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«Воронежский государственный технический университет»

Кафедра иностранных языков и технологии перевода

ИНОСТРАННЫЙ ЯЗЫК

МЕТОДИЧЕСКИЕ УКАЗАНИЯ

для организации самостоятельной работы студентов всех форм обучения специальности 24.05.07 Самолето- и вертолетостроение

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Основной целью методических указаний является развитие навыков чтения, понимания и аннотирования текстов по специальности, а также развитие навыков говорения по отдельным темам в рамках дисциплины «Иностранный язык» в соответствии с тематикой рабочей программы дисциплины.

Предназначены для организации самостоятельной работы студентов всех форм обучения специальности 24.05.07 Самолето- и вертолетостроение.

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Введение

Целью проведения занятий по дисциплине «Иностранный язык» является приобретение коммуникативной компетенции, позволяющей будущим специалистам ориентироваться в современном информационном поле и владеть элементарными навыками межкультурной профессиональной коммуникации; повышение уровня культуры, общего образования и кругозора будущего специалиста.

Выполнение самостоятельной работы направлено на решение следующих задач:

- развитие навыка публичной речи (сообщение, доклад, дискуссия);
- развитие навыка чтения специальной литературы с целью получения профессиональной информации;
- формирование умения реферирования и аннотирования научных текстов по специальности;
- развитие основных навыков письма для подготовки публикаций и ведения переписки по специальности;
- развитие навыка использования иностранного языка для профессионального общения, достижения профессиональных целей и решения профессиональных задач (научно-исследовательских, аналитических, организационно-управленческих);
- развитие умения самостоятельно совершенствовать знания по иностранному языку.

В методических рекомендация приведены задания для самостоятельной работы обучающихся. Задания выполняются с использование возможностей глобальной сети Интернет для поиска необходимой информации на специализированных сайтах, работы с отраслевыми словарями.

UNIT 1

Упражнение 1. *Прочтите слова и словосочетания и постарайтесь запомнить их русские эквиваленты.*

charge – доза (топлива) **compression stroke** – такт сжатия (смеси) **combustible** – воспламеняемый, горючий **cylinder** – цилиндр **crankshaft** – коленчатый вал **exhaust stroke** – такт выпуска **expulsion** - удаление **fuel** - топливо	**inward** – направленный внутрь **mixture** - смесь **new-charge** – новая порция **outboard engines** – двигатель, установленный вне фюзеляжа **outward** – направленный наружу **piston** - поршень **prime mover** – первичный двигатель **pumping** - выталкивающий **scavenging** – продувка (цилиндра)

ignite - воспламенять **internal-combustion engine** – двигатель внутреннего сгорания **intermittent** - прерывистый	**stroke** - ход (поршня) **vehicle** – транспортное средство, летательный аппарат **volatility** - летучесть

Упражнение 2. *Переведите слова на русский язык, обращая внимание на суффиксы.*

to combust – combust**ion**; to ignite – ignit**ion**; to compress – compress**ion**; to operate – operat**ion**; to admit – admiss**ion**; to evacuate – evacuat**ion**; to expand – expans**ion**; to act – act**ion**.

Упражнение 3. *Прочтите и переведите интернациональные слова:*

Mechanically, motorcycle, airplane, type, cycle, piston, operation, cylinder, product, gas, process, economy, chance, practical, phase.

Упражнение 4. *Переведите предложения на русский язык, используя терминологию упражнения 1.*

1. Combustion engines may be divided into types according to the duration of the cycle on which they operate, in terms of piston strokes.
2. In the cycle which is completed in two piston strokes a combustible gaseous mixture is compressed in the cylinder during the outward stroke of the piston, and burned and allowed to expand during the following inward stroke.
3. Evacuation of the products of combustion and admission of a new-charge take place during the latter part of the expansion, and the early part of the compression stroke.
4. Scavenging is a process during which the burnt gases are blown out by either fresh air or combustible mixture under pressure.
5. Two-stroke engines with scavenging by combustible mixture are used only in small units and generally only in applications where the operation is quite intermittent.

Прочтите и переведите текст, а затем выполните следующие за ним упражнения.

TEXT
Internal Combustion Engines

The engines of practically all mechanically propelled road vehicles, motorcycles, airplanes, farm tractors, motor boats, and mobile industrial units belong to that class of prime movers known as heat engines, and to the subdivision thereof which has been generally referred to as "internal-combustion" engines. The internal combustion engine is called so because fuel is burnt directly inside the engine itself.

Combustion engines may be divided into types according to the duration of the cycle on which they operate, in terms of piston strokes. By a cycle is meant the succession of operations in the engine cylinder which constantly repeats itself. The great majority of modern automotive engines operate on the four-stroke cycle, usually referred to as the Otto cycle, which is completed in four strokes of the piston, or during two revolutions of the crankshaft. Engines are also being built to operate on a cycle which is completed in two piston strokes. In this cycle a combustible gaseous mixture is compressed in the cylinder during the outward stroke of the piston, and burned and allowed to expand during the following inward stroke. Evacuation of the products of combustion and admission of a new-charge take place during the latter part of the expansion, and the early part of the compression stroke. Since there is no separate exhaust stroke, the burnt gases cannot be expelled from the cylinder by a pumping action of the piston therein; they must be blown out, by either fresh air or combustible mixture, under pressure, a process known as scavenging. Two-stroke engines with scavenging by combustible mixture are used only in small units (outboard engines, for example), and generally only in applications where the operation is quite intermittent. Their chief advantage is low first cost; their disadvantages are low fuel economy and lack of flexibility. A few engines have been built to operate on a six-stroke cycle, which has certain advantages where fuel of low volatility is to be used. Four of the six strokes of this cycle are used for the same operations as in the four-stroke cycle; during the remaining two strokes the combustible mixture is retained in the cylinder without being ignited, to give the fuel a better chance to vaporize and to diffuse uniformly throughout the air charge. Six-cycle engines have never reached a practical stage, and of all of the high-speed combustion engines in use today that operate on volatile fuels, more than 99 per cent, of the total horse power undoubtedly work on the four-stroke cycle.

The four-stroke cycle comprises the following four phases or operations, which succeed one another in the order in which they are given:

Admission of the charge to the cylinder.

Compression of the charge.

Combustion of the charge (which includes its ignition and expansion).

Expulsion of the products of combustion.

Послетекстовые упражнения

Упражнение 5. *Ответьте на вопросы по тексту.*

1. What engines do we call internal combustion engines?
2. What types may combustion engines be divided?
3. What is a cycle?
4. What takes place during the cycle which is completed in two piston strokes?
5. What takes place during the cycle which is completed in six piston strokes?
6. What phases does the four-stroke cycle comprise?

Упражнение 6. *Закончите предложения, выбрав правильный по смыслу ответ.*

1. The internal combustion engine is called so because fuel is burnt …
   a) outside the engine;
   b) inside the engine.
2. The four-stroke cycle is completed in …
   a) two strokes of the piston;
   b) four strokes of the piston;
   c) six strokes of the piston.
3. In two-stroke cycle a combustible gaseous mixture is compressed in the cylinder during …
   a) the outward stroke of the piston;
   b) the inward stroke of the piston.
4. Two-stroke engines with scavenging by combustible mixture are used only in applications where…
   a) the operation is quite constant;
   b) the operation is quite intermittent.
5. During the remaining two strokes of the six-stroke cycle the combustible mixture is retained in the cylinder …
   a) without being ignited;
   b) being ignited.

Упражнение 7. *Закончите предложения, выбрав соответствующее по смыслу окончание.*

1. In the internal combustion engine …	1. in six-stroke engines.
2. Combustion engines may be divided into types …	2. in outboard engines.
3. By a cycle is meant …	3. admission of the charge to the cylinder; compression of the charge, combustion of the charge, expulsion of the products of combustion.
4. In two-stroke cycle …	4. the fuel is burned inside the engine itself.
5. Two-stroke cycle is used …	5. the succession of operations in the engine cylinder which constantly repeats itself.
6. Fuel of low volatility is to be used …	6. according to the duration of the cycle on which they operate.
7. The four-stroke cycle comprises the following phases …	7. a combustible gaseous mixture is compressed in the cylinder during the out-

	ward stroke of the piston.

Упражнение 8. *Переведите следующие предложения на английский язык и запишите их.*

1. В двигателе внутреннего сгорания топливо сгорает внутри двигателя.
2. Классификация двигателей внутреннего сгорания зависит от длительности рабочего цикла.
3. Цикл – это последовательность повторяющихся операций в цилиндре двигателя.
4. При двухтактном цикле горючая газовая смесь сжимается в цилиндре во время направленного наружу хода поршня.
5. Двухтактный цикл используется в двигателях, устанавливаемых вне фюзеляжа.
6. В шеститактном двигателе необходимо использовать топливо, обладающее низкой летучестью.
7. Четырехтактный цикл включает следующие фазы: подача дозы топлива в цилиндр, сжатие дозы топлива, сгорание дозы топлива, удаление продуктов сгорания.

