V. V. Ryzhkova, S. V. Ryzhkov

FUNDAMENTALS OF AEROSPACE ENGINEERING

2018

MINISTRY OF SCIENCE AND EDUCATION OF UKRAINE
National Aerospace Unversity “Kharkiv Aviation Institute”

V. V. Ryzhkova, S. V. Ryzhkov

FUNDAMENTALS OF AEROSPACE ENGINEERING

Elementary course for linguistics students
Manual

Kharkiv “Khai” 2018

УДК 811.111:629.7 (075.8)
R 98

Подано основну інформацію за темами: «Історія розвитку авіації», «Класифікація літаків», «Класифікація літаків за призначенням», «Загальні принципи теорії польоту ЛА», «Конструкція ЛА», «Основні частини літака, їх призначення та конструкція», «Основні енергетичні системи ЛА», «Двигуни, що застосовуються на ЛА», «Кабіна екіпажу». Розроблено вправи різного ступеня складності для відпрацювання англомовної авіаційної термінології. Підібрано відеофільми відповідної тематики як аудіо- та відеосупровід посібника.

Для студентів спеціальності «Прикладна лінгвістика», які вивчають курс «Інженерні основи аерокосмічної техніки».

Reviewers: Doctor of Philolology, prof. L. S. Pikhtovnikova,
Doctor of Engineering Science, prof. N. F. Khayrova

Ryzhkova, V. V.
R98 Fundamentals of aerospace engineering: manual / V. V. Ryzhkova, S. V. Ryzhkov. – Kharkiv : National Aerospace Unversity “Kharkiv Aviation Institute”, 2018. – 109 p.

The main information on the following topics is presented: "History of Aviation Development", "Aircraft Classification", “General Principles of the Aircraft Flight Theory", "Aircraft Structure", "Aircraft Basic Parts, their Purpose and Design", “Basic Aircraft Power Systems”, “Engines used on Aircraft”, "Crew cabin". The excersices of varying difficulty level have been developed in order to practice English aviation vocabulary. Videos of the corresponding subject area have been selected serving as audio and video accompaniments to the manual.

The manual is designed for the students of the "Applied Linguistics" specialty studying the course "Fundamentals of aerospace engineering".

Illustrations: 54. Tables: 7. References: 16 items.

УДК 811.111:629.7 (075.8)

CONTENTS

CHAPTER 1

The history of aviation development in Ukraine

The history of development and formation of global aviation numbers a little more than a century. The progress of aircraft construction is getting even more impressive separating age of primitive aircraft with motorcycle engines from the era of modern high-speed jets.

The history of world aviation is closely connected with Ukrainian lands. Several aircraft constructors worked here; they are Alexander Mozhaysky – the constructor of one of the first aircraft which took off, Nicholay Kibalchich – the founder of the rocket production theory and Alexander Zasyadko – the founder of combat missiles. Fearless Ukrainian falcons Konstantin Artseulov and Vladimir Dybovsky managed to “tame” the fear of the first aviators before airplanes stalling into a spin. A courageous and talented pilot Yevgraf Kruten laid the groundwork of the fighter aviation tactics, which is used as a basis for current techniques of air combat.

Modern Ukraine as a country has rich history of domestic aircraft development that took decades to have its aviation heritage since that old time when people started dreaming about flying.

On December 17, 1903, brothers Orville and Wilbur Wright (Fig. 1.1), piloted the first engine airplane “Flyer – 1”. The flight lasted 12 seconds and covered 37 meters. The Wright brothers' plane was officially recognized as the world's first heavier-than-air aircraft, which performed motor controlled flight with a human on board. This date is considered to be the beginning of aviation era. Since that moment it became clear and evident that the airplanes and not balloons or airships will become the true conquerors of the air element.

Fig. 1.1. Orville and Wilbur Wrigh

Since the time airplanes appeared they have showed a significant advantage over the lighter-than-air aircraft. And it is not surprising that the whole army of innovators around the world were engaged in the improvement and modernization of the invention that had just recently appeared. Not all the ideas of the inventors could work, not all their airplanes and other aircraft could get off the ground, but selfless labour of these aircraft pioneers subsequently brought the results. As an example we consider the work of the Kiev aircraft designers that constructed about 40 different aircraft in the first decades of the twentieth century. In this regard, none of the cities in the Russian Empire could go in comparison with Kiev. Due to the designed aircraft, the names of Kiev residents I. Sikorskiy and D. Grigorovich became the world famous not only in their homeland, but also worldwide. Here in Kiev P. Nesterov (Fig. 1.2), performed world's first loop using the airplane “Nieuport-4” thus initiating the aerobatics. The first plane designed in Ukraine (in the Russian Empire as a whole) took off on May 23 in 1910 in Kiev. It was a biplane designed by Professor Alexander Kudashev from Kiev Polytechnic Institute (KPI). Ten days later the aircraft BiS № 2 constructed by Igor Sikorsky performed his first flight.

Fig. 1.2. P. Nesterov

KPI was founded in 1898. At that time the institute had four departments: mechanical department, chemical department, department of construction engineering and agricultural department. In 1899 there were some actions concerning the establishment of the fifth department – aeronautic department headed by one of the biggest aviation enthusiasts Professor Nikolai Artemyev, a talented pupil of Nikolai Zhukovsky. On his initiative in 1905-1906 along with mechanical club the university organized an aeronautical section. The first honorable chairman of the section was Professor Stepan Timoshenko and its vice-chairman was a student of the mechanical section Victorin Bobrov. In November 1908 the section was reorganized in an aeronautic club with the departments of airplanes, helicopters, ornithopter and engines. The members of the club studied aviation theoretical basics and techniques, made attempts to build gliders and airplanes. Among them were the students of KPI, future aviators Sikorsky, Bylinkin, Karpeka, Adler and the others.

Among the founders of Ukrainian aviation there’re natives of the city Cherkasy – brothers Eugene, Gregory, Andrew and Ivan Kasyanenko. After the creation of KPI aeronautic club Eugene Kasyanenko headed the section “Airplanes” and Andrew Kasyanenko – “Helicopters.” In addition to scientific and organizational work, they performed fruitful work as designers. From 1910 to 1921 the brothers created six aircraft. We should mention “Kasyanenko-4” – a monoplane with a low power motor. Eugene Kasyanenko promoted particularly the idea of a low-power multipurpose aircraft. In addition to aircraft construction, brothers Kasyanenko were developing propellers that during the First World War were series-produced at KPI aviation workshops. The propellers of brother Kasyanenko were better than the French ones. They developed greater traction that could increase the speed of the aircraft. Military department was ordering them in big quantities for army needs.

But Kiev is not the only city in Ukraine, which was overwhelmed with the idea of aviation. Odessa became famous because of the pilots S.Utochkin and M. Yefimov. It was the city where Russian pilot performed the first official flight in the Russian Empire. One of the first Russian aircraft factories was built in Odessa. Soon it became the largest factory in the south of the Empire.

Kharkiv was different because the activities of the creative community here were mainly aimed to establish aviation scientific basis without which further successful development of the aircraft manufacture would be impossible. However, it did not mean that there were no aviation industry practitioners in Kharkov. The work of certain enthusiasts (those are essentially all Ukrainian aircraft designers of that period) is of more interest in terms of some trends in aircraft design. After some attempts and misfortunes, from a variety of bad options the inventors gained the aircraft, which, in the end, showed excellent performance quality.

Only when series-produced aircraft replaced experimental aircraft designed in one item it became possible to talk about real aviation in the full sense of this word. This was the beginning of aviation, as an organized force (power).

Before the First World War the territory of Ukraine hosted the only aircraft factory, which had the full right to be called like that. It was the Anatra factory in Odessa. The second largest Ukrainian aviation enterprise belonged to a millionaire F. Tereschenko from Kiev and till 1914 it resembled a workshop. There were also several semi-handicraft workshops; sometimes they belonged to larger non-aviation enterprises.

The II World War was a trigger for the aviation further development. Big aircraft losses, their rapid aging, both physical and moral, required from aircraft manufacturers constant (and increasing every year) flow of combat vehicles in front-line units. The necessity to improve the combat and flying qualities of manufactured airplanes forced their creators to use new steel, aluminum alloys and light wood; to install more sophisticated weapons and equipment, more reliable and powerful engines; to improve the quality of aviation fuel and lubricants. In order to do that it constructors had to modernize the whole industry. Planes became a very expensive type of armament.

Russian Army satisfied their needs of new aircraft with imported ones mainly from France. The domestic aircraft were also used, but France at that time was considered the most developed country in the aviation respect. During the war the manufacture at the Odessa plant “Anatra” increased significantly. Thus a branch of the enterprise appeared in the Crimea, and it was essentially a separate plant. Other aircraft factories appeared in Ukraine: Adamenko plant in Karasubazar, “Mathias” plant in Berdyansk, an aircraft engine plant in Zaporozhye society (branch “Deca”). It was planned to establish an enterprise of seaplane assembly in Yevpatoria. Three-quarters of all front-line aircraft of the Russian army were of domestic production; in the marine and bomber aircraft Russian designs were dominating. Russia was the only country that entered the war with heavy multiengine aircraft, armed with the airplanes “Ilya Muromets”. However, Russian production and technical base turned out to be not sufficient to meet the needs of the fast developing aviation. There was a lack of aircraft engines, which production was insufficient in the Russian empire.

To maintain a quantity of planes in flying stock it was necessary to repair airplanes, especially when there were no spare parts or they were not in a big number. Some machines were repaired several times. As a result, aircraft of the Russian Army in 1917 had a small amount of combat-ready aircraft; many of them were old, worn-out and not very serviceable. February revolution and then October revolution caused a real disorder in the army worsening already bad aviation state. The civil war that began afterwards caused a big damage to the economy. The aviation of Red Army withdrew from the war in a terrible state. Purchasing aircraft from abroad was the only decision to replace worn-out and outdated machines, as the domestic industry couldn’t provide the airfreight even with a minimal amount of modern aircraft. To revive the industry the country needed time.

Besides, the reviving aviation industry needed competent engineers and designers. In the early 20s of the 20th century Kiev and Kharkov Polytechnic Institute of Technology started aviation specialization following several universities in the center of the country, where due to the tireless work of N. Zhukovsky (Fig. 1.3) and his followers aviation specialists were getting the proper training. In those years, however, enthusiastic teachers and students played the leading role in the formation of the aviation specialties in Ukraine.

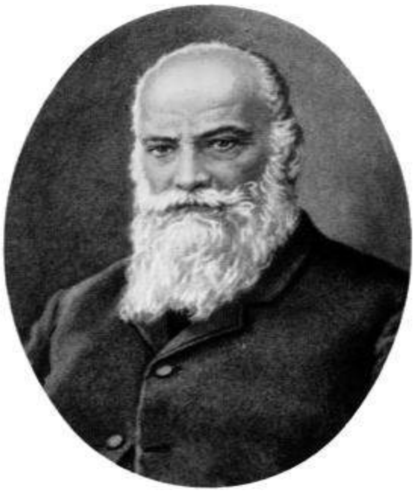


Fig. 1.3. N. Zhukovsky

One of such enthusiastic students of KPI from 1926 to 1928 was Sergei Korolev (Fig. 1.4). He finished university course of instructors of glider aerobatics and designed a glider KPIR-3. There at the university he became acquainted with the works of K.Tsiolkovsky, and just there he cherished the ideas about jet propulsion that he eventually was developing so successfully.

Fig. 1.4. Sergei Korolev

Among of KPI students' name was Alexander Mikulin. A plane in which the legendary pilots Chkalov and Gromov implemented outbound flight over the North Pole was equipped with engines of Mikulin's design. Then Mikulin engines could get the largest aircraft “Maxim Gorky” off the ground. In the Great Patriotic War his engines were installed on the attack plane Il-2 and a bomber Pe-8, and in the peacetime – on the passenger jet airliner Tu-104. In 1931 another student of KPI – Artem Lulka received a diploma. He was the one who came up with the idea of a turbo-jet engine and could take this idea to the practical implementation.

In 1923 in Ukraine as a result of reorganizations and renaming, companies emerged and got the name of OSOAVIAHIM. Their only aim was to involve thousands of young people to the primary military on-the-job training, to choose students for flying schools and colleges, to raise funds for the construction of airplanes, airports and airlines. Certainly there was not enough money to carry out major programs. However in terms of insufficient state funding for aviation and aerospace production, the developments of OSOAVIAHIM were of great importance.

The development of air service and the beginning of civil aircraft production occurred in Ukraine with a certain time lag from Western Europe. In April 1923, in Kharkov (capital of the Ukrainian SSR) a corporation “Ukrvozduhput” was founded which in order to establish air transportation purchased a number of aircraft "Comet" from "Dornier" company in Germany. The workshop, where these aircraft were repaired, soon became an aircraft enterprise – Sovnarkom (Council of People's Commissars, SNK) Aircraft Factory of the Ukrainian SSR. This enterprise became the only one in the USSR, established specifically for the production of civil aircraft (the others had solely military specialization), and the only one that was beyond the power of Union bodies being subjected only to Kharkiv authorities. However the air transportation in Ukraine became really regular with the appearance of domestic aircraft series K-4 and K-5, designed by Kharkov aircraft factory. The constructor of these wonderful machines was an outstanding aircraft designer K. Kalinin.

Another outstanding Ukrainian designer of pre-war period was I. Neman (Fig. 1.5), Kalinin's pupil. The name of I. Neman is primarily connected with the design of the first Soviet high-speed passenger aircraft KhAI-1. A single-engine KhAI-1 is the first in Europe and second in the world (after the American model company “Lockheed”) aircraft with a retractable landing gear. This machine appeared a few months before German aircraft of similar design – “Heinkel” He70. This event became an eloquent proof of the victory over the domestic aircraft that used to stay behind European aircraft production. Constructors managed to design only 40 aircraft KhAI-1 before the war began. But such little number was compensated with thousands of military KhAI-5 (R-10) – light bombers and reconnaissance aircraft designed on the basis of KhAI-1.

Fig. 1.5. I. Neman

It should be noted that for a long time the civil aircraft was dominant manufacture in Ukraine for several reasons, but in the early 30s the militarization of the industry began, and at the end of the decade the airline switched to military production. Prepared for the future war started achieving real momentum. Throughout the pre-war period the Air Force of the The Red Workers' and Peasants' Army (RKKA) went under the modernization several times. In 1933-1934 the fighters I-15 and I-16 were designed. Soon they became the main combat vehicle of the Red Army.

In late 1937-early 1938 mass repressions took place in the Soviet Union and almost at the same time many aircraft designers of the country were arrested. Those were A. Tupolev, K. Kalinin, V. Petlyakov, V. Myasischev, A. Putilov, R. Bartini, I. Neman, V. Chizhevsky and many others. However even after that no one stopped improving fighters. Less experienced designers who changed their teachers and those who survived in the repressions got involved in the construction of qualitatively new combat vehicles. Among them were N. Polikarpov, S. Ilyushin and P. Sukhoy. However by the beginning of World War II Air Force did not have time to rearm. Only in 1943, the aircraft of the Soviet Air Force and its allies quantitatively and qualitatively surpassed air forces of fascist states. Considerable contribution to the defeat of Nazi occupiers was made by civil aircraft pilots, including the pilots of Ukrainian Civil Air Fleet (CAF). In 1930 the society of air transportation “Ukrvozduhput” ceased to exist, having joined the All-Union Association of Civil Aviation, reorganized into a chief directorate of CAF at SNK USSR in 1932. Apart from Kalinin aircraft K-4 and K-5, Civil Air Fleet Apart widely used PS-9 aircraft. However, the growing demands for air transport passes ahead of the new aircraft deliveries in the flying stock. That’s why such military planes as P-5, MP-1, P-6 converted for required purposes were often used for air traffic.

The development of passenger and transport aviation stayed considerably behind from the civil aviation of capitalist countries. This situation was a bit when the plants obtained the license from the USA for production of DC-3 (“Duglas”). In the USSR this aircraft got the name PS-84 (Li-2) and for a long time it was the main transport and passenger aircraft of the Soviet aviation.

