МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
Національний університет кораблебудування
імені адмірала Макарова

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АНГЛІЙСЬКА МОВА ЗА ПРОФЕСІЙНИМ СПРЯМУВАННЯМ

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Вміщено ключові теми управління судновими технічними системами і комплексами. Матеріал подано через систему інформаційних текстів, лексико-граматичних, фонетичних і комунікативних вправ, глосарій та граматичні зрізи. Посібник орієнтований на досягнення рівня володіння мовою B2, що відповідає стандарту підготовки бакалавра. Розвиває критичне мислення, професійну мобільність та здатність студентів ефективно спілкуватися англійською мовою в професійному середовищі.

Призначено для здобувачів вищої освіти другого курсу спеціальності J5 «Морський та внутрішній водний транспорт» спеціалізації J5.02 «Управління судновими технічними системами і комплексами».

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ПЕРЕДМОВА

Посібник призначений для студентів закладів, що надають вищу технічну освіту, має професійно орієнтований характер і спрямований на комплексний розвиток іншомовної комунікативної компетентності в усіх видах мовленнєвої діяльності з урахуванням потреб майбутньої професійної реалізації. Видання також покликане сформувати вміння, необхідні для самостійної роботи з англомовними технічними джерелами, зокрема фаховою літературою та технічною документацією.

У межах програми англійської мови за професійним спрямуванням комунікативна компетенція трактується як сукупність мовленнєвої поведінки, що передбачає оволодіння лінгвістичною, соціолінгвістичною та прагматичною компетенціями, необхідними для виконання навчально-професійних завдань. Формування зазначених компетенцій здійснюється з урахуванням фахових знань студентів і їхнього попереднього досвіду та реалізується в межах ситуативно зумовленого навчального контексту, пов'язаного зі спеціалізацією.

Структурно посібник охоплює три тематичні розділи та чотирнадцять підрозділів. Теми, обрані для практичних занять, відповідають програмному забезпеченню спеціальності J5 «Морський та внутрішній водний транспорт». Кожен підрозділ включає в себе інформаційний, граматичний та лексичний матеріал. У кінці кожного підрозділу студентам пропонується пройти тести на перевірку засвоєних

знань з теми. Навчальний матеріал включає в себе систему фонетичних, лексичних і граматичних вправ, спрямованих на формування мовленнєвих умінь і реалізацію комунікативних намірів у межах професійно значущих ситуацій.

У результаті опанування курсу студент має засвоїти граматичний і лексичний мінімум, що забезпечує адекватне розуміння іншомовних фахових текстів, сформувати навички правильної вимови, читання, усного й писемного мовлення та набути здатності ефективно використовувати англійську мову в професійному середовищі.

UNIT 1
OPERATION OF MARINE DIESEL ENGINES

SECTION 1. CYCLES OF DIESEL ENGINES
INFORMATION FOCUS

1. Read the text and answer the questions that follow:

The four main types of internal combustion engines used in marine practice are diesel engines, steam turbines, gas turbines, and marine nuclear power plants.

At present, the diesel engine has proved to be the most efficient and reliable for operation on board merchant ships. Its power output is expressed in brake horsepower or kilowatts. The speed of large diesel engines with a cylinder diameter of up to 900 mm is relatively slow (up to 145 rpm). They can be connected to the propeller without gearing. They operate on low-grade heavy fuel, which results in reduced operating and maintenance costs. They also have a more efficient combustion process due to a longer piston stroke.

Any internal combustion engine, regardless of the principle on which it operates, is said to have either a four-stroke cycle or a two-stroke cycle. The engines of either type may be single- or double-acting and of the trunk-piston type, crosshead type, or opposed-piston type.

The four-stroke cycle consists of the suction stroke, compression stroke, combustion and expansion stroke, and exhaust stroke. The piston begins its downward movement during the suction stroke.

The air inlet valve is open, and air is drawn into the cylinder through the air inlet pipe. The exhaust valve and the fuel injection valve are closed. As the piston reaches the end of the suction stroke, the air inlet valve closes, and as the piston rises during the second, or compression, stroke, the air in the cylinder is compressed. At the end of this stroke, the air is compressed to about 480 psi, and its temperature rises to about 1,000 °F. The fuel injection valve then opens, and fuel oil is sprayed into the cylinder under a pressure of about 3,550 psi. The high temperature of the compressed air in the cylinder ignites the fuel, and it continues to burn as long as injection is maintained. This combustion raises the temperature of the gas to approximately 3,000 °F.

Meanwhile, the piston starts moving downward on the third, or power, stroke. Shortly after fuel injection ceases, the piston continues its downward movement during this stroke. At the end of this stroke, the exhaust valve opens, and the burned gases in the cylinder, now reduced to about 40 psi and correspondingly reduced in temperature, start to flow out through the exhaust pipe. During the fourth, or exhaust, stroke, the piston pushes the remaining gas out of the cylinder. At the end of this stroke, the exhaust valve closes, the air inlet valve opens, and the cycle of operations begins again.

It is thus seen that one complete cycle requires four piston strokes, which comprise two complete revolutions of the crankshaft.

In the two-stroke, single-acting diesel engine, instead of an exhaust valve, there is a ring of exhaust ports around the lower part of the cylinder, communicating with the exhaust pipe. The spray valve and starting valve are the same as in the four-stroke cycle. In place of air inlet valves, there are scavenging ports; in uniflow scavenging engines, exhaust valves are also used. The scavenging ports are in communication with a passage leading to

a low-pressure scavenging air compressor driven by the engine. When the piston, on its downward stroke, uncovers the exhaust ports and the cylinder pressure drops to atmospheric pressure, the scavenging ports open and the air, under pressure, flows into the cylinder and pushes the exhaust gases out through these ports. As the piston, on its upward stroke, covers the scavenging ports, the exhaust ports close, leaving the cylinder filled with fresh air. The piston, moving upward on its compression stroke, compresses this air, and at the end of compression, fuel injection occurs, just as previously described for the four-stroke cycle.

It is thus seen that the complete series of operations, including fuel injection and combustion, expansion, exhaust, filling the cylinder with fresh air, and compression, occurs in two piston strokes, or one revolution of the crankshaft.

COMPREHENSION

2. Answer the following questions using the information from the text:

1. What types of internal combustion engines are used in marine practice?
2. What type of engine is considered to be the most efficient and reliable?
3. What main classifications of internal combustion engines are described in the text?
4. What does a four-stroke cycle consist of?
5. How does an air inlet valve operate?
6. How does a piston operate in a diesel engine?
7. How many piston strokes are required to complete one full cycle?
8. How does a two-stroke diesel engine operate?
9. What is the difference between two-stroke and four-stroke diesel engines?

3. Match the following English words and phrases with their Ukrainian equivalents:

1) internal combustion engine	a) чотиритактний
2) principal of operation	b) двосторонній
3) four-stroke cycle	c) поршневий
4) two-stroke cycle	d) з протилежно розташованими поршнями
5) single acting	e) хід всмоктування, хід стиснення
6) double acting	f) односторонній
7) trunk-piston type	g) хід згоряння та розширення
8) crosshead type	h) двотактний
9) opposed-piston type	i) хід випуску
10) suction stroke	j) впускний клапан
11) compression stroke	k) двигун внутрішнього згоряння
12) combustion and expansion stroke	l) випускний клапан
13) exhaust stroke	m) односторонній
14) inlet valve	n) пусковий клапан
15) exhaust valve	o) клапан впорскування палива
16) starting valve	p) випускний отвір
17) fuel injection valve	q) принцип роботи
18) exhaust port	r) прямопотокова продувка
19) spray valve	s) розпилювальний клапан
20) scavenging ports	t) продувні отвори
21) uniflow scavenging	

GRAMMAR FOCUS

Prepositions in English are small words (like *in, on, at, of, to*) that link nouns, pronouns, and phrases to other words, showing relationships in time, place, direction, or logic. They form prepositional phrases and are crucial for adding detail and context, though their correct usage can be tricky, with common ones including *in, on, at, for, from, with.*

4. Insert the correct prepositions into the text (*at, with, up, into, by, of, to, through, down, in*):

A cross-section of a four-stroke cycle engine. The engine is made … of a piston which moves up and … in a cylinder,

which is covered at the top … a cylinder head. The fuel injector, through which fuel enters the cylinder, is located … the cylinder head. The inlet and exhaust valves are also housed in the cylinder head and held shut by springs. The piston is joined … the connecting rod by a gudgeon pin. The bottom end, or big end, of the connecting rod is joined to the crankpin, which forms part … the crankshaft. With this assembly, the linear up-and-down movement of the piston is converted … the rotary movement of the crankshaft. The crankshaft is arranged to drive, … gears, the camshaft, which either directly or through pushrods operates rocker arms, which open the inlet and exhaust valves. The camshaft is "timed" to open the valves … the correct point in the cycle. The crankshaft is surrounded by the crankcase and the engine framework, which supports the cylinders and houses the crankshaft bearings. The cylinder and cylinder head are arranged … water-cooling passages around them.

WRITING PRACTICE

5. Translate the sentences from Ukrainian into English.

1. Поршень рухається вниз під час такту всмоктування.
2. Впускний клапан повітря відкривається, і повітря всмоктується в циліндр через впускний патрубок.
3. Висока температура стисненого повітря в циліндрі запалює паливо, і воно продовжує горіти доти, доки триває впорскування.
4. Поршень починає рухатися вниз на третьому такті – такті згоряння та розширення.
5. Під час четвертого такту, або такту випуску, поршень виштовхує решту газів із циліндра.
6. У двотактному дизельному двигуні замість випускного клапана є кільце випускних отворів, а замість впускних клапанів повітря – продувні отвори.

7. Впускний клапан закривається в кінці такту всмоктування.

8. Клапан впорскування палива відкривається після завершення такту стиснення.

9. Паливо потрапляє в циліндр у кінці такту стиснення.

10. Газ розширюється під час такту згоряння та розширення.

11. Газ виходить під час такту випуску.

12. Випускний клапан відкривається під час такту випуску.

13. Тиск і температура газу знижуються під час такту розширення.

14. Випускний клапан розміщений у головці циліндра.

15. До циліндра підключена випускна труба.

16. Паливо запалюється всередині циліндра.

17. Впускний клапан розміщений у головці циліндра.

18. У нижній частині циліндра розташоване кільце випускних отворів.

19. Замість впускних клапанів повітря розташовано кілька продувних отворів.

20. Двигун приводить у дію компресор для продувки повітря.

21. У цьому циклі колінчастий вал робить лише один оберт.

6. Work on your vocabulary:

• internal combustion engine /ɪnˈtɜːnəl kəmˈbʌstʃən ˈendʒɪn/ – двигун внутрішнього згоряння

• four-stroke cycle /ˈfɔːr strəʊk ˈsaɪkəl/ – чотиритактний цикл

• single or double-acting /ˈsɪŋgl ɔː ˈdʌbəl ˈæktɪŋ/ – односторонньої або двосторонньої дії

- crosshead type /ˈkrɒshed taɪp/ – крейцкопфний тип
- suction stroke /ˈsʌkʃən strəʊk/ – хід всмоктування
- exhaust stroke /ɪgˈzɔːst strəʊk/ – хід випуску (вихлопу)
- combustion and expansion stroke /kəmˈbʌstʃən ənd ɪkˈspænʃən strəʊk/ – хід горіння та розширення
- air inlet pipe /eə ˈɪnlet paɪp/ – впускний патрубок
- air inlet valve /eə ˈɪnlet vælv/ – впускний клапан
- fuel injection valve /ˈfjuːəl ɪnˈdʒekʃən vælv/ – клапан впорскування палива
- to maintain injection /tə meɪnˈteɪn ɪnˈdʒekʃən/ – підтримувати впорскування
- exhaust port /ɪgˈzɔːst pɔːt/ – випускне (вихлопне) вікно
- spray valve /spreɪ vælv/ – розпилювальний клапан
- scavenging port /ˈskævɪndʒɪŋ pɔːt/ – продувне вікно
- uniflow scavenging /ˈjuːnɪfləʊ ˈskævɪndʒɪŋ/ – прямоточне продування
- downward stroke /ˈdaʊnwəd strəʊk/ – хід поршня вниз
- to uncover /tə ʌnˈkʌvə/ – відкривати (оголювати)
- pressure /ˈpreʃə/ – тиск
- exhaust /ɪgˈzɔːst/ – випуск / вихлоп

SPEAKING PRACTICE

7. a) Describe the principle of operation of diesel engines. Tell about the difference between two-stroke and four-stroke engines.

b) Imagine that you are a mechanic on a ship and your diesel engine breaks down, tell what you would do first to fix the problem.

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. Which four main types of internal combustion engines are used in marine practice?

A. Diesel engines, gas engines, electric motors, turbines
B. Diesel engines, steam turbines, gas turbines, marine nuclear plants
C. Diesel engines, petrol engines, gas turbines, boilers
D. Steam engines, diesel engines, compressors, turbines

2. Which engine is considered the most efficient and reliable for merchant ships?

A. Gas turbine
B. Steam turbine
C. Diesel engine
D. Nuclear plant

3. How is the power output of a diesel engine expressed?

A. In revolutions per minute
B. In pressure units
C. In brake horse power or kilowatts
D. In fuel consumption

4. What is the typical speed of large marine diesel engines?

A. Up to 500 rpm
B. Up to 300 rpm
C. Up to 145 rpm
D. Up to 1,000 rpm

5. Why can large diesel engines be connected directly to the propeller?

A. Because they are very light
B. Because they operate at low speed
C. Because they use nuclear fuel
D. Because they have high rpm

6. What type of fuel do large marine diesel engines use?

A. Light diesel oil
B. Gasoline
C. Heavy fuel of lower grade
D. Natural gas

7. What advantage does a longer piston stroke provide?

A. Lower pressure
B. Faster engine speed
C. Better combustion process
D. Reduced cylinder size

8. Any internal combustion engine operates on:

A. Only a four-stroke cycle
B. Only a two-stroke cycle
C. Either a four-stroke or a two-stroke cycle
D. A continuous cycle

9. Which of the following is NOT mentioned as an engine type?

A. Trunk-piston type
B. Crosshead type
C. Opposed-piston type
D. Rotary type

10. How many strokes are there in a four-stroke cycle?
A. Two
B. Three
C. Four
D. Five

11. During which stroke is air drawn into the cylinder?
A. Compression stroke
B. Exhaust stroke
C. Suction stroke
D. Combustion stroke

12. What happens to the air during the compression stroke?
A. It is expelled
B. It is cooled
C. It is compressed and heated
D. It is mixed with exhaust gases

13. At what pressure is fuel injected into the cylinder?
A. About 480 p.s.i.
B. About 1,000 p.s.i.
C. About 3,550 p.s.i.
D. About 40 p.s.i.

14. What causes the fuel to ignite in the cylinder?
A. A spark plug
B. External flame
C. High temperature of compressed air
D. Exhaust gases

15. What happens at the end of the expansion stroke?
A. Fuel injection starts
B. Air inlet valve opens
C. Exhaust valve opens
D. Compression begins

16. How many crankshaft revolutions are required for one four-stroke cycle?
A. Half a revolution
B. One revolution
C. Two revolutions
D. Four revolutions

17. What replaces exhaust valves in a two-stroke diesel engine?
A. Air inlet valves
B. Exhaust ports
C. Fuel valves
D. Scavenging pumps

18. How many crankshaft revolutions are required for a complete two-stroke cycle?
A. Half a revolution
B. One revolution
C. Two revolutions
D. Four revolutions.

SECTION 2. SCAVENGING IN MARINE DIESEL ENGINES INFORMATION FOCUS

1. Read the text to find the information you need:

The process of exchanging the gases present in the cylinder after completion of expansion with a charge of uncontaminated fresh air is termed as scavenging.

There are three types of scavenging methods used in marine diesel engines: uniflow scavenging, cross-flow scavenging, and loop scavenging.

Uniflow scavenging:

- The scavenge air enters through the scavenge ports in the lower part of the cylinder liner, while the exhaust gas is expelled through the centrally mounted exhaust valve in the cylinder cover. The scavenge ports are angled to generate a rotational movement of the rising column of air.
- The charge flows in one direction, and intermixing is minimum. The efficiency is maximum in this type of scavenging.
- Stroke, bore ratio: 2.4–2.9.

In modern engines, 3.5–4.0.

Advantages of uniflow scavenging:

- Scavenge efficiency is highest.
- There is no exhaust and scavenge intermixing.
- Lubricating oil consumption is reduced.
- Liner design is much simpler.
- High stroke to bore ratio.

Disadvantages of uniflow scavenging:

- Requires exhaust valves, resulting in additional cost and maintenance.
- Require two or more fuel valves to be fitted per cylinder.

Cross scavenging:

• In this system, the air is directed upwards, passing under the cylinder cover and down on the opposite side, expelling exhaust gas through exhaust ports located diametrically opposite side to the scavenge ports.

• Stroke, scavenge ratio: 2.0–2.2.

Loop scavenging:

• Exhaust ports are placed above scavenge ports on the same side of the liner. Air passes over the piston crown and rises to form a loop within the cylinder, expelling exhaust gas through exhaust ports.

• Stroke, bore ratio: 1.75.

Advantages of cross/ loop scavenging:

• Cylinder head design is simpler. They don't require an exhaust valve.

• There is no valve gear maintenance.

• Only one centrally located fuel valve is sufficient.

Disadvantages of cross/ loop scavenging:

• The design of the cylinder liner is complicated because of exhaust ports, hence liner is expensive.

• There is a greater possibility of mixing between charge air and exhaust gases.

• Scavenging efficiency is less, resulting in** lower purity of charge air and higher temperature.

• Large temperature difference, resulting in high thermal stresses.

• Greater chance of piston ring leakage or breaking due to uneven wear.

• Consumption of cylinder lubricating oil increases.

• It cannot use the advantage of modern engines' increased stroke-to-bore ratio, which is why it is rarely used.

Scavenging efficiency is defined as the ratio of mass of air in the cylinder in beginning to the mass of air at the end of compression.

COMPREHENSION

2. Based on the text above, answer the following questions:

1. What is scavenging?
2. What types of scavenging are there?
3. What are the advantages of unflow scavenging?
4. Compare the advantages of cross/loop scavenging and unflow scavenging.
5. Compare the disadvantages of cross/loop scavenging and unflow scavenging.
6. What type of scavenging has high efficiency?
7. What is the ratio of piston stroke to cylinder diameter in loop scavenging?
8. What is scavenging efficiency?

3. Match the definitions to the corresponding concepts:

1) Cross Flow Scavenging	a) is the gas exchange process in which the charge air passes straight up through the length of the cylinder, forcing the exhaust gas through an exhaust valve at the top of the cylinder
2) Loop Scavenging	b) is where the contaminants that were removed from the intake air by the equipment's OEM pre-cleaner go to be disposed of
3) Uniflow scavenging	c) are poppet valves located in the cylinder head, used specifically in uniflow scavenging systems, most commonly found in two-stroke diesel engines, to allow fresh intake air to sweep exhaust gases out of the cylinder
4) Scavenging air	
5) A scavenger port	
6) Scavenging valves	

	d) is the gas exchange process in which the charge air passes over the piston crown and rises to form a loop within the cylinder, expelling exhaust gases through exhaust ports cut on the same side of the liner above the scavenge ports e) is the fresh air (or air-fuel mixture) used to replace the exhaust gases within an internal combustion engine cylinder during the scavenging process, which is the simultaneous removal of exhaust and the introduction of a fresh charge for the next power cycle f) is the gas exchange process in which the charge air is directed upwards, passing under the cylinder cover and down the opposite side, expelling exhaust gas through exhaust ports on that side.

4. Complete the following sentences to get a complete text. Use the clues below:

the scavenging air rushes in
are scavenging ports
the combustion products
the liability to crack
good combustion of the oil
residue being left
the scavenging ports are opened
in the cylinder head
out through the exhaust ports
is compressed
uniflow scavenging system (B. & W.)
at the bottom of the cylinder
admitting scavenge air

In the two-stroke cycle engine. the scavenge air is admitted through scavenging ports located ……

In the scavenging arrangement, the exhaust ports are placed on one side of the cylinder and, on the opposite side, …… The exhaust ports are slightly higher than the scavenging ports so that the piston uncovers the exhaust ports first, thus allowing the pressure in the cylinder to fall before …… By the time the scavenging ports are uncovered, the pressure in the cylinder has fallen to atmospheric, and …… By inclining the scavenging ports and shaping the piston head, the entering air is deflected upward, and sweeps the burned gases out of the upper part of the cylinder and ……

When the piston covers the ports on its up stroke, the air is trapped in the cylinder and then …… This arrangement of scavenging does away with the necessity for scavenging valves …… The only cylinder head valves then required are the spray valve and the starting air valve. This simplifies the head, makes cooling easier, and reduces …

There are a number of different systems in use for ……

In two-stroke diesel engines, the following three methods are used for the scavenging of the cylinder: cross scavenging system (Sulzer), loop scavenging (M.A.N.) and ……

Uniflow scavenging is of greater advantage when compared to the two other systems. It ensures better removal of all residues of ……

By giving the scavenging port an inclined shape, a rotary motion of the scavenging air is obtained, which means that the air ascends through the cylinder without mixing with the combustion gases, consequently, the latter are forced out of the cylinder, no ……

As a consequence of the advantageous flow conditions, this system requires less surplus air and less scavenging work, too.

The rotary motion of the scavenging air ensures a very even mixture of air and oil, and this, in its turn, will ensure an unusually ……

WRITING PRACTICE

5. Translate the sentences from Ukrainian into English:

1. Порти продувки розташовані в нижній частині циліндра.
2. Спалені гази виводяться в атмосферу.
3. Розпилювальний клапан і клапан пускового повітря розташовані в головці циліндра.
4. Гази згоряння виштовхуються в атмосферу.
5. Система циркуляційної продувки використовується у двигунах M. A. N.
6. Повітря стискається в циліндрі.
7. Повітря, що надходить, відхиляється вгору.
8. Система односторонньої продувки використовується у двигунах B. & W.
9. Повітря надходить через отвори для продувки.
10. Випускні отвори були відкриті.
11. Спалені гази були видалені.
12. Отвори були закриті поршнем.
13. Отвори для продувки були нахилені в цій конструкції.
14. Система односторонньої продувки використовується у двигунах B. & W.
15. Система петльової продувки використовується у двигунах M. A. N.
16. Випускні отвори розташовані вище, ніж отвори для продувки.
17. Випускні отвори та отвори для продувки розташовані на протилежних сторонах циліндра.
18. Розпилювальний клапан та клапан пускового повітря розміщені в головці циліндра.

6. Work on your vocabulary:

- two-stroke cycle /ˈtuː stroʊk ˈsaɪkəl/ – двотактний цикл
- scavenging air /ˈskævɪndʒɪŋ eə(r)/ – повітря для продувки
- scavenging ports /ˈskævɪndʒɪŋ pɔːrts/ – отвори для продувки
- exhaust ports /ɪgˈzɔːst pɔːrts/ – отвори для випуску
- piston head /ˈpɪstən hed/ – головка поршня
- entering air /ˈentərɪŋ eə(r)/ – повітря, що надходить
- burned gases /bɜːrnd ˈgæsɪz/ – спалені гази
- upper part of the cylinder /ˈʌpər pɑːrt əv ðə ˈsɪlɪndər/ – верхня частина циліндра
- up stroke /ʌp stroʊk/ – верхній хід
- cylinder head /ˈsɪlɪndər hed/ – головка циліндра
- spray valve /spreɪ vælv/ – розпилювальний клапан
- starting air valve /ˈstɑːrtɪŋ eə(r) vælv/ – клапан пускового повітря
- cross scavenging /krɒs ˈskævɪndʒɪŋ/ – поперечна продувка
- loop scavenging (M. A. N.) /luːp ˈskævɪndʒɪŋ/ – петльова продувка (M. A. N.)
- uniflow scavenging (B. & W.) /ˈjuːnɪfləʊ ˈskævɪndʒɪŋ/ – однопоточна продувка (B. & W.)
- great advantage /greɪt ədˈvɑːntɪdʒ/ – велика перевага
- removal of combustion products /rɪˈmuːvəl əv kəmˈbʌstʃən ˈprɒdʌkts/ – видалення продуктів згоряння
- rotary motion /ˈroʊtəri ˈmoʊʃən/ – обертальний рух
- combustion gases /kəmˈbʌstʃən ˈgæsɪz/ – продукти згоряння
- mixture of air and oil /ˈmɪkstʃər əv eə(r) ənd ɔɪl/ – суміш повітря та масла.

SPEAKING PRACTICE

7. Compare the types of scavenging, taking into account indicators such as:

- *direction of air flow;*
- *efficiency;*
- *typical marine applications*

Use useful phrases like:

- *The main difference between…*
- *This type is more efficient because…*
- *In large marine engines…*

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. What is scavenging in a diesel engine?

A. The process of fuel injection
B. The process of cooling the cylinder
C. The process of replacing exhaust gases with fresh air
D. The process of compressing air

2. How many main scavenging methods are used in marine diesel engines?

A. Two
B. Three
C. Four
D. Five

3. Which of the following is NOT a scavenging method mentioned in the text?

A. Uniflow scavenging
B. Cross scavenging
C. Loop scavenging
D. Reverse scavenging

4. In uniflow scavenging, where does the exhaust gas leave the cylinder?

A. Through exhaust ports in the liner
B. Through scavenging ports
C. Through a centrally mounted exhaust valve
D. Through the piston crown

5. Where does scavenge air enter the cylinder in uniflow scavenging?

A. Through the cylinder head
B. Through exhaust valves
C. Through scavenge ports in the lower part of the liner
D. Through the fuel valve

6. What is the main advantage of uniflow scavenging?

A. Low manufacturing cost
B. Simple liner design
C. Maximum scavenging efficiency
D. No exhaust valves required

7. What stroke-to-bore ratio is typical for modern uniflow engines?

A. 1.5–1.8
B. 2.0–2.2
C. 2.4–2.9
D. 3.5–4.0

8. Which of the following is a disadvantage of uniflow scavenging?

A. Poor scavenging efficiency
B. Increased lube oil consumption
C. Requirement for exhaust valves
D. Complicated liner design

9. In cross scavenging, where are the exhaust ports located?
A. On the same side as scavenge ports
B. In the cylinder head
C. Diametrically opposite the scavenge ports
D. At the bottom of the cylinder

10. What is the typical stroke-to-bore ratio for cross scavenging?
A. 1.75
B. 2.0–2.2
C. 2.4–2.9
D. 3.5–4.0

11. Where are exhaust ports placed in loop scavenging?
A. Below scavenge ports on opposite sides
B. Above scavenge ports on the same side
C. In the cylinder head
D. Around the piston crown

12. What is the stroke-to-bore ratio for loop scavenging?
A. 1.75
B. 2.0–2.2
C. 2.4–2.9
D. 3.5–4.0

13. What is an advantage of cross and loop scavenging systems?
A. Higher scavenging efficiency
B. Lower thermal stresses
C. No exhaust valve is required
D. Reduced liner wear

14. Which disadvantage is typical for cross/loop scavenging?
A. High scavenging efficiency
B. No mixing of air and exhaust gases
C. Increased cylinder lubricating oil consumption
D. Simple liner construction

15. Why is scavenging efficiency lower in cross/loop scavenging?
A. Low air pressure
B. Greater mixing of air and exhaust gases
C. Absence of fuel valves
D. Short piston stroke

16. How is scavenging efficiency defined?
A. Ratio of exhaust gas pressure to air pressure
B. Ratio of fuel mass to air mass
C. Ratio of air mass at beginning to that at end of compression
D. Ratio of piston speed to crankshaft speed

17. Why are exhaust ports placed higher than scavenging ports?
A. To increase fuel efficiency
B. To allow exhaust gases to leave first
C. To cool the piston crown
D. To reduce liner wear

18. Why is uniflow scavenging considered superior to other systems?
A. It has lower manufacturing cost
B. It requires no surplus air
C. It ensures better removal of combustion residues
D. It eliminates the need for lubrication.

SECTION 3. FUEL SEPARATOR ON BOARD A VESSEL INFORMATION FOCUS

1. Read the text carefully and translate it:

Modern marine internal combustion engines typically use heavy fuel with high viscosity and low quality. It contains mechanical impurities and water. To ensure trouble-free and efficient operation of internal combustion engines, thorough cleaning of fuel and lubricating oil is necessary. Cleaning is performed by marine fuel separators from various manufacturers. The variety of fuel separator designs and their constant improvement require ship specialists to have good knowledge and qualified technical maintenance skills.