Упражнение 9. *Выпишите из правой колонки русские слова и словосочетания, соответствующие английским из левой колонки.*

1. engine	1. ход поршня
2. road vehicle	2. внутренне сгорание
3. motor boat	3. такт сжатия
4. industrial unit	4. воспламенение
5. internal combustion	5. четырехтактный цикл
6. fuel	6. горючая смесь
7. piston stroke	7. оборот, вращение
8. succession of operations	8. подача новой дозы топлива
9. engine cylinder	9. продувка
10. crankshaft	10. моторная лодка
11. revolution	11. недостаточная гибкость
12. four-stroke cycle	12. такт выхлопа
13. combustible mixture	13. промышленная установка
14. products of combustion	14. продукты сгорания
15. admission of a new-charge	15. последовательность операций
16. compression stroke	16. топливо
17. exhaust stroke	17. автодорожное транспортное средство
18. scavenging	18. цилиндр двигателя
19. lack of flexibility	19. двигатель

20. ignition	20. коленчатый вал

Упражнение 10. *Составьте аннотацию текста, используя в качестве плана ответы на вопросы упражнения 5.*

UNIT 2

Упражнение 1. *Прочтите слова и словосочетания и постарайтесь запомнить их русские эквиваленты.*

air compressor – воздушный компрессор	**propeller thrust** – тяга воздушного винта
auxiliary - дополнительный	**provided for** - предусмотренный
auxiliaries – вспомогательные устройства	**reliability** - надежность
bearing - подшипник	**rim speed** – окружная скорость
blade - лопатка	**safeguard** – предохранять
bucket temperature – температура лопасти	**serviceability** – эксплуатационная пригодность, ремонтопригодность
common - общий	**shaft power** – мощность на валу; мощность, передаваемая валом
conventional - обычный	**steam turbine** – паровая турбина
constructional feature – конструктивная особенность	**strength** – прочность, предел прочности
thermal distortion – температурная деформация	**stress** - напряжение
deliver – освобождать, избавлять	**sufficient** – достаточный
drive – приводить в движение	**supercharger** - нагнетатель
exhaust gases – выхлопные газы	**sustained period** – длительный, продолжительный период
frontal area – лобовая площадь	**thermal jet engine** – тепловой реактивный двигатель
furnish – поставлять, снабжать	**thrust** - тяга
jet – реактивный	**turbine-propeller engine** – турбовинтовой двигатель
means - устройства	
power output – выходная мощность	
propeller – пропеллер, воздушный винт	

Упражнение 2. *Переведите слова на русский язык, обращая внимание на суффиксы.*

To propel – propell**er**; to compress – compress**or**; to add – add**ition**; particular – particular**ly**; help – help**ful**; to develop – develop**ment**; high – high**ly**; to apply – applica**tion**; construction – construction**al**; to evaluate- evalu**ation**; to distort – distort**ion**; equal – equal**ly**; to require – require**ment**; efficient – efficien**cy**; reliable – reliabil**ity**.

Упражнение 3. *Прочтите и переведите интернациональные слова:*

Turbine, component, gas, thermal, information, decade, metallurgy, temperature, rotor, diameter, period, disk, maximum, limit, characteristic, material, compromise.

Упражнение 4. *Переведите предложения на русский язык, используя терминологию упражнения 1.*

1. It is required to furnish only sufficient power to drive the air compressor and the auxiliaries.
2. Usually thrust is comprised of 80 per cent propeller thrust and 20 per cent auxiliary jet thrust.
3. The experience gathered in the development of turbo-superchargers and also steam turbines for high-pressure and high-temperature applications is particularly helpful to the development of turbines which operate with highly heated gases.
4. The basic requirements for the turbine are the same for either type of engine.
5. There is a lower limit to the rim speed imposed by the dictates of high efficiency which improves with rim speed.

Упражнение 5. *Переведите предложения на русский язык, обращая внимание на перевод независимого причастного оборота.*

1. Some new devices having been obtained, the researchers could make more complex experiments.
2. It being late, the designers decided to stop working.
3. All machines have energy loss, some energy being converted into useless heat due to friction.
4. Gas turbine-propeller engines are designed to deliver auxiliary jet thrust from the exhaust gases in addition to the propeller thrust, the usual proportions being 80 per cent propeller thrust and 20 per cent auxiliary jet thrust.
5. In many respects the turbine for gas turbine-propeller engines or turbo-jet engines is quite similar to the conventional steam turbine, the major difference being in the metallurgy, the means provided for cooling the bearings and highly stressed parts, and in the constructional features to safeguard against thermal distortion.

Прочтите и переведите текст, а затем выполните следующие за ним упражнения.

TEXT
GAS TURBINE
(Part I)

The turbine is a major component common to the gas turbine-propeller engine, and to the thermal jet engine. In the gas turbine-propeller engine the turbine must develop the shaft power for driving the air compressor, propeller, and the auxiliaries. In the thermal jet engine, however, it is required to furnish only sufficient power to drive the air compressor and the auxiliaries. It should be noted that, in general, gas turbine-propeller engines are designed to deliver auxiliary jet thrust from the exhaust gases in addition to the propeller thrust, the usual proportions being 80 per cent propeller thrust and 20 per cent auxiliary jet thrust. The general characteristics of turbines are well understood, and a wealth of information concerning them has been gathered during the past decades. Particularly helpful to the development of turbines which operate with highly heated gases is the experience gathered in the development of turbo-superchargers and also steam turbines for high-pressure and high-temperature applications. In many respects the turbine for gas turbine-propeller engines or turbo-jet engines is quite similar to the conventional steam turbine, the major difference being in the metallurgy, the means provided for cooling the bearings and highly stressed parts, and in the constructional features to safeguard against thermal distortion. The basic theory underlying their design and the evaluation of their operating characteristics is identical with that for steam turbines.

The basic requirements for the turbine are the same for either type of engine. Although the remarks which follow apply specifically to the turbine for a turbojet engine, it should be understood that they apply equally well to the turbines for turboprop engines. The principal requirements are: (a) light weight; (b) small frontal area; (c) high efficiency; (d) ability to operate for sustained periods at high temperature; and (e) reliability and serviceability.

Light weight is secured by operating the turbine rotor with the highest permissible rim speed, using small-diameter rotors. Since the stresses in a given turbine disk increase approximately as the square of the rim speed, the maximum rim speed is limited by strength considerations, which are governed by the stress characteristics of the disk and blade materials at the operating temperature. Although low rim speeds are desirable from a stress standpoint, there is a lower limit to the rim speed imposed by the dictates of high efficiency which, in general, improves with rim speed. Since the turbine efficiency improves, in general, with increasing rim speed and permits using lower bucket temperatures for the same power output, the choice of rim speed is a compromise between allowable stress and turbine efficiency. The rim speeds of most turbojet turbines range from 820 to 1000 fps.

Послетекстовые упражнения

Упражнение 6. *Найдите в тексте данные ниже слова и напишите их русские эквиваленты.*

Gas turbine-propeller engine, thermal jet engine, to furnish, sufficient power, auxiliary jet thrust, exhaust gases, propeller thrust, wealth of information, development, highly heated gases, turbo-supercharger, the means provided for, highly stressed parts, constructional features, to safeguard against, thermal distortion, turbine rotor, turbine disk, stress characteristics, operating temperature, dictates of high efficiency, bucket temperatures, allowable stress, turbine efficiency.

Упражнение 7. *Найдите в тексте ответы на следующие вопросы:*

1. What is a major component common to the gas turbine-propeller engine, and to the thermal jet engine?
2. What is the turbine intended for?
3. What is required in the thermal jet engine?
4. What are gas turbine-propeller engines designed for?
5. In what does the turbine for gas turbine-propeller engines or turbo-jet engines differ from the conventional steam turbine?
6. What are the principle requirements for the turbine?
7. What is light weight secured by?
8. What is the maximum rim speed limited by?
9. What is a lower limit to the rim speed imposed by?
10. What is the choice of rim speed determined by?

Упражнение 8. *Заполните пропуски предлогами и переведите предложения на русский язык.*

1. The turbine is a major component common … the gas turbine-propeller engine.
2. In the gas turbine-propeller engine the turbine must develop the shaft power … driving the air compressor, propeller, and the auxiliaries.
3. Gas turbine-propeller engines are designed to deliver auxiliary jet thrust … the exhaust gases … addition … the propeller thrust.
4. Particularly helpful … the development … turbines which operate … highly heated gases is the experience gathered … the development … turbo-superchargers and also steam turbines … high-pressure and high-temperature applications.
5. The basic requirements … the turbine are the same … either type … engine.
6. Light weight is secured … operating the turbine rotor … the highest permissible rim speed, using small-diameter rotors.
7. The maximum rim speed is limited … strength considerations, which are governed … the stress characteristics … the disk and blade materials … the operating temperature.
8. Although low rim speeds are desirable … a stress standpoint, there is a lower limit … the rim speed imposed … the dictates … high efficiency which, in general, improves … rim speed.

