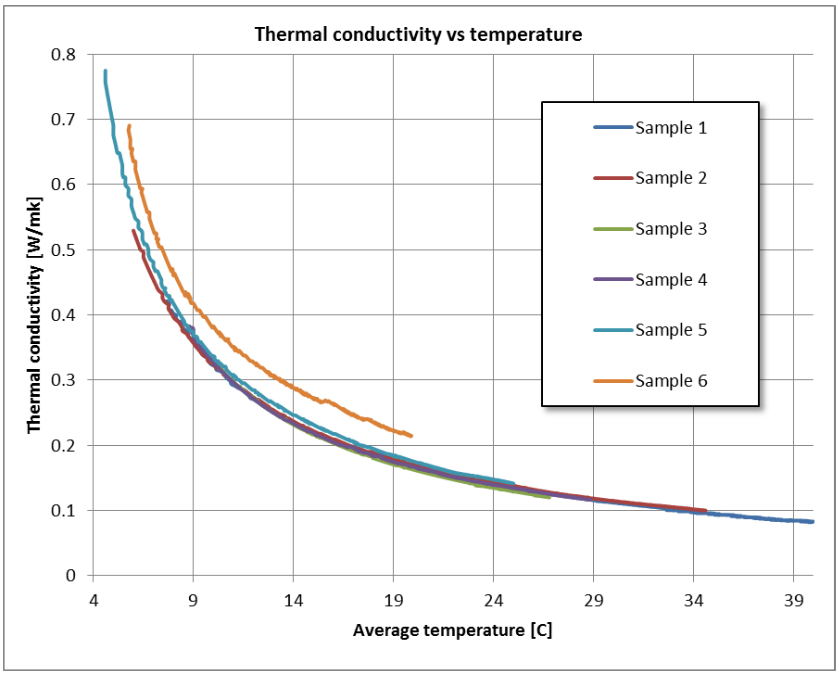


Figure 8. Thermal conductivity vs temperature, for the six samples

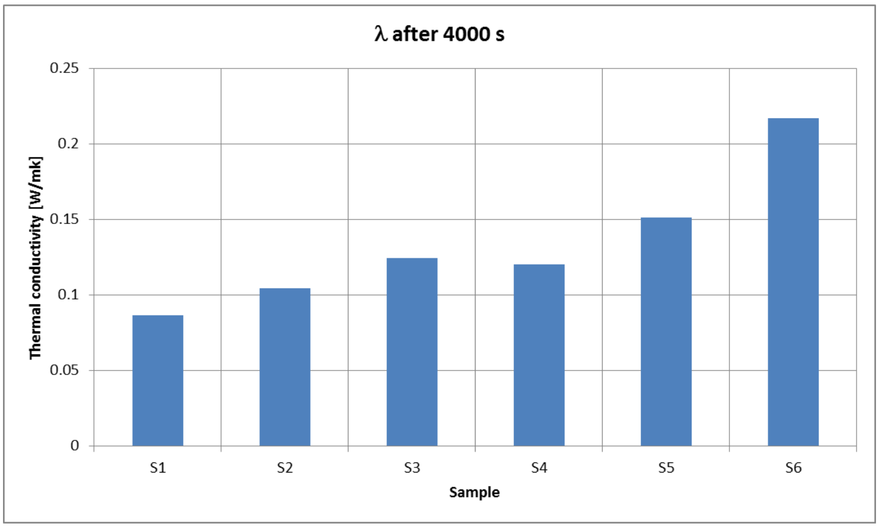


Figure 9. Comparative values of the thermal conductivity for the six samples

In conclusions, we can say that the first material sample can be used as a thermal insulation material for coating the intake manifold of an internal combustion engine.

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