The situation is complicated by the fact that maintenance has to be carried out by a reduced engine room crew. To reduce the amount of manual work, manufacturers have developed automated separation systems that operate on a pre-set program without the intervention of technical personnel.

However, this, in turn, has required an increase in the level of knowledge, the ability to configure the effective operation of modern separation systems and, of course, to quickly assess the causes and nature of possible failures and malfunctions of their components.

Ship diesel engines running on heavy fuel oil (fuel oil) are the most common type of engine used in the world fleet.

During storage on board, fuel becomes contaminated with water and mechanical impurities (particles of sand, dust, and iron scale), which impairs its performance.

The use of fuel with a high content of mechanical impurities leads to contamination of the nozzles, excessive wear of the fuel pump plunger pairs, and wear of the cylinder-piston group.

For trouble-free and efficient operation of marine diesel engines when using heavy fuel grades (fuel oil with a viscosity of up to 700 cSt), special attention must be paid to its purification.

Three methods of heavy fuel purification are used on ships:

The first method involves settling in a settling tank for 20–22 hours. During this time, heavy particles and water settle at the bottom of the settling tank and are then removed through a drain valve.

The second method (the most effective) is to separate the fuel using a centrifugal separator, where foreign particles and water are separated from the fuel and removed due to the difference in density of the components contained in the fuel, using centrifugal forces.

The third method is filtration. The separated fuel from the supply tank is passed through a fuel filter under pressure (0.4–0.6 MPa) by a fuel transfer pump and then fed to the diesel fuel pumps.

COMPREHENSION

2. Answer the questions using information from the text:

1. What needs to be done to ensure trouble-free and efficient operation of internal combustion engines?
2. How is fuel cleaned on a ship?
3. What have fuel separator manufacturers done to reduce manual labor?
4. What contaminates fuel during storage on board?
5. What does the use of fuel with a high content of mechanical impurities lead to?

6. What methods of heavy fuel purification are used on ships?

7. Which method of heavy fuel purification is considered the most effective?

8. How does the third method of heavy fuel purification differ from the second?

3. Fig. 1 shows a diagram of a drum clarifier. Your task is to: a) sign the names of the components of the drum clarifier, indicated by numbers, using the words and phrases given below, b) explain the principle of operation of the drum clarifier:

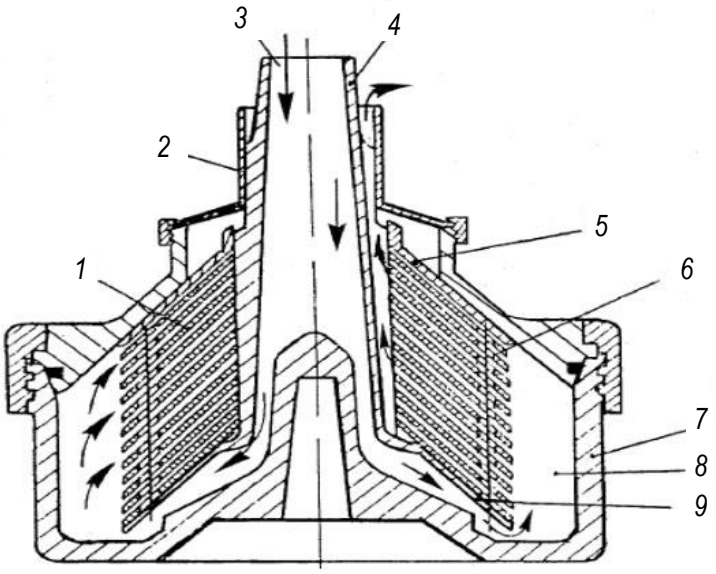

Fig. 1 Diagram of the drum clarifier

GRAMMAR FOCUS

Gerund is an impersonal form of a verb with the ending -ing, which combines the properties of a noun and a verb. The gerund does not express number, person, or manner, and is not used with articles.

Gerund forms

Form	***Active voice***	***Passive voice***
Indefinite	doing	being done
Perfect	having done	having been done

1. When is the gerund used?

The gerund is used in the following cases:

a) After certain verbs:

The gerund is used after verbs such as *enjoy, finish, avoid, mind, suggest, keep,* and *practice*.

- *The engineer avoids operating the fuel separator without proper warming-up.*
- *The crew finishes cleaning the fuel separator before starting the main engine.*

b) After prepositions:

The gerund is used after prepositions such as *of, in, about, for, without, after, before,* and *by*.

- *The separator is started after checking the oil temperature.*
- *The engineer is responsible for maintaining the fuel separator.*
- *Fuel purification is carried out by separating water and solid particles.*

c) As the subject of a sentence:

The gerund can function as the subject of a sentence.

- *Operating the fuel separator correctly is essential for safe engine performance.*
- *Regular cleaning of the separator improves fuel quality.*

d) After fixed expressions:

The gerund is used after fixed expressions such as *look forward to, can't help, it's no use, feel like,* and *be worth*.

- *It is worth monitoring the separator during operation.*
- *There is no use starting the fuel separator without heating the fuel.*

2. The difference between the gerund and the infinitive:

(in the context of fuel separator operation)

Some verbs change their meaning depending on whether they are followed by a gerund or an infinitive.

Stop + gerund

***Meaning*:** to cease an activity completely.

- *The engineer stopped operating the fuel separator due to abnormal vibration.*

(The operation was completely discontinued.)

Stop + infinitive

***Meaning*:** to stop in order to do something else.

- *The engineer stopped to inspect the fuel separator.*

(He stopped another activity in order to perform an inspection.)

4. Find the gerund in the sentences and explain what role it plays.

1. Removing these unwanted substances contributes to the longevity and reliable operation of equipment, reducing maintenance costs and downtime.
2. Marine separators play a crucial role in maintaining the operational efficiency and environmental compliance of a marine vessel.
3. Understanding their different functions and applications is necessary for choosing the right one for your ship.

4. This equipment ensures that discharged water and fuel meet established quality standards, minimizing the impact on marine ecosystems and preserving water quality.

5. Replacing separator spare parts

6. Their role is to keep the bilge water clean, preventing oil contamination

7. Fuel separators are used in the marine sector to guarantee the distribution of clean fossil fuel to engines, improving performance, reducing fuel consumption, and extending the lifespan of vital parts.

8. They are essential for preventing pollution, managing waste, and guaranteeing adherence to environmental regulations.

5. Insert the missing phrases that are needed for a complete context. Choose the clues below

condensation
vents
the bottom of the filter
sounding pipes
a transfer pump
accumulated water and sediments
all openings have been closed
a holding tank or bowl
cracked heating coils
by the heat
a purifier
not properly sealed
a paper element

1) How does a marine fuel separator work?

A marine fuel water separator separates your fuel from water. The way it works is pretty straightforward. The top of

the filtration system consists of …… and the bottom of the filter is …… . Water is heavier in comparison to fuel, so water sinks to …… until it's emptied.

Although it is based on a very simple principle no marine engine will function properly without it. The strength of the fuel water separator lies in its simplicity.

2) How does water get into fuel? Can this be prevented?

There are multiple ways of water getting into your fuel. The most obvious way is when pipes are …… and water can get in. This one is fairly easy to prevent, you have to make sure that …… . Another example is when …… builds up in the fuel tank. The condensation is caused, for example, …… in the engine room. This is a lot harder to prevent, so it is wise to check your fuel water separators from time to time.

3) How do service tanks work?

The service tanks in the fuel oil supply system are filled using …… . It is important to note that the service tanks should never be topped up from …… unless there are no other options available. The tanks are equipped with …… to allow air to displace fuel during normal fuel movements. Vent cocks are also present to drain any ……, as mentioned previously. Heavy fuels are more prone to water contamination, but it can also be caused by factors such as …… (if steam is used over thermal oil) or …… (if located on deck).

6. Work on your vocabulary:

- heavy fuel /ˈhevi ˈfjuːəl/ – важке паливо
- viscosity /vɪˈskɒsɪti/ – в'язкість
- mechanical impurities /mɪˈkænɪkəl ɪmˈpjʊərɪtiz/ – механічні домішки
- lubricating oil /ˈluːbrɪkeɪtɪŋ ɔɪl/ – мастило
- fuel separator /ˈfjuːəl ˈsepəreɪtə/ – паливний сепаратор

- automated separation systems /ˈɔːtəmeɪtɪd ˌsepəˈreɪʃən ˈsɪstəmz/ – автоматизовані системи сепарації
- iron scale /ˈaɪən skeɪl/ – залізні відкладення
- the fuel pump plunger /ðə ˈfjuːəl pʌmp ˈplʌndʒə/ – плунжер паливного насоса
- the cylinder–piston group /ðə ˈsɪlɪndə ˈpɪstən gruːp/ – циліндро-поршнева група
- settling tank /ˈsetlɪŋ tæŋk/ – відстійник
- a drain valve /ə dreɪn vælv/ – зливний клапан
- centrifugal separator /ˌsentrɪˈfjuːgəl ˈsepəreɪtə/ – відцентровий сепаратор
- filtration /fɪlˈtreɪʃən/ – фільтрація
- the supply tank /ðə səˈplaɪ tæŋk/ – запасний бак
- a fuel transfer pump /ə ˈfjuːəl ˈtrænsfɜː pʌmp/ – паливний насос

SPEAKING PRACTICE

7. Work in pairs. The following situational role-play is proposed:

Situation 1: Abnormal Operation

Student A – Duty Engineer

Student B – Chief Engineer

Discuss the situation using gerunds and infinitives:

– abnormal vibration
– stopping the separator
– checking the bowl
– cleaning the discs
– restarting the separator

Example prompts:

– I suggest stopping the separator and checking the bowl.
– It’s no use continuing the operation without cleaning the discs.

Situation 2: Pre-start Procedures

Explain to a junior engineer how to prepare the fuel separator before starting it.

Use:

– avoid + gerund
– stop to + infinitive
– be worth + gerund

Example prompts:

– Avoid starting the separator without heating the fuel.
– Stop to check the oil temperature before operation.

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. What type of fuel is typically used in modern marine internal combustion engines?

A. Light diesel fuel
B. Gas fuel
C. Heavy fuel with high viscosity
D. Biofuel

2. Why does heavy fuel require thorough cleaning before use?

A. It evaporates easily
B. It contains water and mechanical impurities
C. It has low energy content
D. It is difficult to pump

3. What equipment is mainly used for cleaning marine fuel and lubricating oil?

A. Filters only
B. Pumps
C. Marine fuel separators
D. Heat exchangers

4. Why must ship specialists have high technical knowledge of fuel separators?

A. Because separators are very cheap
B. Because their designs are simple
C. Because separator designs are diverse and constantly improving
D. Because separators work manually

5. What factor complicates the maintenance of fuel separation systems on board?

A. High fuel prices
B. Large engine rooms
C. Reduced engine room crew
D. Lack of fuel

6. What is the main purpose of automated separation systems?

A. To increase fuel viscosity
B. To eliminate separators
C. To reduce manual work
D. To increase crew size

7. What additional requirement comes with automation of separation systems?

A. Less training for engineers
B. Higher fuel consumption
C. Higher level of technical knowledge
D. Manual adjustment during operation

8. What type of engine is most common in the world fleet?

A. Gas turbine engines
B. Steam turbine engines

C. Diesel engines running on heavy fuel oil
D. Electric propulsion engines

9. How does fuel become contaminated during storage on board?
A. Through chemical reactions
B. By overheating
C. By water and mechanical impurities
D. By improper combustion

10. What can excessive mechanical impurities in fuel cause?
A. Improved lubrication
B. Reduced engine power
C. Contamination of nozzles and wear of engine components
D. Lower fuel temperature

11. What engine parts are especially affected by dirty fuel?
A. Crankshaft only
B. Fuel pump plunger pairs and cylinder-piston group
C. Bearings only
D. Turbocharger blades

12. What viscosity of fuel requires special attention to purification?
A. Up to 50 cSt
B. Up to 180 cSt
C. Up to 380 cSt
D. Up to 700 cSt

13. How many main methods of heavy fuel purification are used on ships?

A. Two
B. Three
C. Four
D. Five

14. What happens during the settling process in a settling tank?

A. Fuel is heated rapidly
B. Heavy particles and water settle at the bottom
C. Fuel is mixed with air
D. Fuel viscosity increases

15. Which fuel purification method is considered the most effective?

A. Filtration
B. Settling
C. Centrifugal separation
D. Heating

16. What physical principle is used in a centrifugal fuel separator?

A. Thermal expansion
B. Magnetic attraction
C. Difference in density and centrifugal force
D. Chemical reaction

17. At what pressure is fuel passed through filters in the filtration method?

A. 0.1–0.2 MPa
B. 0.2–0.3 MPa
C. 0.4–0.6 MPa
D. 0.8–1.0 MPa

18. Why should service tanks normally be filled using a purifier?

A. To reduce fuel temperature
B. To avoid water and sediment contamination
C. To increase fuel pressure
D. To simplify tank design.

SECTION 4. SUPERCHARGING IN MARINE DIESEL ENGINE INFORMATION FOCUS

1. Read the information below and use it to complete the next tasks:

Supercharging is used in internal combustion engines, including those used in marine applications, to improve their performance.

Supercharging (or pressure charging) is a process in which a greater mass of air is admitted into the cylinder for combustion and, consequently, a greater amount of fuel is burned efficiently.

The core function of a marine diesel engine supercharger is to improve fuel combustion efficiency by increasing the intake air density and the oxygen content in the cylinder, ultimately achieving increased power output, reduced fuel consumption, and optimized emissions.

The fundamental idea behind supercharging is to increase the amount of air entering the engine's cylinders.

An engine produces power by burning fuel. The amount of fuel that can be effectively burned is limited by the amount of oxygen available, which comes from the intake air. Naturally aspirated engines rely on atmospheric pressure to force air into the cylinders during the intake stroke. Supercharging involves using a compressor (the supercharger), driven by the engine's crankshaft (or sometimes electrically), to force more air into the cylinders than would naturally enter. By forcing more air into the cylinders, more oxygen becomes available for combustion. With more oxygen available, the engine can burn more fuel efficiently during each combustion cycle. Burning more fuel per cycle directly leads to an increase in the engine's power output.

Therefore, the main reason for implementing supercharging in marine engines, or any internal combustion engine, is to achieve greater power output from a given engine size or displacement.

There are two types of supercharging methods: pulse-type and constant-pressure type.

In the pulse-pressure system, the energy of the exhaust gases from the cylinder is transferred to the turbocharger by pressure pulses. These pressure waves travel through the exhaust manifold to the turbine nozzles, where they are converted into kinetic energy at high velocity, causing the turbine blades to rotate. This results in a rapid buildup of turbine speed when the engine is started or during manoeuvring.

To maintain strong pressure pulses, rapid opening of the exhaust valves is required, exhaust connections must be of limited diameter, sharp bends must be avoided, and the turbocharger must be installed close to the engine. To prevent backflow, the exhaust system is subdivided into several manifolds, each connected to a separate nozzle box at the turbine. Up to three cylinders may be connected to each manifold, depending on the firing order, without mutual interference.

Due to the small volume of exhaust ducting and the direct routing of exhaust gases to the turbine inlet, this system does not require any form of scavenging assistance at low speeds or during engine starting.

In the constant-pressure type of turbocharging, exhaust gases from each cylinder are led into a common exhaust manifold. From this manifold, the gases flow to the turbine at nearly constant pressure. When the exhaust gases expand through the turbine nozzles and blades, work is produced by utilizing the thermal energy of the exhaust gases. The exhaust manifold must be large enough to accommodate exhaust gases from all cylinders without a significant rise in pressure.

Normally, the constant-pressure type is used in two-stroke marine diesel engines.

To summarize, supercharging is a method of increasing the performance of marine engines by increasing the density of the intake air, which allows more fuel to be burned and, therefore, increases the engine's power output.

COMPREHENSION

2. Define whether the statements are *true* or *false* according to the text.

1. Supercharging in marine engines is used to reduce engine output.
2. The basic idea behind supercharging is to increase the amount of air entering the engine cylinders.
3. Supercharging is specifically designed to reduce engine output.
4. Supercharging is primarily associated with a reduction in fuel pressure.
5. Supercharging directly affects the increase in fuel pressure.
6. By forcing more air into the cylinders, supercharging provides more efficient fuel combustion, resulting in a significant increase in output power.
7. Non-supercharged engines use atmospheric pressure to force air into the cylinders during the intake stroke.

3. Read the text, find and underline the sentences in the *passive voice*, and if possible, rephrase them into the *active voice*.

Marine turbochargers boost the performance of marine diesel engines and generate electricity for consumption on board the ship. They work by using exhaust gases to power a generator,

which is installed on the rotor shaft of the turbocharger. This generator acts as an exhaust heat recovery device, resulting in energy savings. A highly efficient, small, and powerful generator is required to make this process effective.

Marine turbochargers operate on the principle of using exhaust gases from the engine to drive a turbine, which is connected by a shaft to a compressor. The compressor then supplies compressed air to the engine's combustion chamber to increase its power output.

The process works as follows: the exhaust gases leave the engine and are directed into the turbine, causing it to rotate. This rotation is transferred through the shaft to the compressor, which increases the pressure of the intake air. The compressed air is then fed back into the engine, where it combines with fuel to create a more powerful combustion process, resulting in increased engine output.

This mechanism is used as a waste heat recovery system that supplies about 10 % of exhaust gases to power the turbine that drives a generator. Hybrid marine turbochargers have a generator inside their housing and require similar space as traditional turbochargers, with only minor adjustments needed for conventional diesel engines.

By virtue of bidirectional frequency converters, a turbocharger can function both as an engine and a generator. To implement this, the generator needs to be small enough to fit inside the turbocharger. Before installing it on a ship, the compressor needs thorough testing to ensure it complies with the engine and vessel requirements.

A hybrid turbocharger with a generator uses exhaust gas energy to create electricity, similar to a standard gas power turbine. However, a hybrid turbocharger has several advantages over a conventional power turbine, such as:

Installing the turbocharger requires minimal engine modifications, and the upgrade is relatively simple. There's hardly any increase in external dimensions, given that exhaust gas piping and valve regulators are not required.

A hybrid turbocharger delivers higher efficiency due to the absence of heat and pipeline losses.

The turbocharger can be accelerated by using the generator as an engine.

4. Complete the table № 1 by matching the statements with the appropriate supercharging method:

- steady pressure before turbine, efficient operation
- this system is slower in its buildup of pressure when starting and insufficient air is available for engines during manoeuvring of operating at low speed
- better and more rational utilization of exhaust heat
- to overcome this difficulty engines have electric driven auxillary blower
- compressor capacity can be increased as more energy is available
- exhaust piping is simpler
- utilizes high kinetic energy of exhaust gases
- complicated exhaust piping
- expantion in cylinder can be carried out longer as no pressure pulse is required
- does not require aux blowers at low speeds or during starting of the engine
- due to effective scavenging SFS can be reduced
- exhaust grouping required
- chance of blow back and there by chance of low efficiency.

Table № 1. **Advantages and disadvantages 2 Types of supercharging methods**

Advantages pulse type	Disadvantages pulse type	Advantages constant pressure type	Disadvantages constant pressure type

GRAMMAR FOCUS

An adjective is an independent part of speech that expresses a characteristic of a person, living being, object, concept, phenomenon and answers the question "which?". Adjectives in English do not have gender and number categories, therefore they never change their form. Adjectives are most often used with nouns and in sentences act as a definition or the nominal part of a complex predicate.

In English, adjectives are classified by formation (simple, derived, compound) and by meaning (qualitative, quantitative, possessive, demonstrative, etc.). They are also classified by degrees of comparison (ordinary, superior, highest), such as big, bigger, biggest.

In some situations, a noun can act as an adjective, performing its functions. That is, a noun characterizes another noun. In such cases, these nouns are translated into Ukrainian as a noun with an adjective. A noun that acts as an adjective does not change in form. Let's consider in which cases nouns can perform the function of an adjective:

When the first noun denotes time: a summer day – summer day, day dream – day dream.

When the first noun denotes a place: London streets – London streets (or London streets, anyway "London" characterizes "streets"), street art – street art.

When the first noun denotes some material from which the second noun is made:

a silk dress – silk dress, glass lamp – glass lamp.

So, we see that both words are nouns, but the first noun characterizes the second, that is, it performs the functions of an adjective, while still remaining a noun, without changing its form.

5. Complete the sentences with appropriate words from below. Find among them nouns that act as adjectives:

compressor variable integral thermal waste specific mechanic
efficient centrifugal sucked inlet scavenge kinetic mnemonic
nozzle essential ball and roller exhaust shell-and-tube further heat-resistant
monochrome additional air high-velocity

A turbocharger of a marine diesel engine is an _____ part of the ship's engine. It is a form of _____ energy recovery system which uses the engine exhaust to rotate the turbine and provide fresh air to the combustion chamber through compressor fitted in the same shaft. With the use of a turbocharger the engine power can be increased without increasing the size of the engine and at the same time reducing the _____ fuel oil consumption. The marine engines _____ thermal and scavenge efficiencies are improved due to better air supply and use of exhaust gases. The _____ loading is reduced due to shorter more _____ burning period of the few the marine engine turbocharger.

Components consist of mainly two parts the blower side and the turbine side. The turbocharger consists of a single stage impulse turbine connected to a _____ impeller on the other side through a shaft. Both the sides are provided with the casing which carries turbine and blower. The blower side casing consists of filter to sub clean air without dust or particles which

may damage the _____ blower blades. A diffuser is provided in the blower side for increasing the pressure of the _____ air in the turbine side. An _____ casing is provided which directs the exhaust to the turbine blades. It also has a nozzle drink to convert the pressure into _____ energy before hitting the turbine blade. The shaft is carried on bearings which helps the turbocharger to rotate at extremely high speed of about 5,000 to 10,000 rpm depending on the size of the turbocharger. The bearings are usually _____ type.

When engine is started it compresses and burns the fuel. Some of the energy gets basted and produces _____ gases which needs to be drawn out of the cylinder using an exhaust wall. These exhaust gases from each cylinder go to an exhaust trunk. The turbine is driven by the engine exhaust gas. The exhaust gas from the trunk enters via the gas inlet casing of the turbocharger. The gas expands through a _____ ring where the pressure energy of the gas is converted to kinetic energy. This _____ gas is directed onto the turbine blades where it drives the turbine wheel as the compressor is connected to the same shaft. It also rotates the blower at high speeds. The nozzle drink converts the exhaust gas into kinetic energy. It is fabricated from a _____ nickel steel or a _____ alloy which can withstand the high temperatures and be resistant to corrosion. The turbine side outlet is connected to the exhaust optic pipes which leads the exhaust gasses to the ship's funnel on the air side. The air is drawn in through the filters. A felt cloth can additionally be put on top of the filter for _____ filtration. The air enters the compressor we actually where it achieves high velocity by exiting the impeller. The air goes out radially and passes through a diffuser where some of the kinetic energy is converted to pressure energy. In the end the air is then passed into the volume casing where _____ energy conversion takes place. The outlet from

the blower side is supplied to the _____ cooler arrangement on the ship's engine. The arrangement is a _____ type air cooler where sea water or fresh water is passed inside the tubes as a cooling agent to reduce air temperature. This cool air is then supplied as fresh air inside the _____ trunk of the engine from where it takes the supply of combustion air through scavenge ports of the liner. During the start of the engine the turbocharger is also standstill. Hence no fresh air is supplied to the scavenge force which is _____ to start the combustion. Therefore, additional blowers are installed which are switched on during the start of the engine. When the turbocharger of the engine reaches arranged where turbocharger supplies fresh air the blower is cut off (_____ geometry).

6. Learn or repeat the following words and phrases:

- supercharging /ˈsuːpətʃɑːdʒɪŋ/ – наддув
- pressure charging /ˈpreʃə ˈtʃɑːdʒɪŋ/ – наддув під тиском
- internal combustion engine /ɪnˈtɜːnəl kəmˈbʌstʃən ˈendʒɪn/ – двигун внутрішнього згоряння
- marine applications /məˈriːn ˌæplɪˈkeɪʃənz/ – суднове застосування
- air intake /eə ˈɪnteɪk/ – впуск повітря
- cylinder /ˈsɪlɪndə/ – циліндр
- combustion /kəmˈbʌstʃən/ – згоряння
- fuel combustion efficiency /ˈfjuːəl kəmˈbʌstʃən ɪˈfɪʃənsi/ – ефективність згоряння палива
- intake air density /ˈɪnteɪk eə ˈdensɪti/ – щільність впускного повітря
- oxygen content /ˈɒksɪdʒən ˈkɒntent/ – вміст кисню
- power output /ˈpaʊə ˈaʊtpʊt/ – вихідна потужність
- fuel consumption reduction /ˈfjuːəl kənˈsʌmpʃən rɪˈdʌkʃən/ – зменшення витрати палива

• emission optimization /ɪˈmɪʃən ˌɒptɪmaɪˈzeɪʃən/ – оптимізація викидів

• naturally aspirated engine /ˈnætʃrəli ˈæspɪreɪtɪd ˈendʒɪn/ – атмосферний двигун

• atmospheric pressure /ˌætməsˈferɪk ˈpreʃə/ – атмосферний тиск

• compressor /kəmˈpresə/ – компресор

• supercharger /ˈsuːpətʃɑːdʒə/ – нагнітач (компресор наддуву)

• crankshaft /ˈkræŋkʃɑːft/ – колінчастий вал

• combustion cycle /kəmˈbʌstʃən ˈsaɪkəl/ – цикл згоряння

• engine displacement /ˈendʒɪn dɪsˈpleɪsmənt/ – робочий об’єм двигуна

• pulse type supercharging /pʌls taɪp ˈsuːpətʃɑːdʒɪŋ/ – імпульсний наддув

• constant pressure supercharging /ˈkɒnstənt ˈpreʃə ˈsuːpətʃɑːdʒɪŋ/ – наддув постійного тиску

• exhaust gas /ɪgˈzɔːst gæs/ – вихлопні гази

• pressure waves /ˈpreʃə weɪvz/ – хвилі тиску

• manifold /ˈmænɪfəʊld/ – колектор

• turbine nozzles /ˈtɜːbaɪn ˈnɒzəlz/ – сопла турбіни

• kinetic energy /kɪˈnetɪk ˈenədʒi/ – кінетична енергія

• turbine blades /ˈtɜːbaɪn bleɪdz/ – лопатки турбіни

• manoeuvring /məˈnuːvərɪŋ/ – маневрування

• exhaust valve /ɪgˈzɔːst vælv/ – випускний клапан

• back flow /bæk fləʊ/ – зворотний потік

• scavenge assistance /ˈskævɪndʒ əˈsɪstəns/ – допомога продування

• two-stroke marine diesel engine /ˈtuː strəʊk məˈriːn ˈdiːzəl ˈendʒɪn/ – двотактний судновий дизельний двигун.

SPEAKING PRACTICE

7. a) Explain the following key processes in your own words:

1. Clarify how a supercharger increases engine performance.
2. Describe the role of oxygen in fuel combustion.
3. Explain why forcing more air into the cylinders increases power output.
4. What is the main advantage of supercharging for marine engines?

b) Orally compose a sentence or short story using these terms:

– supercharging /ˈsuːpətʃɑːdʒɪŋ/
– intake air density /ˈɪnteɪk eə ˈdensɪti/
– pulse type /pʌls taɪp/
– constant pressure /ˈkɒnstənt ˈpreʃə/
– turbine blades /ˈtɜːbaɪn bleɪdz/
– exhaust gas /ɪgˈzɔːst gæs/
– manifold /ˈmænɪfəʊld/

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. What is the main purpose of supercharging in marine engines?

