Государственный комитет Российской Федерации
по высшему образованию

Самарский государственный аэрокосмический
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КОНСТРУКЦИЯ ГАЗОТУРБИННЫХ ДВИГАТЕЛЕЙ

Учебные задания по английскому языку

САМАРА 1995

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ББК Ш I43.2I-923

Конструкция газотурбинных двигателей: Учебные задания по англ.яз./Самар., гос. аэрокосм. ун-т; Сост.: Л.М.Скрябина, О.Я.Степанова.Самара, I995. 35 с.

Задания содержат оригинальные американские и английские тексты по специальности "Двигатели летательных аппаратов". В работе имеются упражнения, снимающие трудность при работе над текстами. Цель данных заданий - дальнейшее усовершенствование навыков чтения оригинальной английской литературы по упомянутой выше специальности. Данные задания рассчитаны на студентов 2 курса 2 факультета.
Задания рекомендуются для работы в I- м семестре 2-го курса.

Печатаются по решению редакционно-издательского совета Самарского государственного аэрокосмического университета имени академика С.П.Королева

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Урок I.

Exercise I. Запомните следующие слова:

1. performance n - работа, характеристики
2. compression ratio n - степень сжатия
3. axial-flow compressor n - осевой компрессор
4. centrifugal-flow compressor n - центробежный компрессор
5. airfoil n - аэродинамическая поверхность
6. blade=vane n - лопасть, лопатка
7. blading n - комплект лопаток
8. stage n - ступень
9. spool n - каскад (компрессора)
10. frontal area n - фронтальная поверхность
11. pump n, v - насос, нагнетать, накачивать
12. pumping n - нагнетание
13. damage n - повреждение
14. section n - сечение
15. bring down v - снижать
16. flexibility n - гибкость, приспособляемость

Exercise II. Найдите слова с одинаковыми значениями:

a) to set free, to use, whole, modern, besides

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b) present-day, overall, in addition to, to consume, to release

Exercise III. Найдите слова с противоположными значениями.

a) maximum, expansion, under, rotating, front, wide, input, complexity

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b) over, narrow, output, simplicity, minimum, compression, rear stationary

Exercise IV. Переведите следующие словосочетания:

High-pressure air, minimum pressure rise, engine performance, temperature change, compression ratio, total pressure ratio, rotor and stator vane stages, foreign object damage, air pumping.

Exercise V.. Подберите русские эквиваленты следующих слов:
1-since, 2-key, 3-affect, 4-approximately, 5-addition,
6-entire, 7-alternating, 8-design, 9-therefore, 10-advantage,
11-relatively, 12-unfortunately, 13-especially, 14-furthermore.

I-влиять, 2-приблизительно, 3-весь, 4-особенно, 5-чередующийся,
6-сравнительно, 7-конструкция, 8-поэтому, 9-преимущество,
IO-к сожалению, II-добавление, I2-ключ, I3-поскольку, I4-более того.

Exercise VI. Прочитайте и переведите интернациональные слова:
compressor, minimum, maximum, proportional,component, efficient, efficiency, total, construction, operation, complex, temperature, gas, turbine, characteristics, stationary, parallel.

Exercise VII. Прочитайте текст.

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 ratios 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.

It will be the purpose of this chapter to examine, in some detail, the construction and operation of each of these compressors.

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.

Exercise VIII. Расшифруйте сокращения:
lb; kg/s; lb/s; etc.

Exercise IX. Найдите в тексте эквиваленты следующим словам и выражениям:

Ограниченный объем, употребляемый воздух, повлияет на изменение температуры, как следует из названия, плотная посадка деталей, более узкий диапазон, снижают стоимость, требования эффективности.

Exercise X. Переведите следующие предложения, выбрав правильное значение указанных слов:

Unfortunately the delicate blading, especially toward the rear, makes this type of air pump especially susceptible to foreign-object damage.

