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Analysis of structures and application of different types of engines in cars

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Abstract. Problem. *The publication analyzes the structures and application of various types of engines in a car, which allows to determine the structural aspects, features of placement and operation of engines, their future application prospects.* ***Purpose.*** *The purpose of the work is to analyze the design and operation of engines used in modern cars, to determine their advantages and disadvantages, and the prospects for the development and application of various types of engines.* ***Methodology.*** *The approaches adopted in the work to achieve the set goal consist in the analysis of designs of various types of engines of modern cars, their layout and features of their use.* ***Results.*** *The paper includes a comparative analysis of various types of engines used in modern cars. The peculiarity of the design and structure of internal combustion engines, electric cars and hybrid cars is considered. The scheme of the general configuration of electric vehicles, possible configurations of electric vehicles, layout schemes of hybrid cars are given. The advantages and disadvantages of each type of engine, the main prospects for their development and application are shown.* ***Originality****. The conducted analysis of the design features of various types of engines that are installed in modern cars allows us to formulate a general idea about the peculiarities of the operation of cars with the considered types of engines.* ***Practical meaning.*** *The obtained results of the analysis and the given advantages and disadvantages in the use of different types of engines allow us to formulate the main directions in the development of structures and the prospects of their application in different types of cars.*

Key words: *internal combustion engine, gasoline engine, diesel engine, electric car, electric motor, hybrid car.*

Introduction

One of the most important units of a car is the engine. It is the torque created by the engine that sets the driving wheels of the car in motion. Modern cars are equipped with various types of engines, for example, an internal combustion engine, an electric motor, and others.

Each of these types of engines has its own peculiarities in design and operation. Also, some manufacturers equip the car with several types of engines.

The analysis of designs of various types of engines and their use in cars makes it possible to determine their influence on the traction and speed properties of cars, to determine their advantages and disadvantages, possible directions of development and prospects for their us.

Analysis of publications

The basics of the internal combustion engine design and its characteristics are discussed in works [1,2]. In [3], the study of the effect on the performance of the car of switching its engine to run on biodiesel fuel was carried out. In [4], the structure and principle of operation of the fuel injection systems of gasoline engines of modern cars are given.

In work [5], a review of electric vehicles of various types was carried out, and work [6] is devoted to a review of hybrid energy storage systems for electric vehicles. The work [7] presents an overview of scientific studies that are devoted to various aspects related to electric vehicles, namely: an overview of the state of the electric vehicle market, an overview of the performance of accumulator batteries, electric

motors and electronic systems, an overview of charging devices, etc. The paper [8] presents the main concepts of electric vehicles, an overview of various components and energy storage systems used in electric vehicles.

The work [9] is devoted to the optimization of the movement of a hybrid car with a non-working internal combustion engine. In work [10], research was carried out on the optimization of the movement of a hybrid car with an internal combustion engine and an electric drive system working simultaneously on a common shaft.

Purpose and Tasks

The purpose of the work is to analyze the designs and operation of engines used in modern cars, to determine their advantages and disadvantages, and the prospects for the development and application of various types of engines.

To achieve the goal, it is necessary to complete the following tasks:

1) Compile the classification of energy units;

2) Perform an analysis of transmission schemes.

The classification of energy units

The engine is the source of mechanical energy that is needed to move the car. Mechanical energy is generated due to the conversion in the engine of another type of energy (energy of burning fuel, electricity, energy of pre-compressed air, etc.). Depending on the type of energy used and the process of its transformation into mechanical energy, the following ones can be applied to the car:

- engines using fuel energy (piston internal combustion engine, gas turbine, steam engine, rotary piston engine, external combustion engine, etc.);
- motors that use electricity - electric motors;
- a combination of several types of engines (for example, an electric engine and an internal combustion engine);
- engines that use the energy of pre-compressed air;
- engines that use the energy of a pre-spinned flywheel.

Internal combustion piston engines, which use liquid fuel of petroleum origin (gasoline, diesel fuel) or combustible gas as an energy source, have become the most common in cars.

There are few types of internal combustion engines [11]:

- reciprocating, in which the entire work process is carried out in cylinders;
- pistonless, for example, gas turbines, in which the work process is sequentially carried out in the air compressor, combustion chamber and gas turbine.