In the 40s “Duglas” was already considered to be an outdated aircraft but the airplanes were still exploited on air routes and not only in the Soviet Union that was exhausted after the war but in the United States that was prospering at that time. After 1945 the Soviet Union also got a large quantity of military aircraft that were out of the armament. They were converted in a certain way and could be used as transport and even passenger aircraft. Due to this the CAF considerably extended.

As opposite to Ukrainian civil and military aviation, aircraft construction during several years after the war was going through difficult times. There were not enough funds to repair and moreover to modernize the enterprises, so the order they executed was secondary as they didn’t require so much money.

Kharkiv aviation plant being famous for its passenger aircraft in pre-war times began prospering due to the decision of the authorities to start the production of the first domestic jet passenger liners Tu-104 at this plant. To establish series production the authority gave a big grant and besides there was a resolution about the development of the civil aircraft construction. Nowadays it is a high-technology aviation enterprise that has a great production power and qualified specialists.

Another important event for the further history of Ukrainian aircraft construction was the foundation of Antonov engineering office in Kiev. Probably at that time contemporaries didn’t appraise the importance of that step. “Kukuruznik” An-2 (Fig. 1.6) made his constructor O. Antonov famous in the whole world but still it couldn’t go in comparison to Tupolev aircraft and other outstanding constructors.

Fig. 1.6. An-2

But another Antonov aircraft – two-engined military-transport An-8 convincingly proved that the engineering office headed by O.Antonov could solve the most difficult tasks. An-8 (Fig. 1.7) was different in its high carrying capacity and takeoff and landing characteristics. Besides the fuel consumption in turboprop engines that were installed on the airplane turned out to be less than in the machines with turbojet engines though at smaller cruising speed.

Fig. 1.7. An-8

In 1957 a new Antonov aircraft An-10 “Ukraine” got off the ground and at the exposition in Brussels another airliner An-10A designed for 100 passengers got the golden medal. Along with long-haul airliner Antonov engineering office constructed transport aircraft An-12 due to which the group of constructors got Lenin award. Since the early 60s during many years An-12 was the main aircraft of the USSR airborne troops, and nowadays it is still in the armies of the CIS countries and the countries of the former Warsaw Pact.

We could continue enumerating all the machines designed by Antonov engineering office as well as their advantages: AN-22 “Antei”, AN-24, AN-72, AN-124 “Ruslan”, AN-225 “Mriya” (Fig. 1.8) – each of these aircraft is unique, and this list is far from complete.

Fig. 1.8. AN-225 “Mriya” and "Buran"

The activity of Antonov Aviation Scientific and Technical Complex raise our expectations for further Ukrainian aircraft development. To replace outdated machines new aircraft are designed by Kiev constructors: AN-38, AN-70, AN-140 and AN-218, created under the direction of chief designer P. Balabuev.

It’s impossible to imagine the future of Ukrainian aviation industry without aircraft engine production represented at “Motor-Sich” plant, centered in Kiev and in engineering office “Progress”. Over eighty years of development from semi-handicraft production to ultramodern enterprise, motor builders from Zaporozhye designed thousands of aircraft engines that helped the world-famous pilots to perform numerous historical flights, to set world records, and to fight in the skies during World War II. In the postwar years, the main products of this group were engines for passenger and cargo aircraft which are exported to more than 40 countries.

The aviation industry in any country, as we know, belongs to strategically important sectors of the economy. After the disintegration of the Soviet Union Ukraine managed to keep almost all the major aircraft manufacturing links. Therefore modern Ukraine is one of the nine countries that has its own full cycle aircraft production.

Vocabulary notes

№	English	Ukrainian	Russian
1	aerobatics	вищий пілотаж	высший пилотаж
2	air traffic	транспортне повідомлення	транспортное сообщение
3	aircraft construction	літакобудівництво	самолетостроение
4	airline	авіалінія, авіакомпанія, авіаційне підприємство	авиалиния, авиакомпания, авиационное предприятие
5	airship	дирижабль	дирижабль
6	aluminum alloys	алюмінієвий сплав	алюминиевый сплав
7	armament	озброєння	вооружение
8	aviation heritage	авіаційна спадщина	авиационное наследие
9	balloon	повітряна куля	воздушный шар
10	combat	бій, бойовий	бой, боевой
11	constructor	конструктор, проектувальник	конструктор, проектировщик
12	domestic production	вітчизняне виробництво	отечественное производство
13	flying stock	літаковий парк	самолетный парк
14	front-line aircraft	фронтовий літак	фронтовой самолет
15	glider	планер	планер
16	handicraft industry	кустарне виробництво	кустарное производство
17	heavier-than-air aircraft	ЛА важчий від повітря	ЛА тяжелее воздуха
18	light bomber	легкий	легкий

№	English	Ukrainian	Russian
		бомбардувальник	бомбардировщик
19	lighter-than-air aircraft	ЛА легший від повітря	ЛА легче воздуха
20	loop	петля	петля
21	manufacture	виробництво	производство
22	merge	об'єднуватися (про компанії)	сливаться (о компаниях)
23	missile	ракета	ракета
24	motorcycle engine	мотоциклетний мотор	мотоциклетный мотор
25	multi-purpose aircraft	літак широкого застосування	самолета широкого применения
26	ornithopter	орнітоптер	орнитоптер
27	outbound flight	наддалекий переліт	сверхдальний перелет
28	outdated	застарілий	устаревший
29	reconnaissance aircraft	літак-розвідник	самолет-разведчик
30	retractable landing gear	шасі, що прибираються	убирающееся шасси
31	*series (mass) production*	серійне виробництво	серийное производство
32	spin	штопор	штопор
33	to get off the ground	піднятися у повітря, злетіти	подняться в воздух, взлететь
34	to take off	злітати	взлетать
35	workshop	майстерня	мастерская

Вправи до тексту 1

I. Вправи на перевірку знань лексичного матеріалу

1) Give the definition to the following words. Use the dictionary to help you:

a) Heavier-than-air aircraft;
b) Glider;
c) Ornithopter;
d) On-the-job training;
e) Series-produced aircraft.

2) Chose the correct word to complete the sentence:

1. How many planes does the Air Force have in its flying *stock / park*?
2. It's necessary to have *extra / spare* parts to repair an aircraft.
3. I hope they can get this plane off the *land / ground*.
4. This airline exploits only *domestic / home-made* aircraft.
5. Our mission is to collect, preserve and promote the military *aviation / aircraft* heritage of our country.
6. *Heavier / Larger-than-air* aircraft include airplanes, gliders and helicopters.
7. *Acrobatics / Aerobatics* is the practice of flying maneuvers involving aircraft attitudes that are not used in normal flight.
8. In aviation, a ground *loop / eye* is a rapid rotation of a fixed-wing aircraft in the horizontal plane while on the ground.
9. On this day 15 years ago the Eurofighter Typhoon *made / performed* its first flight.
10. The AN-32 light military transport *multi-purpose / aim* aircraft can be operated in various climate conditions, including hot climate.

II. Вправи на перевірку знань лексики і розуміння вивченого матеріалу

1) Cross out the wrong word. Use dictionary to help you:

1. Airplanes, gliders, helicopters, balloons.
2. Fighter aircraft, attack aircraft, surveillance aircraft, bomber aircraft.
3. Airliners, reconnaissance aircraft, cargo aircraft, mail aircraft.
4. Sikorsky, Mikulin, Karpeka, Adler, Zhukovsky.
5. “Antey”, “Ruslan”, “Maxim Gorky”, “Mriya”.
6. Freight aircraft, freighter, airlifter, freight lifter.
7. I. Sikorsky, A. Tupolev, K. Kalinin, V. Petlyakov.
8. Loop, spin, tank roll, dive.
9. “Anatra”, “Mriya”, “Mathias”, “Motor Sich”.
10. An-22, An-38, An-70, An-140.

2) Put events in their chronological order:

№	Events	Right chronological order
1	The aircraft BiS № 2 constructed by Igor Sikorsky performed his first flight.	
2	The foundtation of “Antonov” serial production plant	
3	The foundation of KPI	
4	Kiev and Kharkov Polytechnic Institute of Technology started aviation specialization	
5	Brothers Orville and Wilbur Wright piloted the first engine airplane "Flyer -1"	
6	Outbound flight over the North Pole with Mikulin’s engines	
7	The construction of the first Soviet high-speed passenger aircraft KhAI-1	
8	The first plane designed in Ukraine (in the Russian Empire as a whole) took off	
9	The foundation of Adamenko plant in Karasubazar	
10	The foundation of Sovnarkom aviation plant	

III. Вправи на перевірку знань лексики і розуміння вивченого матеріалу на більш високому рівні

1) Translate from Russian/Ukrainian into English:

1. Толчком к дальнейшему развитию авиации послужила мировая война. / Поштовхом до подальшого розвитку авіації послугувала світова війна.
2. Самолет становился весьма дорогостоящим видом вооружения. / Літак ставав досить дорогим видом озброєння.
3. Их цель – привлечение к начальному военному обучению без отрыва от производства тысяч молодых людей. / Їх мета – залучення до початкового військового навчання без відриву від виробництва тисяч молодих людей.
4. Этот самолет стал основной боевой машиной Красной Армии. / Цей літак став основною бойовою машиною Червоної Армії.
5. Самолет вошел в штопор. / Літак увійшов у штопор.
6. Самолет не смог оторваться от земли. / Літак не зміг відірватися від землі.

7. Три четверти всех фронтовых самолетов российской армии были отечественного производства. / Три чверті всіх фронтових літаків російської армії були вітчизняного виробництва.

8. Россия была единственной страной, вступившей в войну с многомоторной тяжелой авиацией. / Росія була єдиною країною, що вступила у війну з багатомоторною важкою авіацією.

9. Здесь он вынашивал идею реактивного движения. / Тут він виношував ідею реактивного руху.

10. Автором этих замечательных машин являлся выдающийся авиационный конструктор К.А. Калинин. / Автором цих чудових машин був видатний авіаційний конструктор К.А. Калінін.

2) Read a small abstract from the text about ANTONOV airlines from the real web page of the company. Fill in the gaps with the words given in the box:

air fleet	loading	airline	airports	Antei
sizes	delivery operations	cargoes	transportations	large−size

Antonov Airlines is the ANTONOV company's subdivision that specializes in international cargo transportation. It was founded in 1989. Antonov Airlines became the first (1) ____ which performed charter air transportation of (2) _____ and extra−heavy cargoes on the AN-124 Ruslan heavy transport. Successful operations in this direction formed absolutely new market segment on airlift of super-heavy cargoes. Since 1989, the airlines increased its (3) _____ from two to five Ruslans. At present, the airlines' fleet includes one AN-225 Mriya, seven AN-124-100 Ruslans, one AN-22 (4) _____, two AN-12s, one AN-26 and one AN-74T.

Every year it carries hundreds of thousands of tons of unique (5) ____, including those which can not be transported otherwise, to 800 (6) ____ across the world. Antonov Airlines have performed the most extreme (7) ____ in history, such as the delivery of a 175−ton transformer from Linz, Austria, to Houston, TX; 186,7−ton generator from Frankfurt, Germany, to Yerevan, Armenia; and 247 tons of large−size construction equipment from Prague, Czech Republic, to Tashkent, Uzbekistan.

Often these transportations can require development of special preparation and (8) ____ technologies, which are not necessary for standard (9) _____ as usual. Sometimes it is necessary to use the very limits of the aircraft's structural and performance capabilities. Special attention is given by the airlines to these operations, including use of specially developed software packages for modeling loading of the AN-

225 and the AN-124 aircraft on the basis of 3D models of their cargo compartment. This provides a high reliability factor while developing technologies on loading the cargoes of extreme (10) _____.

3) Answer the questions after the text:

1. When was the company's subdivision founded?
2. What does company's subdivision specialize in?
3. What do require such international transportations?
4. How many aircraft does airlines' fleet include now?
5. What do the designers use when modeling loading of the AN-225 and the AN-124 aircraft?

IV. Додаткові питання (за змістом навчальних відеофільмів)

1. Which aircraft do the young pilots learn to run, using the simulator? (based on the film "The Antonov design bureau")
2. Did the Chief designer know Oleg Antonov personally? (based on the film "The Antonov design bureau")
3. What were the names of the Wright brothers? (based on the film "The Wright brothers")
4. When did they manage to fly for the first time? (based on the film "The Wright brothers")
5. Which problem did they face during their experiments? (based on the film "The Wright brothers")

CHAPTER 2

Aircraft classification

The variety of aircraft, particularly planes, which have been recently exploited by the modern society needs to be classified. There are many examples when aircraft are widely used in various fields of the national economy to solve different vitally important tasks for the society. Aircraft are used for military purposes as well, being in service in many countries.

Modern aircraft are very diverse not only in their outside appearance. Planes differ from each other in geometric, weight and flight characteristics; in general/overall arrangement and equipment used in aircraft; in the size of payload, as well as in the design of individual parts. It is exactly these factors that determine the necessity to classify aircraft, primarily based on their purpose.

According to the purpose they carry out all planes are usually divided into two large groups: civil aircraft and military aircraft.

Civil aircraft

Civil aircraft are designed to carry passengers, various cargo, mail, and as well as for service in different sectors of national economy. All of them, in turn, may be also divided into the following main types:

Passenger aircraft. Passenger aircraft are designed to carry passengers, baggage and mail. Depending on the flying range, number of passengers carried in a plane, sizes and types of runways, passenger aircraft are divided into mainline aircraft and commuter aircraft. In turn, according to the flight range mainline aircraft are divided into:

a) long-haul aircraft with the range of 5000 ... 11,000 km;

b) medium-haul aircraft with the range of 3000 ... 4000 km;

c) short-haul aircraft with the range of 1000 ... 2000 km.

For long distances wide-body jets are used. They are frequently called twin-aisle aircraft because these planes generally have two separate aisles running from the front to the back of the passenger cabin. These aircraft are usually used for long-haul flights between airline hubs and major cities with many passengers. Aircraft in this category are the Boeing 747, Boeing 767, Boeing 777, Boeing 787, Airbus A300/A310, Airbus A330, Airbus A340, Airbus A380 (Fig. 2.1). Lockheed L-1011 TriStar, McDonnell Douglas DC-10, McDonnell Douglas MD-11, Ilyushin Il-86, and Ilyushin Il-96.

Fig. 2.1. Airbus A380

A smaller, more common class of airliners is the narrow-body or single aisle aircraft. These smaller airliners are generally used for medium-distance flights with fewer passengers than their wide-body counterparts.

Fig. 2.2. Tu-154

Examples include the Boeing 717, 737, 757, Tu-214 Tu-154 (Fig. 2.2) jets also fit into this category.

Commuter aircraft are usually engaged to carry passengers in regionals. Therefore, this type of aircraft can be included to the class of regional jets. For these purposes, more fuel-efficient aircraft with even smaller dimensions or close-range narrow-body airlines are used. In comparison with medium-range and close-range aircraft, regional airliners have smaller seating capacity. Passenger cabins of such type of airplanes can accommodate on the average from 8 to 100 passengers.

The smallest type of commuter passenger aircraft is called local flying aircraft. This type includes aircraft designed to carry a small number of passengers at small distances – up to 1000 kilometers.

Commuter aircraft are divided into:

a) heavy-weight aircraft with the number of passengers 50 ... 55;

b) medium-weight aircraft with the number of passengers 24 ... 30;

c) light-weight aircraft with the number of passengers 8 ... 20.

Cargo aircraft. A cargo aircraft (also known as freight aircraft, freighter, airlifter, or cargo jet) is a fixed-wing aircraft that is designed or converted for the carriage of goods, rather than passengers. Such aircraft usually do not incorporate passenger amenities, and generally feature one or more large doors for loading cargo.

Mail planes. A mail plane is an aircraft used for carrying mail. Aircraft that were purely mail planes existed almost exclusively prior to World War II. Because early aircraft were too underpowered to carry cargoes, and too costly to run any "economy class" passenger-carrying service, the main civilian role for aircraft was to carry letters faster than it was possible before. In 1934, some mail services in the USA were operated by the United States Army Air Corps (USAAC), soon ending in the Air Mail scandal.