Delicate - I)тоненький, 2)изящный, 3)чувствительный

Susceptible - I)восприимчивый, 2)чувствительный, 3)подверженный

The entire compressor is made up of a series of alternating rotor and stator vane stages.

Entire - I)сплошной, 2)весь, 3)непрерывный

Alternating - I)перемежающийся, 2)переменный, 3)сменяющийся

Exercise XI. Найдите в тексте предложения, в которых говорится о:

I) характеристиках современных компрессоров;

2) преимуществах осевых компрессоров;

3) применении осевых компрессоров.

Exercise XII. Найдите в тексте слова, определяющие характеристики осевого компрессора.

Exercise XIII Найдите в тексте предложения, являющиеся ответом на поставленные вопросы:

I. 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 ?

Exercise XIV. Письменно переведите последний абзац текста.

Урок 2.

Exercise I. Запомните следующие слова:

1. impeller n - рабочее колесо(турбины компрессора)
2. manifold n - трубопровод
3. draw in v - втягивать(воздух)
4. rim n - кромка
5. ruggedness n - прочность
6. ingestion n - засасывание(в двигатель посторонних предметов)
7. shock-wave n - ударная волна
8. stage n - ступень (зд.)
9. single adj - единственный
10. multiple adj - множественный
11. plenum chamber n - нагнетательная камера

Exercise II. Переведите следующие словосочетания:
pressure rise, diffuser manifold, static pressure energy, relatively high compressor ratio, per stage, impeller tip speeds, low fuel consumption, shock-wave formation, double-entry compressor.

Exercise III. Подберите русские эквиваленты:
to cause, in part, because of, excessively, to rule out, although, through, rather than, attribute

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из-за, чрезмерно, исключать, хотя, через, а не, отличительная черта, частично, заставлять

Exercise IV. Найдите слова с одинаковыми значениями:
edge, speed, mainly, a number of, produce, main, quick, get

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

Exercise V. Найдите слова с противоположными значениями:
inward, more, below, front, outlet, quick, inefficient, larger, high

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low, less, rear, slow, outward, below, inlet, above, efficient

Exercise VI. Прочитайте и переведите интернациональные слова и словосочетания:

component, kinetic energy, produce, diffuser, conversion, type, recommend, gas turbine, chief, massive, construction, efficiency, shock, formation, diffuser.

Exercise VII. Прочитайте текст.

The Centrifugal-Flow Compressor.

The centrifugal compressor consists basically of an impeller and a diffuser manifold. Other components such as a 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 ingestion of foreign objects. The centrifugal compressor is capable of a 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.

Exercise VIII. Найдите в тексте эквиваленты следующих слов и выражений:

могут быть добавлены; втягивается в отверстие; заставляет его двигаться; ось вращения; выбрасывается с высокой скоростью; частично; разнообразие конструкций; ряд черт; низкая стоимость; на ступень; когда он проходит; частично компенсируется; основные требования; способность обрабатывать.

Exercise IX. Переведите предложения, выбрав правильное значение выделенных слов.

Above this ratio, efficiency drops off at a rapid rate because of excessively high impeller tip speeds and attending shock-wave formation.

to drop off - 1) выходить, расходиться
2) выходить (из машины)
3) уменьшаться

to attend - 1) присутствовать
2) уделять внимание
3) следить (за чем-либо)
4) сопровождать

Exercise X. Найдите в I абзаце текста предложения с инфинитивом в функции обстоятельства цели. Переведите его.

Exercise XI. Найдите в тексте предложения с сочетанием because of и правильно их переведите: because of - из-за, вследствие.

Exercise XII. Найдите в тексте слова, определяющие характеристики центробежного компрессора.

Exercise XIII. Найдите в тексте прилагательные в сравнительной степени и дайте их недостающие формы.

Exercise XIV. Найдите в тексте предложения, являющиеся ответом на поставленные вопросы.

