МИНОБРНАУКИ РОССИИ

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Кафедра иностранных языков

Методические указания по английскому языку для студентов направлений подготовки бакалавров 23.03.01 «Технология транспортных процессов», 23.03.03 «Эксплуатация транспортно-технологических машин и комплексов»

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Методические указания предназначены для усвоения необходимого минимума словарного состава текстов по специальности, включая общенаучную, терминологическую, служебную лексику. Данное пособие также способствует формированию навыков перевода текста.

Предназначены для студентов 1-2 курсов направлений подготовки бакалавров 23.03.01 «Технология транспортных процессов», 23.03.03 «Эксплуатация транспортно-технологических машин и комплексов» очной и заочной форм обучения как для аудиторной, так и самостоятельной работы.

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UNIT 1

COMPONENTS OF THE AUTOMOBILE

Ex. 1 Read and memorize the following words.
Trackless – безрельсовый
Self-propelled – самодвижущийся
Vehicle – транспортное средство
Framework – каркас
Body – кузов
Combustion – горение, сгорание
Transmission – передача, трансмиссия
Ignition – зажигание, воспламенение
Intake – поглощение, впуск
Exhaust – выпуск, выброс, выхлоп
Piston stroke – ход поршня
Gear – механизм
Valve – клапан
Wheelbase – подвеска, колесная база

Ex. 2. Find and read sentences with these words in the text given below.

TEXT

COMPONENTS OF THE AUTOMOBILE

Automobiles are trackless, self-propelled vehicles for land transportation of people or goods, or for moving materials. There are three main types of automobiles. These are passenger cars, buses and lorries (trucks). The automobile consists of the following components: a) the engine; b) the framework; c) the mechanism that transmits the power from engine to the wheels; d) the body.

Passenger cars are, as a rule, propelled by an internal combustion engine. They are distinguished by the horsepower of the engine, the number of cylinders in the engine and the type of the body, the type of transmission, wheelbase, weight and overall length.

There are engines of various designs. They differ in the number of cylinders, their position, their operating cycle, valve mechanism, ignition and cooling system.

Most automobile engines have six or eight cylinders. The activities that take place in the engine cylinder can be divided into four stages which are called strokes. The four strokes are: intake, compression, power and exhaust. "Stroke" refers to the piston movement. The upper limit of piston movement is called top dead centre, TDC. The lower limit of piston movement is called bottom dead centre, BDC. A stroke constitutes, piston movement from TDC to BDC or from BDC to TDC. In other words, the piston completes a stroke each time it changes the direction of motion.

Ex. 3. Find the English equivalents for the words and word combinations given below.

Двигатель внутреннего сгорания, коробка передач, мощность двигателя в л. с., колесная база, приводной цикл, система охлаждения, двухтактный (четырехтактный) двигатель, верхний предел, нижний предел, верхняя мертвая точка, нижняя мертвая точка.

Ex. 4. Answer the following questions.

1. What are automobiles?
2. What are three main types of automobiles?
3. Can you name the components of an automobile? What are they?
4. What are passenger cars distinguished by?
5. What is a passenger car propelled with?
6. What is the difference of various engine designs?
7. What is a stroke of an automobile?
8. What is top dead centre?
9. What is bottom dead centre?

Ex. 5. Match the synonyms.

1. component	a) various
2. lorry	b) discharge
3. car	c) truck
4. different	d) constituent
5. exhaust	e) automobile
6. gear	f) mechanism

Ex.6. Make up all possible questions to this sentence.

The activities that take place in the engine cylinder can be divided into four stages which are called strokes.

Ex.7. Translate into Russian paying attention to the word "as".
1. As the mixture burns, high pressure is created. 2. The automobile uses gasoline as a fuel. 3. As long as the car is in order, you can be carried from one place to another. 4. No special cooling fans are, as a rule, required. 5. Some semiconductors are almost as good conductors as metals.
Ex. 8. Summarize the text.

UNIT 2

ENGINE OPERATION

Ex. 1 Read and memorize the following words.
Powered by – оснащенный
Flywheel – маховое колесо, маховик
Crankshaft – коленчатый вал
Carburettor – карбюратор
Throttle – дроссель, регулятор
Lubrication – смазка
Flexibility – гибкость, легкость
Breaks – тормоза
Steering wheel –управление, рулевое колесо
Linkage – рычажный механизм
To lessen – облегчить, ослабить
Springs – пружины, амортизаторы
Shock – удар, толчок
Leaf spring – пластинчатая пружина, рессора
Coil spring – спиральная пружина
Torsion bars – торсионы (стержень, выполняющий функции пружины)
Air suspensions – пневматические подвески
Spark – искра
Steering system – рулевая система

Connecting rod – шатун
Crude oil – сырая нефть

Ex. 2. Find and read sentences with these words in the text given below.

TEXT

ENGINE OPERATION

An automobile, powered by a petrol engine, begins to operate when the driver turns a flywheel connected to the engine crankshaft. As the crankshaft revolves, a mixture of fuel and air is drawn from a carburettor into the engine cylinders. The ignition system provides the electric sparks that ignite this mixture. The resultant explosions of the mixture turn the crankshaft, and the engine starts moving. By regulating the flow of the fuel and air with a throttle, the driver controls the rotational speed of the crankshaft.

Cooling, electrical ignition and lubrication systems are of great importance for the good .performance of. a car. The lights, radio and heater add to the flexibility, comfort, and convenience of the car. The indicating devices keep the driver informed as to engine temperature, oil pressure, amount of fuel, and battery charging rate.

Brakes are of drum and disk types. The steering system consists of a manually operated steering wheel which is connected by a steering column to the steering gear from which linkages run to the front wheels. it is difficult to turn the steering wheel, and special hydraulic power mechanism are used to lessen this effort. Suitable springings are used against shocks. These are leaf springs, coil springs, torsion bars and air suspensions.

Ex. 3. Find the English equivalents for the words and word combinations given below.

Система зажигания, вращение коленчатого вала, воспламенить топливную смесь, регулировать впрыск топлива, система смазки, давление масла, температура двигателя, количество топлива, уровень зарядки аккумулятора, пластинчатая пружина, рессора, пневматическая подвеска.

Ex. 4. Answer the following questions.

1. When does an automobile begin to operate?
2. What ignites the mixture of fuel and air?
3. What do the resultant explosions of the mixture do?
4. How does the driver control the rotational speed of the crankshaft?
5. What types of brakes do you know?

Ex.5. Translate into Russian paying attention to the word "by".
1. The high pressure created by the compressed gases causes the crankshaft to turn or rotate? 2. Petroleum, or crude oil, is put through a refining process by which the gasoline is distilled out. 3. The method of cooling by water is easy to accomplish. 4. A new car plant will have been constructed by the end of this year. 5. The crank is linked to the piston by means of the connecting rod. 6. The driver can make the car operate by turning the flywheel.

Ex.6. Ask questions on all the parts of the following sentences.
1. The piston can slide up and down inside the cylinder. 2. The automobile engineer sees in the car a triumph of engineering and production skill.

Ex. 7. Summarize the text.

UNIT 3

THE EARLY DAYS OF AN AUTOMOBILE

Ex. 1 Read and memorize the following words.
Supply – снабжение
Lag – запаздывать, отставать
Steam-driven – паровой, приводимый в движение паром
Gasoline – бензин
Motorist – автомобилист
Can – канистра
Spare tires – запасные шины
To fine – штрафовать

Transmission – коробка передач
Reliable – надежный

Ex. 2. Find and read sentences with these words in the text given below.