According to the method of fuel mixture formation and ignition, automobile piston engines are divided into two groups:

– those with external or internal mixture formation and forced ignition of fuel from an electric spark;

– those with internal mixture formation and ignition of fuel from contact with air, heated as a result of its strong compression in the cylinder (diesel).

The internal combustion engine consists of the following main mechanisms and systems:

– crank mechanism;
– gas distribution mechanism;
– cooling systems;
– lubrication systems;
– power systems;
– ignition systems (gasoline engines).

The connecting rod mechanism is designed to convert the reciprocating motion of the piston into the rotational motion of the crankshaft. The gas distribution mechanism ensures timely filling of cylinders with a fuel mixture (or air) and removal of exhaust gases from them.

The cooling system is designed to maintain the optimal thermal regime of the engine.

The lubrication system ensures the lubrication of the friction surfaces of the engine, the supply of lubricant to them, their partial cooling, the removal of combustion products and the cleaning of lubricant.

The fuel system of a gasoline engine is designed to clean fuel and air, inject fuel into a cylinder or form a fuel mixture, supply it to the cylinders and remove combustion products.

The diesel fuel system provides air and fuel cleaning, fuel injection into the cylinder under high pressure in finely atomized form and removal of combustion products.

The ignition system ensures the ignition of the fuel mixture in the cylinders of the gasoline engine, contains a source of electrical energy and a low-voltage converter of the car's power supply system to the high voltage of the spark plug, the spark from which ignites the fuel mixture in the engine cylinder at the right moment. Figure 1 shows the cylinder diagram of a four-stroke gasoline engine [12].

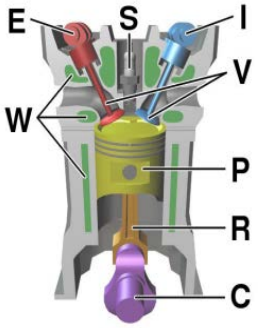

Fig. 1. Cylinder diagram of a four-stroke gasoline engine [12]: C – crankshaft, E – exhaust camshaft. I – intake camshaft, P – piston, R – connecting rod. S – spark plug, V – valve, W – liquid cooling jacket

Analysis of transmission schemes

In electric cars, mechanical energy is generated due to the use of electric motors. The transmission of electric vehicles consists of three main subsystems: the power plant of the electric motor, the energy source and the auxiliary system. The electric traction subsystem consists of a vehicle controller, a power electronic converter, an electric motor, a mechanical transmission and drive wheels. The power source subsystem consists of a power source, a control unit, and a charging unit. The auxiliary subsystem consists of a power steering unit, a climate control unit and an auxiliary power supply unit. Figure 2 shows a diagram of the general configuration of electric vehicles [13].