1. Как достигается повышение давления в центробежном компрессоре?
2. Какие разновидности центробежных компрессоров могут быть изготовлены ?
3. Какие свойства делают центробежный компрессор пригодным к применению в некоторых газотурбинных двигателях ?
4. Почему центробежный компрессор менее подвержен повреждению инородными телами ?
5. Что исключает применение центробежного компрессора в больших двигателях ?
6. Чем достигаются более высокие степени сжатия ?
7. Где находит применение центробежный компрессор и почему ?

Exercise XV. Переведите письменно первый абзац текста.

Урок 3.

Exercise I.

1. assembly n - узел, агрегат, блок
2. bearing n - подшипник
3. casing n - корпус, кожух, оболочка
4. row n - ряд
5. guide vane n - направляющая лопатка
6. setting n - установка, регулировка
7. angular adj - угловой

8. annulus n - кольцо, отверстие
9. annular adj - кольцевой, кольцеобразный
10. convergence n - сходимость
11. tapering n - сужение
12. by-pass adj - двухконтурный
13. to bypass v - обходить
14. percentage n - часть, доля
15. propelling nozzle n - реактивное сопло
16. intermediate adj - промежуточный
17. inlet (intake) n - вход, входное отверстие
18. inlet (intake) guide vane n - лопатка входного направляющего устройства

Exercise II. Найдите слова с одинаковыми значениями:
a) inlet, flow, blade, guide, annular, maintain, manifacture, reach

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b) lead, produce, round, intake, stream, keep, vane, achieve

Найдите слова с противоположными значениями:
a) single, front, increase, inlet, inner, outward

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b) rear, outlet, outer, multiple, reduction, inward

Exercise III. Дайте русские эквиваленты следующих слов:
gradual, maintain, influence, achieve, desired, through, although, suitable

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пригодный, через, постепенный, хотя, влиять, желаемый, достигать, поддерживать

Exercise IV. Переведите следующие словосочетания:
multi-stage unit, angular setting of the vanes, throughout the length, as many stages as necessary, by-pass flow, large rotor fan blades, i.e., a percentage of the air, airfoil section.

Exercise V. Прочитайте и переведите интернациональные слова:
section, location, rotor, stator, guide, automatically, control, mechanical, factor, optimum, front.

Exercise VI. Дайте грамматический анализ 4-го абзаца.

Exercise VII. Прочтите текст.

Construction and Operation of the Axial-Flow Compressor.

An axial-flow compressor consists of one or more rotor assemblies that carry blades of airfoil section and are mounted between bearings in the casings in which are located the stator blades. The compressor is a multi-stage unit as the amount of work done (pressure increase) by each stage is small; a stage consists of a row of rotating blades followed by a row of stator blades, known as intake or inlet guide vanes, to guide the air on the first row of rotor blades. The angular setting of the vanes can be automatically controlled to suit the airflow requirements at various operating conditions.

From the front to the rear of the compressor i.e. from the low to the high pressure end, there is a gradual reduction of the air annular area between the rotor shaft and the stator casing. This is necessary to maintain the axial velocity of the air constant as the density increases throughout the length of the compressor. The convergence of the air annulus is achieved by the tapering of the casing or rotor. A combination of both is also possible with the arrangement being influenced by manufacturing problems and other mechanical design factors.

A single-spool compressor consists of one rotor assembly and stators with as many stages as necessary to achieve the desired pressure ratio and all the airflow from the intake passes through the compressor.

The multi-spool compressor consists of two or more rotor assemblies, each driven by their own turbine at an optimum speed to achieve higher pressure ratios and to give greater operating flexibility.

Although a twin-spool compressor can be used for a pure jet engine, it is most suitable for the by-pass type of engines where the front or low pressure compressor is designed to handle a larger mass airflow than the high pressure compressor. Only a percentage of the air from the low pressure compressor passes into the high pressure compressor. Both flows mix in the exhaust system before passing to the propelling nozzle.

