analysis and modeling, numerical techniques,
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THE INFLUENCE OF THE ENGINE SPEED ON THE TEMPERATURE DISTRIBUTION IN THE PISTON OF THE TURBOCHARGED DIESEL ENGINE

Summary. This article presented the numeric computations of non-stationary heat flow in the form of distribution of temperature fields on characteristic surfaces of the piston for two different rotational speeds for the same engine load during 60 seconds during in which the engine worked. The object of research was a turbocharged Diesel engine with a direct fuel injection to the combustion chamber and the engine cubic capacity that is 2390 [cm^3] and power rating, which is 85 [kW]. The numeric computations were carried out by the use of the finite element method (FEM) with the help of COSMOS/M software and the use of the two – zone combustion model.

WPŁYW PRĘDKOŚCI OBROTOWEJ SILNIKA NA ROZKŁAD TEMPERATURY W TŁOKU DOŁADOWANEGO SILNIKA Z ZAPŁONEM SAMOCZYNNYM

Streszczenie. W pracy przedstawiono obliczenia numeryczne niestacjonarnego przepływu ciepła w postaci rozkładu pól temperatury na charakterystycznych powierzchnia tłoka dla dwóch prędkości obrotowych silnika przy porównywalnym współczynniku nadmiaru powietrza w czasie 60 sekundowej jego pracy. Przedmiotem badań był doładowany silnik wysokoprężny z wtryskiem bezpośrednim o pojemności 2390 [cm^3] i mocy znamionowej 85 [kW]. Obliczenia numeryczne zostały przeprowadzone przy zastosowaniu metody elementów skończonych (MES) za pomocą programu COSMOS/M oraz przy wykorzystaniu dwustrefowego modelu procesu spalania.

1. INTRODUCTION

In this article the mathematical description of most characteristic surfaces of the piston under the angle of exchange of warmth as well as temperature distribution for turbocharged Diesel engine in the initial phase of its work was introduced. Numeric computations were carried out by the use of the finite element method (FEM) [6 – 8] with the help of COSMOS/M software. The object of research was a turbocharged Diesel engine with a direct fuel injection to the combustion chamber and the engine cubic capacity that is 2390 [cm^3] and power rating, which is 85 [kW]. The calculations were conducted for two different rotational speeds n = 2000 [rpm] and n=4250 [rpm] for the same engine load during 60 seconds during in which the engine worked. On the basis of the indicated diagrams registered on the engine test house for two rotational speeds which complied the excess air number λ= 1,66 the average temperature of the working medium (Fig. 1) and total surface film conductance

(Fig. 2) in function of crank angle was marked. Further information about the other engine components can be found in ref. [12-16].

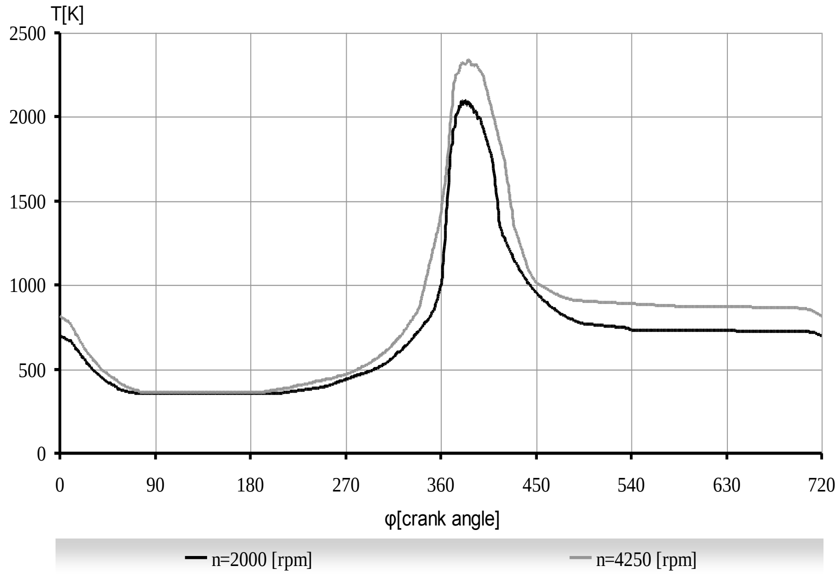


Fig. 1. The diagrams of average temperature of working medium of Diesel engine about power rating N=85 [kW] and λ=1,66 for engine speed n=2000 [rpm] and n=4250 [rpm]

