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РАЗВИТИЕ ПРОФЕССИОНАЛЬНЫХ КОМПЕТЕНЦИЙ СТУДЕНТОВ ТЕХНИЧЕСКИХ ВУЗОВ

(АНГЛИЙСКИЙ ЯЗЫК)

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Учебное пособие предназначено для студентов технических ВУЗов факультета «Двигателестроение». Четко структурированная система заданий обеспечивает поэтапную отработку материала и гармонично развивает навыки перевода технической литературы. Упражнения пособия имеют также коммуникативную направленность, что помогает студентам развивать устную речь по технической тематике.

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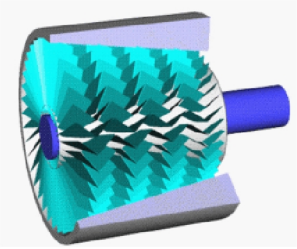
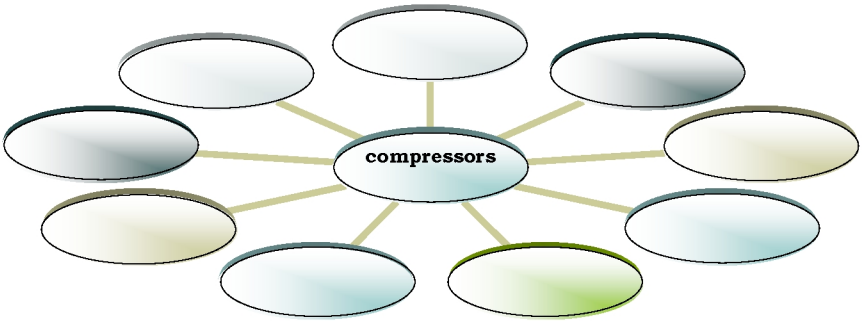
Unit I
COMPRESSORS



Before you Begin

I. Have you ever met the term "Compressor" in technical literature? Can you suggest a definition? What sphere of application do you think it may concern?

II. Brainstorm all possible terms related to the topic.



Reading

I. In the text, find definitions of :

a) -compressor efficiency
-axial flow compressor
-centrifugal flow compressor
-centrifugal-axial-flow compressor
-stage
-rotor blades
-stator vanes

b) try to define the meaning of the term "compression ratio" as you understand it.

II. Skim the text and try to explain the meaning of marked words from the context.

III. Read the text and write out the words and word combinations you don't know, try to guess their meaning from the context. Compare your notes with your partners.

Compressors

The role of the compressor in a gas turbine engine is to provide a maximum of high-pressure air which can be heated in the limited volume of the combustion chamber and then **expanded** through the turbine. The energy that can be released in the combustion chamber is proportional to the mass of air **consumed**; therefore the compressor is one of the most important components of the gas turbine engine since its efficient operation (maximum compression with minimum temperature rise) is the key to high **overall** engine performance. The compressor efficiency will determine the power necessary to create the pressure rise of a given airflow and will **affect** the temperature change which can take place in the combustion chamber. Present-day compressors have compression ratios **approaching** 15:1, efficiencies near 90 percent, and airflows up to **approximately** 350 lb/s.(158,8 kg/s).

With the addition of a fan, total pressure ratio of 25:1 and mass airflows of over 1000 lb/s (453,6 kg/s) have been achieved.

Types of Compressors

All gas turbine engines use one of the following forms of compressors:

1. Axial flow.
2. Centrifugal flow.

The centrifugal-axial-flow compressor is a combination of the two, with operating characteristics of both.

The Axial-Flow Compressors

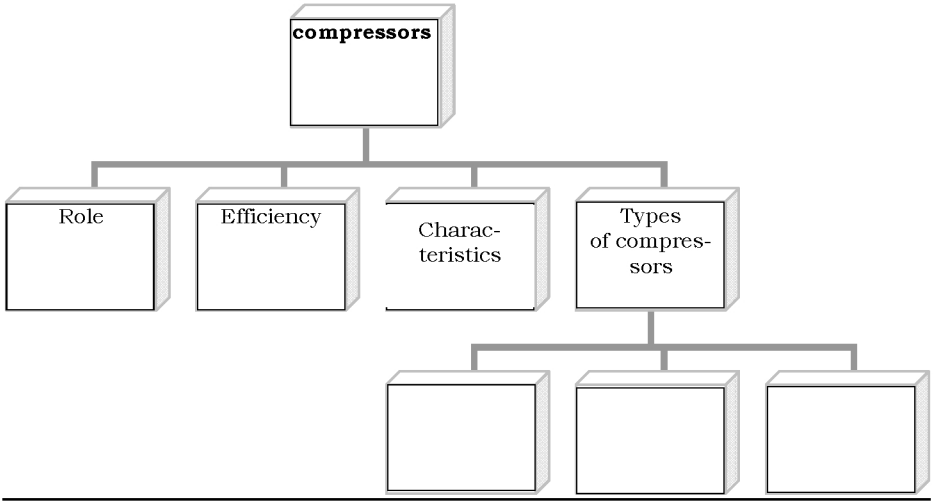
The axial-flow compressor is made up of a **series** of **rotating** airfoils called rotor blades and a **stationary** set of airfoils called stator vanes. As its name implies, the air is being compressed in a direction parallel to the axis of the engine. A row of rotating and stationary blades is called a stage. The **entire** compressor is made up of a series of alternating rotor and stator vane stages. Some axial-flow designs have two or more compressors or spools which are driven by **separate** turbines and are **therefore** free to rotate at different speeds.

Axial compressors have the advantage of being **capable** to very high compression ratios with relatively high efficiencies.

In addition, the small frontal area created by this type of compressor **lends** itself to installation in high-speed aircraft. Unfortunately the **delicate** blading, especially toward the rear, makes this type of air pump especially **susceptible** to foreign object **damage**. Furthermore, the number of compressor blades and stator vanes (which can **exceed** 1000 in a large jet engine), the **close fits** required for efficient air **pumping**, and the much narrower range of possible operating conditions, make this type of compressor very complex and very expensive to manufacture. Modern manufacturing techniques are **bringing down** the cost for small axial-flow compressors. For these reasons the axial-flow design finds its greatest application where the demands of efficiency and output **predominate** considerations of cost, simplicity, **flexibility** of operation, etc. Most manufacturers utilize several **dodges** to increase flexibility and to improve the operating characteristics of the axial-flow compressor.

Post Reading

I. a) Fill in the diagram according to the content of the text.



b) Make a diagram for the part of the text where axial-flow compressors are described Fill it in. Share the information with your partner.

II. a) Find the English equivalents to the following words and word combinations in the text:

Работа; степень сжатия; осевой компрессор; центробежный компрессор; аэродинамическая поверхность; лопасть; комплект лопаток; ступень; каскад (компрессора); фронтальная поверхность; насос; нагнетание; повреждение; сечение; снижать; приспособляемость; полный; перемежающийся; ограниченный объём; употребляемый воздух; повлияет на изменение температуры; как следует из названия; плотная посадка деталей; более узкий диапазон; снижают стоимость; требования эффективности.

b) Reproduce the context in which they were used.

III. Complete the following sentences using the ideas from the text.

1. The role of the compressor in a gas turbine engine is to provide …
2. The compressor efficiency will determine …
3. The compressor efficiency will affect the temperature …
4. The centrifugal-axial-flow compressor is a …
5. The air in the axial-flow compressor is being compressed in a direction …
6. The entire compressor is made up of …
7. Spools are driven by …
8. Axial compressors have the advantage of …
9. The small frontal area of axial-flow compressor lends itself to …
10. … make axial-flow compressor very complex and very expensive to manufacture.
11. Axial-flow design finds its greatest application …

III. Explain the difference between rotating and stationary blades.

IV. Translate the following sentences into English and answer them according to the content of the text.

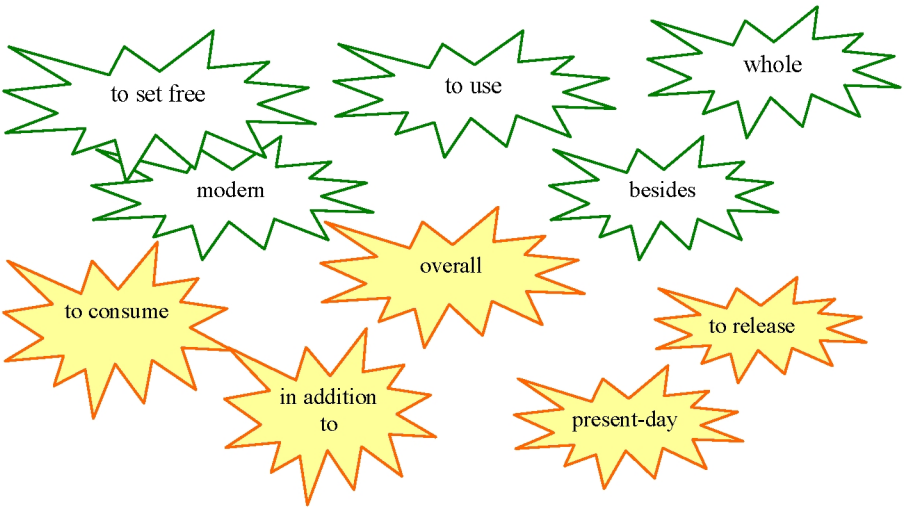
1. Почему компрессор является одним из наиболее важных компонентов газотурбинных двигателей?
2. Что определяет КПД компрессора?
3. Что называется ступенью компрессора?
4. Из чего состоит компрессор?
5. Какими преимуществами и недостатками обладает осевой компрессор?
6. Что делает осевой компрессор сложным и дорогостоящим в изготовлении?
7. Где осевой компрессор находит наибольшее применение?

Language in Use

I. Find the Russian equivalents to the words from column a) from the words from column b)

a)	b)
Since	Влиять
Key	Приблизительно
Affect	Весь
Approximately	Особенно
Addition	Чередующийся
Entire	Сравнительно
Alternating	Конструкция
Design	Поэтому
Therefore	Преимущество
Advantage	К сожалению
Relatively	Добавление
Unfortunately	Ключ
Especially	Поскольку
furthermore	Более того

II. Find pairs of synonyms among the words.

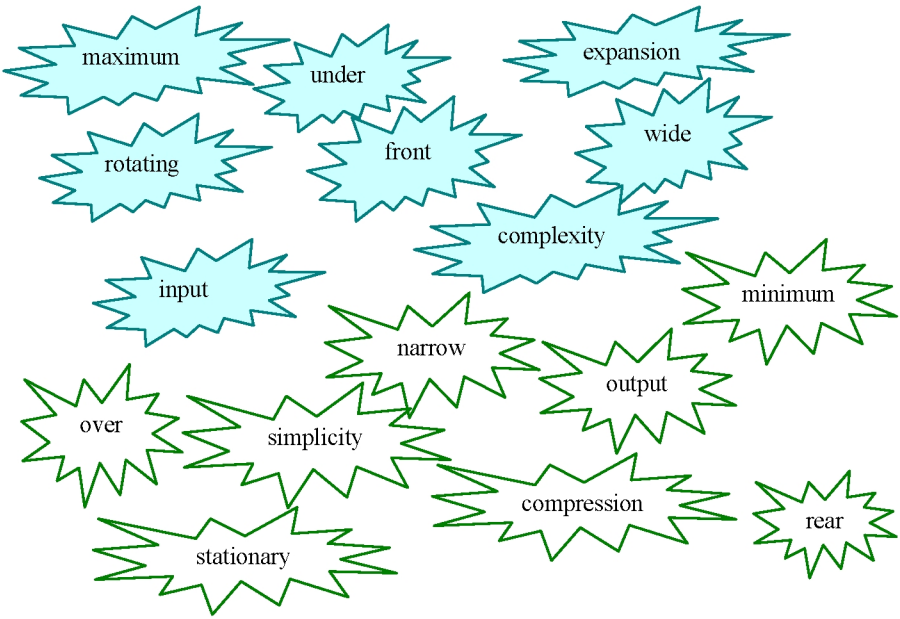


III. Use the prepositions in the oval to complete the sentences in the text. Translate the text with the help of a dictionary in written.

Of, for, in, with

Axial-flow compressors are dynamic rotating compressors that use arrays … fan-like airfoils to progressively compress the working fluid. They are used where there is a requirement … a high flows or a compact design. The arrays … airfoils are set … rows, usually as pairs: one rotating and one stationary. The rotating airfoils, also known as blades or *rotors*, accelerate the fluid. The stationary airfoils, also known as a *stators* or vanes, turn and decelerate the fluid; preparing and redirecting the flow … the rotor blades … the next stage. Axial compressors are almost always multi-staged, … the cross-sectional area … the gas passage diminishing along the compressor to maintain an optimum axial Mach number. Beyond about 5 stages or a 4:1 design pressure ratio, variable geometry is normally used to improve operation.

IV. Find pairs of antonyms among the words.



V. Fill in the gaps with the suitable derivative of the word given in brackets, use the suffixes in the oval. Translate the text, define the main idea of it in one phrase.

-ing; -ly; -ed; -al; -able

Axial compressors rely on _____ (to spin) blades that have aerofoil sections, similar to aeroplane wings. As with aeroplane wings in some conditions the blades can stall. If this happens, the airflow around the _____ (to stall) compressor can reverse direction _____ (violent). Each design of a compressor has an _____ (to associate) operating map of airflow versus _____ (to rotate) speed for characteristics peculiar to that type.

At a given throttle condition, the compressor operates somewhere along the steady state running line. Unfortunately, this _____ (to operate) line is displaced during transients. Many compressors are fitted with anti-stall systems in the form of bleed bands or _____ (to vary) geometry stators to decrease the likelihood of surge. Another method is to split the compressor into two or more units, operating on separate concentric shafts.

VI. Match words in A with their definitions in B and use them in your own sentences.

A	B
1. limited	1. to become larger in size and filling more space
2. to determine	2. to use a supply of smth such as time, energy, or fuel
3. efficiency	3. not together
4. to expand	4. all or every part of smth
5. to release	5. Able to do smth
6. to consume	6. the process of putting a new system or piece of equipment in its place and making it ready for use
7. set	7. the ability to make changes or to deal with a situation that is changing
8. separate	8. to have more power, influence,or importance then other things
9. to rotate	9. not allowed to go above a particular number, amount, or level

10. entire	10. smth that can be easily damaged or broken
11. capable	11. easily influenced or affected by smth
12. installation	12. the ability to work well and produce good results
13. flexibility	13. adjustment
14. delicate	14. making a gas or liquid move into or out of smth
15. fit	15. to control or to officially decide smth
16. pumping	16. a dishonest or clever way to avoid doing smth unpleasent
17. to predominate	17. to move in a circle around a fixed central point
18. susceptible	18. a group of things
19. dodge	19. to let smth leave a place where they have been kept

VII. Translate the following sentences. Pay special attention to the marked words. Give your own explanation of them.

1. Another design **consideration** in axial-flow compressor manufacturing is the average stage loading.

2. This can be kept at a **sensible** level either by increasing the number of compression stages (more weight/cost) or the mean blade speed (more blade/**disc stress**).