A. To reduce engine weight
B. To increase intake air density and improve combustion
C. To cool the exhaust gases
D. To lubricate engine parts

2. Supercharging allows a greater amount of fuel to be burned because:

A. Fuel pressure is increased
B. More oxygen is available in the cylinder

C. Combustion temperature is reduced
D. Exhaust gases are recycled

3. Naturally aspirated engines rely on:
A. A compressor driven by exhaust gases
B. An electric blower
C. Atmospheric pressure for air intake
D. Pressurized air tanks

4. How does supercharging increase engine power?
A. By increasing engine speed
B. By reducing friction losses
C. By allowing more fuel to burn per cycle
D. By cooling the cylinder walls

5. What drives a supercharger in most marine engines?
A. Electric motor only
B. The crankshaft
C. Hydraulic pressure
D. Cooling water

6. How many types of supercharging methods are described in the text?
A. One
B. Two
C. Three
D. Four

7. In the pulse pressure system, turbine speed builds up rapidly because:
A. Exhaust gas temperature is constant
B. Exhaust pressure waves act directly on the turbine

C. The exhaust manifold volume is large
D. External blowers assist scavenging

8. Why must exhaust pipes in a pulse system have limited diameter and no sharp bends?
A. To reduce corrosion
B. To increase exhaust cooling
C. To maintain pressure pulses
D. To lower exhaust noise

9. What is a key advantage of the pulse pressure system at low speeds?
A. Lower fuel consumption
B. No need for scavenging assistance
C. Lower exhaust temperature
D. Reduced lubrication demand

10. In a constant pressure turbocharging system:
A. Each cylinder has its own manifold
B. Exhaust gas pressure fluctuates strongly
C. Exhaust gases flow into a common manifold
D. The turbine works only at low speed

11. Constant pressure turbocharging is normally used in:
A. Four-stroke auxiliary engines
B. Small gasoline engines
C. Two-stroke marine diesel engines
D. High-speed automotive engines

12. What is the function of a marine turbocharger compressor?
A. To cool exhaust gases
B. To supply compressed air to the engine

C. To reduce emissions directly
D. To generate electricity only

13. Which part of the turbocharger converts exhaust gas pressure into kinetic energy?
A. Diffuser
B. Compressor impeller
C. Nozzle ring
D. Air filter

14. What speed range do turbocharger shafts typically operate at?
A. 500–1,000 rpm
B. 1,000–3,000 rpm
C. 5,000–10,000 rpm
D. Over 20,000 rpm

15. What is one function of the air cooler in the turbocharging system?
A. To heat intake air
B. To remove moisture from fuel
C. To reduce the temperature of compressed air
D. To filter exhaust gases

16. Why are additional blowers used during engine start?
A. To increase fuel pressure
B. Because the turbocharger is not yet rotating
C. To cool the turbocharger bearings
D. To reduce exhaust back pressure

17. What is a major advantage of a hybrid marine turbocharger?

A. Larger external dimensions
B. High heat losses
C. Ability to generate electricity from exhaust energy
D. Increased engine size

18. Using a turbocharger allows the engine to:

A. Increase power without increasing engine size
B. Eliminate the need for cooling systems
C. Operate without lubrication
D. Run only at constant speed.

UNIT 2
MARINE DIESEL ENGINE SYSTEMS

SECTION 5. DIESEL ENGINE FUEL SYSTEM
INFORMATION FOCUS

1. Read the text and answer the questions that follow:

Fuel systems are used to receive, store, pump, clean, heat, and supply fuel for engines and boilers, as well as to transfer fuel to shore or other vessels.

A fuel system consists of a number of independent pipelines that perform specific functions. The configuration of each of them with mechanisms, devices, and pipelines depends on the type of power plant and the type of fuel used. The entire fuel preparation system can be divided into four sections: fuel reception on the ship; long-term fuel storage (reserve tanks and fuel transfer pumps); comprehensive fuel processing and daily storage in settling and consumption tanks; and fuel preparation before delivery to the diesel engine or boiler.

Modern low-speed and medium-speed engines run on heavy fuel. For operation during start-up and pre-shutdown periods, they are equipped with a light fuel system. Fuel is received in the corresponding light and heavy fuel reserve tanks from the deck through a pipeline via a filter; if they overflow, the fuel is transferred to an overflow tank via an overflow pipe. Fuel ballast or replaceable tanks can be used for fuel storage. The use of medium and high viscosity fuels requires the installation of general or local steam heating coils in the tanks or equipment for so-called jet heating in the tank; in the latter

case, steam coils are provided in the discharge pipe area for local fuel heating.

Settling tanks are provided in the system for preliminary cleaning of fuel from water and mechanical impurities. Some vessels do not have settling tanks; their functions are performed by separators. The separation system includes: the separators themselves and receiving filters; autonomous or separator-mounted pumps; fuel heaters; and delivery pumps that send the separated fuel to separate storage tanks for heavy fuel and diesel fuel. Before entering the separator, the fuel passes through a steam heater. Self-cleaning separators (at least two) operating in automatic mode are used to separate heavy fuel. Separators can be connected in parallel or in series. Diesel fuel is not heated before separation. Separation waste is sent to a tank, from where it is pumped through the deck to a waste oil, fuel, and sludge collector or to an incinerator. Instead of separators, special filters that separate mechanical impurities and water with the same efficiency may be used. Recently, it has been proposed to homogenize fuel before feeding it into filters. To do this, fuel from the settling tank is sent to a homogenizer, where asphalt-resin formations are broken down. Fuel homogenization is not yet widely used on domestic ships.

Fig. 2 shows a structural diagram of the fuel supply system to the main engine from the valve boxes 1 of the bunker tanks to the pipeline 15 to the high-pressure fuel pumps. The main engine fuel supply section includes: fuel transfer pump 2; heaters 3, 5; separator 4; supply tank 7; mixing column 8; coarse 6 and fine 12 filters; relief valves 10; fuel feed pumps 9. Fuel heating before delivery to the high-pressure fuel pump ensures the specified fuel viscosity using a device called a viscometer 13, which measures and regulates viscosity by changing the amount of steam supplied to the heater 11. When switching the main

engine from one type of fuel to another, tank 8 acts as a mixing tank, ensuring a smooth change in the viscosity of the fuel supplied to the main engine from the diesel fuel supply tank via pipeline 14.

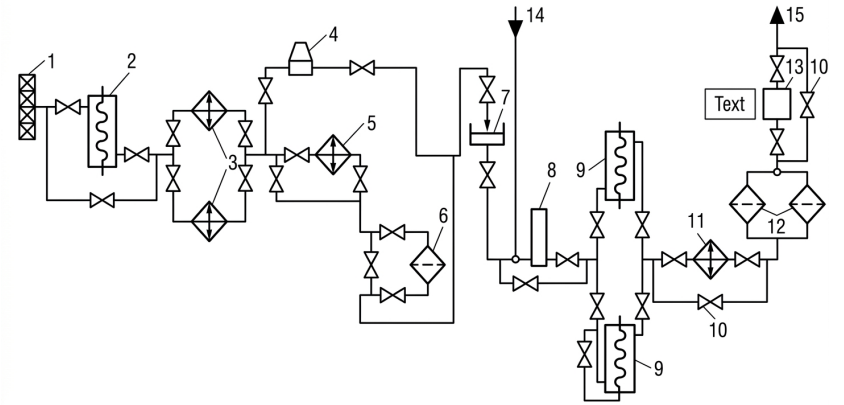

Fig. 2. Fuel preparation and delivery system to the main engine

COMPREHENSION

2. Answer the questions using the information from the text above:

1. What is the fuel system used for?
2. What does the fuel system consist of?
3. Into which sections can the entire fuel preparation system be divided?
4. How do modern low- and medium-speed engines work?
5. What can be used to store fuel?
6. Looking at Fig. 2, describe how the fuel preparation and delivery system to the main engine works.

GRAMMAR FOCUS

Active Voice in English is when the subject performs the action itself (e.g., The engine broke down), and ***Passive Voice*** is when the subject is acted upon by someone else (e.g., The engine was broken), where the emphasis is on the object of the action, and the doer may be optional or unknown, formed using to be + the third form of the verb (V3).

The difference between Active and Passive Voice in English is that in sentences with Active Voice it is clear who is the doer of the action. Passive Voice places the focus of attention on the object that is being influenced.

The sentence may or may not contain information about who exactly is performing the action. In order to indicate the agent who is exerting influence, the preposition ***by*** is used in the passive voice.

Tense Passive	*Voice Formula*
Present Simple	am/is/are + V3
Present Continuous	am/is/are + being + V3
Past Simple	was/were + V3
Past Continuous	was/were + being + V3
Present Perfect	have/has + been + V3
Past Perfect	had + been + V3
Future Simple	will + be + V3
Future Continuous	doesn't exist
Future Perfect	will + have + been + V3

3. Change the sentences below from active to passive. For example:

Active: Over the years, scientists have developed a number of different systems to implement and control the fuel injection process.

Passive: Over the years, a number of different systems have been developed by scientists to implement and control the fuel injection process.

1. Some engines also use electric transfer pumps.
2. Mechanical electronic unit injectors replace the injection pump.
3. Low pressure fuel deliver to each injector through a gallery in the cylinder head.
4. A dedicated fuel pump generates high fuel pressure.
5. The engine can start up and manoeuvre on diesel oil or even a blend of diesel and heavy fuel oil.
6. Engineers pump fuel from the service tank to the fuel injection system.
7. The fuel system filters impurities before fuel enters the engine.
8. The injectors spray fuel into the combustion chamber at the correct time.
9. The control system regulates fuel flow according to engine load.

4. Find the sentences in the *passive voice* in the text below. Explain whether they can be changed to the *active voice*.

The fuel piping system comprises the fuel supply lines, high-pressure fuel lines, and fuel heating pipes, if heavy fuel is used. Fuel supply lines include the supply lines from the fuel transfer pumps and preheating arrangements to the fuel filters and fuel pumps on the engine, also the fuel supply lines to the installation. High-pressure fuel lines connect the fuel pumps with the fuel valves and are under very high intermittent pressure. Defective high-pressure fuel lines must not be repaired by welding, because the welding beads which get inside the pipe may damage the fuel nozzle.

The preheating system employs steam up to 7 kg/sq. cm. g. and is led adjacently along all fuel pressure and supply lines, as well as filters. The drain lines for leakage fuel are also partially heated.

Fuel system fittings are: fuel transfer pump, fuel filter, fuel pressure-maintenance valve, fuel shut-off valve, fuel non-return valve.

The fuel transfer pump is driven separately by an electric motor, as a rule, and its capacity must be chosen so that it is always fully capable of discharging against the counter-pressure adjusted at the pressure-retaining valve.

The fuel filter contains several filter elements which can be switched over during operation and is designed for steam heating.

The fuel pressure-retaining valve is designed for adjustable back pressure. The pressure adjusted should be so high that there is no formation of vapour on the suction side of the fuel pumps.

The fuel shut-off valve opens during operation and is provided with a double cone seat to prevent leakage. It enables the main pipe to be isolated temporarily for dismantling the fuel pump or preheating.

The non-return valve is situated between the fuel pump and the overflow line with single-controlled fuel pumps. During operation, the surplus fuel delivered by the fuel transfer pump runs off into the overflow line. When dismantling a fuel pump, the latter is isolated from the overflow line by the non-return valve.

Each cylinder possesses its own fuel pump, which discharges a definite quantity of fuel through the discharge line to the fuel valve at the correct moment and under high pressure. The fuel is then sprayed into the combustion chamber in certain direction through a number of accurate nozzle orifices, and is finely atomized in the process.

WRITING PRACTICE

5. Translate the sentences from Ukrainian into English.

1. Система подачі палива забезпечує подачу палива, придатного для використання системою впорскування.
2. Низькооборотний двотактний дизельний двигун зазвичай призначений для безперервної роботи на важкому паливі.
3. Повільний двотактний дизельний двигун зазвичай влаштований таким чином, щоб безперервно працювати на важкому паливі і мати в наявності запас дизельного палива для маневрування.
4. Паливо зберігається в резервуарах з подвійним дном, звідки воно перекачується у відстійник і нагрівається.
5. Після проходження через центрифуги очищене, нагріте паливо перекачується в резервуар для щоденного обслуговування.
6. З резервуара для щоденного обслуговування масло проходить через триходовий клапан до змішувального резервуара.
7. У систему вбудований витратомір, який показує витрату палива.
8. Підсилювальні насоси використовуються для перекачування масла через нагрівачі та регулятор в'язкості до паливних насосів, що приводяться в дію двигуном.
9. Паливні насоси подають паливо під високим тиском до відповідних форсунок.
10. Регулятор в'язкості контролює температуру палива, щоб забезпечити правильну в'язкість для згоряння.
11. Клапан регулювання тиску забезпечує постійний тиск у насосах з двигуном.
12. Може бути встановлений резервуар для щоденного обслуговування дизельного палива, який підключається до системи за допомогою триходового клапана.

6. Work on your vocabulary:

- fuel system /ˈfjuːəl ˈsɪstəm/ – паливна система
- main engine /meɪn ˈendʒɪn/ – головний двигун
- low-speed engine /ˌloʊ spiːd ˈendʒɪn/ – малооборотний двигун
- medium-speed engine /ˌmiːdiəm spiːd ˈendʒɪn/ – середньооборотний двигун
- valve box /vælv bɒks/ – клапанна коробка
- fuel ballast tank /ˈfjuːəl ˈbæləst tæŋk/ – паливний баластний бак
- outlet pipe /ˈaʊtlet paɪp/ – випускна труба (випускний патрубок)
- steam coil /stiːm kɔɪl/ – парова котушка (паровий змійовик)
- bunker tank /ˈbʌŋkər tæŋk/ – бункерна цистерна
- high-pressure fuel pump /ˌhaɪ ˈpreʃər ˈfjuːəl pʌmp/ – паливний насос високого тиску
- incinerator /ɪnˈsɪnəreɪtər/ – інсинератор (спалювальна піч)
- fuel transfer pump /ˈfjuːəl ˈtrænsfɜːr pʌmp/ – паливний перекачувальний насос
- preheater /ˌpriːˈhiːtər/ – підігрівач
- separator /ˈsepəreɪtər/ – сепаратор
- outlet tank /ˈaʊtlet tæŋk/ – витратна цистерна
- mixing column /ˈmɪksɪŋ ˈkɒləm/ – змішувальна колонка
- coarse filter /kɔːrs ˈfɪltər/ – фільтр грубого очищення
- fine filter /faɪn ˈfɪltər/ – фільтр тонкого очищення
- relief valve /rɪˈliːf vælv/ – перепускний клапан
- fuel feed pump /ˈfjuːəl fiːd pʌmp/ – паливопідкачувальний насос
- fuel viscosity /ˈfjuːəl vɪˈskɒsɪti/ – в'язкість палива
- viscometer /vɪˈskɒmɪtər/ – віскозиметр

SPEAKING PRACTICE

7. a) Work in pairs. Ask each other as many questions as possible about the operation of the fuel system.

b) Look at the diagram of the fuel preparation and delivery system to the main engine (Fig. 2) and try to describe this process.

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. What is the main purpose of a fuel system on board a ship?

A. To generate electrical power
B. To cool engines and boilers
C. To receive, store, treat, and supply fuel
D. To lubricate moving parts

2. Which of the following functions is NOT performed by a fuel system?

A. Pumping fuel
B. Heating fuel
C. Cleaning fuel
D. Producing fuel

3. What does the configuration of a fuel system mainly depend on?

A. Ship speed
B. Crew size
C. Type of power plant and fuel
D. Weather conditions

4. Into how many main sections can the fuel preparation system be divided?

A. Two
B. Three
C. Four
D. Five

5. Which section includes reserve tanks and fuel transfer pumps?

A. Fuel reception on board
B. Long-term fuel storage
C. Fuel preparation before engine
D. Fuel consumption control

6. What type of fuel is normally used by modern low-speed and medium-speed engines?

A. Gas fuel
B. Diesel fuel only
C. Heavy fuel
D. Biofuel

7. Why is a light fuel system provided on ships?

A. For emergency operation only
B. For start-up and pre-shutdown operation
C. For fuel transfer to shore
D. For boiler operation

8. How is fuel received on board the ship?

A. Through the engine room
B. From the settling tank
C. From the deck through a pipeline via a filter
D. From the overflow tank

9. What happens if reserve fuel tanks overflow?
A. Fuel is discharged overboard
B. Fuel is burned in boilers
C. Fuel is transferred to an overflow tank
D. Fuel is sent to the separator

10. Why are steam heating coils installed in fuel tanks?
A. To cool the fuel
B. To reduce fuel consumption
C. To heat medium- and high-viscosity fuels
D. To clean fuel from impurities

11. What is the main purpose of settling tanks?
A. Fuel storage only
B. Fuel heating
C. Preliminary cleaning from water and impurities
D. Fuel viscosity control

12. What equipment can replace settling tanks on some vessels?
A. Pumps
B. Filters
C. Separators
D. Heaters

13. Which fuel must be heated before separation?
A. Diesel fuel
B. Light fuel
C. Heavy fuel
D. Gas fuel

14. How many separators are usually used for heavy fuel separation?

A. One
B. At least two
C. Three
D. One per engine

15. How can separators be connected in a fuel system?

A. Only in series
B. Only in parallel
C. In parallel or in series
D. Only individually

16. Where is separation waste sent?

A. To the settling tank
B. To the engine
C. To a waste oil or sludge collector or incinerator
D. To the mixing column

17. What is the purpose of a homogenizer in a fuel system?

A. To heat fuel
B. To pump fuel
C. To break down asphalt-resin formations
D. To separate water

18. What device regulates fuel viscosity before delivery to the high-pressure fuel pump?

A. Separator
B. Filter
C. Viscometer
D. Mixing column.

SECTION 6. DIESEL ENGINE COOLING SYSTEM INFORMATION FOCUS

1. Read the text carefully and translate it:

Engines are cooled by circulating coolant through internal channels within the engine. As a result, the coolant is heated and then cooled by a seawater circulation cooler. Without proper cooling, some engine parts exposed to very high temperatures as a result of fuel combustion may fail prematurely.

Cooling allows the engine metals to maintain their mechanical properties. Fresh water is the most commonly used coolant; salt water is not used directly as a coolant due to its corrosive effects. Since leaks into the crankcase will not cause problems, lubricating oil is sometimes used to cool the piston. However, due to its lower specific heat capacity, approximately twice as much oil as water is required.

Water circulating through pipes is used to cool the engines. The primary engine is cooled by two different but related systems: an open system that takes water from the sea and returns it to the sea, and a closed system in which fresh water circulates around the engine casing.

Fresh water is used directly to cool the equipment, while seawater is used to cool the fresh water after it has passed through the heat exchanger. A continuous flow of fluid is a distinctive feature of the engine cooling system. Abrasive corrosion and erosion are caused by the movement of the fluid. Seawater systems use large-diameter mild steel pipes, the ends of which extend into the sea through Kingston boxes with valves to reduce the impact of turbulent flows.

A standard marine diesel cooling system operates like this:

Seawater is drawn in through a through-hull fitting or the drive leg.

A raw water pump (impeller-driven) draws in seawater.

The seawater flows through various engine coolers–heat exchanger, aftercooler, oil cooler, and fuel cooler.

It then exits through the exhaust mixer, where it's expelled with the exhaust gases.

This continuous flow of raw water cools the engine indirectly, reducing corrosion and heat stress on the engine block.

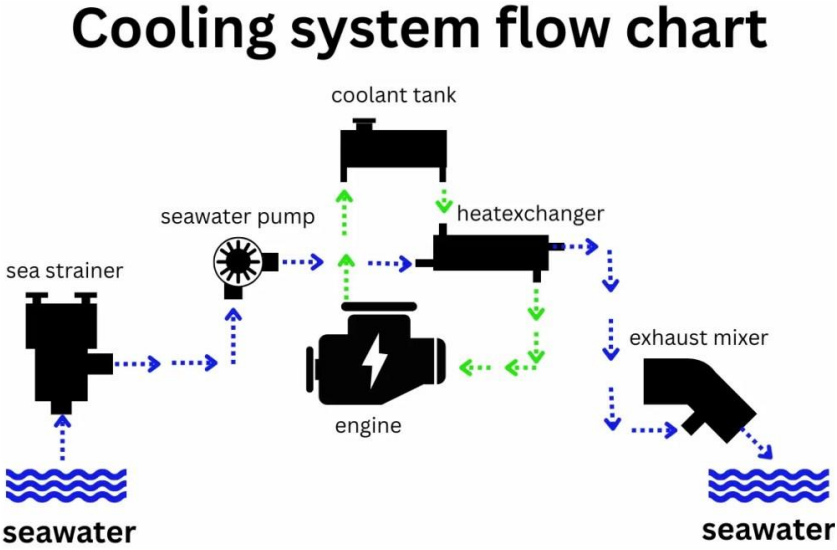

Fig. 3. Cooling system flow chart

COMPREHENSION

2. Answer the questions using information from the text:

1. How are engines cooled?
2. How does the marine diesel cooling system work?
3. How does coolant heat up and cool down?
4. What is the most common coolant?

5. What systems cool the main engine?
6. What are fresh water and seawater used for?
7. Why do you need a raw water pump?
8. Look at the cooling system flow chart (Fig. 3) and explain how this system works.

3. Fill in the blanks in the table № 2:

Table № 2. **Main components of the cooling system:**

Component	***Function***
1. Raw Water Pump	1. …
2. …	2. Filters debris (weeds, silt, etc.) from the incoming raw water before it reaches the pump or heat exchanger, preventing blockages and damage.
3. Heat Exchanger	3. …
4. …	4. An alternative to a heat exchanger in some closed-loop systems, where the engine coolant is pumped through pipes mounted on the outside of the hull to be cooled by the surrounding water.
5. Coolant Pump	5. …
6. …	6. A temperature-regulating valve that controls the flow of coolant to the heat exchanger or radiator, ensuring the engine reaches and maintains its optimal operating temperature.
7. Engine Block/ Water Jackets	7. …
8. …	8. Allows for the thermal expansion of the coolant and provides a location for topping up the system and venting air.
9. Hoses and Clamps	9. …
10. …	10. A mixture of fresh water and antifreeze/ corrosion inhibitors, used in the internal closed-loop system to absorb heat and protect internal components from corrosion and freezing
11. …	Often present in raw water systems (especially in salt water) to prevent galvanic corrosion of metal components like the heat exchanger.

GRAMMAR FOCUS

An article is a special particle and a functional part of speech that is used with nouns. It indicates their definiteness or indefiniteness and helps to distinguish nouns from verbs, adjectives, and other parts of speech.

Articles make it possible to show whether a noun is specific (the) or general (a/an/zero article), which is crucial for understanding context, since the Ukrainian language does not have articles.

In English, there are three main types of articles: the indefinite article (a/an), which is used for unspecified objects (any, one of); the definite article (the), which is used for specific or known objects; and the zero article, which refers to cases where no article is used at all and indicates generalization or abstraction. Articles are placed before nouns and serve to specify their meaning.

1. Indefinite Article – *a/an* is used with singular countable nouns when an object is mentioned for the first time or in a general sense ("some," "a certain"):

a is used before a consonant sound: a book, a car, a university (sound [j]).

an is used before a vowel sound: an apple, an hour (sound [aʊə]), an idea.

2. Definite Article – *the* is used with singular, plural, and uncountable nouns when the object is already known, specific, unique, or has been mentioned previously.

Examples: the book (previously mentioned), the sun, the teacher.

3. Zero Article – the absence of an article is used with uncountable nouns and plural nouns when referring to something abstract or in a general sense rather than a specific instance.

Examples: Water is important (water as a general concept), I like technology, They play football.

4. Insert *articles* (the, a, -) into the text where necessary:

Central cooling system

The seawater circuit in … central cooling system consists of high- and low-suction lines, usually located on both sides of … engine room, suction filters, and …multiple seawater pumps. Seawater is pumped through … central coolers before being discharged overboard.

The fresh water system has both … low-temperature and … high-temperature circuit. Fresh water in … high-temperature circuit circulates in … main engine and can be used as a heat transfer medium for … evaporator if necessary. The main engine air coolers, lubricating oil coolers, and all other heat exchangers circulate in … low-temperature circuit. A control valve regulates … mixing of water between the high-temperature and …low-temperature circuits. A temperature sensor sends a signal.

The advantages of … centralized cooling system include:

– less maintenance due to the clean purified water of … fresh water system;

– fewer salt water pumps with associated corrosion and hunting problems;

– simpler and easier cooler cleaning.

Higher water velocities are possible in … fresh water system, resulting in smaller pipe sizes and … lower installation costs.

The number of valves made of …expensive materials is significantly reduced, and cheaper materials can be used throughout the system to maintain … constant temperature regardless of … outside water temperature, as well as to eliminate cold starts, reducing cylinder liner wear, etc.

WRITING PRACTICE

5. Complete the sentence:

1. By routing seawater through coolers rather than the engine block itself, you avoid ….
2. Coolant removes heat from the hot engine block and seawater removes heat from ….
3. A closed cooling system circulates ….
4. Coolants provide corrosion resistance, ….
5. The raw water system draws seawater into the cooling circuit, where it: ….
6. A heat exchanger (radiator) transfers heat from ….
7. Seawater absorbs heat from high-pressure fuel, preventing ….
8. Aftercooler (Intercooler) cools turbocharged air using ….
9. Thermostats open and close at set temperatures to regulate coolant flow and ensure ….
10. Temperature sensors monitor coolant and exhaust temperatures, ….

6. Remember or repeat the following words or expressions:

- coolant /ˈkuːlənt/ – охолоджуюча рідина
- a seawater circulation cooler /ə ˈsiːˌwɔːtə ˌsɜːkjəˈleɪʃən ˈkuːlə/ – охолоджувач з циркуляцією морської води
- proper cooling /ˈprɒpə ˈkuːlɪŋ/ – належне охолодження
- seawater pump /ˈsiːˌwɔːtə pʌmp/ – насос морської води
- impeller-driven /ɪmˈpelə ˈdrɪvən/ – імпелерний привід
- exhaust mixer /ɪgˈzɔːst ˈmɪksə/ – вихлопний змішувач
- heat exchanger /ˈhiːt ɪksˌtʃeɪndʒə/ – теплообмінник
- a through-hull fitting /ə ˌθruːˈhʌl ˈfɪtɪŋ/ – прохідний фітинг
- aftercooler /ˈɑːftəˌkuːlə/ – післяохолоджувач

- abrasive corrosion /əˈbreɪsɪv kəˈrəʊʒən/ – абразивна корозія
- erosion /ɪˈrəʊʒən/ – ерозія
- crankcase /ˈkræŋkkeɪs/ – картер
- heat capacity /ˈhiːt kəˈpæsɪti/ – теплоємність
- engine casing /ˈendʒɪn ˈkeɪsɪŋ/ – корпус двигуна
- turbulent flow /ˈtɜːbjʊlənt fləʊ/ – турбулентний потік
- thermostat /ˈθɜːməstæt/ – термостат
- engine block /ˈendʒɪn blɒk/ – блок циліндрів
- suction filter /ˈsʌkʃən ˈfɪltə/ – фільтр всмоктування

7. Describe the operation of a standard marine diesel engine cooling system step by step, using the words *first, then, after that, finally*.

Reproduce orally:

- intake of seawater
- operation of the raw water pump
- flow through engine cooler
- exhaust mixer and discharge

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. How are engines cooled according to the text?

A. By air flowing around the engine
B. By circulating coolant through internal channels
C. By spraying seawater directly on engine parts
D. By lubricating oil only

2. What happens to the coolant after it circulates through the engine?

A. It evaporates
B. It is discharged overboard

C. It is heated and then cooled by a seawater circulation cooler

D. It is stored in tanks

3. Why is proper cooling essential for engine parts?

A. To reduce fuel consumption

B. To prevent noise

C. To avoid premature failure due to high temperatures

D. To increase exhaust pressure

4. What is the main purpose of engine cooling?

A. To increase engine speed

B. To maintain mechanical properties of engine metals

C. To clean the engine

D. To improve lubrication

5. Which coolant is most commonly used in marine engines?

A. Salt water

B. Lubricating oil

C. Fresh water

D. Fuel

6. Why is salt water not used directly as a coolant?

A. It has low heat capacity

B. It evaporates quickly

C. It causes corrosion

D. It is too expensive

7. Why is lubricating oil sometimes used to cool the piston?

A. It has higher heat capacity than water

B. Leaks into the crankcase do not cause problems

C. It is cheaper than water
D. It cools faster than fresh water

8. Compared to water, how much lubricating oil is needed to remove the same amount of heat?
A. The same amount
B. Half as much
C. Twice as much
D. Three times as much

9. How many cooling systems are used to cool the primary engine?
A. One
B. Two
C. Three
D. Four

10. What characterizes the open cooling system?
A. Fresh water circulates in a closed loop
B. Water is taken from the sea and returned to the sea
C. Oil is used as coolant
D. Water is stored in tanks

11. What is the function of the closed cooling system?
A. To circulate seawater around the engine casing
B. To cool exhaust gases
C. To circulate fresh water around the engine casing
D. To lubricate engine parts

12. What cools the fresh water after it passes through the engine?
A. Air coolers
B. Oil coolers

C. Seawater through a heat exchanger
D. Fuel coolers

13. What is a distinctive feature of the engine cooling system?
A. Intermittent water flow
B. High pressure
C. Continuous flow of fluid
D. Manual operation

14. What causes abrasive corrosion and erosion in cooling systems?
A. High temperature
B. Fuel combustion
C. Movement of fluid
D. Oil contamination

15. Why are Kingston boxes with valves used in seawater systems?
A. To increase pressure
B. To filter oil
C. To reduce the impact of turbulent flows
D. To heat seawater

16. What component draws in seawater in a standard marine diesel cooling system?
A. Heat exchanger
B. Exhaust mixer
C. Raw water pump (impeller-driven)
D. Fuel cooler

17. Where does seawater go after passing through engine coolers?

A. Into the fresh water tank
B. Into the crankcase
C. Through the exhaust mixer and out with exhaust gases
D. Into the lubricating oil system

18. Which of the following is an advantage of a centralized cooling system?

A. Increased number of seawater pumps
B. Higher corrosion rates
C. Less maintenance due to clean fresh water
D. Larger pipe sizes

SECTION 7. MARINE DIESEL ENGINE LUBRICATION SYSTEM INFORMATION FOCUS

1. Read the text carefully and translate it:

Lubrication of marine engines is the process of reducing friction between moving parts by supplying a lubricant, which ensures their reliable operation, prevents wear, and dissipates heat. This is achieved by means of a lubrication system that supplies lubricant to areas of friction, such as crankshaft bearings. Important aspects include forced pre-start oil pumping, lubricant pressure control, and regular lubricant replacement to prevent engine damage.

