experimental internal combustion engine when solving the problems of cold start based on TA and accelerating the internal combustion engine warm-up using the SPC. The results of the study also show that by increasing the circulation speed of the OC flow in the CO of the ICE from 0.08 m/s (which corresponds to the circulation speed of the OC when warming up the ICE at idle with a standard pump) to 0.22 m/s (which corresponds to the characteristics of the SKP circulation pump), we obtain a reduction in the warm-up time g.s. on average by 14%, fuel consumption for warming up GT by 25%, reduce emissions of particulate matter K during warming up by 28%, and nitrogen oxides NO_x during warming up by 23%.

Conclusion. Thus, the assessment of the effectiveness of the use of SPC in the cycle of pre-starting and starting the internal combustion engine confirmed the improvement of fuel efficiency when working with the combined heating system, as well as the effectiveness of the use of SPC as one of the directions for improving the environmental performance of the internal combustion engine without worsening fuel efficiency.

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MODELING OF WORKING PROCESSES OF ENGINES OPERATING ON GASEOUS FUELS

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This paper examines a promising approach to reducing operating costs of internal combustion engines: converting them to run on gaseous fuel. The challenge with this method is the fundamental change in the operating conditions of most powertrain components and assemblies, which requires careful preliminary analysis. To address this issue, a mathematical model was developed, which is a universal system of volume balance differential equations. A key advantage of the proposed model is its capability to interact with other subsystems—such as intake and exhaust manifolds—via feedback loops, enabling comprehensive simulation of heat and mass transfer, mixture formation, fuel supply, and air exchange processes. Implemented in the MathCAD environment, the model is currently adapted for high-speed, naturally aspirated gas engines with external mixture formation and a cylinder diameter of 70–95 mm. The developed approach provides a reliable tool for predicting key engine performance parameters, optimizing operating conditions, and reducing the time and cost of experimental refinement during the conversion of conventional engines to gaseous fuels.

A promising way to reduce operating costs of internal combustion engines is to convert them to use gaseous fuels. This conversion changes the operating conditions of most engine components and assemblies.

In this regard, before converting a specific engine, it is necessary to perform mathematical modeling of the gas engine's operating process in order to determine its key parameters and reduce the time, material, and financial costs of further refinement work, as well as to ensure its fuel efficiency and service life.

The developed mathematical model of the engine's working process is a core, the basis of which is a system of differential equations of volume balance developed and proposed by N.M. Glagolev. Its peculiarity is that it allows one to determine with sufficient accuracy the parameters of the working fluid in the engine cylinder throughout the entire working cycle, taking into account the peculiarities of heat and mass transfer processes. One of its advantages is the ability to interact with other models using the feedback principle. That is, having, for example, parameters or functional dependencies for gas-dynamic processes in the intake manifold, one can link them with the above-mentioned model and obtain a more accurate calculation of the processes in the cylinder and vice versa, knowing the parameters of gas outflow from the cylinder through the valve into the intake port, one can estimate the influence of the working fluid parameters on the gas-dynamic processes in the intake manifold. Thus, the interconnected calculation blocks take into account the processes in the engine systems and units, before/after the cylinder, they can be constantly expanded and the mathematical model can be improved, forming its basis based on design features the engine under consideration.

This model is related to the gas-dynamic and thermodynamic parameters of the working fluid, and is also associated with the processes of mixture formation, fuel supply, air supply, the thermal state of the engine, and parameters that determine mechanical losses.

The system of differential equations defining the core of the program is based on the following assumptions:

a) the cylinder during gas exchange processes can be considered as an open thermodynamic system;

b) the cylinder during the processes of compression, combustion and expansion can be considered as a conditionally closed thermodynamic system;

c) the processes occurring in a thermodynamic system are of a quasi-stationary nature;

d) heat exchange processes are of a quasi-equilibrium nature;

d) the physicochemical properties of gaseous fuels obey the law of additivity.

The change in the parameters of the working fluid is shown schematically in the Fig. 1.

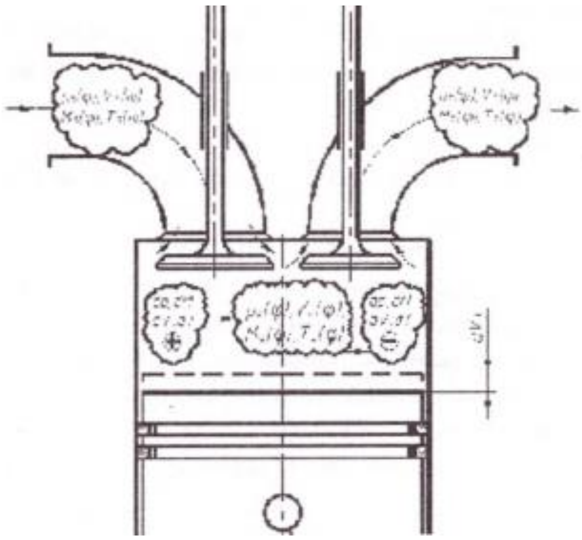

Fig. 1 - Change in the parameters of the working fluid in the cylinder

The model itself is implemented in the MathCAD environment and at this stage is adapted for the calculation of high-speed naturally aspirated gas engines with external mixture formation and a cylinder diameter of 70...95 mm.

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ЛОГІКО-ЙМОВІРНІСНЕ ТРАЄКТОРНЕ МОДЕЛЮВАННЯ ІЄРАРХІЧНИХ СИСТЕМ ВІЙСЬКОВОГО УПРАВЛІННЯ

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Запропоновано застосування методу логіко-ймовірнісного траєкторного моделювання до оцінювання безперервності та живучості ієрархічних систем військового управління (C2) типу «штаб—бригада—батальйон—рота». Структура подається як орієнтований граф із критичними вузлами в двох станах: працює / відмова. Логіко-ймовірнісний метод траєкторного моделювання трактує проходження «ймовірнісних пакетів» як траєкторії доведення наказів/збирання звітів через багаторівневі шляхи з урахуванням правил місії (AND/OR, k-of-n) та кінцевиї часових термінів. Метод надає метрики: (1) ймовірність P{успішне доведення наказу в межах часу T}, (2) ймовірність P{керованість при деградаціях}, (3) чутливість до відмов вузлів і ліній. Порівняно з підходами на базі характеристичних поліномів Логіко-ймовірнісний метод траєкторного моделювання забезпечує меншу обчислювальну складність і кращу масштабованість для оперативного «what-if» аналізу великих ієрархій.

Ключові слова: *С2; ієрархічна структура; живучість; надійність; критичні вузли.*