3. Although large flow compressors are usually all-axial, the rear stages on smaller units are too small **to be robust**.

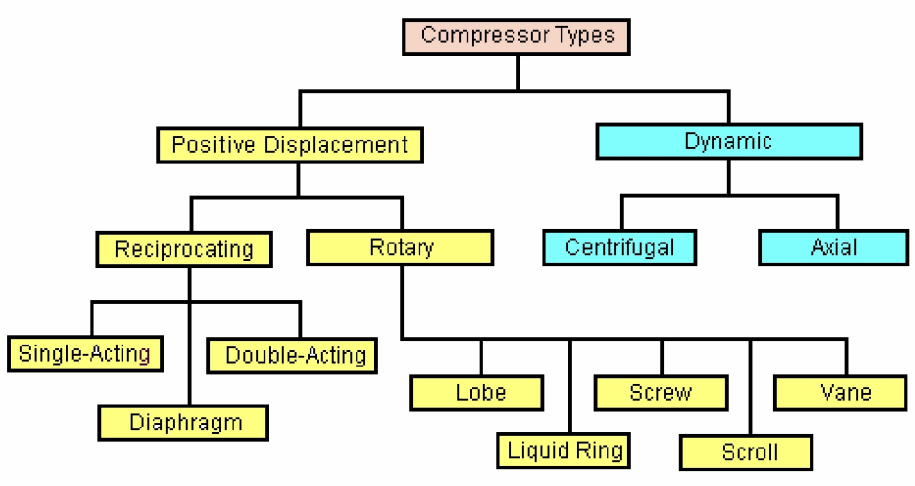
4. **Consequently**, these stages are often replaced by a single centrifugal unit.

5. Very small flow compressors often employ two centrifugal compressors, connected **in series**.

6. Although in **isolation** centrifugal compressors are capable of running at quite high pressure ratios (e.g. 10:1), impeller stress considerations limit the pressure ratio that can **be employed** in high overall pressure ratio engine cycles.

Speaking

Here is the diagram illustrated the main types of gas compressors. Choose one of the types and make a short report for your group mates could compare the performances and sphere of their application.



Writing

Summarize the information given in the text "Compressors". Use the key-patterns.

As the title implies the article describes…
The article deals with…
The text is of interest to…
It is spoken in detail about…
It should be stressed that…
A mention should be made that…
The text is of great help to…
The difference between the terms … and… should be stressed.
It is noted…
It is discussed…

Unit II
The Centrifugal-Flow Compressors

Before you Begin

I. Write these words in the correct group.

impeller; manifold; rim; ruggedness; shock-wave; stage; single; multiple; plenum chamber; double-entry; excessively, attribute; rapid; inefficient; diffuser, conversion, gas turbine, chief; massive; shock; centrifugal; multiple-stage; simplicity; flexibility

construction

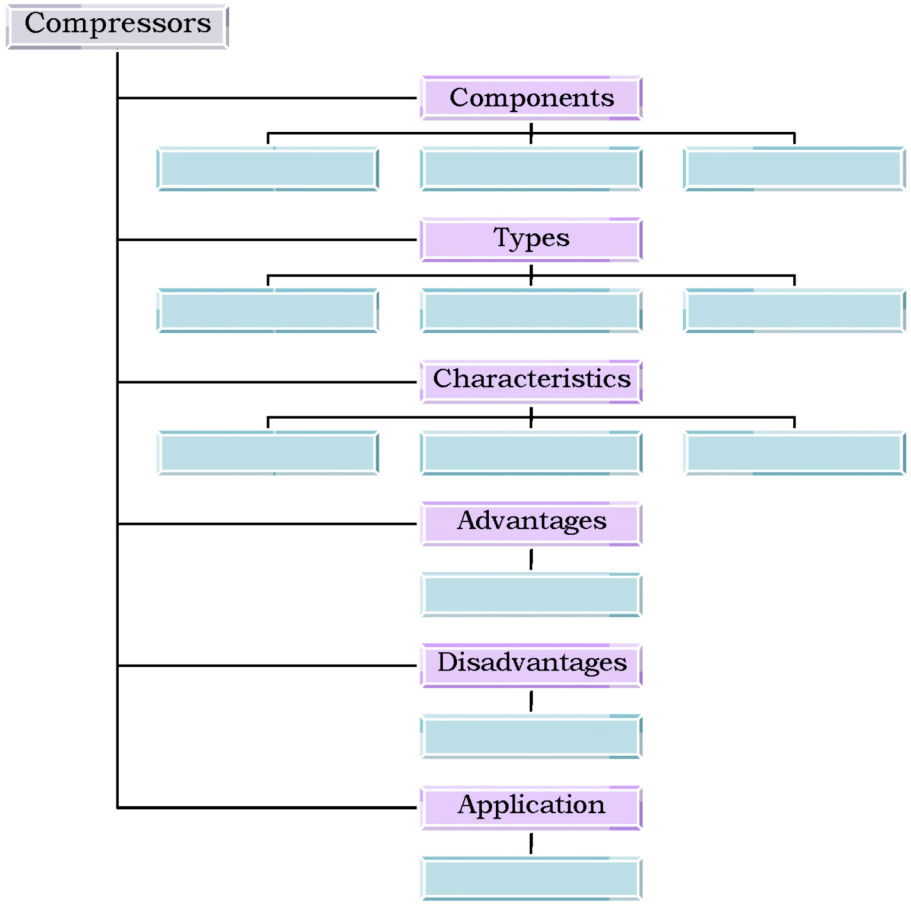
characteristics

II. Scan the text to find main components and characteristcs of a centrifugal-flow compressor. Check if your predictons were correct. Put them down.

Reading

I. Read the text and write a brief heading for each paragraph.

II. Fill in the diagram with missing information from the text.



The Centrifugal-Flow Compressor

The centrifugal compressor consists basically of an impeller and a diffuser manifold. Other components such as compressor manifold may be added to direct the compressed air into the combustion chamber. As the impeller revolves at high speed, air is drawn in at the eye. Centrifugal force provides high acceleration to this air and causes it to move outward from the axis of rotation toward the rim of the rotor where it is ejected at high velocity and high kinetic energy.

The pressure rise is produced in part by expansion of the air in the diffuser manifold by conversion of the kinetic energy of motion into static pressure energy.

The centrifugal compressors can be manufactured in a variety of designs including single-stage, multiple-stage, and double-sided types. The centrifugal compressor has a number of features to recommend its use in certain types of gas turbine engines. Chief among its attributes are its simplicity, ruggedness, and low cost. Because of its massive construction, it is much less susceptible to damage from the injection of foreign objects. The centrifugal compressor is capable to relatively high compressor ratio per stage. Above 80 percent efficiency may be reached with a compression ratio of 6 or 7 to 1. Above this ratio, efficiency drops off at a rapid rate because of excessively high impeller tip speeds and attending shock-wave formation. This rules out this type of compressor for use in larger engines since high compression ratios are necessary for low fuel consumption. Some centrifugal-flow engines obtain somewhat higher ratios through the use of multistage compressors. Although the tip speed problem is reduced, efficiency is again lost because of the difficulty in turning the air as it passes from one stage to another. Double-entry compressors also help to solve the high-tip-speed problems, but this advantage is partially offset by the complications in engine design necessary to get air to the rear impeller, and by the requirement of a large plenum or air chamber, where the air from the inlet duct is brought to a slower speed for efficient direction change and higher pressures. The plenum chamber acts as a diffuser by which means the rear impeller can receive its air.

Because of the problems inherent in this type of design the centrifugal compressor finds its greatest application on the smaller engines, where simplicity, flexibility of operation and ruggedness are the principle requirements rather than small frontal area, and ability to handle high air flows and pressures with low loss of efficiency.

Post-Reading

I. Match these English words with their Russian equivalents:

impeller, manifold, to draw in, rim, ruggedness, ingestion, shock-wave, stage, single, multiple, plenum chamber, to direct, to revolve, eye, to cause, outward, toward, in turn, expansion, conversion, feature, chief, attribute, susceptible, damage, capable, to drop off, tip, attending, to rule out, to obtain, partially, offset, inherent, rather than, to handle

а не, рабочее колесо, камера сгорания, подверженный, расширение, признак, повреждение, ударная волна, единственный, превращение, способный, извне, достигать, частично, отверстие, исключать, управлять, кромка, к, в свою очередь, заставлять, ступень, втягивать, прочность, засасывание, направлять, вращать, компенсировать, множественный, присущий, свойство, кончик, главный, снижать, трубопровод, присутствие, а не

II. Match verbs from the text with their definitions.

- to put smth with another thing or group of things
- to make goods in large quantities in a factory
- to deliberately let smth fall
- to balance the effect of smth, with the result that there is no advantage or disadvantage
- to stop considering smth as a possibility

III. Complete the following sentences using the ideas from the text.

1. The centrifugal compressor consists basically of …
2. The pressure rise is produced in part by …
3. The centrifugal compressors can be manufactured in a variety of designs including …
4. Because of its massive construction, it is much less susceptible to …
5. … may be reached with a compression ration of 6 or 7 to 1.
6. High compression ratios are necessary for …
7. Although the tip speed problem is reduced, efficiency is again lost because of …
8. … help to solve the high-tip-speed problems.
9. The plenum chamber acts as …
10. The centrifugal compressor finds its greatest application on…

IV. Rearrange the words to make a meaningful sentence.

1. Acceleration force to move rotation outward centrifugal high from provides this to and air the axis causes it of.
2. Conversion the pressure kinetic energy of motion part into of the air static rise energy is produced by expansion in by pressure into the diffuser in manifold.
3. Is ratio to relatively centrifugal stage compressor the capable high per compressor.

V. Match parts of the sentences in columns A and B.

A	B
1. The plenum chamber acts as a diffuser	its simplicity, ruggedness, and low cost.
2. Above ratio of 80 percent, efficiency	since high compression ratios are necessary for low fuel consumption.
3. Chief among its attributes are	the difficulty in turning the air as it passes from one stage to another.
4. This rules out this type of compressor for use in larger engines	by which means the rear impeller can receive its air.
5. Efficiency is again lost because of	drops off at a rapid rate because of excessively high impeller tip speeds and attending shock-wave formation.

VI. a) Answer the following questions.

1. What does a centrifugal compressor consist of?
2. What does centrifugal force provide?
3. What is the pressure rise produced by?
4. What types of design of a centrifugal compressor exist?
5. What are the advantages of a centrifugal compressor?
6. Why is a centrifugal compressor much less susceptible to damage from foreign object?
7. When does the efficiency drop off at a rapid rate?
8. By means of what do some centrifugal-flow compressors obtain higher ratios?

b) Think of 3 more questions to the text.

VII. Retell the text.

Language in Use

I. Find pairs of synonyms among the words.

edge, speed, mainly, a number of, produce, main, quick, get

basically, velocity, rim, manufacture, variety of, rapid, obtain, chief

II. Find the antonyms among the words.

inward, more, below, front, outlet, quick, inefficient, high

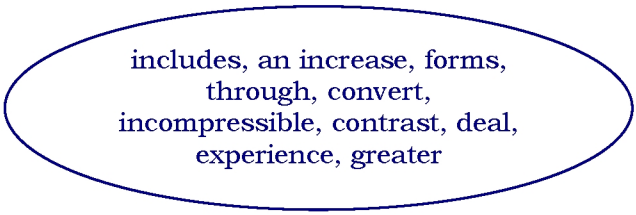
low, less, rear, slow, outword, inlet, above, efficient

III. a) Match the adjectives with their definitions.

1. kinetic	1. main or most important
2. static	2. very large or heavy
3. certain	3. relating to, caused by, or producing movement
4. chief	4. happening, moving, or acting quickly
5. massive	5. at the back of smth
6. rapid	6. not moving or changable
7. rear	7. this quality is basic or essential feature that gives smth its character
8. inherent	8. having no doubt that smth is true

b) Reproduce the context where they are used.

IV. Fill in the gaps using the words from the oval. Mind, there is one extra word! Translate the sentences into Russian.



1. Centrifugal compressor, (sometimes referred to as radial compressors) are a special class of radial-flow work-absorbing turbomachinery that _____ pumps, fans, blowers and compressors.

2. The earliest _____ of these dynamic turbomachines were pumps, fans and blowers.

3. What differentiates these early turbomachines from compressors is that the working fluid can be considered _____ thus permitting accurate analysis through Bernoulli's equation.

4. In contrast, modern centrifugal compressors are higher in speed and analysis must _____ with compressible flow.

5. For purposes of definition, centrifugal compressors often have density increases _____ than 5 percent.

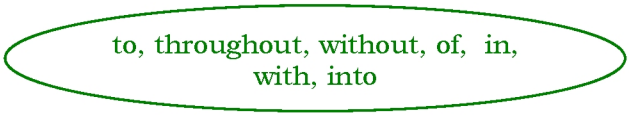
6. Also, they often _____ relative fluid velocities above Mach 0.3 when the working fluid is air or nitrogen.

7. In _____, fans or blowers are often considered to have density increases of less than 5 percent and peak relative fluid velocities below Mach 0.3

8. In an idealized sense, the dynamic compressor achieves a pressure rise by adding kinetic-energy/velocity to a continuous flow of fluid _____ the rotor or impeller.

9. This kinetic energy is then converted to _____ in static pressure by slowing the flow through a diffuser.

V. Use the prepositions in the oval to complete the sentences in the text. Translate the text.



Centrifugal compressors are used _____ industry because they have fewer rubbing parts, are relatively energy efficient, and give higher airflow than a similarly sized reciprocating compressor (i.e. positive-displacement). Their primary drawback is that they cannot achieve the high compression ratio reciprocating compressors _____ multiple stages. Centrifugal fan/blowers are more suited _____ continuous-duty applications such as ventilation fans, air movers, cooling units, and other uses that require high volume _____ little or no pressure increase. _____ contrast, multi-stage centrifugal compressors often achieve discharge pressures of 8,000 _____ 10,000 psi (59 MPa to 69MPa). One example _____ an application _____ centrifugal compressors is their use _____ re-injecting natural gas back _____ oil fields to increase oil production.

VI. Fill in the gaps with the suitable derivative of the word given in brackets. Translate the sentences.

-ing, -ly, -tion, -*able*, -*ment*, -ence, -ic, -ance, -*al*

Operating limits

Many centrifugal compressors have one or more of the following **(to operate)** limits:

- *Minimum Operating Speed* - the minimum speed for **(to accept)** operation, below this value the compressor may be controlled to stop or go into an "Idle" condition.
- *Maximum **(to allow)** Speed* - the maximum operating speed for the compressor. Beyond this value stresses may rise above prescribed limits and rotor vibrations may increase rapidly. At speeds above this level the **(to equip)** will likely become very dangerous and be controlled to slower speeds.
- *Stonewall or Choke* - occurs under one of 2 conditions. **(Typical)** for high speed equipment, as flow increases the velocity of the gas/fluid can approach the gas/fluid's sonic speed somewhere within the compressor stage. This **(to locate)** 0may occur at the impeller inlet "throat" or at the vaned diffuser inlet "throat". In most cases, it is generally not **(detriment)** to the compressor. For low speed equipment, as flows increase, losses increase such that the pressure ratio drops to 1:1.
- *Surge* - is the point at which the compressor cannot add enough energy to overcome the system **(resist)**. This causes a rapid flow reversal (i.e. surge). As a result, high vibration, temperature increases, and rapid changes in axial thrust can occur. These **(occur)** can damage the rotor seals, rotor bearings, the compressor driver and cycle operation. Most turbomachines are designed to easily withstand **(occasion)** surging. However, if the turbomachine is forced to surge repeatedly for a long period of time or if the

turbomachine is poorly designed, repeated surges can result in a **(catastrophe)** failure. Of particular interest, is that while turbomachines may be very durable, the cycles/processes that they are used within can be far less robust.