Ambulance aircraft. An air ambulance is a specially outfitted aircraft that transports injured or sick people in case of medical emergency or over distances or terrain impractical for a conventional ground ambulance. These operations are called aeromedical. In some circumstances, the same aircraft may be used to search for missing or wanted people. On board of such aircraft there’s medical staff being ready to react immediately in any minute.

Agricultural aircraft. Agricultural aircraft are designed for inspection of agricultural and forest land involving aviation chemical treatment that kills plant pests. For these purposes mainly light single-engine aircraft, adapted for takeoffs and landings with limited ground surfaces are used. They do not require a lot of technical staff and astronomical time to prepare for takeoff. Depending on the problem to be solved such planes can be quickly retooled for other kinds of equipment.

Experimental aircraft. Experimental aircraft are used for aircraft testing, missile testing and testing of other machines in order to carry out design analysis as well as experimental and research work. Experimental aircraft are divided into prototype aircraft, modified aircraft, modernized aircraft, serial aircraft passing the test, flying laboratories, as well as secondary aircraft.

Water-bombing aircraft. Water-bombing aircraft are designed to extinguish a fire by water bombing, which is by discharging water on fire from the aircraft. Such aircraft are mainly used to extinguish a fire covering large areas of forest and steppe, as well as territories of oil-producing complexes. For these purposes people use heavy transport aircraft, having special equipment on board for storing a large amount of fire extinguishing liquid, as well as discharging it.

There are several kinds of fire amphibian aircraft, which can land on appropriate water surface (like a boat) in order to collect water for equipment operation. For a short time of plane sliding on water special pumps have time to pump water into fire-fighting equipment, and aircraft soaring skyward is ready again to extinguish a fire. The main advantages of these aircraft are the following: very fast arrival to the area to be extinguished; instant discharge of big amount of water or other extinguishing substance on the fire area; the ability to extinguish a fire over rather large areas accessible only from the sky.

Light-sport aircraft. A light-sport aircraft (LSA) is designed for practicing air sports. They are lightweight, consume little fuel and such aircraft are easy to maintain. Sport aircraft are maneuverable, and rapidly gain altitude. For takeoff and landing such aircraft requires very short runway. LSA piloting, its takeoff and landing performance is not so different from conventional aircraft control.

Trainers. A trainer is a class of aircraft designed specifically to facilitate in-flight training of pilots and aircrews.

The use of a dedicated trainer aircraft with additional safety features – such as tandem flight controls, forgiving flight characteristics and a simplified cockpit arrangement – allows pilots-in-training to safely advance their real-time piloting, navigation and/or warfighting skills without the danger of overextending their abilities alone in a fully featured aircraft. Trainers also include a specific kind of aircraft that are used to train pilots to fly the exploited airplanes being in serious production.

Military aircraft

Military aviation is the use of aircraft and other flying machines for the purposes of conducting or enabling warfare, including national airlift (cargo) capacity to provide logistical supply to forces stationed in a theater or along a front. Air power includes the national means of conducting such warfare including the intersection of transport and war craft.

Fighters. A fighter aircraft is a military aircraft designed primarily for air-to-air combat against other aircraft, as opposed to bombers and attack aircraft, whose main mission is to attack ground targets.

Bombers. A bomber is a military aircraft designed to attack ground and sea targets, by dropping bombs on them, firing torpedoes at them, or – in recent years – by launching cruise missiles at them.

a. Strategic bombers. Strategic bombing is done by heavy bombers primarily designed for long-range bombing missions against strategic targets such as supply bases, bridges, factories, shipyards, and cities themselves, in order to diminish an enemy's ability to wage war by limiting access to resources through crippling infrastructure or reducing industrial output.

Current examples include the strategic nuclear-armed strategic bombers: B-2 Spirit, Tupolev Tu-95 'Bear', Tupolev Tu-22M 'Backfire'; historically notable examples are: Gotha G.IV, Avro Lancaster, Heinkel He-111, Boeing B-17 Flying Fortress, Consolidated B-24 Liberator, Boeing B-29 Superfortress.

b. Tactical bombers. Tactical bombing, aimed at countering enemy military activity and in supporting offensive operations, is typically assigned to smaller aircraft operating at shorter ranges, typically near the troops on the ground or against enemy shipping.

This role is filled by tactical bomber class, which crosses and blurs with various other aircraft categories: light bombers, medium bombers, dive bombers, interdictors, fighter-bombers, attack aircraft, multirole combat aircraft, and others. Current examples: F-15E Strike Eagle, F/A-18 Hornet, Sukhoi Su-27, Xian JH-7, Dassault-Breguet Mirage 2000, and the Panavia Tornado; historical examples: Ilyushin Il-2 Shturmovik, Junkers Ju 87 Stuka, Republic P-47 Thunderbolt, Hawker Typhoon, McDonnell-Douglas F-4 Phantom II and Mikoyan MiG-27.

Transports. Military transport aircraft or military cargo aircraft are typically fixed and rotary wing cargo aircraft which are used to deliver troops, weapons and other military equipment by a variety of methods to any area of military operations around the surface of the planet, usually outside of the commercial flight routes in uncontrolled airspace. Originally derived from bombers, military transport aircraft were used for delivering airborne forces during the Second World War and towing military gliders. Some military transport aircraft are tasked to performs multi-role duties such as aerial refueling and, tactical, operational and strategic airlifts onto unprepared runways, or those constructed by engineers.

Surveillance aircraft. A surveillance aircraft is an aircraft used for surveillance – collecting information over time. They are operated by military forces and other government agencies in roles such as intelligence gathering, airspace surveillance, observation (e.g. artillery spotting), border patrol and fishery protection. Part of the surveillance aircraft can be equipped with certain types of weapons to destroy the detected prime targets.

Training and combat aircraft. Training and combat aircraft are used for teaching and training flight personnel of military troops. The main requirement for this type of aircraft is reliability. Typically, these aircraft have dual controls, notably, all the necessary aircraft flight controls available for a trainee as well as for a pilot instructor.

Secondary aircraft. This category includes spotting aircraft/observation place, liaison aircraft, air refuellers, ambulance aircraft etc. They are not major planes, and serve as the provision of basic air forces.

Vocabulary notes

№	English	Ukrainian	Russian
1	aerial refueling	дозаправка паливом у польоті	дозаправка топливом в полёте
2	agricultural aircraft	сільськогосподарський літак	сельскохозяйственный самолет
3	air cargo fleet	вантажний повітряний флот	грузовой воздушный флот
4	air refueller	літак-заправник	самолет-заправщик
5	aircrew	екіпаж літака	экипаж самолета
6	airliner	авіалайнер, пасажирський літак	авиалайнер, пассажирский самолет
7	ambulance airplane	санітарний літак	санитарный самолет
8	bomber	винищувач	истребитель
9	cargo aircraft (also known as freight aircraft, freighter, airlifter)	транспортний (вантажний) літак	транспортный (грузовой) самолёт
10	civil aircraft	цивільний літак	гражданский самолет
11	commuter aircraft	літак місцевих ліній	самолет местных линий
12	experimental aircraft	експериментальний ЛА	экспериментальный ЛА
13	fighter	бомбардувальник	бомбардировщик
14	fighter-bomber	штурмовик, винищувач-бомбардувальник	штурмовик, истребитель-бомбардировщик
15	fire-bomber aircraft	пожежний літак	пожарный самолет

№	English	Ukrainian	Russian
16	flight controls	органи управління літального апарата	органы управления летательного аппарата
17	fuselage	фюзеляж	фюзеляж
18	heavy-weight aircraft	важкий літак	тяжелый самолет
19	hypersonic	гіперзвуковий	гиперзвуковой
20	liaison aircraft	літак зв’язку	самолет связи
21	light aircraft	легкомоторний літак	легкомоторный самолет
22	light bombers	легкий бомбардувальник	лёгкий бомбардировщик
23	light-sport aircraft	надлегкий спортивний літак	сверхлегкий спортивный самолет
24	light-weight aircraft	легкий літак	легкий самолет
25	loading	розподіл навантаження	распределение нагрузки
26	loading cargo	багажний люк	багажный люк
27	long-haul aircraft	літак далекого прямування	самолет дальнего следования
28	mail plane	поштовий літак	почтовый самолет
29	mainline aircraft	магістральний літак	магистральный самолет
30	medium-haul aircraft	літак із середньою дальністю польоту	самолет со средней дальностью полета
31	medium-weight aircraft	середній літак	средний самолет

№	English	Ukrainian	Russian
32	military aircraft	військовий літак	военный самолет
33	military reconnaissance aircraft	літак-розвідник у військових цілях	самолет-разведчик в военных целях
34	multirole combat aircraft	багатоцільовий бойовий літак	многоцелевой боевой самолёт
35	passenger aircraft	пасажирський літак	пассажирский самолет
36	seaplane	гідроплан	гидроплан
37	secondary aircraft	допоміжний літак	вспомогательный самолет
38	short takeoff and landing aircraft	літак укорочених зльоту і посадки	самолёт укороченных взлёта и посадки
39	short-haul aircraft	літак із близькою дальністю польоту	самолет с близкой дальностью полета
40	spotting aircraft	літак-корегувальник	самолет-корректировщик
41	surveillance aircraft	літак-розвідник	самолет-разведчик
42	trainer	навчальний літак	учебный самолет
43	twin-aisle aircraft	широкофюзеляжний літак	широкофюзеляжный самолет
44	water-bombing aircraft	пожежний літак	пожарный самолет
45	wide-body airliner	широкофюзеляжний авіалайнер	широкофюзеляжный авиалайнер

Вправи до тексту 2

I. Вправи на перевірку знань лексичного матеріалу

1) Give the definition to the following words:
a) Cargo aircraft;
b) Mail plane;
c) Ambulance aircraft;
d) Fighter aircraft;
e) Surveillance aircraft.

2) Fill in the gaps with appropriate word (one word can be used several times):

LSA	Air ambulance	Wide-body airliners	Cargo aircraft

1. ____ are usually used for long-haul flights between airline hubs and major cities with many passengers.
2. An ___ is a specially outfitted aircraft that transports injured or sick people.
3. _____ are frequently called twin-aisle aircraft.
4. ____ is a small aircraft that is simple to fly.
5. ____ is a fixed-wing aircraft that is designed or converted for the carriage of goods, rather than passengers.
6. Aircraft which is qualified as ___ may be operated by holders of a sport pilot certificate
7. In some circumstances, an ____ may be used to search for missing or wanted people.
8. The largest airliners are ______.
9. _____ is designed without regardless of either passenger or military requirements.
10. ____ also have less restrictive maintenance requirements and may be maintained and inspected by traditionally certificated Aircraft Maintenance Technicians.q

II. Вправи на перевірку знань лексики і розуміння вивченого матеріалу

1) Choose the right statement, put true (T) or false (F):

1. Civilian aircraft are designed to carry passengers, cargo and mail.
2. A smaller, more common class of airliners is a wide-body airliner.
3. Agricultural airplanes can be quickly retooled for other kinds of equipment.

4. A bomber is a military aircraft designed to attack ground and sea targets, by dropping bombs on them.

5. Long-range aircraft can fly the distance of 10000 ... 12,000 km.

6. Experimental aircraft are those that can be used in scientific research.

7. Agricultural aircraft require a lot of technical staff and astronomical time to prepare for take-off.

8. Aircraft that were purely mail planes existed almost exclusively prior to World War II.

9. Strategic bombing is done by heavy bombers primarily designed for long-range bombing missions.

10. Support aircraft include training and surveillance aircraft.

2) Describe the given picture. What kind of plane can you see? What is this plane for? Prove your answer. Use words from the box to make your speech more professional.

Medical emergency	Impractical
Aeromedical operations	Air ambulance
Ground ambulance	Outfit

III. Вправи на перевірку знань лексики та розуміння вивченого матеріалу на більш високому рівні

1) Translate from Russian / Ukrainian into English:

1. Пассажирский самолет предназначенный для перевозки пассажиров и багажа. / Пасажирський літак призначений для перевезення пасажирів і багажу.
2. Пожарные самолеты предназначены для тушения пожаров путем водной бомбардировки, а именно сброса воды с борта самолета на пожар. / Пожежні літки ризначені для гасіння пожеж шляхом водного бомбардування, а саме скиданням води на пожежу з борту літака.
3. Основным преимуществом этих самолётов является возможность тушить пожар на территориях, доступных только с воздуха. / Основною перевагою цих літаків є можливість гасити пожежу на територіях, доступних тільки з повітря.
4. Как правило, такие самолёты имеют двойное управление. / Як правило, такі літаки мають подвійне управління.
5. К этой категории относятся самолеты-корректировщики, самолеты связи, самолеты-заправщики, санитарные и т.п. / До цієї категорії відносяться літаки-коригувальники, літаки зв'язку, літаки-заправники, санітарні та т.п.
6. Пассажирские салоны такого класса самолётов могут вмещать в среднем от 8 до 100 пассажиров. / Пасажирські салони такого класу літаків можуть вміщати в середньому від 8 до 100 пасажирів.
7. Самолеты отличаются друг от друга геометрическими, весовыми и летными характеристиками. / Літаки відрізняються один від одного геометричними, ваговими і льотними характеристиками.
8. Для этих целей используются более экономичные воздушные суда. / Для цих цілей використовуються більш економічні повітряні судна.
9. Региональные самолеты имеют меньшую пассажировместимость. / Регіональні літаки мають меншу пасажиромісткість.
10. Этот самолёт-амфибия может осуществлять посадку на водную поверхность. / Цей літак-амфібія може здійснювати посадку на водну поверхню.

2) Imagine a real life situation. You’re the owner of a new air company that wants to provide Ukrainian travelers with a new air route Kyiv-Lviv. Imagine what kind of plane your company might buy for this route.

Describe the plane and prove your answer.

IV. Додаткові питання (за змістом навчальних відеофільмів)

1. When was the Civil Aviation Council established? (based on the film “Soviet Civil Aircraft”)
2. Who made an aircraft for the Moscow-Beijing airflight? (based on the film “Soviet Civil Aircraft”)
3. What was the airframe of that aircraft like? (based on the film “Soviet Civil Aircraft”)
4. How many passengers could its cabin hold? (based on the film “Soviet Civil Aircraft”)
5. How much time did it take to build that aircraft? (based on the film “Soviet Civil Aircraft”)

CHAPTER 3

Fundamentals of airplane flight mechanics, aircraft design

Aerodynamic forces. A force may be thought of as a push or pull in a specific direction. A force is a vector quantity so a force has both a magnitude and a direction. When describing forces, we have to specify both the magnitude and the direction. The Fig. 3.1 shows the forces that act on an airplane in flight.

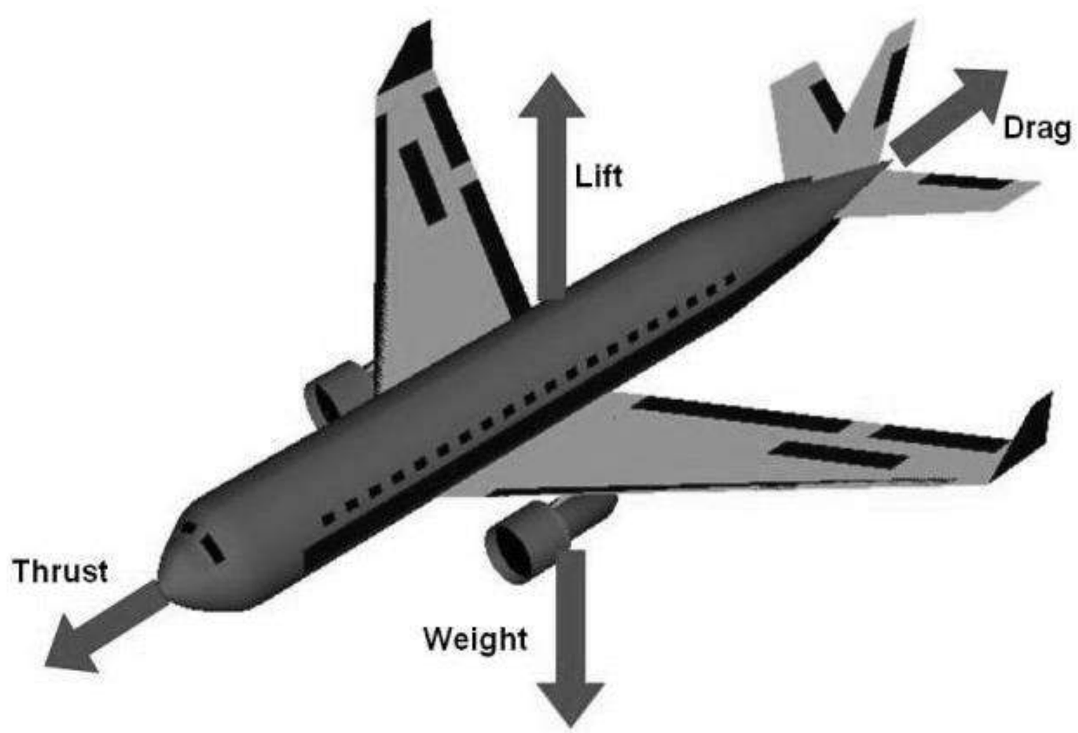


Fig. 3.1. Four Forces on an Airplane

Weight. Weight is a force that is always directed toward the center of the earth. The magnitude of the weight depends on the mass of all the airplane parts, plus the amount of fuel, plus any payload on board (people, baggage, freight, etc.). The weight is distributed throughout the airplane. But we can often think of it as collected and acting through a single point called the center of gravity. In flight, the airplane rotates about the center of gravity.