There are four key types of marine engine lubrication:

- **Hydrodynamic lubrication**

The engine oil creates a thick film between the moving parts of the engine. The two metal surfaces, moving relative to each other, create the film. That means that, in this type of lubrication, the pressure is self-generated.

For example, tilting-pad thrust bearings, bottom-end bearings, and journal bearings in the main engine use hydrodynamic lubrication.

- **Hydrostatic lubrication**

As its name suggests, in hydrostatic lubrication, the motion of the moving parts does not allow the creation of the oil film. Therefore, the oil pressure needs to be provided externally, with the help of an external oil pump. This type of lubrication depends on the inlet pressure of the oil, as well as the clearance between the metal surfaces. Crosshead bearings require hydrostatic lubrication and use a crosshead lubrication pump to increase the pressure.

- **Boundary lubrication**

It occurs when the creation of a full-fluid film is not possible. A thin film is formed between two sliding surfaces. There is high friction between these surfaces, meaning there is a certain level of metal-to-metal contact. It occurs when a shaft moves from rest, when the speed is very low, or when the load is extremely high. It may also be a result of low oil viscosity.

- **Elastohydrodynamic lubrication**

Elastohydrodynamic lubrication (EHD) is the lubrication principle in which notable elastic deformation of the surfaces occurs, and it changes the shape and thickness of the lubricant film in the contact zone. It is often the result of contact between rolling and sliding surfaces.

The main engine has three separate lubricating oil systems:

– Main lubricating oil system.
– Cylinder oil system.
– Turbocharger lubricating oil system.

The main, or crankcase, lubrication system is supplied by one of two pumps, one of which operates, while the other is on standby and set for automatic cut-in should there be a lubricating oil pressure reduction or primary pump failure. The main LO pumps take their suction from the main engine sump tank and discharge oil via the main LO cooler, which removes heat. An automatic backflushing filter unit with a magnetic core helps to remove metal debris. The plate-type LO cooler is cooled by the low-temperature central cooling freshwater system.

The supply pressure in the main lubrication system depends on the design and requirements and is generally around 4.5 kg/cm^2. LO supply to the cooler is via a three-way valve, which enables some oil to bypass the cooler. The three-way valve maintains a temperature of 45 °C at the lubricating oil

inlet to the engine. The main LO system supplies oil to the main bearings, camshaft, and camshaft drive.

Lubrication of marine engines is critical for their reliable and efficient operation, as it reduces friction, dissipates heat, protects against corrosion, and cleans friction surfaces.

COMPREHENSION

2. Answer the following questions using the information from the text:

1. What is lubrication of marine engines?
2. How does the lubrication system work?
3. Why is a marine engine lubrication system necessary?
4. What types of marine engine lubrication are there?
5. Give an example of the use of hydrodynamic lubrication.
6. How does hydrostatic lubrication work?
7. When does boundary lubrication occur?
8. What is elastohydrodynamic lubrication?
9. What are the three separate lubrication systems of the main engine?
10. What determines the supply pressure to the main lubrication system?

3. Insert the missing phrases or words necessary for complete context. Choose from the suggestions below:

carbon deposits
spraying oil flowing
clean oil
the circulation system
friction units
combined systems
a cylinder diameter
high-pressure pumps

camshaft bearings
internal combustion engines
on the perfection of the oil system
corrosion
supplying lubricant

The internal combustion engine lubrication system is designed to ensure the timely supply of the required amount of purified and cooled oil to …. (to protect their surfaces from wear and ….); to remove heat from friction surfaces and parts; to remove wear products and …. from friction surfaces and to ….. The reliability and durability of the engine depend to a large extent …. and the efficiency of its operation. Depending on the method of …. to the friction surfaces of parts and components of the internal combustion engine, the following lubrication systems are distinguished: circulation under pressure, splash, and ….. Lubrication of the frame, connecting rod, and main bearings, …., and drive auxiliary units is carried out using a circulating lubricant at a pressure of 0.15–0.6 MPa. Lubrication of cylinder liners, piston guides and piston rings in low- and medium-power engines is carried out by …. through the gaps in the bearings. In modern powerful medium-speed …., oil for lubricating cylinder liners, pistons, and some other components is supplied by special ….. An autonomous cylinder lubrication system allows the use of special types of oil and also makes it possible to regulate its quantity.

In most trunk internal combustion engines with …. of up to 400 mm use a combined lubrication system, i.e., frame, connecting rod and main bearings and camshaft bearings are lubricated with oil supplied by …., while cylinder liners, pistons, rings, etc. are lubricated by splashing.

4. Draw a schematic diagram of the piston lubrication and cooling system. Explain how it works using the following words and phrases:

oil pump, autonomous oil pump, coarse and fine filters, oil cooler, pipelines and control and monitoring devices, oil pan, bearing lubrication, camshaft, high-pressure fuel pump, air distributor, crankshaft main bearing, control panel components, crankshaft main bearings, water pump ball bearings.

WRITING PRACTICE

5. Translate the sentences from English into Ukrainian:

1. Змащувальна система двигуна внутрішнього згоряння (ДВЗ) складається з двох незалежних систем: системи циркуляційного змащення й охолодження поршнів та системи змащення втулок циліндрів.

2. Змащувальна циркуляційна система, залежно від розташування маслозбірника, може бути з мокрим або сухим картером.

3. У системі із сухим картером масло з піддону двигуна постійно стікає самопливом або відкачується спеціальним насосом в окрему цистерну, встановлену поза двигуном.

4. У системі з мокрим картером основною ємністю для масла є піддон або нижня частина картера, з якої масло забирається масляним насосом двигуна.

5. У сучасних суднових двигунах як масляні насоси переважно застосовуються шестеренні та гвинтові насоси.

6. За приводом масляні насоси можуть бути навішеними на двигун або автономними, з незалежним приводом (електродвигуном).

7. Для змащення циліндрів застосовуються поршневі насоси плунжерного типу, навішені на двигун.

8. Лубрикатори являють собою багатоплунжерні насоси високого тиску і слугують для подачі мастила до циліндрових втулок.

9. Відмінною особливістю суднових масел є висока вологостійкість.

6. Remember the important words and expressions that appeared in this section :

• lubrication of marine engine /ˌluːbrɪˈkeɪʃən əv məˈriːn ˈendʒɪn/ – змащення суднового двигуна

• lubricant /ˈluːbrɪkənt/ – змащувальний матеріал, мастило

• lubrication system /ˌluːbrɪˈkeɪʃən ˈsɪstəm/ – система змащення

• friction /ˈfrɪkʃən/ – тертя

• crankshaft bearing /ˈkræŋkʃɑːft ˈbeərɪŋ/ – підшипник колінчастого вала

• pre-start oil pumping /ˌpriː ˈstɑːt ɔɪl ˈpʌmpɪŋ/ – передпускове перекачування масла

• lubricant pressure /ˈluːbrɪkənt ˈpreʃə/ – тиск мастила

• lubricant replacement /ˈluːbrɪkənt rɪˈpleɪsmənt/ – заміна мастила

• prevent engine damage /prɪˈvent ˈendʒɪn ˈdæmɪdʒ/ – запобігання пошкодженню двигуна

• hydrodynamic lubrication /ˌhaɪdrəʊdaɪˈnæmɪk ˌluːbrɪˈkeɪʃən/ – гідродинамічне змащення

• hydrostatic lubrication /ˌhaɪdrəʊˈstætɪk ˌluːbrɪˈkeɪʃən/ – гідростатичне змащення

• boundary lubrication /ˈbaʊndəri ˌluːbrɪˈkeɪʃən/ – граничне змащення

• elastohydrodynamic lubrication /ɪˌlæstəʊˌhaɪdrəʊdaɪˈnæmɪk ˌluːbrɪˈkeɪʃən/ – еластогідродинамічне змащення

- turbocharger /ˈtɜːbəʊˌtʃɑːdʒə/ – турбокомпресор
- automatic backflushing filter /ˌɔːtəˈmætɪk ˈbækˌflʌʃɪŋ ˈfɪltə/ – автоматичний фільтр зворотного промивання
- the plate-type LO cooler /ðə ˈpleɪt taɪp ˌelˈəʊ ˈkuːlə/ – пластинчастий охолоджувач масла
- three-way valve /ˌθriː ˈweɪ vælv/ – триходовий клапан
- bearing lubrication /ˈbeərɪŋ ˌluːbrɪˈkeɪʃən/ – змащення підшипників
- main bearings /ˈmeɪn ˈbeərɪŋz/ – головні підшипники
- camshaft /ˈkæmʃɑːft/ – розподільний вал
- camshaft drive /ˈkæmʃɑːft draɪv/ – привід розподільного вала

SPEAKING PRACTICE

7. a) Problematic questions for discussion:

1. Why does the main lubrication system use two pumps?
2. What could happen if the backflushing filter fails?
3. Why is the lubricating oil cooler connected to the freshwater cooling system?
4. How does lubrication help prevent corrosion?

b) Make up oral sentences with the terms:

– hydrodynamic lubrication
– lubricant pressure
– backflushing filter
– camshaft drive
– turbocharger lubrication.

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. What is the main purpose of lubrication in marine engines?

A. To increase engine power
B. To reduce friction and dissipate heat
C. To cool exhaust gases
D. To increase fuel efficiency only

2. Which engine parts are specifically mentioned as friction areas?

A. Cylinder liners only
B. Crankshaft bearings
C. Exhaust valves
D. Fuel injectors

3. What important procedure ensures lubrication before engine start?

A. Manual oil filling
B. Forced pre-start oil pumping
C. Oil spraying
D. Oil draining

4. How many key types of marine engine lubrication are described?

A. Two
B. Three
C. Four
D. Five

5. In which lubrication type is the oil film pressure self-generated?

A. Boundary lubrication
B. Hydrostatic lubrication
C. Hydrodynamic lubrication
D. Elastohydrodynamic lubrication

6. Which bearings use hydrodynamic lubrication?

A. Crosshead bearings
B. Tilting-pad thrust and journal bearings
C. Piston rings
D. Cylinder liners

7. Why is external oil pressure required in hydrostatic lubrication?

A. Oil viscosity is too high
B. Motion prevents oil film formation
C. Metal surfaces are stationary
D. Oil temperature is too low

8. Which component provides pressure in hydrostatic lubrication?

A. Gravity tank
B. Main LO cooler
C. External oil pump
D. Oil sump

9. When does boundary lubrication occur?

A. At high engine speeds
B. When full-fluid film cannot be formed
C. When oil pressure is high
D. During normal steady operation

10. Which condition may cause boundary lubrication?
A. High oil viscosity
B. High engine speed
C. Extremely high load
D. Excessive oil pressure

11. What characterizes elastohydrodynamic lubrication (EHD)?
A. No surface deformation
B. Thick oil film at rest
C. Elastic deformation of surfaces
D. Absence of oil film

12. How many separate lubricating oil systems does the main engine have?
A. One
B. Two
C. Three
D. Four

13. What happens if the primary main LO pump fails?
A. The engine stops immediately
B. Manual pump is started
C. The standby pump cuts in automatically
D. Oil flow stops completely

14. What is the function of the main LO cooler?
A. To filter oil
B. To increase oil pressure
C. To remove heat from the oil
D. To store oil

15. What device removes metal debris from lubricating oil?
A. Oil sump
B. Plate-type cooler
C. Magnetic backflushing filter
D. Three-way valve

16. What temperature is maintained at the lubricating oil inlet to the engine?
A. 35 °C
B. 40 °C
C. 45 °C
D. 55 °C

17. Which lubrication system is most common in trunk engines with cylinder diameters up to 400 mm?
A. Splash system only
B. Circulation system only
C. Combined lubrication system
D. Boundary lubrication system

18. What is one key advantage of an autonomous cylinder lubrication system?
A. It eliminates oil pumps
B. It allows regulation of oil quantity
C. It reduces engine speed
D. It increases oil contamination.

UNIT 3
SHIP TURBINE UNITS

SECTION 8. PURPOSE OF TURBINES AND THEIR TYPES INFORMATION FOCUS

1. Read the text and work over the italicized terminology:

Ship turbines are used to convert the *thermal energy* of steam or gas into mechanical work. The method of energy conversion in a *turbine* does not depend on the working fluid used in the turbine. Therefore, the working processes in *steam turbines* do not differ significantly from those in *gas turbines*, and the basic principles of steam and gas turbine design are the same.

Fresh steam or gas entering the *nozzle*, which is a guiding device, expands, *potential energy* is converted into *kinetic energy*, and the steam or gas acquires considerable speed. Upon exiting the nozzle, the steam or gas enters the channels of the working blades mounted on the rim of the *turbine disc* sitting on the *turbine shaft*. The working fluid presses against the curved surfaces of the working blades, causing the disc with the shaft to rotate. The combination of these guide devices (nozzles) and working blades on the turbine disc is called a *turbine stage*. Turbines with only one stage are called *single-stage turbines*, as opposed to *multi-stage turbines*.

Turbines are divided into two main groups based on the working principle of the *working fluid* (steam or gas). Turbines in which the *expansion of steam* or gas occurs only in stationary guide devices, and only their kinetic energy is used on the working blades, are called *impulse turbines*. Turbines in which

the expansion of steam or gas also occurs when the working fluid moves in the channels of the working blades are called *reaction turbines*. Turbines rotate in only one direction and are *non-reversible*, i.e., they cannot change the direction of rotation. Therefore, reverse turbines are usually provided on the same shaft as the main forward turbines. *The power of ship reverse turbines* does not exceed 40-50 % of the power of *forward turbines*. Since these turbines do not need to be highly efficient, they have a small number of stages.

COMPREHENSION

2. Work with the words and phrases that are italicized in the text above. Choose the correct definition from the options below.

1) Thermal energy 2) A turbine 3) A steam turbine 4) A gas turbine 5) A nozzle 6) Potential energy 7) Kinetic energy 8) A turbine disc 9) A turbine shaft 10) The turbine stage 11) A single stage turbine 12) A multi-stage turbine 13) A working fluid 14) The expansion of steam 15) An impulse turbine 16) A reactive turbine (or reaction turbine) 17) A “non-reversible turbine” 18) The “power of ship reverse turbines” 19) Forward turbine	a) a type of propulsion engine that uses steam, gas, or water current to turn a propeller or generator, which moves the ship forward; b) refers to the ability of these turbines to generate reverse thrust for a ship, though this is often achieved through different methods; c) a real-world turbine that is not perfectly efficient due to thermodynamic and mechanical irreversibilities, such as friction, heat loss, and turbulence, which reduce the actual work output compared to an ideal reversible process; d) a type of turbine that generates power from the force of a fluid moving over its blades;

	e) a turbine in which the potential energy of the working fluid (gas, steam, liquid) is converted into kinetic energy (i.e., the pressure of the working fluid decreases and its velocity increases) in stationary channels (nozzles), and the conversion of kinetic energy into mechanical work occurs on the working blades; f) the dramatic increase in volume that occurs when liquid water turns into steam, and also the continuous expansion of steam as a gas; g) a substance (gas or liquid) that circulates in a closed system (e.g., in an engine or heat pump) and is used to transfer energy by changing its state of aggregation; h) a type of turbine with more than one stage, used to efficiently convert energy from a fluid (like steam or gas) into rotational mechanical energy; i) defined as a type of steam turbine that consists of one Curtis stage, which utilizes two blade rows to reduce blade loading and is designed to extract maximum energy from the vapor to produce power; j) the main component of the turbine, consisting of a single rotary assembly (rotating blades) and its static components, such as the stator (guide vanes); k) a component that connects the turbine to a generator or other machinery, transmitting the rotational energy produced by the turbine to perform work; l) a rotating component of turbines, usually made of high-strength alloys, which holds the turbine blades and transfers energy from hot gases; m) energy that an object or system has because it is moving; n) the stored energy an object has due to its position, configuration, or state, which has the potential to do work;

	o) a channel with a variable cross-section designed to accelerate a liquid or gas to a certain speed and direct the flow; p) a type of continuous internal combustion engine that converts fuel into mechanical energy; q) a machine that converts thermal energy from pressurized steam into mechanical energy by spinning a rotor connected to a shaft; r) is the total kinetic energy of all particles (atoms and molecules) in a system, caused by their chaotic motion; s) a rotating machine that converts the thermal energy of high-pressure steam or the kinetic energy of a gas into rotational force, which either directly powers a propeller or generates electricity to power an electric motor.

3. Consider the main functions of turbines. Find words in the text which have a similar meaning to the words or phrases below:

installation
construct
set in motion
production
accessorial
complementary
exploit
considerably

Main functions of ship turbines:

Main engine (propulsion unit): conversion of steam or gas energy into the rotary motion of the propeller shaft to generate thrust that propels the ship.

Auxiliary machinery drive: ensuring the operation of other ship equipment, such as pumps, fans, and, most importantly, electric generators for producing electricity on board the ship.

Heat recovery: as part of turbo-compound units (TCUs), turbines utilize heat from diesel engine exhaust gases to generate additional power or electricity, thereby increasing the overall efficiency of the power plant.

Engine supercharging: as part of turbochargers, turbines use the energy of exhaust gases to compress the air supplied to the cylinders of diesel engines, significantly increasing their power output and efficiency.

4. Make the following sentences complete by translating the words and phrases in brackets:

Marine turbines are classified according to various characteristics, including the type of (*робоча рідина*) and purpose.

1) *By type of working fluid:*

a) Steam turbines:

They use the energy of high-pressure and (*високотемпературна пара*) produced in steam boilers and are used as main engines on large ships (e.g., aircraft carriers, icebreakers with (*атомні електростанції*), large tankers), as well as (*допоміжні двигуни*) for driving generators and pumps.

Steam turbines are divided into:

• Condensing: most of the steam energy is converted into mechanical work, and (*випускна пара*) condenses in the condenser.

• Heating (with steam extraction): part of the steam is extracted for domestic or technological needs of the ship (e.g., heating, (*опріснення води*).

b) Gas turbines:

They use the energy of hot gases formed in (*камера згоряння*), are characterized by (*висока питома потужність*), quick start-up, and compactness.

Gas turbines are used on high-speed vessels, military ships, and as peak or reserve power sources on other types of vessels and often used in (*комбіновані установки*) (e.g., CODAG, COGOG).

2) *By purpose in the ship's power plant:*

a) Main turbines: designed to rotate (*карданний вал*) and propel the ship. They are divided into forward and (*реверсивні турбіни*).

b) Auxiliary turbines: (*привод допоміжних механізмів*) such as electric generators, pumps, and compressors.

c) Supercharger turbines (turbochargers): used to increase the (*тиск повітря*) supplied to diesel engines, increasing their power.

3) *By design features:*

a) Active (pulse): the pressure drop occurs only in the (*сопла*) (stationary part).

b) Reactive: (*падіння тиску*) occurs both in the nozzles and in the moving (*лопаті ротора*).

c) Single-stage and multi-stage: depending on the number of stages (rows of moving and stationary blades) for the efficient use of (*енергія робочої рідини*).

WRITING PRACTICE

5. Translate the sentences from Ukrainian into English:

1. Суднові турбіни – це парові, газові або гідравлічні машини, що перетворюють теплову енергію пари чи газу або потенційну енергію води на механічну енергію для обертання гребного вала.

2. Суднові турбіни слугують для перетворення теплової енергії пари або газу на механічну роботу.

3. Суднові турбіни можуть бути основною рушійною силою (особливо на великих суднах) або допоміжними, що живлять генератори, насоси тощо.

4. Головний принцип роботи суднових турбін полягає в тому, що робоче тіло (пара, газ, вода) проходить через сопла, де його тиск перетворюється на кінетичну енергію, яка штовхає лопаті турбінного колеса, змушуючи його обертатися.

5. На великих вантажних суднах, танкерах та деяких пасажирських кораблях турбіни можуть бути основним джерелом енергії для руху.

6. Турбіни використовуються для виробництва електроенергії на суднах, що мають допоміжні механізми, які потребують великої потужності.

7. Турбіни широко застосовуються на великих суднах завдяки своїй високій потужності, компактності та відносно низькому рівню вібрації.

8. Суднові турбіни є основою енергетичних установок на багатьох військових кораблях, круїзних лайнерах, танкерах та інших великих комерційних суднах.

6. Remember the following words and phrases mentioned in this section:

- turbine /ˈtɜːbaɪn/ – турбіна
- auxiliary turbines /ɔːgˈzɪliəri ˈtɜːbaɪnz/ – допоміжні турбіни
- steam turbine /stiːm ˈtɜːbaɪn/ – парова турбіна
- gas turbine /gæs ˈtɜːbaɪn/ – газова турбіна
- nozzle /ˈnɒzl/ – сопло
- potential energy /pəˈtenʃəl ˈenədʒi/ – потенційна енергія
- kinetic energy /kɪˈnetɪk ˈenədʒi/ – кінетична енергія
- turbine disc /ˈtɜːbaɪn dɪsk/ – диск турбіни

- single stage turbine /ˈsɪŋgəl steɪdʒ ˈtɜːbaɪn/ – одноступінчаста турбіна
- multi-stage turbine /ˈmʌlti steɪdʒ ˈtɜːbaɪn/ – багатоступінчаста турбіна
- working fluid /ˈwɜːkɪŋ ˈfluːɪd/ – робоча рідина
- the expansion of steam /ðɪ ɪkˈspænʃən əv stiːm/ – розширення пари
- action turbine /ˈækʃən ˈtɜːbaɪn/ – робоча турбіна
- reactive turbine (or reaction turbine) /rɪˈæktɪv ˈtɜːbaɪn/ – реактивна турбіна
- non-reversible turbine /nɒn rɪˈvɜːsəbl ˈtɜːbaɪn/ – «незворотна турбіна»
- power of ship reverse turbines /ˈpaʊə əv ʃɪp rɪˈvɜːs ˈtɜːbaɪnz/ – «потужність зворотних турбін судна»
- forward turbine /ˈfɔːwəd ˈtɜːbaɪn/ – передня турбіна
- supercharger turbines (turbochargers) /ˈsuːpətʃɑːdʒə ˈtɜːbaɪnz/ – турбіни наддуву (турбокомпресори)
- moving and stationary blades /ˈmuːvɪŋ ənd ˈsteɪʃənəri bleɪdz/ – рухомі та нерухомі лопаті
- rotary motion /ˈrəʊtəri ˈməʊʃən/ – обертальний рух
- propeller shaft /prəˈpelə ʃɑːft/ – гвинтовий вал

SPEAKING PRACTICE

7. a) Give detailed oral answers to the following questions:

1. Why is it necessary to have reverse turbines on the same shaft as forward turbines?
2. How does turbine design differ depending on whether the working fluid is steam or gas?
3. Why are non-reversible turbines safer for ship operation?
4. Why do multi-stage turbines generally provide more power than single-stage turbines?

b) Prepare a short presentation (2–3 min) on the following topics:

1. "Conversion of thermal energy into mechanical work by ship turbines".
2. "Difference between forward and reverse turbines".

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. What is the main function of ship turbines?

A. To cool the engine
B. To convert thermal energy into mechanical work
C. To store energy
D. To reduce fuel consumption

2. What working fluids are mainly used in ship turbines?

A. Water and oil
B. Steam and gas
C. Air and fuel
D. Oil and gas

3. Why are the basic principles of steam and gas turbine design similar?

A. They use the same fuel
B. They operate at the same speed
C. The energy conversion method does not depend on the working fluid
D. They have identical components

4. What happens to steam or gas when it enters the nozzle?

A. It condenses
B. It slows down
C. Potential energy is converted into kinetic energy
D. It loses pressure without acceleration

5. What is the main purpose of a nozzle in a turbine?
A. To cool the working fluid
B. To accelerate and direct the flow
C. To reduce vibration
D. To store energy

6. What causes the turbine disc and shaft to rotate?
A. Friction between blades
B. Gravity
C. Pressure of the working fluid on curved blades
D. Magnetic force

7. What is a turbine stage?
A. Only the turbine shaft
B. A single turbine blade
C. A combination of nozzles and working blades
D. The turbine casing

8. What distinguishes a single-stage turbine from a multi-stage turbine?
A. The type of fuel used
B. The direction of rotation
C. The number of turbine stages
D. The operating temperature

9. In which turbines do expansion occur only in stationary guide devices?
A. Reactive turbines
B. Gas turbines
C. Active (action) turbines
D. Reverse turbines

10. What characterizes a reactive turbine?
A. Expansion occurs only in nozzles
B. Expansion occurs in both nozzles and moving blades
C. No pressure drop occurs
D. Only kinetic energy is used

11. Why are ship turbines considered non-reversible?
A. They rotate at low speed
B. They cannot change the direction of rotation
C. They are inefficient
D. They use only one stage

12. What is the typical power of ship reverse turbines compared to forward turbines?
A. Equal power
B. 10–20 %
C. 40–50 %
D. Over 80 %

13. Why do reverse turbines usually have fewer stages?
A. They operate at lower temperature
B. They do not require high efficiency
C. They use different working fluids
D. They rotate in the opposite direction

14. What is thermal energy according to the text?
A. Energy stored in fuel
B. Energy due to pressure
C. Total kinetic energy of particles due to chaotic motion
D. Electrical energy

15. What is the function of a turbine shaft?
A. To cool the turbine
B. To direct exhaust gases
C. To transmit rotational energy to machinery
D. To store thermal energy

16. Which turbines use high-pressure and high-temperature steam from boilers?
A. Gas turbines
B. Steam turbines
C. Supercharger turbines
D. Hydraulic turbines

17. Gas turbines are mainly characterized by:
A. Low power density and slow start-up
B. High specific power and compactness
C. High corrosion resistance only
D. Low exhaust temperature

18. Which classification is based on the number of turbine stages?
A. By purpose
B. By working fluid
C. By design features
D. By direction of rotation.

SECTION 9. SHIP STEAM TURBINE PLANTS INFORMATION FOCUS

1. Please read the following information carefully:

Ship steam turbines are devices on steamships that are used to convert steam energy into mechanical energy, which drives the propeller and propels the ship through the water.

A steam turbine unit (STU) is a set of units, engines, and devices connected by a single thermal circuit. The working fluid (steam) is generated in a steam boiler or steam generator. Steam with the appropriate parameters (pressure and temperature) drives a steam turbine. The steam passing through the turbine enters the condenser, where it is converted into water (condensate), which is then used to feed the steam boiler. Thus, the steam cycle is closed. The steam turbine transmits torque through a gear transmission via the ship's shaft to the propeller. Steam turbine units are highly reliable and relatively easy to maintain.

The location of the main components can be seen in the example of an active-reactive turbine, a simplified design diagram of which is shown in Fig. 4. The turbine rotor consists of a drum b, on which ten rows of reactive blades 7 are mounted, and a disc 5 with two rows of active blades 12. In this case, the turbine stator consists of a casing 13, a nozzle box with nozzles 5, a diaphragm 4, guide blades 11, and end seal boxes 8. The rotor is mounted in the casing on support bearings 9. The double-row disc 5 with diaphragm 4 forms the two-stage active part of the turbine, and ten rows of working blades with guide blades form the ten-stage reactive part of the turbine.

Fresh steam is supplied through pipe 1 to the nozzle chamber 2. Exhaust steam exits through pipe 10.