Speaking

Work in pairs and make up a dialogue discussing similarities and distinctions of an axial-flow compressor and a centrifugal-flow one. Touch upon such questions as :

- components
- characteristics
- preferences
- drawbacks
- sphere of application

Use phrases in the box.

I quite agree.
You are right.
That's true.
Absolutely.
No doubt about it.
That's just what I was thinking.
I wish, I could agree but…
I am not sure about it.
I wouldn't say that.
Would you say that…?

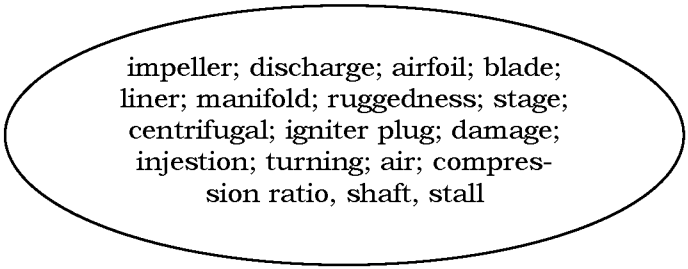
Writing

Summarize the information given in the text "Compressors". Use the key-patterns.

Unit III
Compressor Stall

Before you Begin

I. Tick the words which come to your mind when you think of such part of an engine as "Compressor". Add your own words and expressions. Make the sentences on the subject using as many words from the list as possible.



II. Try to answer the questions before you read the text.

1. What are the most stressed parts of a compressor?
2. What problems may be inherent to the compressor?
3. What are solutions for these problems?

III. Scan the text and check if your predictions were correct.

Reading

I. While reading try to devide the text into logical parts and make a plan of the text.
II. Read the text and highlight the ideas not mentioned in the discussion.

Compressor Stall

Since an axial-flow compressor consists of a series of alternately rotating and stationary airfoils or wings, the same rules and **limitations** which apply to an airfoil will apply to the entire compressor.

The picture is somewhat more complicated than in the case for a single airfoil, because the blades are close together, and each blade is affected at the leading edge by the passage through the air of the **preceding** blade. This "cascade" effect can be more readily understood if the airflow through the compressor is viewed as flow through a series of ducts formed by the individual blades, rather than flow over an airfloil that is **generating** lift. The cascade effect is of prime importance in determining blade design and placement.

The axial compressor is not without its difficulties, and the most vital of these is the stall problem. If for some reason the angle of attack, i.e., the angle at which the airflow strikes the rotor blades, becomes too low, the pressure zones will be of low value and the airflow and compression will be low. (The angle of attack should not **be confused** with the angle of incidence, which is a **fixed** angle determined by the manufacturer when the compressor is constructed). If the angle of attack is high, the pressure zones will be high and airflow and compression ratio will be high. If it is too high the compressor will stall. That is, the airflow over the upper foil surface will become **tubulent** and destroy the pressure zones. This is, of course, decrease the compression and airflow. The angle of attack will vary with engine rpm, compressor inlet temperature, and compressor discharge or burner pressure. Decreasing the velocity of airflow or increasing engine rotor speed will tend to increase the angle of attack.

In general, any action that decreases airflow **relative** to engine speed will increase the angle of attack and increase the tendency to stall. The decrease in airflow may result from the compressor discharge pressure becoming too high, for example, from excessive fuelflow schedule during **acceleration**. On compressor inlet pressure may become too low in respect to the compressor discharge pressure because of high inlet temperatures and distortion of inlet air. Several other causes are possible.

During ground operation of the engine, the prime action that tends to cause a stall is **choking**. If the engine speed is decreased from the design speed, the compresion ratio will decrease with the lower rotor velocities. With a decrease in compression the volume of air in the rear of the compressor will be greater. This excess volume of air causes a choking action in the rear of the compressor with a de-

crease in airflow, which in turn decreases the air velocity in the front of the compressor and increases the tendency to stall. If no corrective design action is taken, the front of the compressor will stall at low engine speeds.

Another important **cause** of stall is high compressor inlet air temperatures. High-speed aircraft may experience an inlet air temperature of 250° F (121°C) or higher because of ram effect. These high temperatures cause low compression ratios (due to density changes) and will also cause choking in the rear of the compressor. This choking stall condition is the same as that caused by low compression ratio **due to** low engine speeds. High compressor inlet temperatures will cause the length of the airflow vector to become longer since the air velocity is directly affected by the square root of any temperature change.

Each stage of a compressor should develop the same pressure ratio as all other stages. But when the engine is slowed down or the compressor inlet temperature climbs, the front stages supply too much air for the rear stages to **handle** and the rear stages will choke.

Post-Reading

I. In the text find definitions for the following terms:

- angle of attack
- angle of incidence
- a choking action

II. Find the Russian equivalents to the following words and word combinations from the text:

-to be affected; to be viewed; to be confused; destroy; discharge; to be slowed down; to handle; result from
- leading edge; cascade affect; placement; stall; incidence; schedule; prime action; choking; excess volume; ram effect; square root; tendency
- vital; turbulent; relative; excessive
- since; rather than; due to; in general

III. Complete the following sentences using the ideas from the text.

1. This "cascade" effect can be more readily understood if...

2. The angle of attack will vary with...

3. ... will increase the angle of attack and increase the tendency to stall.

4. If the engine speed is decreased from the design speed, the compresion ratio will...

5. High-speed aircraft may experience...

6. High compressor inlet temperatures will cause the length of the airflow vector to...

7. On compressor inlet pressure may become too low in respect to...

IV. Match the begining of the sentence with its ending using the ideas from the text.

1. This "cascade" effect is	a) a fixed angle determined by the manufacture when the compressor is constructed.
2. The angle of attack is	b) the pressure zones will be high and airflow and compression ratio will be high.
3. The angle of incidence is	c) will tend to increase the angle of attack.
4. If the angle of attack is high,	d) which in turn decreases the air velocity in the front of the compressor and increases the tendency to stall.
5. Decreasing the velocity of airflow or increasing engine rotor speed	e) that caused by low compression ratio due to low engine speeds.
6. The excess volume of air causes a choking action in the rear of the compressor with a decrease in airflow,	f) viewed as flow through a series of ducts formed by the individual blades.
7. The choking stall condition is the same as	g) the angle at which the airflow strikes the rotor blades.

V. Explain the meaning of the words marked in the text in English.

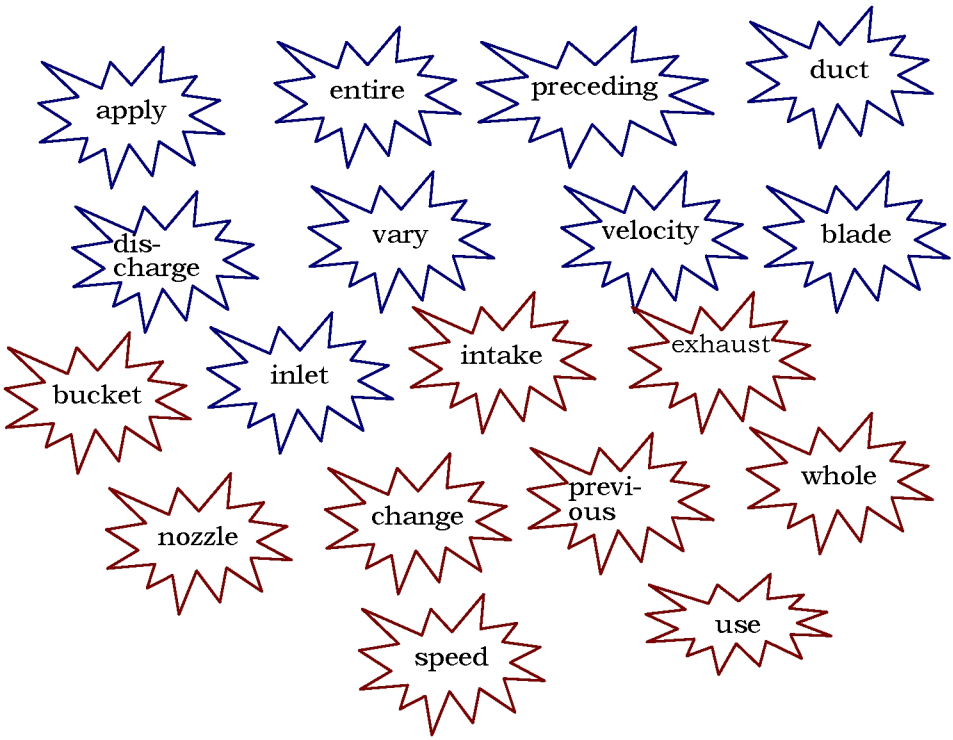
VI. a)Answer the following questions according to the text.

1. What does an axial flow compressor consist of?
2. What is a cascade affect?
3. What is the vital problem of a compressor?
4. At what conditions does the compressor stall occur?
5. What is the prime action that tends to cause a stall during ground operation?

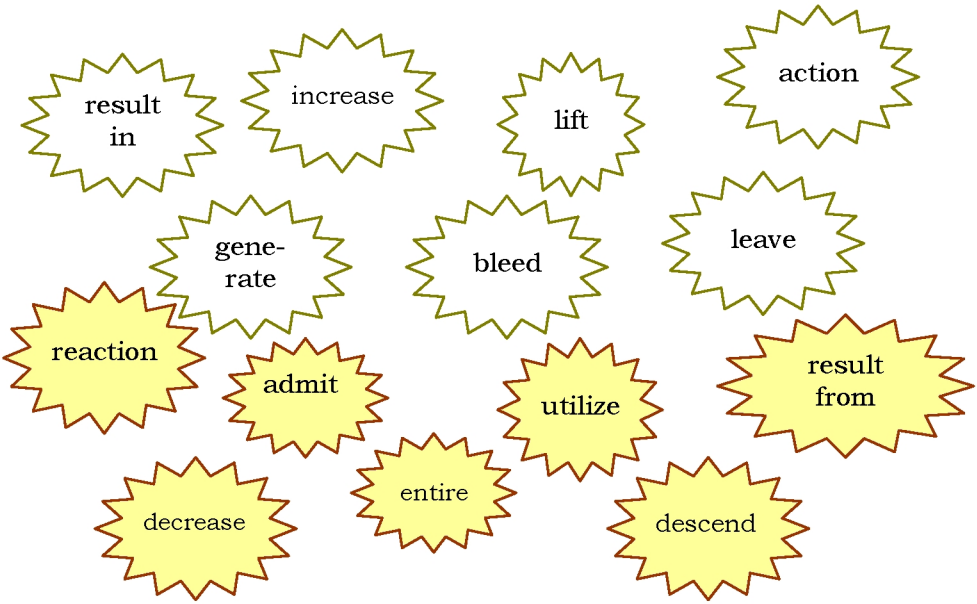
b) Think of 4 more questions to the text.

Language in Use

I. Match pairs of synonyms .



II. Match pairs of antonyms.



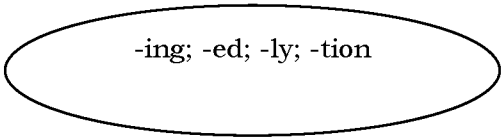
III. Use the prepositions in the oval to complete the sentences in the text. Translate the text with the help of a dictionary in written.

by (2); in (3); to (2); of (2);
from(2)within

This characteristic has been called both " Surge " and " Stall " _____the past , but is more properly called SURGE when it is response _____ the entire engine. The word stall applies_____ the action occurring at each individual compressor blade. Compressor surge , also called Compressor stall , is a phenomenon which is difficult to understand because it is usually caused _____complex combination of factors . The basic cause of compressor surge is fairly simple , each blade _____an axial flow compressor is a miniature airplane wing which , when subjected _____a higher angle of attack , will stall just as an airplane stalls. Surge may define as results_____ an unstable

air condition _____the compressor. The unstable condition of air is often caused _____air piling up _____the rear stages of the compressor. Surge may become sufficiently pronounce to cause loud bangs and engine vibration. In most case , this condition is of short duration , and will either correct itself or can be corrected _____ retarding the throttle or power lever to Idle and advancing it again , slowly.

IV. Open the bracket and form new words in using the suffixes in the oval. Translate the text, define the main idea of it in one phrase.

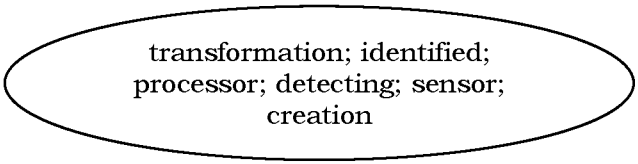


a) A compressor stall is an event which can occur inside the (to work) of a turbojet or turbofan engine.

Now, turbojets and their ilk contain several sets of fans. In the frontmost part of the engine, the fans are part of what is called the compressor stage, because they compress (to income) air into the combustion chambers of the engine behind them. So, at the front of every jet engine you can clearly see a circular bladed fan.

b) Each blade of the fan is, in fact, a little tiny airfoil (to design) to convert horizontal (to rotate) energy into perpendicular kinetic force - the force that pushes the air into the engine. If you need to know how this works, find your local fan and examine it (careful). In order for this to work, the leading edge of the fan must be 'hitting' the air within a range of proper angles of attack. Outside that range, the fan blade's shape is incorrect for the purpose, and the fan blades will stop pushing air, even though they're spinning. When this happens, bad things escalate. The airflow into the combustion chamber is (dramatical) reduced, leading to a (to reduce)in thrust. At worst, it may mean flame out as the engine is starved for air.

V. Fill in the gaps using the words from the oval. Mind, there is one extra word! Translate the sentences into Russian.



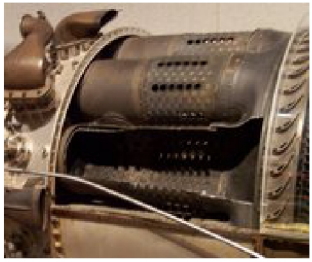
A method of _____ onset of a gas turbine condition, such as compressor stall, includes receiving data indicative of an operating parameter of a compressor of the gas turbine. The method also includes performing a wavelet transformation on the data to generate wavelet transformed data. The wavelet _____ is configured to affect a processing characteristic regarding a performance of the wavelet transformation. Features indicative of onset of the gas turbine condition in the wavelet transformed data are then

_____ to provide an indication for controlling the gas turbine to prevent compressor stall from occurring. A system for detecting onset of compressor stall in a gas turbine includes a _____ for providing data indicative of an operating parameter of the compressor and a _____ for performing a wavelet transform on the data to identify features of the optimized wavelet transformed data indicative of onset of stall.