Flying encompasses two major problems: overcoming the weight of an object by some opposing force, and controlling the object in flight. Both of these problems are related to the object's weight and the location of the center of gravity. During a flight, an airplane's weight constantly changes as the aircraft consumes fuel. The distribution of the weight and the center of gravity also changes. So the pilot must constantly adjust the controls to keep the airplane balanced, or trimmed.

Lift. To overcome the weight force, airplanes generate an opposing force called lift. Lift is generated by the motion of the airplane through the air and is an aerodynamic force. "Aero" stands for the air, and "dynamic" denotes motion. Lift is directed perpendicular to the flight direction. The magnitude of the lift depends on several factors including the shape, size, and velocity of the aircraft. As with weight, each part of the aircraft contributes to the aircraft lift force. Most of the lift is generated by the wings. Aircraft lift acts through a single point called the center of pressure. The center of pressure is defined just like the center of gravity, but using the pressure distribution around the body instead of the weight distribution.

The distribution of lift around the aircraft is important for solving the control problem. Aerodynamic surfaces are used to control the aircraft in roll, pitch, and yaw.

Drag. As the airplane moves through the air, there is another aerodynamic force present. The air resists the motion of the aircraft and the resistance force is called drag. Drag is directed along and opposed to the flight direction. Like lift, there are many factors that affect the magnitude of the drag force including the shape of the aircraft, the "stickiness" of the air, and the velocity of the aircraft. Like lift, we collect all of the individual components' drags and combine them into a single aircraft drag magnitude. And like lift, drag acts through the aircraft center of pressure.

Thrust. To overcome drag, airplanes use a propulsion system to generate a force called thrust. The direction of the thrust force depends on how the engines are attached to the aircraft. In the figure shown above, two turbine engines are located under the wings, parallel to the body, with thrust acting along the body center line. On some aircraft the thrust direction can be varied to help the airplane take off in a very short distance. The magnitude of the thrust depends on many factors associated with the propulsion system including the type of engine, the number of engines, and the throttle setting.

For jet engines, it is often confusing to remember that aircraft thrust is a reaction to the hot gas rushing out of the nozzle. The hot gas goes out the back, but the thrust pushes towards the front. Action <--> reaction is explained by Newton's Third Law of Motion.

The motion of the airplane through the air depends on the relative strength and direction of the forces shown above. If the forces are balanced, the aircraft cruises at constant velocity. If the forces are unbalanced, the aircraft accelerates in the direction of the largest force.

Wing lift. Lift is defined as the component of the total aerodynamic force perpendicular to the flow direction, and drag is the component parallel to the flow direction (Fig. 3.2).

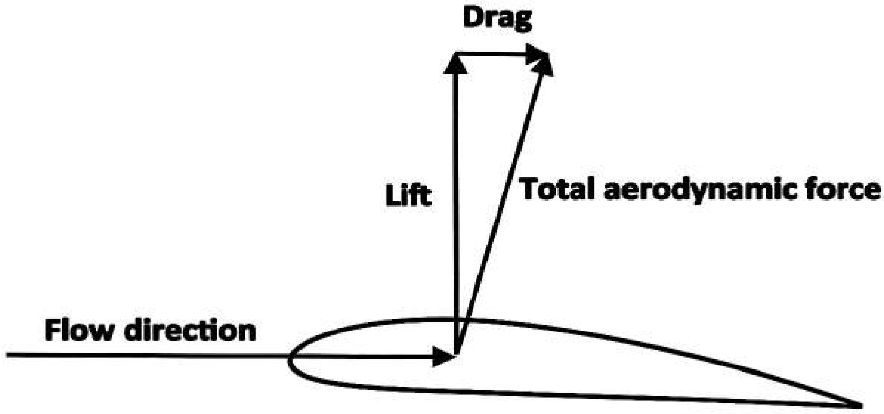


Fig. 3.2. Lift on an airfoil

Airplane wings are shaped to make air move faster over the top of the wing. When air moves faster, the pressure of the air decreases. So the pressure on the top of the wing is less than the pressure on the bottom of the wing. The difference in pressure creates a force on the wing that lifts the wing up into the air.

An airfoil generates lift by exerting a downward force on the air as it flows past. According to Newton's third law, the air must exert an equal and opposite (upward) force on the airfoil, which is the lift. Newton's third law says that for every action there is an equal and opposite reaction. When an airfoil deflects air downwards, the air exerts an upward force on the airfoil (Fig. 3.3).

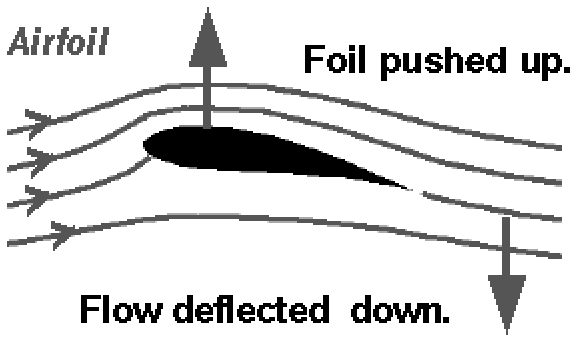


Fig. 3.3. Forces on an airfoil

The air flow changes direction as it passes the airfoil following a path that is curved downward, and the overall result is that a reaction force is generated opposite to the directional change. In the case of an airplane wing, the wing exerts a downward force on the air and the air exerts an upward force on the wing.

Vocabulary notes

№	English	Ukrainian	Russian
1	aerodynamic force	аеродинамічна сила	аэродинамическая сила
2	airfoil	аеродинамічна поверхня; профіль крила	аэродинамическая поверхность; профиль крыла
3	airplane	літак	самолет
4	center of gravity	центр тяжіння	центр тяжести
5	center of pressure	центр прикладання сили	центр давления; центр приложения давления
6	drag	аеродинамічний опір	лобовое сопротивление
7	engine	двигун	двигатель
8	flow direction	напрям потоку	направление потока
9	force	сила	сила
10	fuel	паливо	топливо
11	jet engine	реактивний двигун	реактивный двигатель
12	lift	підйомна сила	подъёмная сила
13	magnitude	величина, параметри	величина, параметры
14	nozzle	форсунка; сопло	форсунка; сопло
15	pitch	тангаж	тангаж
16	roll	крен	крен
17	throttle; throttle control	дросель; важіль керування двигуном	дроссель; рычаг управления двигателем (РУД)
18	thrust	тяга	тяга
19	to trim	балансувати	балансировать
20	turbine engine	турбінний двигун	турбинный двигатель
21	wing	крило	крыло
22	wing lift	підйомна (підіймальна) сила крила	подъёмная сила крыла
23	yaw	рискання	рыскание

Вправи до тексту 3

I. Вправи на перевірку знань лексичного матеріалу

1) Give the definition to the following words:

a) Force;
b) Weight;
c) Lif;t
d) Drag;
e) Total aerodynamic force.

2) Fill in the gaps with appropriate word (one word can be used several times):

Magnitude	Faster	"Dynamic"	Size
Velocity	Center	Payload	Direction
"Aero"	Shape	Throughout	Distance
Take off	Engines	Largest	Downward

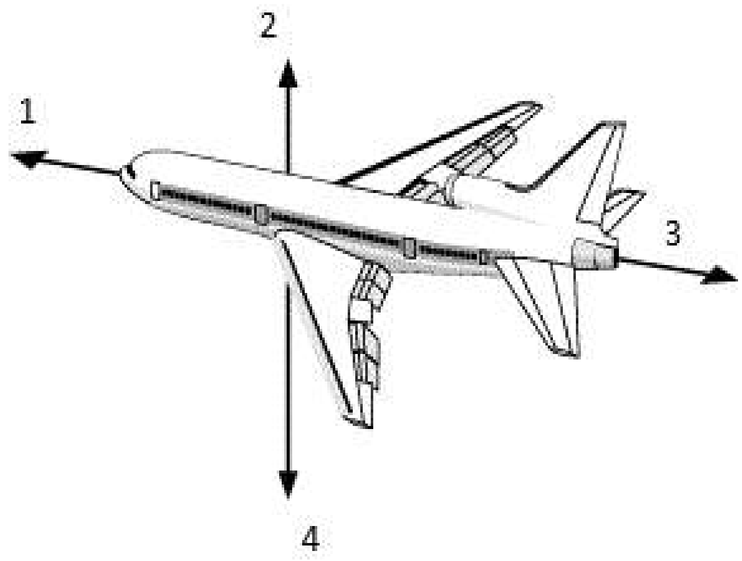
1. The _____ of the weight depends on the mass of all the airplane parts, plus the amount of fuel, plus any ____ on board.
2. The weight is distributed _____ the airplane.
3. ____ stands for the air, and ____ denotes motion.
4. In flight, the airplane rotates about the ____ of gravity.
5. The magnitude of the lift depends on several factors including the ____, ____, and ____ of the aircraft.
6. The thrust ____ can be varied to help the airplane ____ in a very short ____.
7. If the forces are unbalanced, the aircraft accelerates in the direction of the ____ force.
8. The wing exerts a ____ force on the air.
9. Airplane wings are shaped to make air move ____ over the top of the wing.
10. The direction of the thrust force depends on how the ____ are attached to the aircraft.

II. Вправи на перевірку знань лексики і розуміння вивченого матеріалу

1) Choose the right statement, put *true* (T) or *false* (F):

1. The two major problems of flying are overcoming the lift of an object by some opposing force, and controlling the object in flight.
2. According to Newton's third law, for every action there is an equal and opposite re-action.
3. When air moves slower, the pressure of the air decreases.
4. Aerodynamic surfaces are used to control the aircraft in roll, pitch, and yaw.
5. An airplane's weight constantly changes during a flight.

2) Indicate the forces in the picture:



III. Вправи на перевірку знань лексики і розуміння вивченого матеріалу на більш високому рівні

1) Translate from Russian/Ukrainian into English:

1. Сила – это векторная величина. / Сила – це векторна величина.
2. Самолёт вращается вокруг центра гравитации в полёте. / Літак обертається навколо центру тяжіння в польоті.
3. Преодоление силы тяжести какой-либо противоположной силой – одна из главных проблем лётного дела. / Подолання сили

тяжіння якоюсь протилежною силою є однією з головних проблем льотної справи.

4. Летательный аппарат потребляет топливо во время полёта, поэтому вес самолёта постоянно меняется. / Літальний апарат споживає паливо під час польоту, тому вага літака постійно змінюється.

5. Чтобы преодолеть силу тяжести, самолёты создают провивоположную ей силу, которая называется подъёмной силой. / Щоб подолати силу тяжіння, літаки створюють протилежну до неї силу, що зветься підйомною силою.

6. Большая часть подъёмной силы создаётся крыльями. / Більша частина підйомної сили створюється крилами.

7. Воздух оказывает сопротивление движению самолёта. / Повітря чинить опір руху літака.

8. Чтобы создать тягу, на самолёте используется силовая установка. / Щоб створити тягу, на літаку використовується силова установка.

9. Когда воздух движется быстрее, его давление уменьшается. / Коли повітря рухається швидше, його тиск зменшується.

10. Третий закон Ньютона гласит: «Для каждого действия существует равное противодействие». / Третій закон Н'ютона гласить: «Для кожної дії існує протидія, що їй дорівнює».

2) Draw a sketch of an airfoil; indicate the areas of high and low pressure, as well as the forces on the airfoil.

IV. Додаткові питання (за змістом навчальних відеофільмів)

1. How much does the Boeing 737 weigh? (based on the film “The aerodynamics of flight”)

2. How many pounds of thrust do its engines produce? (based on the film “The aerodynamics of flight”)

3. How many forces are there on an airplane? What are they? (based on the film “The aerodynamics of flight”)

4. What is the role of an airfoil in creating lift? (based on the film “The aerodynamics of flight”)

5. What is the gross weight? How can we calculate it? (based on the film “The aerodynamics of flight”)

CHAPTER 4

Aircraft structural members: their purpose and structure

Looking through the section "*Aircraft construction*", we should note that constructively a plane, like any other aircraft, is a complex technical aggregate, which consists of interconnected components and assemblies regarding their purpose, location and operation of their parts, components and assemblies. Moreover, an aircraft consists of numerous simple and complex systems, subsystems, and structural elements of smaller units connected together by big amount of cross links.

Aircraft design, in addition, should provide the plane with high aerodynamic performance; have the required strength, stiffness, survivability, endurance; be technological in manufacture and maintenance as well as have minimum weight.

Thus, a plane is an aircraft, heavier than air, with a wing on which aerodynamic lift force is generated due to thrust given by power plant during the motion of the plane in the airspace.

The most often aircraft design is a glider, consisting of the fuselage, a wing and an empennage, equipped with power plant and landing gear (see Fig. 4.1). Modern airplanes also include avionics and on-board equipment, and military airplanes have aviation armament.

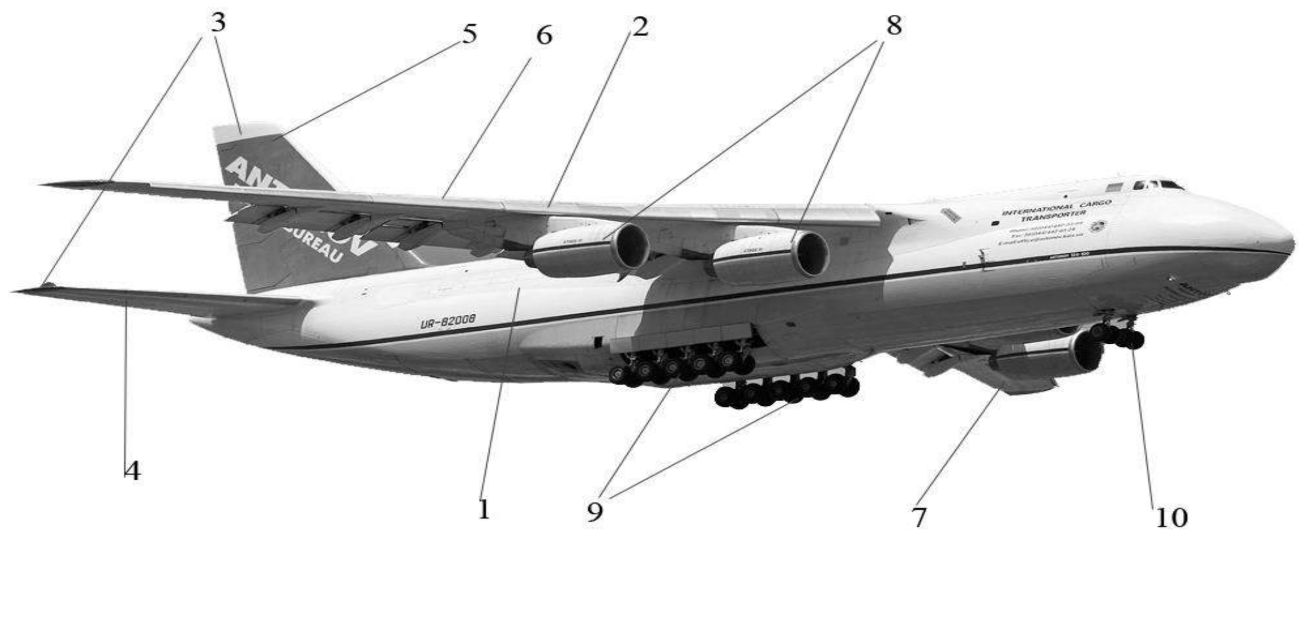


Fig. 4.1. Aircraft structural members

1-fuselage; **2**-wing; **3**-empennage; **4**-horizontal stabilizer; **5**-vertical stabilizer; **6-**right wing panel; **7**-left wing panel; **8**-aircraft engines; **9**-main landing gear; **10**- nose landing gear.