A fan may be fitted to the front of a single or twin-spool compressor and, on these types of engines, the fan is driven at the same speed as the compressor to which it is fitted. On engines of the triple-spool type, the fan is, in fact, the low pressure compressor and is driven by its own turbine separately from the intermediate pressure compressor and the high pressure compressor. The low pressure compressor has large rotor fan blades and stator blades and is designed to handle a far larger mass airflow than the other two compressors,each of which has several stages of rotor blades. A large proportion of air from the outer part of the fan and known as the "cold" stream, by-passes the other two compressors and is ducted to atmosphere through the cold stream nozzle. The smaller air flow from the inner part of the fan and known as the "hot" stream passes through the intermediate and high pressure compressors where it is further compressed before passing into the combustion system.

Exercise VIII. Найдите в тексте английские эквиваленты следующих слов и выражений:

Известный как, отвечать требованиям, по всей длине, постепенное уменьшение, наиболее пригоден, подается в атмосферу, гораздо больший.

Exercise IX. Прочитайте абзац № I. Озаглавьте его. Ответьте на вопросы.

1. What are the main parts of an axial-flow compressor ?
2. What is a stage in an axial-flow compressor ?
3. What are the inlet or intake guide vanes ?

Exercise X. Выделите термины, связанные с описанием компрессора.

Exercise XI. Найдите в тексте описание:

а) односкадного компрессора ;

в) многоскадного компрессора;

с) роли вентилятора в односкадном и двухскадном компрессорах.

Exercise XII. Прочитайте абзац № 2. Озаглавьте его. Передайте его содержание на русском языке.

Exercise XIII. Прочитайте абзац № 3. Ответьте на вопрос: Для каких типов двигателей применение двухкаскадного компрессора более эффективно, почему ?

Exercise XIV. Дайте письменный перевод последнего абзаца.

Урок 4.

Exercise I. Запомните следующие слова:

1. burner n = combustion chamber
2. atomize v - распылять
3. spray n - струя
4. vaporize v - испарять
5. liner n - жаровая труба (камеры сгорания)
6. recirculate v - рециркулировать
7. blowout n - срыв пламени
8. pilot n - регулятор
9. turbulence n - турбулентность
10. ignitor plug n - свеча зажигания
11. cross-ignition tube n - трубопровод перекрестного зажигания
12. can n - отдельная камера сгорания
13. can-annular burner n - трубчато-кольцевая камера сгорания

14. reverse adj - обратный
15. combustible adj - горючий
16. dilution n - разжижение
17. blanket n - слой

Exercise II. Найдите слова с одинаковыми значениями:

rapidly, velocity, purpose, transfer, locate, initiate, completely

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situate, speed, fully, aim, transmit, begin, quickly.

Exercise III. Найдите слова с противоположными значениями:

front, forward, upstream, unburned, inner, outside, before, secondary, result from

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downstream, after, rear, result in, backward, burned, primary, inside, outer.

Exercise IV. Подберите русские эквиваленты:
to introduce, specially, through, remaining, to tend, to prevent, to act, to spread, approximately, therefore, to accomplish, thereby, actually

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поэтому, оставшийся, предотвращать, действовать, распространяться, вводить, таким образом, специально, стремиться, приблизительно, выполнять, фактически, через

Exercise V. Переведите следующие словосочетания:
highly atomized spray, specially designed nozzle, combustion air holes, opposing liner holes, low-velocity stabilization zone, upstream, reverse-flow region, relatively large holes.

Exercise VI. Прочитайте и переведите интернациональные слова:
front, specially, geometry, section, action, stabilization, zone, energy, approximately, proportion, normally, protection, process.

Exercise VII. Прочтите текст.

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 usually only two ignitor plugs in an engine, cross ignition tubes are necessary in the can and can-annular types of burners in order that burning may be initiated in the other cans or inner liners. The ignitor 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 invelved. 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 temperatures 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.