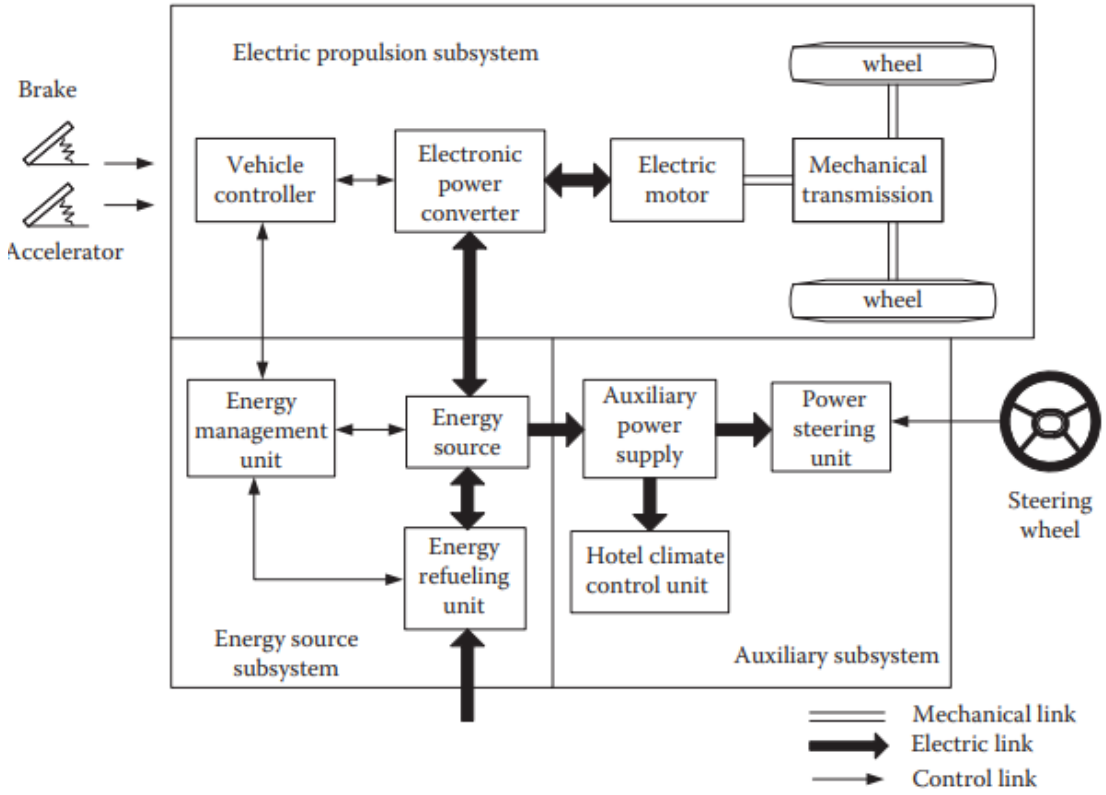

Fig. 2. Scheme of the general configuration of electric vehicles

Based on the control signals from the accelerator and brake pedals, the electric vehicle controller provides control signals to the electronic energy converter, whose function is to regulate the flow of power between the electric motor and the energy source. The reverse flow of energy occurs thanks to the regenerative braking of the electric vehicle. This regenerated energy can be recovered in the energy source. The energy management unit is connected to the vehicle controller to control the regenerative braking and its energy recovery. It also works with the power charging unit to monitor the charging unit and the suitability of the power source. The auxiliary power source provides the necessary power with different voltage levels for all auxiliary devices of electric vehicles, especially climate control systems and power steering [13]. Depending on the location of the electric motor and energy sources, there are various possible configurations of electric vehicles, as shown in Figure 3 [13].

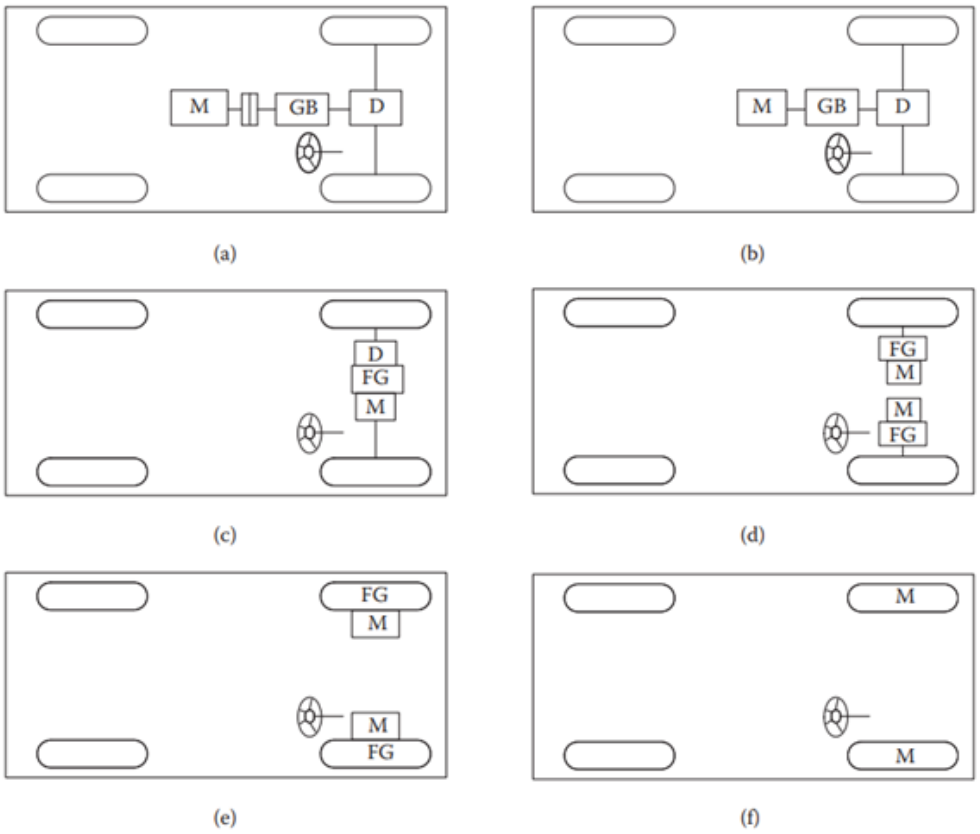

Fig. 3. Possible configurations of electric cars: C– clutch; D–differential; FG–fixed gearing; GB–gearbox; M–electric motor