Writing

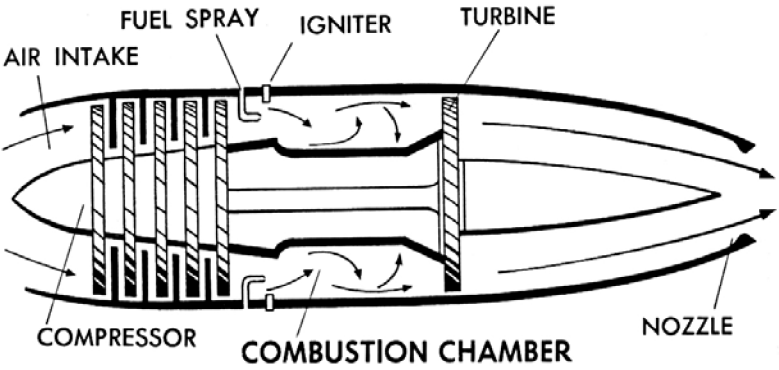
Summarize the information given in the text "Operation of the combustion chamber". Use the key-patterns.

Unit IV
Operation of the Combustion Chamber



Before you Begin

I. Look at the picture and say what main components a gas-turbine engine consists of. Try to predict what role a combustion chamber performs in an engine.

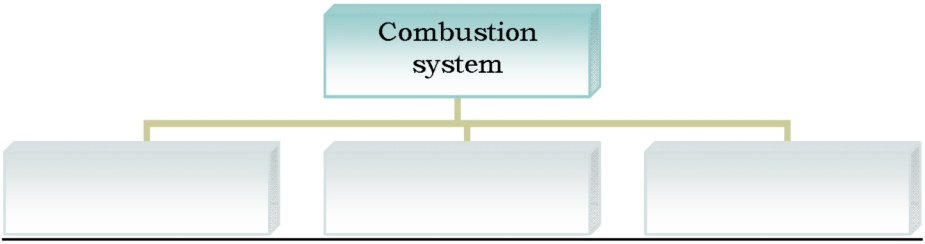


II. Scan the text to find the function of the combustion chamber. Check if your predictions were correct. Put them down.

Reading

I. Divide the text into paragraphs. Give a title for each one. Choose the key words of each part and define the main point of it in one phrase.

II. a) While reading make a graphic representation of the text.



Operation of the Combustion Chamber

Fuel is introduced at the front end of the burner in either a highly atomized spray from specially designed nozzles, or in a prevaporized form from devices called vaporizing tubes. Air flows in around the fuel nozzle and through the first row of combustion air holes in the liner. The burner geometry is such that the air near the nozzle stays close to the front wall of the liner for **cooling** and **cleaning** purposes, while the air entering through opposing liner holes mixes rapidly with the fuel to form a combustible mixture. **Additional** air is introduced through the remaining air holes in the liner. The air entering the forward section of the liner tends to **recirculate** and move upstream against the fuel spray. During combustion this action permits rapid mixing and **prevents** flame **blowout** by forming a low-velocity stabilization zone which acts as a continuous **pilot** for the rest of the burner. The air entering the downstream part of the liner provides the correct mixture for combustion, and it creates the intense turbulence that is necessary for mixing the fuel and air and for **transferring** energy from the burned to the unburned gases. Since there are only two igniter plugs in an engine, cross ignition tubes are necessary in the can-annular types of burners in order that burning may be **initiated** in the other cans or inner liners. The igniter plug is usually located in the upstream reverse-flow region of the burner. After ignition, the flame quickly **spreads** to the primary or combustion zone where there is approximately the correct proportion of air to completely burn the fuel. If all the air flowing through the engine were mixed with the fuel at this point, the mixture would be **outside** the combustible limits for the fuels normally used. Therefore only about one-third to one-half is

allowed to enter the combustion zone of the burner. About 25 percent of the air **actually** takes place in the combustion process. The gases that result from combustion have temperatures of 3560°F (1900°C). Before entering the turbine the gases must be cooled to approximately half this value, which is determined by the design of the turbine and the **materials involved.** Cooling is done by diluting the hot gases with secondary air that enters through a set of relatively large holes located toward the rear of the liner. The liner walls must also be protected from the high temperature of combustion. This is usually accomplished by **introducing** air at several stations along the liner, thereby forming an insulated blanket between the hot gases and the metal walls.

Post-Reading

I. Match parts of the sentences in columns A and B.

A	B
1. Fuel is introduced at the front end of the burner in either	1. must also be protected from the high temperature of combustion.
2. Before entering the turbine the gases	2. the primary or combustion zone where there is approximately the correct proportion of air to completely burn the fuel.
3.The liner walls	3. the first row of combustion air holes in the liner.
4. After ignition, the flame quickly spreads to	4. the remaining air holes in the liner.
5. Air flows in around the fuel nozzle and through	5. must be cooled to approximately half this value, which is determined by the design of the turbine and the materials involved.
6. Additional air is introduced through	6._a highly atomized spray from specially designed nozzles, or in a prevaporized form from devices called vaporizing tubes.

II. a) Give the Russian equivalents to the words and word combinations from the text.

Front end; either…or; atomized; prevaporized; air flow; fuel nozzles; holes; liner; cooling and cleaning purposes; rapidly; combustible mixture; to introduce; to tend; upstream; to prevent; flame blowout; low-velocity stabilization zone; to transfer; igniter plug; cross-ignition tubes; burner; to initiate; reverse-flow region; to spread; completely; at this point; combustible limits; to take place; to determine; materials involved; diluting; to protect; to accomplish; an insulated blanket

b) Reproduce the context.

III. Agree or disagree with the statements. Correct the wrong ones.

1. Fuel is introduced at the rear end of the burner in either a highly atomized spray from specially designed nozzles.

2. Air flows in around the fuel nozzle and through the last row of combustion air holes in the liner.

3. Highly pressurized gas is introduced through the remaining air holes in the liner.

4. During combustion this action permits slow mixing and prevents flame blowout by forming a low-velocity stabilization zone.

5. The air entering the downstream part of the liner provides the correct mixture for combustion.

6. Since there is only one igniter plug in an engine, cross ignition tubes are not necessary in the can-annular types of burners in order that burning may be initiated in the other cans or inner liners.

7. The igniter plug is usually located in the downstream reverse-flow region of the burner.

8. If all the air flowing through the engine were mixed with the fuel at this point, the mixture would be inside the combustible limits for the fuels normally used.

9. Before entering the turbine the gases must be cooled to approximately one third this value.

10. The liner walls must also be protected from the high temperature of combustion.

IV. Try to guess and explain the meaning of marked words in the text from the content.

V. a) Answer the following questions.

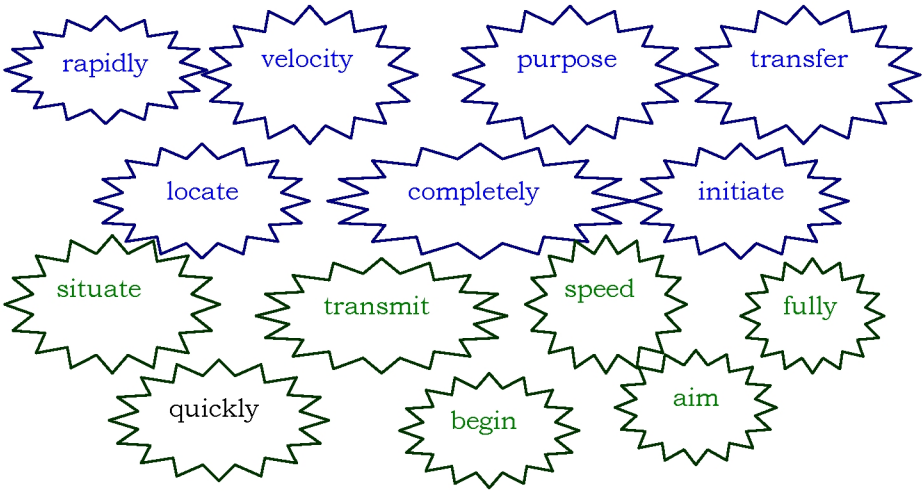
1. How is the fuel introduced to the combustion chamber?
2. What is the burner geometry?
3. What is a combustible mixture?
4. How is a flame blowout prevented?
5. What is turbulence necessary for?
6. How many igniter plugs in the combustion chamber?
7. Where are igniter plugs located?
8. When would the combustible mixture be outside the limits?

b) Think of three more questions and write them down.

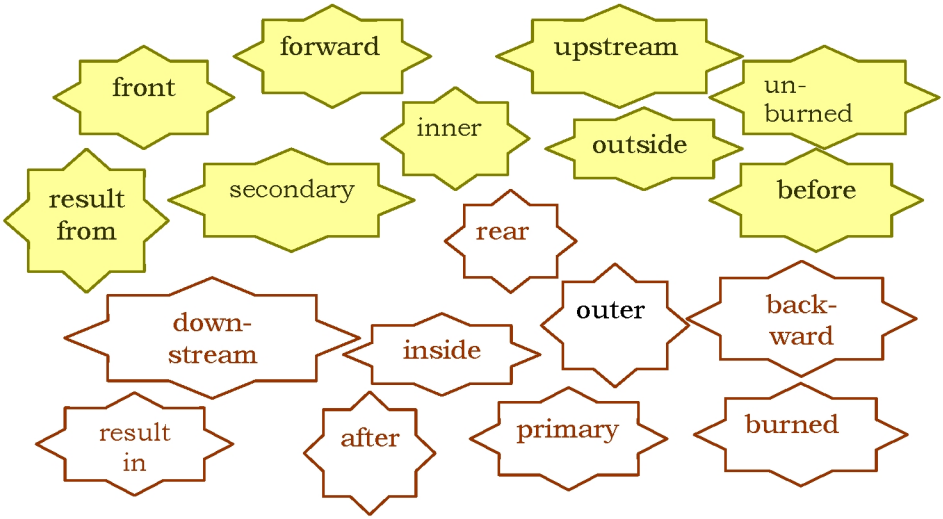
VI. Retell the text.

Language in Use

I. Find pairs of synonyms among the words.



II. Find the antonyms among the words.



III. a)Find words in the text that mean:

1. A narrow part at the end of a tube through which liquid flows.
2. An occasion when a flame suddenly stops to blow.
3. Sudden violent movements of air or water.
4. Making a liquid less strong by adding water or another liquid.
5. A thick layer of something.

IV. Use the prepositions in the oval to complete the sentences in the text. Translate the text with the help of a dictionary in written.

at, in, through, of, for, to,
through, from

Combustion chamber GE J79

Flame fronts generally travel _____ just Mach 0.05, whereas airflows _____ jet engines are considerably faster than this. Combustors typically employ structures to give a sheltered (закрытая) combustion zone called a flame holder. Combustor configurations include can, annular, and can-annular.

Great care must be taken to keep the flame burning _____ a moderately fast moving airstream, at all throttle conditions, as efficiently as possible. Since the turbine cannot withstand stoichiometric temperatures (a mixture ratio of around 15:1), some _____ the compressor air is used to quench the exit temperature of the combustor to an acceptable level (an overall mixture ratio _____ between 45:1 and 130:1 is used.) Air used _____ combustion is considered to be primary airflow, while excess air used _____ cooling is called secondary airflow. The secondary airflow is ported _____many small holes _____ the burner cans to create a blanket _____ cooler air to insulate the metal surfaces of the combustion can _____ the flame. If the metal were subjected _____ the direct flame for any length of time, it would eventually burn through.

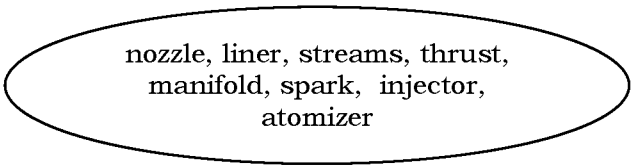
V. a) Collocate the words in the table.

A	B
1. atomized	blowout
2. vaporizing	zone
3. cooling	turbulence
4. combustible	tube
5. flame	plug
6. stabilization	spray
7. intense	region

8. igniter	involved
9. reverse-flow	mixture
10. materials	air
11. secondary	purpose
12. insulated	blanket

b) Make up sentences with these word combinations in written.

VI. Fill in the gaps using the words from the oval. Mind, there is one extra word! Translate the text into Russian in written.



Also known as a *firing chamber*, the chamber of a rocket engine in which the fuel and the oxidizer burn to produce high pressure gas expelled from the engine _____ to provide thrust. To begin with, the fuel and oxidizer pass (separate) through a complex _____ in which each component is broken down into smaller and smaller flow _____, in the same way that arteries in the body divide into increasingly small capillaries. Then the propellants are injected into the combustion chamber via the _____ – a plate at the top of the chamber which takes the small flow streams and forces them through an _____. The purpose of the injector is to mix the fuel and oxidizer molecules as thoroughly and evenly as possible. Once mixed, the fuel and oxidizer are ignited by the intense heat inside the chamber. To start the combustion, an ignition source (such as an electric _____) may be needed. Alternatively, some propellants are hypergolic – they spontaneously combust on contact – and do not need an ignition source.

VII. Translate the following sentences. Pay special attention to the marked words. Give your own explanation of them.

Incomplete combustion (a state in which not all the fuel in the combustion chamber burns) may result from **inadequate** chamber design, or it may be **deliberately** designed into the system so that the

unburned fuel acts as a chamber **coolant**. Generally, incomplete combustion is **indicative** of a system not functioning efficiently.

Combustion chamber is a space over, or in front of, a boiler furnace where the gases from the fire become more **thoroughly** mixed and burnt. The **clearance space** in the **cylinder** of an internal combustion engine is **compressed** and ignited.

Speaking

Work in pairs and make a dialogue discussing the operation of the combustion chamber on such points:

- introducing of fuel
- air circulation
- mixing the fuel and the air
- ignition
- resultant gases
- protection from high temperature of combustion

Use the phrases below

- The point is...
- It seems to me...
- As far as I know...
- I am sure. (I am not sure)
- I wouldn't say that...
- On the contrary...

Writing

Summarize the information given in the text "Operation of the combustion chamber". Use the key-patterns.

Unit V
Inlet Ducts

Before you Begin

I. Read the text and render its idea in Russian. Try to guess what the term "Inlet Ducts" means.

Pilot intakes are the dominant type for subsonic applications. A subsonic pilot inlet is little more than a tube with an aerodynamic fairing (обтекатель) around it.

At zero airspeed, air approaches the intake from a multitude of directions: from directly ahead, radially, or even from behind the plane of the intake lip.

At low airspeeds, the stream tube approaching the lip is larger in cross-section than the lip flow area, whereas at the intake design flight Mach number the two flow areas are equal. At high flight speeds the stream tube is smaller, with excess air spilling (распыление) over the lip.

