

## **РАСЧЁТ НАГРУЗКИ, ДЕЙСТВУЮЩЕЙ НА ПОРШЕНЬ В ДВИГАТЕЛЯХ ВНУТРЕННЕГО СГОРАНИЯ, И АНАЛИЗ ПРОЦЕССОВ СЖАТИЯ И РАСШИРЕНИЯ.**

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**Аннотация.** В статье проведён анализ параметров процессов сжатия и расширения в двигателях внутреннего сгорания. Показано, что наряду с традиционными характеристиками важное значение имеет определение нагрузки, действующей на поршень. Представление силы, действующей на поршень, в килограммах и тоннах позволяет более наглядно оценить величину механических нагрузок в цилиндре двигателя. Предложенный подход способствует более глубокому пониманию рабочих процессов двигателя и условий работы его деталей при высоких механических нагрузках

**Ключевые слова:** двигатель внутреннего сгорания, процесс сжатия, процесс расширения, нагрузка на поршень, давление в цилиндре, механическая работа, индикаторная диаграмма.

## **CALCULATION OF THE LOAD ACTING ON THE PISTON IN INTERNAL COMBUSTION ENGINES AND ANALYSIS OF COMPRESSION AND EXPANSION PROCESSES.**

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**Abstract.** This paper analyzes the parameters of compression and expansion processes in internal combustion engines. It is shown that, in addition to conventional parameters, determining the load acting on the piston is important for studying engine working processes. Expressing the force acting on the piston in kilograms and tons provides a clearer understanding of the

mechanical loads occurring in the engine cylinder. The proposed approach contributes to a deeper understanding of engine operation and helps evaluate the operating conditions of internal combustion engine components under high mechanical loads.

**Keywords:** internal combustion engine, compression process, expansion process, piston load, cylinder pressure, mechanical work, indicator diagram.

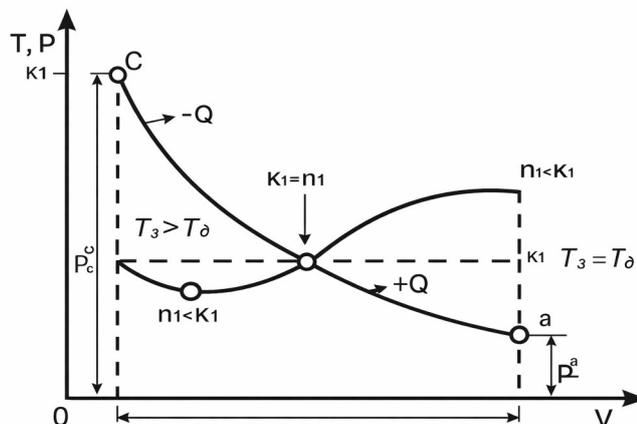
**INTRODUCTION.** In modern transport vehicles (automobiles, tractors, and road construction machinery), internal combustion engines are mainly used as power units. In such engines, the thermal energy generated as a result of the combustion of the working mixture is converted into mechanical work. Both liquid and gaseous fuels can be used in internal combustion engines.

In motor vehicles, internal combustion engines operate under various power modes. In addition, when studying the operating processes of the engine, the analysis of the parameters of the compression and expansion processes is of great importance.

**MAIN PART.** During the compression process, in four-stroke engines with and without supercharging, the piston begins to move toward the top dead center after the intake valves are closed, while in two-stroke engines the compression process begins after the completion of the gas exchange process. As a result, the fresh charge that has entered the cylinder is compressed, and its temperature and pressure increase.

The compression ratio in carburetor engines is limited by the occurrence of detonation combustion, whereas in diesel engines it is limited by the self-ignition temperature of diesel fuel. Therefore, at the end of the compression process the temperature and pressure of the charge remain within certain limits. The characteristics of the compression process in a real cycle are shown in Figure 1. At the initial stage of the compression process, the temperature of the charge is lower than the temperature of the cylinder walls, the cylinder head, and the piston crown; therefore, the charge begins to heat up. In a real cycle,

since the combustion products expand at high temperatures, part of the heat is transferred to the external environment through the cylinder head, cylinder walls, and the piston crown. As a result, the temperature of the combustion products decreases.



