

The Dispersion of the Heat Flow in the Engine Compartment. Case Study on Ford Fiesta 1.4i

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Abstract. This paper presents a study concerning the influence of the dispersion of the heat upon the air filter and the intake manifold. The data was registered in real time with the help of thermo imaging camera at different operating regimes, route and traffic installed on a FORD Fiesta car, equipped with a gasoline engine with a cylindrical capacity of 1.4l. The propeller group is mounted transversely, a front constructive solution. The gas circulation is a inline cross flow type with the intake manifold placed in front of the engine and the exhaust manifold behind the engine. The air circulation through the air filter is a loop flow type having the in/out port orientated towards the front of the vehicle. This study wants to determine the influence of the materials which were used for the construction of the air filter and of the intake manifold upon the performance of the internal combustion engine. The results obtained after the tests allow us to determine the optimum parameters on the efficiency of the heat transfer.

1. Introduction

Because of the position in the engine compartment the intake is highly expose to thermal radiations from the cooling radiator, exhaust pipe and engine itself 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. Air intake temperature is important to ensure higher amount of fuel involves in the combustion process. We can say that the fuel consumption is improved with the decrease of air intake temperature regardless of engine speed. Also, carbon monoxide and unburned hydrocarbons were decreased with the decrease of air intake temperature, again regardless of engine speed. So, based on the specialized studies, the lower air intake temperatures resulted in lowest fuel consumption and reduced exhaust emissions regardless of engine speed [1].

The study focused on Ford Fiesta1.4i, which engine is characterized by having a crossflow type gas circulation with the intake manifold placed in front and the exhaust manifold behind the engine. The air filter is placed in the upper part of the engine, the shell being made from plastics in a prismatic shape. The air circulation through the air filter is a loop flow type having the in/out port orientated towards the front of the vehicle.

2. Conditions and measurements

The measurements were made in the engine compartment of the FORD Fiesta car, equipped with a gasoline engine with a cylindrical capacity of 1.4i (figure 1.a), gasoline, multi point injection. The air filter is placed in the upper part of the engine, the shell being made from plastics in a prismatic shape.



The air circulation through the air filter (figure 1.b) is a loop flow type having the in/out port orientated towards the front of the vehicle.

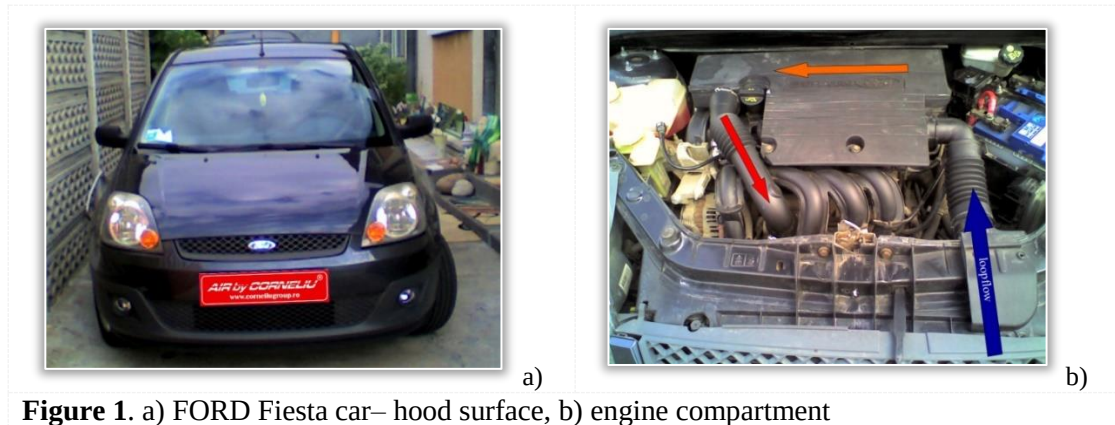


Figure 1. a) FORD Fiesta car– hood surface, b) engine compartment

The comparative measurements were made after reaching the regime temperature of the engine, at the level of the engine compartment, from the air filter shell, of the intake manifold and the in/out connections hoses of the air filter [2].

