THE INFLUENCE OF THE ENGINE LOAD ON THE VALUE AND TEMPERATURE DISTRIBUTION IN DRY CYLINDER SLEEVE

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Abstract

In this work the influence of the engine load on the value and temperature distribution in dry cylinder sleeve in turbocharged Diesel engine was definition. The computations were performed by means of the original two-zone combustion model, the boundary conditions of III kind and the finite elements method (FEM) by using of COSMOS/M program. The characteristic surfaces of the cylinder sleeve were analyzed. The registered results of the computations get appointed on experimental measured parameters of the state of the engine work for the excess air number λ = 1.66 and λ = 3.08 and for the same engine speed n=2000 rpm. The computations were conducted for initial 60 seconds of the engine work. On basis of received calculations it was determined that the increase of the engine load at the same engine speed causes the growth of the temperature of cylinder sleeve. Maximum temperature of the dry cylinder sleeve during 60 second of engine work carry out about 420 K for λ = 1.66 and 380 K for λ = 3.08. Moreover the calculations show that top parts of the cylinder sleeve near of the mount flange heat up the most quickly and the temperature below the 3rd ring in outer dead centre of the piston is the lowest. The speed of increase temperature of dry cylinder sleeve is the largest in initial phase of warming up engine. After 10 seconds the average speed of increase temperature carries out about 8 K per second for larger load and about 5 K per second for lower load of the engine. Between 10 and 20 second the speed of increase temperature falls down and it starts stabilizing slowly.

Keywords: *numerical techniques, engine load, cylinder sleeve, FEM*

1. Introduction

The modeling of the heat loads in the dry cylinder sleeve on the basis of the periodically changing the boundary conditions III kind which describes the total surface film conductance α as well as the temperature T of the working medium surrounding the surfaces [3] of the cylinder sleeve was carried out by means of the two zone combustion model [1]. The analysis was carried out from the moment of starting the engine to the moment when the distribution of temperatures changed in a small range. The results of the computations get appointed on experimental measured parameters of the state of the engine work for the excess air number λ = 1.66 and λ = 3.08 and for the same engine speed n=2000rpm. In Fig. 1 the diagrams of indicated pressures and in Fig. 2 the courses of the calculated temperatures of working medium turbocharged Diesel engine were presented. Moreover in Fig. 3 was introduced the graph of calculated total surface film conductance α for two of engine loads.

Geometrical conditions define the shape and sizes of the considered body. The geometrical models of the analyzed sleeve were made by means of solid tetrahedral three-dimensional elements of 4 nodes (TETRA 4) and dimensions of 3 mm accessible in Cosmos/M system. In Fig. 4 was presented discrete model of cylinder sleeve created by means of Cosmos/M software [4].

In the analyzed cylinder sleeve (Fig. 5) five characteristic heat exchange surfaces were defined and the boundary conditions values of III type were attributed to them[3].