TEXT

THE EARLY DAYS OF AN AUTOMOBILE

One of the earliest attempts to propel a vehicle by mechanical power was suggested by Isaac Newton. But the first self-propelled vehicle was constructed by the French military engineer Cugnot in 1763. He built a steam-driven engine which had three wheels, carried two passengers and ran at maximum speed of four miles. The carriage was a great achievement but it was far from perfect and extremely inefficient. The supply of steam lasted only 15 minutes and the carriage had to stop every 100 yards to make more steam.

In 1825 a steam engine was built in Great Britain. The vehicle carried 18 passengers and covered 8 miles in 45 minutes. However, the progress of motor cars met with great opposition in Great Britain. Further development of the motor car lagged because of the restrictions resulting from legislative acts. The most famous of these acts was the Red Flag Act of 1865, according to which the speed of the steam-driven vehicles was limited to 4 miles per hour and a man with a red flag had to walk in front of it.

Motoring really started in the country after the abolition of this act.

From 1860 to 1900 was a period of the application of gasoline engines to motor cars in many countries.

In 1896 a procession of motor cars took place from London to Brighton to show how reliable the new vehicles were. In fact, many of the cars broke for the transmissions were still unreliable and constantly gave trouble.

The cars of that time were very small, two-seated cars with no roof, driven by an engine placed under the seat. Motorists had to carry large cans of fuel and separate spare tires, for there were no repair or filling stations to serve them.

After World War I it became possible to achieve greater reliability of motor cars brakes became more efficient. Constant efforts were

made to standardize common components. Multi-cylinder engines came into use, most commonly used are four-cylinder engines.

Like most other great human achievements, the motor car is not the product of any single inventor. Gradually the development of vehicles driven by internal combustion engine-cars, as they had come to be known, led to the abolition of earlier restrictions. Huge capital began to flow into the automobile industry.

From 1908 to 1924 the number of cars in the world rose from 200 thousand to 20 million; by 1960 it had reached 60 million. No other industry had ever developed at such a rate.

In England there is the famous "Beaulieu Motor Museum" — the home for veteran cars.

The founder of the Museum is Lord Montague, the son of one of England's motoring pioneers, who opened it in 1952 in memory of his father. Lord Montague's father was the first person in England to be fined by the police for speeding. He was fined 5 pounds for going faster than 12 miles per hour!

In the Museum's collection there is a car called the *Silver Ghost* which people from near and far go to see. It was built by Rolls-Royce in 1907, and called the *Silver Ghost* because it ran so silently and was painted silver.

There is a car called *The Knight.* It is the first British petrol-driven car. Its top speed was only 8 m.p.h. In the Museum there is also a two-seater car, built in 1903.

Ex. 3. Find the English equivalents for the words and word combinations given below.

Приводимый в движение паром, максимальная скорость, великое достижение, законодательные акты, запреты, транспортные средства, применение бензиновых двигателей, автомобильные заправочные станции, надежность автомобилей, многоцилиндровые двигатели, четырехцилиндровый двигатель, отмена запретов, автомобильная промышленность, быть оштрафованным за превышение скорости, свыше 12 миль в час.

Ex. 4. Answer the following questions.

1. Who was the first to suggest the idea of propelling vehicle by mechanical power?
2. Whom was a self-propelled vehicle constructed by?
3. When and in what country was a steam engine built?
4. What do you know about the Red Flag Act of 1865?
5. When did it become possible to achieve greater reliability of the cars?
6. What was the number of the cars by 1960?
7. What can you say about the Museum of veteran cars?
8. What was the speed of the first British petrol-driven car?

Ex. 5. Match the synonyms.

1. gasoline	a) provision
2. spare	b) penalty
3. supply	c) motorist
4. fine	d) petrol
5. abolition	e) reserve
6. automobilist	f) cancellation

Ex.6. Make up all possible questions to this sentence.
The carriage was a great achievement but it was far from perfect and extremely inefficient.

Ex. 7. Summarize the text.

UNIT 4

TYPES OF ENGINES

Ex. 1 Read and memorize the following words.
Expenditure – расход, затрата
Combustion chamber – камера сгорания
Integral – неотъемлемый, полный, целый
Turbine – турбина
Power-plant – силовая установка
Electric-generating – энергогенерирующий

Fixed – неподвижный, закрепленный
Close – закрытие, запирание
Fitting – монтаж, подгонка, сборка
Piston – поршень
Torque – крутящий момент
Provision – предосторожность
Gear to – соединять, входить в зацепление
Clutch – сцепление
Disengage – выводить из зацепления, расцеплять
Crank – пусковая рукоятка
Rope wound – заводной трос
Flywheel – маховик
Inertia starter– инерционный стартер (с маховиком)
Explosive starter – взрывной стартер
Blank cartridge – патрон с холостым зарядом

Ex. 2. Find and read sentences with these words in the text given below.

TEXT

TYPES OF ENGINES

Internal-combustion engine, any type of machine that obtains mechanical energy directly from the expenditure of the chemical energy of fuel burned in a combustion chamber that is an integral part of the engine. Four principal types of internal-combustion engines are in general use: the Otto-cycle engine, the diesel engine, the rotary engine, and the gas turbine. The Otto-cycle engine, named after its inventor, the German technician Nikolaus August Otto, is the familiar gasoline engine used in automobiles and airplanes; the diesel engine, named after the French-born German engineer Rudolf Christian Karl Diesel, operates on a different principle and usually uses oil as a fuel. It is employed in electric-generating and marine-power plants, in trucks and buses, and in some automobiles. Both Otto-cycle and diesel engines are manufactured in two-stroke and four-stroke cycle models.

The essential parts of Otto-cycle and diesel engines are the same. The combustion chamber consists of a cylinder, usually fixed, that is closed at one end and in which a close-fitting piston slides. The in-and-out

motion of the piston varies the volume of the chamber between the inner face of the piston and the closed end of the cylinder.

Unlike steam engines and turbines, internal-combustion engines develop no torque when starting, and therefore provision must be made for turning the crankshaft so that the cycle of operation can begin. Automobile engines are normally started by means of an electric motor or starter that is geared to the crankshaft with a clutch that automatically disengages the motor after the engine has started. Small engines are sometimes started manually by turning the crankshaft with a crank or by pulling a rope wound several times around the flywheel. Methods of starting large engines include the inertia starter, which consists of a flywheel that is rotated by hand or by means of an electric motor until its kinetic energy is sufficient to turn the crankshaft, and the explosive starter, which employs the explosion of a blank cartridge to drive a turbine wheel that is coupled to the engine. The inertia and explosive starters are chiefly used to start airplane engines.

Ex. 3. Find the English equivalents for the words and word combinations given below.

Получение механической энергии от затрат химической энергии сжигаемого топлива, неотъемлемая часть, бензиновый двигатель, работать по другому принципу, составные части двигателя, камера внутреннего сгорания, паровой двигатель, двигатель внутреннего сгорания, выводить из состояния сцепления, приводить в движение коленчатый вал с помощью пусковой рукоятки, инерционный стартер, вращение маховика вручную, задействовать патрон с холостым зарядом для запуска турбины.

Ex. 4. Answer the following questions.

1. What is an internal-combustion engine?
2. What types of engines are in general use now?
3. Who was an inventor of gasoline engine used in automobiles today?
4. What is the origin of diesel engines?
5. What are the advantages of internal combustion engines when starting?
6. What is normal starting of an automobile engine?

7. What is manual starting of engines?
8. What methods of starting large engines do you know?
9. What kinds of starters are chiefly used to start airplane engines?

Ex. 5. Match the synonyms.

1. engineer	a) with the help of
2. manufactured	b) by hand
3. essential	c) appropriate
4. motion	d) basic
5. provision	e) technician
6. by means of	f) movement
7. manually	g) precaution
8. sufficient	h) produced

Ex.6. Make up all possible questions to this sentence.
The inertia and explosive starters are chiefly used to start airplane engines.