A simplified block diagram of aircraft construction is presented below (Fig. 4.2).

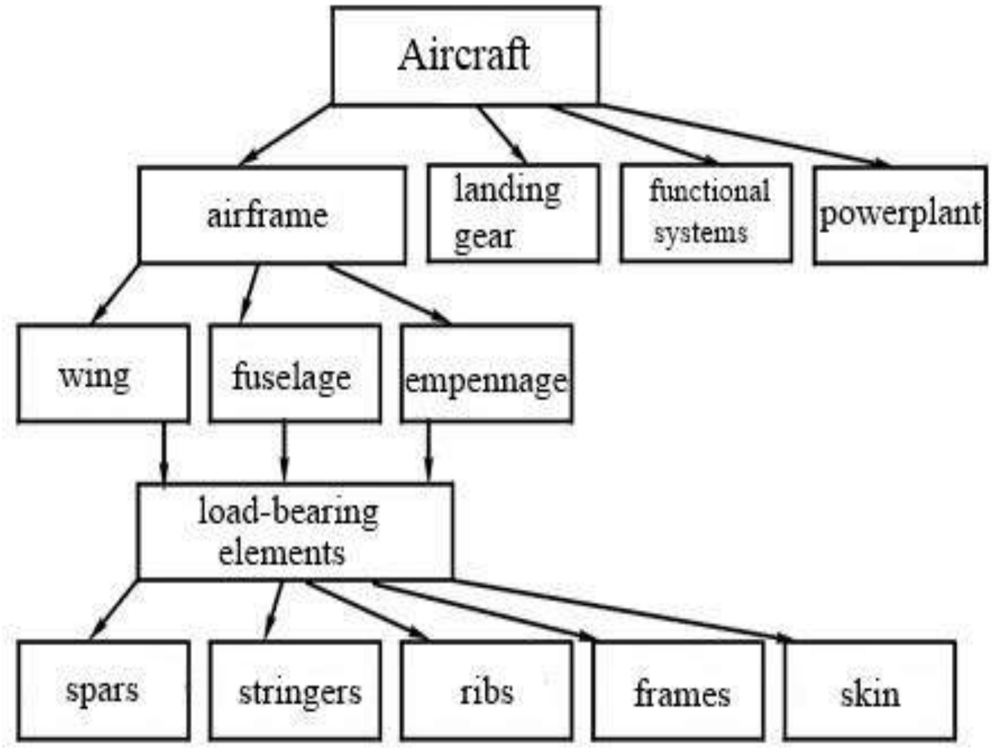


Fig. 4.2. Block Diagram of Aircraft

Aircraft fuselage. Aircraft fuselage is designed to accommodate the crew, the equipment and the payload. Aircraft fuselage is a body of the airplane to which load-bearing wing panels, empennage and landing gear are attached. In some cases, aircraft engines may be attached to the fuselage as well. The fuselage is a place for a cabin crew and a passenger cabin, cargo bays, equipment, fuel tanks, landing gear and engines. A streamlined cigar-shaped form of the fuselage provides the plane with a minimum airflow drag in flight. That's why the supersonic aircraft fuselage has strongly pointed nose part.

The fuselage consists of a frame made of load-bearing elements: spars, stringers, frames and skin. The simplest example of the fuselage structure is shown in Fig. 4.3, wherein the stringers (2) strengthen the skin (4) in the longitudinal direction of the fuselage, and the normal frames (5) strengthen the skin in the transversal direction, providing a predetermined shape of its contours. Strengthened bulkheads (3) are mounted in the fuselage at the points where wings, horizontal stabilizer (tail unit) and vertical stabilizer are attached to aircraft as well as where the concentrated forces from the landing gear, engines, etc. are applied.

Strong frames (1) are also designed to compensate for concentrated loads applied to the fuselage.

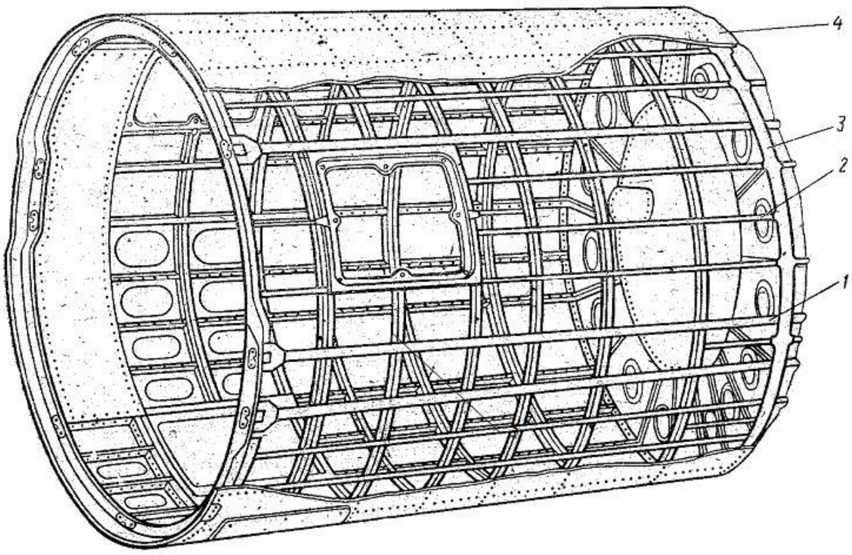


Fig. 4.3. Simplest fuselage construction

Airframe load-bearing elements of the fuselage are made of light and strong structural materials such as aluminum, titanium alloys and composite materials. Skin is made of aluminum and its alloys.

With the increasing speed and altitude there's a necessity to design pressurized cockpits and passenger cabins with pressure and temperature inside of them required for normal human vital activity. In this regard, the requirements for modern aircraft fuselage construction also increased considerably.

The overwhelming majority of aircraft is designed mainly according to one-fuselage scheme, very seldom – according to double-beam scheme. But there are some experimental non-fuselage planes – they are called a flying wing.

Wing. A wing is essential part of aircraft structure. Performance of aircraft depends on the shape, the size and the location of a wing. The main function of a wing is to create aerodynamic lift that is necessary to ensure all operational modes and maneuvers during the flight. Therefore, along with horizontal and vertical stabilizers, a wing refers to the load-bearing parts of the aircraft structure and provides a plane with lateral stability and control. It should be noted that wings have from 30 to 50 % of the total weight of the whole airframe.

Structurally a wing consists of several parts: inner wing (center wing section) and outer wing detachable parts (wing panels). The center wing section is attached to aircraft fuselage or structurally configured in such a way that a wing and the fuselage form integral unit. Outer wings are attached to the center wing section from the left and the right sides of the fuselage forming a wing itself. Airplanes with one wing are called monoplanes and aircraft with two wings are called biplanes (Fig. 4.4).

1

2

Fig. 4.4. Airplanes: a monoplane and a biplane

1-*Yak-52 – monoplane;***2**-*An-2 – biplane.*

Aircraft controls are located on a wing. Aircraft controls include ailerons and spoilers which provide control of the airplane relative to the longitudinal axis. The high-lift devices for wing mechanization are located on wings as well. With the help of these devices one can control aerodynamics of a wing, thereby improving the take-off and landing performance of the plane. These devices include flaps and slats (Fig. 4.5.a and 4.5.b). The main takeoff and landing characteristics are assumed to be takeoff run, landing length, takeoff and landing speed of aircraft.

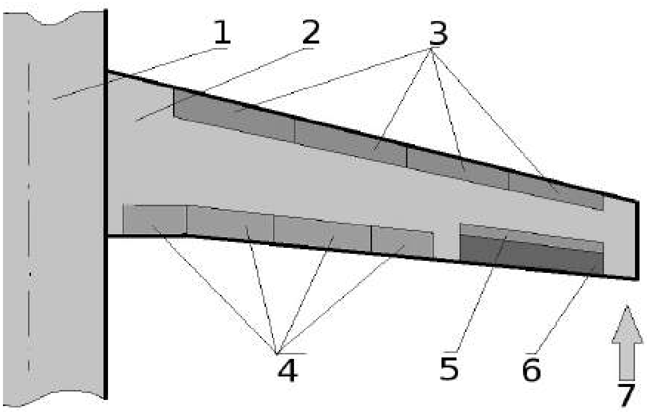


Fig. 4.5.a. General Scheme of wing surfaces control

1-fuselage; **2**-right wing panel; **3**-slats; **4**-flaps; **5**-spoiler; **6**-aileron; **7**-aircraft flight direction; **3**,**4**-wing high-lift devices; **5**,**6**-aircraft controls.

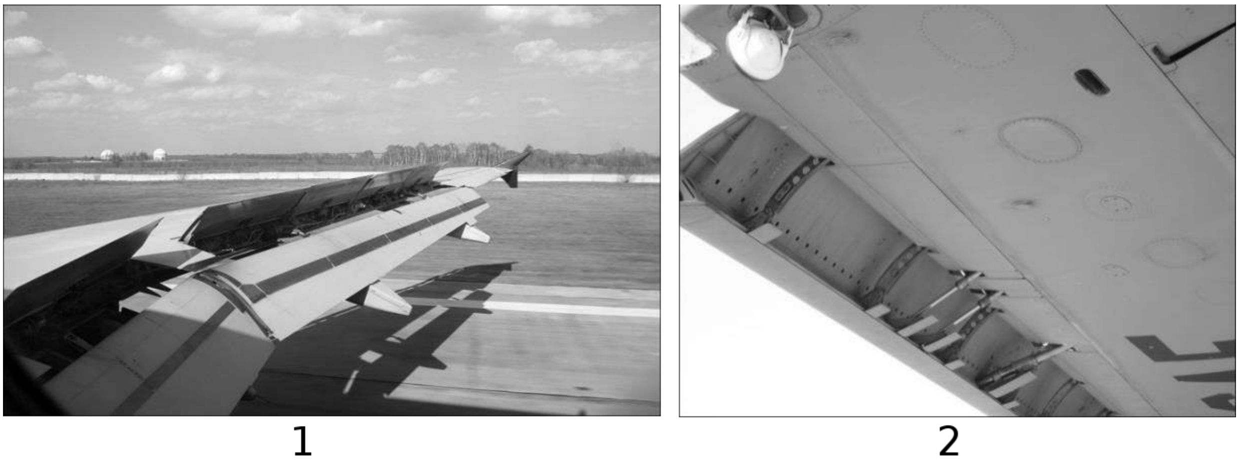


Fig. 4.5.b. Wing mechanization

1-flaps; **2-**slats.

Inner space of a wing can be used to accommodate the fuel tanks, various aggregates, landing gear, aircraft communications, etc. Aircraft engines can be mounted on a wing or below it as well by means of special devices – pylons. For military aircraft, there are devices for armament to be placed under a wing.

The forms of the wings of various aircraft types may differ significantly from each other. The most common forms that are widely used in aircraft are straight wings, swept wings, delta wings and integral wings (the fuselage and the wing form integral unit) (Fig. 4.5.c).

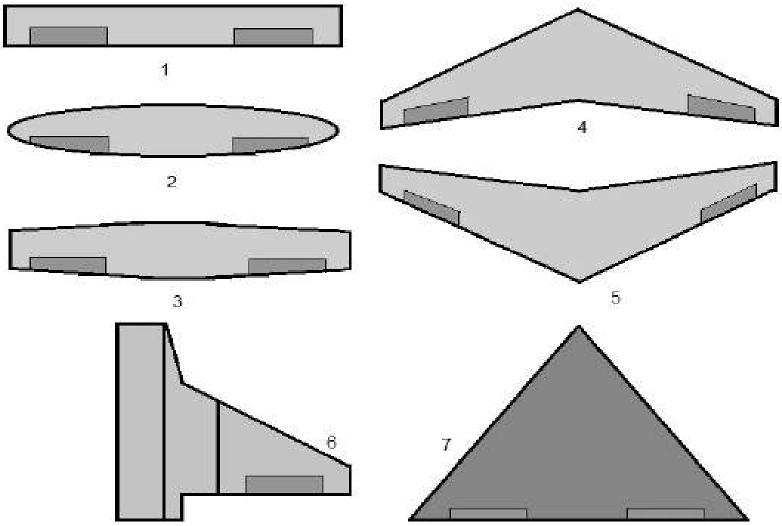


Fig. 4.5.c. External wing shapes

1-direct-rectangular; **2**-direct elliptic; **3**-direct trapezoidal;
4-swept-swept back; **5**-swept-forward; **6**-integral with the scheme fuselage;
7-triangular.

Initially, when designing certain types of aircraft, a number of tactical and technical requirements should be met. To meet all these requirements a wing with the corresponding shape and size is selected.

Structurally a wing consists of a frame and a skin (Fig.4.6). The frame, in turn, is assembled from the elements of the longitudinal structural members, namely, spars, stringers and transverse structural members that are ribs. Skin is relativelt fixed above the frame and provides a wing with the necessary aerodynamic shape.

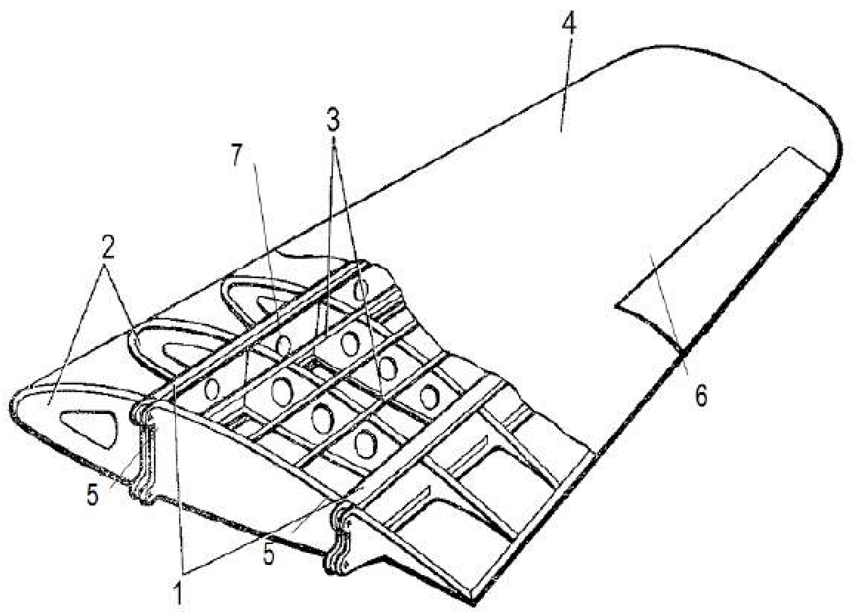


Fig. 4.6. Simplest wing construction

1-spars; **2**-ribs; **3**-stringers; **4**-skin; **5**-hinge fittings; **6**-aileron; **7**-technological rib apertures to lessen the wright of the wing.

Empennage

The empennage is load-bearing surfaces designed to create stability, control and balance of the aircraft in the longitudinal and lateral motion. The empennage of the most aircraft is located on the rear part of the fuselage.

The empennage is divided into a horizontal stabilizer and a vertical (Fig.4.7) stabilizer, and consists of fixed and movable parts. The fixed part of the horizontal stabilizer is called a stabilizer (2); the movable part is called an elevator (4). The fixed part of the vertical stabilizer is called a fin (1) and the moving part is a rudder (3). The rudder and the elevator are used to create control moments relative to the central axes of aircraft.