The temperatures were monitorized depending on the functioning regime (normal traffic, crowded traffic) and route (altitude difference, ramp, downhill) as it follows:

- » A – cold stopped engine– reference state
- » B – traffic mode highway
- » C – traffic mode normal urban
- » D – traffic mode mountain (ascending)
- » E – traffic mode mountain (discending)
- » F – traffic mode crowded urban

The air filter (figure 2) is of panel type filter element (from microporous cardboard) placed in the upper part of the engine, the framework is made from plastics in a prismatic shape and it covers 100% the engine. The air circulation is loopflow type, having the direction from front to front [3].



Figure 2. Air filter



Figure 3. Intake manifold

The intake manifold (figure 3) is placed in the front part of the engine. On the intake manifold there are placed the throttle module and the multipoint injection ramp. The material used in the construction of the intake manifold is PA66 GF35 [4].

The heat sourced of the air filter and of the intake manifold are the following, in the case of the Ford car: exhaust manifold, engine, and cooling radiator.

3. The heat flow dispersion highlighted by the thermographic measurements

Comparative temperature measurements are presented next from the engine compartment (overview), from the air filter shell, of the intake manifold and of the in/out connections of the air filter for the above mentioned situations. Using the thermal imaging camera one can highlight the areas influenced by the heat transfer as a result of the dispersion through the engine compartment [5].

The comparative measurements on the surface of the hood are presented in Figure 4.