Ex. 7. Summarize the text.

UNIT 5

OTTO-CYCLE ENGINES

Ex. 1 Read and memorize the following words.
Compress – сжимать, сдавливать
Four-stroke engine – четырехтактный двигатель
Simultaneously – одновременно
Exert – оказывать (действие)
Exhaust valve – выпускной клапан
Ratio – коэффициент
High-octane – высокооктановый
Antiknock – высокооктановое число, антидетонатор
Percentage – процентное содержание
Suck – поглощать, всасывать
Compression ratios - степень сжатия

Ex. 2. Find and read sentences with these words in the text given below.

TEXT

OTTO-CYCLE ENGINES

The ordinary Otto-cycle engine is a four-stroke engine; that is, in a complete power cycle, its pistons make four strokes, two toward the head (closed head) of the cylinder and two away from the head. During the first stroke of the cycle, the piston moves away from the cylinder head while simultaneously the intake valve is opened. The motion of the piston during this stroke sucks a quantity of a fuel and air mixture into the combustion chamber. During the next stroke, the piston moves toward the cylinder head and compresses the fuel mixture in the combustion chamber. At the moment when the piston reaches the end of this stroke and the volume of the combustion chamber is at a minimum, the fuel mixture is ignited by the spark plug and burns, expanding and exerting a pressure on the piston, which is then driven away from the cylinder head in the third stroke. During the final stroke, the exhaust valve is opened and the piston moves toward the cylinder head, driving the exhaust gases out of the combustion chamber and leaving the cylinder ready to repeat the cycle.

The efficiency of a modern Otto-cycle engine is limited by a number of factors, including losses by cooling and by friction. In general, the efficiency of such engines is determined by the compression ratio of the engine. The compression ratio (the ratio between the maximum and minimum volumes of the combustion chamber) is usually about 8 to 1 or 10 to 1 in most modern Otto-cycle engines. Higher compression ratios, up to about 15 to 1, with a resulting increase of efficiency, are possible with the use of high-octane antiknock fuels. The efficiencies of good modern Otto-cycle engines range between 20 and 25 percent—in other words, only this percentage of the heat energy of the fuel is transformed into mechanical energy.

Ex. 3. Find the English equivalents for the words and word combinations given below.

Впускной клапан, движение поршня, подвергать компрессии топливную смесь, свеча зажигания, увеличение давления на поршень, выхлопные газы, коэффициент полезного действия

современных двигателей, компрессионный коэффициент работы двигателя, механическая энергия, тепловая энергия сгораемого топлива.

Ex. 4. Answer the following questions.

1. What does “a complete power cycle” of ordinary gasoline engines mean?
2. Can you explain what is the first stroke of the cycle?
3. What is the movement of the piston during next two strokes (the second and the third)?
4. What is the final stroke of the engine?
5. What factors limit the efficiency of modern Otto-cycle engine?
6. What is the compression ratio?
7. What are compression ratios of good modern Otto-cycle engines?

Ex. 5. Find the antonyms to the underlined words.

1. complicated
a) expensive; b) simple; c) similar; d) numerous.
2. shortage
a) current; b) delay; c) distance; d) plenty.
3. to remain
a) to lend; b) to be; c) to measure; d) to stretch.
4. to destroy
a) to drag; b) to pave; c) to restore; d) to step.
5. huge
a) small; b) strong; c) free; d) hard.
6. to connect
a) to charge; b) to collapse; c) to introduce; d) to part.
7. gradually
a) also; b) at once; c) chiefly; d) rather.
8. repair
a) pay; b) remark; c) surface; d) damage.
9. the same
a) due; b) total; c) different; d) essential.
10. strength
a) combustion; b) device; c) weakness; d) force.

11. wide
a) powerful; b) narrow; c) dry; d) necessary.

Ex. 6. Match the synonyms.

1. one moment	a) gasoline
2. fuel mixture	b)octane value
3. limitation	c) one second
4. participate	d) restriction
5. octane number	e) share

Ex.7. Make up all possible questions to this sentence.
During the next stroke the piston moves toward the cylinder head and compresses the fuel mixture in the combustion chamber.

Ex. 8. Summarize the text.

UNIT 6

DIESEL-CYCLE ENGINES

Ex. 1 Read and memorize the following words.
Constant – постоянный
Volume – объем, масса, емкость, вместимость
Compression – сжатие, давление, уплотнение
Suction – впуск, всасывание
To draw – затягивать
Intake valve – впускной клапан
Air fraction – частица, объем воздуха
Former – прежний, бывший
Approximately – приблизительно
Vaporization – выпаривание, испарение
Instantly – мгновенно, немедленно
To warm up – прогревать
Combustion – воспламенение, возгорание
Exhaust – выпуск, выхлоп
To govern – управлять, регулировать

Inherently – по существу
Disadvantage – недостаток

Ex. 2. Find and read sentences with these words in the text given below.

TEXT

DIESEL-CYCLE ENGINES

Theoretically, the diesel cycle differs from the Otto cycle in that combustion takes place at constant volume rather than at constant pressure. A diesel engine is an internal combustion engine which operates using the diesel cycle (named after Dr. Rudolph Diesel). The defining feature of the diesel engine is the use of compression ignition to burn the fuel, which is injected into the combustion chamber during the final stage of compression. This is in contrast to a petrol (gasoline) engine, which uses the Otto cycle, in which a fuel/air mixture is ignited by a spark plug. Most diesels are also four-stroke engines but they operate differently than the four-stroke Otto-cycle engines. The first, or suction, stroke draws air, but no fuel, into the combustion chamber through an intake valve. On the second, or compression, stroke the air is compressed to a small fraction of its former volume and is heated to approximately 440°C (approximately 820°F) by this compression. At the end of the compression stroke, vaporized fuel is injected into the combustion chamber and burns instantly because of the high temperature of the air in the chamber. Some diesels have auxiliary electrical ignition systems to ignite the fuel when the engine starts and until it warms up. This combustion drives the piston back on the third or power stroke of the cycle. The fourth stroke, as in the Otto-cycle engine, is an exhaust stroke.

The efficiency of the diesel engine, which is in general governed by the same factors that control the efficiency of Otto-cycle engines, is inherently greater than that of any Otto-cycle engine and in actual engines today is slightly more than 40 percent. Diesels are, in general, slow-speed engines with crankshaft speeds of 100 to 750 revolutions per minute (rpm) as compared to 2500 to 5000 rpm for typical Otto-cycle engines. Some types of diesel, however, have speeds up to 2000 rpm. Because diesels use compression ratios of 14 or more to 1, they are generally more heavily built than Otto-cycle engines, but this

disadvantage is counterbalanced by their greater efficiency and the fact that they can be operated on less expensive fuel oils.

Ex. 3. Find the English equivalents for the words and word combinations given below.

Воспламенение от сжатия, постоянный объем, воспламенение от свечи зажигания, всасывать воздух в камеру внутреннего сгорания через впускной клапан, в результате сжатия воздух нагревается приблизительно до 440^0 С, впрыск топлива в камеру внутреннего сгорания, мгновенное воспламенение, вспомогательная (дополнительная) электрическая система зажигания, прогреть двигатель, частота вращения коленчатого вала от 100 до 750 оборотов в минуту, степень сжатия, недостатки, дешевая топливная смесь, преимущества, недостатки, уравновешивать степень сжатия.

Ex. 4. Answer the following questions.