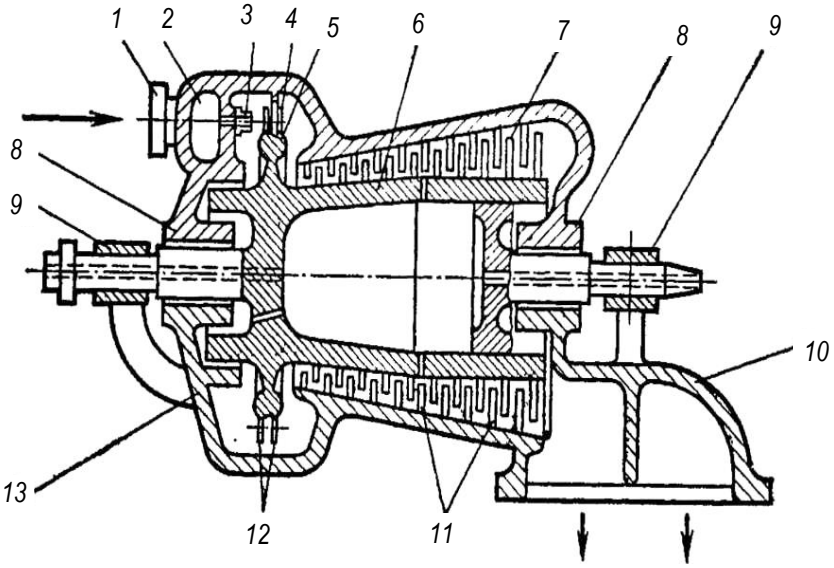

Fig. 4. Diagram of a marine steam turbine

Ship steam turbines are classified according to the following main characteristics:

By purpose – main and auxiliary. Main turbines rotate the propeller shaft and are divided into forward and reverse turbines, which are usually located in the same housing.

By steam operating principle – active and reactive. Active turbines are in turn divided into pressure stage turbines, speed stage turbines, and combined turbines. Active turbines are used on ships as main and auxiliary turbines. Reactive turbines are installed as medium- and low-pressure turbines (MPT and LPT) of the main multi-casing turbo-gear unit.

By number of casings, they are single-casing and multi-casing. Single-casing turbines are installed as main and auxiliary turbines in electric transmission (turbine-electric unit). Multi-casing turbines are installed only as main turbines. They are

connected by a sequential steam flow and combined by a single gear transmission.

By the number of steam passages, they are single-pass and double-pass. In single-pass turbines, the steam flows in one direction, while in double-pass turbines, the steam flows in two directions (this reduces the height of the blades and the diameter of the turbine). Double-flow turbines can have either diverging or converging steam flows and are used only as low-pressure turbines.

There are different types of marine steam turbines: reaction turbines, impulse turbines, single-stage and multi-stage. Each type of turbine has its own characteristics and applications on ships.

COMPREHENSION

2. Taking into account the information from the text, answer the following questions?

1. What type of energy is converted into mechanical energy in a steam turbine?
2. What is a steam turbine unit (STU)?
3. Why are steam turbine units considered reliable and easy to maintain?
4. Where is the working fluid for the steam turbine generated?
5. What parameters of steam are important for driving a steam turbine?
6. Why is the steam cycle described as a closed cycle?
7. How is the condensate used after leaving the condenser?
8. What role does the gear transmission play in the steam turbine unit?
9. Why is the propeller shaft an important part of the system?
10. What are the main components of the turbine rotor?

3. Match the concepts with the definitions, selecting the correct definition from the right column for each concept from the left column:

a) A steam turbine nozzle b) Steam turbine rotor c) The steam turbine stator d) Steam turbine thrust bearings e) A steam turbine blade f) A steam turbine labyrinth seal g) A steam turbine carbon seal h) A double-row steam turbine disc i) Steam turbine gear units j) The steam turbine gear reducer	1) the stationary part of the turbine, consisting of a casing and nozzles, which directs the steam flow to the rotor blades to generate mechanical energy. 2) assemblies designed to absorb axial (longitudinal) loads acting on the turbine shaft and fix its axial position relative to the stator. 3) the rotating part of the turbine with blades that converts the energy of expanding steam into the mechanical energy of shaft rotation. 4) a guiding device designed to convert the internal energy of steam into kinetic energy, which is then transferred to the turbine rotor blades, causing it to rotate. 5) a non-contact shaft seal that prevents steam and air leakage by creating a complex, winding path for the medium to pass through. 6) a device consisting of rings made of compressed carbon with a high graphite content that prevents steam from leaking out of the turbine and air from being sucked in. 7) a radial aerodynamic wing attached to the rim of a turbine disc. 8) a mechanical device that reduces the very high rotational speed of the turbine rotor to a lower speed required to drive the ship's propellers or other mechanisms. 9) a turbine wheel with two rows of working blades mounted on it, which is part of the pressure stage. 10) the main engines of a ship, combining a steam turbine, a gear transmission (reduction gear), and a thrust bearing to convert the thermal energy of steam into mechanical work that rotates the propeller.

4. Read the text below and find in the text words and expressions which mean:

1) *a system installed on a ship to ensure its movement*

2) *a continuous-action engine that converts the thermal energy of water vapor into the mechanical work of rotor rotation*

3) *the performance of a process, project, etc., defined as the ratio of the effect or result to the costs incurred to achieve that result*

4) *a unit that converts mechanical energy obtained as a result of turbine rotation*

5) *an intensive physical quantity, numerically equal to the force acting on a unit area of a surface perpendicular to that surface*

6) *energy of motion and accompanying interaction*

7) *a device, apparatus or machine that produces any products, electricity or converts one form of energy into another*

8) *A term applied collectively to all machinery and apparatus forming the nonpropulsive equipment of a ship*

9) *a vessel used for transporting passengers and cargo*

10) *a part of a machine that supports another part that turns around*

Steam turbines generally were used as a main engine in several kinds of ships which required more power for propulsion during the 19th century and the mid-20th century. After that period, the use of steam turbines declined because of higher oil prices and the introduction of new technologies such as diesel engines and gas turbines. For competitive reasons, many steam turbine manufacturers decided to improve steam turbine efficiency. Nowadays, steam turbines are used as a main engine and/or combined engines with turbo-generators or reduction gears in ships requiring high power, such as nuclear naval and

commercial vessels, LNG carriers, supertankers, icebreakers, cruise ships, and FPSO vessels.

A steam turbine is a heat engine that converts the high-temperature and high-pressure thermal energy of steam into mechanical or electrical energy using its fixed and moving blades and generators. Steam turbine systems produce energy and/or supply district heating as main engines or combined engines (with gas turbines or diesel engines). Steam turbines have been commonly used for many years as main engines or auxiliary machinery in land-based and marine installations to supply power requirements. Since 1894, when the first turbine was used by Sir Charles Parsons to propel his 34.5-knot ship Turbina, steam turbines were the most preferred main engines for marine applications until the mid-20th century. After the oil crisis and the development of more efficient engines in the 1960s–1970s, the use of steam turbines for marine applications decreased and became limited to ships requiring high power, such as nuclear-powered naval and commercial vessels, cruise ships, and LNG carriers.

Steam turbines, like other heat engines, absorb heat from a high-temperature heat source and convert it into mechanical energy, while the remaining heat is exhausted from the engine as waste heat. High-temperature and high-pressure steam enters the turbine and expands to a pressure lower than atmospheric pressure while flowing over the turbine blades. During this expansion, energy conversion from thermal energy to mechanical energy takes place.

A steam turbine consists of fixed and moving parts. The lower and upper casings, bearings, and fixed (stationary) blades belong to the fixed parts, while the turbine shaft and moving blades belong to the moving parts.

The quality and proper interaction of turbine components are very important for building a high-performance system, and steam operating conditions are also of great importance.

GRAMMAR FOCUS

In English, there are basic question words that often begin with *wh-* and are used to obtain detailed answers: Who (хто), What (що, який), Where (де), When (коли), Why (чому), How (як), Which (який), Whose (чий) та Whom (кого, кому). Additionally, constructions such as How many (скільки), How much (скільки), How often (як часто) are used.

The difference between "How many" and "How much" lies in the type of noun to which the question refers: "how many" is used for countable nouns (things that can be counted), and "how much" is used for uncountable nouns (things that cannot be counted as individual units).

The difference between "What" and "Which" lies in the choice: "which" is used to choose from a limited, known number of options (e.g., "Which of these two turbines is better to use?"), while "what" is used for general questions where the number of options is unknown or unlimited (e.g., "What kind of turbine do you use?").

WRITING PRACTICE

5. Try to ask a question for each of the sentences below, using question words:

***For example*:** Steam turbines can be used either as main engines or as combined engines to propel the ship and produce sufficient power for the operation of auxiliary machinery.

How can steam turbines be used? or ***What*** are steam turbines used for?

1. During the Industrial Revolution, steam replaced human power and began to be used in large factories, triggering major social and economic changes in Western countries.

2. In the following years, more productive engines, such as steam turbines, were developed and then widely used in land-based and marine applications.

3. Nowadays, various types of steam turbines are used in land and marine applications with different fuels.

4. A geothermal power plant uses the heat energy of hot water sources near the Earth's surface. This energy is absorbed by the steam turbine working fluid–steam–, and then the steam expands through the turbine.

5. As a result of research into alternative and environmentally friendly energy sources, solar collectors have been developed to produce energy from solar radiation.

6. Solar collectors, either individually or in combination, can provide the required energy to generate heat for the steam turbine working fluid. This system can also be used for lower-temperature heat sources with organic fluids whose boiling point is lower than that of water.

7. A very large part of the world's energy production is supplied by nuclear and fossil fuel power plants. When these fuels are fired in the boiler, the working fluid reaches high temperatures (500–600 °C) and enters the turbine. It then expands in the turbine, producing energy.

8. A steam turbine is a rotational machine that can reach high rotational speeds (more than 3000 rpm).

9. When turbines reach high speed, they can produce more power, and their efficiency increases. However, ship propellers are more efficient at lower speeds (200–300 rpm).

6. Memorize or repeat the following words and phrases:

- ship steam turbine /ʃɪp stiːm ˈtɜːbaɪn/ – суднова парова турбіна
- thermal circuit /ˈθɜːməl ˈsɜːkɪt/ – тепловий контур
- water vapor /ˈwɔːtə ˈveɪpə/ – водяна пара
- appropriate parameter /əˈprəʊpriət pəˈræmɪtə/ – відповідний параметр
- drum /drʌm/ – барабан
- steam turbine blade /stiːm ˈtɜːbaɪn bleɪd/ – лопатка парової турбіни
- reactive blade /rɪˈæktɪv bleɪd/ – реактивна лопатка
- active blade /ˈæktɪv bleɪd/ – активна лопатка
- guide blade /gaɪd bleɪd/ – направляюча лопатка
- single-casing and multi-casing turbines /ˈsɪŋgl ˈkeɪsɪŋ ænd ˈmʌlti ˈkeɪsɪŋ ˈtɜːbaɪnz/ – однокорпусні та багатокорпусні турбіни
- nozzle box /ˈnɒzl bɒks/ – коробка сопла
- end seal boxes /end siːl ˈbɒksɪz/ – коробки кінцевих ущільнень
- support bearings /səˈpɔːt ˈbeərɪŋz/ – опорні підшипники
- double-row disc /ˈdʌbl rəʊ dɪsk/ – дворядний диск
- two-stage active part of the turbine /tuː steɪdʒ ˈæktɪv pɑːt əv ðə ˈtɜːbaɪn/ – двоступенева активна частина турбіни
- ten-stage reactive part of the turbine /ten steɪdʒ rɪˈæktɪv pɑːt əv ðə ˈtɜːbaɪn/ – десятиступенева реактивна частина турбіни
- forward and reverse turbines /ˈfɔːwəd ænd rɪˈvɜːs ˈtɜːbaɪnz/ – прямі та зворотні турбіни
- pressure stage turbine /ˈpreʃə steɪdʒ ˈtɜːbaɪn/ – турбіна ступеня тиску
- speed stage turbine /spiːd steɪdʒ ˈtɜːbaɪn/ – турбіна ступеня швидкості

- combined turbine /kəmˈbaɪnd ˈtɜːbaɪn/ – комбінована турбіна
- medium- and low-pressure turbines /ˈmiːdiəm ænd ləʊ ˈpreʃə ˈtɜːbaɪnz/ – турбіни середнього та низького тиску
- steam turbine nozzle /stiːm ˈtɜːbaɪn ˈnɒzl/ – сопло парової турбіни
- steam turbine rotor /stiːm ˈtɜːbaɪn ˈrəʊtə/ – ротор парової турбіни
- steam turbine stator /stiːm ˈtɜːbaɪn ˈsteɪtə/ – статор парової турбіни
- steam turbine thrust bearings /stiːm ˈtɜːbaɪn θrʌst ˈbeərɪŋz/ – опорні (упорні) підшипники парової турбіни
- steam turbine labyrinth seal /stiːm ˈtɜːbaɪn ˈlæbərɪnθ siːl/ – лабіринтове ущільнення парової турбіни
- steam turbine carbon seal /stiːm ˈtɜːbaɪn ˈkɑːbən siːl/ – вуглецеве ущільнення парової турбіни
- double-row steam turbine disc /ˈdʌbl rəʊ stiːm ˈtɜːbaɪn dɪsk/ – дворядний диск парової турбіни
- steam turbine gear unit (reducer) /stiːm ˈtɜːbaɪn gɪə juːnɪt (rɪˈdjuːsə)/ – редуктор парової турбіни
- multi-hull turbo-gear unit /ˈmʌlti hʌl ˈtɜːbəʊ gɪə juːnɪt/ – багатокорпусний турборедуктор
- turbine-electric unit /ˈtɜːbaɪn ɪˈlektrɪk juːnɪt/ – турбоелектрична установка
- gear transmission /gɪə trænzˈmɪʃn/ – редукторна передача
- single-pass and double-pass turbines /ˈsɪŋgl pɑːs ænd ˈdʌbl pɑːs ˈtɜːbaɪnz/ – однопрохідні та двопрохідні турбіни
- diverging or converging steam flows/daɪˈvɜːdʒɪŋ ɔː kənˈvɜːdʒɪŋ stiːm fləʊz/ – розбіжні або збіжні потоки пари
- jet turbine /dʒet ˈtɜːbaɪn/ – реактивна турбіна
- impulse turbine /ˈɪmpʌls ˈtɜːbaɪn/ – імпульсна турбіна

SPEAKING PRACTICE

7. a) Describe the closed steam cycle in a marine steam turbine using the following terms: **boiler, steam, turbine, condenser, condensate, closed cycle**.

b) Explain how marine steam turbines are classified according to:

- purpose
- principle of steam operation
- number of casings
- number of steam passes

c) Imagine that a problem has occurred with the reverse turbine on board a ship. Discuss:

- its purpose
- why its power is lower than that of the forward turbine
- what actions the engineer can take

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. What is the main function of ship steam turbines?

A. To generate electricity for ship lighting
B. To convert steam energy into mechanical energy
C. To cool the ship's engine
D. To produce steam for auxiliary system

2. What does a steam turbine unit (STU) consist of?

A. Only a steam turbine and a propeller
B. A boiler and a condenser only
C. A set of units, engines, and devices connected by a single thermal circuit
D. Only mechanical transmission equipment

3. Where is the working fluid for the steam turbine generated?
A. In the condenser
B. In the gearbox
C. In the steam boiler or steam generator
D. In the propeller shaft

4. Which steam parameters are required to drive a steam turbine?
A. Volume and density
B. Speed and direction
C. Pressure and temperature
D. Mass and viscosity

5. What happens to the steam after it passes through the turbine?
A. It is released directly into the atmosphere
B. It enters the condenser and turns into water
C. It returns immediately to the boiler
D. It is mixed with fuel

6. Why is the steam cycle considered closed?
A. Steam is reused after condensation
B. Steam never changes its state
C. Steam is exhausted to the sea
D. Steam pressure remains constant

7. How is torque transmitted from the steam turbine to the propeller?
A. Directly through the turbine casing
B. Through a belt drive
C. Through a gear transmission and ship’s shaft
D. Through hydraulic pumps

8. Which components form the turbine rotor?
A. Casing and guide blades
B. Drum with reactive blades and disc with active blades
C. Nozzle box and diaphragm
D. Bearings and seal boxes

9. What elements belong to the turbine stator?
A. Drum and shaft
B. Bearings and disc
C. Casing, nozzles, guide blades, diaphragm
D. Propeller and gearbox

10. How many stages does the active part of the turbine described in the text have?
A. One stage
B. Two stages
C. Ten stages
D. Twelve stages

11. How many rows of reactive blades form the reactive part of the turbine?
A. Two
B. Five
C. Ten
D. Twelve

12. How are ship steam turbines classified by purpose?
A. Single and multi-stage
B. Active and reactive
C. Main and auxiliary
D. Single-pass and double-pass

13. What is the function of forward and reverse turbines?
A. To cool the steam
B. To control steam pressure
C. To rotate the propeller shaft in different directions
D. To generate electricity

14. Which turbines are installed as medium- and low-pressure turbines?
A. Active turbines
B. Jet turbines
C. Reactive turbines
D. Single-stage turbines

15. What is the main difference between single-pass and double-pass turbines?
A. The number of blades
B. The direction of steam flow
C. The type of working fluid
D. The turbine speed

16. Why are double-pass turbines used as low-pressure turbines?
A. They increase steam temperature
B. They simplify maintenance
C. They reduce blade height and turbine diameter
D. They eliminate the need for a condenser

17. Which types of marine steam turbines are mentioned in the text?
A. Hydraulic and electric turbines
B. Axial and radial turbines
C. Jet, impulse, single-stage, and multi-stage turbines
D. Gas and diesel turbines.

18. Why are steam turbine units widely used on ships?
A. They are cheap to manufacture
B. They are highly reliable and easy to maintain
C. They require no fuel
D. They operate without a boiler.

SECTION 10. GAS TURBINE OPERATION INFORMATION FOCUS

1. Read the text carefully and translate it:

A gas turbine differs from a steam turbine in that its working medium is not steam from boilers, but gases produced by the combustion of fuel in special chambers.

The design and operation of a gas turbine are similar to those of a steam turbine. They can also be active or reactive, single-casing, multi-casing, etc. Gas turbines differ from steam turbines in that they are subjected to higher temperature loads: the temperature of hot gases ranges from 700 to 800 °C. These higher temperatures reduce the operating life of gas turbines.

Depending on the method of air compression and hot gas formation, there are gas turbine units with a combustion chamber and GTUs with free-piston gas generators (FPGGs). A negative feature of GTUs is the significant heat loss associated with the discharge of exhaust gases.

One method of increasing the efficiency of GTUs is the utilization of exhaust gas heat to preheat the air entering the combustion chamber, a process known as regeneration.

The use of regeneration with simultaneous two-stage air compression increases the effective efficiency of the unit to 28–30 %. Such gas turbine units are used as marine power plants.

In a marine gas turbine plant with a combustion chamber (Fig. 5), atmospheric air is sucked in, compressed by a low-pressure compressor (1) located on the same shaft as the gas turbine (5), and sent to a cooler (2) cooled by seawater. The cooled air enters the high-pressure compressor (3), where it is compressed again to a higher pressure, after which it is fed into the regenerator (4), where it is heated by exhaust gases, and then enters the combustion chamber (6), where the fuel supplied is

burned. The combustion products expand in the gas turbine (5) and, after passing through the regenerator, where they transfer part of their heat to the air, are released into the atmosphere or utilized in a waste heat boiler.

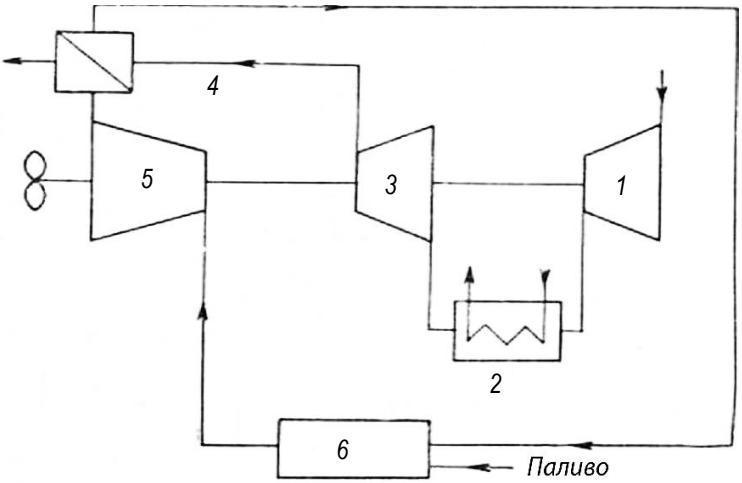

Fig. 5. Diagram of a gas turbine plant with regeneration and two-stage air compression

The energy generated in a gas turbine is not fully used for its primary purpose, but is partially consumed to drive the compressors. To start a gas turbine, it must be spun up by starter electric motors.

A gas turbine unit with a free-piston gas generator (FPGG) consists of an active or reactive turbine and a diesel cylinder in which fuel combustion takes place. A combined gas turbine unit with an FPGG is shown in Fig. 6.

The FPGG cylinder (1) has two working pistons (2) on the same rods as the compressor pistons (3). When the mixture of air and fuel supplied through the nozzle (11) burns, the gases

in the cylinder expand, pushing the pistons apart. A vacuum is created in the cavities (6) of the compressor cylinders (5), and atmospheric air is sucked in through the valves (7). At the same time, the air in the cavities (4) of the compressor cylinders is compressed, and the working pistons return to their original position.

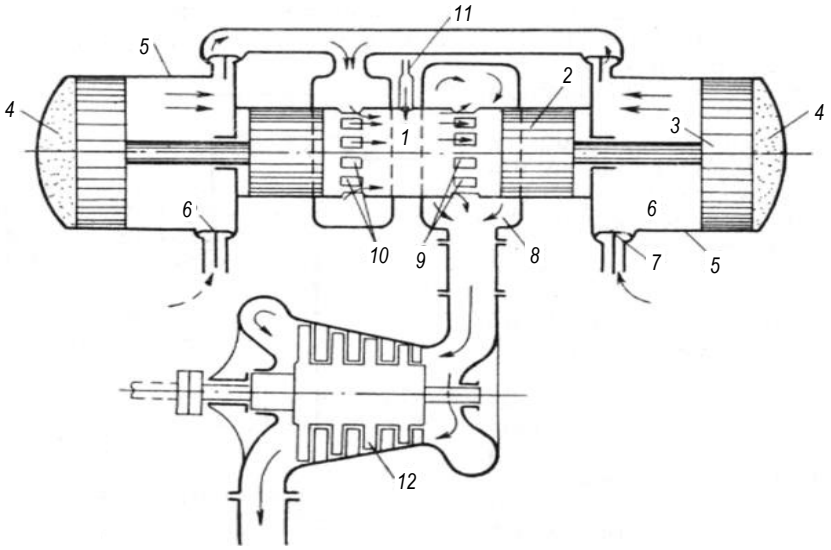

Fig. 6. Diagram of a gas turbine plant with a free-piston gas generator (FPGG)

When the pistons diverge in the cylinder, the exhaust ports (9) open first, followed by the blow-off ports (10). The exhaust gases pass through the exhaust ports into the receiver (8) and from there into the gas turbine (12).

During the reverse stroke of the compressor pistons, the exhaust and purge ports close, air from cavity (6) is forced into the purge receiver, and the air in the working cylinder is

compressed. At the end of compression, the air temperature rises, and the fuel injected by the nozzle at this moment ignites. A new cycle of the free-piston gas generator begins.

The effective efficiency of such a combined gas turbine plant with an FPGG is close to 40 %, which makes its installation on ships economically justified.

COMPREHENSION

2. Answer the questions, taking into account the information from the text above:

1. What is the difference between a gas turbine and a steam turbine?
2. What are gas turbines?
3. What types of gas turbine units are there depending on the air compression method?
4. What is the negative quality of gas turbine units?
5. What is considered a method for improving the efficiency of a gas turbine unit?
6. How does a gas turbine unit with regeneration and two-stage air compression work?
7. How is the energy generated in a gas turbine used?
8. What is needed to start a gas turbine?
9. What is a free-piston gas turbine generator?
10. What does a combined cycle gas turbine plant include?

3. Work on the comparative aspects of steam and gas turbines. Choose from the following phrases that will complete the text:

water vapor
high power
under pressure
the turbine blades

stable operation
the turbine rotor
mechanical work
a combustion chamber
the type of working fluid

Marine turbines convert thermal energy into _____. The difference between steam and gas turbines lies in _____ that drives the turbine blades.

In steam turbines, the working fluid is _____, which is generated in a boiler, heated to high temperatures, and supplied to the blades _____. As it passes through the turbine, the steam expands, performing work and rotating _____.

Gas turbines use the products of fuel combustion mixed with air as the working fluid. The process occurs as follows: air is compressed in a compressor, then mixed with fuel in _____ and ignited. The resulting high-temperature and high-pressure gases are directed to _____, causing them to rotate.

One of the key advantages of turbines is their ability to deliver _____ in a relatively compact package. Gas turbines have better starting characteristics and maneuverability, while steam turbines are characterized by more _____ and a longer service life under constant loads.

4. Fill in the blanks in the table:

Parameter	Steam turbines	Gas turbines
Working fluid		
Efficiency		
Operating temperature		
Launch time		
Specific gravity		

5. Select from the following components those that are suitable for a gas turbine and those that are suitable for a steam turbine:

- *Air intake and compressor*
- *Steam generation boiler*
- *Combustion chamber*
- *High-pressure turbines*
- *High-pressure turbine (drives the compressor)*
- *Low-pressure turbines*
- *Low-pressure turbine (power turbine)*
- *Exhaust system*
- *Condenser for cooling and condensing exhaust steam*
- *Control system and auxiliary equipment*
- *Feedwater regeneration and heating systems*
- *Lubrication and control systems*

***The main components of a marine gas turbine include*:**

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

***A steam turbine plant consists of*:**

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

GRAMMAR FOCUS

In English, **adjectives are classified by** formation (simple, derived, compound) and by meaning (qualitative, quantitative, possessive, demonstrative, etc.). They are also classified by degrees of comparison (positive, comparative, superlative), such as big, bigger, biggest.

By formation, adjectives are:

- Simple: don't have prefixes or suffixes: big, short, cold.
- Derived: are formed using suffixes or prefixes: unhappy, beautiful, natural, incorrect.
- Compound: are formed from two or more words that denote one concept: old-fashioned, high-speed, dark-blue.

By meaning, adjectives are:

- Qualitative/Descriptive: describe a feature (color, size, feeling): beautiful, interesting, small.
- Quantitative/Numeral: denote quantity: two, many, few.
- Possessive: indicate belonging: my, your, his, her.
- Demonstrative: indicate objects: this, that, these, those.
- Interrogative: used for questions: which, what, whose.

By degree of comparison, adjectives are:

- Positive: the basic form: good.
- Comparative: compares two objects (using -er or more): better.
- Superlative: compares more than two objects (using -est or most): the best.

WRITING PRACTICE

6. Translate the text from English into Ukrainian. Write down all the adjectives from the text according to their formation and place them in the following table:

simple adjectives	derived adjectives	compound adjectives

In terms of how it works, a gas turbine engine has a lot in common with internal combustion engines, and in terms of how it converts thermal energy into mechanical work, it is similar to a steam turbine. Therefore, gas turbine installations have the following significant disadvantages: the high temperature of hot gases (800–900 °C) leaving the combustion chamber, which necessitates the use of heat-resistant steels and special heat-resistant materials for heated parts (nozzles, working and guide blades); and significant unproductive power consumption of the gas turbine by the compressor and fuel pump.

The disadvantages also include the difficulty of reversing powerful units, the need to limit the temperature in the flow section (the rotor operates in a dark crimson glow mode and heat-resistant alloy steels are very expensive), as well as the need to supply the combustion chamber with large amounts of air at high pressure, which consumes a significant part of the useful power of the gas turbine.

However, despite these shortcomings, gas turbine units have clear advantages over other power plants and are currently being increasingly introduced as engines in various types of transport.

Gas turbines often have a single stage and operate at speeds of up to 15,000 rpm. These turbines are widely used to drive superchargers in diesel supercharging systems.

Gas turbine plants are a promising type of marine power plant. They combine the positive qualities of steam turbine plants and diesel plants, while being less complex in design.