Figure 3 a show the configuration of the first option, in which the electric motor replaces the internal combustion engine. This scheme consists of an electric motor, a clutch, a gearbox and a differential. The clutch and gearbox can be replaced with an automatic gearbox. The clutch is designed to connect or disconnect the electric motor from the drive wheels. A gearbox provides a set of gear ratios to vary speed and power (torque) according to load requirements, and a differential allows the wheels of one axle to move at different speeds.

By using an electric motor that has constant power over a wide range of speeds, a fixed-ratio gearbox can be replaced by a continuously variable transmission. In this case, the clutch is not used. This configuration not only reduces the size and weight of the mechanical transmission, but also simplifies the control of the transmission, since gear shifting is not required (see, Fig. 3 b).

Similar to the transmission shown in Figure 3 b, the electric motor, fixed gear and differential can be combined into a single unit (see, Fig. 3 c). The entire transmission is further simplified and compacted.

In Figure 3 d, the mechanical differential is replaced by the use of two traction motors. Each motor drives a separate wheel and operates at a different speed when the car is traveling on a curved road.

To further simplify the transmission, the traction motor can be placed inside the wheel (see, Fig. 3 e). A planetary gear can be used to reduce speed and increase engine torque. The planetary gear has high-speed reduction ratios and an in-line arrangement of input and output shafts.

Figure 3 f shows a configuration in which there is no mechanical transmission between the electric motor and the drive wheel. The output rotor of the low-speed electric motor in the wheel drive is directly connected to the drive wheel. Controlling the speed of the electric motor is equivalent to controlling the speed of the wheels, and therefore the speed of the car. However, in such a layout, it is necessary to use an electric motor with a large torque to enable the car to move from a standstill and accelerate.

Hybrid Electric Vehicle (HEV) are cars that have several independent sources of mechanical energy, such as an internal combustion engine and an electric motor. These sources of mechanical energy can work both separately and together. Usually, a car with an internal combustion engine, a generator, an electric motor and a battery pack is called a hybrid. Charging of the high-voltage

battery is carried out in the engine operating modes at partial loads, provided that the power developed by the internal combustion engine is higher than the power required to drive the car.

The power source of such a car is an internal combustion engine, since only the mechanical energy of the internal combustion engine is used for the operation of the traction electric motor, which is converted into electrical energy with the help of a generator and stored in a high-voltage battery. Such a transmission allows you to install an internal combustion engine of lower power on the car. When designing a car, many different technical requirements are taken into account, such as: maximum acceleration, maximum speed and maximum load.

At the same time, requirements regarding environmental safety and fuel economy of the car are always mandatory. The power of the internal combustion engine installed on the car is determined by the need to ensure maximum acceleration when the car is fully loaded. But in this mode, the car moves for a short time. When driving at partial loads, on which the car works most of the time, the engine power is used only partially, therefore, the power of the internal combustion engine installed on the car is often excessive, which reduces the economic and environmental performance of the car. This part of the power is used to charge the high-voltage traction battery.

Under such road conditions and driving modes, when the power of the internal combustion engine of the car is not enough to ensure the set acceleration or maximum speed, the electronic power control system connects the traction electric motor. The joint operation of two engines provides the necessary dynamic characteristics of the car.

The fuel efficiency and environmental performance of an internal combustion engine strongly depend on its operating mode, that is, on the load and speed of rotation of the crankshaft. The electric part of the transmission of a hybrid car allows the internal combustion engine to work more often in the most economical modes. This reduces the release of harmful substances into the atmosphere.

Hybrid cars are equipped with a kinetic energy recovery system. During regenerative braking, the traction electric motor switches to generator mode, the electrical energy produced by the motor-generator is used to charge the traction battery. At the same time, fuel economy can be within 30% in city driving mode.

