CIRCUMFLUENCE OF THE CYLINDER IN A NON-CONVENTIONAL COMBUSTION ENGINE

Vladimír Hlavňa, Dušan Sojčák

University of Žilina, Univerzitná 1, 010 26 Žilina, Slovak republic
tel.: +421 41 513 2670, fax +421 41 5253016,
e-mail: vladimir.hlavna@fstroj.utc.sk

Abstract

When solving the project "A non-conventional energetic unit equipped with a cooling combustion engine" it was necessary to deal with flow and transfer of heat along the cylinder liner

The contribution is a continuation of already published results gathered from experiments focused on the circumfluence of the combustion engine cylinder by a traditional cooler. The paper points out heat flows, velocity profiles, and turbulent intensity during the cylinder liner circumfluence by a non-conventional cooler – lithium bromide. Non-conventional cooling circuit of the engine, physical properties of the coolant for the engine (including specific heat capacity, absolute viscosity, density and thermal conductivity), model net, adaptation in the boundary layer area, velocity field in the vicinity of the inserted cylinder and the liner temperature profile from the side soaked with fluid, pressure field in the inserted cylinder chamber and temperature field of heat transfer, turbulent intensity on the cylinder liner and streamlines of the flow field are presented in the paper.The examined combustion engine will be able of a long-term operation when the alternate coolant is used

Keywords: *non-conventional ICE, non-conventional LiBr-H_2O coolant, energetic equation*

1. Introduction

Non-conventionality of the combustion engine used in the solution of the non-conventional energetic unit is given by a new construction of its cooling system, Fig. 1, [1]. The cooling system as part of the absorptive cooling equipment is to provide an evaporation process. In order to provide the evaporation process it is necessary to use a non-conventional LiBr-H_2O coolant in the engine jacket. The coolant features other physical properties than the original coolant - Table 1 [4].

Fig.1 Non-conventional cooling circuit of the engine

Physical properties of the coolant for the engine at 65^{O}C. *Table1*

	specific heat capacity [kJ.kg^{-1}.K^{-1}]	absolute viscosity [Pa.s]	density [kg.m^{-3}]	thermal conductivity [W.m^{-1}.K^{-1}]
original coolant	4.19	0.4355	980.5	0.677
LiBr-H_2O	2.95	0.771	1300	0.579

Due to the above mentioned reason of the combustion engine cooling by means of the non-conventional coolant it was necessary to examine heat transfer – energy from the cylinder liner into the fluid and flow in its vicinity. In the previous contributions we published the basic energetic equation of the cooling system. The equation was consequently modelled on the engine block in order to find the point of cooperation with the absorptive system [1].

The energetic equation of one chamber of the inserted cylinder is the result of the solution. On the basis of the equation it is possible to examine the engine cooling.

$$Q_{ch1} = m_{ch}.c_{LiBr-H_2O}.\Delta T_{v1} \tag{1}$$

Modelling takes into account transfer of heat through the cylinder liner into the coolant. The temperature profile from the combustion space was expected to extend alongside the cylinder. Non-uniformity of the temperature profile along the circumference was neglected. The wall of the liner soaked with the fluid is not considered as rough surface. Neither bubble nor membrane effect at cooling was taken into consideration.

2. Computational model

The geometrical shape of the cavity in the vicinity of the cylinder liner was achieved after the liner dismantling [1]. After creation of the model the net was formed considering the boundary layer formation, Fig. 2.