Rys. 1. Wykres średniej temperatury czynnika roboczego silnika ZS o mocy nominalnej N=85 [kW] i obciążeniu silnika λ=1,66 dla prędkości obrotowej n=2000 [min^{-1}] i n=4250 [min^{-1}]

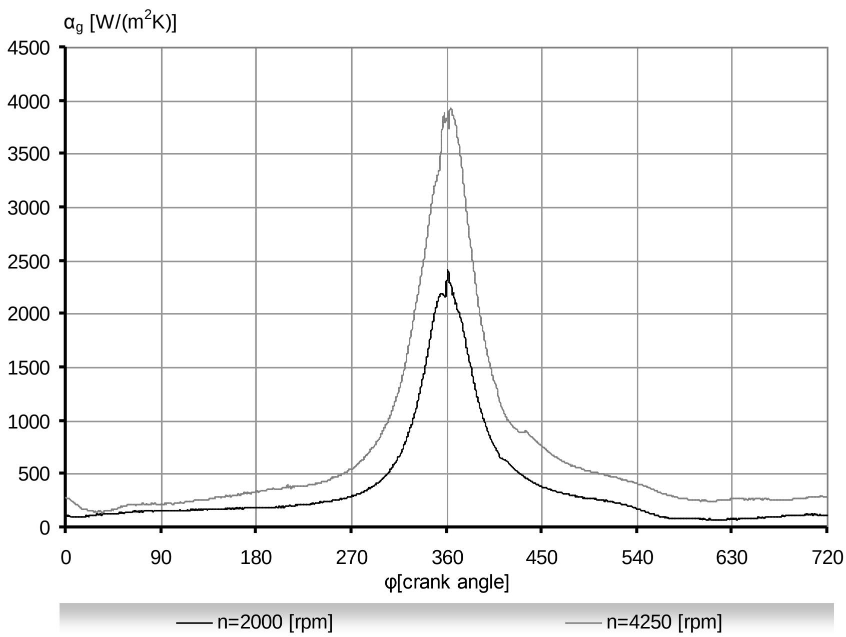


Fig. 2. The diagrams of total surface film conductance in function of crank angle for λ = 1,66 and engine speed n=2000 [rpm] and n=4250 [rpm]

Rys. 2. Wykresy zmian globalnego współczynnika przejmowania ciepła w funkcji [˚OWK] dla obciążeniu silnika λ = 1,66 i prędkości obrotowej n=2000 [min^{-1}] i n=4250 [min^{-1}]

2. GEOMETRICAL MODEL

The geometrical model of the piston (Fig. 3b) was executed with the help of the Geostar computer program COSMOS/M on basis of the real element (Fig. 3a). The order of its creation is introduced as follows:

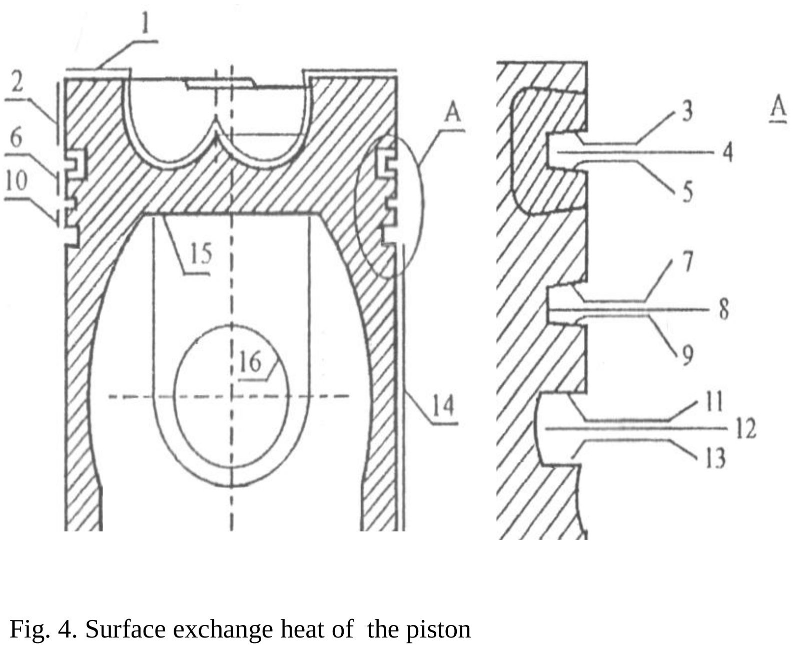
- was created the three-dimensional intersection of the piston engine;
- the intersection of the piston was divided with mesh of the finite elements;
- the mesh was based on the three-dimensional elements of tetrahedral solids (tetra 4) about 4 knots and dimensions 1,5[mm].

a) b)

Fig. 3. The piston engine: a) real element , b) discreet model
Rys. 3. Tłok silnika: a) model rzeczywisty, b) model dyskretny

3. BONDUARY AND INITIAL CONDITIONS

In analyzed the engine piston 16 characteristic surfaces of the heat exchange (Fig. 4) were distinguished which definite the values of the III kind boundary conditions were attributed [5, 14].