Beginning around Mach 0.85, shock waves can occur as the air accelerates through the intake throat.

Careful radiusing of the lip region is required to optimize intake pressure recovery (and distortion) throughout the flight envelope.

II. Scan the text and speak about the 2 main classification of inlet ducts.

Reading

I. In the text, find definitions of :

- the duct pressure efficiency ratio

- the ram recovery point
- a bellmouth inlet

II. Skim the text and try to explain the meaning of marked words from the content of the text.

Inlet Ducts

The inlet duct is made by the aircraft manufacturer. During flight operations it becomes very important to the overall jet engine performance, and will greatly influence jet engine thrust output. The faster the airplane goes, the more **critical** the duct design becomes. Engine thrust can be high only if the inlet duct supplies the engine with the required airflow at the highest possible pressure.

The inlet duct must operate from **static** ground run up to high aircraft Mach numbers with a high duct efficiency at all altitudes, attitudes, and flight speeds. **To compound** the problem, the amount of air required by a turbojet engine is approximately 10 times or more than that of a piston engine of comparable size.

Inlet ducts should be as straight and **smooth** as possible, and should be designed in such a way that the boundary layer air (a layer of still, dead air lying next to the surface) be held to the minimum. The length, shape, and placement of the duct is determined to a great extent by the location of the engine in the aircraft.

Not only must the duct be large to supply the proper airflow, but it must be shaped correctly to deliver the air to the front of the compressor with an **even** pressure distribution. Poor air pressure and velocity distribution at the front of the **compressor** may result in compressor stall.

Another primary task a duct must do during flight operation is to convert the kinetic energy of the rapidly moving inlet stream into a ram pressure rise inside the duct. To do this it must be shaped so that the ram velocity is slowly and smoothly decreasing, while the ram pressure is slowly and smoothly rising.

Inlet ducts are **rated** in two ways: the duct pressure efficiency ratio and the ram recovery point. The duct pressure efficiency ratio is defined as the ability of the duct to convert the kinetic or dynamic pressure energy at the inlet of the duct into static pressure energy at the inlet of the compressor without a loss in total pressure. It will

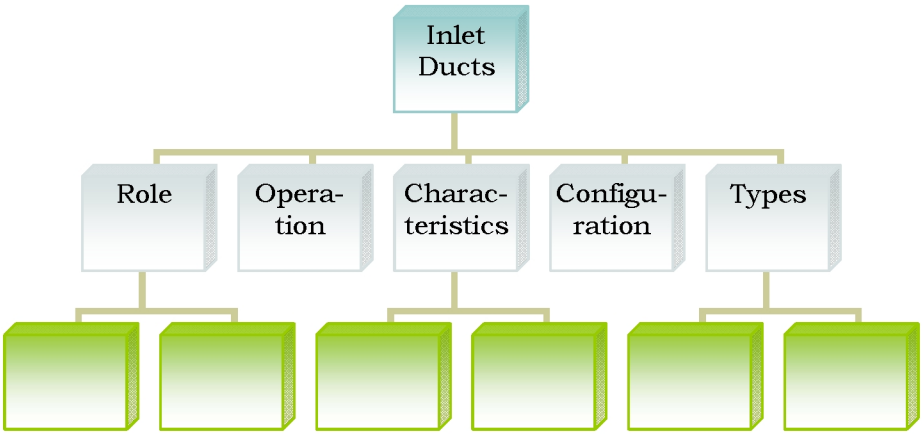
have a high value of 98 percent if the friction loss is low and if the pressure rise is accomplished with small losses. The ram recovery point is that aircraft speed at which the ram pressure rise is equal to the friction pressure losses, or that airspeed at which the compressor inlet total pressure is equal to the outside **ambient** air pressure. A good subsonic duct will have a low ram recovery point (about 160 mph (280km/h)).

Inlet ducts may be divided into two broad categories: subsonic ducts and supersonic ducts.

It is interesting to note that the engine manufacturers rate their engines using a bellmouth inlet. This type of inlet is **essentially** a bell-shaped funnel having carefully rounded shoulders, which offer practically no air resistance. The duct loss is so small that it is considered zero, and all engine performance data can be gathered without any correction for inlet duct loss being necessary. Normal duct inefficiencies may cause thrust losses of 5 percent or more because a decrease in duct efficiency of 1 percent will decrease airflow 1 percent, decrease jet velocity ½ percent, and result in 1 ½ percent thrust loss. The decrease in jet velocity occurs because it is necessary to increase the area of the jet nozzle **in order to** keep the turbine temperature within limits when duct losses occur.

Post Reading

I. a) Fill in the diagram according to the content of the text



b) Divide the text into logical parts and give the title for each one.

II. Find the English equivalents to the following words and word combinations in the text:

Уязвимый; обеспечивает; неподвижный; число Маха; положение; чтобы решить; сравнимый размер; ровный; таким способом; пограничный слой воздуха; быть сведённым; в значительной мере; доставлять; распределение; привести; срыв компрессора; основная задача; скоростной поток; плавно; характеризуются; точка восстановления скоростного потока; потеря; трение; равен; внешний; воронкообразный; по существу; сопротивление; исправление; для того, чтобы; в допустимых пределах

III. Complete the following sentences using the ideas from the text.

1. The faster the airplane goes, the more critical... .
2. The inlet duct must operate from ... .
3. The length, shape, and placement of the duct is determined ... .
4. Inlet duct must be shaped correctly to deliver the air to ... .
5. Inlet ducts are rated in two ways ... .
6. The ram recovery point is ... .
7. It is interesting to note that the engine manufacturers rate their engines ... .
8. Normal duct inefficiencies may cause ... .
9. The decrease in jet velocity occurs ... .

III. Explain what a term “bellmouth inlet” means.

IV. Choose the one sentence that best keeps the content of the text.

V. a) Answer the following questions:

1. What is the significance of the inlet duct?
2. In what conditions must the inlet duct operate?
3. How is the inlet duct to be designed?

4. Where does the inlet duct deliver the air?
5. What is one of the primary tasks of the inlet duct?
6. How are inlet ducts rated?
7. Into what categories may inlet ducts be divided?

b) Think of three more questions and write them down.

Language in Use

I. Find the Russian equivalents to the words from column a) from the words from column b)

A	B
1. approximately	1. для того, чтобы
2. comparable size	2. приблизительно
3. in such a way	3. соизмеримый размер
4. result in	4. высокое значение
5. high value	5. вызывать
6. to be equal to	6. таким образом
7. offer resistance	7. в определённых пределах
8. without any correction	8. приводить к
9. cause	9. оказывать сопротивление
10. in order to	10. быть равным чему-либо
11. within limits	11. без каких-либо поправок

II. Find pairs of synonyms among the words.

occur; convert; duct; attitude; amount; shape; extent; location; determine; correct

right; define; take place; transform; nozzle; placement; degree; position; form; value

III. Find pairs of antonyms among the words.

supersonic; increase; inlet;
primary; inside; with; result in

outlet; secondary; outside;
without; decrease; subsonic;
result from

IV. a) Match the verbs with their definitions.

A	B
1. to influence	1. to provide someone or smth with smth that they need or want
2. to compound	2. to change from one system, use, or method to another
3. to supply	3. to consider that smth has a particular quality or has achieved a particular standard or level
4. to convert	4. to succeed in doing smth, especially smth that you have been trying for a long period of time
5. to rate	5. to affect smth happens
6. to accomplish	6. to make a problem or difficult situation worse

b) Reproduce the context where they are used.

V. Fill in the gaps using the words from the oval. Mind, there is one extra word! Translate the text into Russian in written.

increase;
supersonic; subsonic;
decrease; shockwaves;
minimize;

Air intake (Inlet) — The standard reference frame for a jet engine is the aircraft itself. For _____aircraft, the air intake to a jet engine presents no special difficulties, and consists essentially of an opening which is designed to _____drag, as with any other aircraft component. However, the air reaching the compressor of a normal jet engine must be travelling below the speed of sound, even for _____ aircraft, to sustain the flow mechanics of the compressor and turbine blades. At supersonic flight speeds, _____ form in the intake system and reduce the recovered pressure at inlet to the compressor. So some supersonic intakes use devices, such as a cone or ramp, to _____ pressure recovery, by making more efficient use of the shock wave system.

VI. Use the prepositions in the box to complete the sentences in the text. Translate the text in written.

to; of; for; into; throughout; on; from; until

There are basically two forms of shock waves:

1) Normal shock waves lie perpendicular _____ the direction _____ the flow. These form sharp fronts and shock the flow _____ subsonic speeds. Microscopically the air molecules smash _____ the subsonic crowd _____ molecules like alpha rays. Normal shock waves tend to cause a large drop in stagnation pressure. Basically, the higher the supersonic entry Mach number _____ a normal shock wave, the lower the subsonic exit Mach number and the stronger the shock (i.e. the greater the loss in stagnation pressure across the shock wave).

2) Conical (3-dimensional) and oblique shock waves are angled rearwards, like the bow wave _____ a ship or boat, and radiate _____ a flow disturbance such as a cone or a ramp. _____ a given inlet Mach number, they are weaker than the equivalent normal shock wave and, although the flow slows down, it remains supersonic _____ . Conical and oblique shock waves turn the flow, which continues in the new direction, _____ another flow disturbance is encountered downstream.

VII. Fill in the gaps with the suitable derivative of the word given in brackets. Translate the text in written.

-y, -tion, -al, -ed

More advanced supersonic intakes are designed to have a normal shock in the ducting downstream of intake lip, so that the flow at compressor/fan entry is always subsonic. However, if the engine is throttled back, there is a _____ **(to reduce)** in the _____ **(to correct)** airflow of the LP compressor/fan, but (at supersonic conditions) the corrected airflow at the intake lip remains constant, because it is determined by the flight Mach number and intake incidence/yaw. This _____ **(discontinue)** is overcome by the normal shock moving to a lower _____ **(cross-section)** area in the ducting, to decrease the Mach number at entry to the shockwave. This weakens the shockwave, improving the overall intake pressure _____ **(recover)**. So, the absolute airflow stays constant, whilst the corrected airflow at compressor entry falls (because of a higher entry pressure). Excess intake airflow may also be dumped overboard or into the exhaust system, to prevent the conical/oblique shock waves being disturbed by the normal shock being forced too far forward by engine throttling.

Speaking

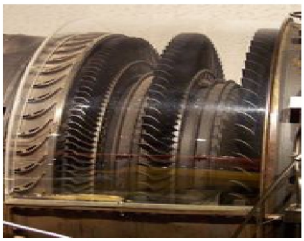
Work in pairs and compare the subsonic and supersonic ducts from the point of view of their characteristics and configuration. Use the phrases below:

- As far as I know
- I'd like to tell you
- I'd like to add
- It's quite right
- It's quite on the contrary
- If I'm not mistaken

Writing

Summarize the information given in the text "Inlet Ducts". Use the key-patterns.

Unit VI
Turbine (Part I)



Before you Begin

I. Discuss the following questions with your peer.

1. Can you give any explanation of the term turbine?
2. What are its main components?
3. How many types of turbines are produced? What are they?

II. Choose the suitable title for the text:

1. Turbine Operation
2. Turbine Construction
3. Types of Turbines

III. Try to predict the beginning of the text in accordance with the title you chose.

Reading

Read the text below then answer which paragraph, A-F, tells you about:

1. Some operations the blades undergo before their operations.
2. Work and use of multistage turbines.
3. Distortions in the turbine.
4. Shrouded and unshrouded blades.
5. The turbine wheel.
6. The turbine assembly.
7. Methods of cooling the disk and the blades.
8. A member of compressors in the turbine.

The turbine wheel is one of the most highly stressed parts of the engine. Not only must it operate at temperatures of approximately 1800°F (982°C), but it must do so under severe centrifugal loads imposed by high rotational speeds of over 60,000 rpm for small engines to 8,000 rpm for the larger ones. Consequently, the engine speed and turbine inlet temperature must be accurately controlled to keep the turbine within safe operating limits.

The turbine assembly is made of two main parts, the disk and the blades. The disk or wheel is a statically and dynamically balanced unit of specially alloyed steel usually containing large percentages of chromium, nickel, and cobalt. After forging, the disk is machined all over and carefully inspected using X-rays, sound waves, and other inspection methods to assure structural integrity. The blades or buckets are attached to the disk by means of a "fir tree" design to allow for different rates of expansion between the disk and the blade while still holding the blade firmly against centrifugal loads. The blade is kept from moving axially either by rivets, special locking tabs or devices, or another turbine stage.

Some turbine blades are open at the outer perimeter, whereas in others a shroud is used. The shroud acts to prevent blade-tip losses and excessive vibration. Distortion under high loads, which tend to twist the blade toward low pitch, is also reduced. The shrouded blade has an aerodynamic advantage in that thinner blade sections can be used and tip losses can be reduced by using a knife-edge or labyrinth seal at this point. Shrouding, however, requires that the turbine run cooler or at a reduced rpm because of the extra mass at the tip. On blades that are not shrouded, the tips are cut or recessed to a knife edge to permit a rapid "wearing-in" of the blade tip to the turbine casing with a corresponding increase in turbine efficiency.

Blades are forged from highly alloyed steel and are passed through a carefully controlled series of machining and inspection operations before being certified for use. Many engine manufacturers

will stamp a "moment weight" number on the blade to retain rotor balance when replacement is necessary.

The temperature of the blade is usually kept within limits by passing relatively cool air bled from the compressor over the face of the turbine, thus cooling the disk and blade by the process of convection. This method of cooling may become more difficult, as high Mach number flights develop high compressor inlet and outlet temperatures.

Some gas turbine engines use a single-stage turbine, whereas other employ more than one turbine wheel. Multi –stage turbines are used where the power required to drive the compressor would necessitate a very large turbine wheel. Multistage wheels are also used foe turboprops where the turbine has to extract enough power to drive both the compressor and the propeller. When two or more turbine wheels are used, a nozzle diaphragm is positioned directly in front of each turbine wheel. The operation of the multistage turbine is similar to that of the single stage, except that the succeeding stages operate at lower gas velocities, pressures, and temperatures. Since each turbine stage receives the air at a lower pressure than the preceding stage, more blade area is needed in the rear stage to assure an equitable load distribution between stages. The amount of energy removed from each stage is proportional to the amount of work done by each stage.

Most multistage turbines are attached to a common shaft. However, some multistage turbine engines have more than one compressor. In this case, some turbine wheels drive one compressor and the remaining turbines drive the other.

The wheel is subjected to both high speed and high temperature. Because of these extreme conditions, blades can easily deform by growing in length (a condition known as creep) and by twisting and changing pitch. Since these distortions are accelerated by exceeding engine operating limits, it is important to operate within the temperature and rpm points set by the manufacture.

