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# CYLINDER HEAD ANALYSIS FROM THERMAL POINT OF VIEW USING FINITE ELEMENT METHOD (FEM) OF A SPARK IGNITION ENGINE BY USING ZONAL COOLING PRINCIPLE

BY

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**Abstract.** In this paper, it is in focus a detailed analysis of the temperature distribution in the cylinder head. For this scope is build up a tree-dimensional (3D) model using Catia V5. The thermal analysis was performed using 3D finite element method, Ansys Workbench 16.1.

**Keywords:** cylinder head; FEM; finite element analysis; temperature distribution; engine.

## 1. Introduction

The design of modern internal combustion engines requires a precise determination of temperature distribution in order to optimize the design. Therefore, precise determination of temperature is obtained by using the finite element method with finite element analysis program, Ansys. This program, as it is known, has a great advantage that offers the possibility to use a wide range of scenarios (Ulian, 2021).

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## 2. The Analysis of the Temperature Variation of the Inside Intake Channel Depending on the Coolant Temperature

The analysis is made on a cylinder head, shown in Fig. 1, that is created using Catia V5 and are made of cast aluminum alloy, AlSi7Cu0.5Mg.

The next step after the 3d model is completed, is to import the geometry into finite element analysis software, Ansys (Kummitha, 2017; Vijayashree, 2018).

After the 3d model is imported into Ansys, we need to define the material properties, temperature for the fresh air fuel mixture and temperature for combustion chamber gas. According to existing data, the conductivity coefficient for this alloy, is $\lambda_{ch} = \lambda_{Al}$ = 122 W/m2K, the temperature of the fresh air fuel mixture, $T_0$ is considered $T_0$ = 293 K and temperature for combustion chamber gas, $T_g$ is considered $T_g$ = 1600 K.

In order to run the simulation, the 3d model of cylinder head is meshed by automatic mesh tool. Discretization was done with tetrahedral finite elements, having the size of 2 mm.

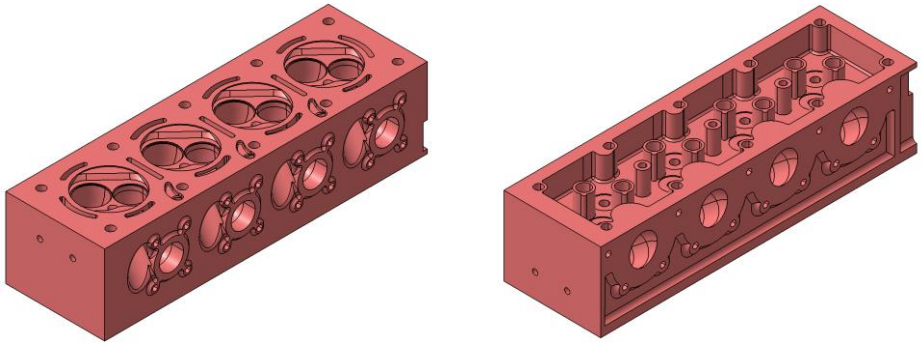
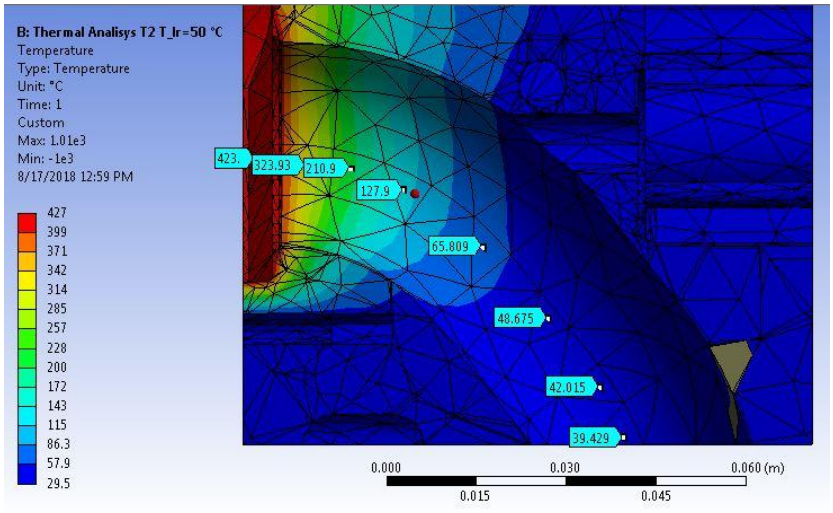


Fig. 1 – Cylinder head block (Ulian, 2021).

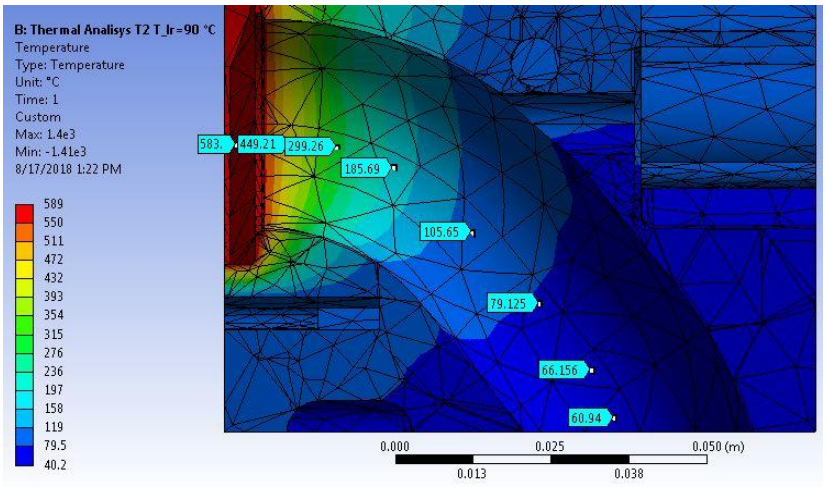
The previous research shows that the fresh air-fuel mixture meets with the warm engine components and it is mixed with the residual gases from the combustion chamber. These processes lead to increasing the initial temperature of the fresh air-fuel mixture and to a drastic reduction of the volumetric efficiency (Ulian *et al.*, 2018).