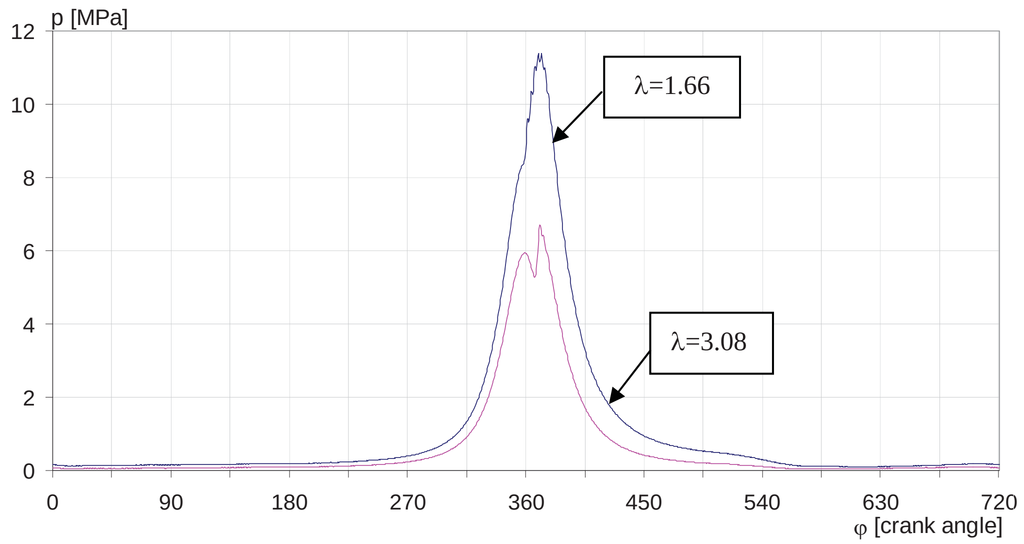


Fig. 1. The diagrams of the indicated pressures engine for λ = 1.66 and λ = 3.08

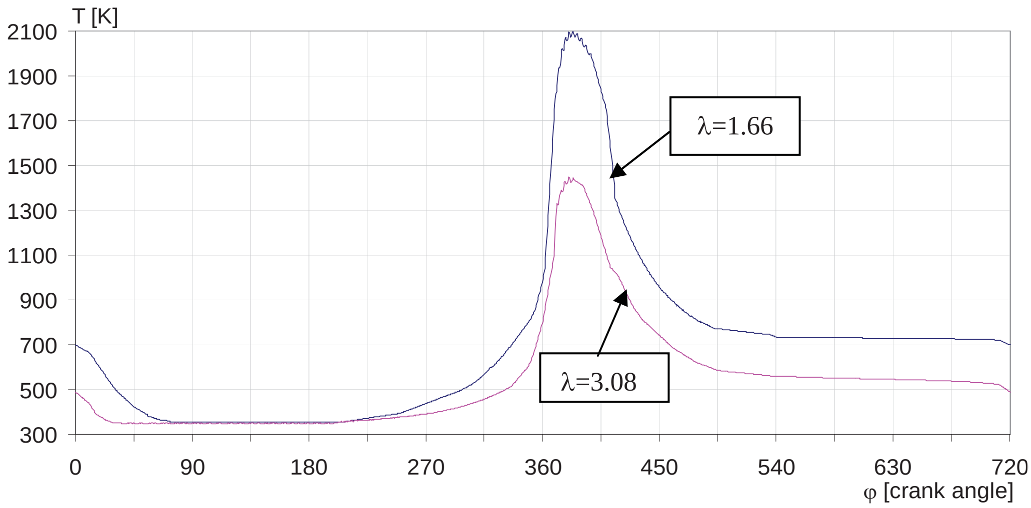


Fig. 2. The diagrams of the temperatures working medium for λ = 1.66 and λ = 3.08

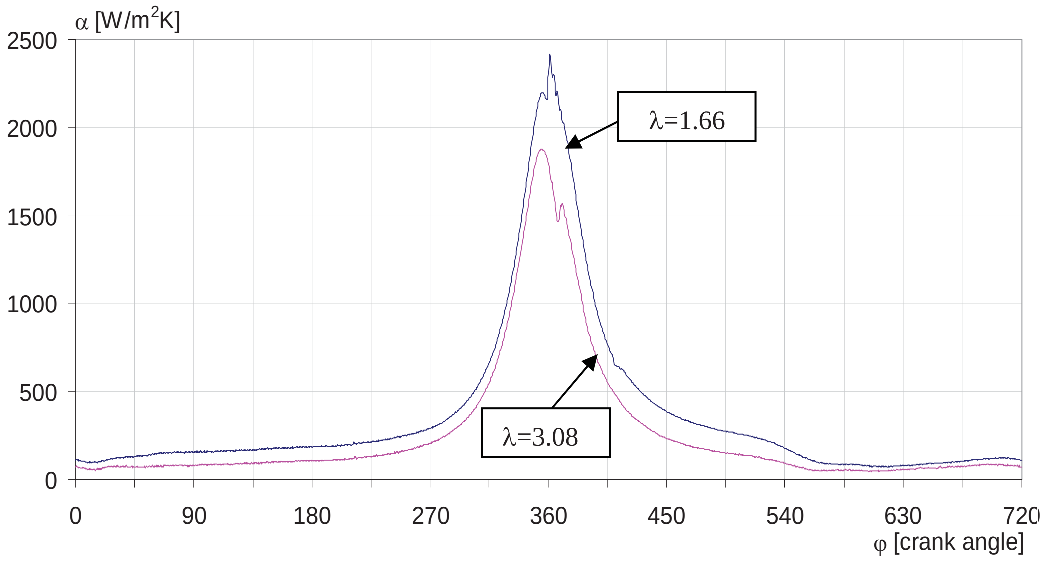


Fig. 3. The diagrams of the total surface film conductance α for λ = 1.66 and λ = 3.08