Exercise VIII. Найдите в тексте эквиваленты следующих слов и выражений:

В целях охлаждения и очистки, отверстия для оставшегося воздуха, двигаться вверх по потоку, предотвращает срыв пламени, создает интенсивную турбулентность, для передачи энергии, может быть начато, в этом месте, за пределами, определяется конструкцией, участвующие материалы, обычно выполняется.

Exercise IX. Найдите в последнем абзаце текста:

а) Эквивалент модального глагола may и переведите предложение с этим эквивалентом;

в) предложение с result in и переведите его.

Exercise X. Переведите предложения из текста, обращая внимание на сослагательное наклонение.

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

Exercise XI. Найдите в тексте предложения, в которых говорится о том:

1) как топливо подается в камеру сгорания ;
2) какие функции выполняют потоки воздуха в камере сгорания ;
3) как распространяется пламя после зажигания ;
4) каким образом происходит охлаждение газов после горения.

Exercise XII. Найдите в тексте слова, определяющие характеристики центробежного компрессора.

Exercise XIII. Переведите письменно первый абзац текста.

Exercise XIV. Найдите слова с одинаковым значением.

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

---

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

Exercise XV. Найдите слова с противоположными значениями.

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

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

Exercise XVI. Переведите следующие словосочетания:

aircraft manufacturer, overall jet engine performance, jet engine thrust output, boundary layer air, duct pressure efficiency ratio, ram recovery point, compressor inlet total presure, outside ambient air pressure

Exercise XVII. Подберите русские эквиваленты.
approximately, comparable size, in such a way, result in, high value, be equal to, offer resistance, without any correction, cause, in order to, within limits

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для того, чтобы; приблизительно; соизмеримый размер; высокое значение; вызывать; таким образом; в определенных пределах; приводить к; оказывать сопротивление; быть равным чему-либо; без каких-либо поправок.
Exercise XVIII.Прочтите и переведите следующие слова:
operation, static, front, compressor, convert, efficiency, kinetic, dynamic, total, percent, correction, normal, limit, turbine.

Exercise XIX. Прочтите текст.

Inlet Ducts

Although 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 a 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 enough 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 duct 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 (28 km/h).

Inlet ducts may be divided into two broad categories:

1. Subsonic ducts
2. 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 1/2 percent, and result in 1 1/2 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.

Exercise XX. Найдите в тексте и переведите следующие предложения.

1. Not only must the duct be large enough 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.
2. This type of inlet is essentially a bell-shaped funnel having carefully rounded shoulders, which offer practically no air resistance.

Exercise XXI. Найдите в тексте эквиваленты следующих русских предложений:

I. Количество воздуха, потребляемого турбореактивным двигателем, приблизительно в 10 или более раз больше, чем потребляют поршневые двигатели подобных размеров.
2. Чем быстрее двигается самолет, тем большее значение приобретает конструкция сопла.
3. Входные каналы должны быть как можно более прямыми и ровными.

Exercise XXII. Найдите во II и V абзацах текста инфинитив в функции обстоятельства, переведите эти предложения.

Exercise XXIII. Найдите абзац и предложение, где говорится о том,

а) каким должен быть входной канал;
в) для чего служит входной канал;
с) как объясняется понятие "точка восстановления давления".

Exercise XXIV. Ответьте на вопросы:

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?

Exercise XXV. Переведите письменно 6й абзац текста.

Урок 5.

Exercise I. Запомните следующие слова:

1. accessories n - вспомогательные агрегаты
2. extract v - извлекать
3. furnish v - доставлять
4. bucket = blade = vane n
5. radial inflow turbine n - центростремительная турбина
6. stationary adj - стационарный, неподвижный
7. impulse blade n - активная лопатка
8. reaction blade n - лопатка обратного действия
9. contoured adj - профильный

Exercise II. Дайте перевод следующих слов, знакомых из предыдущих уроков:

to drive, turboprop, propeller, combustion, percent, thrust, to compress, blade, zone, average, advantage, manufacture, ruggedness, nozzle, to exhaust, efficiency.