Post-reading

I. Find the English equivalents to the following words and word combinations:

a) в пределах; процентное соотношение; тогда как; подвергаться; посредством; следовательно; позволять; благодаря; вследствие.

b) наиболее напряжённые части; при сильных центробежных нагрузках; в пределах безопасных эксплуатационных режимов; тщательно проверяется; для обеспечения структурной целостности; при высоких нагрузках; в этом месте; соответствующее увеличение; выпущенный из компрессора; требуемый для приведения в движение; размещается непосредственно; равномерное распределение нагрузки; оставшиеся турбины; экстремальные условия.

II. a) Have a look at these three figures. What does each of them illustrate?

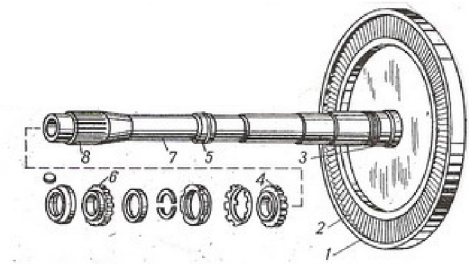


Fig.1

b) name all the components of the device in fig.1?

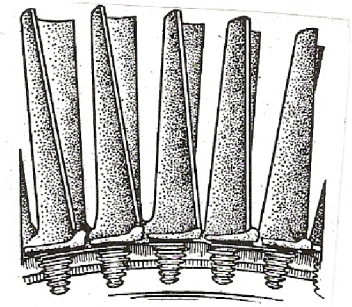


Fig.2

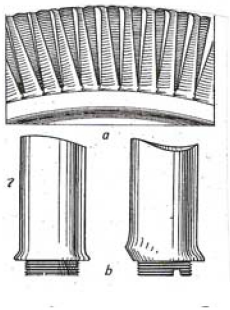


Fig.3

c) What do you know about the device in fig.2?

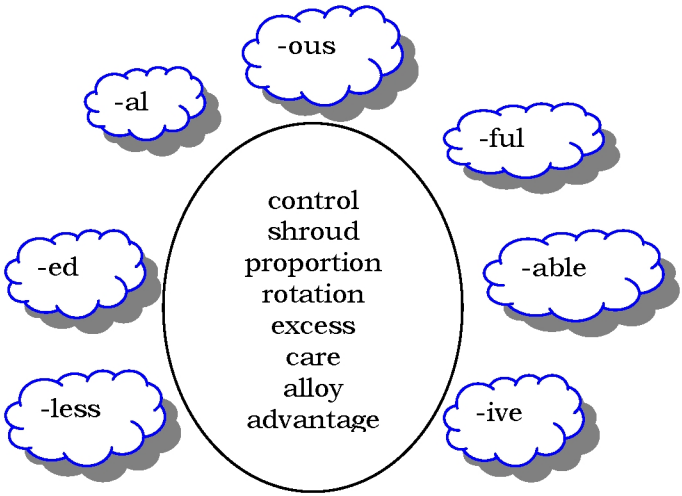
d) What part of the text does fig. 3 correspond to? Prove your answer.

III. Complete the sentences. If necessary refer to the text.

1. The engine speed and turbine inlet temperature must be accurately controlled _____ .
2. After forging, the disk is machined all over and carefully inspected using _____ .
3. Blades are forged from _____ .
4. The temperature of the blade is kept _____ , thus cooling the disk and blade by the process of convection.
5. Multistage turbines are used where _____ would necessitate a very large turbine wheel.
6. _____ , a nozzle diaphragm is positioned directly in front of each turbine wheel.
7. Since each turbine stage receives the air at a lower pressure than the preceeding stage _____ .

Language in Use

I. Form adjectives from the nouns below. Use the suffixes that are in the clouds. Mind, more than one variant is possible.

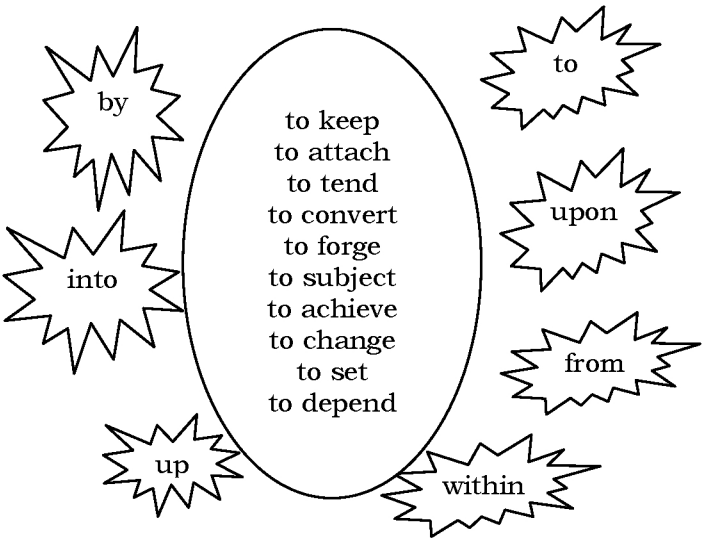


II. a) Find the proper prepositions for each verb. Watch out! There may be more than one combination.

b) Explain their meaning.

c) Quote the sentences from the text to illustrate their use.

d) For the rest of the prepositional verbs give examples.



III. Fill in the gaps using the words from the oval. Mind, there is one extra word!

hot; to cause; combustion; wheel; seriously; raise; turbine; uncommon; vibratory; flow; various; rim; encounter

Among the most _____ stressed components in a gas-turbine engine is the turbine wheel. The buckets of the wheel are subjected to high centrifugal stresses and to a fluctuating stream of _____ gases which _____ temperature and may, at the same time, introduce _____ stresses. The disk of the _____ is subjected to heat by con-

duction from the buckets and may, in some cases, be directly heated by the _____ gases. Temperatures of over 1500°F are not _____ near the _____ of the first-stage turbine disk. Where there is more than one _____ disk in an engine, the second and third-stage disks do not _____ such high temperatures. Turbine disks are often cooled by means of air bled from the compressor section and directed through _____ passages to _____ around the turbine disk.

Speaking

I. Use the information from the text and exercise II of the Post-Reading section to make a diagram on the topic "Turbine Construction"

II. Compare your and your partner's diagrams. Choose the diagram which better reflects the topic. Fill it in.

III. Basing on your diagram be ready to speak before the class. The following phrases may help you.

- I want to begin my presentation with…
- The subject that I will speak is …
- It should be emphasized that …
- Let me now turn to …
- On the one hand …, on the other hand …
- In conclusion let me say …

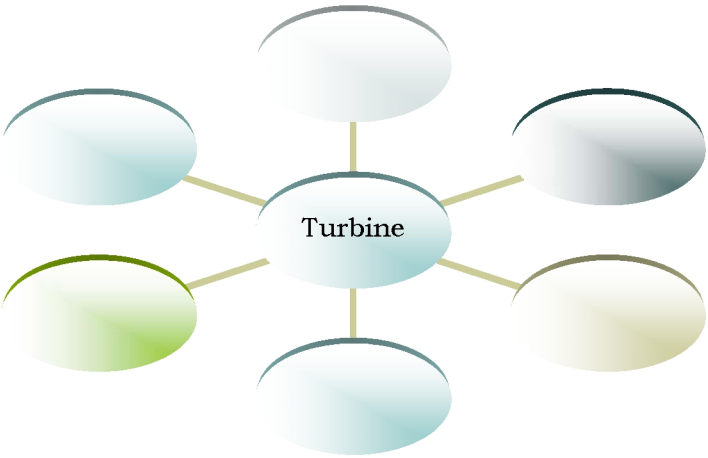
Writing

In the text it is spoken about a fir-tree design by means of which the blades are attached to the disk. It is the most satisfactory and the most widely used attachment. Do a search on other types of the blades attachment. Compare them with the fir-tree design.

Unit VII
Turbines
(Part II)

Before you Begin

I. Brainstorm all possible ideas related to the topic



II. Read this abstract and render its idea in Russian

The function of the turbine is to drive the compressor and accessories, and, in the case of the turboprop, the propeller, by extracting a portion of the pressure and kinetic energy from the high temperature combustion gases. In a typical jet engine about 75 percent of the power produced internally is used to provide the compressor. What is left is used to produce the necessary thrust. In order to furnish the drive power to compress the air, the turbine must develop as much as 100, 000 hp (74, 570 kw) or more for the large jet engines. One blade or bucket of a turbine can extract about 250 hp (185 kw) from the moving gas stream. This is equivalent to the power produced by a typical eight-cylinder automobile engine. It does all of this in a space smaller than the average automobile engine, and with a considerable advantage in weight.

Reading

Skim the text and try to guess the meaning of the marked words from the content of the text.

With a few exceptions, gas turbine manufacturers have concentrated on the axial-flow turbine although some manufactures are building engines with a radial inflow turbine. The radial inflow turbine has the advantage of ruggedness and simplicity, and is relatively inexpensive and easy to manufacture when compared with axial-flow type. On this type of turbine, inlet gas flows through peripheral nozzles to enter the wheel passages in an inward radial direction. The speeding gas exerts a force on the wheel blades and then exhausts the air in an axial direction to the atmosphere. These turbine wheels used for small engines are well suited for a lower range of specific speeds and work at relatively high efficiency.

The axial-flow turbine is comprised of two main elements consisting of a set of stationary vanes and one or more turbine rotors. The turbine blades themselves are of two basic types, the impulse and the reaction. The modern aircraft gas turbine engine utilizes blades which have both impulse and reaction section.

The stationary part of the turbine assembly consists of a row of contoured vanes set at an angle to form a series of small nozzles which discharge gases into the blade of the turbine wheel. For this reason, the stationary vanes assembly is usually referred to as the turbine nozzle, and the vanes themselves are called nozzle guide vanes.

Post-Reading

I. Name two types of turbines most often produced by gas manufacturers today.

II. Speak about their advantages and disadvantages.

III. Schematically show the flow of gas in the radial-inflow turbine.

IV. Make a list of all design features typical for each type of the turbine and its stationary part.

Types of the Turbines/Parts of the Turbine	**Design features**
Radial-Inflow type	
Axial-Inflow Type	
Stationary Part	

Language in Use

I. Give Russian equivalents to the following word combinations and phrases:

moving gas stream; gas turbine manufactures; inward radial direction; stationary vanes assembly; nozzle guide vane; modern aircraft gas turbine engine

II. a) Form words opposite in the meaning using the prefixes in the box. Consult the dictionary if necessary. Translate them.

	-un; -in; -dis
Easy	
Expensive	
Suited	
Efficiency	
Advantage	
Charge	
stability	

b) Use them in the sentences of your own.

III. Match the keywords with their translation.

1. to finish	a) вспомогательные агрегаты
2. impulse blade	b) извлекать
3. to extract	c) лопасть
4. contoured	d) неподвижный
5. accessories	e) доставлять
6. bucket	f) профильный
7. stationary	

IV. a) Find the right word for the words in the box below. The first example is done for you.

verb	translation	noun	translation
1. to flow	протекать	flow	поток
2. to force		force	сила
3. to exhaust		exhaust	
4. to use		use	
5. to work		work	работа
6. to set	устанавливать	set	
7. to assembly		assembly	
8. to form		form	форма
9. to discharge	разряжать	discharge	
10. to sound		sound	звук

b) Define what part of speech the marked words belong to.

1. By reason of the rapid expansion, the heated air and combustion products at increased velocity **force** their way through the only exit from chamber.

2. Thrust is an applied **force** tending to produce motion in a body or to alter the motion of a body.

3. These vanes direct the **flow** to the appropriate angle of attack for the blades on the periphery of the turbine wheel.

4. In that position the valve allows the oil to **flow** from the engine through the transfer rings.

5. Internal combustion engines **use** any fuels that can be combined with an oxidizer in the chamber.

6. Extensive **use** of titanium in the front part of the compressor and high-nickel steel alloys in the rear is made.

7. Daimler's new engine **set** the basis for all car engines going forward.

8. The axial-flow turbine is comprised of two main elements consisting of a **set** of stationary vanes and one or more turbine rotors.

9. The pattern of **sound** from a jet engine makes the noise problem even more bothersome than that coming from other types of engine.

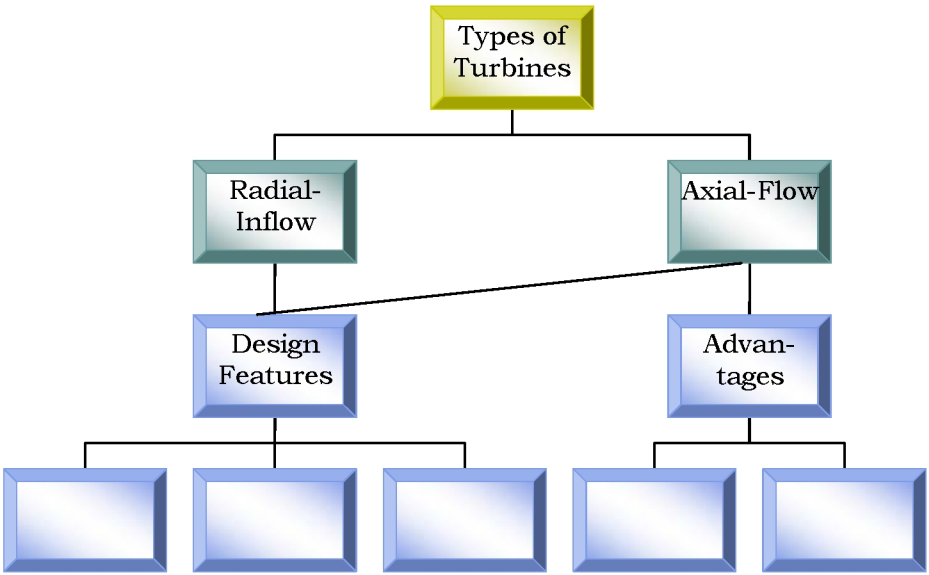
Speaking

a) Which of these two graphs better reflects the content of the text. Discuss it with your partner.

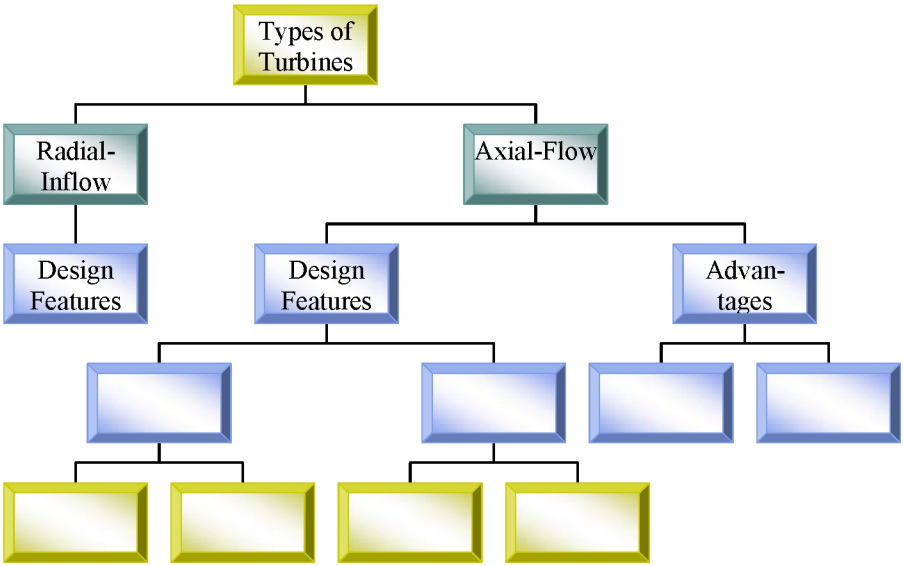
b) Fill in the chosen graph with the words or phrases from the text.

c) Compare the results with your peers from the other group.