Упражнение 9. *Выпишите из правой колонки русские слова и словосочетания, соответствующие английским из левой колонки.*

1. thermal distortion	1.подшипник
2. propeller thrust	2. температура лопасти
3. constructional feature	3. вспомогательные устройства
4. rim speed	4.эксплуатационная (ремонтная) пригодность
5. air compressor	5. мощность на валу
6. stress	6. реактивный
7. blade	7. паровая турбина
8. thermal jet engine	8. тяга
9. auxiliaries	9. воздушный винт
10. sustained period	10. нагнетатель
11. exhaust gases	11. прочность
12. serviceability	12. конструктивная особенность
13. bearing	13. турбовинтовой двигатель
14. supercharger	14. устройства
15. bucket temperature	15.воздушный компрессор
16. frontal area	16. выходная мощность
17. shaft power	17. лобовая площадь
18. propeller	18.окружная скорость
19. jet	19. напряжение
20. thrust	20. продолжительный период
21. strength	21. температурная деформация
22. means	22. тепловой реактивный двигатель
23.turbine-propeller engine	23.выхлопные газы
24. steam turbine	24. тяга воздушного винта
25. power output	25.лопатка

Упражнение 10. *Переведите следующие предложения на английский язык и запишите их.*

1. Турбина является основным компонентом газотурбинного винтового двигателя.
2. Турбина должна развивать мощность на валу для приведения в движение воздушного компрессора, воздушного винта и вспомогательных устройств.
3. Газотурбинный винтовой двигатель сконструирован для высвобождения дополнительной реактивной тяги из выхлопных газов в дополнение к тяге воздушного винта.
4. По многим параметрам турбина для газотурбинных винтовых двигателей или турбореактивных двигателей подобна обычной паровой турбине.
5. Небольшой вес обеспечивается работой ротора турбины с максимально

разрешенной окружной скоростью и использованием роторов малого диаметра.

6. Максимальная окружная скорость ограничивается характеристиками напряжения материалов диска и лопатки при рабочей температуре.

7. Выбор окружной скорости – это компромисс между допустимым напряжением и коэффициентом полезного действия турбины.

Упражнение 11. *Составьте аннотацию текста, используя в качестве плана ответы на вопросы упражнения 7.*

UNIT 3

Упражнение 1. *Прочтите слова и словосочетания и постарайтесь запомнить их русские эквиваленты.*

annulus - кольцо **attain -** достигать **axial -** осевой **axial-flow compressor** – осевой компрессор **benefit** -преимущество **bucket -** створка **centrifugal -** центробежный **choking of the flow** – запирание потока **to derive -** извлекать **elastic theory** – теория упругих деформаций **extremity** – конец, крайняя точка **failure** – повреждение, отказ **fluid dynamical -** гидрогазодинамический **frontal area** – лобовая площадь **gas seal** – газонепроницаемое уплотнение **hollow -** полый **impose** – зд. вызывать **interior** – внутренность, внутренняя строна **nearly** – почти	**outlet –** выход, выпускное отверстие **plastic** – пластик, пластмасса **propulsion engine** – главный двигатель, тяговый двигатель **remedies** – способы устранения неисправностей **residual stress** – остаточное напряжение **rim** – обод, край, зубчатый венец **root -** основание **to run hot -** нагреваться **securing** – организация защиты, обеспечение безопасности, надежности **steep temperature gradient** – крутой температурный коэффициент **plastic strain** – пластическая деформация **stress distribution** – распределение напряжений **stress-strain** – растяжение-сжатие **to subject -** подвергать **tapered** – суженный, конический **value unity** – единица значения **vanish** – принимать нулевое значение

Упражнение 2. *Переведите слова, обращая внимание на суффиксы.*

Consider – consider**ation**, possible – possibil**ity**, develop – develop**ment**, apply – applic**ation**, incorporate – incorpor**ation**, deform – deform**ation**, vibrate – vibr**ation**, secure – secur**ing**, combust – combust**ion**, construct – construc**tion**.

Упражнение 3. *Прочтите и переведите интернациональные слова.*

Design, mass, gas, acoustic, critical, disk, method, metallurgy, metallurgical, problem, temperature, gradient, natural, function, period, characteristics, material, crystal structure, compressor, problem, type.

Прочтите и переведите текст, а затем выполните следующие упражнения.

TEXT
GAS TURBINE
(Part II)

The general design of the turbine passages is based primarily on considerations which are mainly fluid dynamical. The flow conditions must be so designed that, for the required thrust output and mass flow of gas, the acoustic velocity (unity Mach number) * is not reached at the outlet from the buckets (or in the ducting downstream leading the exhaust gases away from the turbine, or in the exhaust nozzle), for choking of the flow occurs if the Mach number in these flow passages attains the value unity. The critical Mach number is based on the axial velocity of the gas in the exit annulus from the turbine. The possibility of attaining unity Mach number in the outlet from the turbine buckets is a consideration to be investigated in Rateau stage turbines.

Disk and rim failures in turbo-jet turbines did occur in the early development stages of this propulsion engine. They have now been overcome by the application of such methods as improved gas seals, the incorporation of methods for cooling the disk, and improved metallurgy. One of the major factors has been a better understanding of the metallurgical problem. Research has shown that if the disk operates with high temperatures or steep temperature gradients it is likely to develop plastic deformation. If this occurs the stress distribution can no longer be based on conventional elastic theory, and when the disk cools off after operating it is subjected to large residual stresses. As a consequence of the residual stresses there is a change in the natural vibration frequencies, which are functions of the stress conditions. Furthermore, successive periods of plastic strain, cooling, and then heating again modify the stress-strain characteristics of the disk material and may lead to changes in its crystal structure. By applying the remedies mentioned above these difficulties can be avoided.

In turbo-jet engines employing a centrifugal compressor, the turbine imposes no problem in the securing of small frontal area. The frontal area of the turbine is much smaller than that of the compressor and combustion chamber assembly and has little influence upon the overall size in that type of application. Where the turbine drives an axial-flow compressor the frontal areas of the turbine and compressor become more nearly equal.

The turbine blades may be either solid or hollow, the type of construction being influenced by the material selected for their manufacture. The hollow blade offers the advantages of being adapted to cooling by flowing cold air through its interior and of reducing weight. The walls of the blade are usually tapered so that the outer extremity, where the stress vanishes, is quite thin. The greatest benefit derived from cooling is at the root of the blade where the stresses are high; the outer edge, because of its small stress, may be allowed to run hot.

* Mach number (M) — число Маха, т. е. отношение скорости движения потока к скорости звука при данных условиях (движения потока).

Послетекстовые упражнения

Упражнение 4. *Найдите в тексте данные ниже слова и словосочетания и напишите их русские эквиваленты.*

Turbine passages, thrust output, mass flow of gas, ducting downstream, exhaust gases, exhaust nozzle, flow passages, to occur, velocity, exit, unity Mach number, turbine buckets, Rateau stage turbines, propulsion engine, improved metallurgy, conventional, to cool off, residual stresses, vibration frequencies, combustion chamber, turbine blades, solid, hollow blade, to offer, outer edge.

Упражнение 5. *Найдите в тексте ответы на следующие вопросы.*

1. What is the general design of the turbine passages based on?
2. What way must the flow conditions be designed?
3. What is the critical Mach number based on in the exit annulus from the turbine?
4. How have disk and rim failures now been overcome?
5. When does disk develop plastic deformation?
6. What is a consequence of the residual stresses?
7. What modifies the stress-strain characteristics of the disk material and may lead to changes in its crystal structure?
8. Why does the turbine impose no problem in the securing of small frontal area in turbo-jet engines employing a centrifugal compressor?
9. What does the hollow blade offer?
10. What size are the walls of the blade?

Упражнение 6. *Подберите из правой колонки соответствующие окончания предложений из левой колонки.*

1. The critical Mach number is based on …	1. a consideration to be investigated in Rateau stage turbines.
2. The possibility of attaining unity Mach number in the outlet from the turbine buckets is …	2. at the root of the blade where the stresses are high; the outer edge, because of its small stress.
3. The turbine blades may be …	3. the frontal areas of the turbine and compressor become more nearly equal.
4. The greatest benefit derived from cooling is …	4. the axial velocity of the gas in the exit annulus from the turbine.
5. Where the turbine drives an axial-flow compressor …	5. either solid or hollow.

Упражнение 7. *Переведите предложения на английский язык.*

1. Критическое число Маха основано на осевой скорости газа в выхлопном кольце, ведущем из турбины.
2. Работа диск в условиях высокой температуры или крутого температурного градиента ведет к образованию пластической деформации.
3. Остывая после работы, диск подвергается высоким остаточным напряжениям.
4. Следствием остаточных напряжений является изменение частот естественной вибрации.
5. Лобовая площадь турбины гораздо меньше лобовой площади турбины и блока камеры сгорания.
6. Лопасти турбины могут быть твердотельными или полыми.
7. Стенки лопасти обычно сужаются так, что на внешнем конце, где напряжение принимает нулевое значение, они очень тонкие.