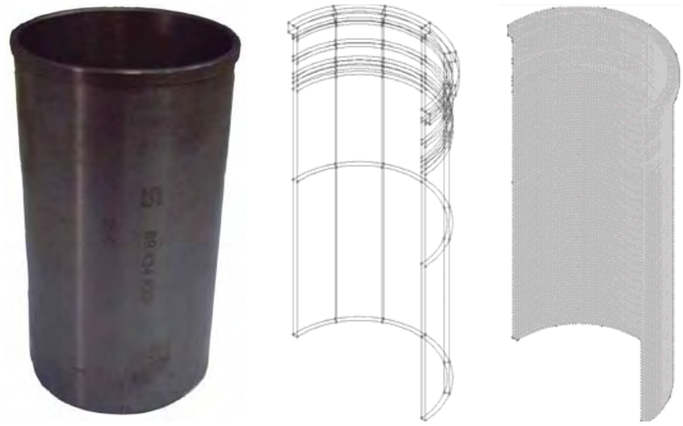
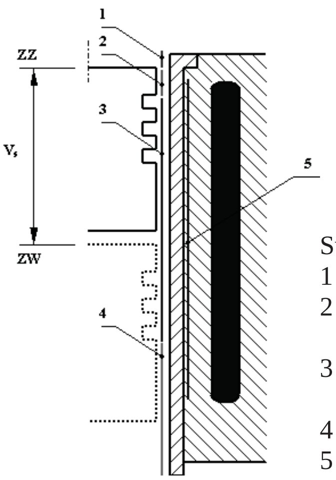


Fig. 4. Discrete model of cylinder sleeve



Surface:
1 - from the side of combustion chamber,
2 - from the piston head in the inner dead centre (ZZ) to the first ring in ZZ of the piston,
3 - from the first ring in the inner dead centre (ZZ) to 3rd ring in the outer dead centre (ZW) of the piston,
4 - below the 3rd ring in ZW of the piston,
5 - from the side of the cooling liquid.

Fig. 5. Drawing of the dry cylinder sleeve

- surface 1 (from side of combustion chamber) - washed constantly by working medium about variable the temperature and pressure in the time of singular cycle - for this surface the changing boundary conditions were accepted,
- surface 2 (from the piston head in the inner dead centre - ZZ to the first fire ring in ZZ of the piston) washed in dependence from the piston position by working medium or surface of the piston (from head piston to first fire ring) - for this surface the changing boundary conditions were accepted,
- surface 3 (from the first ring in the inner dead centre - ZZ to 3rd ring in the outer dead centre - ZW of the piston) - washed in dependence from the piston position by working medium or surface of the piston (from head piston to first fire ring, as well as the ring section of piston and below 3rd ring) - for this surface the changing boundary conditions were accepted,
- surface 4 (surface of cylinder sleeve below the 3rd ring in ZW of the piston) exchange the heat with piston surface below 3rd ring - for this surface the changing and average boundary conditions were accepted.

2. Results of calculations

In this paper the heat loads for the dry cylinder sleeve for a turbocharged Diesel engine about engine cubic capacity 2390 cm^3 and nominal power 85 kW and rotation speed 2000 rpm were modeled. In Fig. 6-12 following phases of the heating up of the dry cylinder sleeve for the same piston position equals 5 crank angle during the cycle of filling up the engine after inner dead centre (ZZ) of the piston during 10, 20, 30, 40, 50 and 60 seconds of the engine work were presented.

