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INCREASING THE EFFICIENCY OF INTERNAL COMBUSTION ENGINES ПОВЫШЕНИЕ КОЭФФИЦИЕНТА ПОЛЕЗНОГО ДЕЙСТВИЯ ДВИГАТЕЛЕЙ ВНУТРЕННЕГО СГОРАНИЯ

Сидрихин С.С., студент ФГБОУ ВО
«Воронежский государственный
лесотехнический университет имени
Г.Ф. Морозова», Воронеж, Россия,
Воронеж, Россия.

Sidrikhin S.S., student of Voronezh State University of
Forestry and Technologies named after G.F. Morozov,
Voronezh, Russia.

Рабеев С.К.Б., к. филол. н., доцент
кафедры иностранных языков
ФГБОУ ВО «Воронежский
лесотехнический университет имени
Г.Ф. Морозова», Воронеж, Россия

Rabeev S.K.B., PhD in philology Associate Professor of
the Department of Foreign Languages, of Voronezh State
University of Forestry and Technologies named after
Morozov, Voronezh, Russia.

Abstract: This article examines current issues and current trends in improving the efficiency of internal combustion engines. It analyzes the main factors hindering efficiency gains (thermal and mechanical losses, incomplete fuel combustion) and proposes ways to overcome them. It also provides an overview of design solutions, such as the use of turbocompound units for exhaust gas energy recovery, the use of antifriction coatings, and the improvement of direct fuel injection systems. This material will be useful to engineers, researchers, and students interested in the future development of automotive and tractor technology.

Keywords: efficiency, internal combustion engine, automobile, development, fuel, material, hybrid engine.

Аннотация: В данной статье рассматриваются актуальные проблемы и современные тенденции повышения эффективности двигателей внутреннего сгорания. Анализируются основные факторы, препятствующие повышению эффективности (тепловые и механические потери, неполное сгорание топлива), и предлагаются пути их преодоления. Также представлен обзор конструктивных решений, таких как

использование турбокомпрессоров для рекуперации энергии отработавших газов, применение антифрикционных покрытий и усовершенствование систем непосредственного впрыска топлива. Данный материал будет полезен инженерам, исследователям и студентам, интересующимся будущим развитием автомобильной и тракторной техники.

Ключевые слова: эффективность, двигатель внутреннего сгорания, автомобиль, разработка, топливо, материал, гибридный двигатель.

The current stage of development of the global automotive industry is characterized by a complex interplay of global trends: on the one hand, there is

A rapid transition to a low-carbon economy and green energy, while on the other, dependence on traditional powertrains remains. Despite unprecedented investment in electric vehicle and hydrogen technology startups, internal combustion engines (ICEs) remain the dominant driving force in the global vehicle fleet. According to international agencies, the share of vehicles with ICEs (including hybrid versions) still exceeds 90% of the total number of vehicles in use, and no alternative to ICEs is expected in the next decade in the heavy commercial vehicle, agricultural, and construction equipment segments due to the requirements for fuel autonomy, reliability, and energy density. Currently, the potential for increasing internal combustion engine efficiency has not yet been exhausted. The main areas of research and development remain improving combustion and mixture formation processes, exhaust emissions, the use of alternative fuels, and powertrain hybridization.

In addition to thermodynamic and fuel considerations, design and manufacturing preparation play a fundamental role in improving efficiency. Proper tolerance management and dimensional control during component assembly are often the "decisive finishing touch" that transforms a theoretically efficient design into a high-performance engine that actually performs.

A method for improving the efficiency of an internal combustion engine involves

supplying an energy carrier (fuel) into the above-piston cavity in the form of two separate charges, followed by ignition. The second charge is introduced during the piston's movement on the power stroke, specifically when the angle between the connecting rod and the crankshaft lies within the range of 150 to 190 degrees. For a given engine operating mode, the nominal mass of the energy carrier in each of the two charges remains constant.

This invention relates to techniques for enhancing the efficiency of internal combustion engines (including both gasoline and diesel units) by optimizing the timing and manner of thermal energy delivery.

Conventional thermodynamic cycles, such as the Otto cycle and the Diesel cycle, involve heat addition at the very beginning of the power stroke. At that moment, although the pressure inside the cylinder reaches its maximum value, the piston is positioned in a geometrically unfavorable orientation for effectively transmitting force to the crankshaft. Specifically, the angle formed between the connecting rod and the crank arm deviates significantly from 90 degrees. This geometric disadvantage results in a reduction of both the generated torque and the overall efficiency of the engine.

The proposed method solves the problem of increasing average torque on the shaft through two-stage fuel injection:

1. The first injection (30–50% of the fuel) is performed at top dead center to initiate the combustion process.
2. The second injection (the remaining 70–50%) is performed during the piston's power stroke, when the angle between the connecting rod and crank is 150–190°. In this position, the burning fuel creates additional pressure precisely when the force applied to the crank is closest to the optimal angle (90°).