Exercise III. Подберите русские эквиваленты:

exception, although, relatively, through, average, considerable, a few, advantage, inward

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сравнительно, через, средний, значительный, преимущество, исключение, внутрь, хотя, несколько

Exercise IV. Подберите слова с одинаковыми значениями:

portion, nearly, utilize, inlet, combustion, exhaust, manufacture, furnish

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about, use, part, burning, produce, supply, input, discharge

Exercise V. Подберите слова с противоположными значениями:

easy, inlet, extract, drive, expensive, leave, advantage, peripheral

---

stop, enter, outlet, inexpensive, disadvantage, add, central, difficult.

Exercise VI. Переведите следующие словосочетания:
high-temperature combustion gases, moving gas stream, typical eight-cylinder automobile engine, gas turbine manufactures, inward radial direction, modern aircraft gas turbine engine, stationary vane assembly, nozzle guide vane

Exercise VII. Прочитайте и переведите интернациональные слова:
turbine, propeller, kinetic energy, equivalent, automobile, typical, concentrate, peripheral, contour, section, atmosphere, series

Exercise VIII. Прочитайте текст.

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 (74,570kw) 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.

Types of Turbines

With a few exceptions, gas turbine manufacturers have concentrated on the axial-flow turbine although some manufacturers 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 the 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 sections.

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 vane assembly is usually referred to as the turbine nozzle, and the vanes themselves are called nozzle guide vanes.

Exercise IX. Найдите в тексте ответы на следующие вопросы:

1. В чем заключается функция турбины ?
2. Как работает турбина ?
3. Какие типы турбин используются в газотурбинных двигателях ? Назовите их различия.
4. Каковы технические характеристики осевых турбин ?

Exercise X. Найдите в тексте слова, определяющие качественные характеристики турбин.

Exercise XI. Найдите:

I. В первом абзаце текста:
   a) предложения с неправильным глаголом в 3 форме. Назовите его основную форму. Переведите предложения;
   в) предложения с причастием в функции правого определения. Дайте их перевод;
   c) предложение с союзом in order to и правильно его переведите. Обратите внимание на то, что выражение as much as + количество переводится как - до, не менее;
   d) переведите последнее предложение текста, обращая внимание на то, что выражение to refer to as переводится как - называть, именовать, обозначать.

Exercise XII. Переведите письменно первый абзац текста.

Урок 6.

Exercise I. Запомните слова:

1. degree n - степень
2. strike v (struck, struck) - ударяться)
3. impinge v - ударять(ся)
4. impact v - ударять(ся)
5. restrict v - ограничивать
6. relate v - иметь отношение, относиться
7. relationship n - отношение
8. occur v - происходить, иметь место
9. discharge pressure n - давление на выходе
10. back pressure n - противодавление
11. area n - площадь
12. stall n - срыв
13. choke n - дроссель, дросселировать
14. result in v - приводить к
15. adjust v - регулировать, налаживать
16. overhaul n - капитальный ремонт
17. angle n - угол
18. accomplish v - производить, осуществлять
19. setting n - установка, регулировка
20. variable adj - изменчивый
21. auxilliary adj - вспомогательный

Exercise II. Найдите синонимы:

a) convert, vane, impringe, occur, critical, discharge, fast, velocity, setting

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b) quick, adjustment, take place, transform, impact, bucket, decisive, exhaust, speed

Exercise III. Найдите антонимы:

kinetic, restrict, accelerate, inlet, closely, increase, variable, auxiliary

---

fixed, decelerate, far, decrease, static, exit, expand, main

Exercise IV. Дайте русские эквиваленты следующих слов и выражений: choke, choked conditions, result in, occur, proper direction, closely related, specific fuel consumption, in turn.