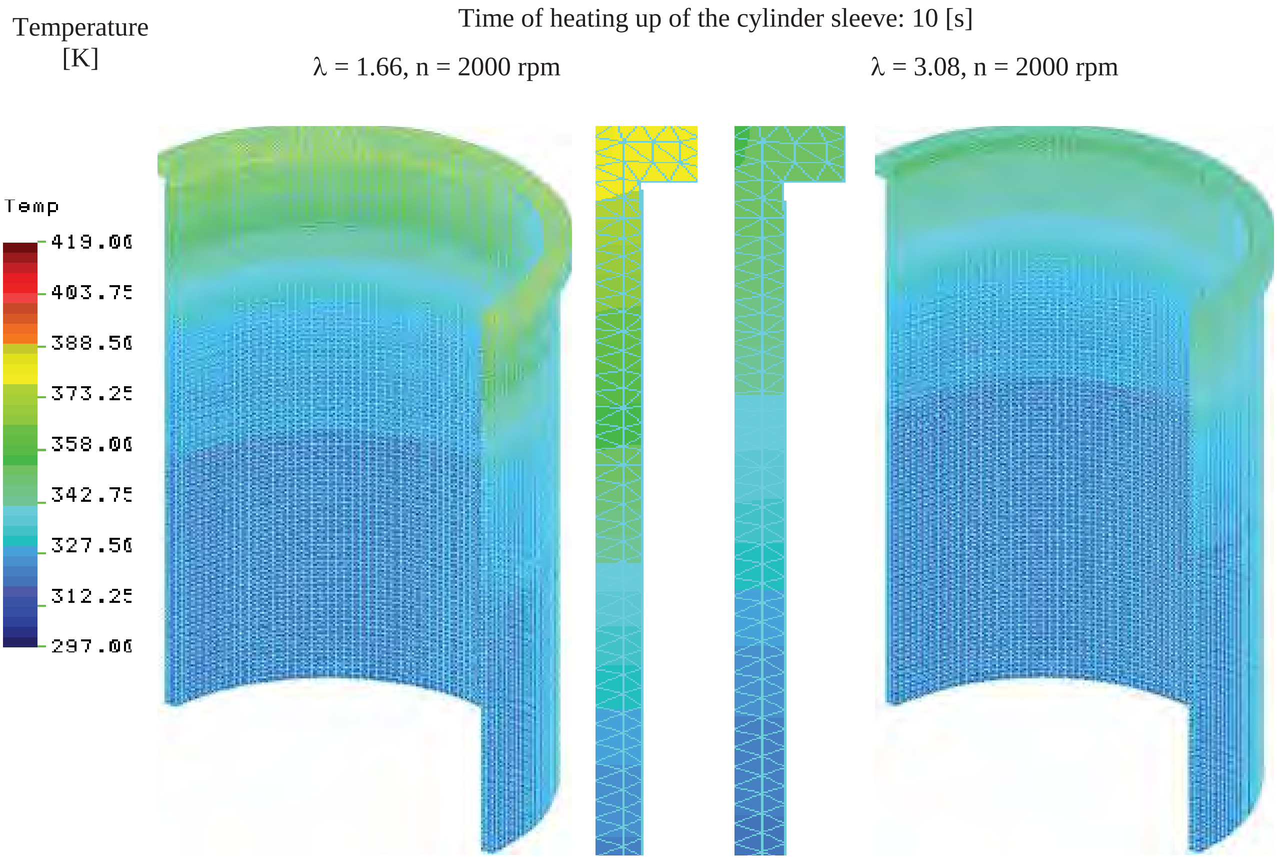


Fig. 6. The following phases heating up of the cylinder sleeve after 10 seconds

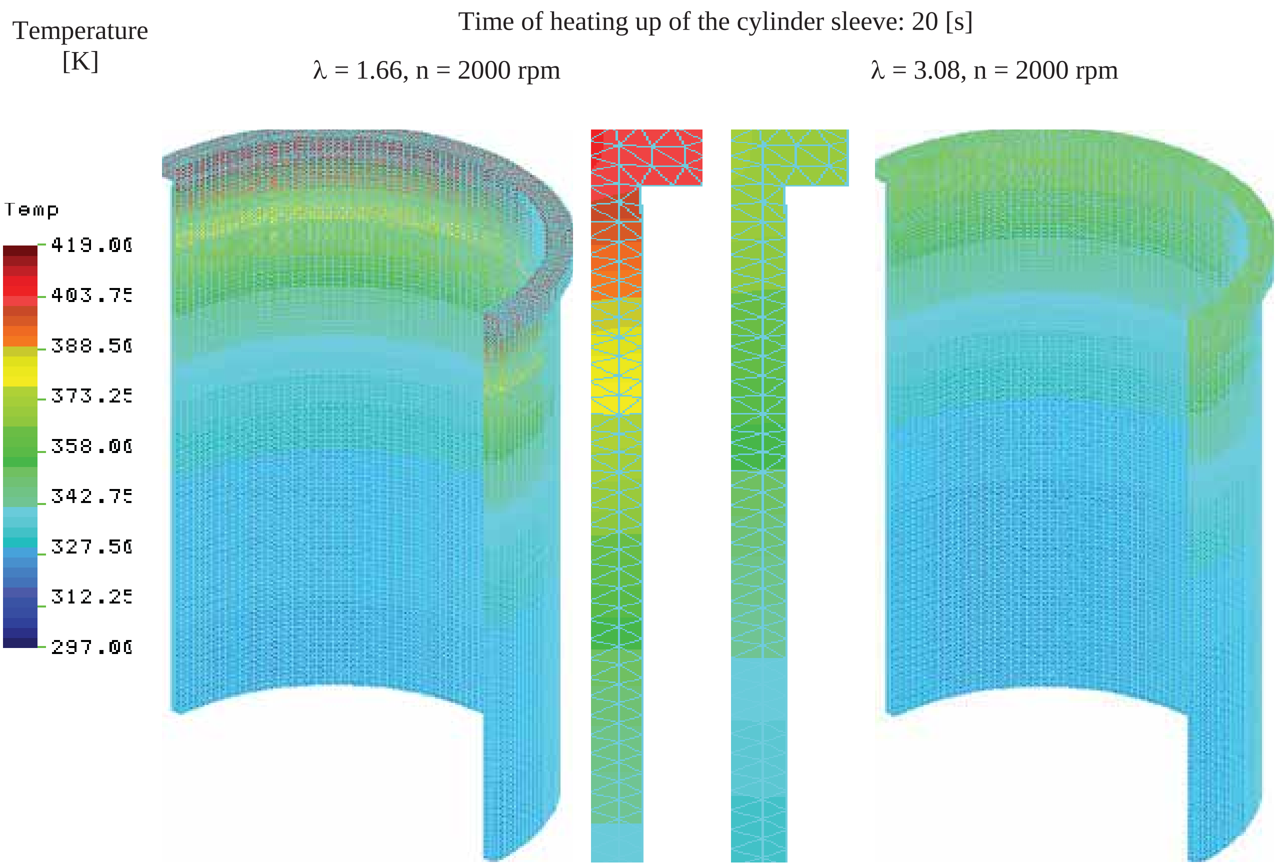