1. How does diesel cycle differ from the Otto cycle theoretically?
2. Is diesel engine an internal combustion engine?
3. How does it operate?
4. What is the defining feature of the diesel engine?
5. How does a fuel/air mixture ignite in Otto-cycle engines?
6. Are most diesels four-stroke engines?
7. Is it typical for diesels to have auxiliary electrical ignition systems?
8. What is the first or suction stroke of diesel engines?
9. What happens on the second or compression stroke of diesel engines?
10. What drives the piston back on the third or power stroke of the cycle?
11. What is the fourth stroke?
12. Are there any disadvantages of diesel engines?

Ex. 5. Match the synonyms.

1. constant	a) cheap
2. less expensive	b) permanent
3. feature	c) to work

4. to ignite	d) the last
5. to operate	e) to fire
6. final	f) characteristic
7. fraction	g) modern
8. auxiliary	h) part
9. actual	i) additional
10.in general	j) on the whole

Ex.6. Make up all possible questions to this sentence.
The fourth stroke, in the Otto-cycle engine, is an exhaust stroke.

Ex. 7. Summarize the text.

UNIT 7

TWO-STROKE ENGINES

Ex. 1 Read and memorize the following words.
Suitable – подходящий
Power (compression) stroke – рабочий ход, рабочий такт
Pressure power – ход давления, ход сжатия
Double – удваивать, дублировать
Displacement – рабочий объем
Lawn mower – газонокосилка
Chain saw – цепная пила
Outboard – наружный, навесной
To introduce – вводить, подавать
Poppet valve – сквозной (проходной) клапан
Sleeve valve – сквозной канал, (полый) клапан
Port – окно, отверстие
Outward – наружный, внешний, движение поршня вниз
Charge – заряд, загрузка
To restrict – ограничивать
Lubricating oil – моторное масло, машинное масло
Hydrocarbons – углеводород
Under arrangements – согласно договорам

Withdrawn – в нижней мертвой точке

Ex. 2. Find and read sentences with these words in the text given below.

TEXT

TWO-STROKE ENGINES

By suitable design it is possible to operate an Otto-cycle or diesel as a two-stroke or two-cycle engine with a power stroke every other stroke of the piston instead of once every four strokes. The power of a two-stroke engine is usually double that of a four-stroke engine of comparable size. Thus it develops more power with the same displacement, or can be lighter and yet deliver the same power. For this reason it is used in lawn mowers, chain saws, small automobiles, motorcycles, and outboard marine engines.

The general principle of the two-stroke engine is to shorten the periods in which fuel is introduced to the combustion chamber and in which the spent gases are exhausted to a small fraction of the duration of a stroke instead of allowing each of these operations to occupy a full stroke. In the simplest type of two-stroke engine, the poppet valves are replaced by sleeve valves or ports (openings in the cylinder wall that are uncovered by the piston at the end of its outward travel). In the two-stroke cycle, the fuel mixture or air is introduced through the intake port when the piston is fully withdrawn from the cylinder. The compression stroke follows, and the charge is ignited when the piston reaches the end of this stroke. The piston then moves outward on the power stroke, uncovering the exhaust port and permitting the gases to escape from the combustion chamber.

However, there are several disadvantages that restrict its use. Since there are twice as many power strokes during the operation of a two-stroke engine as there are during the operation of a four-stroke engine, the engine tends to heat up more, and thus is likely to have a shorter life. Also, in the two-stroke engine lubricating oil must be mixed with the fuel. This causes a very high level of hydrocarbons in its exhaust, unless the fuel-air mixture is computer calculated to maximize combustion. A highly efficient, pollution-free two-stroke automobile engine is currently being developed by world Engineering, under arrangements with all auto makers.

Ex. 3. Find the English equivalents for the words and word combinations given below.

Рабочий объем, полный такт, двухтактный цикл, сократить период подачи топлива в камеру сгорания, топливо и воздух поступают через входной канал при полном выходе поршня из цилиндра (в максимально нижнем положении), такт сжатия (рабочий ход), перегреваться, смешивать масло с бензином, высокий уровень содержания углеводорода в выхлопных газах, усилить сгорание.

Ex. 4. Answer the following questions.

1. Is it possible to operate an Otto-cycle or diesel as two-stroke or two-cycle engine?
2. Do two-cycle engines with the same displacement (as four-cycle engines) develop more power?
3. What are other advantages of two-stroke cycle engines?
4. What is the general operating principle of two-stroke engines?
5. Is there any difference between two and four-stroke engines?
6. What are disadvantages of two-stroke engines?
7. What causes a very high level of hydrocarbons in the exhaust of two-stroke cycle engines?

Ex. 5. Match the synonyms.

1. double	a) come out
2. withdraw	b) back
3. introduce	c) limit
4. spent gases	d) twofold
5. duration	e) remove
6. allow	f) to inject
7. simple	g) exhaust gases
8. escape from	h) continuance
9. restrict	i) permit
10.outward	j) ordinary

Ex.6. Complete and translate the sentences.

1. The general principle of two-stroke engine is to …
2. The compression stroke follows and … the end of this stroke.

3. This causes a very high level of … .
4. The piston then moves … uncovering … to escape from the combustion chamber.
5. A highly efficient … is currently being developed … .

Ex.7. Make up all possible questions to this sentence.
There are several disadvantages that restrict the use of two-stroke cycle engines.

Ex. 8. Summarize the text.

UNIT 8

ROTARY (WANKEL) ENGINE

Ex. 1 Read and memorize the following words.
Three cornered rotor – треугольный, трехгранный ротор
To draw in – нагнетать
Chamber – корпус, камера
Trapped – удерживаемый
Face – поверхность; передняя часть
Turning – вращение
Expel – вытеснять
Alternately – поочередно
Consequent – последовательный, соответственный
Option – дополнительный агрегат, дополнение
Gravity – сила тяжести
Safe – безопасный, надежный
Bulk – масса, вместимость
Reciprocating – поршневой, возвратно-поступательное движение
Advanced pollution control devices – устройства предварительной регулировки уровня загрязнения
Conventional – общепринятый, обыкновенный
Rotating – вращение
Offset – компенсировать, возмещать
Torque – вращающийся момент

Fuel consumption – расход горючего
Performance – характеристика
Efficiency – коэффициент полезного действия
Innovation – техническое новшество

Ex. 2. Find and read sentences with these words in the text given below.

TEXT

ROTARY (WANKEL) ENGINE

In the 1950s the German engineer Felix Wankel developed an internal-combustion engine of a radically new design, in which the piston and cylinder were replaced by a three-cornered rotor turning in a roughly oval chamber. The fuel-air mixture is drawn in through an intake port and trapped between one face of the turning rotor and the wall of the oval chamber. The turning of the rotor compresses the mixture, which is ignited by a spark plug. The exhaust gases are then expelled through an exhaust port through the action of the turning rotor. The cycle takes place alternately at each face of the rotor, giving three power strokes for each turn of the rotor. Because of the Wankel engine's compact size and consequent lesser weight as compared with the piston engine, it appeared to be an important option for automobiles. In addition, its mechanical simplicity provided low manufacturing costs, its cooling requirements were low, and its low center of gravity made it safer to drive.

The Wankel engine has 48% fewer parts and about a third the bulk and weight of a reciprocating engine. Its main advantage is that advanced pollution control devices are easier to design for it than for the conventional piston engine. Another advantage is that higher engine speeds are made possible by rotating instead of reciprocating motion, but this advantage is partially offset by the lack of torque at low speeds, leading to greater fuel consumption.

A line of Wankel engine cars was produced in Japan in the early 1970s, and several United States automobile manufacturers researched the idea as well. However, production of the Wankel engine was discontinued as a result of its poor fuel economy and its high pollutant emissions. Nowerdays Mazda, a Japanese car manufacturer, has continued to design and innovate the rotary engine, improving performance and fuel efficiency.