According to their design, hybrid cars are divided into:

1. Series;
2. Parallel;
3. Series-parallel;
4. Hybrid cars with the possibility of charging the battery from an external source of electrical energy.

Series Hybrid Electric Vehicles. Figure 4 shows a diagram of a series HEV [14]. They have an internal combustion engine and an electric motor. In this scheme, the internal combustion engine is not mechanically connected to the drive wheels. The internal combustion engine drives the generator, and the traction electric motor receives power from the generator. Such a hybrid car has a block of large-capacity batteries, which allows the car to move in certain modes with the internal combustion engine turned off. However, in this car, the internal combustion engine remains the only source of energy. In the established driving modes of the car, when the power produced by the generator exceeds the power consumed by the traction electric motor, the excess electrical energy is fed to the battery through the electrical control elements. Normally, the electric motor will receive power from the generator, but in acceleration mode or other increased loads, this electric power may not be enough. In this case, additional energy is supplied from the battery. During braking, the traction motor starts working in generator mode and feeds the batteries. The presence of a powerful battery allows you to install an internal combustion engine with a smaller volume. The traction characteristics of an electric motor differ from an internal combustion engine. The internal combustion engine develops maximum power and maximum torque only at high revolutions, and the electric motor develops maximum torque at minimum revolutions. The electric motor can change the direction of rotation. This allows you to remove the clutch and gearbox from the car structure, and when using the motor-wheel and the differential. The absence of these units greatly simplifies the design of the car and reduces noise and vibrations. The car's own weight is also reduced, but this is compensated by the installation of batteries, which have a lot of weight.

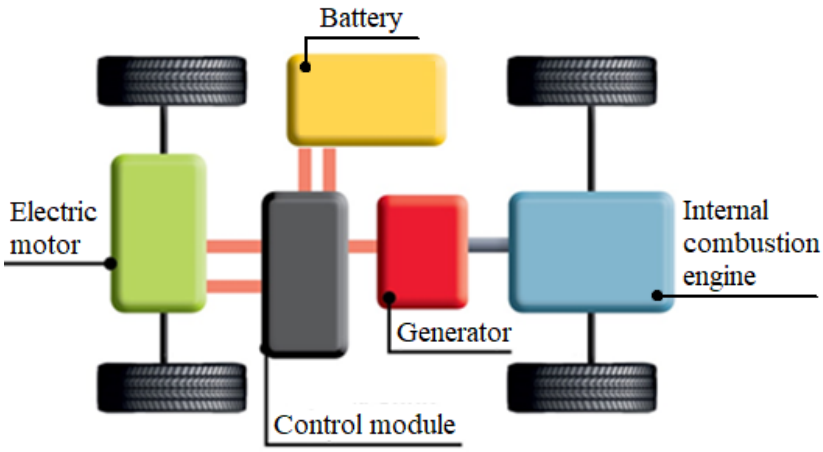

Fig. 4. The scheme for determining the angle of elastic inclination

Modern batteries have an increased specific capacity, which made it possible to increase the total capacity of the battery. At the same time, the mileage of the car increased significantly, working only on batteries.

Parallel Hybrid Electric Vehicle. A parallel hybrid vehicle has an internal combustion engine and an electric motor, which are arranged so that each of them can drive the car either individually or together. Usually, such cars have only one electric motor. Often, the electric motor is installed instead of the flywheel of the internal combustion engine, in this case the electric motor is the internal combustion engine flywheel, motor-generator and starter. As a starter, the motor-generator is used when the car is moving in the start and stop modes. In addition, if there is an automatic clutch installed between the motor-generator and the internal combustion engine, the generator is used to recharge the batteries in regenerative braking mode. Parallel hybrid cars, in comparison with serial hybrid cars, have a much smaller capacity, which allows to significantly reduce the weight of the car. Often, a car with a similar layout cannot move at all only with the help of an electric motor. In this case, the electric motor starts to turn on only in the intensive acceleration mode. Figure 5 shows a diagram of a parallel type hybrid vehicle [14].