Fig. 7. The following phases heating up of the cylinder sleeve after 20 seconds

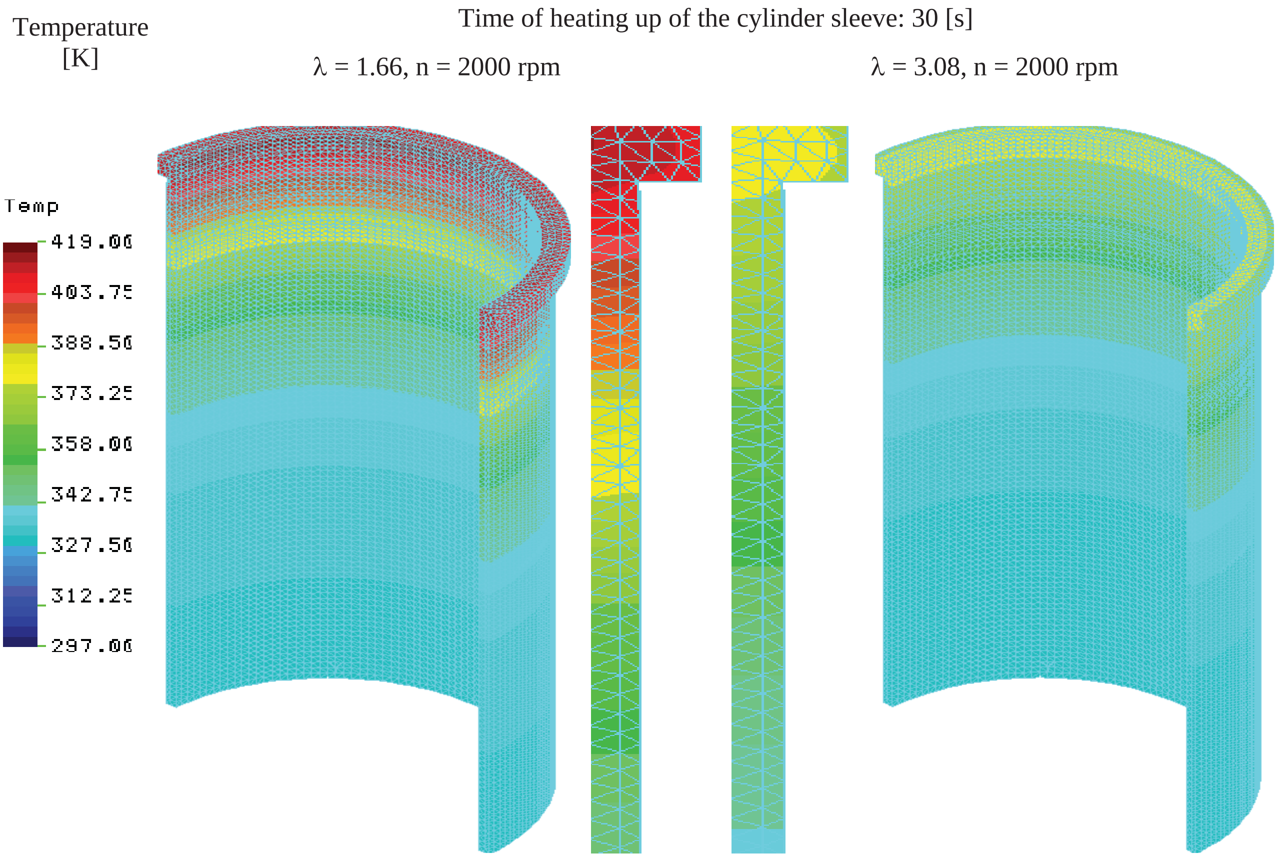


Fig. 8. The following phases heating up of the cylinder sleeve after 30 seconds

