EXPERIMENTAL AND COMPUTATIONAL STUDY ON THERMAL STRESSES IN THE CYLINDER HEAD OF A SPARK IGNITION ENGINE FUELED WITH ETHANOL - GASOLINE BLENDS

Krisztina UZUNEANU, Tănase PANAIT, Marcel DRĂGAN, Spiru PARASCHIV

UNIVERSITY „DUNAREA DE JOS” OF GALATI, ROMANIA

Rezumat. The thermal stresses in the cylinder head of an internal combustion engine are determined as a function of the level of temperature. Measuring the temperatures in different parts of the cylinder head, we can adjust the cooling, or we can improve the materials, or even we can improve the properties of the fuels. The present paper deals with the thermal stresses in the cylinder head of a spark ignition engine fueled with a mixture of gasoline with ethanol.
Cuvinte cheie: cylinder head, temperatures, thermal stress, ethanol-gasoline.

Abstract. The thermal stresses in the cylinder head of an internal combustion engine are determined as a function of the level of temperature. Measuring the temperatures in different parts of the cylinder head, we can adjust the cooling, or we can improve the materials, or even we can improve the properties of the fuels. The present paper deals with the thermal stresses in the cylinder head of a spark ignition engine fueled with a mixture of gasoline with ethanol.
Keywords: cylinder head, temperatures, thermal stress, ethanol-gasoline.

1. INTRODUCTION

The thermal stresses are due to the difference in the parts temperatures. These further depend on the speed and the way the heat is transferred to the parts, on the part shape, their thermal conductivity and cooling. If an ethanol - gasoline mixture is used to fuel an unmodified spark ignition engine a lower level of the part temperatures is obtained as compared with the case when only gasoline is used.

2. EXPERIMENTAL STAND TO MEASURE THE TEMPERATURE IN THE CYLINDER HEAD

A comparative study was carried out on a spark-ignition engine fueled with gasoline and a mixture of gasoline - ethanol.

The engines parameters were : capacity $V_t = 2500$ cm^3, power P_e = 65 kW and speed n = 4500 min^{-1}. The engine was instaled on a testing stand. Chromel -alumel thermocouples were provided to measure the outlet gas temperature and the cylinder - head wall temperature near the inlet and outlet ports.

The temperature measuring points in the inlet, outlet valves and the bridge between the valves are given in the figures 1, 2, 3.

The temperatures were read on a digital gauge type Multy-Tester. The first stage of the experiment was to supply gasoline to the engine.

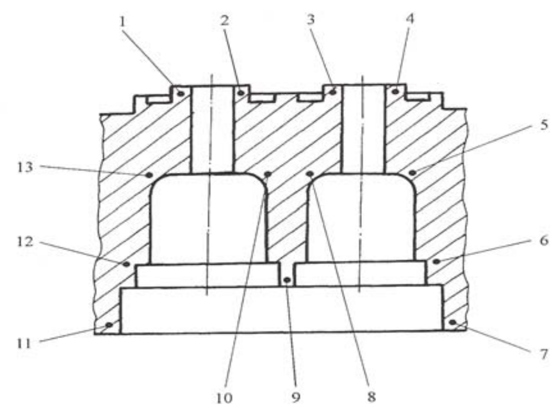

Fig. 1. Cross section at bridge between valves.

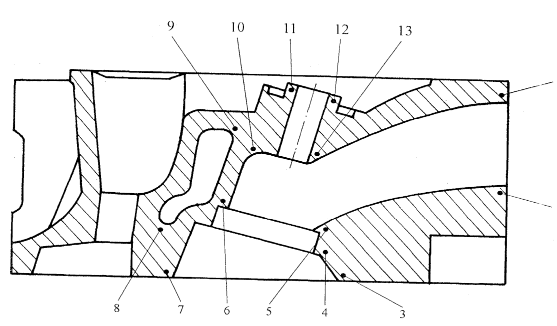

Fig. 2. Cross section at admission area.

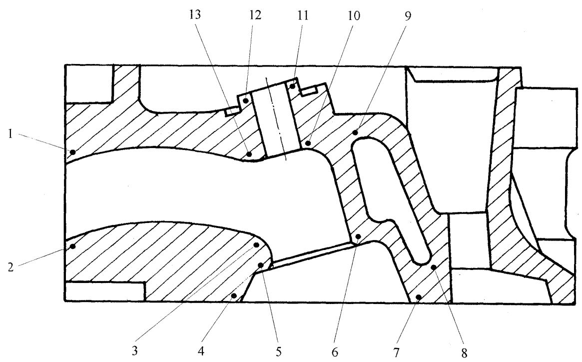

Fig. 3. Cross section at exhaust area.