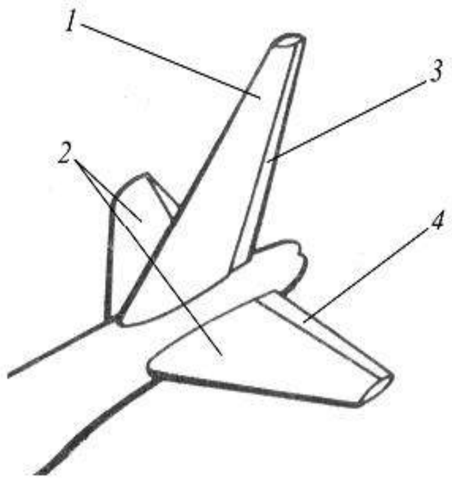


Fig. 4.7. Aircraft empennage

A stabilizer, in turn, consists of two panels: left one and right one. The main function of the empennage elements is the stabilization of flight. It means the empennage helps to maintain the direction and the flight altitude of aircraft, which was originally set by the crew. The fin controls the direction of the flight, and the stabilizer controls the altitude.

Supersonic aircraft empennage may not have an elevator and a rudder because of their low efficiency at high speeds. Their functions are performed by controlled wall-moving fin and stabilizer.

The empennage configuration is similar to the one of a wing and in most cases copies its shape. Modern civil and military airplanes use the most common one-fin empennage but there're aircraft models with distributed vertical empennage that consists of two fins.

Structurally a fin and a stabilizer are similar. Elevators and rudders are identical in their design as well. The empennage frame on modern aircraft is made of aluminum alloy; the skin of a fin and a stabilizer is made of duralumin. Structurally the main components of the primary structure of the empennage are the same as of the wing and they work identically: bending is taken up by spar caps, stringers and partly by skin. The lateral force (cross force) is taken up by spar webs and torsion is taken up by closed loop. A stabilizer and a fin are attached to the fuselage by means of hinge fittings on the spars and the frames.

Fig. 4.8 presents the structure of a fin: 1 - front spar, 2 - skin, 3 - rear spar, 4 - wing-tip fairing, 5- rudder hinge fittings, 6 - rib. The control surfaces and the ailerons are often designed as one-spar units with a set of stringers and ribs. In order the skin can take up better bending moment and keep the shape and the airfoil, the designers use the control surfaces with foam or honeycomb filling. Such design allows one to increase the stiffness of control surfaces and decrease its weight.

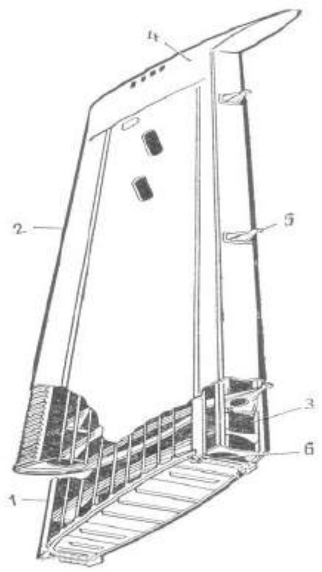


Fig. 4.8. Fin construction

Civil aircraft use two the most widely used empennage schemes: conventional one and T-shaped. Conventional empennage is characterized by a fin and a stabilizer being attached directly to the fuselage. It provides minimum weight, simple design of a fin, a stabilizer and rudder control linkage.

T-shaped empennage is characterized by a stabilizer being attached to the top of the fin (Fig. 4.9). It provides: the removal of a horizontal tail wing from the backwash of a wing and engines; the enlargement of the arm of a horizontal stabilizer; the improving of the vertical stabilizer aerodynamic efficiency. However, the weight is increased as well as the design of a fin, a stabilizer and rudder control linkage are getting more complicated.

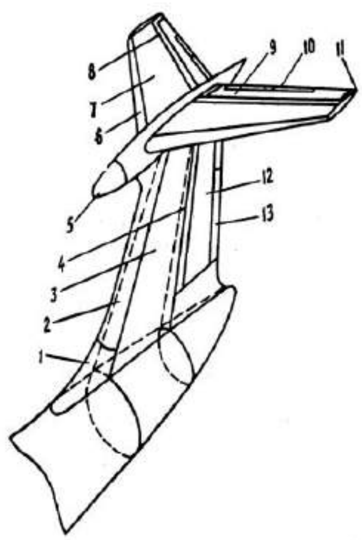


Fig. 4.9. T-shaped empennage scheme

1-dorsal fin; **2-**vertical stabilizer leading edge; **3**-middle part of the fin; **4**-rear fin; **5**-fairing; **6**, **7**, **8**-front, middle and rear stabilizer, respectively; **9**-elevator; **10**-elevator trimming tab; **11-**stabilizer fin; **12**-rudder; **13**-rudder spring balance tab.

Deicing devices, electric harnesses and antennae are located on the front part of the fin and stabilizer. Fuel (Il-62M) and engine air intakes (Tu-154, Yak-40, Yak-42) can be located in the middle monoblock part of the fin. Control surfaces are located in the tail part of the fin and stabilizer.

Landing gear

Landing gear is designed to move an aircraft on the airfield and taxiing it down the runway during takeoff and landing, as well as to keep the aircraft on the ground or water during parking. Among the variety of the aircraft the most common landing gear is a wheeled one. In winter light aircraft landing gear can have skis instead of wheels. Seaplanes in turn have floats instead of wheels. During the flight the wheeled landing gear is retracted into the wing or into the fuselage in order to reduce the air drag. Light sport aircraft, trainers and the other types of light airplanes are often designed with the non-retractable landing gear, which are structurally simpler and lighter than retractable landing gear.

Regarding the location of the landing gear struts relatively to the mass center, the aircraft differ in the following basic schemes: tail-wheel landing gear (Fig. 4.10), nose-wheel landing gear (tricycle undercarriage) and a bicycle one.

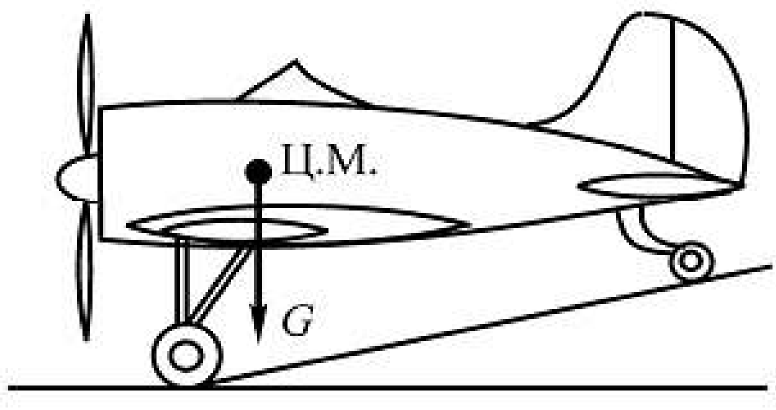


Fig. 4.10. Tail-wheel landing gear (tricycle undercarriage)

Tail-wheel landing gear is usually mounted on a small aircraft with non-retractable nose struts. The takeoff and landing of such airplanes are carried out by means of the main (nose) struts that are ahead of the mass center, or close to it. The tail strut is needed to maintain stable position of the aircraft on the ground and when taxiing on the runway. With a relatively small weight and simplicity, this scheme has a number of significant disadvantages.

Nose-wheel landing gear (tricycle undercarriage) (Fig. 4.11) does not have disadvantages that are present in the tail-wheel landing gear because the aircraft's mass center thus is located in front of the main struts and the nose strut is offset far ahead relative to the aircraft mass center.

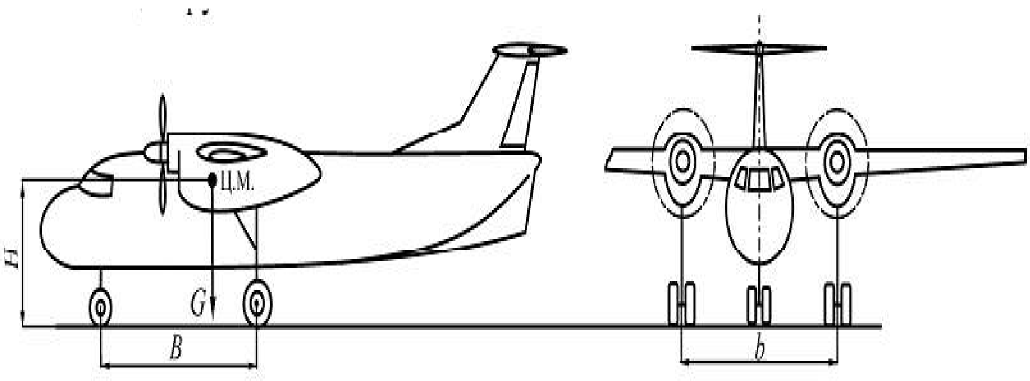


Fig. 4.11. Nose-wheel landing gear (tricycle undercarriage)

Such scheme provides one with better visibility from the cockpit and good directional stability of the plane.

Bicycle scheme includes two struts mounted under the fuselage that are approximately equal in the loads taken up by struts. Two underwing struts that can take up to 5% of the parking load can be mounted in order to prevent the aircraft from stalling on the wing. This scheme is not widely used on long-haul aircraft, as it causes the difficulties in piloting during the aircraft landing, complicates the design and makes the mechanism of the nose landing strut heavier.

Modern jet aircraft are equipped with tricycle landing gear with nose strut in the front of the fuselage and two struts near the gravity center of the aircraft under the fuselage or the wing (Fig. 4.12). This tricycle landing gear provides one with safe landing at higher speeds and stable aircraft motion during takeoff run and landing run. Heavy passenger airplanes are equipped with bogie landing gear to reduce loads and pressure on the aerodrome surface (Fig. 4.12-2, 3, 4).

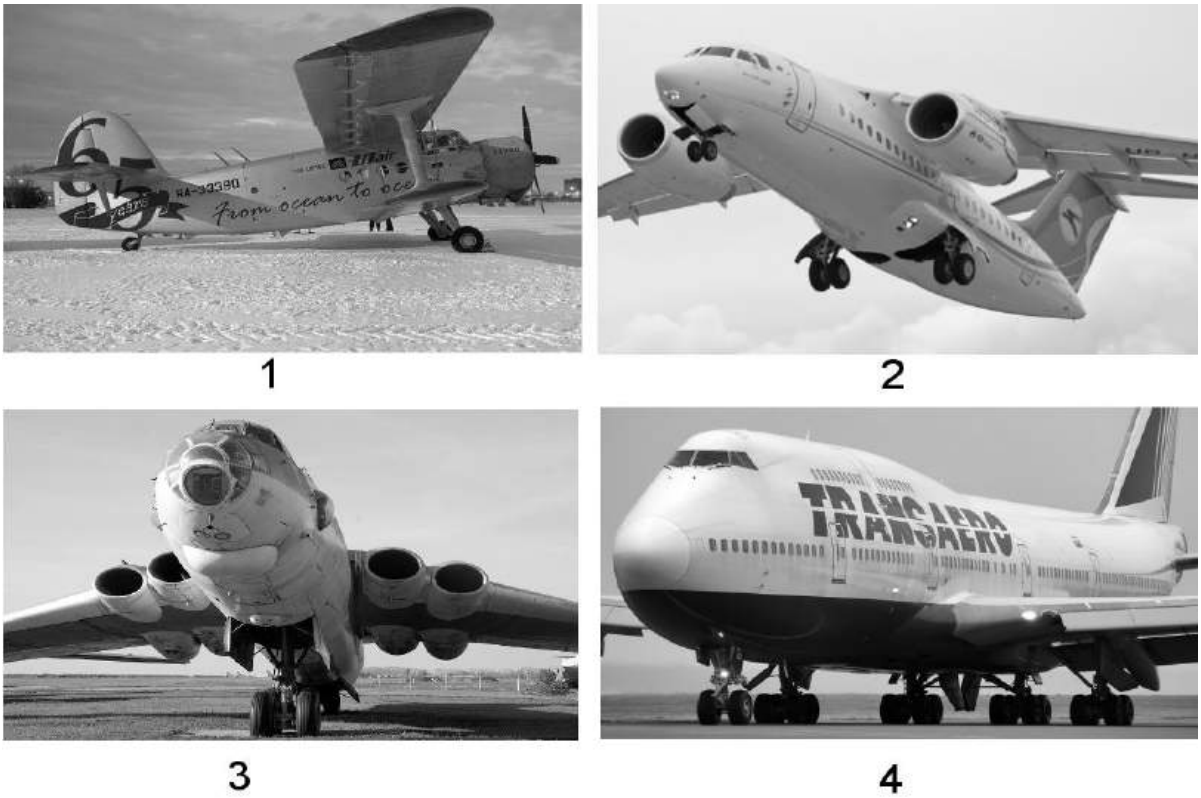


Fig. 4.12. Main landing gear configurations

1-tail-wheel landing gear An-2; **2**-tricycle landing gear with a nose gear (tricycle undercarriage) An-148; **3**-bicycle scheme M-4 ”Bison”; **4**-Bogie landing gear B-747.

All landing gears are equipped with liquid-gas or liquid absorbers to soften the impacts that occur during aircraft landing and when it’s moving on the airfield. The nose strut has a castoring wheel in order to taxi an aircraft. Aircraft taxiing on the ground can also be carried out due to separate braking wheels of main struts.

The design of retractable landing gear (Fig. 4.13) is much more complicated than non-retractable landing gear. Retractable landing gear has greater mass due to retraction (extension) mechanisms of landing gear. At the same time the aerodynamic drag of the aircraft with a retractable landing gear is by 20-35% less compared to the plane with a non-retractable landing gear.

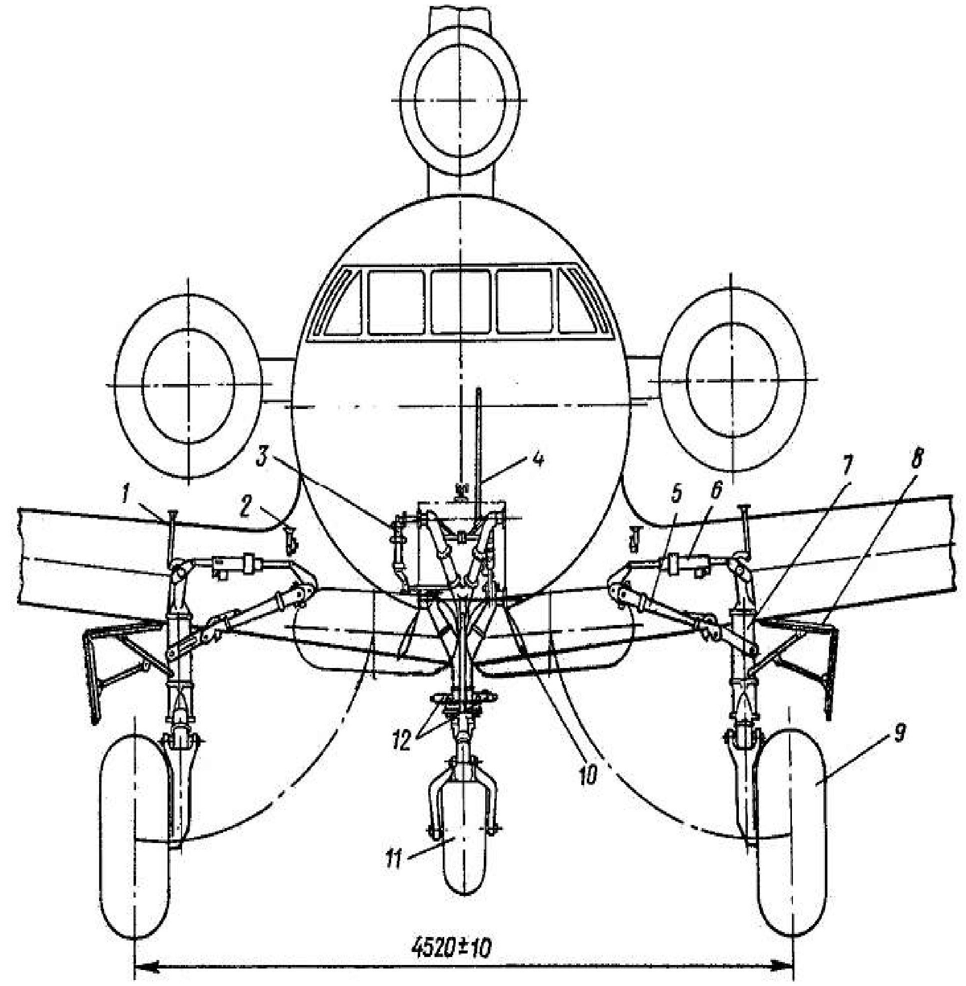


Fig. 4.13. Main components of retractable landing gear

The main components of retractable landing gear are the following:

- supporting elements ensuring contact of an aircraft with the basing surface: wheels, skis, floats, boats and other supporting elements. Fig. 13 depicts the supporting element, that is the nosewheel (11) and the main wheels (9);
- struts (7) ensuring the transfer of loads from the main gear elements to the aircraft construction through the suspension components. If the inner cavity of the strut is used to place the shock absorber, then it is called a shock strut;
- folding struts (5) which are an additional supporting strut;
- hydrocylinders (6) to retract and extend main landing gear and hydraulic cylinders (12) and to retract and extend the nose gear;
- locks (2) (mechanical and hydraulic) to fix the landing gear in the retracted or extended position;
- doors (10) closing the nose landing gear and doors (8) closing the main gear in the retracted position;

- differential mechanism (3) to control the nosewheel steering;
- mechanical gear position indicators to determine the position of the struts (retracted - extended) of main (1) and nose (4) gear units.