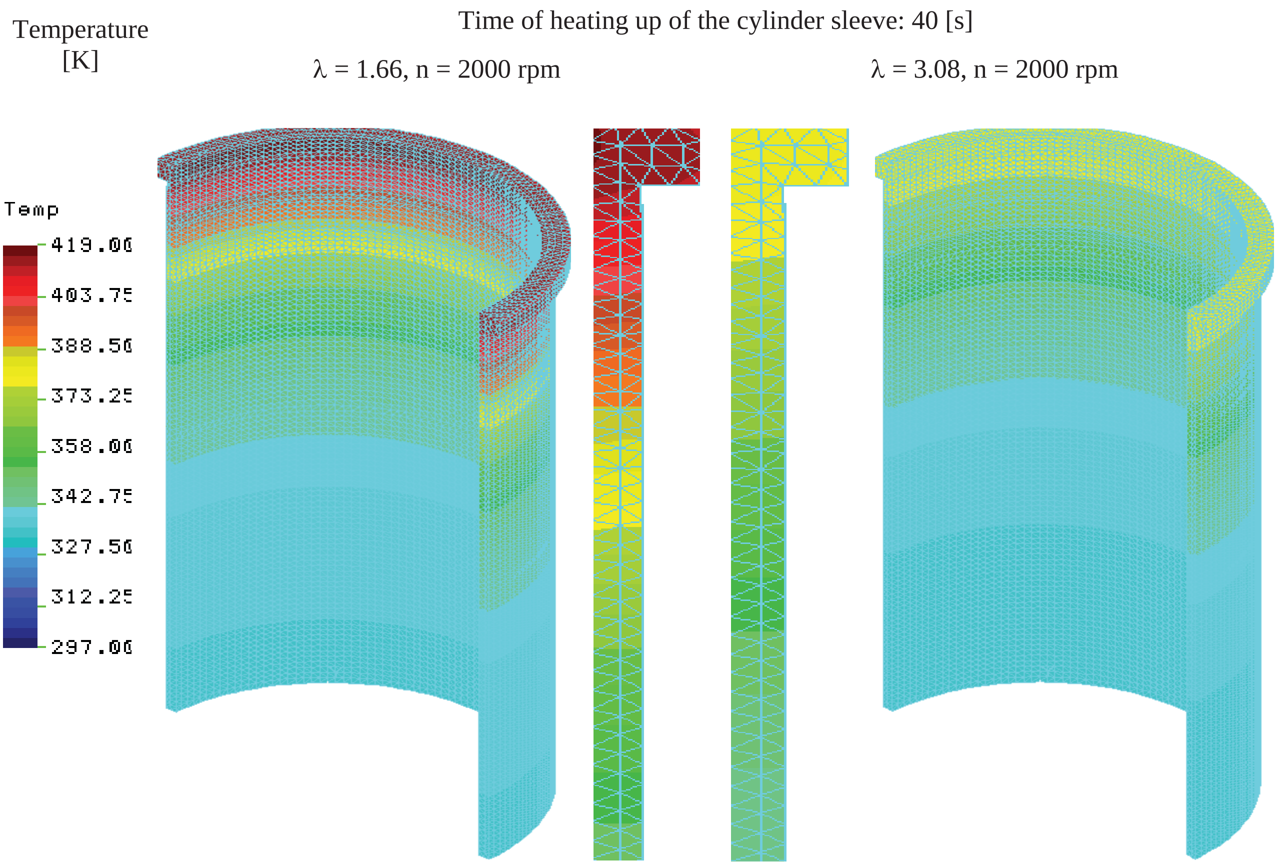


Fig. 9. The following phases heating up of the cylinder sleeve after 40 seconds

Temperature [K]

Time of heating up of the cylinder sleeve: 50 [s]