**Figure 1. Diagram of the compression process.**

After the expansion process, the exhaust process takes place. When the exhaust valve opens, the exhaust gases leave the engine cylinder at high velocity, resulting in a high level of noise. To reduce this noise, a muffler (silencer) is installed in the exhaust pipe.

**MATERIALS AND METHODS.** During the research process, the operating processes of internal combustion engines were studied based on the results of bench tests and mathematical calculation methods.

The maximum pressure values occurring in the engine cylinder, the piston surface area, and the load acting on the piston were determined based on the pressure. In the calculations, the following value was adopted as the maximum pressure for diesel engines:

$$P = 8 \text{ MPa} = 8 \times 10^6 \text{ Pa}$$

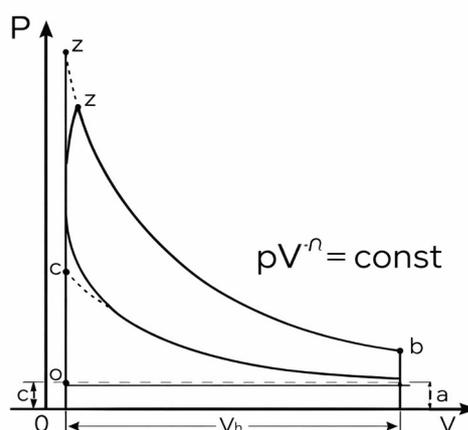
Here:

**S** – piston surface area,

**P** – pressure acting on the piston.

The calculation results were analyzed based on the following parameters for different types of engines: compression ratio, maximum temperature, pressure, and the amount of work performed.

**RESEARCH WORK.** The power of each engine is characterized by the maximum pressure generated inside the cylinder. Therefore, it is important to determine the load acting on the piston as a result of fuel combustion in the cylinder of an engine operating under nominal conditions.



**Figure 2. Diagram of the expansion process.**

Based on the calculations, the values of the load acting on the piston of the diesel engine were determined. In diesel engines, the maximum pressure is equal to 8 MPa, and under the influence of this pressure a significant mechanical force acts on the piston. The calculation results show that the force acting on the piston is an important indicator in analyzing the operating processes of the engine.

**DISCUSSION.** The analysis of the parameters of compression and expansion processes shows that the operating process in engine cylinders proceeds differently under various operating conditions. Most transport vehicles often do not operate at full power.

For example, in urban conditions during cargo transportation, due to speed restrictions, the engine usually operates at a load of up to 50%. Transport machines operating in open-pit mines or in construction work also function for long periods while utilizing only a part of their nominal power. Therefore, the

fuel efficiency, emission of harmful substances, and the degree of wear of such machines depend on the engine's partial load operating modes.

**RESULTS.** As a result of the conducted calculations, the following results were obtained:

- ❖ the maximum pressure in diesel engines is approximately **8 MPa**;
- ❖ the mechanical force acting on the piston is approximately **76 kN**;
- ❖ this value corresponds to a weight force of approximately **7.6 tons**.

Expressing the load acting on the piston in kilograms or tons makes it possible to more accurately evaluate the mechanical forces generated inside the engine cylinder.

**CONCLUSION.** The results of the study show that the compression and expansion processes in internal combustion engines are important stages that determine the main operating processes of the engine. During these processes, high pressure and temperature are generated inside the cylinder, resulting in significant mechanical loads acting on the piston.

The combined analysis of parameters such as the load acting on the piston, the work performed, and the pressure inside the cylinder plays an important role in evaluating the operational efficiency of internal combustion engines. This approach helps to better understand engine operating processes during laboratory studies of internal combustion engines as well as in engineering calculations.

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