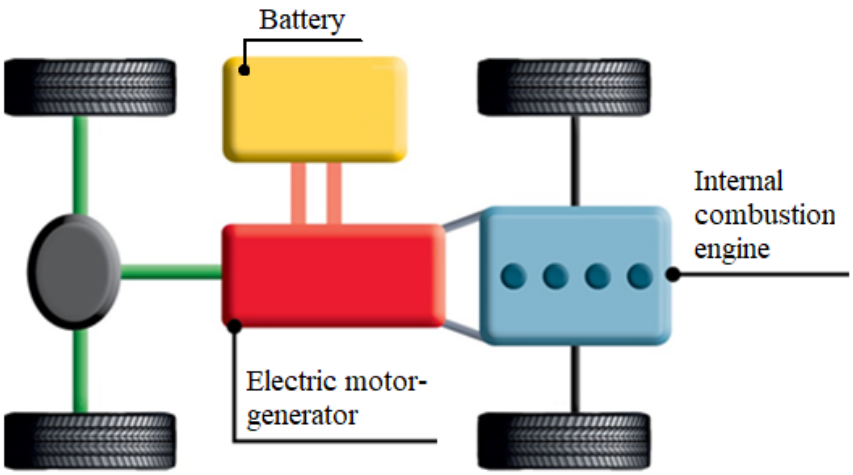

Fig. 5. Scheme of a Parallel Hybrid Electric Vehicle

Series-Parallel Hybrid Electric Vehicles. In the transmission of this car, there is a device - a power divider, which divides the power sent from the internal combustion engine into two streams. One part of the power flow is directed to the drive wheels, and the other part to the generator. The power flow divider transmits to the drive wheels exactly the amount of power that is determined by the specified driving mode of a car. The remaining power drives the generator, which feeds the batteries or feeds the electric motor at increased loads on the car. Figure 6 shows a diagram of a series-parallel hybrid electric vehicle [14].

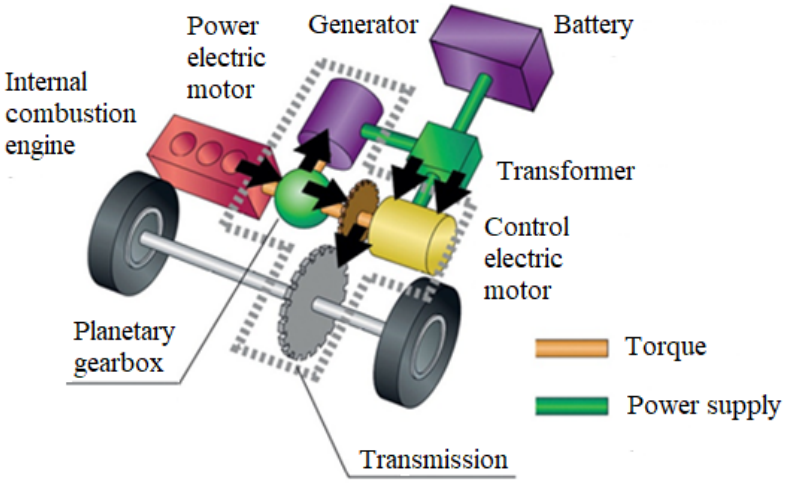

Fig. 5. Scheme of a Series-Parallel Hybrid Electric Vehicles

Conclusion

The internal combustion engine was and remains, at the moment, the most common type of engine used in a car. The main advantages of internal combustion engines: a large power value with relatively small dimensions, a large power reserve, relative simplicity of construction, ease of diagnosis, maintenance and repair. Since these engines have a large power, they are the ones that make up trucks, which are primarily intended for commercial transportation. The main disadvantages are the presence of harmful substances in exhaust gases and relatively low efficiency. The main prospects for the development and operation of these engines are the development of new electronic fuel supply control systems and control of the composition and amount of harmful substances, the use of various alternative fuels (for example, biodiesel) instead of traditional petroleum fuel.

The main advantages of electric cars are environmental friendliness, since it has no exhaust gas emissions at all, lower charging costs compared to a car with an internal combustion engine, low noise level, better acceleration dynamics, since the maximum torque is achieved from the first revolutions, high safety indicators. The main disadvantages are limited range, high cost, insufficiently developed infrastructure, high cost of maintenance, diagnostics and repairs, sensitivity to the temperature of the surrounding environment (reduction of battery capacity when the temperature drops). The main prospects for development are the development of batteries with a large capacity, the expansion of the infrastructure with an increase in the number of charging stations, technical inspection and repair, the development of electronic control systems and electric motors with high traction characteristics.