Ex. 3. Find the English equivalents for the words and word combinations given below.

Двигатель внутреннего сгорания абсолютно новой конструкции, горючая смесь из воздуха и топлива нагнетается через впускной клапан, в результате вращения ротора происходит сжатие смеси, рабочий цикл осуществляется поочередно на передних гранях ротора, масса и вес, простота конструкции, себестоимость (производства), автопроизводители, надежный в управлении.

Ex. 4. Answer the following questions.

1. What was developed by the German engineer Felix Wankel?
2. Is there any difference between reciprocating engines and rotary engines?
3. How does fuel-air mixture circulate in a rotary engine?
4. What is the cycle of a rotary engine?
5. What is appeared to be an important option of the Wankel engine?
6. What are the advantages of a rotary engine?
7. What is its main advantage?
8. Were there any manufacturers of Wankel engine cars in the early 1970s?
9. What are disadvantages of a rotary engine?
10. Are there any perspectives of rotary engines?

Ex. 5. Match the synonyms.

1. radically	a) generally accepted
2. design	b) mass
3. offset	c) absolutely
4. bulk	d) model
5. to discontinue	e) compensation
6. conventional	f) to stop

Ex.6. Complete and translate the sentences.

1. The Wankel engine has 48% … .
2. In the 1950s the German … .
3. Its main … conventional piston engine.
4. In addition … made it safer to drive.

5. However … pollutant emissions.

Ex.7. Make up all possible questions to this sentence.
The exhaust gases are then expelled through an exhaust port through the action of the turning rotor.

Ex. 8. Summarize the text.

UNIT 9

COOLING AND LUBRICATION OF ENGINES

Ex. 1 Read and memorize the following words.
Aircraft engine – авиационный двигатель
Cooling fins – охлаждающие пластины радиатора
Water-jacket – водяная рубашка, оболочка, кожух
To enclose – ограждать
Water pump – водяной насос (помпа)
To draw – вытягивать
Thermostatic valve – терморегулирующий клапан
Optimum – оптимальный
To lubricate – смазывать
Crankcase – картер
Pan – поддон
External tank – внешний корпус, резервуар
Gear pump – шестеренчатый насос
To deliver – подавать, нагнетать
Bearings – подшипники
Oil splash – впрыск, залив масла
Crankshaft – коленчатый вал
Camshaft – распределительный вал
Gauge – измерительный прибор
Dashboard – приборная панель

Ex. 2. Find and read sentences with these words in the text given below.

TEXT

COOLING AND LUBRICATION OF ENGINES

Most small two-stroke engines are air-cooled. Air flows over cooling fins around the outside of the cylinder and head, either by the natural motion of the vehicle or from a fan. Many aircraft four-stroke engines are also air-cooled; larger engines have the cylinders arranged radially so that all cylinders are directly in the air stream. Most four-stroke engines, however, are water-cooled. A water jacket encloses the cylinders; a water pump forces water through the jacket, where it draws heat from the engine. Next, the water flows into a radiator where the heat is given off to the air; it then moves back into the jacket to repeat the cycle. During warm-up a thermostatic valve keeps water from passing to the radiator until optimum operating temperatures are attained.

Oil is the life-blood of the engine. An engine running without oil will last about as long as a human without blood.

Four-stroke engines are lubricated by oil from a separate oil reservoir, either in the crankcase, which is a pan attached to the underside of the engine, or in an external tank. In an automobile engine a gear pump delivers the oil at low pressure to the bearings. Some bearings may depend on oil splashed from the bottom of the crankcase by the turning crankshaft.

Oil is pumped under pressure to all the moving parts of the engine. The oil pump is mounted at the bottom of the-engine in the oil pan and is connected by a gear to either the crankshaft or the camshaft.

When the engine is turning, the oil pump is pumping. There is an oil pressure sensor near the oil pump that monitors pressure and sends this information to a warning light or a gauge on the dashboard. When you turn the ignition key on, but before you start the car, the oil light should light, indicating that there is no oil pressure yet, but also letting you know that the warning system is working. In a two-stroke engine the lubricating oil is mixed with the fuel.

Ex. 3. Find the English equivalents for the words and word combinations given below.

Многие авиационные двигатели имеют воздушное охлаждение, большинство четырехтактных двигателей имеют водяное

охлаждение, водяная помпа проталкивает воду через охлаждающую рубашку, повторение цикла, во время прогревания терморегулирующий клапан закрывает проход воды в радиатор, жизнедеятельность двигателя, отдельный масляный резервуар, низкое давление, работа подшипников зависит от впрыскивания масла из картера при вращении распределительного вала, повернуть ключ зажигания.

Ex. 4. Answer the following questions.

1. How does air circulate in small air-cooled two-stroke engines?
2. What is typical of larger four-stroke engines' air-cooling?
3. Is water-cooling of engines widely spread?
4. In what way are four-stroke engines water cooled?
5. What for does a thermostatic valve exist?
6. What do we call life-blood of the engine?
7. What is oil lubrication of four-stroke engines?
8. Where is oil pump mounted?
9. Is it connected by a gear to the crankshaft?
10. What will let you know that the warning system is working?

Ex. 5. Match the synonyms.

1. optimum	a) to allow
2. to deliver	b) bottom
3. to oil	c) tank
4. radial	d) working
5. air stream	e) to reach
6. to attain	f) airflow
7. running	g) oval
8. reservoir	h) to lubricate
9. underside	i) to bring
10.to let	j) maximum

Ex.6. Complete and translate the sentences.

1. Most … are water cooled.
2. A water jacket … cylinders, … from the engine.
3. An engine running … without blood.
4. Some bearings may … by the turning crankshaft.

5. In a two-stroke engine … mixed with the fuel.

Ex.7. Make up all possible questions to this sentence.
There is an oil pressure sensor near the oil pump that monitors pressure and sends this information to a warning light or a gauge on the dashboard.

Ex. 8. Summarize the text.

UNIT 10

ELECTRIC CAR ENGINE

Ex. 1 Read and memorize the following words.
Controller – регулятор
Battery pack – блок питания, аккумуляторная батарея
Ultracapacitor – ультраконденсатор
Flywheel – маховик
Charge-sustained mode – режим поддерживающей (длительной) зарядки
Charge-depleting mode – режим подзарядки
Convergence – схождение в одной точке, сходимость (бесконечного ряда)
Solar – солнечный
Aeronautical – воздухоплавательный, авиационный
Innovative – новаторский
Radar – радиолокатор, радиолокационная установка
Satellite – спутник
Automotive – самодвижущийся, автомобильный
Muffler – глушитель
Tune-up – наладить, отрегулировать
Alternating current – переменный ток
Brushless – безупречный
Spinning – кружение
High performance cell – К.П.Д. элемент
Lead acid – окись свинца

Integral – неотъемлемый, полный
Power inverter – преобразователь (постоянного тока в переменный)
Convert – преобразовывать
Current electricity – электрический ток
Congest – перегружать
Obsolete – изношенный, устарелый
Crude – грубый, простой
Small-scale – небольшого размера, маломасштабный
Congestion – загруженность автодорог
Paradigm – пример, образец
Advancement – прогресс, продвижение, распространенность
Accelerator – ускоритель, акселератор

Ex. 2. Find and read sentences with these words in the text given below.

