SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2024 **Issue:** 11 **Volume:** 139

Published: 19.11.2024 **http://T-Science.org**

Issue Article

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TWO-DIMENSIONAL REPRESENTATION OF THE TEMPERATURE GRADIENT IN THE CYLINDER VOLUME OF AN INTERNAL COMBUSTION ENGINE

Abstract*: The calculation of the temperature gradient in the cylinder volume of an internal combustion engine is performed in the article. The temperature distribution in the cylinder in one of the strokes of cycle of the internal combustion engine is illustrated.*

Key words*: cylinder, temperature gradient, exhaust stroke, internal combustion engine.*

Language*: English*

Citation: Chemezov, D., et al. (2024). Two-dimensional representation of the temperature gradient in the cylinder volume of an internal combustion engine. *ISJ Theoretical & Applied Science, 11 (139),* 196-198.

Soi: http://s-o-i.org/1.1/TAS-11-139-24 *Doi*: crossref https://dx.doi.org/10.15863/TAS.2024.11.139.24
Scopus ASCC: 2210.

Introduction

An internal combustion engine is an aggregate, the functionality of which is expressed in the conversion of the combustion energy of fuel inside the cylinders into the mechanical work of the car movement [1]. The inner surface of the cylinders of the internal combustion engine of a car is subjected to a variable cyclic combination of pressures and temperatures. The temperature loads in the cylinder vary from minimum to maximum values depending on the strokes of cycle of the internal combustion engine. A large number of scientific papers [2-10] have been devoted to the study of ongoing mechanical and thermal processes in the parts of the internal combustion engine during its operation. However, there are practically no studies to determine the rate of temperature change in a certain direction (temperature gradient) in the cylinder volume and its associated parts. This article visually presents the distribution of the temperature gradient in the cylinder volume during the exhaust stroke.

Materials and methods

The thermodynamic analysis of the temperature gradient change in the piston engine cylinder was carried out in a two-dimensional formulation. To calculate the temperature gradient in the cylinder of the internal combustion engine, electronic models of the unit parts were built, which were subsequently connected in accordance with the actual assembly of the internal combustion engine. The computer calculation was performed under the following specified conditions: the piston diameter is 80 mm, the crank diameter is 80 mm, length of connecting rod is 200 mm, initial cylinder volume is 0.000442659 m^3, air density is 1.1886 kg/m^3, specific gas constant of air is 287 J/(kg×K), heat generated during combustion is 600 J. The cylinder model was made of structural steel with the following properties: density is 7850 kg/m^3, Young's modulus is 200×10^9 Pa, Poisson's ratio is 0.3. The cycle of operation of the three-cylinder internal combustion engine in 0.16 seconds of rotation of the crankshaft was simulated.

Results and discussions

The calculation results are shown in the Fig. 1.

The outer contour of the two-dimensional model is represented by the diametrical surface of the cylinder along the side faces and the surface of the piston head along the lower face. The temperature gradient in the cylinder volume during the exhaust stroke is modeled. The demonstration of the temperature gradient is represented by directional contours with a density of 800.

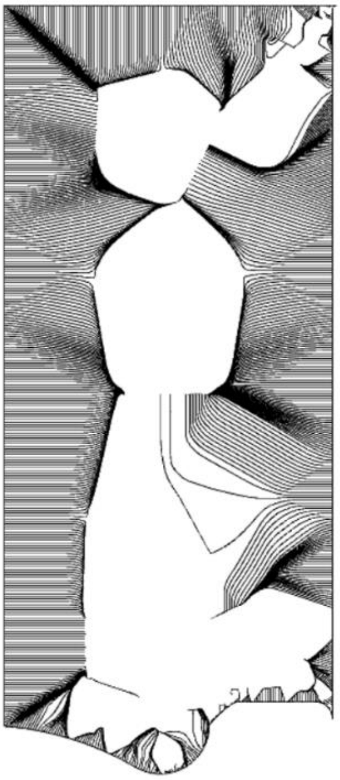

Figure 1. Contours of the temperature gradient in the cylinder volume of the internal combustion engine.

The temperature distribution in the cylinder volume is uneven. Closer to the diametrical walls, the heat flows are directed perpendicular to the axial line of the cylinder. However, closer to the center, the heat flows shift at some angle in different directions. Also, local zones with a high contour density are marked throughout the entire volume of the cylinder, which indicates an increase in the value of the temperature gradient. At the piston head, the heat flows have a chaotic direction, while the value of the temperature gradient on this surface is minimal. Unfilled volumes of the cylinder are formed due to an insignificant difference in the value of the temperature gradient relative to the displayed contours.

Conclusion

Based on the results of computer simulation of the thermodynamics process in the cylinder of the internal combustion engine, the following conclusions can be drawn:

1. The unevenness of the temperature gradient in the cylinder volume during the exhaust stroke is marked by a higher density of contours, which indicates the nonlinearity of the direction of heat flows.

2. The minimum temperature change is at the piston head; the largest temperature change is at the volume of middle and upper parts of the cylinder.

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