приводить к, нужное направление, дросселирование, происходить, удельный расход топлива, тесно связанный, условия дросселирования, в свою очередь.

Exercise V. Переведите следующие словосочетания:
Nozzle guide vanes, nozzle guide vane inlet (exit), area, turbine nozzle area, auxiliary power unit, turbine-powered ground vehicles, variable angle nozzle vanes, to bring the compressor closer to stall.

Exercise VI. Расшифруйте и переведите следующие сокращения: rpm; apu; i.e.

Exercise VII. Прочтите и переведите интернациональные слова: diaphragm, energy, dynamic, kinetic, turbine, component, gas, theorem, accelerate, portion, critical, tendency, result.

Exercise VIII. Найдите: в I- м абзаце все слова со значением "лопатка", "ударяться",
во 2- м абзаце: а) сказуемые в страдательном залоге;
в) проследите употребление глагола to have, переведите найденные предложения.

Exercise IX. Прочтите текст.

Function of the Nozzle Guide Vanes.

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 to 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 blade 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 a tendency to choke (gas flowing at the speed of sound). Many engines are designed to have the nozzle operating in this 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.

Exercise X. Найдите в тексте эквиваленты следующих слов и выражений:

Чрезмерное уменьшение сопла; так, чтобы газ ударялся о лопатки турбины; условия дросселирования; установка лопаток под нужным углом; лопатки сопла с переменным углом; регулируется на заводе.

Exercise XI. Выделите термины, связанные с описанием направляющих лопаток соплового аппарата.

Exercise XII. Просмотрите I- й абзац текста, ответьте на следующие вопросы:

1. What does this article deal with ?
2. What are the functions of the nozzle guide vanes ?
3. What is the first function ?
4. What job is done by utiiizing the Bernoulli theorem ?
5. What is the result of the gas acceleration ?

Exercise XIII. Просмотрите 2- й абзац текста. Озаглавьте его. Найдите предложение, описывающее результат увеличения диафрагмы сопла.

Exercise XIV. Письменно переведите 3- й абзац.

Урок 7.

Exercise I. Запомните слова:

1. supersonic - сверхзвуковой
2. transonic - околозвуковой
3. subsonic - дозвуковой
4. overhaul - переборка, ремонт, разборка
5. performance - характеристики
6. shock wave - ударная волна
7. buzz - зудящий звук
8. accomplish - выполнять
9. spike - амортизирующая игла
10. establish - устанавливать
11. oblique - наклонный, непрямой
12. angle - угол
13. occur - иметь место, происходить
14. airflow - воздушный поток
15. develop - развивать
16. keep - хранить
17. waste - тратить впустую
18. swallow - заглатывать

Exercise II. Прочитайте и переведите следующие слова:
Zone, modification, problem, control, vibrating, shock, instability, alternately, section, process, combination, minimize, energy, temperature, locating, front, produce.

Exercise III. Найдите синонимы:

reduction	corner
inlet	as
occur	decrease
accomplish	airstream
angle	fulfil
airflow	place
	increase
locate	collect
rise	take place
gather	increase
because	entry

Exercise IV. Найдите антонимы:
Supersonic, outside, behind, strong, stability, minimize, slow
in front of, accelerate, inside, subsonic, weak, maximize, instability.

Exercise V. Переведите следующие словосочетания:
A slightly different inlet duct design, high duct loss, the least possible waste of energy, excessive air temperature rise, supersonic velocities out of the inlet duct.

Exercise VI. Найдите в тексте и переведите следующие предложения, обращая внимание на выделенные слова:

1. At these speeds sonic shock waves are developed which, if not controlled, will give high duct loss in pressure and airflow.
2. 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.
3. The airflow is controlled so that the air velocity at the duct inlet is exactly equal to the speed of sound.

Exercise VII. Найдите в тексте эквиваленты следующих выражений:
1) будут возникать (устанавливаться) вибрационные условия;
2) неустойчивость, вызываемая тем, что ударная волна будет попеременно заглатываться или выталкиваться на входе в канал;
3) входной канал конструируется так, чтобы (сохранять) удерживать ударную волну вне сопла.