TEXT

ELECTRIC CAR ENGINE

An electric car is a type of alternative fuel car that utilizes electric motors and motor controllers instead of an internal combustion engine. The electric power is usually derived from battery packs in the vehicle.
In general terms an electric car is a rechargeable battery electric vehicle. Other examples of rechargeable electric vehicles are ones that store electricity in ultracapacitors, or in a flywheel.
Vehicles using both electric motors and other types of engine are known as hybrid electric vehicles and are not considered pure electric vehicles because they operate in a charge-sustaining mode.
The electric car was among some of the earliest automobiles, small electric vehicles predate the Otto cycle upon which Diesel (diesel engine) and Benz (gasoline engine) based the automobile. Between 1832 and 1839 (the exact year is uncertain), Scottish businessman Robert Anderson invented the first crude electric carriage. Professor Sibrandus Groningen, the Netherland, designed the small-scale electric car built by his assistant Christopher Becker in 1835.

Nowadays the development of the electric automobile will owe more to innovative solar and aeronautical engineering and advanced satellite and radar technology than to traditional automotive design and construction. The electric car has no engine, exhaust system, transmission, muffler, radiator, or spark plugs. It will require neither tune-ups nor – truly revolutionary – gasoline. Instead, its power will come from alternating current electric motors with a brushless design capable of spinning up to 20,000 revolutions/minute. Batteries to power these motors will come from high performance cells capable of generating more than 100 kilowatts of power. And, unlike the lead-acid batteries of the past and present, future batteries will be environmentally safe and recyclable. Integral to the braking system of the vehicle will be a power inverter that converts direct current electricity back into the battery pack system once the accelerator is let off, thus acting as a generator to the battery system even as the car is driven long into the future.

An electric car's efficiency is affected by its charging efficiencies. A typical charging cycle is about 85% efficient, and the discharge cycle converting electricity into mechanical power is about 95% efficient, resulting in 81% of each kW-h is put to use.

The growth of automobile use and the increasing resistance to road building have made our highway systems both congested and obsolete. But new electronic vehicle technologies that permit cars to navigate around the congestion and even drive themselves may soon become possible. Turning over the operation of our automobiles to computers would mean they would gather information from the roadway about congestion and find the fastest route to their instructed destination, thus making better use of limited highway space. The advent of the electric car will come because of a rare convergence of circumstance and ability. Growing intolerance for pollution combined with extraordinary technological advancements will change the global transportation paradigm that will carry us through the twenty-first century.

Ex. 3. Find the English equivalents for the words and word combinations given below.

Автомобиль - альтернатива двигателю внутреннего сгорания, электрические средства передвижения, электромобиль, простая

электроколяска, работать в режиме продолжительной подзарядки, современные спутниковые и радиолокационные технологии, пункт назначения, загруженность автодорог, аккумулятор, безопасный для окружающей среды, малогабаритный, мощность электромотора зависит от переменного тока, передовые электронные технологии, перегруженность автодорог.

Ex. 4. Answer the following questions.

What does an electric car utilize in comparison with an internal combustion engine?

1. Where is the electric power usually derived from?
2. How do we call an electric car in general terms?
3. What are hybrid electric vehicles?
4. Why do we call them “hybrid”?
5. What is the origin of an electric car?
6. Who invented the first crude electric carriage?
7. What are the advantages of an electric car?
8. Will it require gasoline as a fuel?
9. What is the efficiency of an electric car?

Ex. 5. Match the synonyms.

1. Global	a) An old one
2. Extraordinary	b) Fastener
3. Limited	c) Absolutely new
4. Progress	d) Self-propelled
5. Paradigm	e) Example
6. Automotive	f) Advancement
7. Innovative	g) Minimized
8. Accelerator	h) Unusual
9. Obsolete	i) Overall

Ex.6. Complete and translate the sentences.

1. The electric power …from …in the vehicle.
2. Other examples of …, or in a flywheel.
3. …car was among some of the earliest ….
4. Nowadays …will owe …than to traditional automotive design and construction.

5. …for pollution combined with …through the twenty-first century.

Ex.7. Make up all possible questions to this sentence.
An electric car is a type of alternative fuel car that utilizes electric motors and motor controllers.

Ex. 8. Summarize the text.

TEXTS FOR SUPPLEMENTARY READING

A Short Course on Automobile Engines

Internal combustion gasoline engines run on a mixture of gasoline and air. The ideal mixture is 14.7 parts of air to one part of gasoline (by weight.) Since gas weighs much more than air, we are talking about a whole lot of air and a tiny bit of gas. One part of gas that is completely vaporized into 14.7 parts of air can produce tremendous power when ignited inside an engine.

Let's see how the modern engine uses that energy to make the wheels turn.

Air enters the engine through the air cleaner and proceeds to the throttle plate. You control the amount of air that passes through the throttle plate and into the engine with the gas pedal. It is then distributed through a series of passages called the intake manifold, to each cylinder. At some point after the air cleaner, depending on the engine, fuel is added to the air-stream by either a fuel injection system or, in older vehicles, by the carburetor.

Once the fuel is vaporized into the air stream, the mixture is drawn into each cylinder as that cylinder begins its intake stroke. When the piston reaches the bottom of the cylinder, the intake valve closes and the piston begins moving up in the cylinder compressing the charge. When the piston reaches the top, the spark plug ignites the fuel-air mixture causing a powerful expansion of the gas, which pushes the piston back down with great force against the crankshaft, just like a bicycle rider pushing against the pedals to make the bike go.

Engine Types

The majority of engines in motor vehicles today are four-stroke, spark-ignition internal combustion engines. The exceptions like the diesel and Rotary engines will not be covered in this article.

There are several engine types which are identified by the number of cylinders and the way the cylinders are laid out. Motor vehicles will have from 3 to 12 cylinders which are arranged in the engine block in several configurations. The-most popular of them are shown on the left. In-line engines have their cylinders arranged in a row. 3, 4, 5 and 6 cylinder engines commonly use this arrangement. The "V" arrangement uses two banks of cylinders side-by-side and is commonly used in V-6, V-8, V-10 and V-12 configurations. Flat engines use two opposing banks of cylinders and are less common than the other two designs. They are used in engines from Subaru and

Porsche in 4 and 6 cylinder arrangements as well as in the old VW beetles with 4 cylinders. Flat engines are also used in some Ferraris with 12 cylinders

Most engine blocks are made of cast iron or cast aluminum. Each cylinder contains a piston that travels up and down inside the cylinder bore. All the pistons in the engine are connected through individual connecting rods to a common crankshaft.

The crankshaft is located below the cylinders on an in-line engine, at the base of the V on a V-type engine and between the cylinder banks on a flat engine. As the pistons move up and down, they turn the crankshaft just like your legs pump up and down to turn the crank that is connected to the pedals of a bicycle.

A cylinder head is bolted to the top of each bank of cylinders to seal the individual cylinders and contain the combustion process that takes place inside the cylinder. Most cylinder heads are made of cast aluminum or cast iron. The cylinder head contains at least one intake valve and one exhaust valve for each cylinder. This allows the air-fuel mixture to enter the cylinder and the burned exhaust gas to exit the cylinder. Engines have at least two valves per cylinder, one intake valve and one exhaust valve. Many newer engines are using multiple intake and exhaust valves per cylinder for increased engine power and efficiency. These engines are sometimes named for the number of valves that they have such as "24 Valve V6" which indicates a V-6 engine with four valves per cylinder. Modern engine designs can use anywhere from 2 to 5 valves per cylinder.