λ = 1.66, n = 2000 rpm λ = 3.08, n = 2000 rpm

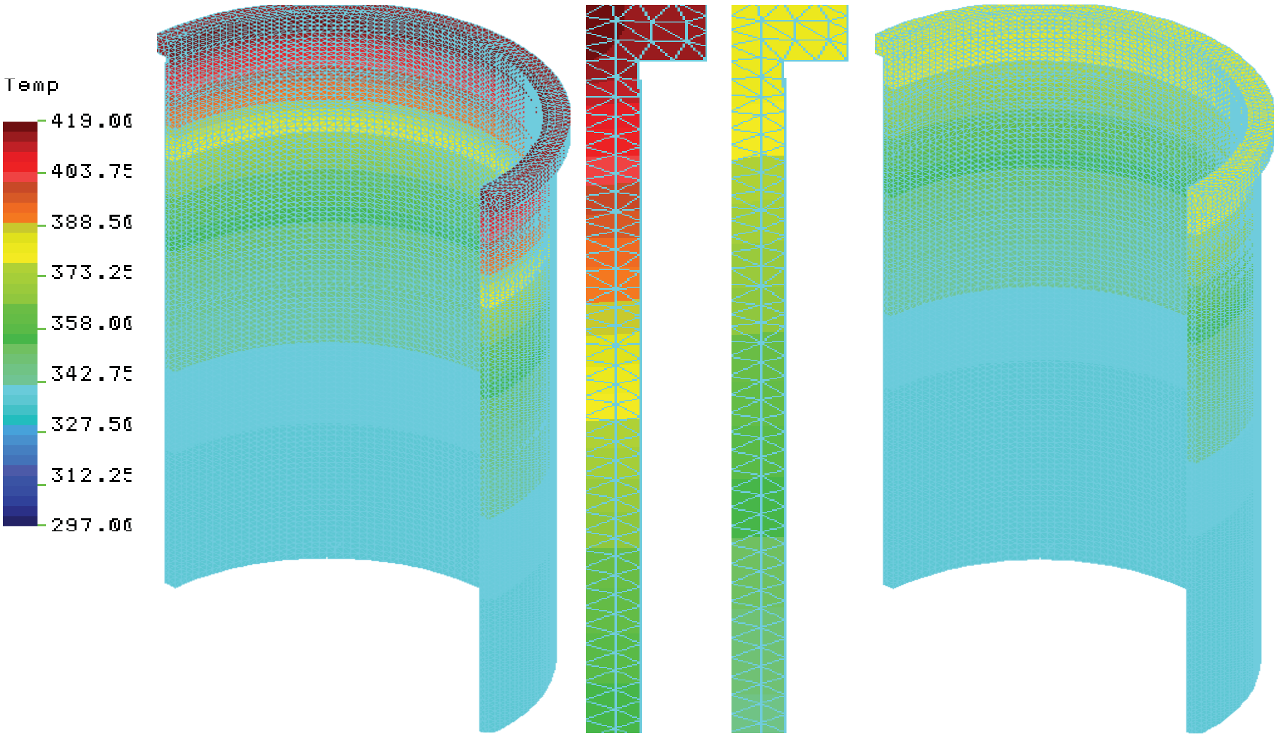


Fig. 10. The following phases heating up of the cylinder sleeve after 50 seconds

Temperature [K]

Time of heating up of the cylinder sleeve: 60 [s]