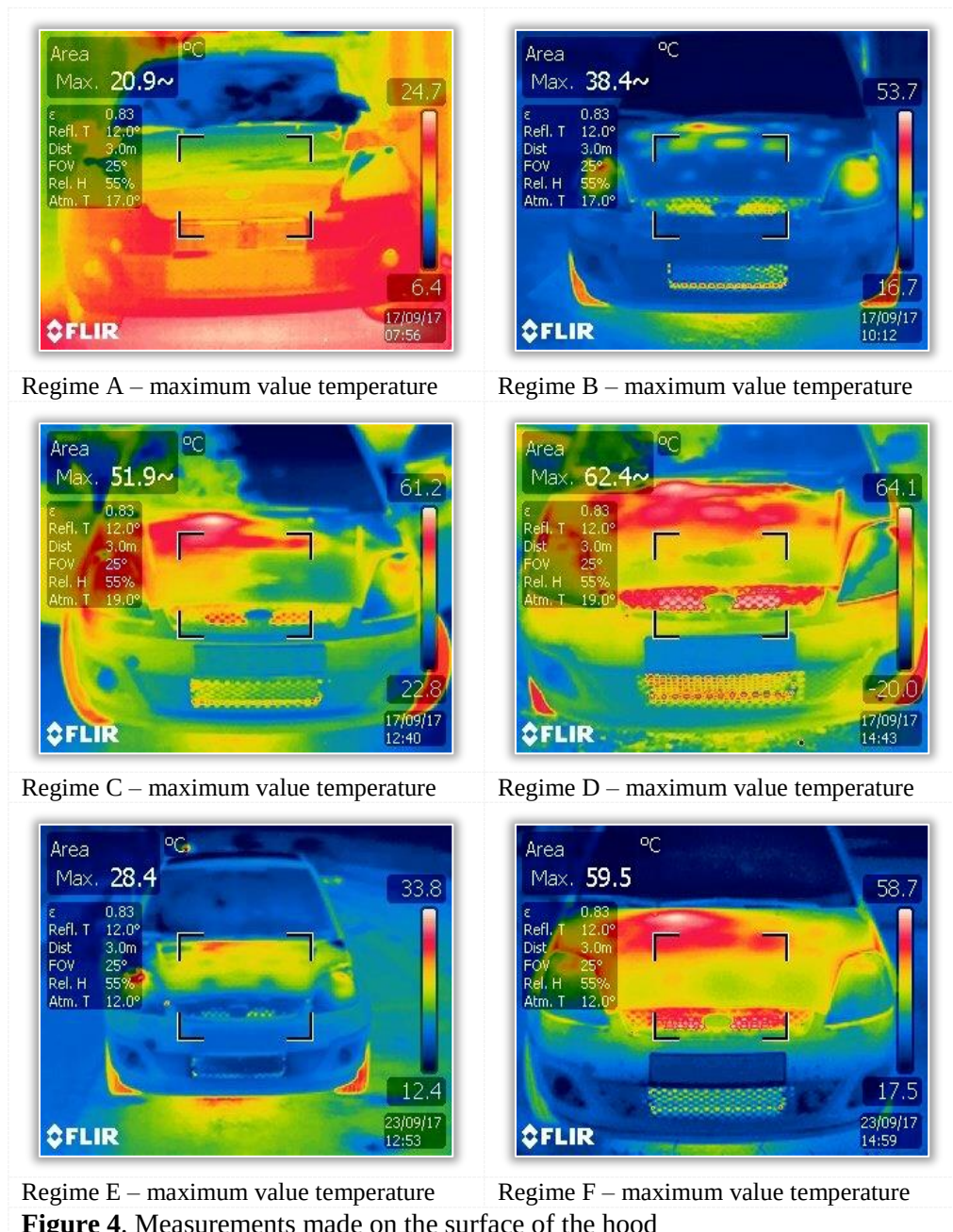
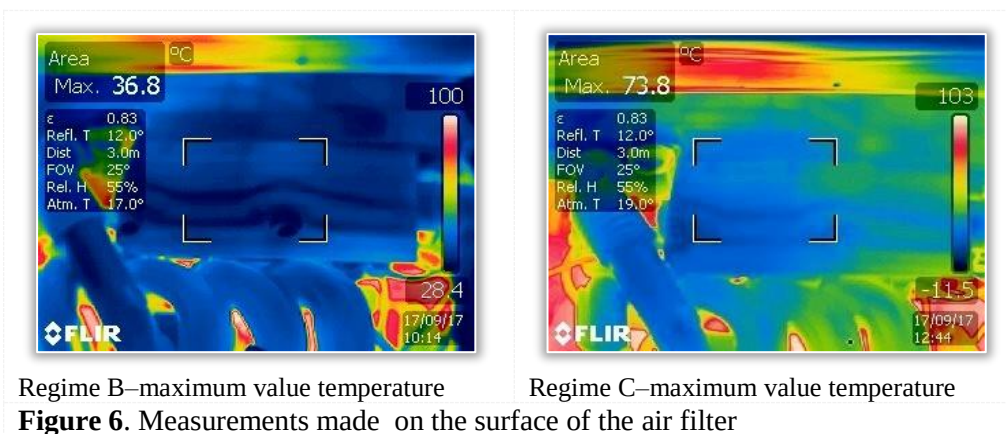