Surface:
1 – *piston head,*
2 – *flank piston over I ring,*
3 – *upper groove of I ring,*
4 – *bottom groove of I ring*
5 – *under groove of I ring,*
6 – *between rings I-II,*
7 – *upper groove of II ring,*
8 – *bottom groove of II ring,*
9 – *under groove of II ring,*
10 – *between rings II-III,*
11 – *upper groove of III ring*
12 – *bottom groove of III ring*
13 – *under groove of III ring,*
14 – *leading of the piston,,*
15 – *internal of the piston,*
16 –. *the point of contact of the piston pin with* the engine *piston*

Fig. 4. Surface exchange heat of the piston
Rys. 4. Powierzchnie wymiany ciepła tłoka

While analyzing the heat load it was assumed that at the beginning (at the moment t=0s) temperature distribution in the piston is steady and equal to the temperature of the surroundings. [5].

4. CALCULATIONS RESULTS

The comparative distributions of temperatures for two different rotational speed on the surface of the piston head during 15[s] , 30[s] as well as 60[s] work of engine on Figure 5 were introduced. However the course of maximum temperature as well as the course of the speed of the temperature changes on surface of the piston engine on Figures 6 and 7 was introduced.

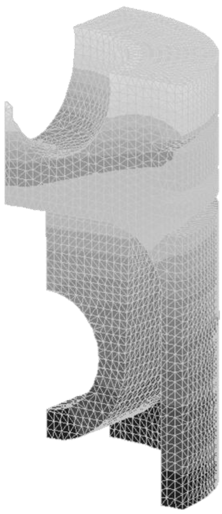
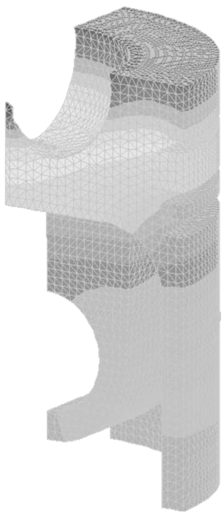
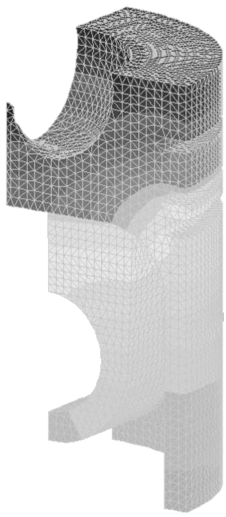
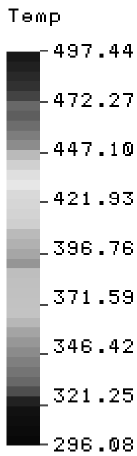
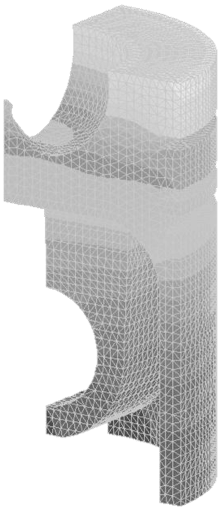
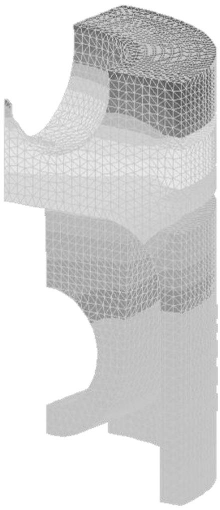
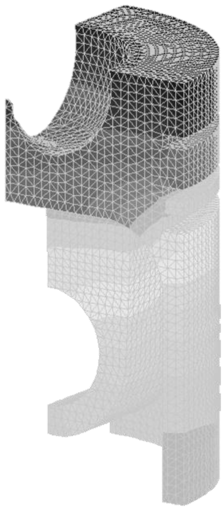
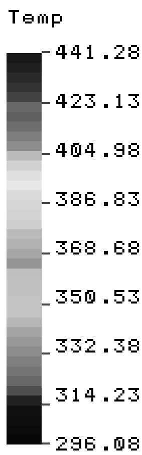
TIME			**T[K]**
15[s]	**30[s]**	**60[s]**	
n = 2000 [rpm], λ = 1,66			
			
n = 4250 [rpm], λ = 1,66			
			

Fig. 5. The following phases warming up of the piston engine
Rys. 5. Kolejne fazy nagrzewania się tłoka silnika