Hybrid cars have the main advantages and disadvantages of the internal combustion engine and electric cars. The main advantage of hybrid cars is the presence of two power sources (the ability to use both fuel and electricity) and rational control of engines under different driving conditions. The main disadvantages include the high cost of the car itself, its diagnostics, repair and maintenance, as well as insufficiently developed infrastructure. Prospects for the development of hybrid cars lie in the creation of high-capacity batteries while reducing their mass and developing the infrastructure.

Electric and hybrid cars are most efficient when operating in urban conditions and in places with increased requirements for environmental friendliness and noise level.

In addition to the main prospects for the development of cars with different types of engines, the use of various high-performance methods of mechanical processing can be highlighted to increase production efficiency [15, 16].

References

1. Омеличев А. (2022). *Підручник з будови автомобіля*. Omelychev A. (2022). *Pidruchnyk z budovy avtomobilia*. [Textbook of car construction]
2. Шапко В. Ф. (2014). *Автомобільні двигуни. Основи теорії та характеристики поршневих двигунів внутрішнього згоряння*. Shapko V. F. (2014). *Avtomobilni dvyhuny. Osnovy teorii ta kharakterystyky porshnevykh dvyhuniv vnutrishnoho zghoriannia* [Automobile engines.

Fundamentals of the theory and characteristics of internal combustion piston engines]
3. Поляков А. П., Галущак Д. О. (2014). Дослідження впливу на показники автомобіля переведення його двигуна на роботу на біодизельному паливі. *Міжвузівський збірник «Наукові нотатки»*,46, 431-438. Poliakov A. P., Halushchak D. O. (2014). Doslidzhennia vplyvu na pokaznyky avtomobilia perevedennia yoho dvyhuna na robotu na biodyzelnomu palyvi. [Research of the impact on car performance of switching its engine to run on biodiesel fuel]. *Mizhvuzivskyi zbirnyk «Naukovi notatky»*, 46, 431-438.
4. Білоконь Я.Ю., Вайнтрауб М.А. (2015). *Уприскувальні системи живлення бензинових двигунів сучасних автомобілів*. Bilokon Ya.Iu., Vaintraub M.A. (2015). *Upryskuvalni systemy zhyvlennia benzynovykh dvyhuniv suchasnykh avtomobiliv* [Fuel injection systems of gasoline engines of modern cars].
5. Ding, N., Prasad, K. & Lie, T. (2017). The electric vehicle: a review. *International Journal of Electric and Hybrid Vehicles*, 9(1), 49-66. https://doi.org/10.1504/IJEHV.2017.082816
6. Rahul, C., Savier, J., (2022). An overview on hybrid energy storage systems for electric vehicles. *International Journal of Electric and Hybrid Vehicles*, 14(1/2), 56-64 https://doi.org/10.1504/IJEHV.2022.125248
7. Muratori, M., Alexander, Marcus, Arent, Doug, Bazilian, Morgan, Dede, Ercan M., Farrell, John, Gearhart, Chris, Greene, David, Jenn, Alan, Keyser, Matthew, Narumanchi, Sreekant, Pesaran, Ahmad, Sioshansi, Ramteen, Suomalainen, Emilia, Tal, Gil, Walkowicz, Kevin, Ward & Jacob. (2021). The rise of electric vehicles – 2020 status and future expectations. *United States*. https://doi.org/10.1088/2516-1083/abe0ad
8. Sharma, S., Amrish K. & Tripathi M. (2020). Storage technologies for electric vehicles. *Journal of Traffic and Transportation Engineering*. 7(3), 340-361 https://doi.org/10.1016/j.jtte.2020.04.004
9. Мокін О. Б, Мокін Б. І., Лобатюк В. А. & Кубрак О. П. (2015). Оптимізація руху гібридного автомобіля з непрацюючим двигуном внутрішнього згоряння. *Вісник Вінницького політехнічного інституту*, 5, 69–77. Mokin O. B, Mokin B. I., Lobatiuk V. A. & Kubrak O. P. (2015). Optymizatsiia rukhu hibrydnoho avtomobilia z nepratsiuiuchym dvyhunom vnutrishnoho zghoriannia. [Optimization of the movement of a hybrid car with a non-working internal combustion engine]. *Visnyk Vinnytskoho politekhnichnoho instytutu*, 5, 69–77. https://visnyk.vntu.edu.ua/index.php/visnyk/article/view/1836
10. Мокін О. Б., Мокін Б. І. & Лобатюк В. А. (2016). Оптимізація руху гібридного автомобіля з одночасно працюючими на спільний вал двигуном внутрішнього згоряння та системою електропривода. *Вісник Вінницького політехнічного інституту*, 2, 33-38. Mokin O. B., Mokin B. I. & Lobatiuk V. A. (2016). Optymizatsiia rukhu hibrydnoho avtomobilia z odnochasno pratsiuiuchymy na spilnyi val dvyhunom vnutrishnoho zghoriannia ta systemoiu elektropryvoda. [Optimization of the movement of a hybrid car with an internal combustion engine and an electric drive system working simultaneously on a common shaft.]. *Visnyk Vinnytskoho politekhnichnoho instytutu*, 2, 33-38. https://visnyk.vntu.edu.ua/index.php/visnyk/article/view/1897
11. Кисликов В.Ф., Лущик В. В. (2006) *Будова й експлуатація автомобілів*. Kyslykov V.F., Lushchyk V. V. (2006). *Budova y ekspluatatsiia avtomobiliv* [Construction and operation of cars].
12. Brody Walker. (2018). *Engineering Fundamentals of Internal Combustion Engine*.
13. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz M. Ebrahimi. (2018). *Modern Electric, Hybrid Electric and Fuel Cell Vehicles*.
14. Типи гібридних силових установок (2023): веб-сайт. URL: https://www.autocentre.ua/ua/opyt/tehnologii/tipy-gibridnyh-silovyh-ustanovok-305550.html (дата звернення: 10.05.2023). Typy hibrydnykh sylovykh ustanovok [Types of hybrid power plants]. Retrived from: https://www.autocentre.ua/ua/opyt/tehnologii/tipy-gibridnyh-silovyh-ustanovok-305550.html /(Accessed 10.05.2023).
15. Kalchenko V., KalchenkoV., Sira N., Kuzhelnyi Ya. & Vynnyk V. (2020). Research of the milling process of a cylindrical surface by an oriented instrument. *Technology audit and production reserves*. 16-18. https://doi.org/10.15587/2312-8372.2020.202793
16. Kalchenko V., Kalchenko V., Sira N., Kuzhelnyi Ya. & Sklyar V. (2021). Model of milling the root and connecting rod necks of the crankshaft for one manufacturing process. *Lecture Notes in Mechanical Engineering*. https://doi.org/10.1007/978-3-030-91327-4_16