Unlike steam marine engines, there are no boilers, deaerators, condensers, etc. (i.e., all elements of the condensate supply system). At the same time, gas turbine units, as rotary engines, have higher maneuverability compared to diesel units (better load–speed characteristics), as well as a much simpler design.

Other advantages include the ability to use virtually any fuel, low weight, and compactness.

In gas turbine units, unlike steam turbine units, the working fluid does not undergo phase changes during the supply and removal of energy. Therefore, instead of a feed pump, which consumes up to 1–2 % of the power of a steam turbine plant, a gas turbine plant is equipped with a compressor that consumes up to 75 % of the power of the gas turbine plant due to the compressibility of air.

Despite a number of advantages, gas turbine units on merchant ships have recently been used only to a limited extent for a number of reasons.

7. Memorize or repeat the following words and phrases:

- gas turbine /ˈgæs ˈtɜːbaɪn/ – газова турбіна
- impulse turbine /ˈɪmpʌls ˈtɜːbaɪn/ – активна турбіна
- reaction turbine /rɪˈækʃən ˈtɜːbaɪn/ – реактивна турбіна
- single-casing turbine /ˈsɪŋgl ˈkeɪsɪŋ ˈtɜːbaɪn/ – однокорпусна турбіна
- multi-casing turbine /ˈmʌlti ˈkeɪsɪŋ ˈtɜːbaɪn/ – багатокорпусна турбіна
- combustion chamber /kəmˈbʌstʃən ˈtʃeɪmbə/ – камера згоряння
- regeneration /rɪˌdʒenəˈreɪʃən/ – регенерація
- two-stage air compression /ˌtuː steɪdʒ eə kəmˈpreʃən/ – двоступеневе стиснення повітря
- low-pressure compressor /ˌləʊ ˈpreʃə kəmˈpresə/ – компресор низького тиску
- low-pressure turbine /ˌləʊ ˈpreʃə ˈtɜːbaɪn/ – турбіна низького тиску
- waste-heat boiler /ˌweɪst ˈhiːt ˈbɔɪlə/ – утилізаційний (котел-утилізатор)

• starting electric motor /ˈstɑːtɪŋ ɪˈlektrɪk ˈməʊtə/ – пусковий електродвигун

• free-piston gas generator /ˌfriː ˈpɪstən gæs ˈdʒenəreɪtə/ – газогенератор з вільним поршнем

• piston rods /ˈpɪstən rɒdz/ – поршневі штоки

• compressor cylinder /kəmˈpresə ˈsɪlɪndə/ – циліндр компресора

• purge port /pɜːdʒ pɔːt/ – продувний отвір

• exhaust port /ɪgˈzɔːst pɔːt/ – випускний отвір

• receiver /rɪˈsiːvə/ – ресивер, приймач

• purge receiver /pɜːdʒ rɪˈsiːvə/ – продувний приймач

• water vapor /ˈwɔːtə ˈveɪpə/ – водяна пара

• turbine blade /ˈtɜːbaɪn bleɪd/ – лопатка турбіни

• turbine rotor /ˈtɜːbaɪn ˈrəʊtə/ – ротор турбіни

• mechanical work /mɪˈkænɪkəl wɜːk/ – механічна робота

• working fluid /ˈwɜːkɪŋ ˈfluːɪd/ – робоче тіло

• efficiency /ɪˈfɪʃənsi/ – коефіцієнт корисної дії (ККД)

• operating temperature /ˈɒpəreɪtɪŋ ˈtemprətʃə/ – робоча температура

• launch time /lɔːntʃ taɪm/ – час пуску

• specific gravity /spəˈsɪfɪk ˈgrævɪti/ – питома вага

• air intake /eə ˈɪnteɪk/ – повітрозабірник

• steam generation boiler /stiːm ˌdʒenəˈreɪʃən ˈbɔɪlə/ – парогенераторний котел

• high-pressure turbine /ˌhaɪ ˈpreʃə ˈtɜːbaɪn/ – турбіна високого тиску

• condenser for cooling /kənˈdensə fə ˈkuːlɪŋ/ – конденсатор для охолодження

• condensing exhaust steam /kənˈdensɪŋ ɪgˈzɔːst stiːm/ – конденсація відпрацьованої пари

• auxiliary equipment /ɔːgˈzɪljəri ɪˈkwɪpmənt/ – допоміжне обладнання

• feedwater regeneration /ˈfiːdwɔːtə rɪˌdʒenəˈreɪʃən/ – регенерація живильної води

• heating system /ˈhiːtɪŋ ˈsɪstəm/ – система опалення.

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. What is the main difference between a gas turbine and a steam turbine?

A. The number of stages
B. The type of working medium
C. The direction of rotation
D. The shaft speed

2. What working medium is used in a gas turbine?

A. Steam from boilers
B. Water vapor
C. Gases produced by fuel combustion
D. Compressed air only

3. How does the design of a gas turbine compare to that of a steam turbine?

A. Completely different
B. Simpler and unrelated
C. Similar in design and operation
D. Identical in all aspects

4. What temperature range do hot gases in gas turbines usually reach?

A. 300–400 °C
B. 500–600 °C
C. 700–800 °C
D. 1000–1200 °C

5. What is the effect of higher operating temperatures on gas turbines?

A. Increased efficiency only
B. Longer service life
C. Reduced operating life
D. Lower maintenance costs

6. What is a negative feature of gas turbine units (GTUs)?

A. Low power output
B. Large heat losses with exhaust gases
C. Low rotational speed
D. Poor combustion

7. What process increases GTU efficiency by using exhaust heat to warm intake air?

A. Compression
B. Cooling
C. Regeneration
D. Condensation

8. What efficiency can be achieved using regeneration and two-stage air compression?

A. 15–20 %
B. 20–25 %
C. 28–30 %
D. About 40 %

9. What drives the low-pressure compressor in a gas turbine plant with a combustion chamber?

A. An electric motor
B. A diesel engine
C. The gas turbine shaft
D. Hydraulic pressure

10. What is the function of the regenerator in a gas turbine plant?
    A. To cool the exhaust gases
    B. To heat the air using exhaust gases
    C. To compress the air
    D. To burn the fuel

11. Why must a gas turbine be spun up by starter electric motors?
    A. To cool the turbine
    B. To lubricate the bearings
    C. To start the turbine operation
    D. To reduce exhaust emissions

12. What component replaces the combustion chamber in a GTU with a free-piston gas generator (FPGG)?
    A. Steam boiler
    B. Diesel cylinder
    C. Regenerator
    D. Waste heat boiler

13. What causes the pistons in an FPGG to move apart?
    A. Compressed air
    B. Mechanical drive
    C. Expansion of combustion gases
    D. Hydraulic pressure

14. What is the approximate efficiency of a combined gas turbine plant with an FPGG?
    A. 25 %
    B. 30 %
    C. 35 %
    D. Close to 40 %

15. What is a key advantage of gas turbines compared to steam turbines?

A. Longer service life under constant load
B. Lower operating temperature
C. Better starting characteristics and maneuverability
D. Lower compressor power consumption

16. What is a major disadvantage of gas turbine units?

A. Low compactness
B. Need for boilers and condensers
C. High power consumption by compressors
D. Low rotational speed

17. Gas turbines used for driving superchargers usually:

A. Have many stages and low speed
B. Operate at speeds up to 15,000 rpm
C. Use water as working fluid
D. Require condensers

18. Why are gas turbine units rarely used on merchant ships today?

A. They cannot use different fuels
B. They are too heavy
C. Despite advantages, they have several significant drawbacks
D. They are unreliable.

SECTION 11. MARINE NUCLEAR POWER PLANTS INFORMATION FOCUS

1. Read the text carefully and remember the necessary information:

Ship nuclear power plants are used to generate thermal energy as a result of the fission of fissionable elements, which occurs in devices called nuclear reactors. Ships with such power plants have a virtually unlimited cruising range.

The energy released by the fission reaction when using 1 kg of uranium is approximately equal to the energy obtained by burning 1,400 tons of fuel oil. The daily consumption of nuclear fuel on transport ships is estimated at only several tens of grams. The replacement interval for fuel elements in ship reactors is two to three years.

Despite the large mass of the nuclear plant, caused by the significant weight of biological shielding, the useful carrying capacity of ships with nuclear power plants is significantly greater than that of ships of the same size with conventional power plants. The increase in cargo capacity on these ships is due to the absence of conventional fuel reserves.

To increase the speed of ships, the use of nuclear-powered installations is economically advantageous, as it allows an increase in propulsion power without a significant increase in weight. A decisive advantage of ship nuclear installations is that they do not require air to operate. This feature solves the problem of long-duration underwater navigation for ships.

As is well known, vessels moving underwater in a homogeneous environment encounter less hydrodynamic resistance than surface vessels and, therefore, can develop higher speeds with the same engine power. Large-displacement underwater transport vessels

can be significantly more cost-effective to operate than surface vessels of the same displacement.

Artificially enriched uranium with a U-235 isotope content of 3–5 % is used as nuclear fuel for modern ship reactors.

The part of the reactor where the chain reaction takes place is called the reactor core. A special substance, called a neutron moderator, is introduced into this zone to slow down neutrons to thermal velocities. Light water (H_2O), heavy water (D_2O), beryllium, or graphite are used as moderators.

Reactors are classified as homogeneous or heterogeneous based on the type of core. In homogeneous reactors, the nuclear fuel and the moderator form a uniform mixture. In heterogeneous reactors, the nuclear fuel is located in the moderator in the form of rods or plates called fuel elements. Only heterogeneous reactors are used in ship nuclear power plants.

During a nuclear reaction, about 80 % of the energy is converted into heat, and approximately 20 % is released in the form of radiation (alpha, beta, and gamma radiation). Alpha and beta radiation do not pose a significant hazard under normal operating conditions. However, gamma radiation and neutron radiation, which have high penetrating ability, cause secondary radiation in many materials. This radiation can cause serious damage to the human body.

To prevent such radiation exposure, nuclear power plants must have reliable protection, known as biological shielding. Biological shielding is usually made of metal, water, and concrete and is large in size and mass.

COMPREHENSION

2. Based on the text, determine which statement is correct and which is not, marking *true* or *false*.

1. Ship nuclear power plants generate thermal energy through the fission of fissile elements.

2. Ships equipped with nuclear power plants have a limited cruising range due to fuel consumption.

3. The energy released by fission of 1 kg of uranium is approximately equal to the energy from burning 1,400 tons of fuel oil.

4. The daily consumption of nuclear fuel on transport ships is measured in kilograms.

5. The useful carrying capacity of nuclear-powered ships is greater because they do not need conventional fuel.

6. Nuclear-powered installations allow an increase in propulsion power without a significant increase in weight.

7. Nuclear power plants require air to operate, which limits underwater navigation.

8. Modern ship reactors use artificially enriched uranium with a U-235 content of 3–5 %.

9. Both homogeneous and heterogeneous reactors are used in ship nuclear power plants.

10. Biological protection is necessary because gamma and neutron radiation are highly penetrating and dangerous to humans.

GRAMMAR FOCUS

When studying English, it is important to pay attention to **the pronunciation of verbs and adjectives ending in -ed.**

The ending -ed in English is pronounced in three ways: [id] after t, d (wanted, needed), [t] after unvoiced consonants (k, s, ch, sh, p, f), and [d] after voiced consonants (l, n, r, b, g, m, z, v) and vowels (played, lived). The main thing is to focus on the last sound of the verb, not the letter.

Three basic rules of pronunciation:

[id] – after the sounds t, d (for example, wanted, needed).

[t] – after unvoiced consonants (k, s, ch, sh, p, f): watched, laughed, booked.

[d] – after vowels and voiced consonants (l, n, r, b, g, m, z, v): played, loved.

3. Choose verbs and adjectives from the text below and sort them into three columns according to their pronunciation:

[d]	[t]	[id]

Nuclear power plants (NPPs) offer seagoing vessels capabilities that are unattainable with fossil fuel-powered marine propulsion systems. These include, first and foremost, an unlimited cruising range at high power, higher speeds, and extended endurance. The use of NPPs increases the overall performance of cargo vessels of all types by reducing the total weight of the propulsion system, which includes the propulsion system itself and the fuel required for it. Fuel stored for a voyage accounts for up to 15 % of the cargo weight, equivalent to approximately 10,000 tons for a cargo vessel with a propeller-driven power of 40–60 MW.

NPPs with any established reactor type, using a steam turbine or gas turbine cycle, can be used on seagoing vessels. The most widely used nuclear power plants are double-loop pressurized water reactors (PWRs), as they are the most proven, compact, easy to operate, and resistant to pitching and trim. Such plants are used on the transport vessels Savannah (USA), Otto Hahn (Germany), and Mutsu (Japan).

Naval vessels in developed countries most often use fast-neutron or intermediate-neutron nuclear power reactors (with neutron energies in the 1–1000 eV range), whose cores are cooled by liquid sodium or liquid lead (or their alloys). These

reactors, while delivering the same power as other reactor types, have the smallest dimensions, and the high temperature of the liquid-metal coolant (approximately 600 °C) ensures a nuclear power plant efficiency of about 40 %.

WRITING PRACTICE

4. Write down all the words that have the ending -ed and indicate how it should be pronounced and according to which rule:

Marine nuclear power plants are used on some types of ships to generate energy for propulsion and onboard systems. They operate by using a controlled nuclear fission process inside a nuclear reactor. During fission, a large amount of heat is produced. This heat is used to generate steam, which drives steam turbines connected to the ship's propulsion system.

One of the main advantages of marine nuclear power plants is their long operating time without refuelling. A very small amount of nuclear fuel can produce a large amount of energy. Because of this, nuclear-powered ships can travel very long distances and have an almost unlimited cruising range. In addition, these power plants do not require air to operate, which makes them especially suitable for submarines and other underwater vessels.

Marine nuclear reactors usually use enriched uranium as fuel. The fuel is placed in special fuel elements inside the reactor core. A moderator, such as water or graphite, is used to slow down neutrons and control the nuclear reaction. The reactor works under strict control to ensure safe and stable operation.

Safety is extremely important in marine nuclear power plants. During nuclear reactions, radiation is produced, which can be dangerous to humans. To protect the crew, nuclear power plants are equipped with biological protection made of metal,

water, and concrete. This protection reduces radiation levels and allows safe operation of the ship.

5. Translate the text from Ukrainian into English. Select the verbs listed below that can be used in the text in these forms and find synonyms for them:

are positioned
holds out
requires
could look
will not happen
would be
is gaining
to provide
is needed
can be viewed

Потенціал ядерної енергії можна розглядати у двох основних аспектах: ядерна енергія для суден та ядерна енергія для майбутніх видів палива. Обидва напрями пропонують значні можливості, але потребують набагато глибшого розвитку як у технологічній, так і в нормативно-регуляторній базах.

Ядерна енергія має потенціал суттєво трансформувати рівень викидів вуглецю у виробництві електроенергії, промисловості та транспорті. Її здатність забезпечувати чисті альтернативні джерела енергії в судноплавстві вже привернула значну увагу, і шлях до екологічно чистішої морської енергетики набирає обертів.

З точки зору досягнення амбіцій Міжнародної морської організації (ІМО) щодо нульових викидів до 2050 року, було б помилково ігнорувати ядерну енергію як складову

паливно-енергетичного балансу. Однак прогрес не буде можливим без створення правил, які забезпечують фундаментальну основу для визначення того, якими можуть бути ядерні системи в морському секторі.

Ядерна енергія має потенціал стати руйнівною (трансформаційною) силою для морського сектора. Забезпечення її успішної та безпечної інтеграції в судноплавну галузь вимагає нового формату міжнародної, міжгалузевої та міжінституційної співпраці.

Ядерна енергія для суден відкриває перспективу використання передових малих модульних ядерних реакторів (SMR) як джерела рушійної енергії, тоді як ядерна енергія для майбутніх видів палива включає в себе сценарії, за яких малі модульні ядерні реактори розміщуються поблизу узбережжя для виробництва енергії для портів та підтримки процесів створення альтернативних видів палива.

6. Work on the diagram below and fill in the gaps in the text, choosing from the clues below:

the single-circuit design
biological shielding
the working fluid
conventional fuel reserves
reactor
slightly superheated
pump
a dual-circuit (two-loop) scheme
mechanical work
refuelling
the primary circuit
the heat exchanger (steam generator)
turbine

the fuel elements
auxiliary systems
the condenser

Currently, marine nuclear power plants are designed according to _____ using water as a reactor coolant and as _____. The diagram of such a plant is shown in the Fig. 7 below.

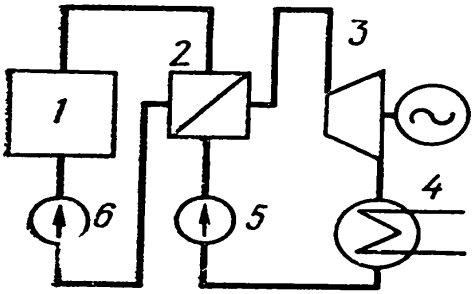

Fig. 7. Schematic diagram of the secondary (steam turbine) circuit of a marine nuclear power plant

Hot water under high pressure leaves _____ (1) and enters _____ (2), from which it is pumped back into the reactor by _____ (6). The heat released by the water in the primary circuit is used to generate steam in the steam generator. This steam then enters _____ (3), expands within the turbine, and performs _____.

The spent steam from the turbine is sent to _____ (4), where it is condensed back into water, which is then fed into the steam generator by pump (5).

The advantages of a dual-circuit nuclear power plant design include the fact that the turbine, condenser, and their _____ are accessible during plant operation.

However, the pressure in the secondary circuit is always significantly lower than in _____ (due to the need to maintain a temperature difference in the steam generator). In addition, the steam in the second circuit can only be _____. Both of these factors are considered disadvantages of the dual-circuit design.

When comparing the two designs, it can be concluded that _____ is structurally much simpler, while the dual-circuit design significantly simplifies biological protection requirements.

The use of nuclear power plants on ships allows for a virtually unlimited cruising range without _____. The daily consumption of nuclear fuel on ships is estimated at only tens of grams; therefore, _____ in the reactors are replaced once every two to three years.

Given that ships with nuclear power plants do not carry _____, their total weight, even when accounting for _____, is lower than that of conventional ship power plants with fuel reserves. This results in an increased payload capacity of the ship.

7. Work on learning new words and phrases and repeating words you know:

- ship nuclear power plant /ʃɪp ˈnjuːklɪə ˈpaʊə plɑːnt/ – суднова ядерна енергетична установка
- thermal energy /ˈθɜːməl ˈenədʒi/ – теплова енергія
- nuclear fission /ˈnjuːklɪə ˈfɪʃən/ – ядерне ділення
- fissionable elements /ˈfɪʃənəbl ˈelɪmənts/ – елементи, здатні до поділу
- nuclear reactor /ˈnjuːklɪə rɪˈæktə/ – ядерний реактор
- cruising range /ˈkruːzɪŋ reɪndʒ/ – дальність плавання
- uranium /jʊˈreɪnɪəm/ – уран
- fuel oil /ˈfjuːəl ɔɪl/ – мазут

- nuclear fuel /ˈnjuːklɪə ˈfjuːəl/ – ядерне паливо
- fuel elements /ˈfjuːəl ˈelɪmənts/ – паливні елементи
- replacement interval /rɪˈpleɪsmənt ˈɪntəvəl/ – інтервал заміни
- biological shielding /ˌbaɪəˈlɒdʒɪkəl ˈʃiːldɪŋ/ – біологічний захист
- carrying capacity /ˈkærɪɪŋ kəˈpæsɪti/ – вантажопідйомність
- conventional power plant /kənˈvenʃənəl ˈpaʊə plɑːnt/ – традиційна енергетична установка
- propulsion power /prəˈpʌlʃən ˈpaʊə/ – рушійна потужність
- underwater navigation /ˌʌndəˈwɔːtə ˌnævɪˈgeɪʃən/ – підводне плавання
- hydrodynamic resistance /ˌhaɪdrəʊdaɪˈnæmɪk rɪˈzɪstəns/ – гідродинамічний опір
- displacement /dɪsˈpleɪsmənt/ – водотоннажність
- enriched uranium /ɪnˈrɪtʃt jʊˈreɪnɪəm/ – збагачений уран
- U-235 isotope /ˈaɪsəˌtəʊp/ – ізотоп U-235
- reactor core /rɪˈæktə kɔː/ – активна зона реактора
- chain reaction /tʃeɪn rɪˈækʃən/ – ланцюгова реакція
- neutron moderator /ˈnjuːtrɒn ˈmɒdəreɪtə/ – сповільнювач нейтронів
- thermal neutrons /ˈθɜːməl ˈnjuːtrɒnz/ – теплові нейтрони
- light water /laɪt ˈwɔːtə/ – легка вода
- heavy water /ˈhevɪ ˈwɔːtə/ – важка вода
- graphite /ˈgræfaɪt/ – графіт
- beryllium /bəˈrɪlɪəm/ – берилій
- homogeneous reactor /ˌhɒməˈdʒiːnɪəs rɪˈæktə/ – гомогенний реактор
- heterogeneous reactor /ˌhetərəˈdʒiːnɪəs rɪˈæktə/ – гетерогенний реактор

- radiation /ˌreɪdɪˈeɪʃən/ – випромінювання
- alpha radiation /ˈælfə ˌreɪdɪˈeɪʃən/ – альфа-випромінювання
- beta radiation /ˈbiːtə ˌreɪdɪˈeɪʃən/ – бета-випромінювання
- gamma radiation /ˈgæmə ˌreɪdɪˈeɪʃən/ – гамма-випромінювання
- penetrating ability /ˈpenɪtreɪtɪŋ əˈbɪlɪti/ – проникна здатність
- steam turbine /stiːm ˈtɜːbaɪn/ – парова турбіна
- gas turbine cycle /gæs ˈtɜːbaɪn ˈsaɪkəl/ – газотурбінний цикл
- pressurized water reactor (PWR) /ˈpreʃəraɪzd ˈwɔːtə rɪˈæktə/ – водо-водяний реактор під тиском
- liquid-metal coolant /ˈlɪkwɪd ˈmetl ˈkuːlənt/ – рідкометалевий теплоносій
- efficiency /ɪˈfɪʃənsi/ – коефіцієнт корисної дії (ККД)
- safe operation /seɪf ˌɒpəˈreɪʃən/ – безпечна експлуатація

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. What is the main purpose of ship nuclear power plants?

A. To generate electrical energy only
B. To generate thermal energy through nuclear fission
C. To store nuclear fuel
D. To reduce ship displacement

2. Where does nuclear fission take place in a ship nuclear power plant?

A. In the condenser
B. In the turbine
C. In the nuclear reactor
D. In the heat exchanger

3. Why do nuclear-powered ships have an almost unlimited cruising range?

A. They use renewable energy
B. They consume very small amounts of nuclear fuel
C. They can refuel at sea
D. They have larger fuel tanks

4. The energy released by fission of 1 kg of uranium is approximately equal to:

A. 14 tons of fuel oil
B. 140 tons of fuel oil
C. 1,400 tons of fuel oil
D. 14,000 tons of fuel oil

5. The daily consumption of nuclear fuel on transport ships is estimated at:

A. several kilograms
B. several tons
C. several grams
D. several liters

6. How often are fuel elements in ship reactors replaced?

A. every six months
B. once a year
C. every two to three years
D. every five years

7. Why is the useful carrying capacity of nuclear-powered ships greater than that of conventional ships?

A. They are built from lighter materials
B. They have smaller engines
C. They do not carry conventional fuel
D. They operate at lower speeds

8. What economic advantage do nuclear power plants provide when increasing ship speed?

A. Reduced crew size

B. Increased propulsion power without significant weight increase

C. Lower maintenance cost

D. Reduced hull resistance

9. Why are nuclear power plants especially suitable for underwater vessels?

A. They are smaller in size

B. They do not require air to operate

C. They use seawater as fuel

D. They reduce noise

10. What type of uranium is used as fuel in modern ship reactors?

A. Natural uranium

B. Depleted uranium

C. Artificially enriched uranium

D. Uranium-plutonium mixture

11. What is the typical U-235 content in nuclear fuel for ship reactors?

A. 1–2 %

B. 3–5 %

C. 10–15 %

D. over 20 %

12. What part of the reactor contains the chain reaction?

A. The moderator

B. The condenser

C. The core
D. The shielding

13. What is the function of a neutron moderator?
A. To absorb radiation
B. To cool the reactor core
C. To slow down neutrons
D. To increase fuel consumption

14. Which of the following substances can be used as a neutron moderator?
A. Diesel fuel
B. Liquid sodium
C. Graphite
D. Concrete

15. Which type of reactor is used in ship nuclear power plants?
A. Homogeneous reactors only
B. Heterogeneous reactors only
C. Both homogeneous and heterogeneous reactors
D. Fast reactors only

16. Approximately what percentage of nuclear reaction energy is converted into heat?
A. 50 %
B. 60 %
C. 80 %
D. 100 %

17. Which types of radiation are considered the most dangerous due to high penetrating power?

A. Alpha and beta radiation
B. Alpha and gamma radiation
C. Gamma and neutron radiation
D. Beta and neutron radiation

18. What materials are commonly used for biological protection in nuclear power plants?

A. Plastic and rubber
B. Wood and insulation
C. Metal, water, and concrete
D. Steel only.

UNIT 4
SHIP STEAM BOILERS

SECTION 12. PRINCIPLES OF OPERATION AND MAIN TYPES OF STEAM BOILERS INFORMATION FOCUS

1. Read the text carefully and remember the information that is new to you:

A steam boiler is a unit designed for the continuous production of steam with specific parameters by converting various types of energy into heat. The most common source of thermal energy used on ships is solid or liquid fuel. In recent years, the heat from gases emitted by internal combustion engines in waste-heat boilers, with a temperature of 300–450 °C, has been increasingly used. Sometimes, electricity (in electric boilers) and nuclear energy (in ship reactors) are also used to produce steam.

In most steam boilers, steam is produced as a result of the transfer of heat released during fuel combustion in the furnace to the working medium – water.

The following processes take place in a steam boiler, resulting in the continuous production of water vapor:

- furnace process – fuel combustion in the boiler furnace;
- aerodynamic process – the supply of air to the furnace and the removal of fuel combustion products from the flues;
- heat-transfer process – the transfer of heat from gases to water through the heating surfaces;
- hydrodynamic process – the movement (circulation) of water and steam inside the boiler along its heating surfaces.

These processes are closely interrelated and are accompanied by side effects such as metal corrosion, deposit formation, and deterioration of boiler component strength, which adversely affect the reliable and economical operation of steam boilers.

Based on the type of gas washing of the heating surfaces of pipes or other elements, marine boilers are divided into gas-tube, water-tube, and combined boilers. In a gas-tube boiler, hot gases, which are the main heat carrier, move inside the pipes, while water surrounds them from the outside. In a water-tube boiler, the opposite arrangement is used: water and a steam-water mixture flow inside the pipes, and hot gases wash them from the outside. Between these two groups, there is always an intermediate group that has the properties of both gas-tube and water-tube boilers (see Fig. 8).

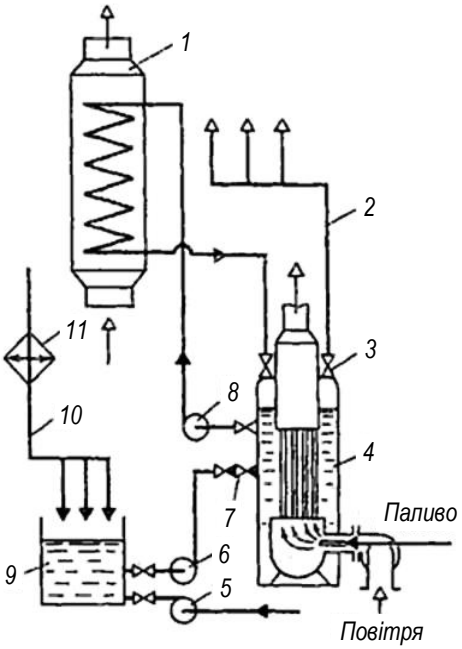

Fig. 8. Diagram of a boiler room with combined heating surfaces

On modern ships, only water-tube boilers are used as main boilers. Auxiliary boilers on motor ships and gas turbine ships can be gas-tube or water-tube (or gas-water-tube) boilers. Gas-water-tube boilers have heating surface elements arranged according to both gas-tube and water-tube principles. Gas-tube and gas-water-tube boilers are more common on foreign-built ships. In recent years, water-tube boilers have become increasingly prevalent.