Powerplant

Aircraft powerplant is designed to create the necessary thrust in the whole range of flight operating conditions and it consists of the aircraft engines, propellers, air intakes, jet nozzles, fuel supply system, lubrication system, control system, regulation system, etc.

It should be noted that almost until the end of the 40s piston inter-combustion engine was a basic type of aircraft engines of all the countries in the world. It had air or liquid cooling that could rotate a propeller (Fig. 4.14). The power of such engines has been brought almost to 3160 kW, and the speed of the aircraft was 700 – 750 km / h.

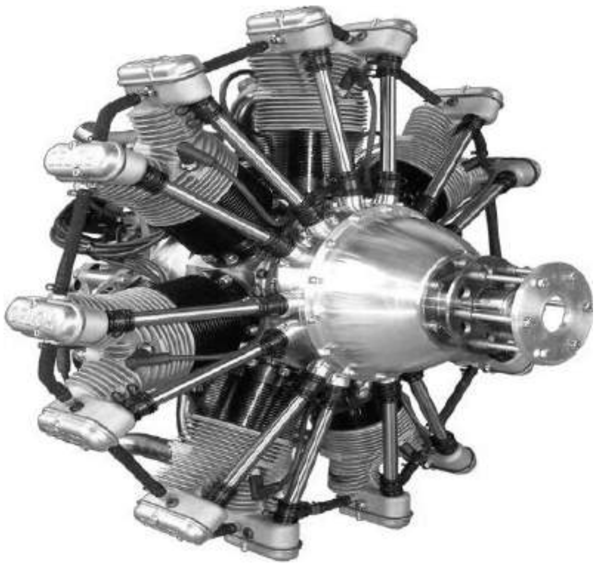


Fig. 4.14. Exterior view of the aircraft piston engine

However, sharp increase of the aerodynamic drag and reduction of the performance efficiency of the propeller prevented further speed increase. Later due to the development of new technologies for military and civil aircraft, designers started to use gas turbine jet engines, namely turbojet and turbofan engines. This change allowed modern aircraft to increase speed and altitude by several times.

The number of engines in the propulsion system of the modern aircraft has been changed as well. As we know, it can be quite varied. Mostly it depends on the function of the aircraft and its flight characteristics. There is a variety of engine locations on the airplane.

Reciprocating engines were usually located on the wing and in the forward fuselage part. In the same way engines are located on the turboprop airplanes. Jet aircraft have more diverse engine locations.

Combat fighter planes have one or two turbojet engines that are usually located in the fuselage. Heavy jet aircraft had engines in the wing root, but the most widespread engine location is the scheme of engine mount on pylons under wings (Fig. 4.15).

Fig. 4.15. Engine mount on pylon under wing

Passenger aircraft can have 2, 3 or 4 engines; they are located often in the fuselage aft portion. If an aircraft have three engines, one of the engines is placed inside the fuselage, and its air intake is located in the fin root. The benefits of such layout include: noise reduction in the passenger cabin and the improvement of the lift-to-drag ratio due to a wing without extra load.

Wing engine mount is used in short take-off and landing aircraft with the blowing of the upper wing surface (AN-74). The engines of some passenger and cargo aircraft are equipped with thrust reversing devices that are used during landing to reduce the landing distance. Aircraft engines use liquid hydrocarbon fuel. Gasoline, for example, is used in piston engines, and so-called jet fuel (kerosene) is used in gas turbine engines.

Aircraft equipment

Aircraft equipment provides aircraft piloting and flight safety; creates the necessary conditions for the life of the crew and the passengers; solves tasks related to the purpose of the airplane.

Aircraft navigation uses flight and navigation equipment, radio equipment and radar equipment. To improve the safety of the flight, fire-extinguishing, emergency, external lighting equipment, de-icing system and others are used. Life support system consists of air-conditioning system (airlock system), air cabin pressurization and oxygen equipment.

Energy supply of the aircraft systems and assemblies provides power-supply system, hydraulic and pneumatic systems.

Mission equipment depends on the type of the aircraft. It includes, for example, units of chemical spraying on the agricultural aircraft, passenger aircraft furnishing, surveillance and sighting systems of the combat aircraft, etc.

Devices, indicators and warning devices are part of the display system, which provides crew with data needed to perform flight tasks, to control power plant performance and avionics (board equipment) performance. Information content of the display equipment has increased. Nowadays the usage of screen indicators is more extended. The functionality of the aircraft equipment is significantly increased, its reliability and accuracy is much higher.

Onboard digital computers (DC) are more and more often used for data processing and operation control automation of various aircraft systems. In modern aircraft cockpit layout, optimal composition and location of display electronics, control panels, and so forth are selected to meet the requirements of aviation ergonomics.

Nowadays continuous technical improvement of modern aircraft on-board equipment) has allowed us not only to increase the flight range and altitude significantly, but also to perform long flights day and night under bad weather and geographical conditions.

Vocabulary notes

№	English	Ukrainian	Russian
1	aerodynamic force	аеродинамічна сила	аеродинамическая сила
2	aerodynamic surface	аеродинамічна поверхня	аэродинамическая поверхность
3	aerodynamical performance	аеродинамічні характеристики	аэродинамические характеристики
4	aft	хвостова частина фюзеляжу	хвостовая часть фюзеляжа
5	aileron	елерон	єэлерон
	air intake	повітрозабірник	воздухозаборник
6	air-conditioning system	система кондиціювання повітря	система кондиционирование воздуха
7	airfield	аеродром	аэродром
8	airflow	повітряний потік	воздушный поток
9	airfoil	аеродинамічна поверхня, профіль крила	аэродинамическая поверхность, профиль крыла
10	airframe	каркас фюзеляжу	каркас фюзеляжа
11	airspace	атмосфера	атмосфера
12	all-moving fin	суцільно поворотний кіль	цельноповоротный киль
13	alloy	сплав	сплав
14	avionics	авіоніка	авионика
15	bars	планка	планка
16	beam	балка	балка
17	bending loads	згинальне навантаження	сгибающая нагрузка
18	bicycle scheme	двохопорна (велосипедна схема)	двухопорная (велосипедная) схема
19	biplane	біплан	биплан
20	bogie landing gear	багатоколісне шасі	многоколесное шасси
21	braking	гальмування	торможение

№	English	Ukrainian	Russian
22	bulkhead	перегородка	перегородка
23	cargo bay	вантажний відсік	грузовой отсек
24	center wing section	центроплан	центроплан
25	composite materials	композитні матеріали	композитные материалы
26	conventional empennage	нормальне оперення	нормальное оперение
27	de-icing system	система протизледеніння	противообледенительная система
28	delta wing	трикутне крило	треугольное крыло
29	door	створка	створка
30	double-beam scheme	двобалкова схема	двухбалочная схема
31	drag	сила опору	сила сопротивления
32	elevator	кермо висоти	руль высоты
33	elliptic wing	еліптичне крило	эллиптическое крыло
34	empennage	хвостове оперення	хвостовое оперение
35	energy supply	енергоживлення	энергопитание
36	fairings	обтічники	обтекатели
37	fin root	корнева частина крила	корневая часть крыла
38	fire-extinguishing	гасіння пожежі	пожаротушение
39	flap	закрилок	закрылок
40	flying wing	літаюче крило	летающее крыло
41	foam filling	пінопластовий наповнювач	пенопластовый наполнитель
42	frame	шпангоут	шпангоут
43	fuel tank	паливний бак	топливный бак
44	fuselage	фюзеляж	фюзеляж
45	high-lift devices	засіб механізації крила	средство механизации крыла
46	honeycomb filling	сотовий наповнювач	сотовый наполнитель

№	English	Ukrainian	Russian
47	horizontal stabilizer	горизонтальне оперення	горизонтальное оперение
48	inner wing	середня частинка крила	средняя часть крыла
49	jet engine	реактивний двигун	реактивный двигатель
50	landing	посадка	посадка
51	landing gear	шасі	шасси
52	lateral axis	поперечна вісь	поперечная ось
53	leading edge	передня кромка крила	передняя кромка крыла
54	lift	підйомна сила	подъемная сила
55	linkage	проводка	проводка
56	liquid absorber	рідкий амортизатор	жидкостный амортизатор
57	load-bearing surface	несуча поверхня	несущая поверхность
58	longitudinal axis	поздовжня вісь	продольная ось
59	lubrication system	система змащування	система смазки
60	maneuver	маневр	маневр
61	mechanic indicator	механічний індикатор	механический индикатор
62	mission equipment	обладнання цілі	целевое оборудование
63	monoblock	моноблок	моноблок
64	monoplane	моноплан	моноплан
65	mount	установка	установка
66	movable part	рухома частинка	подвижная часть
67	non-retractable landing gear	шасі, що не прибирається	неубирающееся шасси
68	nose landing gear	переднє шасі	переднее шасси
69	nose strut	передня опора шасі	передняя опора шасси
70	nose-wheel landing gear	трьохопорне шасі з носовою опорою	трехопорное шасси с носовой опорой

№	English	Ukrainian	Russian
71	nozzle	сопло	сопло
72	on-board equipment	бортове обладнання	бортовое оборудование
73	outer wing	бокова частина крила	боковая часть крыла
74	parking load	стояночне навантаження	стояночная нагрузка
75	payload	навантаження	нагрузка
76	piloting	пілотування	пилотирование
77	pitch	обертання по поперечный осі, тангаж	вращение по поперечной оси, тангаж
78	powerplant	силова установка	силовая установка
79	propeller	пропелер	пропеллер
80	pylon	пілон	пилон
81	radio and radar equipment	радіолокаційне устаткування	радиолокационное оборудование
82	rear spar	задній лонжерон	задний лонжерон
83	reciprocating piston	поршень зворотно-поступального ходу	поршень возвратно-поступательного хода
84	reinforced stringers	посилений стрингер	усиленный стрингер
85	retractable landing gear	шасі, що прибирається	убирающееся шасси
86	rib	нервюра	нервюра
87	rudder	кермо напряму	руль направления
88	skin	обшивка	обшивка
89	slat	предкрилок	предкрылок
90	spar	лонжерон	лонжерон
91	spoiler	інтерцептор	интерцептор
92	stabilizer	стабілізатор	стабилизатор

№	English	Ukrainian	Russian
93	stalling	звалювання	сваливание
94	stiffness	жорсткість	жесткость
95	straight wing	прямовидне крило	прямовидное крыло
96	stringer	стрингер	стрингер
97	structural members	елемент конструкції	элемент конструкции
98	strut	підкіс	подкос
99	supporting element	опорний елемент	опорный элемент
100	swept forward aircraft	крило зворотної стрілоподібності	крыло обратной стреловидности
101	swept wing	стрілоподібне крило	стреловидное крыло
102	sweptback aircraft	крило прямої стрілоподібності	крыло прямой стреловидности
103	tail section	хвостова частина	хвостовая часть
104	tail-wheel landing gear	шасі з хвостовою опорою	шасси с хвостовой опорой
105	take-off	зліт	взлет
106	taxiing	рух літака на землі	движение самолета на земле
107	thrust	тяга	тяга
108	tip	закінцівка крила	законцовка крыла
109	transverse structural member	поперечний силовий набір	поперечный силовой набор
110	trapezoidal wing	трапецеподібне крило	трапециевидное крыло
111	tricycle gear	триколісне шасі	трехколесное шасси
112	trim	триммер	триммер
113	T-shaped empennage	Т-подібне оперення	Т-образное оперение
114	turbofan engine	турбовентиляторний двигун	турбовентиляторный двигатель
115	turbojet engine	турбореактивний двигун	турбореактивный двигатель
116	vertical axis	вертикальна вісь	вертикальная ось
117	vertical stabilizer	вертикальное оперение	вертикальне оперення

№	English	Ukrainian	Russian
118	wing	крило	крыло
119	wing contour	профіль крила	профиль крыла
120	wing panel	консоль крила	консоль крыла

Вправи до тексту 4

I. Вправи на перевірку знань лексичного матеріалу

1) Give the definition to the following words:

a) Plane;
b) Conventional empennage;
c) T-shaped empennage;
d) Powerplant;
e) Fuselage.

2) Fill in the gaps with appropriate words (one word can be used several times):

Composite materials	Rudder	Landing gear	Air intake
Elevator	Wing	Turbojet engine	Fuselage
Navigation equipment		Flying wing	

1. The aircraft controls are located on the ____.
2. Conventional empennage includes a fin and a stabilizer being attached directly to the _____.
3. _____ is equipped with a liquid-gas or liquid absorbers to soften the impacts that occur during aircraft landing.
4. Airframe load-bearing elements of the fuselage are made of light and strong structural materials such as aluminum, titanium alloys and ______.
5. The _____is located in the tail part of a fin and a stabilizer.
6. Combat fighter planes have one or two ____ that are usually located in the fuselage.
7. If the aircraft have three engines, one of the engines is placed inside the fuselage, and its ____ is located in the fin root.
8. Aircraft navigation uses flight and ____, radio equipment and radar equipment.
9. There are some experimental non-fuselage planes – they are called_____.
10. Supersonic aircraft empennage may not have an ____ and a rudder because of their low efficiency at high speeds.

II. Вправи на перевірку знань лексики і розуміння вивченого матеріалу

1) Choose the right statement, put true (T) or false (F):

1. As for construction characteristics fin and stabilizer are similar.

2. T-shaped empennage is a stabilizer being attached to the fuselage.

3. The aircraft controls include ailerons and spoilers which provide control of the airplane relative to the lateral axis.

4. Empennage frame on modern aircraft is made of aluminum alloy.

5. The skin of a fin and a stabilizer is made of aluminum alloy as well.

6. The civil aircraft use only T-shaped empennage scheme.

7. The rudders are located in the tail part of a fin and a stabilizer.

8. The design of retractable landing gear is much more complicated than of a non-retractable landing gear.

9. Retractable landing gear has light mass.

10. The number of engines depends on the purpose of the aircraft and its flight characteristics.

2) Describe the given picture. What kind of plane can you see? What is this plane for? Describe its fuselage, wing configuration, landing gear, empennage and engines. Use words from the box to make your speech more professional.