Упражнение 8. *Переведите текст, пользуясь словарем.*

In most designs the blades are twisted to maintain a favorable angle of attack for the fluid throughout its length. In the early development of the turbo-jet, blading failures did occur, but they are now a rarity. The difficulties were overcome by increased accuracy in the manufacture of the blades, avoidance of small radii at root junctions, better analysis of vibration problems, and improved metallurgy.

Since improving turbine efficiency and output are related to ability to operate with higher temperatures, developments aimed at raising the permissible operating temperature of the turbine are of great importance. One promising approach is the application of ceramic coatings on the turbine blades to take the impact of the hot gases. The problem here is to develop a ceramic coating of high melting point which will bond to the metal and will have a coefficient of expansion close enough to that of the metal to prevent the coating from cracking or flaking off. Another approach proposes to let cooling liquid flow through a passage in the root of the blades.

A general thermodynamic treatment can be applied to both impulse and reaction stages by considering an intermediate stage of a multistage reaction turbine; the intermediate stage typifies the general case of a turbine stage. In such a stage the stationary blade row is the counterpart of the nozzle of an impulse stage.

Упражнение 9. *Составьте аннотацию текста, используя в качестве плана ответы на вопросы упражнения 5.*

Упражнение 10. *Представьте, что:*

1. Вы являетесь одним из разработчиков двигателя внутреннего сгорания. Расскажите о его устройстве и существующих типах двигателей внутреннего сгорания.
2. Вы являетесь преподавателем выпускающей кафедры. Расскажите студентам о газовой турбине.

UNIT 4

Упражнение 1. *Прочтите слова и словосочетания и постарайтесь запомнить их русские эквиваленты.*

axial compressor – осевой компрессор **axial flow compressor** – компрессор с течением воздуха вдоль оси, осевой компрессор **airfoil cross-section** – профилированное поперечное сечение (типа поперечного сечения крыла) **alloy** - сплав **to attach** – устанавливать, закреплять **blades** – лопатки (ротора или статора осевого компрессора) **casing** – корпус, кожух **to cause** - создавать **constant relationship** – постоянное соотношение **coughing** издаваемые звуки, похожие на кашель	**pressure rise** – повышение давления **primarily** – в основном, в первую очередь звуки **to produce shot-like sounds** – издавать звуки, похожие на выстрел **partially or wholly** – частично или полностью **range** - диапазон **rapidly** - быстро **to reduce** сокращать, уменьшать **rise in pressure** – подъем давления **severe vibrations** – сильные вибрации **shrouding** – бандажирование законцовок лопаток (для повышения жесткости) **smooth flow of air** – невозмущенное течение воздуха

to damage - повреждать **to deliver** - подавать **design** - конструкция **duct** – канал, контур **efficient** – эффективный, с высоким КПД **operating condition** условия эксплуатации **powerful bangs** – мощные взрывоподобные	**to stall** – работать в режиме срыва потока в одной ступени компрессора **to surge** - работать в режиме помпажа, при котором срыв потока происходит во всех ступенях компрессора **titanium** - титан **unwanted turbulence** – нежелательная турбулентность **to upset** нарушать, срывать ламинарный поток **volume** – объем (воздуха)

Упражнение 2. *Переведите слова, обращая внимание на суффиксы.*

To combust – combust**ion**, relation – relation**ship**, to compress – compress**or**, power-power**ful**, partial – partial**ly**, whole – whol**ly**, direct – direct**ly**, to vibrate – vibrat**ion.**

Упражнение 3. *Прочтите и переведите интернациональные слова.*

Compressor, temperature, design, rotor, stator, aluminum, vibration, gas, stability.

Прочтите и переведите текст, а затем выполните следующие упражнения.

TEXT
AXIAL COMPRESSOR

Axial compressor is a mechanical device for causing a pressure rise in the air delivered to the combustion chamber. There is a constant relationship between the volume, the temperature, and the pressure of the air as it passes through the axial compressor. The temperature of the air at any point of the duct is the product of the pressure and the volume of that air.

When the volume of the air is being reduced in an axial compressor, there is a rise in both pressure and temperature. The more efficient is the design of the compressor, the higher will be the rise in pressure. The efficiency of an axial-flow compressor depends primarily upon the design of its rotor and stator blades.

Rotor blades have airfoil cross-section and are made of aluminum alloy, steel or titanium. They can operate with maximum efficiency only within a limited range of operating conditions. Outside this range the smooth flow of air in the compressor is usually upset by unwanted turbulence. When one stage of the compressor is upset by turbulence, it is said that the compressor stalls. The stalling compressor usually develops severe vibrations or coughing. Sometimes it may even produce shot-like sounds. When all stages of the compressor are upset by turbulence, it is said that the compressor surges. The surging compressor produces powerful bangs, the temperature of the exhaust gases rapidly rises and the engine may be partially or wholly damaged. Stator blades may be attached directly to the casing of the compressor, with connecting shrouding at the tips to give them greater stability.

Послетекстовые упражнения

Упражнение 4. *Найдите в тексте данные ниже слова и словосочетания и напишите их русские эквиваленты.*

Mechanical device, combustion chamber, the pressure of air, product, a limited range, the stalling compressor, the surging compressor, exhaust gases, stator blades, to attach directly, to give stability, maximum efficiency, turbulence, to be made of, the smooth flow of air.

Упражнение 5. *Найдите в тексте ответы на следующие вопросы.*

1. What does the axial compressor do in a jet engine?
2. How can we calculate the temperature of the air at any point of the duct of the compressor?
3. What happens when the volume of air in the compressor is reduced?
4. What does the efficiency of the compressor depend on?
5. What material are the blades of the compressor made of?
6. What happens when one stage of the compressor is upset by turbulence?
7. What is the axial compressor stall?
8. How does the axial compressor stall manifest itself?
9. What happens when all stages of the axial compressor are upset by turbulence?
10. What is the axial compressor surge?
11. How does the axial compressor surge manifest itself?
12. What are the results of the compressor surging?
13. What is the difference between stalling and surging conditions?
14. Where does the axial compressor take its energy from?
15. What are stator blades for?
16. Where are stator blades attached to?
17. What measures are taken to ensure greater greater stability of the stator blades?

Упражнение 6. *Подберите из правой колонки соответствующие окончания предложений из левой колонки.*

1. When the volume of air is being reduced in an axial compressor, …	1. a mechanical device for causing a pressure rise in the air delivered to the combustion chamber.
2. The efficiency of an axial flow com-	2. the higher will be the rise in pressure.

pressor depends upon …	
3. When one stage of the compressor is upset by turbulence, …	3. it is said that the compressor surges.
4. Axial compressor is …	4. there is a rise in both pressure and temperature.
5. The more efficient is the design of the compressor, …	5. the design of its rotor and stator blades.
6. When all stage of the compressor are upset by turbulence, …	6. it is said that the compressor stalls.
7. The surging compressor produces …	7. vibrations or coughing.
8. The stalling compressor usually develops …	8. powerful bangs.

Упражнение 7. *Переведите предложения на английский язык.*

1. Осевой компрессор представляет собой механическое устройство для создания повышения давления воздуха, подаваемого в камеру сгорания.
2. Температура воздуха в любой точке канала является произведением давления и объема данного воздуха.
3. Когда в осевом компрессоре уменьшается объем воздуха, происходит подъем как давления, так и температуры.
4. Эффективность работы компрессора с течением воздуха вдоль оси зависит, в основном, от конструкции лопаток ротора и статора.
5. Лопатки ротора имеют профилированное поперечное сечение и изготавливаются из алюминиевого сплава, стали или титана.
6. Вне диапазона условий эксплуатации невозмущенное течение воздуха в компрессоре обычно нарушается нежелательной турбулентностью.
7. Компрессор работает в режиме срыва потока в одной ступени компрессора при нарушении турбулентностью работы одной ступени компрессора.
8. Компрессор, работающий в режиме срыва потока в одной ступени компрессора, создает сильные вибрации или издает звуки, похожие на кашель.
9. Компрессор работает в режиме помпажа при нарушении турбулентностью работы всех ступеней компрессора.
10. Компрессор, работающий в режиме помпажа, издает мощные взрывоподобные звуки, при этом температура выхлопных газов быстро повышается, и двигатель может быть частично или полностью поврежден.
11. Бандажирование законцовок лопаток придает лопаткам статора большую стабильность.

Упражнение 8. *Переведите текст, пользуясь словарем.*

Three basic types of air compressors are used in gas-turbine engines: the centrifugal type, the axial single-rotor type, and the axial split-compressor type. Each of these compressors has qualities which are desirable.

The centrifugal-type compressor produces a high pressure rise in a single stage, it is easy to manufacture, it is durable, it will operate under a great number of adverse conditions such as ice and sand, and it is comparatively low in cost. The axial-flow compressor is more efficient than the centrifugal-flow compressor, and it will handle a larger volume of air for a given diameter. It also provides for higher pressure ratios than are possible with the centrifugal compressor.