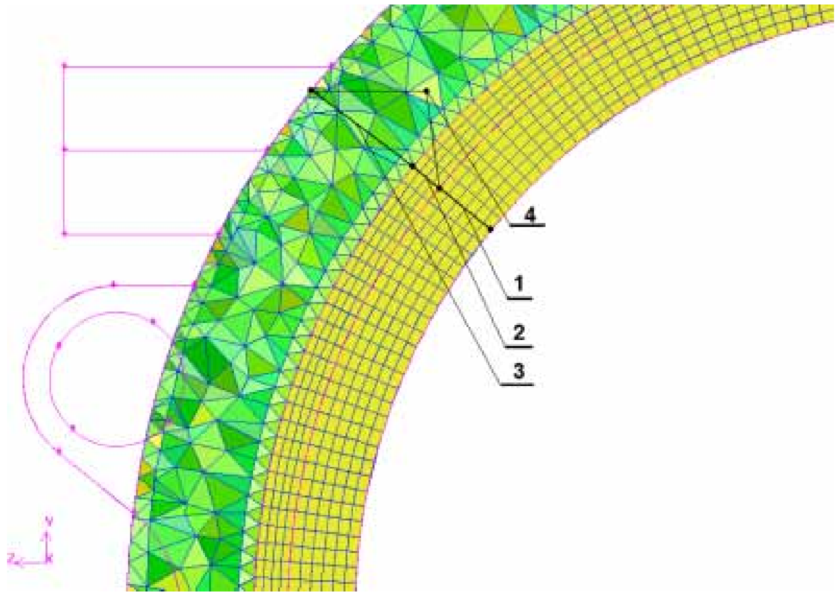

Fig.2 Model net, 1 – cylinder liner, 2 – net for boundary layer modelling, 3 – area of inserted cylinder chamber, 4 – fluid area.

Further, it was necessary to determine the type of boundary conditions and computational continuum. Thus, the model was geometrically plotted. The next step was to determine the mathematical model. For this case the k - ε RNG model was chosen with the solution of energetic equation for the fluid area and the standard wall function was chosen for the solid area.

$$\rho E + \nabla\left[\vec{v}\left(\rho E + p\right)\right] = \nabla\left[k_{eff}\nabla T - \sum_j h_j \vec{J}_j + \left(\tilde{\tilde{\tau}}_{eff}\,\vec{v}\right)\right] \qquad (2)$$

$$\rho h + \nabla\left(\vec{v}\rho h\right) = \nabla\left(k\nabla T\right) \qquad (3)$$

Having plotted the mathematical model and having set the values of physical parameters the computation was carried out. After some iterations it was necessary to adapt the net in the area of the boundary layer in order to achieve the correct results - Fig. 3.

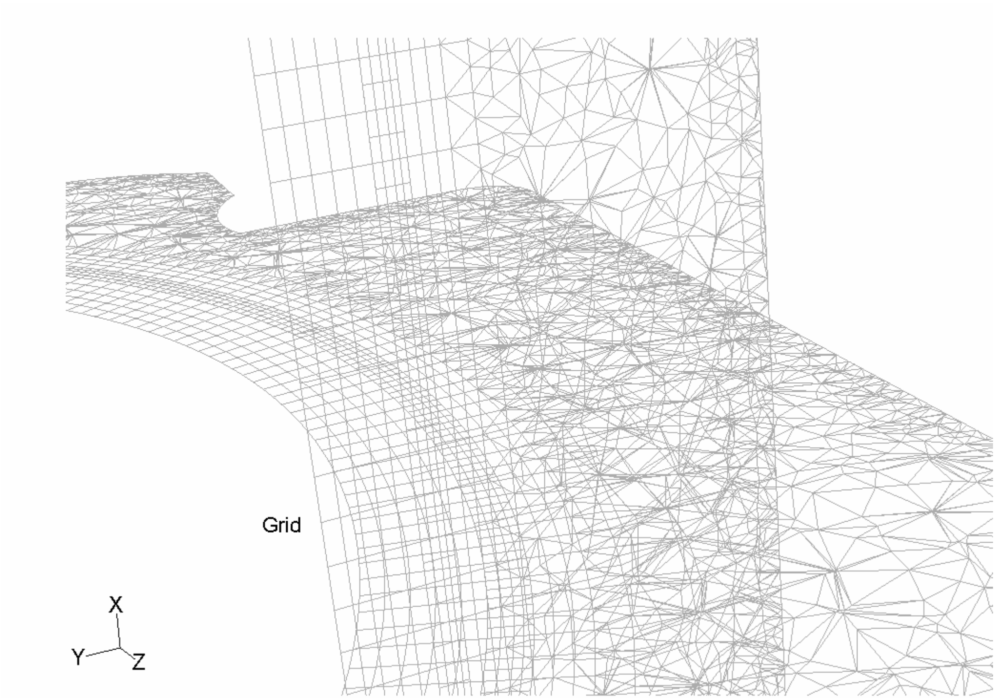

Fig.3 Adaptation in the boundary layer area

3. Results of modelling

To assess the flow and heat transfer in the inserted cylinder vicinity the below parameters were chosen and further examined (related to the thermal state given by the equation (1) :

- ⇒ velocity field,
- ⇒ thermal state of the cylinder liner on the side soaked with fluid,
- ⇒ pressure field in the chamber of the inserted cylinder,
- ⇒ temperature field of heat transfer,
- ⇒ field of turbulent intensity on the cylinder liner,
- ⇒ streamlines for observation of the coolant flow pathways,
- ⇒ value of the specific heat flow through the cylinder liner.