1.



2.



While discussing make use of the following phrases:

- First of all I'd like to…
- I am arguing against…
- It is rather surprising…
- It is worth pointing out…
- Oh, let me think for a moment…
- Actually, I don't know…
- Well, now…

Writing

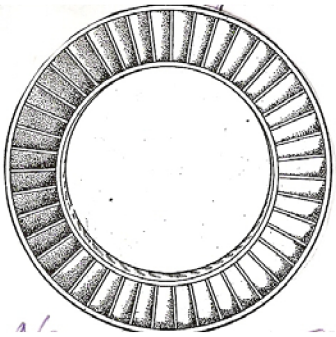
Do a research and write an account to your chief on the turbines mostly used today in aviation.

Unit VIII

* * *

Before you Begin

I. Look at the picture and say what might be the topic of the text.



II. Name 10 words related to the topic.

Reading

I. Read the text and give a title to it.

II. While reading the text, write out the words and word combinations you don't know. Try to guess their meaning from the context.

* * *

The nozzle guide vanes (diaphragm) have two principal functions. First, they must convert part of the gas heat and pressure energy into dynamic and kinetic energy, so that the gas will strike the turbine blades with some degree of force. Second, the nozzle vanes must turn this gas flow so that it will impinge upon the turbine buckets in the proper direction; that is, the gases must impact on the turbine blade in a direction that will have a large component force in the plane of the rotor. The nozzle does its first job by utilizing the Bernoulli theorem. As through any nozzle, when the flow area is restricted, the gas

will accelerate and a large portion of the static pressure in the gas is turned into dynamic pressure. The degree which this effect will occur depends upon the relationship between the nozzle guide vane inlet and exit areas, which, in turn is closely related to the type of turbine blades used.

The turbine nozzle area is a critical part of engine design. Making the nozzle area too small will restrict the airflow through the engine, raise compressor discharge pressure, and bring the compressor closer to stall. This is especially critical during acceleration when the nozzle will have the tendency to choke (gas flowing at the speed of sound). Many engines are designed to have the nozzle operating in these choked conditions. Small exit areas also cause slower accelerations because the compressor will have to work against the increased back pressure. Increasing the nozzle diaphragm area will result in faster engine acceleration, less tendency to stall but higher specific fuel consumption. The area of the nozzle is adjusted at factory or during overhaul so that the gas velocity at this point will be at or near the speed of sound.

The second function, that of turning the gases so that they strike the turbine blades at the correct angle, is accomplished by setting the blades at a specific angle to the axis of the engine. Ideally, this angle should be variable as a function of engine rpm and gas flow velocity, but in practice the vanes are fixed in one position. It should be noted that the auxiliary power unit (APU) for several turbine-powered ground vehicles is equipped with variable angle nozzle vanes.

Post-Reading

I. The text has three logical parts. Think of the heading to each part. Highlight the key words of each part.

II. Find in the text:

a) the definition of Bernoulli theorem

b) the description of increasing the nozzle diaphragm area result

c) English equivalents to the following words and word combinations:

чрезмерное уменьшение сопла; дросселирование; приводить к; нужное направление; происходить; удельный расход топлива; тесно связанный; в свою очередь; установка лопаток под нужным углом; лопатки сопла с переменным углом; регулируется на заводе

III. a) Answer the questions:

1. What does the text deal with?
2. What are the functions of the nozzle guide vanes?
3. What job is done by utilizing the Bernoulli theorem?
4. Why is the turbine nozzle area a critical part of engine design?
5. What is the result of gas acceleration?

b) Put 3 more questions to the text.

Language in Use

I. Match column A and B to find:
Mind, there is one extra word!

a) synonyms

A	B
1. convert	a) quick
2. vane	b) adjustment
3. impinge	c) take place
4. occur	d) relate
5. critical	e) transform
6. discharge	f) impact
7. fast	g) bucket
8. velocity	h) decisive
9. setting	i) exhaust
	j) speed

b) antonyms

A	B
1. kinetic	a) fixed
2. restrict	b) decelerate
3. accelerate	c) far
4. inlet	d) decrease
5. closely	e) adjust
6. increase	f) static
7. variable	g) exit
8. auxiliary	h) expand
	i) main

II. Give Russian equivalents to the following word combinations:

discharge pressure; nozzle guide vanes; nozzle guide vane inlet area; turbine nozzle area; auxiliary power unit; back pressure; turbine-powered ground vehicles; variable angle nozzle vanes; chocked conditions; specific fuel consumption

III. Decipher the abbreviations:

rpm; apu; i.e.

IV. What do the words in bold mean in the text? Choose the correct meaning. Mind, in some cases you may use more than one variant.

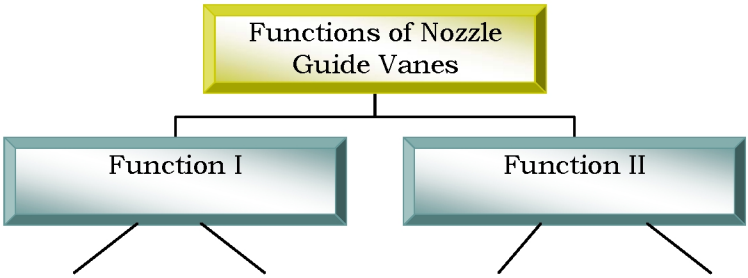
1. degree	a) any of various units of measurement	b) amount of level of something	c) a rank in society
2. occur	a) to take place	b) to exist	c) to come to mind
3. result in	a) to happen or exist because smth else has happened	b) to cause a particular situation happen	c) to have as a result

4. variable	a) likely to change frequently	b) a number, amount, size which can change	c) not steady
5. auxiliary	a) additional	b) giving help or support	c) more than necessary

Speaking

Work in pairs:

a) Finish drawing this diagram.
b) Fill it in with the words or phrases from the text.
c) Discuss it with your peer from the other group.
d) Be ready to speak on the topic.



The following phrases will be of great help:

Try to show your personal opinion:
- As I see it
- What I have in mind is that…
- This is particularly true for…

Interrupt your partner's opinion:
- I am sorry, could you be more specific about …
- On the contrary…
- That's what I mean, but…

Encourage your partner to say more:
- I wonder about...
- Wouldn't you agree with...
- Let's have a closer look at...

Writing

Rewrite the sentences that are jumbled in the correct order to make up a meaningful text on description and location of the nozzle diaphragm. (More than one alternative is possible).

1. The nozzle vanes are usually constructed of high-temperature alloy, and they must be highly heat-resistant.
2. In many engines, the nozzle vanes are hollow and are formed from stainless-steel sheet.
3. The nozzle diaphragm consists of a group of nozzle vanes welded between two shroud rings.
4. In the typical nozzle diaphragm, the inner and outer bands contain punched holes to receive the ends of the nozzle vanes.
5. When there is more than one turbine wheel, additional nozzle diaphragms are installed to direct the heated gases from one wheel to the next.
6. Second-, third- and fourth-stage nozzle vane are often constructed of solid steel alloy.
7. They are then welded and ground smooth before being installed between the shroud rings.
8. These may be either forged or precision-cast.

Unit IX
Supersonic Ducts

Before you Begin

I. Answer the following questions.

1. What does the term “duct” mean?
2. What types of ducts have you read or learnt before?
3. How is each of the ducts mentioned by you designed?

II. Match the keywords with their translations:

1. supersonic	a) иметь место
2. transonic	b) заглатывать
3. subsonic	c) тратить впустую
4. overhaul	d) характеристики
5. performance	e) дозвуковой
6. shock wave	f) амортизирующая игла
7. buzz	g) переработка, ремонт, разборка
8. accomplish	h) зудящий звук
9. spike	i) наклонный, непрямой
10. establish	j) угол
11. oblique	k) устанавливать
12. angle	l) сверхзвуковой
13. occur	m) околозвуковой
14. waste	n) выполнять
15. swallow	o) происходить, иметь место

Reading

Read the text and highlight the ideas not mentioned in the discussion.

Supersonic Ducts

The supersonic inlet duct must operate in three speed zones: subsonic, transonic, supersonic.

Although each of these speed zones needs a slightly different inlet duct design, good overhaul performance can be achieved by designing the supersonic shape with some modifications.

The supersonic duct problems start when the aircraft begins to fly at or near the speed of sound. At these sonic speeds shock waves are developed which, if not controlled, will give high duct loss in pressure and airflow, and will set up vibrating conditions in the inlet duct called inlet buzz. Buzz is an airflow instability caused by the shock wave rapidly being alternately swallowed and expelled at the inlet of the duct.

Air which enters the compressor section of the engine must usually be slowed to subsonic velocity, and this process should be accomplished with the least possible waste of energy. At supersonic speeds the inlet duct does the job by slowing the air with the weakest possible series or combination of shocks to minimize energy loss and temperature rise.

At transonic speeds (near Mach1), the inlet duct is usually designed to keep the shock waves out of the duct. This is done by locating the inlet duct behind a spike or probe so that at airspeeds slightly above Mach 1.0 the spike will establish a normal shock (bow wave) in front of the inlet duct. This normal shock wave will produce a pressure rise and a velocity decrease to subsonic velocities before the air strikes the actual inlet duct. The inlet will then be a subsonic design behind a normal shock front. At low supersonic Mach numbers, the strength of the normal shock wave is not too great, and this type of inlet is quite practical. But at higher Mach numbers the single normal shock wave is very strong and causes a great reduction in the total pressure recovered by the duct and an excessive air temperature rise inside the duct.

At slightly higher airspeeds the normal bow wave will change into an oblique shock. Since the air velocity behind an oblique shock is still supersonic, to keep the supersonic velocities out of the inlet duct, the duct will need to set up a normal shock wave at the duct inlet. The airflow is controlled so that the air velocity at the duct inlet is exactly equal to the speed of sound. At this time the duct pressure rise will be due to: 1) an oblique shock pressure rise; 2) a normal shock pressure rise; 3) a subsonic diverging section pressure rise.

As the airspeed is increased, the angle of the oblique shock will be forced back by the higher air velocity until the oblique shock contacts the outer lip of the duct. When this occurs there will be a slight increase in thrust due to an increase in engine inlet pressure airflow, because the energy contained in the shock front is now enclosed within the duct and delivered to it with less pressure loss. This point is called the duct recovery point.

At high Mach numbers (about 1.4 and above) the inlet duct must set up one or more oblique shocks and a normal shock. The oblique shocks will slow the supersonic velocities, the normal shock will drop the velocity to subsonic then the subsonic section will further decrease the velocity before the air enters the compressor. Each decrease in velocity will produce a pressure rise.

Post-Reading

I. Divide the text into 3 logical parts. Think of the heading for each part. Underline the topic words. Make the main point of each part in one phrase.

II. Find in the text the English equivalents to the phrases:

Будут возникать вибрационные условия; хорошие эксплуатационные характеристики; ударная волна будет попеременно заглатываться или выталкиваться на входе в канал; удерживать ударную волну вне сопла

III. a) In the text find definitions of:

- buzz
- duct recovery point

b) Give your own explanation of the terms:

- normal shock wave
- oblique shock

IV. Complete the following sentences using the ideas from the text.

1. Although each of these speed zones needs a slightly different inlet duct design ...
2. At supersonic speeds the inlet duct does the job by ...
3. At transonic speeds the inlet duct is designed to ...
4. At slightly higher airspeeds the normal low wave ...
5. The duct pressure rise will be due to ...
6. At higher Mach numbers the inlet duct must set up ...

V. Say if the statements are true or false. Correct the false once.

1. The supersonic duct problems start when the aircraft begins to fly at transonic speed.
2. The normal shock wave will produce a pressure rise and a velocity decrease to subsonic velocities after the air strikes the inlet duct.
3. The lower the supersonic Mach numbers, the higher the strength of the normal shock wave.
4. At higher Mach numbers the single normal shock wave is strong.
5. The duct will need to form a normal shock wave at the duct inlet to keep the supersonic velocities out of the inlet duct.

VI. a) Answer the questions below:

1. In what zones must the supersonic inlet duct operate?
2. When are shock waves developed?
3. What affect is caused by shock wave appearance?
4. When is the single normal shock wave strong?
5. What is the reason of the duct pressure rise?

b) Put 3 more questions to the text.

Language in Use

I. Highlight all the prepositions in the text.

II. Distribute them into the columns according to the meaning they contain in parts A-H.

Parts	Direction	Abstract relations	Merely grammatical relations	
A				
B				
C				
D				
E				
F				
G				
H				

III. a) Think of an additional column and entitle it.

b) Add 1-5 more examples and give their meaning using reference materials.

IV. Fill in the gaps with the prepositions from the box below. Translate the sentences.

In; of; at; into; by; before; out; with; to; until

1. The starting _____ a turbojet, or any other gas-turbine engine, requires that the engine be rotated _____ a speed which will provide sufficient air fuel combustion and that the engine be accelerated _____ the point where the power developed _____ the turbine is adequate for engine self-rotation.

2. After combustion commences (light-off) the starter continuous to supply torque _____ the engine _____ engine speed reaches a predetermined level where engine is sufficient to maintain acceleration.

3. Early German engines averaged only ten hours of operation _____ failing _____ often _____ chunks of metal flying _____ the back _____ the engine when the turbine overheated.

4. For a time some US jet engines included the ability to inject water _____ the engine to cool the compressed flow before combustion, usually during takeoff.

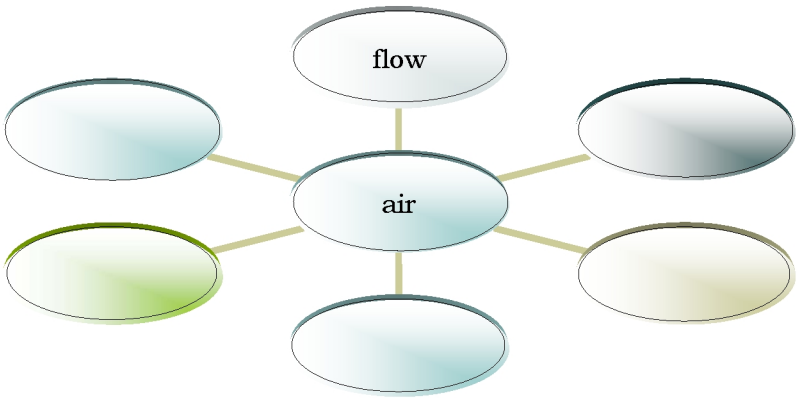
5. _____ most turbojet-powered aircraft, bleed air is extracted from the compressor section at various stages to perform a variety of jobs.