The split, or two-spool, compressor provides for very high pressure ratios which lead to excellent specific fuel consumption. Typical of the pressure ratios obtainable with the split compressor is a ratio of 20: 1. Turbojet engines with this pressure ratio have attained a specific fuel consumption of approximately 0.75, which is exceptionally good for engines of this type. A turboprop engine with a split compressor has attained a specific fuel consumption of approximately 0.45. This figure is comparable to the fuel consumption for the best reciprocating engines.

Упражнение 9. *Составьте аннотацию текста, используя в качестве плана ответы на вопросы упражнения 5.*

Упражнение 10. *Подготовьте небольшие сообщения по следующим вопросам:*

1. Gas-dynamic processes in a convergent duct.
2. Comparative analysis of axial, centrifugal and hybrid compressors.
3. Stall conditions in axial compressors.
4. Surge conditions in axial compressors.

UNIT 5

Упражнение 1. *Прочтите слова и словосочетания и постарайтесь запомнить их русские эквиваленты.*

advantage - преимущество **air-fuel mixture** – топливно-воздушная смесь **air pollution** загрязнение воздушной среды **annular combustion chamber** – кольцевая камера сгорания **capable to withstand** – в состоянии выдержать, противостоять **centrifugal compressor** – центробежный компрессор **corrosive effects** – коррозионные воздействия	жаровыми трубами **layout** – планировка, расположение, схема, компоновка **to manufacture** изготовлять, производить **more fuel-efficient** – с более высокой топливной эффективностью **one side the other** – один внутри другого **products of combustion** – продукты сгорания **to reduce** сокращать, частично решать (проблемы)

double ring – двойное кольцо **flame tube** жаровая труба **to install** - устанавливать **multiple combustion chamber layout** – камера сгорания с отдельными	**separate outer casing** – отдельный внешний кожух **shaped** – имеющие форму **tubo-annular combustion chamber** – трубчато-кольцевая камера сгорания

Упражнение 2. *Переведите слова, обращая внимание на суффиксы.*

Mechanic – mechanic**al**, burn – burn**ing**, differ – differ**ent**, radial – radial**ly**, present – present**ly**, case – cas**ing**.

Упражнение 3. *Прочтите и переведите интернациональные слова.*

Mechanical, mixture, radially, design, form, to group, compact, problem, temperature, corrosive, effect, product.

Прочтите и переведите текст, а затем выполните следующие упражнения.

TEXT

THE COMBUSTION CHAMBER

Combustion chambers are mechanical devices for burning air-fuel mixture. They may be installed in the engine in a number of different ways. The multiple combustion chamber layout is used with engines having centrifugal compressor. In this layout a number of flame tubes are disposed radially round the engine. Annular and tubo-annular designs of combustion chambers are more often used presently.

The flame tube of annular combustion chambers is in the form of a double ring which in turn is fitted into an annular casing of two more rings. Tubo-annular combustion chambers have flame tubes grouped round the engine, as in the multiple layout, but instead of each having a separate outer casing, they are all disposed in a common annular casing, shaped like two broad rings, one inside the other.

Tubo-annular chambers are easier to manufacture and overhaul, while annular chambers, besides pocessing these advantages, are also more compact. Annular chambers are more fuel-efficient and reduce many of the problems of air pollution. All combustion chambers must be capable to withstand very high temperatures, rapid changes of temperature and corrosive effects produced by the products of combustion.

Послетекстовые упражнения

Упражнение 4. *Найдите в тексте данные ниже слова и словосочетания и напишите их русские эквиваленты.*

Combustion chamber, device, to burn, air-fuel mixture, engine, number of different ways, centrifugal compressor, layout, flame tubes, to dispose, annular design, tubo-annular design, multiple layout, common annular casing, to shape, to overhaul, to possess, advantage, fuel-efficient, to withstand, corrosive effects, products of combustion.

Упражнение 5. *Найдите в тексте ответы на следующие вопросы.*

1. What are combustion chambers for?
2. What part of the jet engine is before the combustion chamber?
3. How many layouts of the combustion chamber are known?
4. With what type of compressors is the multiple combustion chamber layout used?
5. What is the flame tubes disposition in the multiple combustion chamber layout?
6. What designs of combustion chambers are more often used presently?
7. What is the form of the flame tube of annular combustion chambers?
8. What is the disposition of flame tubes in tubo-annular combustion chambers?
9. In what do tubo-annular combustion chambers differ from annular combustion chambers?
10. How do annular combustion chambers and tubo-annular combustion chambers compare against one another?
11. Which combustion chambers are easier to manufacture?
12. Which combustion chambers are more compact?
13. What are operating conditions of combustion chambers?
14. What requirements must all combustion chambers comply with?

Упражнение 6. *Подберите из правой колонки соответствующие окончания предложений из левой колонки.*

1. The flame tube of annular combustion chambers is …	1. are disposed radially round the engine.
2. Annular chambers are …	2. with engines having centrifugal compressor.
3. Combustion chambers are …	3. be capable to withstand very high temperatures, rapid changes of temperature and corrosive effects produced by the products of combustion.
4. In the multiple combustion chamber a number of flame tubes …	4. more fuel-efficient and reduce many of the problems of air pollution.
5. The multiple combustion chamber layout is used …	5. in the form of a double ring which in turn is fitted into an annular casing
6. All combustion chambers must …	6. mechanical devices for burning air-fuel mixture.
7. Tubo-annular combustion chambers have …	7. more often used presently.
8. Annular and tubo-annular designs of combustion chambers are …	8. flame tubes grouped round the engine and disposed in a common annular casing, shaped like two broad rings, one inside the other.

Упражнение 7. *Переведите предложения на английский язык.*

1. Камера сгорания – это механическое устройство, предназначенное для сжигания топливно-воздушной смеси.
2. Камера сгорания с отдельными жаровыми трубами используется в двигателях, имеющих центробежный компрессор.
3. В камере сгорания с отдельными жаровыми трубами ряд жаровых труб располагается радиально вокруг двигателя.
4. Жаровая труба кольцевой камеры сгорания имеет форму двойного кольца.
5. Трубчато-кольцевая камера сгорания имеет жаровые трубы, сгруппированные вокруг двигателя.
6. Кольцевые камеры сгорания имеют более высокую топливную эффективность и уменьшают многие проблемы загрязнения воздушной среды.
7. Все камеры сгорания должны быть в состоянии противостоять очень высоким температурам, быстрому изменению температуры и коррозионному воздействию продуктов сгорания.

Упражнение 8. *Переведите текст, пользуясь словарем.*

The purpose of the combustion chambers in a turbine engine is to expand the air passing through the engine by burning fuel in the air stream. The heat released by the burning fuel adds energy to the air in the form of velocity. The acceleration of the air-fuel mixture imparts positive thrust to the combustion chamber structure.

Roughly one-fourth of the air entering the combustion chamber area is burnt with the fuel. The balance of the air serves to keep the temperature of the heated gases down to a level which will not damage the turbine nozzle and blades. For this reason the design of the combustion chambers must be such that adequate fuel combustion is accomplished and that proper cooling is attained.

Упражнение 9. *Составьте аннотацию текста, используя в качестве плана ответы на вопросы упражнения 5.*

Упражнение 10. *Подготовьте небольшие сообщения по следующим вопросам:*

1. Two-zone combustion in modern combustion chambers.
2. Combustion chamber in a fuel-efficient jet engine.
3. Thrust augmentation combustors.
4. Combustion chambers of vectored-thrust jet engines.
5. Plenum combustion chambers of VTOL airplanes.

SUPPLEMENTARY READING

Text 1

Task 1. Read and translate the text

Aircraft Conceptual Design

In order to implement the systems engineering discipline, the aircraft (i.e., system) design process includes four major phases: (i) conceptual design, (ii) preliminary design, (iii) detail design, and (iv) test and evaluation. Conceptual design is the first and most important phase of the aircraft system design and development process. It is an early and high-level lifecycle activity with potential to establish, commit, and otherwise predetermine the function, form, cost, and development schedule of the desired aircraft system. The identification of a problem and associated definition of need provides a valid and appropriate starting point for design at the conceptual level.

Selection of a path forward for the design and development of a preferred system configuration, which will ultimately be responsive to the identified customer requirement, is a major responsibility of conceptual design. Establishing this early foundation, as well as requiring the initial planning and evaluation of a spectrum of technologies, is a critical first step in the implementation of the systems engineering process. Systems engineering, from an organizational perspective, should take the lead in the definition of system requirements from the beginning and address them from a total integrated lifecycle perspective.

The aircraft design process generally commences with the identification of a “what” or “desire” for something and is based on a real (or perceived) deficiency. As a result, a system requirement is defined along with the priority for introduction, the date when the system capability is required for customer use, and an estimate of the resources necessary for acquiring this new system. To ensure a good start, a comprehensive statement of the problem should be presented in specific qualitative and quantitative terms, in enough detail to justify progressing to the new step.

As the name implies, the aircraft conceptual design phase is the aircraft design at the concept level. At this stage, the general design requirements are entered into a process to generate a satisfactory configuration. The primary tool at this stage of design is the selection. Although there are a variety of evaluations and analyses, there are not many calculations. The past design experience plays a crucial role in the success of this phase.