λ = 1.66, n = 2000 rpm λ = 3.08, n = 2000 rpm

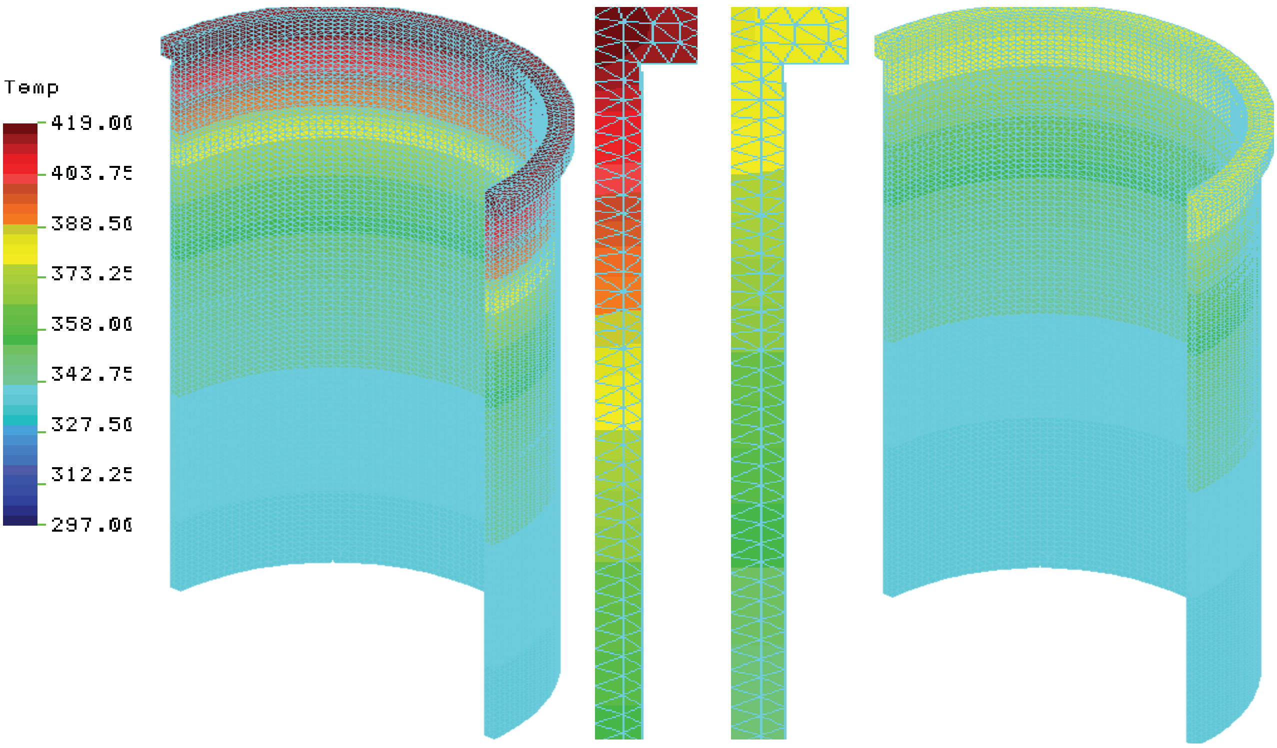


Fig. 11. The following phases heating up of the cylinder sleeve after 60 seconds

On basis of received calculations it was determined that the increase of the engine load at the same engine speed causes the growth of the temperature of cylinder sleeve. Maximum temperature of the dry cylinder sleeve during 60 second of engine work carries out about 420 K for $\lambda = 1.66$ and 380 K for $\lambda = 3.08$. In Fig. 10 was presented the graph of changes maximum temperatures in the analyzed cylinder sleeve.

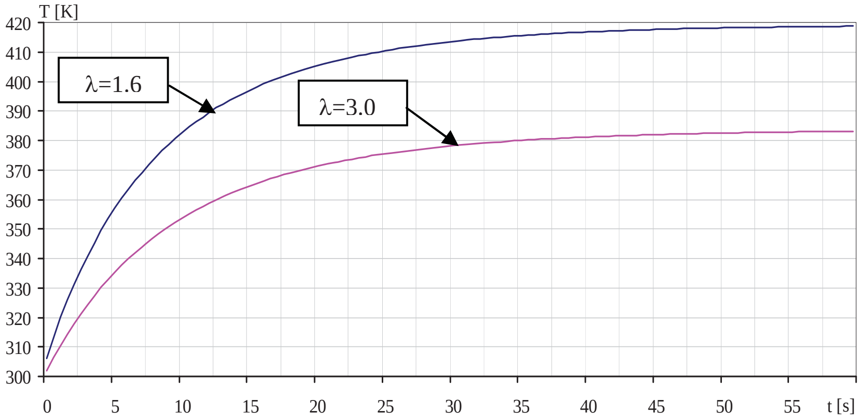


Fig. 12. The graph of changes maximum temperatures in the cylinder sleeve

Moreover the calculations show that top parts of the cylinder sleeve near of the mount flange heat up the most quickly and the temperature below the 3rd ring in outer dead centre of the piston is the lowest. The speed of increase temperature of dry cylinder sleeve is the largest in initial phase of warming up engine. After 10 seconds the average speed of increase temperature carries out about 8 K per second for larger load and about 5 K per second for lower load of the engine. Between 10 and 20 second the speed of increase temperature falls down and it starts stabilizing slowly.

3. Conclusions

For the same engine speed the maximum temperature of the cylinder sleeve more loaded is higher from temperature when engine is less loaded. This results first of all from larger of the value temperature and pressure of the working medium in the time of the cycle compressions and the work of the engine. For the smaller excess air number is supplied the larger amount of the fuel and the heat enlarges therefore the temperature of the parts surrounding the combustion chamber is higher. The high temperatures near in the mount flange of the cylinder sleeve for more and less the engine loaded is caused by difficult heat outflow from this surface to the cooling medium. The low temperatures of the both cylinder sleeve in the central and the bottom part are caused that these surfaces still did not achieve of the maximum temperature after 60 seconds of the engine work.

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