The second injection into the already heated environment occurs by autoignition without an additional spark. This redistribution of heat supply increases the area of the indicator diagram, which directly increases useful work, torque, and, consequently, engine efficiency without increasing overall fuel consumption. [1].

In general, there are many ways to improve an engine:

1. Hybridization (an internal combustion engine works in conjunction with an electric motor, which allows them to significantly optimize the operation of the entire engine under different driving conditions. If we distinguish the main operating modes of such an engine, there are five: directly starting and driving at low speeds, standard driving, acceleration, braking, deceleration, and stopping.)

2. Technology that varies the valve timing of the internal combustion engine ([2,3] Not long ago, the Swedish company Koenigsegg, which is engaged in the production of supercars, introduced an innovative technology into its cars that not only reduced the specific weight of its internal combustion engines, but also increased their power by almost 30%. With a fairly small engine volume (5 liters), they were able to achieve a power of 1,600 hp. For comparison, the French company Bugatti in one of its new Chiron cars was able to achieve almost the same power, but their engine volume was 8 liters. Here it is also important to take into account the fact that the Koenigsegg internal combustion engine had two turbochargers, while the Bugatti's internal combustion engine has four.

The technology is called "Freevalve", and it allows for variable valve timing, which is very effective. [2, 3]

1. Use of turbocharging and new materials (For example, instead of using cast pistons, special forged pistons can be used, which have a number of advantages: greater mechanical strength and lower weight. Turbocharging helps regulate the fuel-air mixture.) [4] [5]

Conclusion

Improving the efficiency of internal combustion engines remains one of the most important challenges in the automotive industry, despite the rapid development of electric powertrains. As shown in this article, there is still significant potential for improving internal combustion engines in several areas: optimizing thermodynamic cycles (such as two-stage fuel injection), using variable valve timing systems (Freevalve), using turbocharging, hybridizing engines, and introducing new materials and coatings.

The efficiency of an engine is determined not only by the successful technical solutions, but also by their proper combination, taking into account the purpose of the vehicle. There is no one-size-fits-all solution, as different combinations of technologies may be optimal for different vehicle classes. However, it is clear that a comprehensive approach that combines advanced developments in fuel combustion, process control, and tribology can lead to significant improvements in power output, fuel efficiency, and emissions reduction without significantly increasing weight or complexity.

The methods and examples presented in the article show that the further development of internal combustion engines will be closely linked to digital control systems, hybrid architectures, and advanced materials, ensuring that internal combustion engines will continue to play a key role in the transportation sector for decades to come.

СПИСОК ЛИТЕРАТУРЫ

1. Таланов, Б. П. Патент Ru2113604C1, опубликован 20.06.1996.
2. Трунов, Е. А. Повышение КПД ДВС в области автомобилестроения / Е. А. Трунов // Международный научный журнал «ВЕСТНИК НАУКИ» / Дальневосточный федеральный университет. – № 9 (90). – Том 3. – СЕНТЯБРЬ 2025. – С. 386-392.
3. Koenigsegg создал двигатели без распределительного вала. – URL: <https://w.drive2.ru/b/461269867937399296> (дата обращения 08.04.2026).
4. Гурьев, В. Г. Система сверхдавления двигателя внутреннего сгорания : учебник для курсантов и студентов морских инженерных факультетов морских академий всех форм обучения / В.Г. Гурьев ; Федеральное государственное бюджетное учебное заведение высшего профессионального образования «Калининградский государственный технический университет». – Калининград: Изд-во БГАРФ, 2021.
5. Изготовлено из стекла и алюминия: в ГУСУ разработано новое покрытие для повышения эффективности двигателя и снижения расхода топлива. – URL: www1.ru (дата обращения 08.04.2026).

REFERENCES

1. Talanov B. P. Patent Ru2113604C1 published 20.06.1996.
2. Trunov E.A. Improving the efficiency KPD of internal combustion engines in the automotive industry // International Scientific Journal "VESTNIK NAUKI" / Far Eastern Federal University. - No. 9 (90). - Volume 3. - SEPTEMBER 2025. – Pp. 386-392.
3. Koenigsegg created engines without a camshaft. – URL: <https://w.drive2.ru/b/461269867937399296> (date accessed 08.04.2026).
4. INTERNAL COMBUSTION ENGINE SUPERPRESSURE SYSTEM : Textbook for cadets and students of marine engineering faculties of maritime academies of all forms of study / V. G. Guryev ; Federal State Budgetary Educational Institution of Higher Professional Education "Kaliningrad State Technical University". – Kaliningrad: Publishing House of BGARF, 2021.
5. Made of glass and aluminum: a new coating has been developed at SUSU to increase engine efficiency and reduce fuel consumption. – URL: www1.ru (date accessed 08.04.2026).