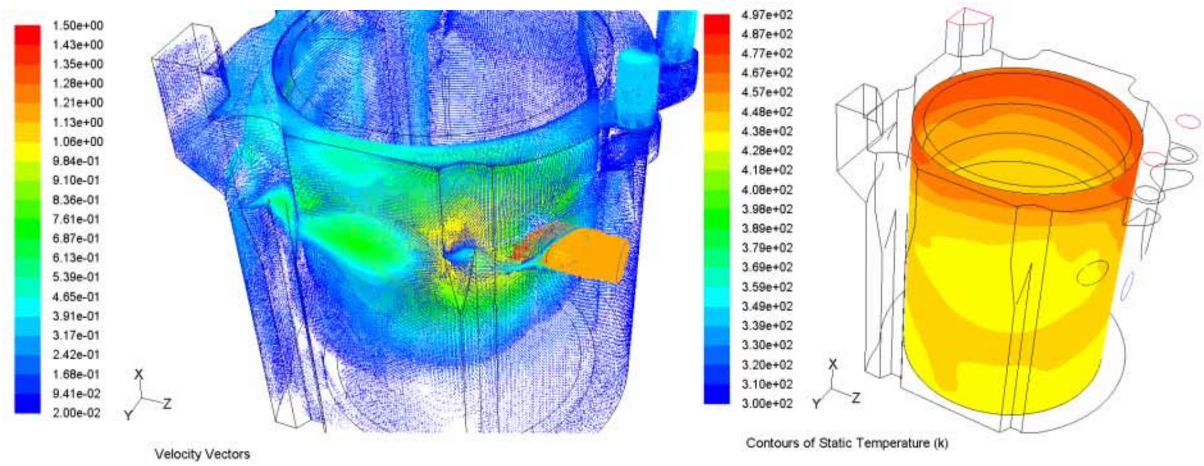

Fig.4 Velocity field in the vicinity of the inserted cylinder and the liner temperature profile from the side soaked with fluid

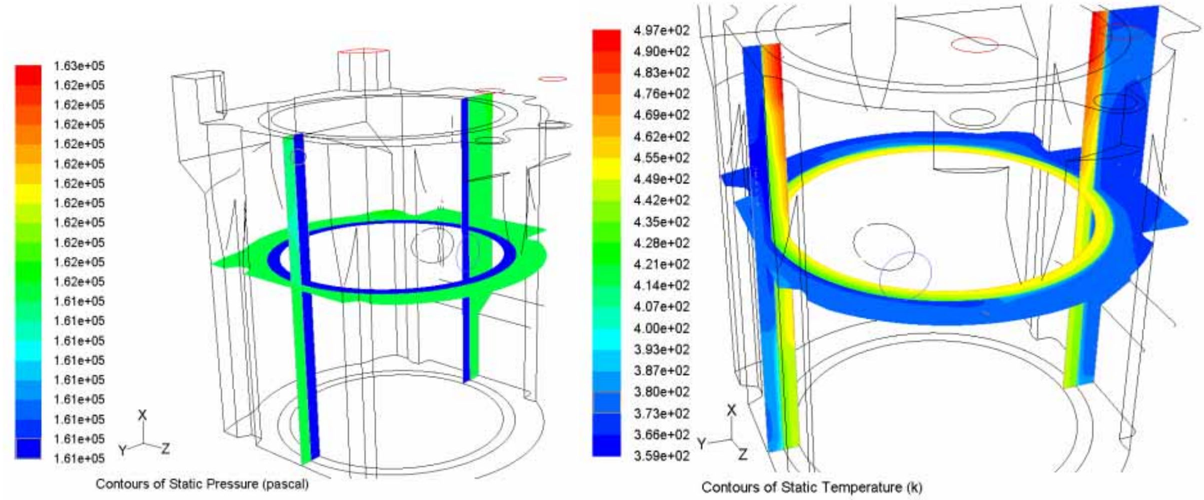

Fig.5 Pressure field in the inserted cylinder chamber and temperature field of heat transfer