Design Phases. There are a number of phases through which the system design and development process must invariably pass. Foremost among them is the identification of the customer-related need and, from that need, the determination of what the system is to do. This is followed by a feasibility analysis to discover potential technical solutions, the determination of system requirements, the design and development of system components, the construction of a prototype, and/or engineering model, and the validation of the system design through test and evaluation. According to the systems engineering approach, a total of four design phases are defined.

At the conceptual design phase, the aircraft will be designed in concert with non-precise results. In other words, almost all parameters are determined based on a decision-making process and a selection technique. In contrast, the aircraft preliminary design phase tends to employ the outcomes of a calculation procedure. As the name implies, at the preliminary design phase, the parameters determined are not final and will be altered later. In addition, at this phase, the parameters are essential and will directly influence the entire detail design phase. Therefore, ultimate care must be taken to insure the accuracy of the results of the preliminary design phase. In summary, three aircraft fundamental parameters are determined in the preliminary design: (i) aircraft maximum take-off weight (W TO), (ii) wing reference area (S_{ref}), and (iii) engine power (P) if the aircraft is prop-driven or engine thrust (T) if a jet engine is selected.

At the aircraft detail design phase, the technical parameters of all components (e.g., wing, fuselage, tail, landing gear, and engine) – including geometry – are calculated and finalized.

Task 2. Put the sentences in order they appear in the text.

1. To ensure a good start, a comprehensive statement of the problem should be presented in specific qualitative and quantitative terms, in enough detail to justify progressing to the new step.
2. Almost all parameters are determined based on a decision-making pro-

cess and a selection technique.

3. As the name implies, the aircraft conceptual design phase is the aircraft design at the concept level.

4. At the preliminary design phase, the parameters determined are not final and will be altered later.

5. At the aircraft detail design phase, the technical parameters of all components are calculated and finalized.

6. Conceptual design is the first and most important phase of the aircraft system design and development process.

7. According to the systems engineering approach, a total of four design phases are defined.

8. Selection of a path forward for the design and development of a preferred system configuration is a major responsibility of conceptual design.

Text 2

Task 1. Read and translate the text

Primary Functions of Aircraft Components

An aircraft comprises several major components. It mainly includes the wing, horizontal tail, vertical tail (VT), fuselage, propulsion system, landing gear, and control surfaces. In order to make a decision about the configuration of each aircraft component, the designer must be fully aware of the function of each component. Each aircraft component has interrelationships with other components and interferes with the functions of other components.

1. **Wing.** The main function of the wing is to generate the aerodynamic force of lift to keep the aircraft airborne. The wing tends to generate two other unwanted aerodynamic productions: an aerodynamic drag force plus an aerodynamic pitching moment. Furthermore, the wing is an essential component in providing the aircraft lateral stability, which is fundamentally significant for flight safety. In almost all aircraft, the aileron is arranged so as to be at the trailing edge of the outboard section. Hence, the wing is largely influential in providing the aircraft lateral control.

2. **Fuselage.** The primary function of the fuselage is to accommodate the payload which includes passengers, cargo, luggage, and other useful loads. The fuselage is often a home for the pilot and crew members, and most of the time fuel tanks and engine(s). Since the fuselage provides a moment arm to the horizontal and VT, it plays an influential role in longitudinal and directional stability and control. If the fuselage is decided to be short, a boom must be provided to allow for the tails to have sufficient arm.

3. **Horizontal tail.** The horizontal tail's primary function is to generate an aerodynamic force to longitudinally trim the aircraft. Furthermore, the VT is an essential component is providing the aircraft longitudinal stability, which is a fundamental requirement for flight safety. In the majority of aircraft, the elevator is a movable part of the horizontal tail, so longitudinal control and maneuverability are applied through the horizontal tail.

4. **Vertical tail.** The VT's primary function is to generate an aerodynamic force to directionally trim the aircraft. Furthermore, the VT is an essential component in providing the aircraft directional stability, which is a fundamental requirement for flight safety. In the majority of aircraft, the rudder is a movable part of the VT, so directional control and maneuverability are applied through the VT.

5. **Engine.** The engine is the main component in the aircraft propulsion system to generate power and/or thrust. The aircraft requires a thrust force to move forward (as in any other vehicle), so the engine's primary function is to generate the thrust. The fuel is considered to be a necessary item of the propulsion system and it sometimes constitutes a large part of the aircraft weight. An aircraft without an engine is not able to take off independently, but is capable of gliding and landing, as performed by sailplanes and gliders. Sailplanes and gliders take off with the help of other aircraft or outside devices (such as a winch), and climb with the help of wind and thermal currents.

6. **Landing gear.** The primary function of the landing gear is to facilitate take-off and landing operations. During take-off and landing operations, the fuselage, wing, tail, and aircraft components are kept away from the ground through the landing gear. The wheels of the landing gear in land-based and ship-based aircraft also play a crucial role in safe acceleration and deceleration of the aircraft. Rolling wheels as part of the landing gear allow the aircraft to accelerate without spending a considerable amount of thrust to overcome friction.

The above six components are assumed to be the fundamental components of an air vehicle. However, there are other components in an aircraft that are not assumed here as major ones.

Traditional aircraft configuration design attempts to achieve improved performance and reduced operating costs by minimizing the maximum take-off weight. From the point of view of an aircraft manufacturer, however, this method does not guarantee the financial viability of an aircraft program. A better design approach would take into account not only aircraft performance and manufacturing cost, but also factors such as aircraft flying qualities and systems engineering criteria.

The historical choice of minimizing the gross take-off weight (GTOW) as the objective in aircraft design is intended to improve performance and subsequently lower operating costs, primarily through reduced fuel consumption. However, such an approach does not guarantee the optimality of a given aircraft design from the perspective of the aircraft consumer. In an increasingly competitive market for aircraft, manufacturers may wish to design for improved systems engineering of an aircraft program, as well as technical merit, before undertaking such a costly investment.

Text 3

Task 1. Read and translate the text

Aircraft Configuration Alternatives

When the necessary aircraft components, to satisfy design requirements, are identified and the list of major components is prepared, the step to select their configurations begins. Each major aircraft component may have several alternatives which all satisfy the design requirements. However, each alternative will carry advantages and disadvantages by which the design requirements are satisfied at different levels. Since each design requirement has a unique weight, each configuration alternative results in a different level of satisfaction. This section reviews the configuration alternatives for each major component.

Wing Configuration. In general, the wing configuration alternatives from seven different aspects are as follows:

Component	Configuration
1. **Number of wings**	a. Monoplane b. Biplane c. Triplane
2. **Wing location**	a. High wing b. Mid-wing c. Low wing d. Parasol wing
3. **Wing type**	a. Rectangular b. Tapered c. Delta d. Swept back e. Swept forward f. Elliptical
4. **High-lift device**	a. Plain flap b. Split flap c. Slotted flap d. Kruger flap e. Double-slotted flap f. Triple-slotted flap g. Leading edge flap h. Leading edge slot
5. **Sweep configuration**	a. Fixed wing b. Variable sweep
6. **Shape**	a. Fixed shape b. Morphing wing
7. **Structural configuration**	a. Cantilever b. Strut-braced i. faired ii. un-faired.

The primary impacts of the wing configuration alternatives are imposed on cost, the duration of production, ease of manufacturing, lateral stability, performance, maneuverability, and aircraft life.

Tail Configuration. In general, the tail configuration alternatives from three different aspects are as follows:

Component	Configuration
1. **Aft or forward**	a. Aft conventional tail b. Canard (foreplane) c. Three surfaces
2. **Horizontal and vertical tail**	a. Conventional b. V-tail c. T-tail d. H-tail e. Inverted U
3. **Attachment**	a. Fixed tail b. Moving tail c. Adjustable tail

The primary impacts of the tail configuration alternatives are imposed on cost, the duration of production, ease of manufacturing, longitudinal and directional stability, longitudinal and directional maneuverability, and aircraft life.

Propulsion System Configuration. In general, the propulsion system configuration alternatives from four different aspects are as follows:

Component	Configuration
1. **Engine type**	a. Human-powered b. Solar-powered c. Piston prop d. Turboprop e. Turbofan f. Turbojet g. Rocket
2. **Engine and the aircraft center of gravity**	a. Pusher b. Tractor
3. **Number of engines**	a. Single-engine b. Twin-engine c. Tri-engine d. Four-engine e. Multi-engine
4. **Engine location**	a. In front of nose (inside) b. Inside fuselage mid-section c. Inside wing d. Top of wing e. Under wing f. Inside vertical tail g. Side of fuselage at aft section h. Top of fuselage.

The primary impacts of the engine configuration alternatives are imposed on cost of flight operation, cost of aircraft production, performance, duration of production, ease of manufacturing, maneuverability, flight time, and aircraft life.