V. Give Russian equivalents to the following phrases:

A slightly different inlet duct design; the least possible waste of energy; excessive air temperature rise; the air is controlled so that the air velocity…; supersonic velocities out of the inlet duct.

VI. a) Combine the noun "air" with other nouns to make up new words or word combinations.

b) Explain their meaning.



Speaking

Work in groups:

a) Discuss the inlet duct design and its operation in three speed zones:

- Group A –in subsonic
- Group B – in transonic
- Group C – in supersonic

b) Draw a picture of the inlet duct peculiar for each zone

- Group A – for subsonic
- Group B – for transonic
- Group C – for supersonic

c) Work with two other partners. Share the information you have. Compare the design and operation of the inlet duct in all three zones. Make up a table.

Writing

Summarize the information given in the text. Use the key-patterns.

The text covers the problem…
The article/text carries material on…
The paragraph deals with…
The text provides the reader with some data/information on…
It is interesting to note…
The information presented is of interest to…

Unit X
Noise Supression Problem

Before you Begin

I. Read the abstract below and say what items are supposed to be touched upon in the text. To prove your point of view refer to the information from the abstract.

Aircraft noise is defined as sound produced by any aircraft on run-up, taxiing, take off, over-flying or landing. Aircraft noise is a significant concern for approximately 100 square kilometers surrounding most major airports. Aircraft noise is the second largest (after roadway noise) source of environmental noise. While commercial aviation produces the preponderance of total aircraft noise, private aviation and military operations also play a role. It is usually measured in Decibels.

II. Scan the text and check if your predictions were correct.

Reading

While reading the text match the keywords with their Russian counterparts.

1. noise	a. облицовка
2. take off	b. относительно, сравнительно
3. landing	c. перекрывать
4. residential areas	d. высокая двухконтурность
5. pattern	e. посадка
6. reciprocating engine	f. кожух
7. reach	g. шум
8. relatively	h. поршневой двигатель
9. overlap	i. взлёт
10. frequency	j. срезать, резать
11. shear	k. жилые кварталы
12. bring down	l. достигать
13. sound suppressor	m. неустойчивость, колебания

14. level	n. частота
15. high-bypass ratio	o. снижать
16. fluctuation	p. уровень
17. lining	q. шумоглушитель
18. shroud	r. образец, способ, пример

Sound Suppression. The Noise Problem

The noise problem created by commercial and military jet take offs, landings and ground operations at airports near residential areas has become a very serious problem within the last years. The pattern of sound from a jet engine makes the noise problem even more bothersome than that coming from other types of engines. For example, the noise from a reciprocating engine rises sharply as the airplane propeller passes an observer on the ground and then drops off almost as quickly. A jet reaches a peak after the aircraft passes, and is at an angle of approximately 45° to the observer. This noise then stays at a relatively high level for a considerable length of time. The noise from a turbojet is also more annoying because it overlaps the ordinary speech frequencies more than the noise from a reciprocating engine and propeller combination. Since the noise is produced by the high-velocity exhaust gas shearing through the still air, it follows that if the exhaust velocity is slower and the mixing area wider, the exhaust noise levels can be brought down to the point where a sound suppressor is not necessary. The exhaust-gas velocity of a turbofan is slower than a turbojet of a comparable size because more energy must be removed by the turbine to drive the fan. The fan exhaust velocity is relatively low and creates less of a noise problem, noise levels are also lower in the high-bypass-ratio turbofan engine through the elimination of the inlet guide vanes and the resulting reduction of the "siren" effect. The noise generated by this effect occurs when the columns of air created by the compressor inlet guide vanes are cut by the rapidly moving compressor blades, generating high-frequency pressure fluctuations. Further noise reductions are achieved by lining the fan shroud with acoustical materials, thus, dampening the pressure fluctuations and by spacing the outlet guide vanes farther away from the compressor. For these reasons, fan engines in general do not need sound suppressor. The function of the noise suppressor is to

lower the level of sound about 25 to 30 dB, as well as to change the frequency, and to do this with a minimum sacrifice in engine thrust or additional weight. The two facets of the noise problem, ground operation and airborne operation, tend themselves to two solutions. Noise suppressors can be portable devices for use on the ground by maintenance personnel, or they can be integral part of the aircraft engine installation. Airborne suppressors are more difficult to design than ground suppressors because of the weight limitations and the necessity of having the air exit in an axial direction to the engine.

Post-Reading

I. Divide the text into paragraphs. Give a title for each one. Choose the topic words of each part and define the main point of it in one phrase.

II. Make a graphic representation of the text. Share it with your partner and fill it in.

III. Say if the statements are true or false. Correct the false once.

1. The problem of aircraft noise has become one of the most urgent problems for the last several years.
2. The more energy is removed by the turbine to drive the fan the slower the exhaust-gas velocity of a turbofan is in comparison to a turbojet of the same size.
3. The elimination of the inlet guide vanes and the resulting reduction of the "siren" effect reduce noise levels in the high-bypass-ratio turbofan engine.
4. The noise generated by the "siren" effect occurs when the columns of air are cut by the stator blades.
5. To achieve better noise reduction the fan shroud is lined with acoustical material.

IV. Give Russian equivalents:

Within the last several years; the pattern of sound; exhaust-gas velocity; comparable size; through the elimination

V. Answer the questions:

1. What does the text deal with?
2. Why has the noise problem become one of the most important within the last several years?
3. What engines are less noisy and why?
4. Why does a turbofan need no sound suppressor?
5. Which of suppressors are more difficult to design and why?

Language in Use

I. Fill in the table using comparative and superlative adjectives. The 1st line in each box may serve as an example.

		-er	-est
of one syllable	low high slow wide few	low**er**	the low**est**
		more	**most**
of two and more sylla-bles	modern difficult important comfortable intelligent bothersome	**more** modern	**the most** modern
		-er or more	**-est or most**
	simple common narrow pleasant quiet	simp**ler** **more** simpler	the simp**lest** **the most** sim-ple
		Irregular Forms	
	good far little bad much many	better	the best

II. a) Use adjectives in brackets either in a comparative or superlative form.

1. One of the _____ (significant) sources of cabin noise from commercial jet aircraft rather than the engines is the Auxiliary Power Unit.

2. The typical noise output of an APU is 113 decibels. This is about 27 decibels _____ (low) than that of a jet engine.

3. _____ (large) aircraft then entering service or in development, such as Lockheed L-1011, Douglass DC-10 and Airbus A3000 were designed with the _____ (stringent) requirements in mind.

4. The development of high-bypass turbofans that powered these _____ (new) aircraft was prompted by the need for _____ (great) thrust and fuel efficiency.

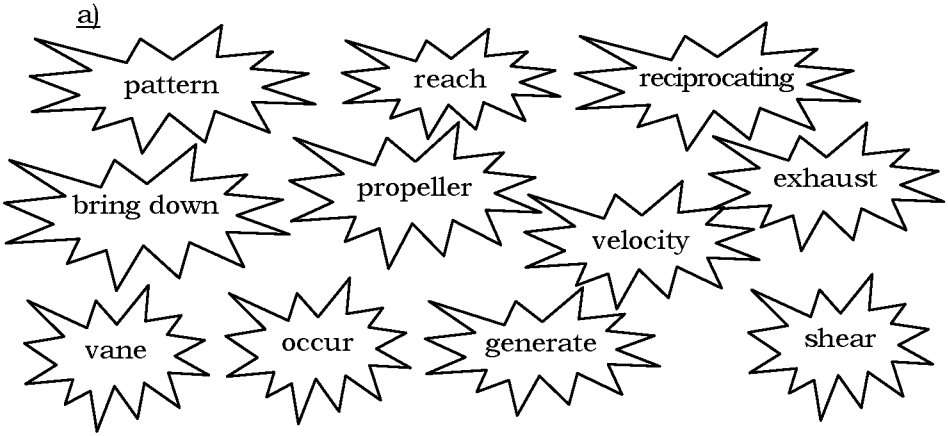
5. Not only does the fan produce (little) noise per pound of thrust, but the _____ (cool) air mixing with the hot jet exhaust also insulates the engine, acting as a muffler.

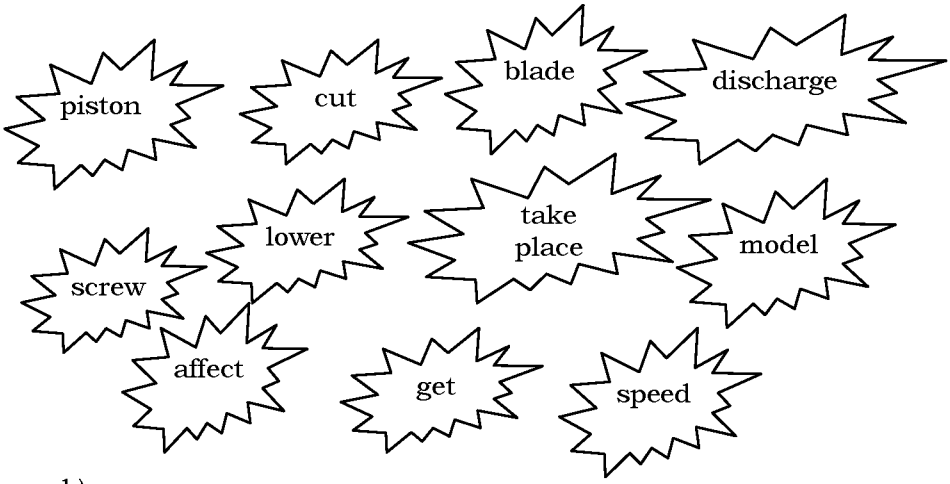
6. This reduction can be directly observed at a major international airport, particularly one that also includes flights of _____ (old) turbojet-powered aircraft operated by _____ (poor) nations.

b) Think of 10 other adjectives and make up your own sentences. Do it the same way as in part a). Exchange your sentences with the partner. Check the results of your work.

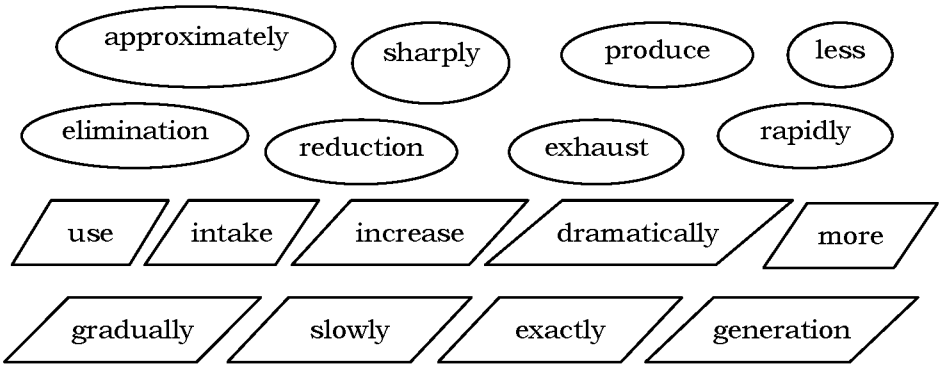
III. Find pairs of a) synonyms, b) antonyms among the words. Mind there is one extra word in each part.

a)





b)



IV. Use the prepositions in the oval to complete the sentences in the text. Render the text in Russian.

to (3) with (3) in (2) at (2)
under (1) by (4) of (2) on (2)

Though long of concern _____ neighbours _____ major airports, aircraft noise first became a major problem _____ the introduction of turbojet-powered commercial aircraft (Tupolev 104, Boeing 707, Dehavilland Comet) _____ the late 1950s. It was recognizes _____ the time that the noise levels produced _____ turbojet powered aircraft

would be unacceptable to persons living _____ the take off pattern of major airports. Accordingly, much effect was devoted _____ developing jet noise suppressors, _____ some modest success. Take-off noise restrictions were imposed _____ some airport managements, and nearly all first-generation turbojet-powered transports were equipped _____ jet noise suppressors _____ a significant cost _____ weight, thrust, and fuel consumption.

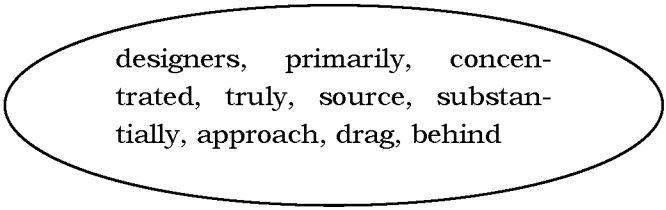
The introduction _____ the turbofan engine, _____ its lower velocity, temporarily alleviated the jet noise problem but increased the high-frequency turbomachinary noise, which became a severe problem _____ landing approach as well as _____ take-off. This noise was reduced somewhat _____ choosing proper rotor and stator blade numbers and spacing and _____ using engines of the single-mixed-jet type.

V. a) Match the words with their definitions.

a	b
1. pattern	**a) the number of times**
2. to overlap	**b) an act of brining smth to land**
3. to reach	**c) to reduce**
4. landing	**d) smth used as a guide for making smth**
5. frequency	**e) to break in half because of sideways or twisting force**
6. relatively	**f) to get to, often after much effort or time**
7. shear	**g) quite, when compared to others of the same kind**
8. take-off	**h) a general standard of quality or quantity**
9. level	**i) to cover smth partly or beyond it**
10. to bring down	**j) the beginning of a flight when a plane rises from the ground**

b) Choose any 7 words from the text "Noise Suppression Problem" and give your own explanation of them.

VI. Fill in the gaps using the words from the oval. Mind, there is one extra word! Translate the text into Russian in written.



The biggest _____ of aircraft noise is the engines _____ of the jet engines suspected that the major source of engine noise came from the region _____ the engine where the high-velocity exhaust mixes with the lower velocity surrounding air. Engine designers in Europe _____ on changing the nozzle designs of engines, _____ by corrugating the outer edge of the exhaust nozzle. Rather than smooth and round, they made it warped or angled, often looking like a flower. This better mixed the high-velocity efflux with the air behind the engine. In the United States, designers used this _____ and also another method involving venting the exhaust from several tubes. But both of these methods increased _____ and reduced engine performance, and the multi-tube approach also increased weight, sometimes _____.

Writing

You were asked to write an article (about 200 words) for a magazine on the main sources of the total noise level and possible solutions of this boring problem. Mind, the readers of the magazine are chiefly your age.

Speaking

Role-Play

Student A

> You are an undergraduate. You are writing a coursepaper the topic of which is "Aircraft Noise Suppression Problem". Present a brief account to your chief on the work done.

The following phrases may be of great help.

Calling attention	I would like to draw your attention to… I would like to note…
Making assessment	The method is particularly important because… The results are of great interest…
Expressing uncertainty	I am not yet certain… I have been rather puzzled by…

Student B

> You are a scientific superviser. Ask a lot of questions on the work done. Moreover, be ready to comment on, to add new facts, to doubt some conclusions in your student's coursepaper.

To do it successfully use the following phrases.

Making remarks	I would like to comment on… I have a point to make…
Proving arguments	Would you agree with..? I wonder about…
Asking for details	Could you be more specific about…? I am not clear about…

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