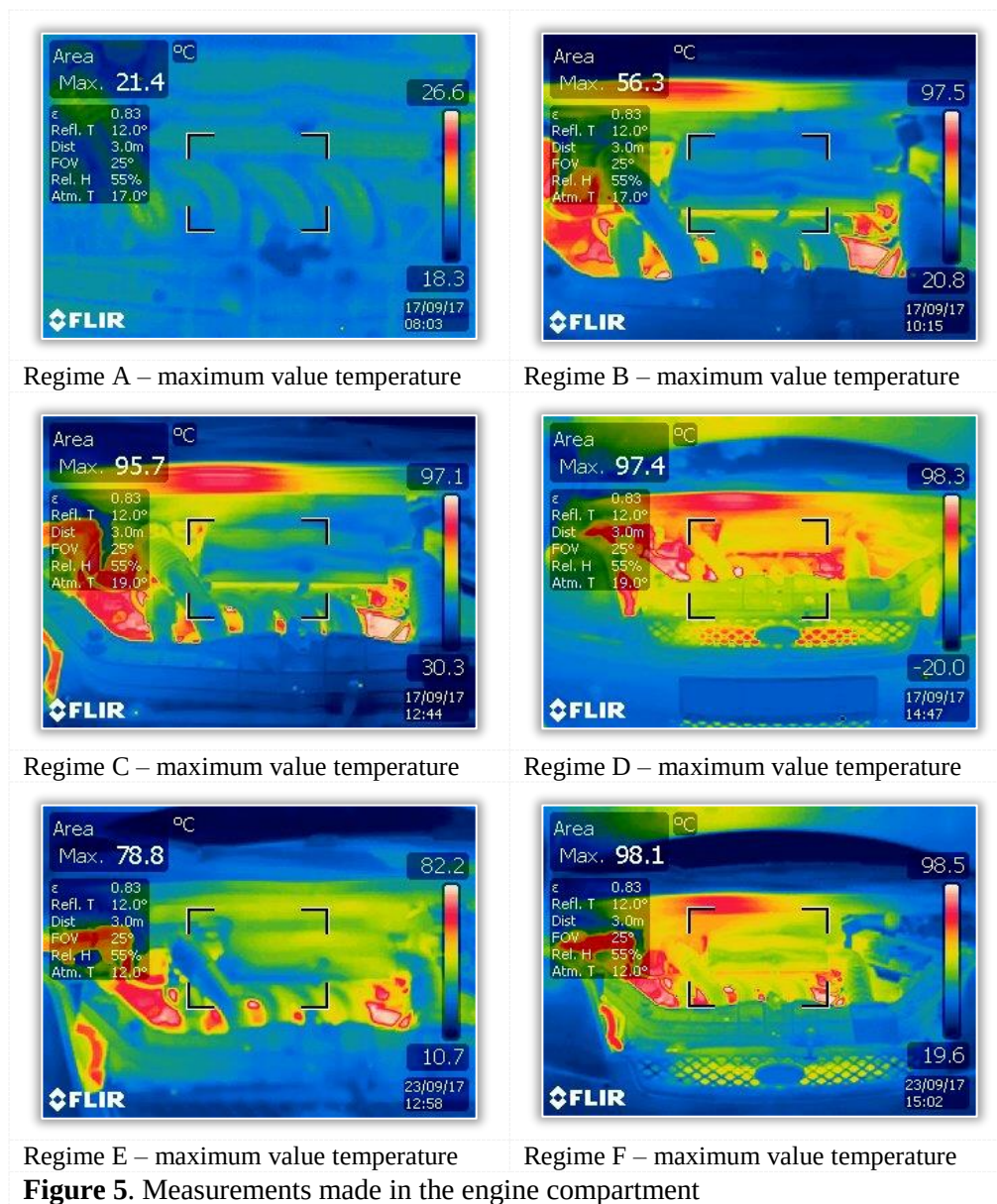