Landing Gear Configuration. In general, the landing gear configuration alternatives from three different aspects are as follows:

1. **Landing gear mechanism**

a. Fixed ((i) faired and (ii) un-faired)

b. Retractable

c. Partially retractable

2. **Landing gear type**

a. Tricycle (or nose gear)

b. Tail gear (tail dragger or skid)

c. Bicycle (tandem)

d. Multi-wheel

e. Bicycle (tandem)

f. Float-equipped

g. Removable landing gear.

Another design requirement that influences the design of the landing gear is the type of runway. There are mainly five types of runway:

3. **Runway**

a. Land-based

b. Sea-based

c. Amphibian

d. Ship-based

e. Shoulder-based (for small remote-controlled aircraft).

The runway requirements will also affect the engine design, wing design, and fuselage design. The primary impacts of the landing gear configuration alternatives are imposed on cost of flight operation, cost of aircraft production, performance, duration of production, ease of manufacturing, and aircraft life.

Task 2. Decide if statements are true or false. Correct false statements.

1. Each major aircraft component may have several alternatives which all satisfy the design requirements.

2. Since each design requirement has a unique weight, each configuration alternative results in a different level of satisfaction.

3. The primary impacts of the wing configuration alternatives are imposed on cost, the duration of production, ease of manufacturing, longitudinal and lateral stability, performance, maneuverability, and aircraft life.

4 There are two different aspects in the tail configuration alternatives.

5. The primary impacts of the tail configuration alternatives are imposed on cost, the duration of production, ease of manufacturing, longitudinal and directional stability, longitudinal and directional maneuverability, and aircraft life.

6. The primary impacts of the engine configuration alternatives are imposed on cost of flight operation, cost of aircraft production, performance, duration of produc-

tion, ease of manufacturing, lateral stability, maneuverability, flight time, and aircraft life.

7. There are three different aspects in the landing gear configuration alternatives.

8. The runway requirements will also affect the engine design, wing design, and fuselage design. The primary impacts of the landing gear configuration alternatives are imposed on cost of flight operation, cost of aircraft production, performance, duration of production, lateral stability, ease of manufacturing, and aircraft life.

Text 4

Task 1. Read and translate the text

Aircraft Classification and Design Constraints

One of the essential steps that a designer must take is to clarify the aircraft type with a relevant full description of specifications. This will help the design process to be straightforward and avoids confusion in the later stages. The aircraft type is primarily based on the aircraft mission, and its required specifications. This section examines the aircraft classifications and types from a variety of aspects.

One of the basic aircraft classifications is to divide aircraft groups into three large types: (i) military, (ii) civil – transport, (iii) civil – General Aviation (GA). The GA aircraft refers to all aircraft other than military, airliner, and regular cargo aircraft, both private and commercial. In terms of weight, GA aircraft have a maximum take-off weight equal to or less than 12 500 lb (for normal and acrobatic categories), or equal to or less than 19 000 lb (for utility categories). Another difference between GA aircraft and transport aircraft lies in the number of seat. The commuter category of GA aircraft is limited to propeller-driven, multi-engine airplanes that have a seating configuration, excluding pilot seats. Any non-military aircraft with a maximum take-off weight of more than 19 000 lb and more than 19 passenger seats is considered to be a transport category aircraft. A transport aircraft is governed by Part 25 of the Federal Aviation Regulation (FAR), while GA aircraft are governed by Part 23 of FAR.

An aircraft that is ordered by a customer is accompanied with a list of requirements and constraints. In the majority of cases, there is no way to escape from these requirements, unless the designer can prove to the customer that a specific requirement is not feasible. Other than that, all requirements and constraints must be considered and met in the design process. There are other requirements as well that are imposed by airworthiness standards such as FAR, the Joint Aviation Requirements (EASA CS, formerly JAR), and Military Standards (MIL-STDs). Several of these requirements might be grouped in the aircraft classification. Aircraft configurations can be classified in many ways, based on various aspects.

One of the major steps in configuration design is to apply constraints and select the classification and type. These constraints range from aircraft mission to payload type, to type of control, and to performance requirements. A designer initially has no influence over these requirements, unless he/she can prove that the requirements are not feasible and not practical. Otherwise, they must all be followed and met at the end of the design process.

One of the significant design constraints originates from government regulations. In this regard, the designer has two options: (i) design an aircraft to comply with government regulations and standards and (ii) design an aircraft regardless of government regulations and standards. The designer is free to make the decision to select either of the above options, but he/she must be aware of the consequences. This decision will impact the whole design process, since this generates a totally different design environment and constraints. In general, the compliance with government regulations and standards increases the cost and makes the design harder. However, it will increase the quality of the aircraft and allows the aircraft to be sold in the US market.

An aircraft which has not been certified by the government aviation authorities is referred to as home-built or garage-built. These aircraft are usually designed by non-expert individuals and used by individual pilots. Their airworthiness has not been confirmed by the authorities, and hence the probability of a crash is much higher than for certified aircraft. Their flight permissions are limited to a few airspaces to reduce the risk of civilian casualties. Home-built aircraft are not allowed to be sold in the US market. Several countries have established an official body to regulate the aviation issues and ratify and collect aviation standards. The US government body that regulates aviation-related issues including aircraft design and manufacture is called the Federal Aviation Administration (FAA). The civil aviation authorities of certain European countries (including the UK, France, and Germany) have established common comprehensive and detailed aviation requirements (referred to as the Certification Specifications, formerly JARs) with a view to minimizing type certification problems on joint ventures, and also to facilitate the export and import of aviation products. The CSs are recognized by the civil aviation authorities of participating countries as an acceptable basis for showing compliance with their national airworthiness codes.

Task 2. Sum up the information given in the text.

Text 5

Task 1. Read and translate the text

Preliminary System Design

An aircraft that is ordered by a customer is accompanied with a list of requirements and constraints. In the majority of cases, there is no way to escape from these requirements, unless the designer can prove to the customer that a specific requirement is not feasible. Other than that, all requirements and constraints must be considered and met in the design process. There are other requirements as well that are imposed by airworthiness standards such as FAR, the Joint Aviation Requirements (EASA CS, formerly JAR), and Military Standards (MIL-STDs). Several of these requirements might be grouped in the aircraft classification. Aircraft configurations can be classified in many ways, based on various aspects.

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By the end of the conceptual design phase, design evolution continues by addressing some of the most fundamental system characteristics. This is accomplished during the preliminary design phase. The essential purpose of the preliminary design is to determine features of the basic components/subsystems. Some products of the preliminary design include: major technical data, design and operational trade studies, interface specifications, system mock-up and model, and plans for verification and verification tests.

The preliminary design phase often includes the following steps:

- Develop design requirements for subsystems from system-level requirements.
- Prepare development, process, and materials specifications for subsystems.
- Determine performance technical measures at the subsystem level.
- Conduct functional analysis at the subsystem level.
- Establish detailed design requirements and prepare plans for their allocation.

• Identify appropriate technical design tools, software packages, and technologies.

• Accomplish a trade-off study at the subsystem level.

• Present the design output for a preliminary design review (PDR) at the end of the preliminary design phase.

The procedures for functional analysis, trade-off study, and design review at the subsystem level are very similar to that one at the conceptual level. Thus, the functional analysis and trade-off study must be extended from the system level down to the subsystem and below as required. Subsystem design requirements evolve from system design requirements according to operational requirements, and identification and prioritization of technical performance measures (TPMs). This involves an iterative process of top-down/bottom-up design (e.g., the "Vee" process model). The system TPM for operational requirements must be related to one or more functions of subsystems. During the preliminary design phase, the selection of hardware, software, technical staff, test facilities, data, and references is made. The subsystems, units, and modules are identified and functions are allocated to each one. The qualitative and quantitative design requirements are determined at the subsystem level.

The preliminary and detail design evaluation process can be facilitated through the application of various analytical/mathematical models. A model is defined as a mathematical representation of a real world which abstracts features of the situation relative to the problem being analyzed. The use of a mathematical model offers significant benefits. There are many interrelated elements that must be integrated into a system and not treated on an individual basis. The mathematical model allows us to deal with the problem as an entity and makes it possible to consider all major variables of the problem simultaneously. The extensiveness of the model depends on the nature of the problem, the number of variables, input parameter relationship, number of alternatives, and complexity of the operation.

There must be a top-down/bottom-up traceability of requirements throughout the overall hierarchical structure of the system. It is essential that these activities be coordinated and integrated, across the lifecycle, from the beginning. In other words, an ongoing communication process must flow throughout the development of hardware, software, and human elements. The design-related activities that occur after functional analysis at the preliminary design phase are: human factor analysis, maintenance and logistic supportability analysis, producibility analysis, disposability analysis, economic analysis, functional packaging of system elements analysis, and reliability analysis. The results of the preliminary design phase will be passed on to the detail design phase, if the PDR committee approves it as meeting the design requirements.

Text 6

Task 1. Read and translate the text

Detail System Design

The conceptual design and preliminary design phases provide a good foundation upon which to base detailed design decisions that go down to the component/part level. At this point, the system configuration as well as the specifications of subsystems, units, subassemblies, software packages, people, facilities, and elements of maintenance and support are known. The procedure for functional analysis, trade-off study, and design review at the subsystem level are very similar to what is described at the conceptual level. Thus, the functional analysis and trade-off study must be extended from the system level down to the subsystem and below as required.