Vertical gas-tube boiler (Fig. 9 a). The cylindrical body (3) of the boiler houses the furnace (4) and smoke chambers (1), which are connected by straight pipes (6). Fuel and air are supplied to the furnace from the fuel injection unit (not shown in Fig. 9 a) through pipe (5), and the combustion products are removed through pipe (2) into the chimney.

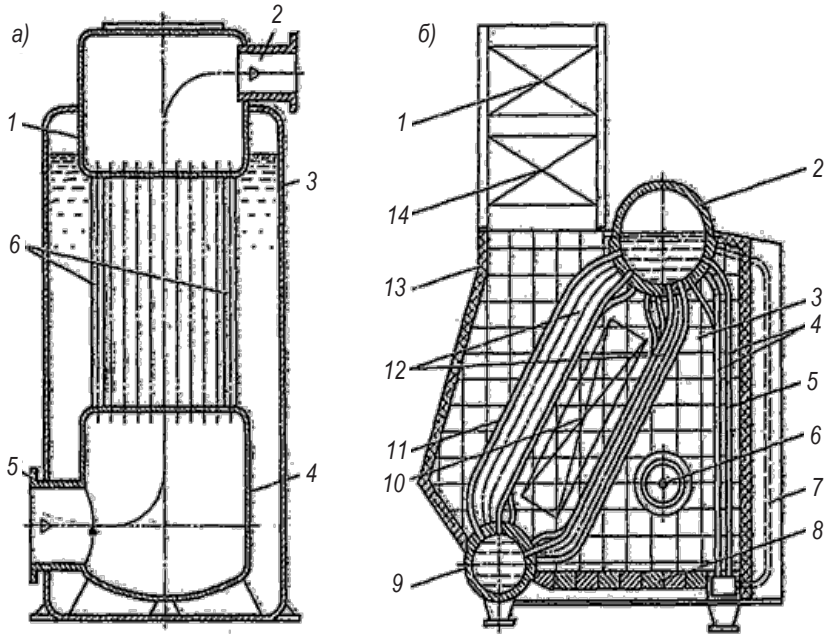

Fig. 9. Gas-fired (a) and water-fired (b) boilers

Water-tube boiler (Fig. 9 b). The boiler consists of an upper steam collector (2) and a lower water collector (9), connected by pipes (12). The bundle of pipes (4) located on the side wall is called a side screen. The pipes (5) of the second row of the screen, shielded by the pipes of the first row, as well as the pipes (7) located outside the furnace or in special enclosures, are called downcomer pipes. In some boilers, the pipes (11), which are furthest from the furnace, are also called downcomer pipes. All other pipes are riser pipes.

Depending on their location, different heating surfaces of the boiler receive different amounts of heat, which largely determines the character of heat exchange. Fig. 9 b also schematically shows the economizer (1), air heater (14), boiler cladding (13), boiler nozzle (6), brickwork (3), furnace bottom (8), and steam superheater (10).

COMPREHENSION

2. Answer the following questions:

1. What is a steam boiler designed for?
2. What types of energy can be converted into heat in a steam boiler?
3. What is the most common source of thermal energy used on ships?
4. How is waste heat from internal combustion engines used in modern ships?
5. How is steam produced in most steam boilers?
6. What main processes take place in a steam boiler during steam production?
7. Why are the processes inside a steam boiler closely interrelated?
8. What side effects can occur during boiler operation?

9. How are marine boilers classified based on the type of gas washing of heating surfaces?

10. What is the main difference between gas-tube and water-tube boilers?

11. Which type of boiler is used as a main boiler on modern ships and why?

12. What boiler components are shown in the diagram of a water-tube boiler?

3. Read the text below and note the main advantages and disadvantages of water-tube and gas-tube boilers.

Fill in the table 4 with the words/ sentences from text below:

Table 4. **The main advantages and disadvantages of water-tube and gas-tube boilers**

Advantages of water-tube boilers	Disadvantages of water-tube boilers	Advantages of gas-tube boilers	Disadvantages of gas-tube boilers
1. 2.	1. 2.	1. 2.	1. 2.

When reviewing the classification of the various types of boilers discussed, it is possible to note the main advantages and disadvantages of water-tube and gas-tube boilers.

Water-tube boilers have a significantly higher steam production capacity and lower mass characteristics than gas-tube (fire-tube) boilers. Auxiliary boilers, especially fire-tube boilers, are usually limited to a pressure of up to 1.8 MPa and a temperature of 300–320 °C.

Depending on the boiler design and operating conditions, the minimum time required to bring steam up to operating pressure is approximately 1.5–3.0 hours for water-tube boilers

and 4–24 hours for fire-tube boilers. This is due to the smaller amount of water in a water-tube boiler, its intensive circulation, and the elasticity of the pipes connecting the boiler drums (manifolds).

Comparing the additional advantages and disadvantages of gas-tube and water-tube boilers, it can also be noted that in a water-tube boiler the amount of water is smaller than the hourly steam production, so the water level can change very quickly from the highest to the lowest permissible level. To avoid emergencies and maintain a stable water level, it is necessary to use more sophisticated automatic control and boiler feed systems, which are associated with automatic fuel combustion control. It is also necessary to use a complex automatic steam pressure control system.

Gas-tube boilers are relatively less sensitive to the quality of feedwater. In highly heat-stressed water-tube boilers, scale deposits on the heating surfaces can create a risk of local overheating of metal pipes and their subsequent rupture. A gas-tube boiler has a relatively low steam capacity but a higher degree of steam dryness, due to the low intensity of steam formation. A gas-tube boiler is also less sensitive to load fluctuations, which is explained by its large water and steam storage capacity.

Despite all the advantages of water-tube waste-heat boilers with multiple forced circulation, they are less reliable due to the need to install circulation pumps that operate in relatively harsh conditions when pumping hot water and steam–water mixtures.

GRAMMAR FOCUS

A ***suffix*** is a morpheme (part of a word) that comes after a root and is used to form new words or change its part-of-speech property.

The most common suffixes and their functions:

For the formation of Adjectives:

-ful: full of something (useful, beautiful).

-less: without something (hopeless, careless, endless).

-ous / -ious: having a certain quality (dangerous, curious).

-able / -ible: capable of (readable, comfortable, edible).

-y: having a characteristic (sunny, noisy, hungry).

-ic: related to (historic, poetic, electric).

-en: made of (golden, wooden, to whiten).

For the formation of Nouns:

-ness: a state or quality (happiness, kindness, loneliness).

-ment: the result of an action (development, enjoyment, adjustment).

-ion / -tion: action or state (action, creation, communication).

-er / -or: one who performs an action (teacher, worker, actor).

-ist / -ism: direction, trend, affiliation (artist, scientist, communism).

For forming Verbs:

-ate: to do something (decorate, communicate).

-en: to become (widen, blacken, weaken).

-ify: to transform (simplify, purify).

-ize / -ise: to do (realize, organize).

For forming Adverbs:

-ly: indicates a method of action (quickly, slowly, happily).

-ward / -wards: indicates a direction (forward, backward).

4. Fill the gaps by adding a suffix to the word in brackets.

A modern boiler consists of the (*follow*) main components: a casing with a developed (*heat*) surface; a frame and foundation; firebrick lining; (*insulate*) and casing; an in-drum unit; a water economizer; a superheater and desuperheater; a furnace with a combustion chamber; an air heater with air ducts; chimneys

with a stack; valves and measuring, monitoring, and control instruments.

A marine boiler plant (*typical*) includes several steam boilers. Their normal operation is ensured by the following systems: feed, fuel supply, air supply and gas (*remove*), blowdown, water (*treat*), soot blower, monitoring, (*regulate*), and control. Each system is supported by various mechanisms and devices that perform specific functions.

A steam boiler has two separate circuits: steam-water and air-gas. The water surface separating the steam and water spaces in the boiler is called the (*evapor*) surface. During operation, the boiler pressure may rise above the design (permissible) level. To prevent a breakdown that could occur in this case, a safety valve is installed on the steam boiler. The steam pressure in the boiler is monitored (*use*) a pressure gauge.

To improve the (*efficient*) of the steam power plant, superheated steam is generated by a superheater located in the (*boil*) flue. For this purpose, the feedwater entering the boiler is preheated in an economizer, which utilizes the heat from the flue gases. The economizer is also installed in the boiler flue. Feedwater can also be preheated in water heaters, which utilize the heat from exhaust steam from the ship's auxiliary (*machine*). Heated water from the water heater is sent through pipelines to the economizer, where it is further heated. From the economizer, the heated water enters the boiler. The steam boiler is installed on a (*found*).

5. Select the definitions (right column of the table 5) for the most common auxiliary boilers on marine vessels (left column of the table 5) and indicate which of the diagrams correspond to them (fig. 10 and fig. 11):

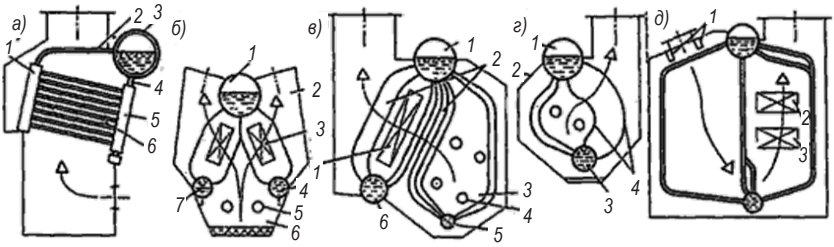

Fig. 10. Diagrams of the main design variants of water-tube boilers with natural circulation

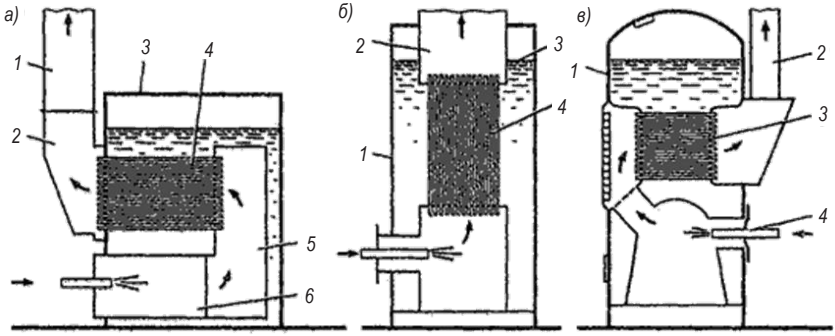

Fig. 11. Schematic diagrams of gas-fired boilers

Table 5. **The most common auxiliary boilers on marine vessels**

Sectional horizontal boiler	– The boiler has a cylindrical vertical body 1, straight horizontal pipes 3 chambers for gas passage, and an exhaust chimney 2. The boiler is powered by a fuel-injection unit 4 with unattended operation. Removable shields are provided to divert gas in the chambers, which also simplify boiler cleaning. – This is a conventional boiler. The boiler has a cylindrical body 1 and vertical straight pipes 4 connected to the smoke chamber 2. The steam space is located above the evaporation mirror 3. The boiler has an automated fuel injection unit with unattended operation. A similar boiler design can be found on Split-type tankers.
Three-collector two-pass boiler	
Three-collector single-pass boiler	
Two-collector, single-pass gas boiler with natural circulation	
Shaft-type boiler	

Continuation Table 5

Horizontal gas-fired boiler Vertical gas-tube boiler with vertical tubes Vertical gas-fired boiler with horizontal pipes	– The boiler has a cylindrical body 3, a furnace (heat pipe) 6, a combustion chamber 5, horizontal straight pipes 4, a smoke box 2, and an exhaust chimney 1. The furnace is equipped with a rotary nozzle. Hatches and necks are provided for internal inspection, rolling, and cleaning of pipes. Significant disadvantages of the boiler are low steam pressure, unorganized water circulation, rigidity of the structure, high metal consumption, and high labor intensity of manufacture and repair. – This is a relatively new type of main boiler with a developed radiation heating surface in the furnace. A distinctive feature of these boilers is the ceiling location of nozzles 1 and the installation of two steam superheaters: main 3 and intermediate 2. Such boilers are installed on large-tonnage ships with powerful steam power plants. – The boiler consists of two collectors 1 and 3 connected by curved rising steam-generating pipes 4, screen pipes 2, downcomer pipes, and pipes of the second and third rows of the screen. – The boiler has four collectors: one steam collector 1, two water collectors 5, b, and one steam superheater 7. The gases formed in the furnace 3 during the operation of the nozzles 4 pass between the tubes 2. The steam superheater 7 generates steam with a temperature of 470 °C at a boiler pressure of 4.4 MPa. The unit is equipped with four steam-mechanical nozzles 4 located at the front of the boiler. – In this boiler, steam collector 1 is connected to two water collectors 4 and 7 by bundles of pipes. The gases formed in the furnace 6 during the operation of the nozzles 5 pass between the pipes. A steam superheater 3 can be located inside the bundles of steam-generating pipes. When each gas pass has different heating elements, if the steam superheater is installed on one side of the gas flow, the boiler will be asymmetrical, and when there are two identical elements on both sides of the gas pass, the boiler will be symmetrical.

Continuation Table 5

	Currently, these boilers can be found as main and auxiliary boilers only on old ships. Boilers of this type are often called tent-type or triangular-type boilers. In triangular-type boilers, the headers and steam-generating pipes can be located vertically and horizontally. – The classification feature of this boiler is the slope of the pipes. In such boilers, the slope of the pipes is less than 30°. The boilers have a horizontal steam collector 3 and straight steam-generating pipes 6, connected by chambers 1 and 5 in the section. Each section is connected to the steam collector by short pipes 4 and a steam outlet pipe 2. These boilers were widely used in the recent past as main boilers; currently, they are used as auxiliary boilers on some series-produced diesel tankers.

6. Work on your vocabulary:

- steam boiler /stiːm ˈbɔɪlə/ – паровий котел
- continuous production of steam /kənˈtɪnjuəs prəˈdʌkʃən əv stiːm/ – безперервне виробництво пари
- specific parameters /spəˈsɪfɪk pəˈræmɪtəz/ – задані параметри
- thermal energy /ˈθɜːməl ˈenədʒi/ – теплова енергія
- solid fuel /ˈsɒlɪd ˈfjuːəl/ – тверде паливо
- liquid fuel /ˈlɪkwɪd ˈfjuːəl/ – рідке паливо
- internal combustion engine /ɪnˈtɜːnəl kəmˈbʌstʃən ˈendʒɪn/ – двигун внутрішнього згоряння
- waste-heat boiler /weɪst hiːt ˈbɔɪlə/ – утилізаційний (утилізаторний) котел
- electric boiler /ɪˈlektrɪk ˈbɔɪlə/ – електричний котел
- nuclear energy /ˈnjuːklɪə ˈenədʒi/ – ядерна енергія
- furnace process /ˈfɜːnɪs ˈprəʊses/ – топковий процес
- fuel combustion /ˈfjuːəl kəmˈbʌstʃən/ – згоряння палива

- aerodynamic process /ˌeərəʊdaɪˈnæmɪk ˈprəʊses/ – аеродинамічний процес
- heat-transfer process /hiːt ˈtrænsfɜː ˈprəʊses/ – процес теплопередачі
- hydrodynamic process /ˌhaɪdrəʊdaɪˈnæmɪk ˈprəʊses/ – гідродинамічний процес
- circulation of water and steam /ˌsɜːkjʊˈleɪʃən əv ˈwɔːtə ænd stiːm/ – циркуляція води та пари
- metal corrosion /ˈmetl kəˈrəʊʒən/ – корозія металу
- deposit formation /dɪˈpɒzɪt fɔːˈmeɪʃən/ – утворення відкладень
- boiler component strength /ˈbɔɪlə kəmˈpəʊnənt streŋθ/ – міцність елементів котла
- reliable and economical operation /rɪˈlaɪəbl ænd ˌekəˈnɒmɪkəl ˌɒpəˈreɪʃən/ – надійна та економічна експлуатація
- marine boiler /məˈriːn ˈbɔɪlə/ – судновий котел
- gas-tube boiler (fire-tube boiler) /gæs tjuːb ˈbɔɪlə/ – газотрубний (жаротрубний) котел
- water-tube boiler /ˈwɔːtə tjuːb ˈbɔɪlə/ – водотрубний котел
- combined boiler /kəmˈbaɪnd ˈbɔɪlə/ – комбінований котел
- heating surface /ˈhiːtɪŋ ˈsɜːfɪs/ – поверхня нагріву
- furnace /ˈfɜːnɪs/ – топка
- smoke chamber /sməʊk ˈtʃeɪmbə/ – димова камера
- chimney /ˈtʃɪmnɪ/ – димова труба
- steam drum / steam collector /stiːm drʌm/ – паровий барабан
- water drum / water collector /ˈwɔːtə drʌm/ – водяний барабан
- side screen /saɪd skriːn/ – боковий екран труб
- riser pipes /ˈraɪzə paɪps/ – підйомні труби

- downcomer pipes /ˈdaʊnkʌmə paɪps/ – опускні труби
- economizer /ɪˈkɒnəmaɪzə/ – економайзер
- air heater /eə ˈhiːtə/ – повітропідігрівач
- steam superheater /stiːm ˌsuːpəˈhiːtə/ – пароперегрівач
- boiler cladding /ˈbɔɪlə ˈklædɪŋ/ – обшивка котла
- boiler nozzle /ˈbɔɪlə ˈnɒzl/ – патрубок котла
- brickwork /ˈbrɪkwɜːk/ – футеровка
- steam production capacity /stiːm prəˈdʌkʃən kəˈpæsɪti/ – паропродуктивність
- operating pressure /ˈɒpəreɪtɪŋ ˈpreʃə/ – робочий тиск
- operating temperature /ˈɒpəreɪtɪŋ ˈtemprətʃə/ – робоча температура
- automatic control system /ˌɔːtəˈmætɪk kənˈtrəʊl ˈsɪstəm/ – автоматична система керування
- feedwater quality /ˈfiːdwɔːtə ˈkwɒlɪti/ – якість живильної води
- scale deposits /skeɪl dɪˈpɒzɪts/ – накип
- local overheating /ˈləʊkəl ˌəʊvəˈhiːtɪŋ/ – місцевий перегрів
- pipe rupture /paɪp ˈrʌptʃə/ – розрив труби
- load fluctuations /ləʊd ˌflʌktʃuˈeɪʃənz/ – коливання навантаження

SPEAKING PRACTICE

7. a) Compare gas-tube boilers and water-tube boilers.

Speak about:

- steam capacity;
- operating pressure and temperature;
- reliability and sensitivity to water quality;
- typical applications on ships.

b) Discuss the advantages and disadvantages of water-tube boilers.

Questions to guide your answer:

1. Why are water-tube boilers used as main boilers on modern ships?
2. Why do they require more complex automatic control systems?
3. What risks are connected with scale deposits and overheating?

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. What is a steam boiler designed for?

A. Intermittent heating of water
B. Continuous production of steam with specific parameters
C. Storage of thermal energy
D. Cooling of exhaust gases

2. What is the most common source of thermal energy used on ships?

A. Nuclear energy
B. Solar energy
C. Solid and liquid fuel
D. Electricity

3. What heat source is increasingly used in waste heat boilers?

A. Solar radiation
B. Heat from internal combustion engine exhaust gases
C. Sea water heat
D. Electrical heaters

4. What is the typical temperature range of exhaust gases used in waste heat boilers?

A. 100–200 °C
B. 200–300 °C
C. 300–450 °C
D. 450–600 °C

5. In most steam boilers, steam is produced due to heat transfer from:

A. electricity to air
B. fuel combustion to water
C. exhaust gases to metal
D. steam to water

6. Which process takes place in the furnace of a steam boiler?

A. Heat transfer
B. Water circulation
C. Fuel combustion
D. Steam condensation

7. What does the aerodynamic process in a boiler include?

A. Water treatment
B. Heat absorption by pipes
C. Air supply and removal of combustion products
D. Steam superheating

8. Heat transfer in a boiler refers to:

A. Heat loss to the environment
B. Heat transfer from gases to water through heating surfaces
C. Electrical heating of water
D. Radiation from boiler walls

9. The hydrodynamic process in a boiler is related to:
A. Fuel injection
B. Movement and circulation of water and steam
C. Heat radiation
D. Gas flow in flues

10. Which of the following is a side effect of boiler operation?
A. Improved metal strength
B. Metal corrosion
C. Increased fuel quality
D. Reduced maintenance

11. Based on gas washing of heating surfaces, marine boilers are classified into:
A. vertical and horizontal
B. low-pressure and high-pressure
C. gas-tube, water-tube, and combined
D. main and auxiliary

12. In a gas-tube boiler:
A. water flows inside the pipes
B. steam flows outside the pipes
C. hot gases move inside the pipes
D. fuel burns inside the pipes

13. In a water-tube boiler:
A. hot gases flow inside the pipes
B. water and steam-water mixture are inside the pipes
C. fuel is stored in the pipes
D. air flows inside the pipes

14. What type of boilers are used as main boilers on modern ships?
A. Gas-tube boilers
B. Water-tube boilers
C. Combined boilers
D. Electric boilers

15. Auxiliary boilers on motor ships can be:
A. only electric boilers
B. only nuclear boilers
C. gas-tube or water-tube boilers
D. only waste heat boilers

16. What is the main structural element of a vertical gas-tube boiler?
A. Steam drum
B. Cylindrical body
C. Economizer
D. Superheater

17. What components are connected by pipes in a water-tube boiler?
A. Furnace and chimney
B. Air heater and economizer
C. Upper steam collector and lower water collector
D. Fuel tank and burner

18. Which pipes in a water-tube boiler are called downcomer pipes?
A. Pipes directly exposed to flame
B. Pipes carrying steam upward
C. Pipes with reduced heating or located away from the furnace
D. Pipes connected to the superheater

SECTION 13. BOILER COMBUSTION DEVICES INFORMATION FOCUS

1. Read the text. Write down any unfamiliar information and unfamiliar words and phrases in English. Learn them.

Ship boilers are equipped with combustion devices that provide a torch-type (flame-type) combustion process for liquid fuel. Nozzles, which are part of the combustion device, are designed to supply finely atomized fuel to the furnace, and fuel particles are mixed with air using an air deflector (swirler). Nozzles with an air deflector (sometimes called burners) can be front-mounted or ceiling-mounted. Front mounting is more common, where the nozzles and air deflector are placed on the front wall of the boiler furnace, called the furnace front (front wall).

Some modern, highly economical main boilers are equipped with nozzles and air deflectors with a ceiling-mounted arrangement in the upper part of the furnace. This creates conditions for a more intensive flame process: the gas–air flow moves more naturally from top to bottom, and the flame is distributed almost throughout the entire furnace volume. Several nozzles with air deflectors are installed on main and some auxiliary boilers, the number of which depends on the steam capacity of the boiler.

The following basic requirements are imposed on nozzles: simplicity of design, reliability of operation, good fuel atomization, a wide adjustment range and ease of flow control, low energy consumption, ease of replacement and cleaning, low cost, and the ability to operate automatically under unattended conditions.

Depending on the method of fuel atomization, the following types of injectors can be used in marine boilers: steam and air atomization, mechanical non-rotating (centrifugal) and rotating (rotary), and steam-mechanical injectors.

Nozzles with steam or air fuel atomization are structurally identical and can atomize fuel using steam or air due to the kinetic energy of the jets, i.e., they operate on the principle of a spray gun. These injectors are simple in design and easy to adjust, but their operation requires continuous (irreversible) consumption of steam or compressed air. Therefore, such injectors are currently found only in a limited number of older auxiliary boilers.

Mechanical centrifugal nozzles, in which fuel is atomized by means of sufficiently high fuel pressure created by a specially installed fuel injection pump, are widely used in marine boiler combustion chambers.

Mechanical centrifugal nozzles are divided into non-adjustable and adjustable types. It should be noted that this division is rather arbitrary: the fuel supply can be changed to some extent in both types of nozzles. Non-adjustable nozzles include those with a narrow adjustment range and those in which the fuel supply can only be changed by shutting them down, removing them from the combustion chamber, and replacing the atomizing element.

Mechanical centrifugal nozzles, which differ in the layout of the spray elements, are sometimes further subdivided into nozzles with replaceable atomizers and those with permanently operating atomizers in all operating modes, which is mainly determined by the operating conditions of the boiler. The figure shows a non-adjustable centrifugal nozzle, the spray part of which consists of a sprayer (atomizer) 1, an insert 2, a sleeve 3, and a head (tip) 4. The nozzle atomizer (Fig. 12, b) has four tangential channels 8 through which fuel enters the vortex chamber 10 and acquires rotational motion. Upon exiting the opening 9, the fuel, as a result of combined translational and rotational motion, forms a hollow fuel cone consisting of droplets.

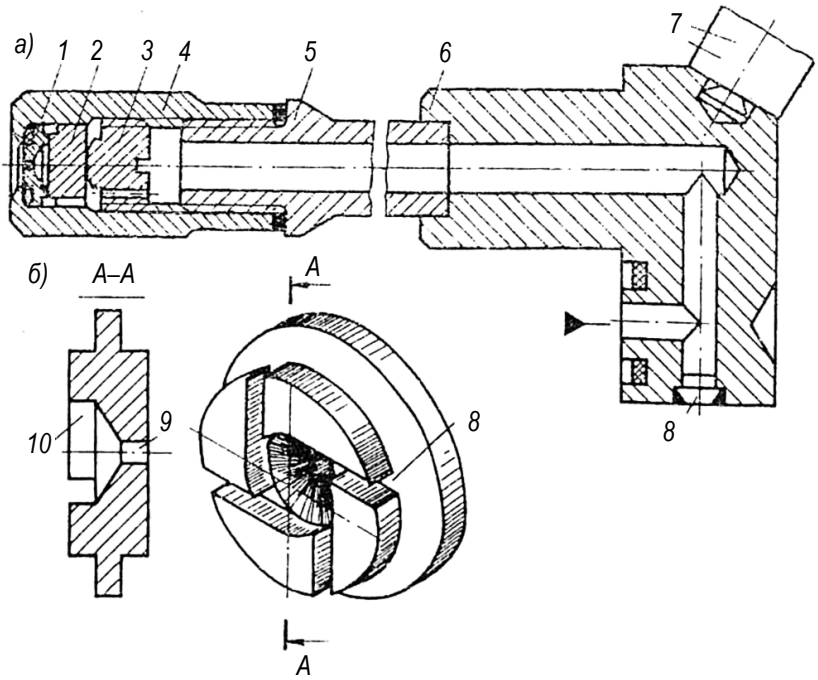

Fig. 12. Mechanical non-adjustable centrifugal nozzle

COMPREHENSION

2. Answer the questions, taking into account the information in the text:

1. What type of combustion process do ship boilers use for liquid fuel?
2. What is the main function of nozzles in the boiler combustion device?
3. How are fuel particles mixed with air in the furnace?
4. What are the two main mounting positions of nozzles with air deflectors?
5. Where are front-mounted nozzles usually installed in the boiler furnace?

6. Why do ceiling-mounted nozzles create a more intensive flame process?

7. What determines the number of nozzles installed on a boiler?

8. What basic requirements are imposed on boiler nozzles?

9. What types of injectors are used in marine boilers according to the method of fuel atomization?

10. Why are steam or air atomizing nozzles rarely used in modern marine boilers?

11. How is fuel atomized in mechanical centrifugal nozzles?

12. How is a hollow fuel cone formed in a centrifugal nozzle?

3. Match the parts of the sentences. Select the correct ending for the types of furnace nozzles shown:

1) In a mechanical nozzle with adjustable discharge…

2) In a semi-mechanical nozzle with a combined spray head…

3) In a semi-mechanical nozzle without spray washers…

4) When operating a rotary nozzle driven by an electric motor…

a) … the cup, together with the hollow shaft, is rotated by an electric motor via a belt drive. Fuel is fed through a nozzle into a stationary pipe located inside the hollow shaft, and from there it flows onto the inner surface of the rotating cup. Under the action of centrifugal forces, the fuel is pressed against the inner walls of the cup; due to their slight conicity, the fuel film moves towards the outlet edge. The fan wheel mounted on the hollow shaft rotates with it, drawing air through a pipe and forcing it into the annular gap at a pressure of approximately 5 kPa.

b) … instead of a spray disc, there is a nozzle with seven cylindrical holes. The nozzle is pressed down using a nut screwed onto the barrel. Fuel flows through channels into the nozzle holes, where steam is also supplied through channels. Fuel atomization is achieved by using the combined impact energy of the fuel jet and steam moving at high speed.

c) … fuel from the fuel injection pump flows through the annular channel of the barrel into the nozzle head and then through the holes into the distributor. From the distributor, the fuel flows through tangential channels in the spray washer into the vortex chamber, where it spins and is directed into the furnace.

d) … fuel atomization is achieved thanks to the relatively high fuel pressure created by a specially installed fuel injection pump. It mainly consists of a body with a handle, a barrel, which is a thick-walled pipe with a nozzle at the end, a locking sleeve, a distributor (nozzle), an atomizing washer, and a head. Fuel from the fuel injection pump flows through the holes in the body and the barrel channel, through the holes in the locking sleeve and distributor, to the spray washer.