The engine speed was kept constant n = 1000 min $^{-1}$ until relatively constant temperatures of the gas and the cylinder head wall near the input and output ports were reached. The temperature of the cylinder- head wall in the area of the gas inlet port stabilizes after τ ~ 30 min while in the of the gas outlet port after τ~35 min.

With a speed of n = 1500 min^{-1} the same measurements are taken and it is found that the cylinder head wall temperatures in the area of the gas inlet port stabilizes after ~ 30 min, in the area of the gas outlet port after ~35 and the gas temperature after 40 min.

With a speed of n = 2200 min^{-1} it is found that the cylinder head wall temperature near the inlet port stabilizes after ~ 30 min, at the outlet port after ~ 30 min and the gas temperature after ~ 45min.

The engine was subsequently fueled with different mixtures:

-mixture of 5% ethanol - 95% gasoline E5,

- mixture 10 % ethanol - 90 % gasoline E10,

- mixture 15 % ethanol - 85 % gasoline E15,

The experiments were made while keeping the speed to the same values as before.

The measured temperatures are inputs to the ANSYS program to determine the temperature field, thermal stresses and deformations due to the temperature difference in the cylinder head wall [5] as you are seen in figs 4, 5, 6.

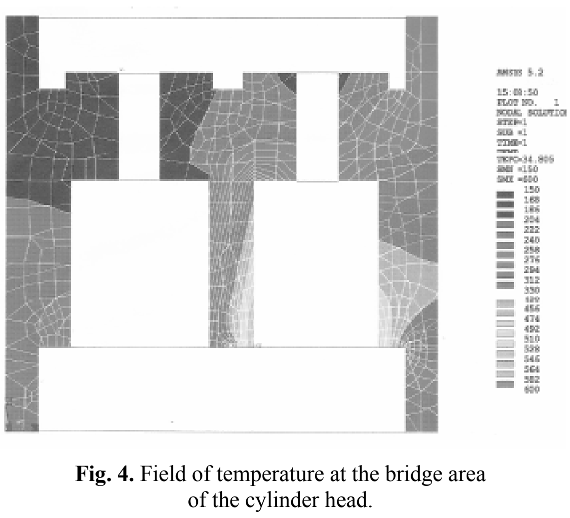

Fig. 4. Field of temperature at the bridge area of the cylinder head.

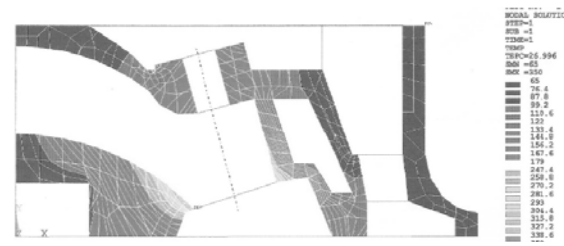

Fig 5. Field of temperature at the inlet valve area.

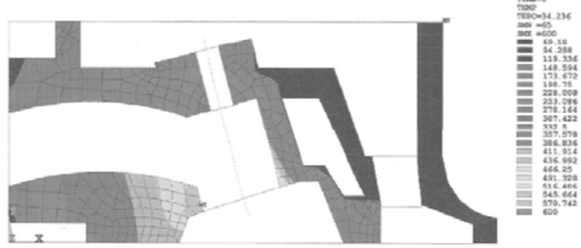

Fig 6. Field of temperature at the outlet valve area.

From the data analysis the following conclusions are reached:

- The temperatures measured when the engine is fueled with 5% ethanol - 95 % gasoline E5 are equal to the temperatures taken when the engine is fueled with gasoline only.
- The temperatures recorded when 10 % ethanol - 90 % gasoline E10 is fed to the engine are lower than in the case of the classical gasoline supplying.
- When the mixture of 15 % ethanol - 85 % gasoline E15 is used, the temperatures are lower by 1- 2 degrees than that measured when E10 is fueled, but there were some difficulties when the engine was started. [1], [3]

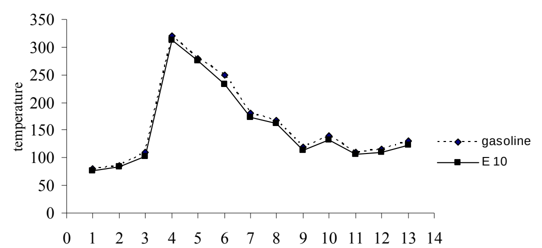

Fig. 7. Temperature in the cylinder head wall in the inlet valve area [^{0}C].