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Аналіз конструкцій та застосування різних типів двигунів у автомобілі

Анотація. Проблема. *В публікації виконано аналіз конструкцій та застосування різних типів двигунів у автомобілі, який дозволяє визначити конструктивні аспекти, особливості розміщення та роботи двигунів, їх перспективи подальшого застосування.* ***Мета****. Мета роботи полягає у аналізі конструкцій та роботі двигунів, які використовуються у сучасних автомобілях, визначенні їх переваг та недоліків і перспективи розвитку та застосування різних типів двигунів.* ***Методологія****. Підходи, які прийняті в роботі для досягнення поставленої мети, полягають в аналізі конструкцій різних типів двигунів сучасних автомобілів, їх компонування та особливостей їх застосування.* ***Результати****. В роботі виконано порівняльний аналіз різних типів двигунів, які використовуються у сучасних автомобіля. Розглянуто особливість конструкції та будову двигунів внутрішнього згоряння, електромобілів та гібридних автомобілів. Приведено схему загальної конфігурації електричних транспортних засобів, можливі конфігурації електромобілів, схеми компонування гібридних автомобілів. Наведено переваги та недоліки кожного типу двигунів, основні перспективи їх розвитку та застосування.* ***Оригінальність****. Проведений аналіз особливостей конструкцій різних типів двигунів, які встановлюють в сучасні автомобілі, дозволяє сформулювати загальне уявлення про особливість роботи автомобілів з розглянутими типами двигунів.* ***Практичне значення.*** *Отримані результати аналізу та наведені переваги і недоліки у використанні різних типів двигунів дозволяють сформулювати основні напрями розвитку конструкцій та перспективи їх застосування у різних типів автомобілів.*

Ключові слова: *двигун внутрішнього згоряння, бензиновий двигун, дизель, електромобіль, електродвигун, гібридний автомобіль.*

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