There are 10 major steps in the detail design phase as follows:

• Develop design requirements for all lower-level components of the system from subsystem requirements.

• Employ design tools and software packages.

• Plan, manage and form, and establish several design groups (based on various engineering disciplines).

• Perform extensive design operations (e.g., technical/mathematical calculations and logical selections) to fulfill all design objectives.

• Implement a trade-off analysis.

• Integrate system subsystems/components/elements/parts.

• Publish design data and documentation.

• Generate a prototype physical model.

• Plan and conduct tests and evaluations.

• Schedule and implement a detail design review (DDR).

Success in systems engineering derives from the realization that design activity requires a "team" approach. Hence, in performing technical/mathematical calculations and logical selections, a number of design groups or teams must be established. Basically, there are two approaches: (i) the sequential approach and (ii) the concurrent approach. Both approaches are based on related engineering disciplines (e.g., mechanical, electrical, aeronautical, computer, and civil engineering). In general, the concurrent approach (i.e., simultaneous engineering) minimizes the time, but the sequential approach minimizes the cost of the design operation.

As one proceeds from the conceptual design into the preliminary design and detail design, the actual team "make-up" will vary in terms of the specific expertise required and the number of project staff assigned. Early in the conceptual and preliminary design phases, there is a need for a few highly qualified individuals with broad technical knowledge. These few people understand and believe in the systems engineering and know when to call on the appropriate disciplinary expertise. As the design progresses, the number of representatives from various individual design disciplines will often increase.

Depending on the project size, there may be relatively few individuals assigned, or there may be hundreds of people involved. Required resources may include engineering technical expertise (e.g., engineers), engineering technical support (e.g., technicians, graphics, computer programmers, and builders), and non-technical support (e.g., marketing, budgeting, and human resources). The objective is to promote the "team" culture, and to create the proper environment for the necessary communications. The design documentation includes design drawings, materials and parts lists, and analyses and reports.

At this phase of the design, an extensive application of computer-based design aids such as computer-aided design (CAD) and computer-aided manufacturing (CAM) throughout the design will facilitate the design process. They are employed to generate drawings and three-dimensional graphic displays to be submitted to the manufacturing team. The application of CAD/CAM will allow the systems engineering process to be implemented effectively, efficiently, and in a seamless manner. In order to minimize cost, it is recommended to select standard parts that are commercially available (i.e., commercial off-the-shelf items) for which there are multiple viable suppliers.

At some points in the detail design phase, a mathematical model is necessary to evaluate the design. However, further in the design, a physical model and even a prototype serves much better in the validation and/or verification of the calculation results. This is due to the fact that the incorporation of any necessary changes for corrective action will be more costly later as the design progresses toward the production/construction phase. A prototype represents the production of a system in all aspects of form, fit, and function except that it has not been fully equipped. The objective is to accomplish a specific amount of testing for the purpose of design evaluation prior to entering the production line.

After a baseline has been established, changes are frequently initiated for any one of a number of reasons: to correct a design deficiency, improve the product, incorporate a new technology, respond to a change in operational requirements, compensate for an obsolete component, etc. So, a change may be applied from within the project, or as a result of some new externally imposed requirement. However, a change in any one item will likely have an impact on many other elements of the system. The process of the incorporation of any change must be formalized and controlled to ensure traceability from one configuration to another. A general challenge in today's environment pertains to implementing the overall system design process rapidly, in a limited amount of time, and at a minimal cost.

Task 2. Answer the questions.

1. What way does the procedure for functional analysis differ from that for conceptual analysis?
2. What steps comprise the detail design phase?
3. What does a 'team' approach mean?
4. What are computer-based design aids used for?
5. What is the objective for using a mathematical model?
6. What are the reasons for changing after a baseline has been established?

Text 7

Task 1. Read and translate the text

Design Review, Evaluation, and Feedback

At each major design phase (conceptual, preliminary, and detail), an evaluation should be conducted to review the design and to ensure that the design is acceptable at that point before proceeding with the next stage. There is a series of formal design reviews conducted at specific times in the overall system development process. An essential technical activity within the design process is that of evaluation. Evaluation must be inherent within the systems engineering process and must be invoked regularly as the system design activity progresses. However, systems evaluation should not proceed without guidance from customer requirements and specific system design criteria. When conducted with full recognition of design criteria, evaluation is the assurance of continuous design improvement.

The evaluation process includes both the informal day-to-day project coordination and data review, and the formal design review. Therefore, there must be "checks and balances" in the form of reviews at each stage of the design progression. The purpose of the design review is to formally and logically evaluate the proposed design in the most effective and economical manner. Through subsequent review, discussion, and feedback, the proposed design is either approved or a list of recommended changes is submitted for consideration.

The purpose of conducting any type of review is to assess if (and how well) the design configuration, as envisioned at the time, is in compliance with the initially specified quantitative and qualitative requirements. The success in conducting a formal design review is dependent on the depth of planning, organization, and preparation prior to the review itself. Each design review serves as an excellent communication medium, creates a better understanding among design and support personnel, and promotes assurance and reliability. The design data/characteristics is released and reviewed for compliance with the basic system requirements. The reviewing operation is performed by a committee formed of technical and operational members. During any design review, a formalized check of the proposed system design is provided, major problems are discussed, and corrective actions are taken. In addition, it provides a common baseline for all project personnel. The design team members are provided the opportunity to explain and justify their design approach through oral and written reports, and reviewer committee members are provided the opportunity to ask various questions from the design team.

A design review provides a formalized check of the proposed system design with respect to specification requirements. Major problems (if any) are discussed and corrective action is taken. The design review also creates a baseline for all project design members. In addition, it provides a means for solving interface problems between design groups and promotes the assurance that all system elements will be compatible. Furthermore, a group review may identify new ideas, possibly resulting in simplified processes and ultimately reduced cost. The outcome of the design project is reviewed at various stages of the design process. In principle, the specific types, titles, and scheduling of these formal reviews vary from one design project to the next. The following main four formal design reviews are recommended for a design project:

1 Conceptual Design Review (CDR);

2 Preliminary Design Review (PDR);

3 Evaluation and Test Review (ETR);

4 Critical (Final) Design Review (FDR).

Design reviews are usually scheduled before each major design phase. The CDR is usually scheduled toward the end of the conceptual design phase and prior to entering the preliminary design phase of the program. The purpose of the CDR is to formally and logically cover the proposed design from the system standpoint. The PDR is usually scheduled toward the end of the preliminary design phase and prior to entering the detail design phase. The FDR is usually scheduled after the completion of the detail design phase and prior to entering the production phase. Design is essentially "fixed" at this point, and the proposed configuration is evaluated in terms of adequacy and producibility.

The ETR is usually scheduled somewhere in the middle of the detail design phase and prior to the production phase. The ETR accomplishes two major tasks: (i) finding and fixing any design problems at the subsystem/component level and then (ii) verifying and documenting the system capabilities for government certification or customer acceptance.

The ETR can range from the test of a single new system for an existing system to the complete development and certification of a new system. Therefore, the duration of an ETR program can vary from a few weeks to several years. When the system is completely assembled and instrumented, it typically conducts days/weeks/months and even years of field testing.

The detail design is divided into two parts, Part I and Part II regarding the ETR. For this purpose, the subsystems/components are divided into two groups: (i) primary or dominant subsystems/components and (ii) secondary or servant subsystems/components. The dominant subsystems/components are those directly responsible for the design requirements, while the servant subsystems/components are those serving the dominant subsystems/components. For instance, in an automobile, the transmission, engine, and body are assumed to be dominant subsystems, while the electric, air conditioning, and engine cooling are servant subsystems. The engine and transmission are responsible for automobile maximum speed, and the body's function is to provide space for the occupant.

As another example, in an aircraft, the wing, fuselage, tail, and engine are assumed to be dominant components, but the electric system, avionic system, air conditioning system, cabin, cockpit, aero-engine, and landing gear may be categorized as servant components.

In an aircraft design project, the aircraft aerodynamic design leads the aircraft structural design, since the structure is a servant subsystem. Thus the aircraft aerodynamic design is performed in Part I of the detail design phase, but the aircraft structural design will be initiated in Part II.

After the dominant subsystems/components (e.g., wing, fuselage, tail, propulsion system) are detail designed, the evaluation and test plan are prepared. When the ETR approves the test plans, a mock-up/model/prototype is fabricated to validate the design. In the case of an aircraft design project, an aircraft model produced and employed in a wind tunnel and a prototype are utilized for flight tests. As soon as the tests are conducted and the results are satisfactory, Part II of the detail design phase begins. During this part of the detail design phase, the servant subsystems are designed. At the end of the detail design phase, the FDR is scheduled to validate/verify the final design.

Task 2. Sum up the information of the text.

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для организации самостоятельной работы студентов всех форм обучения специальности 24.05.07 Самолето- и вертолетостроение

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