The simulation gives us the possibility to study the variation of the temperature of the intake channel, $T_{pcadm}$, depending on the coolant temperature, $T_{lr}$.

The results for this analysis shown in Fig. 2, give us information about the temperature variation of the intake channel when the coolant temperature, are $T_{lr}$ = 50°C (Fig. 2*a*) and $T_{lr}$ = 90°C (Fig. 2*b*).




*a*




*b*

Fig. 2 − The variation of the temperature of intake channel, $T_{pcadm}$, depending on the coolant temperature, $T_{lr}$ (Ulian, 2021).

In Fig. 3 is shown an overview regarding the temperature variation of the intake channel depending on the coolant liquid. Therefore, if it is decreased the coolant temperature from cylinder head from 90°C to 50°C the temperature of intake channel will be decreased with approximately 30%. This lower cylinder head temperature will increase the volumetric efficiency and it also conduct to increased performance (Ulian, 2021).

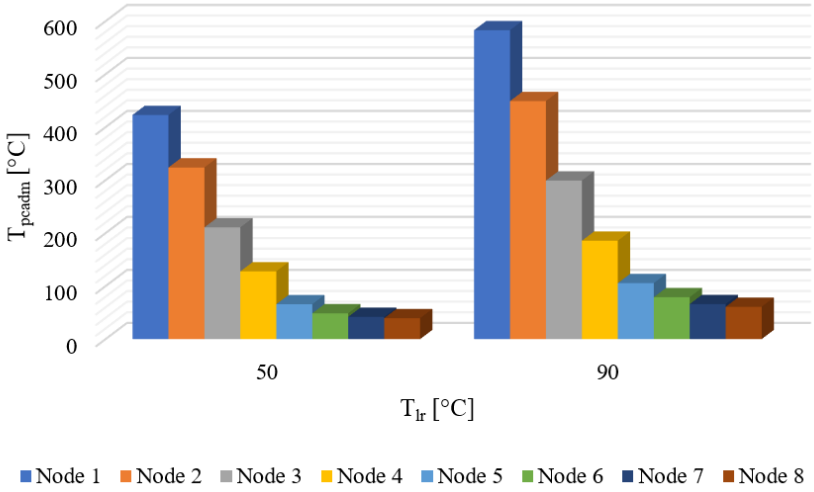



Fig. 3 − Temperature of intake channel, $T_{pcadm}$, depending on the coolant temperature, $T_{lr}$, in different nodes.

On the other hand, was also considered useful a graphical representation of an average value of the wall temperature of the intake channel, $T_{pcadm}$, depending on the temperature of the coolant liquid, $T_{lr}$. This was also determined by FEA simulation and can be seen in the graph in Fig. 4 (Ulian, 2021).

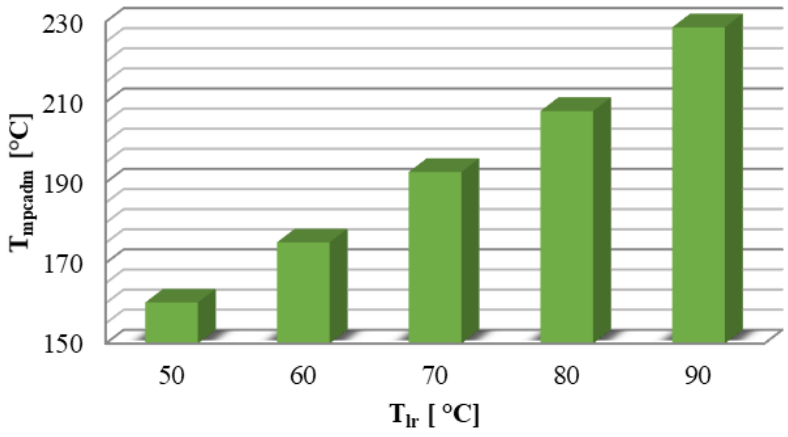



Fig. 4 − The average value of the inlet channel wall temperature, $T_{pcadm}$, as a function of the coolant temperature, $T_{lr}$, determined by FEA simulation.

## 3. Conclusions

The results obtained in this paper, indicate that can lead to a considerable improvement in the performance and economy of the spark ignition engine by using a zonal thermal regime.

The objective of this study is to provide information for the temperature variation of the intake channel depending on the coolant liquid in order to improve the value for volumetric efficiency.

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## ANALIZA TERMICĂ A CHIULASEI MOTORULUI CU REGIM TERMIC ZONAL UTILIZÂND METODA ELEMENTULUI FINIT (FEM)

(Rezumat)

În această lucrare, este realizată o analiză detaliată a distribuției de temperaturi în masa chiulasei. Pentru această analiză s-a realizat un model tri-dimensional (3D) folosind programul de proiectare Catia V5. Analiza termică s-a realizat folosind programul de analiză ce utilizează metoda elementelor finite, Ansys Workbench 16.1.