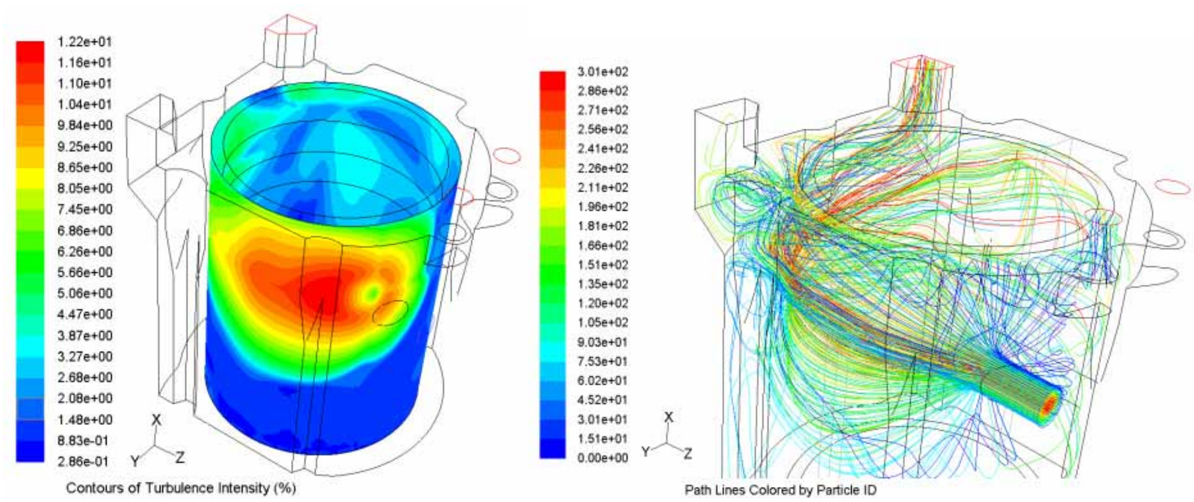

Fig.6 Turbulent intensity on the cylinder liner and streamlines of the flow field

4. Conclusion

The aim of the contribution was to analyze the flow in the vicinity of the inserted cylinder when the non-conventional coolant was used. The emphasis was put on the chosen parameters. The achieved data were compared with the data recommended by literature.

Due to turbulent intensity at the mass flow given by the equation (1) the achieved velocity of flow in the inserted cylinder chamber is 1.5 $m.s^{-1}$, which is in compliance with the recommended interval of 1 up to 2 $m.s^{-1}$ [2]. The temperature profile – Fig. 4 – corresponds with the mass flow, turbulent intensity and velocity of flow. This temperature profile holds for the temperature of $223^{O}C$, which is the temperature of the cylinder liner in the area of the first piston ring on the side of the combustion space. This value can be considered satisfactory. The pressure field – Fig. 5 – is also satisfactory. From the streamlines of the flow field it can be seen how the fluid splits lengthwise as well as along the circumference of the inserted cylinder chamber. Here, it is important to state that the cooling potential of the coolant is not satisfactorily used. This construction of the block is not suitable for the use of the block as an expeller. The required cooling of the engine has to be done, in this case, by an increased mass flow. The ability of cooling the engine would be improved by a suitable constructional design of the inlet of the coolant into the chamber. It is also necessary to examine the inlet openings and to direct the coolant flow by means of sealing under the engine head.

The achieved temperature flow through the liner is 171.151 $W.m^{-2}$. According to [3] this value is within the interval of the given values ranging from 110 up to 190 $W.m^{-2}$.

In conclusion it can be stated that the examined combustion engine will be able of a long-term operation when the alternate coolant is used. This statement relates to the temperature and heat states determined by the equation (1). These results also confirm the correctness of the determination of the point of cooperation of the engine as an expeller for the absorptive cooling system.

5. References

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