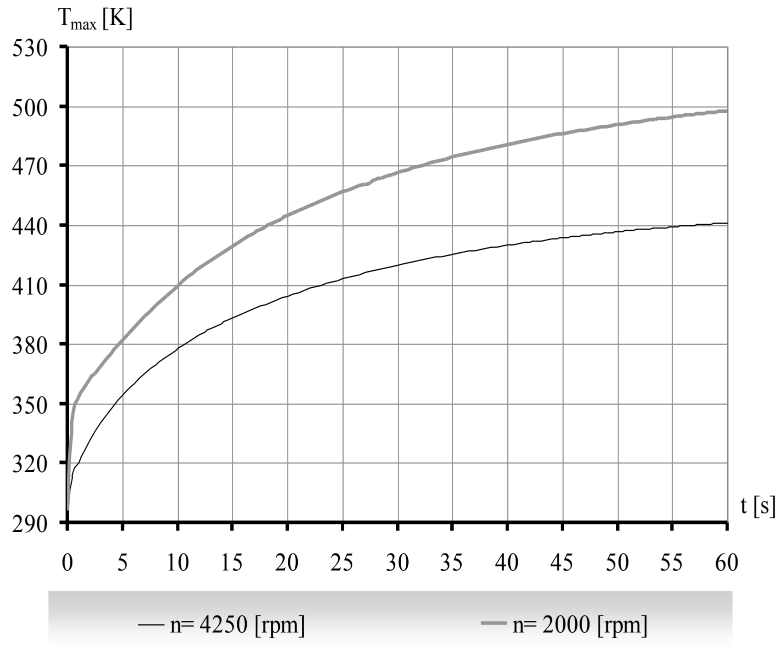


Fig. 6. The diagrams of maximum temperature on the surface of the piston head
Rys. 6. Przebieg zmian temperatury maksymalnej na powierzchni denka tłoka

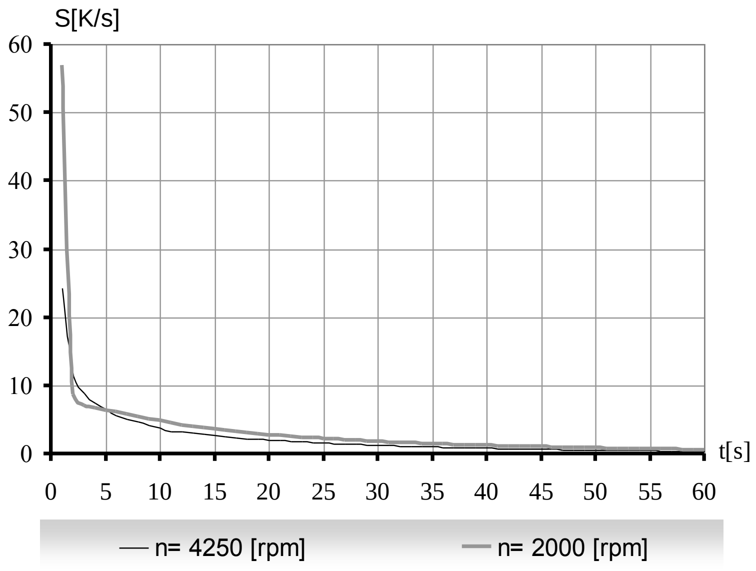


Fig. 7. The course of the speed of the temperature changes on the surface of the piston engine
Rys. 7. Przebieg szybkości zmian temperatury na powierzchni denka tłoka

5. CONCLUSIONS

The enlargement of the engine speed in the turbocharged Diesel engine causes the decrease of temperature on the surface of the engine piston. The calculated value of the maximum temperature of the piston model indicated that after 60 seconds during in which the engine worked carried out about

500 [K] for the engine speed n=2000 [rpm] and for n=4250 [rpm] is about 20% smaller .The maximum value of temperature is on the surface of the piston head as well as in the combustion chamber.

The maximum value of the heat load on the surface of the piston head carries out for engine speed n=2000 [rpm] – 2,14 [K/mm] and for engine speed n=4250 [rpm] – 1,86[K/mm]. The speed of the temperature changes on the surface of the piston head and is the largest in the first five seconds of the engine work.

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