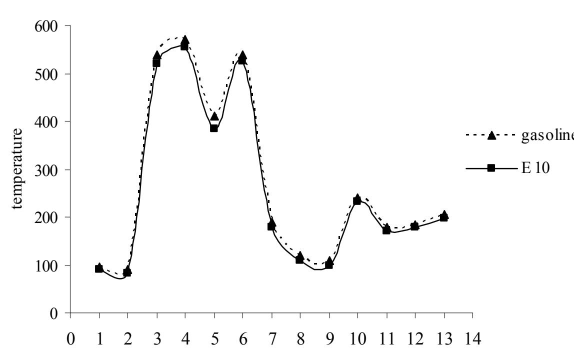

Fig. 8. Temperature in the cylinder head wall in the outlet valve area [^{0}C].

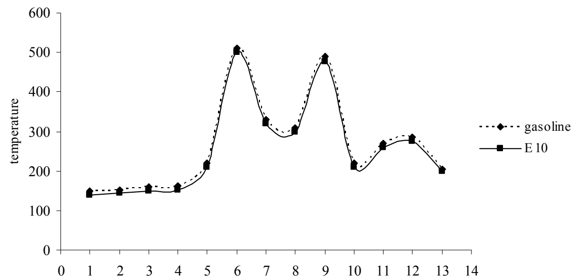

Fig. 9. Temperature in the cylinder head wall in the area between the inlet/outlet valve [^{0}C].

The more recent computation finite element programs have implemented thermal finite elements too. For the purpose of this paper, use was made of the ANSYS program which contains 20 types of elements for the heat transfer out of which the types of "thermal elements" were used: for preset nodal temperatures, axial- symmetric solid, thin plate, three- dimensional solid [4]

Using these elements the piston and cylinder head were investigated in terms of thermal steady conditions and the temperature field, heat flow thermal stresses and displacements along different directions were obtained [4], [5].

3. CONCLUSIONS

The physical and chemical properties of the ethanol are significantly different from those of the conventional liquid oil fuels.

An efficient use of alcohols as fuels calls for construction modifications and adjustments to the engine in order to diminish the negative influences and turn into good account the good properties. That is why, to avoid modifications to the spark ignition engine, the use of the mixture E10 (10 % ethanol -90% gasoline) is worth being considered.

Using this mixture to fuel the spark ignition engine, a number of positive results are obtained, such as:

– a lower polytropic exponent of compression which results in lower pressures and temperatures by the end of the compression and burning and also lower burnt gas mean temperatures, [2],[4];

– the mean thermal stress of the spark ignition engine is lower when using E10 then gasoline in the same engine operating conditions;[4]

– the extent to which heat is saved by using E10 shows that, although the engine efficiency does not increase, supplying two types of fuels to the same engine represents an important research trend;[3]

– the tendency to reduce the effective power at a constant fuel rate as a consequence of the combustion value which is much lower than that of the gasoline,

– the decrease of polluting emissions when using E10 indicates that the future belongs to those engines able to operate while protecting the environment, the atmosphere, i.e. life.[2]

REFERENCES

[1] M. GAMBINO, M. MIGLIACCIO, *Carburanti alternativi per l'autotrazione,*Lignori Editore, Napoli, 1993.

[2] K.UZUNEANU., C.GHEORGHIU, T.PANAIT - *Some aspects regarding the use of alcohols to supply a spark-ignition engine.* Conference MOTAUTO 2000, Sofia, Bulgaria 18-20 Oct.2000 (Proceedings vol. I "Internal Combustion Engines" ISBN 954-90272-3-6, pag.120-124).

[3] UZUNEANU, K., POPESCU, F.- *Considerations on the use of blend ethanol-gasoline to supply a spark ignition engine, regarding the thermal economic performance*. Analele Universităţii "Dunărea de Jos" din Galaţi, Fascicula IV 2001, ISSN 1221-4558 pag. 67-71.

[4] UZUNEANU, K., SCARPETE, D., PANAIT, T. - *Study on Thermal Stress Occuring in the Burning Chamber of an Ethanol-Gasoline Fueled Spark Ignition Engine* - Conference "MOTAUTO' 01", 17-19 October 2001, Varna, Bulgaria; Proceedings ISBN 954-90272-6-0, Vol. I, pag. 99-103.

[5] UZUNEANU KRISZTINA, PANAIT TĂNASE – *A study of levels of temperature in the cylinder head of a ethanol – gasoline fueled spark ignition engine.* Conferinţa Naţională de Termotehnică cu participare internaţională. Ediţia XVI-a, Ploieşti 31 mai – 1 iunie 2007, Vol 1, pag. 281-285, ISSN 1843 – 1992.