Exercise VIII. Просмотрите текст. Выделите основное содержание каждого абзаца. Озаглавьте абзацы. Составьте план текста.

SUPERSONIC DUCTS

The supersonic inlet duct must operate in three speed zones.

1. Subsonic
2. Transonic
3. 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 conditiones 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 Mach 1), 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 and 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 higher 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.

Exercise IX. Ответьте на вопросы:

1. In what zones must the supersonic inlet duct operate ?
2. When are shock waves developed ?
3. What effect is caused by shock wave appearance ?
4. What is buzz ?

5. When is the single normal shock wave very strong ?
6. What is the reason of the duct pressure rise ?
7. What point is called the duct recovery point ?

Урок 8.

Exercise I. Запомните следующие слова:

1. stress - напряжение
2. alloyed steel - легированная сталь
3. forging - ковка
4. to machine - подвергать механической обработке
5. integrity - целостность
6. rivet - заклепка
7. locking tab - шпонка
8. shrouded - бандажированная (о лопатке)
9. low pitch - малый шаг (винта)
10. tip - конец, концевая часть
11. knife edge - острая кромка
12. seal - уплотнение, герметизация
13. to recess - отодвигать
14. wear-in - приработка
15. to certify - получать разрешение
16. to bleed - спускать (воздух)
17. creep - деформация ползучести

Exercise II. Прочитайте и переведите следующие слова:
statically, dynamically, balance, chromium, nickel, cobalt, inspection, method, structural, aerodynamic, labyrinth, efficiency, manufacture, convection, diaphragm, extreme, conditions.

Exercise III. Найдите синонимы:
severe, assure, blade, shroud, run, extra, retain, position, consiquently

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bucket, casing, additional, to keep, place, strong, as a result, quarantee, operate.

Exercise IV. Найдите антонимы:
inlet, outer, low, thin, cool, reduce, preceding, rear

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inner, thick, warm, increase, outlet, high, front, following

Exercise V. Переведите следующие словосочетания:
turbine inlet temperature, blade-tip losses, high Mach number flight, compressor inlet (outlet) temperature, single-stage turbine, milti-stage turbine, multi-stage turbine engines, engine operating limits.

Exercise VI. Просмотрите текст.

TURBINE CONSTRUCTION

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 ca-

sing 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 us. Many engine manufactures 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 others 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 for 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 multiple-stage 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 manufacturer.

Exercise VII. К английским словам и выражениям подберите соответствующий перевод. Запомните эти слова и выражения. Найдите в тексте предложения с ними и переведите:

1) by means of, 2) whereas, 3) to allow for, 4) because of 5) consequently, 6) to be subjected to, 7) within limits, 8) percentage, 9) due to

I) в пределах, 2) процентное соотношение, 3) тогда как, 4) подвергаться, 5) посредством, 6) следовательно, 7) позволять, 8) благодаря, 9) вследствие.

Exercise VIII. Найдите в тексте эквиваленты следующим выражениям:

наиболее напряженные 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.

Exercise IX. Переведите текст. Выделите основное содержание каждого абзаца. Озаглавьте абзацы.

Exercise X. Ответьте на вопросы:

1. Why is the turbine wheel the most highly stressed part of the turbine ?
2. What are the main turbine parts ?
3. What are the advantages and disadvantages of the shrouded blade ?
4. What is the operation principle of single-stage and multi-stage turbines ?

Конструкция газотурбинных двигателей

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Подписано в печать 17.01.95. Формат 60х84 1/16
Бумага офсетная. Печать офсетная.
Усл.печ.л. 2,09. Усл.кр.-отт. 2,21. Уч.-изд.л. 2,0.
Тираж 150 экз. Заказ 25. Арт. С-86 мр/95.

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