GRAMMAR FOCUS

In English, **the Present Perfect and Past Simple tenses** are often confused. Let's define the difference between them.

The Present Perfect and Past Simple are two tenses in English that help to describe situations that took place in the past. They differ in their connection to the present moment and the accuracy of the time of the action.

Past Simple is the simple past tense. It is used to describe events that occurred and ended at a specific moment in the past. It is used with exact dates or time intervals that are no longer related to the moment of speech.

For example,

1. Yesterday, the engineer checked the boiler combustion devices.
2. During the last voyage, the crew cleaned the burner nozzles.
3. The ignition system failed last night.
4. The chief engineer repaired the combustion control unit two days ago.

Present Perfect is the present perfect tense. It is used to describe actions that have consequences or connections to the present, as well as situations where the exact time is unimportant or unknown. Present perfect does not refer to a specific moment, but to experience.

For example,

1. The engineer has checked the boiler combustion devices.
2. The crew has cleaned the burner nozzles.
3. The ignition system has failed, so the boiler cannot operate.
4. The chief engineer has repaired the combustion control unit.

Comparative table of Present Perfect and Past Simple

Present Simple *Action in the past* *Specific time*	***Present Perfect*** *The action is related to the present* *The time is irrelevant or not specified*
e.g. 1) The engineer repaired the burner yesterday. 2) The boiler stopped yesterday.	e.g. 1) The engineer has repaired the burner. 2) The boiler has stopped, and we cannot start the engine now.

WRITING PRACTICE

4. Make the sentences first in the Past Simple, then in the Present Perfect, putting the verbs given in brackets in the correct form:

1. The ship's boiler combustion devices (*to ensure*) efficient fuel burning during the voyage.
2. Engineers (*to inspect*) the burner system to maintain stable combustion.
3. The crew (*to adjust*) the air supply to improve combustion efficiency.
4. Modern boiler combustion devices (*to reduce*) fuel consumption on the ship.
5. The flame scanner *(to monitor*) the burner flame continuously.
6. Engineers (*to replace*) worn-out nozzles in the combustion system.
7. The boiler control system (*to maintain*) proper fuel-air ratio.
8. Combustion devices (*to prevent*) incomplete burning of fuel.
9. The ship's engineers (*to test*) the ignition system before operation.
10. Automatic combustion control (*to increase*) the safety of boiler operation.
11. The boiler combustion equipment (*to operate*) reliably under different load conditions.
12. Regular maintenance (*to improve*) the performance of boiler combustion devices.

5. Translate the sentences using the Present Perfect or Past Simple tense:

1. Система запалювання вийшла з ладу під час нічної вахти.

2. Система запалювання вийшла з ладу, тому котел не може запуститися.

3. Інженери перевірили систему сигналізації згоряння минулого тижня.

4. Котел зупинився, машинне відділення перебуває в режимі очікування.

5. Технічні фахівці замінили пошкоджений датчик полум'я.

6. Неправильна подача повітря спричинила нестабільне горіння.

7. Інженер вчора повідомив про проблему з горінням на місток.

8. Інженер щойно повідомив про проблему з горінням на місток.

9. Під час рейсу котел працював під великим навантаженням.

10. Котел працював під великим навантаженням протягом кількох годин.

11. Інженери вчасно завершили ремонт системи згоряння.

12. Інженери тільки що завершили ремонт системи згоряння.

6. Work on your vocabulary:

- ship boiler /ʃɪp ˈbɔɪlə/ – судновий котел
- combustion device /kəmˈbʌstʃən dɪˈvaɪs/ – пристрій згоряння
- torch-type combustion /ˈtɔːtʃ taɪp kəmˈbʌstʃən/ – факельний тип згоряння
- liquid fuel /ˈlɪkwɪd ˈfjuːəl/ – рідке паливо
- nozzle (injector) /ˈnɒzl (ɪnˈdʒektə)/ – форсунка
- fuel atomization /ˈfjuːəl ˌætəmaɪˈzeɪʃən/ – розпилення палива

- air deflector /eə dɪˈflektə/ – повітряний дефлектор
- burner /ˈbɜːnə/ – пальник
- front-mounted nozzle /frʌnt ˈmaʊntɪd ˈnɒzl/ – форсунка фронтального розташування
- ceiling-mounted nozzle /ˈsiːlɪŋ ˈmaʊntɪd ˈnɒzl/ – форсунка стельового розташування
- boiler furnace /ˈbɔɪlə ˈfɜːnɪs/ – топка котла
- front face /frʌnt feɪs/ – фронтальна стінка
- steam capacity /stiːm kəˈpæsɪti/ – паропродуктивність
- fuel injector requirements /ˈfjuːəl ɪnˈdʒektə rɪˈkwaɪəmənts/ – вимоги до форсунок
- air or steam atomization /eə ɔː stiːm ˌætəmaɪˈzeɪʃən/ – повітряне або парове розпилення
- spray-gun principle /ˈspreɪ gʌn ˈprɪnsəpəl/ – принцип фарборозпилювача
- mechanical centrifugal nozzle /məˈkænɪkəl ˌsentrɪˈfjuːgəl ˈnɒzl/ – механічна відцентрова форсунка
- fuel injection pump /ˈfjuːəl ɪnˈdʒekʃən pʌmp/ – паливний насос
- non-adjustable nozzle /nɒn əˈdʒʌstəbl ˈnɒzl/ – нерегульована форсунка
- adjustable nozzle /əˈdʒʌstəbl ˈnɒzl/ – регульована форсунка
- sprayer /ˈspreɪə/ – розпилювач
- vortex chamber /ˈvɔːteks ˈtʃeɪmbə/ – вихрова камера
- tangential channels /tænˈdʒenʃəl ˈtʃænəlz/ – тангенціальні канали
- fuel cone /ˈfjuːəl kəʊn/ – паливний конус
- droplet formation /ˈdrɒplɪt fɔːˈmeɪʃən/ – утворення крапель
- translational-rotational motion /trænzˈleɪʃənəl ˌrəʊˈteɪʃənəl ˈməʊʃən/ – поступально-обертальний рух

SPEAKING PRACTICE

7. Taking into account the material covered, provide well-reasoned and detailed answers to the following situational and practical questions.

1. What would you do if the burner flame suddenly went out?
2. Do you think modern combustion devices are reliable enough?
3. Imagine that you are working as a mechanic on a ship and you need to explain to a new crew member how the boiler combustion devices work. How would you do it?

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. What type of combustion process is used in ship boilers for liquid fuel?

A. Layer combustion
B. Torch-type combustion
C. Fluidized-bed combustion
D. Pulsed combustion

2. What is the main function of nozzles in ship boilers?

A. To heat feed water
B. To remove exhaust gases
C. To supply atomized fuel to the furnace
D. To control steam pressure

3. How are fuel particles mixed with air in the furnace?

A. By natural diffusion
B. By a condenser
C. By an air deflector
D. By a heat exchanger

4. Nozzles with an air deflector are sometimes called:
A. separators
B. burners
C. economizers
D. superheaters

5. Where are front-mounted nozzles installed?
A. On the ceiling of the boiler room
B. On the rear wall of the furnace
C. On the front wall of the furnace (front face)
D. Inside the steam drum

6. What is an advantage of ceiling-mounted nozzles in modern main boilers?
A. Lower manufacturing cost
B. Easier manual control
C. More intensive flame process
D. Reduced boiler height

7. In ceiling-mounted arrangements, the gas-air flow mainly moves:
A. from bottom to top
B. from side to side
C. from top to bottom
D. randomly

8. The number of nozzles installed in a boiler depends mainly on:
A. fuel viscosity
B. boiler steam capacity
C. boiler age
D. air humidity

9. Which of the following is NOT a basic requirement for nozzles?

A. Reliability of operation
B. Ease of cleaning
C. High manufacturing cost
D. Good fuel atomization

10. Which fuel atomization method uses kinetic energy of steam or air jets?

A. Mechanical centrifugal
B. Rotary mechanical
C. Steam or air atomization
D. Electric atomization

11. Nozzles with steam or air atomization work on the principle of:

A. a compressor
B. a spray gun
C. a piston pump
D. a turbine

12. Why are steam- or air-atomizing nozzles rarely used today?

A. They are difficult to adjust
B. They require irreversible consumption of steam or air
C. They produce unstable flames
D. They cannot atomize heavy fuel

13. Where are steam- or air-atomizing nozzles mainly found today?

A. In modern main boilers
B. In nuclear-powered ships

C. In a few old auxiliary boilers
D. In exhaust gas boilers

14. What creates fuel atomization in mechanical centrifugal nozzles?
A. High air velocity
B. High fuel pressure
C. Electric heating
D. Steam injection

15. Mechanical centrifugal nozzles are widely used because they:
A. consume compressed air
B. require steam for operation
C. work with high fuel pressure only
D. are efficient and reliable

16. Mechanical centrifugal nozzles are divided into:
A. air and steam types
B. front and rear types
C. adjustable and non-adjustable types
D. horizontal and vertical types

17. In non-adjustable nozzles, fuel supply may be changed by:
A. adjusting the air deflector
B. changing steam pressure
C. replacing the atomizing element
D. rotating the furnace

18. What shape does the fuel take when leaving the centrifugal nozzle?

A. Solid fuel jet
B. Flat fuel sheet
C. Hollow fuel cone of droplets
D. Fuel mist cloud.

SECTION 14. BOILER MAINTENANCE INFORMATION FOCUS

1. Read the text carefully, learn unfamiliar information:

Boiler maintenance must comply with the manufacturer's instructions for the operation and maintenance of the boiler and the rules for the technical operation of ship technical equipment, which provide for the following:

1) daily routine operations:

– inspection of the boiler room to check for leakage of water, fuel, steam, and air through pipe flanges, regulators, and fittings;

– external inspection of control system equipment and verification of the serviceability of the electrical circuits and indicator lamps of the protection and alarm system;

– maintaining the proper water regime;

– periodic cleaning of the boiler on the gas side while in operation;

2) periodic intermediate inspections of the boiler;

3) chemical cleaning of the boiler from the steam-and-water side, in agreement with the shipowner's technical service;

4) annual internal inspections and external inspections of the boiler under steam pressure;

5) preparation and presentation of the boiler for inspection and certification by the shipping registry;

6) hydraulic testing of the boiler;

7) inspection and repair of the furnace masonry, boiler fittings and accessories, and its automation and control equipment.

Before allowing personnel to enter the boiler, the requirements of the Safety Regulations for Fleet Vessels must be met, in particular:

– ensure reliable isolation of the boiler being opened from operating boilers and steam-water separators: close and seal the

valves connecting the boiler to the main systems (fuel, steam, water, blowdown), and hang warning signs on the valves bearing the inscription “DO NOT TOUCH! PEOPLE ARE WORKING!” (the boiler must be isolated from pressurized pipelines by two valves; if a second valve is not available, a blind flange (plug) shall be installed);

– before opening manholes and hatches, make sure that there is no pressure inside the boiler by checking the pressure gauge readings and opening the atmospheric or test valve. The upper manhole of the boiler must be opened first;

– ventilate the boiler thoroughly, verify the absence of harmful gases or vapors inside it, and allow it to cool to an air temperature not exceeding 50 °C;

– prepare portable electric lamps with a voltage of no more than 12 V for lighting inside the boiler.

The technical condition of the boiler must be assessed by visual inspection and measurement of its parts and components, using hydraulic tests, non-destructive testing, and metallographic studies when required. Areas where cracks may appear must be cleaned to bare metal and etched. The depth of non-through cracks should be determined by non-destructive testing methods and confirmatory test drilling, if necessary.

When determining the permissible wear and deformation of critical boiler components, it is necessary to be guided primarily by the standards specified in the operating manuals, technical conditions for boiler repair, and the requirements of the shipping registry. In the absence of relevant standards, the question of the continued operation of the boiler or the scope of its repair shall be decided by the shipping registry.

If defects exceeding the permissible limits are identified, the repair of the relevant components shall be carried out using repair technologies approved by the shipping registry.

2. Answer the questions, taking into account the information from the text:

1. Which documents and regulations must boiler maintenance comply with?
2. What tasks are included in the daily routine maintenance of the boiler?
3. For what purpose is the boiler room inspected during the daily check?
4. What does the external inspection of the boiler control system equipment include?
5. What types of boiler inspections, apart from daily work, are provided by the operating rules?
6. Under what conditions and with whom is the chemical cleaning of the boiler agreed?
7. What safety measures must be taken before allowing people to enter the boiler?
8. Why is it necessary to make sure there is no pressure in the boiler before opening manholes and hatches?
9. What requirements are established for ventilation and air temperature inside the boiler before work begins?
10. What equipment is used for lighting during work inside the boiler?
11. By what methods is the technical condition of the boiler and its components checked?
12. What actions must be taken if defects exceeding the permissible limits are found?

GRAMMAR FOCUS

Modal verbs are a special group of verbs that indicate possibility, obligation, desire, permission, and other similar aspects in speech. They do not have their own tense forms and are not used independently without another verb.

Types of modal verbs

Modal verbs can be divided into main, semi-modal, and analogues. The main ones include *must, will, can, would, could, may, should, shall, might*. Semi-modals are represented by *ought to, dare, need*. Analogs are *to be to* and *have to*. Let's consider each of them separately.

Must. Has the meaning of obligation or necessity.

Example: The boiler must be maintained in accordance with the manufacturer's instructions.

Will. Indicates a future action.

Example: The engineer will inspect the boiler room every day during routine maintenance.

Can. Expresses ability or possibility.

Example: Leaks can be detected during a visual inspection of the boiler and pipelines.

Would. Used to express desires or conditional situations.

Example: During inspections, the engineer would carefully check all safety devices.

Could. Indicates a possibility in the past or a condition.

Example: Failure to maintain the boiler properly could lead to serious accidents.

May. Expresses permission or possibility.

Example: Chemical cleaning may be carried out only with the approval of the shipowner's technical service.

Should. Emphasizes a recommendation or advice.

Example: The boiler should be thoroughly ventilated before any internal work is started.

Shall. Used to express a future tense or proposition.

Example: All maintenance procedures shall comply with the rules of the shipping register.

Might. Indicates a possibility or uncertainty.

Example: If the boiler is not cooled sufficiently, workers might be exposed to danger.

Ought to. Expresses a moral or legal obligation.

Example: Engineers ought to follow all safety regulations during boiler maintenance.

Dare. Has a bold or defiant character.

Example: No one dare enter the boiler without ensuring that there is no pressure inside.

Need. Indicates a necessity or lack of necessity.

Example: The boiler need be inspected regularly to ensure safe operation.

To be to. Used to express planned events in the future.

Example: The boiler is to be prepared for inspection and certification by the shipping registry.

Have to. Indicates an obligation or necessity.

Example: Maintenance personnel have to use low-voltage lamps when working inside the boiler.

3. Work with the text. Translate the phrases in brackets, taking into account the need to insert modal verbs where necessary:

Procedure and Remarks for Inspection

Shut off the boiler and allow it to cool down (below 100 °C). The boiler (*не слід скидати*) by lifting the safety valves and then filled with cold feed water since the stress induced by excessively rapid cooling (*може призвести до пошкодження*).

Empty the boiler and close all valves. If the boiler is connected to a second boiler, (*треба перевірити*) that the valves between them are fully closed.

Unscrew and remove the manhole hatch(s) on the boiler and enter the boiler when it is sufficiently cold. Check the welded joints in the boiler. A careful examination (*слід провести*) with respect to possible corrosion and crack formation.

The water line area of the pressure vessel (*потребує особливої уваги*), where oxygen pitting (*може виникнути*).

If deposits are found to form in the boiler tubes, the boiler (*слід хімічно очистити*).

(*Рекомендується звернутися*) a specialised cleaning company that will examine the boiler deposits and treat the boiler accordingly.

After chemical treatment the boiler (*слід продувати*) at least twice a day for approximately one week. This will ensure that excessive sludge deposits due to chemical treatment do not collect in the bottom of the pressure vessel.

4. Work with modal verbs (*must, will, can, would, could, may, should, shall, might, ought to, dare, need, to be to and have to*). Find the necessary modal verbs that are missing in the sentences:

1. The boiler _____ be shut off and allowed to cool down below 100°C before any maintenance work is started.
2. The boiler _____ be damaged if it is depressurised by lifting the safety valves and then filled with cold feed water.
3. During inspection, the engineer _____ carefully examine the welded joints inside the boiler.
4. Rapid cooling _____ cause thermal stress and _____ damage the boiler metal structure.
5. Too rapid cooling _____ result in cracks in the boiler metal.
6. Oxygen pitting _____ occur in the water line area of the pressure vessel.
7. All valves between connected boilers _____ be closed before an internal inspection is carried out.
8. Engineers _____ follow the manufacturer's instructions during boiler maintenance.

9. The boiler _____ prepared for inspection and certification by the shipping register.

10. Maintenance personnel _____ wear protective equipment when working on the boiler.

11. The boiler _____ be emptied and all valves should be closed before opening the manholes.

12. Sludge deposits _____ accumulate at the bottom of the pressure vessel after chemical cleaning.

13. No one _____ enter the boiler unless it has been fully depressurised and ventilated.

14. The boiler _____ be inspected regularly to ensure safe and efficient operation.

WRITING PRACTICE

5. Translate the text from Ukrainian into English. Pay special attention to modal verbs. The text should contain such verbs as *should, must, can, may*.

Огляд води в котлі

Технічне обслуговування котла завжди повинно виконуватися кваліфікованим персоналом та відповідно до чинних правил і норм компетентних органів влади. Одним із таких видів технічного обслуговування є перевірка води в котлі.

Водяну частину котла (внутрішню поверхню) необхідно ретельно оглядати щонайменше двічі на рік. Ця перевірка має велике значення і, безсумнівно, є найважливішою з усіх заходів технічного обслуговування, оскільки вона безпосередньо впливає на довговічність котла та рівень його безпеки.

Під час таких перевірок можна своєчасно виявити тверді відкладення, корозію та порушення циркуляції, і необхідно вжити профілактичних заходів, щоб уникнути непередбачених пошкоджень матеріалу та виходу котла з ладу.

Наявність твердих відкладень на стінках топки та штифтових трубах знижує їх теплопередавальні властивості та призводить до зменшення потужності котла.

Крім того, можна оцінити, чи була обробка живильної води задовільною та чи проводилася продувка в достатньому обсязі.

Неправильна обробка живильної води зазвичай призводить до утворення твердих відкладень або розвитку корозії.

Недостатня продувка призводить до відкладення осаду в трубах та накопичення відкладень на дні котла.

Якщо тверді відкладення не видаляються, це може призвести до перегріву матеріалу котлової плити, яка піддається впливу полум'я в зоні стінок топки. Це, у свою чергу, може спричинити серйозні матеріальні пошкодження.

Неправильна очищення живильної води не завжди безпосередньо призводить до утворення твердих відкладень. Наприклад, занадто низьке або занадто високе значення pH може спричинити електролітичну реакцію, що призводить до корозії в котлі.

Під час перевірки внутрішнього простору котла слід ретельно оглянути всі деталі та звернути увагу на наявність відкладень, корозії та тріщин. Рекомендується приділяти цій перевірці особливу увагу.

6. Work on your vocabulary:

• boiler maintenance /ˈbɔɪlə ˈmeɪntənəns/ – технічне обслуговування котла

• manufacturer's instructions /ˌmænjuˈfæktʃərəz ɪnˈstrʌkʃənz/ – інструкції виробника

• technical operation /ˈteknɪkəl ˌɒpəˈreɪʃən/ – технічна експлуатація

• daily routine work /ˈdeɪli ruːˈtiːn wɜːk/ – щоденні рутинні роботи

- inspection of the boiler room /ɪnˈspekʃən əv ðə ˈbɔɪlə ruːm/ – огляд котельного відділення
- water, fuel, steam and air leaks /ˈwɔːtə, ˈfjuːəl, stiːm ənd eə liːks/ – витоки води, палива, пари та повітря
- pipe flanges, regulators and fittings /paɪp ˈflændʒɪz ˈregjʊleɪtəz ənd ˈfɪtɪŋz/ – фланці труб, регулятори та арматура
- external inspection /ɪkˈstɜːnəl ɪnˈspekʃən/ – зовнішній огляд
- control system equipment /kənˈtrəʊl ˈsɪstəm ɪˈkwɪpmənt/ – обладнання системи керування
- protection and alarm system /prəˈtekʃən ənd əˈlɑːm ˈsɪstəm/ – система захисту та сигналізації
- maintaining the water regime /meɪnˈteɪnɪŋ ðə ˈwɔːtə reɪˈʒiːm/ – підтримання водного режиму
- chemical cleaning of the boiler /ˈkemɪkəl ˈkliːnɪŋ əv ðə ˈbɔɪlə/ – хімічне очищення котла
- shipping registry /ˈʃɪpɪŋ ˈredʒɪstri/ – судновий (морський) реєстр
- hydraulic testing /haɪˈdrɔːlɪk ˈtestɪŋ/ – гідравлічні випробування
- furnace masonry /ˈfɜːnɪs ˈmeɪsənri/ – кладка топки
- Safety Regulations for Fleet Vessels /ˈseɪfti ˌregjʊˈleɪʃənz fə fliːt ˈvesəlz/ – правила безпеки для суден флоту
- reliable isolation of the boiler /rɪˈlaɪəbl ˌaɪsəˈleɪʃən əv ðə ˈbɔɪlə/ – надійна ізоляція котла
- manholes and hatches /ˈmænhoʊlz ənd ˈhætʃɪz/ – люки та лази
- pressure gauge readings /ˈpreʃə ɡeɪdʒ ˈriːdɪŋz/ – показання манометра
- non-destructive testing methods /ˌnɒn dɪˈstrʌktɪv ˈtestɪŋ ˈmeθədz/ – методи неруйнівного контролю.

SPEAKING PRACTICE

7. a) Problem-solving situation: During boiler inspection, a junior engineer wants to open a manhole without checking pressure or ventilation.

Explain:

- Why this is dangerous.
- What safety rules are violated.
- What should be done correctly instead.

b) Answer orally:

- How is the technical condition of a boiler assessed?
- Why are non-destructive testing methods used?
- When are metallographic studies required?

c) Discuss the following questions:

- What actions should be taken if cracks are found in boiler components?
- Who decides whether the boiler can continue operating if standards are absent?
- Why must repairs be approved by the shipping registry?

CHECKING THE ACQUIRED KNOWLEDGE

8. Summary test:

1. Boiler maintenance must comply primarily with:

A. the chief engineer’s instructions

B. the shipowner’s orders only

C. the manufacturer’s instructions and technical operation rules

D. international environmental conventions

2. Which of the following is included in daily routine boiler work?

A. Hydraulic testing

B. Inspection for leaks

C. Certification by the shipping registry
D. Chemical cleaning

3. What should be checked during inspection of the boiler room?
A. Paint condition only
B. Fuel quality
C. Water, fuel, steam, and air leaks
D. Boiler insulation thickness

4. External inspection of the control system includes checking:
A. boiler pressure only
B. electrical circuits and alarm lamps
C. fuel injectors
D. furnace masonry

5. How often must the boiler water side be carefully inspected?
A. once a year
B. every month
C. at least twice a year
D. every five years

6. Before allowing people into the boiler, it is necessary to:
A. increase steam pressure
B. open all valves
C. isolate the boiler from operating systems
D. start the feed pump

7. What inscription must be placed on the isolated valves?
A. “DANGER – HIGH PRESSURE”
B. “BOILER UNDER TEST”

C. “DO NOT TOUCH! PEOPLE ARE WORKING!”
D. “AUTHORIZED PERSONNEL ONLY”

8. Which manhole must be opened first when opening the boiler?
A. lower manhole
B. side manhole
C. any manhole
D. upper manhole

9. Before entering the boiler, its internal air temperature must not exceed:
A. 30 °C
B. 40 °C
C. 50 °C
D. 60 °C

10. What voltage is allowed for portable lamps inside the boiler?
A. 220 V
B. 110 V
C. 24 V
D. 12 V

11. Which methods may be used to check the technical condition of boiler parts?
A. Visual inspection only
B. Hydraulic tests and non-destructive testing
C. Painting inspection
D. Fuel analysis

12. Areas where cracks may appear must be:
A. covered with insulation
B. painted
C. cleaned to bare metal and etched
D. welded immediately

13. Permissible wear and deformation of boiler parts should be determined according to:
A. crew experience
B. shipowner's decision
C. operating instructions and shipping register standards
D. weather conditions

14. If defects exceed permissible standards, repairs must be:
A. postponed
B. done without approval
C. carried out using technology approved by the shipping register
D. done temporarily

15. Why is inspection of the boiler interior especially important?
A. It improves fuel consumption
B. It directly affects boiler longevity and safety
C. It reduces noise
D. It simplifies operation

16. What problems can be detected early during boiler interior inspections?
A. Fuel leaks only
B. Hard deposits, corrosion, and circulation disturbances
C. Electrical faults
D. Steam valve wear

17. What is the effect of hard deposits on furnace walls and tubes?

A. Increased heat transfer
B. Increased boiler capacity
C. Reduced heat transfer and capacity
D. No effect

18. Insufficient blow-down will cause:

A. overheating of fuel injectors
B. corrosion of the control panel
C. sludge deposits in tubes and at the boiler bottom
D. steam pressure increase

RECOMMENDED SOURCES OF INFORMATION

Basic literature

1. Berwick D. Marine Diesel Basics 1: Maintenance, Lay-up, Winter Protection, Tropical Storage, Spring Recommission Paperback. 2017. 224 p.
2. Calder N. Marine Diesel Engines: Maintenance, Troubleshooting, and Repair. 2006. 320 p.
3. Grice T. English for Mariners. A Two-Level Course Book. 2009. 176 p.
4. House D. J. Seamanship Techniques: Shipboard and Marine Operations. 2018. 888 p.
5. Kravets H. B., Tsynova M. V. The Basics of English for Seafarers: *навчальний посібник*. USL: https://skipper.od.ua/the-basics-of-english-for-seafarers.-h.b.-kravets-m.-v.-tsynova/.
6. Latarche M. Pounder's Marine Diesel Engines and Gas Turbines: and Gas Turbines. 10th Edition. 2020. 956 p.
7. Main J. B., Harris F. R., Herbert C. W. Turbine Main Engines. 2013. 276 p.
8. Nikulina O. L. English for marine electrical engineers. Одеса : Фенікс, 2020. 136 p.
9. Ridwan A., Siti Maria Ulfa S. M. English for Maritime: A Supplementary Material for Vocational Maritime High Schools, 2019. 94 p.
10. Russel W. C. Sailors' Language: A Collection of Sea-terms and their Definitions, 2017. 154 p.
11. Russell P. A. General Engineering Knowledge for Marine Engineers. 2024. 640 p.

12. Saravanamutto H. I. H., Rogers G. F. C., Straznicky H. Cohen, P. Gas Turbine Theory. 2013. 510 p.

13. Stachowiak G. W., Batchelor A. W. Engineering Tribology. 2014. 860 p.

14. Tyron O. Maritime English: Conventions of the international maritime organization, documents, topics, first aid and survival at sea : навчальний посібник. Київ : Ліра-К, 2020. 124 с.

Additional literature

15. Advanced English for navigators : навчальний посібник / за заг. ред. Н. О. Івасюк. Одеса : Фенікс, 2014.

16. English of marine electrical and power engineering for seamen N. L. Troukhanova, N. A. Kravchenko. Фенікс, 2003. 168 p.

17. Grice T. English for mariners. Student's Book. Münster: Westfälische Wilhelms-Universität, 2009. 176 p.

18. Jinks S. Collision Regulations Handbook. Reeds Marine Deck 1, 2023. 208 p.

19. Mackey W. J., Dooley J. Marine Engineering. 2017. 35 p.

20. Taylor D. A. Introduction to marine engineering: Elsevier, 2003. 372 p.

ДЛЯ НОТАТОК

Навчальне видання

ВОРЧАКОВА Ірина Євгенівна

АНГЛІЙСЬКА МОВА
ЗА ПРОФЕСІЙНИМ СПРЯМУВАННЯМ

Навчальний посібник

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