The valves are opened and closed by means of a camshaft. A camshaft is a rotating shaft that has individual lobes for each valve. The lobe is a "bump" on one side of the shaft that pushes against a valve lifter moving it up and down. When the lobe pushes against the lifter, the lifter in turn pushes the valve open. When the lobe rotates away from the lifter, the valve is closed by a spring that is attached to the valve. A common configuration is to have one camshaft located in the engine block with the lifters connecting to the valves through a series of linkages. The camshaft must be synchronized with the crankshaft so that the camshaft makes one revolution for every two revolutions of the crankshaft. In most engines, this is done by a "Timing Chain" (similar to a bicycle chain) that connects the camshaft with the crankshaft. Newer engines have the camshaft located in the cylinder head directly over the valves. This design is more efficient but it is more costly to manufacture and requires multiple camshafts on Flat and V-type engines. It also requires much longer timing chains or timing belts which are prone to wear. Some engines have two camshafts on each head, one for the intake valves and one for the exhaust valves. These engines are called Double Overhead Camshaft (D.O.H.C.) Engines while the other type is called Single Overhead Camshaft (S.O.H.C.) Engines. Engines with the camshaft in the block are called Overhead Valve (O.H.V) Engines.

Now when you see "DOHC 24 Valve V6", you'll know what it means.

How an Engine Works

Since the same process occurs in each cylinder, we will take a look at one cylinder to see how the four stroke process works.

The four strokes are Intake, Compression, Power and Exhaust. The piston travels down on the Intake stroke, up on the Compression stroke, down on the Power stroke and up on the Exhaust stroke.

Intake

As the piston starts down on the Intake stroke, the intake valve opens and the fuel-air mixture is drawn into the cylinder (similar to drawing back the plunger on a hypodermic needle to allow fluid to be drawn into the chamber.) When the piston reaches the bottom of the intake stroke, the intake valve closes, trapping the air-fuel mixture in the cylinder.

Compression

The piston moves up and compresses the trapped air fuel mixture that was brought in by the intake stroke. The amount that the mixture is compressed is determined by the compression ratio of the engine. The compression ratio on the average engine is in the range of 8:1 to 10:1.

This means that when the piston reaches the top of the cylinder, the air-fuel mixture is squeezed to about one tenth of its original volume.

Power

The spark plug fires, igniting the compressed air-fuel mixture which produces a powerful expansion of the vapor. The combustion process pushes the piston down the cylinder with great force turning the crankshaft to provide the power to propel the vehicle. Each piston fires at a different time, determined by the engine firing order. By the time the crankshaft completes two revolutions, each cylinder in the engine will have gone through one power stroke.

Exhaust

With the piston at the bottom of the cylinder, the exhaust valve opens to allow the burned exhaust gas to be expelled to the exhaust system. Since the cylinder contains so much pressure, when the valve opens, the gas is expelled with a violent force (that is why a vehicle without a muffler sounds so loud.) The piston travels up

to the top of the cylinder pushing all the exhaust out before closing the exhaust valve in preparation for starting the four stroke process over again.

Oiling System

Oil is the life-blood of the engine. An engine running without oil will last about as long as a human without blood. Oil is pumped under pressure to all the moving parts of the engine by an oil pump. The oil pump is mounted at the bottom of the engine in the oil pan and is connected by a gear to either the crankshaft or the camshaft. This way, when the engine is turning, the oil pump is pumping. There is an oil pressure sensor near the oil pump that monitors pressure and sends this information to a warning light or a gauge on the dashboard. When you turn the ignition key on, but before you start the car, the oil light should light, indicating that there is no oil pressure yet, but also letting you know that the warning system is working. As soon as you start cranking the engine to start it, the light should go out indicating that there is oil pressure.

Engine Cooling

Internal combustion engines must maintain a stable operating temperature, not too hot and not too cold. With the massive amounts of heat that is generated from the combustion process, if the engine did not have a method for cooling itself, it would quickly self-destruct. Major engine parts can warp causing oil and water leaks and the oil will boil and become useless.

While some engines are air-cooled, the vast majority of engines are liquid cooled. The water pump circulates coolant throughout the engine, hitting the hot areas around the cylinders and heads and then sends the hot coolant to the radiator to be cooled off. For more information on the cooling system, click here.

Engine Balance

Flywheel a 4 cylinder engine produces a power stroke every half crankshaft revolution, an 8 cylinder, every quarter revolution. This means that a V8 will be smother running than a 4. To keep the combustion pulses from generating a vibration, a flywheel is attached to the back of the crankshaft. The flywheel is a disk that is about 12 to 15 inches in diameter. On a standard transmission car, the flywheel is a heavy iron disk that doubles as part of the clutch system. On automatic equipped vehicles, the flywheel is a stamped steel plate that mounts the heavy torque converter. The flywheel uses inertia to smooth out the normal engine pulses.

Balance Shaft Some engines have an inherent rocking motion that produces an annoying vibration while running. To combat this, engineers employ one or more balance shafts. A balance shaft is a heavy shaft that runs through the engine parallel to

the crankshaft. This shaft has large weights that, while spinning, offset the rocking motion of the engine by creating an opposite rocking motion of their own.

Cold weather starting of Diesel engines

In cold weather high speed diesel engines, which are mostly prechambered, can be difficult to start because the mass of the cylinder block and cylinder head absorb the heat of compression, preventing ignition because of the higher surface to volume ratio. Prechambered engines therefore make use of small electric heaters inside the prechambers called glow plugs. These engines also generally have a higher compression ratio of 1-19 to 1-21. Low speed and compressed air started larger and intermediate speed diesels do not have glow plugs and compression ratios are around 1-16. Some engines use resistive grid heaters in the intake manifold to warm the inlet air until the engine reaches operating temperature. Engine block heaters (electric resistive heaters in the engine block) connected to the utility grid are often used when an engine is turned off for extended periods (more than an hour) in cold weather to reduce startup time and engine wear. In the past, a wider variety of cold-start methods were used. Some engines, such as Detroit Diesel engines and Lister-Petter engines, used a system to introduce small amounts of ether into the inlet manifold to start combustion. Saab marine engines, Field Marshall tractors (among others) used slow-burning solid-fuel 'cigarettes' which were fitted into the cylinder head as a primitive glow plug. Lucas developed the 'Thermostart', where an electrical heating element was combined with a small fuel valve. Diesel fuel slowly dripped from the valve onto the hot element and ignited. The flame heated the inlet manifold and when the engine was turned over the flame was drawn into the combustion chamber to start combustion. International Harvester developed a WD-40 tractor in the 1930s that had a 7-liter 4-cylinder engine which ran as a diesel, but was started as a gasoline engine. The cylinder head had valves which opened for a portion of the compression stroke to reduce the effective compression ratio, and a magneto produced the spark. An automatic ratchet system automatically disengaged the ignition system and closed the valves once the engine had run for 30 seconds. The operator then switched off the gasoline fuel system and opened the throttle on the diesel injection

system. Such systems fell out of favor when electrical glow plug systems proved to be the simplest to operate and produce. Recently direct-injection systems advanced to the extent that prechambers systems.

Gelling

Diesel fuel is also prone to "waxing" or "gelling" in cold weather, terms for the solidification of diesel oil into a partially crystalline state. The crystals build up in the fuel line (especially in fuel filters), eventually starving the engine of fuel and causing it to stop running. Low-output electric heaters in fuel tanks and around fuel lines are used to solve this problem. Also, most engines have a "spill return" system, by which any excess fuel from the injector pump and injectors is returned to the fuel tank. Once the engine has warmed, returning warm fuel prevents waxing in the tank. Due to improvements in fuel technology, with additives waxing rarely occurs in all but the coldest weather. A mix of diesel and kerosene should be used to start a cold vehicle in the coldest weather.