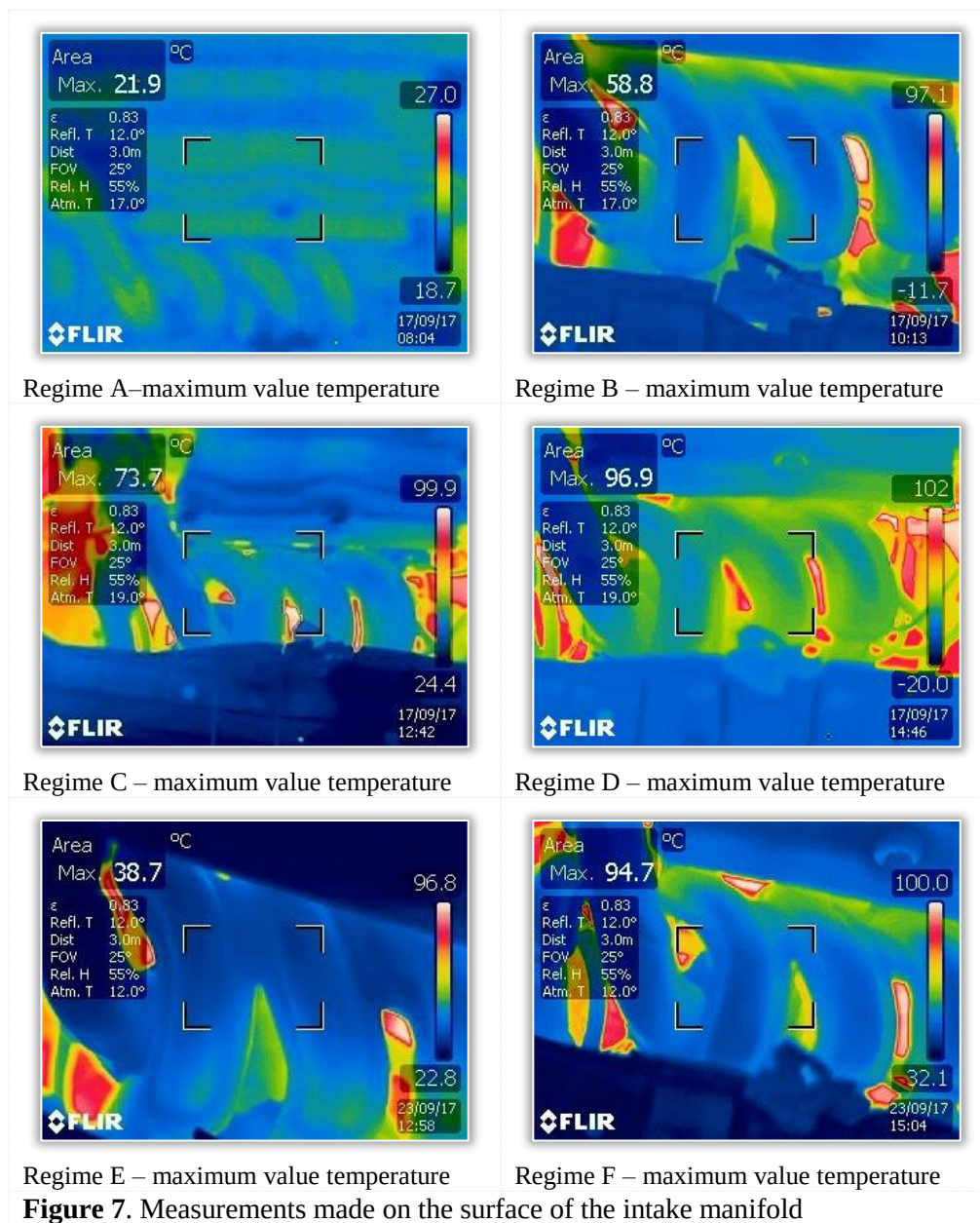
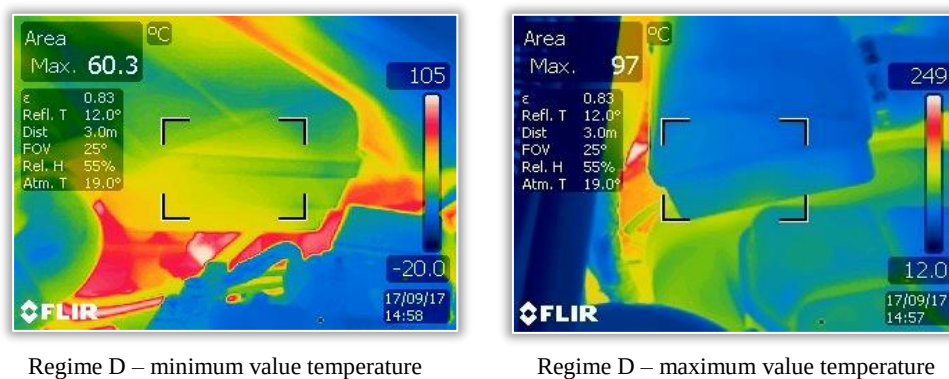