Fuel delivery

A vital component of all diesel engines is a mechanical or electronic governor which limits the speed of the engine by controlling the rate of fuel delivery. Unlike Otto-cycle engines, incoming air is not throttled and a diesel engine without a governor can easily overspeed, resulting in its destruction. Mechanically governed fuel injection systems are driven by the engine's gear train. These systems use a combination of springs and weights to control fuel delivery relative to both load and speed. Modern, electronically controlled diesel engines control fuel delivery and limit the maximum rpm by use of an electronic control module (ECM) or electronic control unit (ECU). The ECM/ECU receives an engine speed signal, as well as other operating parameters such as intake manifold pressure and fuel temperature, from a sensor and controls the amount of fuel and start of injection timing through electric or hydraulic actuators to maximize power and efficiency and minimize emissions. Controlling the timing of the start of injection of fuel into the cylinder is a key to minimizing emissions, and maximizing fuel economy (efficiency), of the engine. The timing is usually measured in units of

crank angle of the piston before top dead center. For example, if the ECM/ECU initiates fuel injection when the piston is 10 degrees before TDC, the start of injection, or timing, is said to be 10° BTDC. Optimal timing will depend on the engine design as well as its speed and load.

Advancing the start of injection (injecting before the piston reaches TDC) results in higher in-cylinder pressure and temperature, and higher efficiency, but also results in elevated engine noise and increased oxides of nitrogen (NO_X) emissions due to higher combustion temperatures. On the other hand, delayed start of injection causes incomplete combustion, reduced fuel efficiency and an increase in exhaust smoke, containing a considerable amount of particulate matter (PM) and unburned hydrocarbons (HC).

Early fuel injection systems

The modern diesel engine is a combination of two inventors' creations. In all major aspects, it holds true to Rudolf Diesel's original design, that of igniting fuel by compression at an extremely high pressure within the cylinder. With much higher pressures and high technology injectors present-day diesel engines use the so-called solid injection system invented by Herbert Akroyd Stuart for his hot bulb engine.

Ignoring the obvious differences, the modern Glow Plug indirect injection engine could be considered the latest reincarnation of these "hot bulb" ignition based engines.

Diesel engines in service today raise the fuel to extreme pressures by mechanical pumps and deliver it to the combustion chamber by pressure-activated injectors. With direct injected diesels, injectors spray fuel through six or more small orifices in its nozzle.

Diesel's original engine injected fuel with the assistance of compressed air, which atomized the fuel and forced it into the engine through a nozzle (a similar principle to an aerosol spray). The nozzle opening was closed by a pin valve lifted by the camshaft to initiate the fuel injection before TDP (top dead center). This is called an air-blast injection. Driving the three stage compressor used some power but the efficiency and net power output was more than any other combustion engine at that time.

In the diesel engine, only air is introduced into the combustion chamber. The air is then compressed to 40 bar (about 600 psi) compared to 14 bar (about 200 psi) in the gasoline engine. This high compression heats the air to 550 °C (about 1000 °F). At this moment, fuel is injected directly into the compressed air. The fuel is ignited by the heat, causing a rapid expansion of gases that drive the piston downward, supplying power to the crankshaft.

Major advantages

Diesel engines have several advantages over other internal combustion engines.

- They burn less fuel than a gasoline engine performing the same work, due to the engine's high efficiency and diesel fuel's higher energy density than gasoline.
- They have no high-tension electrical ignition system to attend to, resulting in high reliability and easy adaptation to damp environments.
- They can deliver much more of their rated power on a continuous basis than a gasoline engine.
- The life of a diesel engine is generally about twice as long as that of a gasoline engine due to the increased strength of parts used, also diesel fuel has better lubrication properties than gasoline.
- Diesel fuel is considered safer than gasoline in many applications. Although diesel fuel will burn in open air using a wick, it will not explode and does not release a large amount of flammable vapour.
- For any given partial load the fuel efficiency (Kgs burned per KWh produced) of a diesel engine remains nearly constant, as opposed to gasoline and turbine engines which vary depending on throttle position.

Mechanical and electronic injection

Many configurations of fuel injection have been used over the past century (1900-2000).

Most present day (2008) diesel engines make use of a camshaft, rotating at half crankshaft speed, lifted mechanical single plunger high pressure fuel pump driven by the engine crankshaft. For each cylinder, its plunger measures the amount of fuel and determines the timing of each injection. These engines use injectors that are basically very precise spring-loaded valves that open and close at a specific fuel pressure. For each cylinder a plunger pump is connected with an injector with a high pressure fuel line. Fuel volume for each single combustion is controlled by a slanted grove in the plunger which rotates only a few degrees releasing the pressure and is controlled by a mechanical governor, consisting of weights rotating at engine speed constrained by springs and a lever. The injectors are held open by the fuel pressure. On high speed engines the plunger pumps are together in one unit. Each fuel line should have the same length to obtain the same pressure delay.

A cheaper configuration on high speed engines with less than six cylinders is to use one rotating pump plunger delivering fuel to a valve and line for each cylinder (functionally analogous to points and distributor cap on an Otto engine).. This contrasts with the more modern method of having a single fuel pump which supplies fuel constantly at high pressure with a common rail (single fuel line common) to each injector. Each injector has a solenoid operated by an electronic control unit, resulting in more accurate control of injector opening times that depend on other control conditions, such as engine speed and loading, and providing better engine performance and fuel economy. This design is also mechanically simpler than the combined pump and valve design, making it generally more reliable, and less noisy, than its mechanical counterpart.

Both mechanical and electronic injection systems can be used in either direct or indirect injection configurations.

Older diesel engines with mechanical injection pumps could be inadvertently run in reverse, albeit very inefficiently, as witnessed by massive amounts of soot being ejected from the air intake. This was often a consequence of push starting a vehicle using the wrong gear. Large ship diesels can run either way.

Indirect injection

An indirect injection diesel engine delivers fuel into a chamber off the combustion chamber, called a prechamber or ante-chamber, where combustion begins and then spreads into the main combustion chamber, assisted by tatujence created in the chamber. This system allows for a smoother, quieter running engine, and because combustion is assisted by turbulence, injector pressures can be lower, about 100 bar using a single orifice tapered jet injector . Mechanical injection systems allowed high-speed running suitable for road vehicles (typically up to speeds of around 4,000 rpm). The prechamber had the disadvantage of increasing heat loss to the engine's cooling system, and restricting the combustion burn, which reduced the efficiency by 5%-10%. Indirect injection engines were used in small-capacity, high-speed diesel engines in automotive, marine and construction uses from the 1950s, until direct injection technology advanced in the 1980s. Indirect injection engines are cheaper to build and it is easier to produce smooth, quiet-running vehicles with a simple mechanical system. In road-going vehicles most prefer the greater efficiency and better controlled emission levels of direct injection.

Direct injection

Modern diesel engines make use of one of the following direct injection methods:

Direct injection injectors are mounted in the top of the combustion chamber. The problem with these vehicles was the harsh noise that they made . Fuel consumption was about 15 to 20 percent lower than indirect injection diesels, which for some buyers was enough to compensate for the extra noise.

This type of engine was transformed by electronic control of the injection pump, pioneered by the Volkswagen Group in 1989. The injection pressure was still only around 300 bar (4350 psi), but the injection timing, fuel quantity, EGR and turbo boost were all electronically controlled. This gave more precise control of these parameters which made refinement more acceptable and emissions lower.

Unit direct injection

Unit direct injection also injects fuel directly into the cylinder of the engine. In this system the injector and the pump are combined into one unit positioned over each cylinder controlled by the camshaft. Each cylinder has its own unit eliminating the high pressure fuel lines, achieving a more consistent injection. This type of injection system, also developed by Bosch, is used by Volkswagen AG in cars (where it is called a *Pumpe-Duse-System*—literally "pump-nozzle system") and by Mercedes Benz ("PLD") and most major diesel engine manufacturers in large commercial engines (CAT, Cummins, Detroit Diesel, Volvo). With recent advancements, the pump pressure has been raised to 2,050 bar (205 MPa, 30127 psi), allowing injection parameters similar to common rail sys
tems.