Figure 4. Measurements made on the surface of the hood

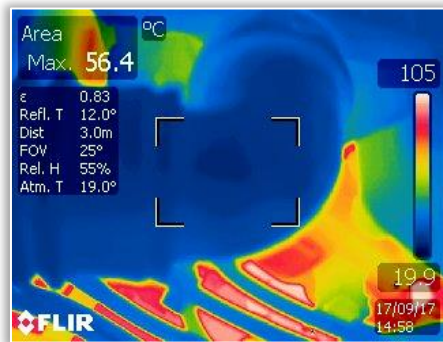
The comparative measurements in the engine compartment are presented in Figure 5. The comparative measurements of the shell of the air filter are presented in Figure 6. The comparative measurements on the surface of the intake manifold are presented in Figure 7.



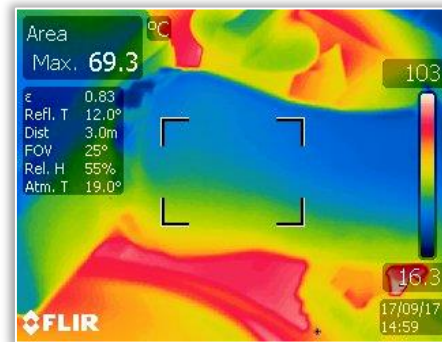
**Figure 7.** Measurements made on the surface of the intake manifold**Figure 8.** Measurements made in critical areas

Area which presents critical temperatures at the entrance and exit from the air filter shell are presented in figure 8.b.

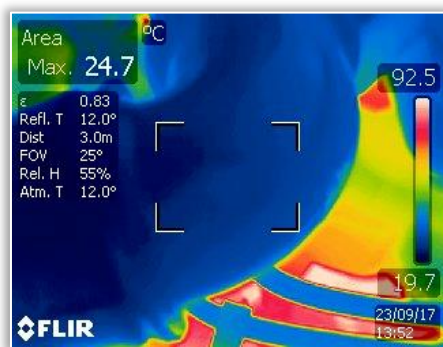
The comparative measurements on the entrance/exit connections hoses of the air filter are presented in figure 8.b.



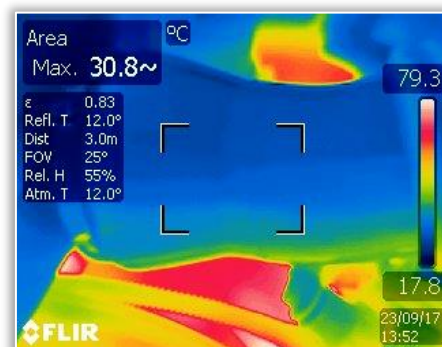
Regime D – minimum value temperature



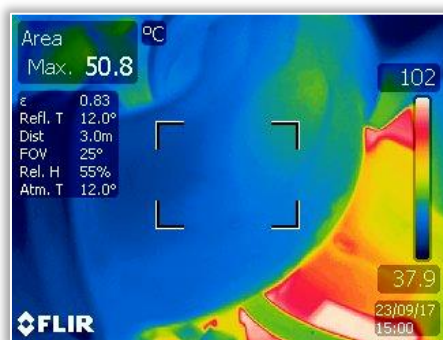
Regime D – maximum value temperature



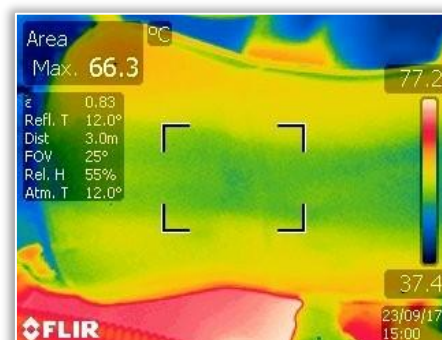
Regime E – minimum value temperature



Regime E – maximum value temperature



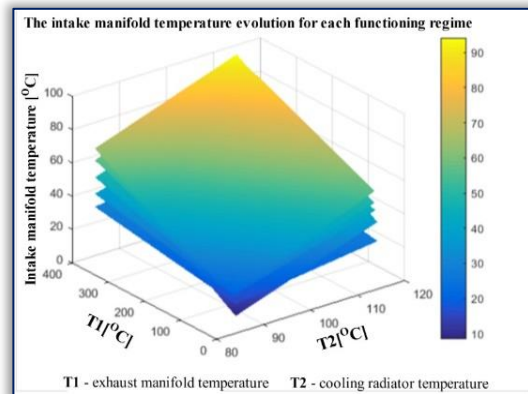
Regime F – minimum value temperature



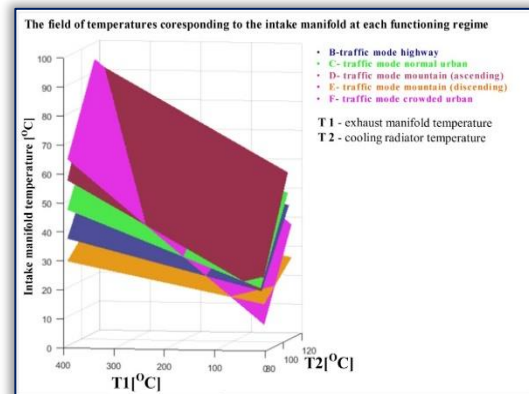
Regime F – maximum value temperature

Figure 9. Measurements on the entrance/exit connections hoses

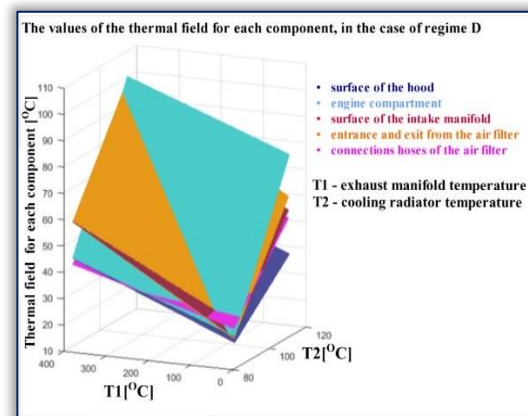
Temperature measurements were made on the surface of the intake manifold for all the considered functioning regimes of the engine (Graphics 1, 2) and in the case of traffic mode mountain (D) data was collected referring to the temperature of all the components (Graphics 3, 4), a modeling was realized using the method of the smallest squares. The programme used to generate the graphics was realized in the Matlab language.



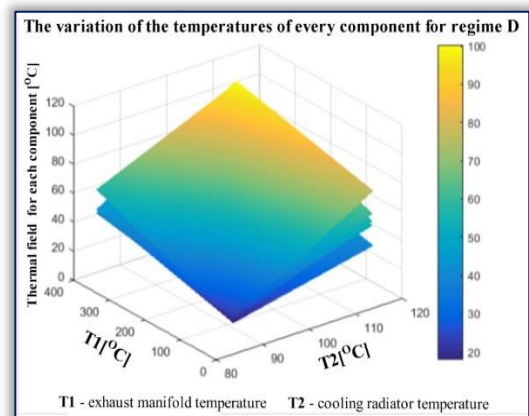
Graphic 1. The intake manifold temperature evolution for each functioning regime



Graphic 2. The field of temperatures corresponding to the intake manifold at each functioning regime



Graphic 3. The values of the thermal field for each component, in the case of regime D



Graphic 4. The variation of the temperatures of every component for regime D

4. Final results and conclusions

At the end of the measurements it is emphasized the fact that the constructive solution chosen for the FORD Fiesta 1.4l car, namely placing the air filter above the engine, and its dimensions, lead to an excessive heat of the air for the functioning of the engine, favoring the appearance of overheating phenomena of the engine, of detonation, or normal wear, etc., with influences on reducing the filling coefficient of the cylinders, with consequences on reducing the power of the engine, growing of the fuel consumption and of the emissions.

Also from figure 8 can notice, on the air filter shell, the existence of some critical areas which present temperatures up to 30% higher than the maximum temperature recorded on the surface of the air filter, this can be explained through the gathered influence of the 3 heat sources (exhaust manifold, engine and cooling radiator).

5. References

- [1] Birtok-Băneasă C, Rațiu S A and Hepuț T, 2017 *Calculation of thermal conductivity for new materials used in intake systems of internal combustion engines*, International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes (Greece), SEP 19–25, 2016, AIP Conference Proceedings **1863** pp 1–6

- [2] Birtok-Băneasă C 2017 The dispersion of the heat flow in the engine compartment. case study fiat panda 1.2i *Annals of Faculty Engineering Hunedoara* **XV**(4) pp 215–219
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- [4] Rațiu S, Birtok-Băneasă C, Alic C and Mihon L 2009 *New concepts in modeling air filters for internal combustion engines* 20th International DAAAM SYMPOSIUM “Intelligent Manufacturing & Automation: Theory, Practice & Education” Vienna (Austria) **20** pp 1–6
- [5] www.corneliugroup.ro