Airliner	Long-haul
Wheels	Wide-body
Bogie type	Outfit
Turbofan engines	Passenger deck
Sweep	Low-mounted wing

III. Вправи на перевірку знань лексики і розуміння вивченого матеріалу на більш високому рівні

1) Translate from Russian/Ukrainian into English:

1. Поршневые двигатели обычно устанавливались на крыле. / Поршневі двигуни за звичай встановлювалися на крилі.
2. Для самолётовождения используется пилотажно-навигационное, радиотехническое и радиолокационное оборудование. / Для керування літака використовується пілотажно-навігаційне, радіотехнічне і радіолокаційне обладнання.
3. Конструкция самолёта должна обеспечивать высокие аэродинамические характеристики. / Конструкція літака повинна забезпечувати високі аеродинамічні характеристики.
4. Современные самолёты оснащаются авионикой и бортовым оборудованием. / Сучасні літаки оснащуються авіоникою і бортовим обладнанням.
5. Конструкция фюзеляжа содержит каркас, изготовленный из силовых элементов: лонжеронов, стрингеров, шпангоутов и обшивки. / Конструкція фюзеляжу містить каркас, виготовлений із силових елементів: лонжеронів, стрингерів, шпангоутів і обшивки.
6. Обшивка изготавливается из алюминия и его сплавов. / Обшивка виготовляється з алюмінію і його сплавів.
7. Оперение сверхзвуковых самолётов может не иметь рулей высоты и направления. / Оперення надзвукових літаків може не мати рулів висоти і напрямку.
8. В передних частях киля чаще всего размещают противообледенительные устройства. / У передніх частинах кіля найчастіше розміщують пристрої проти обледеніння.
9. Все шасси оснащены жидкостно-газовыми или жидкостными амортизаторами. / Всі шасі оснащені рідинно-газовими або рідинними амортизаторами.
10. Дифференциальный механизм управляет поворотом колеса передней стойки. / Диференціальний механізм управляє поворотом колеса передньої стойки.

2) Imagine that you have to fill the blank of aircraft characteristics. The plane that you work with is Boeing 747-400. Fill the small part of the table from this blank using some numbers given below in the box:

Mach 0.92	2	4, turbofan	PW4062	541,2 m²
64,40 m	412.770 kg	max. 660	184.567 kg	13.449 km

Characteristic	Number
Crew	
Passengers	
Propulsion	
Engine model	
Speed	
Range	
Wing span	
Wing area	
Empty weight	
Max. take-off weight	

IV. Додаткові питання (за змістом навчальних відеофільмів)

1. Which plane was called the “Queen of the skies”? (based on the film “How to build a Boeing 747”)
2. What did the manufacturer want to change, to make the old airplane better? (based on the film “How to build a Boeing 747”)
3. Which problem did the Boeing face, having accepted the challenge of building the 747 aircraft? (based on the film “How to build a Boeing 747”)
4. What danger can be caused by flutter? (based on the film “How to build a Boeing 747”)
5. Why did the workers attach heavy concrete blocks to the airplane wings during the aircraft building? (based on the film “How to build a Boeing 747”)

CHAPTER 5

General information about electric power supply systems of an aircraft

The further growth of the scientific and technical progress has made the rise in world aviation science and industry significantly noticeable.

Today modern aircraft transport huge numbers of passengers and various cargoes, they are used in agricultural industry and forestry, as well as in oil and gas fields, and in military field. Thereafter, the requirements to the modern aircraft have become much higher: the aircraft must be reliable; they must be airborne for a long time; they must transport cargoes of particular dimensions and mass; they must be high-speed and maneuvering; they must not depend on the time of day and weather conditions. That's why the modern aircraft design has become more complicated. Their maintenance and flight preparation require more time, as well as using expensive modern equipment. And by using progressive modern materials and technologies, as well as equipping the aircraft with complex modern devices, aircraft designers have placed the airplanes on a higher stage of development.

To control modern aircraft more accurately and effectively both during the flight and during the ground time, aircraft engineers and designers have developed, produced and implemented a number of accessories and systems, which operate independently. Thus, they have simplified the crews' work during the flight time, as well as increase the safety level.

On modern aircraft different types of energy are used to put some separate elements and accessories in operation, for example, an aircraft control system, or an engine control system, as well as other aircraft systems and accessories.

Depending on the type of energy used in this or that aircraft system, there are hydraulic, gas and electric systems. Thus, the hydraulic system, for example, runs on special fluids, the gas system runs on gas energy, the electric system runs on electrical energy, which is produced by electrical power supplies. Such systems are called aircraft energy systems. It is noteworthy, that each of these systems has its specific properties and some advantages as well.

Hydraulic system

The hydraulic system is one of the most important systems on modern aircraft. This is because if its ability to accumulate and concentrate a big quantity of hydraulic energy, which is consumed afterwards by hydraulic gears to control the working surfaces of a stabilizer, which is a part of the aircraft control system.

Hydraulic gears are used on modern aircraft due to their low weight and small dimensions, high speed of response as well. The mass and dimensions of a hydraulic unit are about 10-20 % of the mass and dimensions of an electrical accessory for the same purposes and of similar power. Hydraulic gears provide simple fixation of actuators' intermediate positions.

The hydraulic system of an aircraft runs the systems and mechanisms which are crucial for the flight safety. The reliability and durability of the hydraulic system are provided by perfect accessories construction, multiple reservation both of the power source and the hydraulic gears, control automation, system operation control, as well as providing the crew with necessary information.

Hydraulic systems are widely used on aircraft to control stabilizers and rudders, high-lift devices, and gear kinematics.

Most of the national civil aircraft have the aircraft hydraulic oil (hydraulic fluid) (Russian АМГ-10 – Авиационное Масло Гидравлическое; 10 – вязкость при температуре 50º по Цельсию, используется в качестве рабочей жидкости для гидравлических устройств, работающих в интервале температур окружающей среды от -60°C до +55°C) as the working medium. The operation of the hydraulic system depends on the properties of this hydraulic fluid. It is neutral to steel and duralumin, and its viscosity changes slightly with the change of temperature. However, it can be inflammable. For example, the ignition point of aircraft hydraulic oil АМГ-10 is about 120°C. But the explosion proof non-flammable mineral oil fluid which withstands the temperature of 200°C (Russian НГЖ-4 – негорючая жидкость/гидрожидкость на синтетической основе) is used on the IL-86 aircraft.

The hydraulic system of an airplane comprises two parts: the first one is the network of pressure source accessories, and the second one is the network of consumer accessories. The network of pressure source accessories serves to create the operating pressure, accumulate energy, regulate pressure in the system, distribute energy between consumers, and to place some fluid reserves. The network of consumer accessories includes separate parts; each of them serves to actuate a particular mechanism. For example, a hydraulic complex of a modern airplane serves to deliver the working fluid to:

- the aircraft control system gears and high lift gears;
- the network of gear kinematics accessories;
- breaking action accessories;
- windscreen wiper accessories;
- freight section control accessories.

On modern aircraft two or more hydraulic systems are usually used. One of them is main, another one is the emergency system.
Many aircraft consumer accessories are powered simultaneously from several hydraulic systems. Due to this fact, their reliability is higher, since the failure of one system does not prevent the consumer accessory from being powered.

Each control plane (for example, stabilizers, spoilers, rudders etc.) is run by all the hydraulic systems available on the aircraft, and the other important consumer accessories (flaps, landing gear) are run by two or more hydraulic systems. Less important (for flight and safety) consumer accessories, and those operating only on the ground, are run by one hydraulic system.

Each hydraulic system has primary pumps, which create working pressure. Besides, there are also emergency power sources: fluid converters set up between the hydraulic systems, ram air turbines, and electric pumping units.

The construction of hydraulic systems varies a lot depending on the type of an aircraft; the aircraft construction varies as well. A general hydraulic schematic, present in all aircraft, is shown below.

All the hydraulic systems include:

- pressure sources (pumps, pump units);
- plumbing fitting with commutation accessories (pipe systems, valves, non-return valves, filters etc.);
- actuating accessories (hydraulic cylinders, hydraulic gears etc.);
- a hydraulic fluid filling-in system;
- a hydraulic fluid drain system;
- a pressurization system;
- a control- and gauge devices system.

The working pressure created by hydraulic pumps in the pressure pipe system equals 210 kg/cm^2 or sometimes more on modern aircraft.

The disadvantages of the hydraulic system are the comparatively large mass of accessories, pipelines and the working medium, the dependence of accessories' operation on the environment temperature. The damage of accessories and pipelines can lead to fluid leakages, which will cause more system failures.

Aircraft gas systems

In aircraft gas systems compressed gases energy is often used. These gases are kept in special high-pressure tanks. These systems are actuated by the expanding of the compressed gas (air, nitrogen etc.). The mass of pipelines and working medium is low; the system operates efficiently with high power output and is independent from environment temperature and fire proof. The gases are also used in aircraft accessories for additional control, where the high speed of response is needed, for example, to decelerate an aircraft. The main disadvantage of the system is high gas compressibility. This leads to considerable delays when the mechanism is initially actuated.

A pneumatic aircraft system is one of the gas aircraft systems.

The pneumatic system is used to start the engine, to stow the reverser doors, to actuate the landing gear, to control the landing flap, to brake the wheels. The pneumatic system does not differ much from the hydraulic system. It also includes power sources and power consumers, safety gears and control devices. The major power sources are air tanks, which can be recharged from groundborne power sources and from aircraft engines during the flight.

Electric systems

Electric systems are widely used to control the aircraft accessories remotely. They are also used in the automated systems of actuation devices, in autopilot actuators, in feel mechanisms of aircraft controllers, in trimming flaps control etc.

All the electric system devices consume energy from the onboard power system, which mainly aims to provide the onboard aircraft equipment with high-quality energy. The onboard electric system includes power generating devices and power distribution devices.

The aircraft safety depends on the reliability of the electric system. There are 3 types of power sources used on modern aircraft: main power sources, secondary power sources and emergency power sources. Main power sources provide the aircraft systems and devices with energy in normal flight conditions. Reserve power sources give energy to the consumers when some electric systems fail and the capacity of main power sources is not enough. Emergency power sources give energy only to the vitally important aircraft systems.

The aircraft electric accessories are of high quality, high mechanical and electrical reliability. They are explosion- and fire-proof, and easy to use.

Vocabulary notes

№	English	Ukrainian	Russian
1	Accessory; aggregate	Агрегат	Агрегат
2	Nitrogen	Нітроген; азот	Азот
3	High-pressure tank	Балон високого тиску	Баллон высокого давления
4	Board	Борт	Борт
5	High-lift device	Зльотно-посадочна механізація	Взлетно-посадочная механизация
6	Air	Повітря	Воздух
7	Gas	Газ	Газ
8	Gas system	Газова система	Газовая система
9	Producer; generator	Генератор	Генератор
10	Hydraulic power system	Гідравлічна система	Гидравлическая система
11	Hydraulic energy; hydraulic power	Гідравлічна енергія	Гидравлическая энергия
12	Hydraulic unit	Гідравлічний агрегат	Гидравлический агрегат
13	Hydraulic oils	Гідравлічне мастило	Гидравлическое масло
14	Hydraulic fluid	Гідравлічна рідина	Гидрожидкость (гидравлическая жидкость)
15	Hydraulic gear; hydraulic servo	Гідропривід	Гидропривод
16	Fluid converter; fluid transmission	Гідротрансформатор	Гидротрансформатор
17	Hydraulic actuator; hydraulic cylinder; hydraulic jack	Гідроциліндр	Гидроцилиндр
18	Civil aeronautics	Цивільна авіація	Гражданская авиация (ГА)
19	Cargo bay	Вантажний відсік	Грузовой отсек
20	Pressure	Тиск	Давление
21	Engine	Двигун	Двигатель
22	Duralumin	Дюралюміній	Дюралюминий
23	Liquid	Рідина	Жидкость
24	Flaps	Закрилки	Закрылки
25	Spoiler; strake	Інтерцептор	Интерцептор
26	Valve	Кран	Кран
27	Aircraft	Літальний апарат	Летательный аппарат (ЛА)
28	Manoeuvring ability	Маневреність	Манёвренность
29	High lift devices; wing devices	Механізація крила	Механизация крыла
30	Inflator; pump	Насос	Насос

№	English	Ukrainian	Russian
31	Non-return valve; ball valve	Зворотний клапан	Обратный клапан
32	Single-phase current	Однофазний струм	Однофазный ток
33	Alternating current	Змінний струм	Переменный ток
34	Pneumatic system; air system	Пневматична система	Пневматическая система
35	Direct current	Постійний струм	Постоянный ток
36	Hydraulic action systems	Приводи гідравлічної системи	Приводы гидравлической системы
37	Control plane; aerosurface	Кермова поверхня	Рулевая поверхность
38	Rudder; directional vane	Кермо напряму	Руль направления
39	Pressurization system	Система наддування	Система наддува
40	Electrical power supply	Система енергопостачання	Система электроснабжения
41	Plumbing fitting	З'єднувальна арматура	Соединительная арматура
42	Tail-plane; stabilizer block	Стабілізатор	Стабилизатор
43	Steel	Сталь; криця	Сталь
44	Reverser door	Стулка реверсу	Створка реверса
45	Wiper; wiper arm	Склоочисник	Стеклоочиститель
46	Three-phase current	Трифазний струм	Трёхфазный ток
47	Conduit pipe; pipe system	Трубопровід	Трубопровод
48	Ram air turbine	Турбонасосні установки	Турбонасосные установки
49	Observer; filter	Фільтр	Фильтр
50	Landing gear	Шасі	Шасси
51	Crew	Екіпаж	Экипаж
52	Electric system; electrical power system	Електрична система	Электрическая система
53	Electrical truck	Електричний агрегат	Электрический агрегат
54	Electrical power supply	Електричне джерело живлення	Электрический источник питания
55	Electric equipment	Електрообладнання	Электрооборудование
56	Electric pumping unit	Електроприводні насосні станції	Электроприводные насосные станции
57	Electrical wiring	Електропроводка	Электропроводка
58	Electrical energy	Електроенергія	Электроэнергия
59	Energy systems	Енергетичні системи	Энергетические системы

Вправи до тексту 5

I. Вправи на перевірку знань лексичного матеріалу

1) Give the definition to the following words:

a) Hydraulic system;
b) Hydraulic fluid;
c) Gas;
d) Hydraulic pump;
e) Working medium.

2) Fill in the gaps with appropriate words (each word can be used only once):

passengers	energy	accessories	gears	
kinematics	time	power supplies	weight	
reliability	important	dimensions	safety	fluids

1. Today modern aircraft transport huge numbers of __ and various cargoes.
2. To control modern aircraft more accurately and effectively both during the flight and during the ground __, aircraft engineers and designers have developed, produced and implemented a number of __ and systems, which operate independently.
3. The hydraulic system, for example, runs on special __.
4. The electric system runs on electrical __, which is produced by electrical ___.
5. The hydraulic system is one of the most __ systems on modern aircraft.
6. Hydraulic gears are used on modern aircraft due to their low __ and small __.
7. Hydraulic __ provide simple fixation of actuators' intermediate positions.
8. The hydraulic system of an aircraft runs the systems and mechanisms which are crucial for the flight __.
9. Hydraulic systems are widely used on aircraft to control stabilizers and rudders, high-lift devices, and gear __.
10. The aircraft safety depends on the __ of the electric system.

II. Вправи на перевірку знань лексики і розуміння вивченого матеріалу

1) Choose the right statement, put true (T) or false (F):

1. There are 5 types of power sources used on modern aircraft.
2. All the electric system devices consume energy from the onboard power system.
3. In aircraft gas systems compressed gases energy is often used.
4. The pneumatic system differs much from the hydraulic system.
5. The gases are also used in aircraft accessories for additional control, where the high speed of response is needed.
6. A pneumatic aircraft system is one of the electric aircraft systems.
7. The damage of accessories and pipelines cannot lead to fluid leakages.
8. Electric systems are widely used to control the aircraft accessories remotely.
9. The working pressure created by hydraulic pumps in the pressure pipe system equals 110 kg/cm2 or sometimes more on modern aircraft.
10. The hydraulic fluid is neutral to steel and duralumin, and its viscosity changes slightly with the change of temperature.

2) Choose the right (and appropriate) translation for each term:

1. **Pressurization system**
a) система поддува; b) система наддува; c) система давления.
2. **Direct current**
a) переменный ток; b) неизменный курс полёта; c) постоянный ток.
3. **Observer**
a) обслуживающее устройство; b) фильтр; c) наблюдатель.
4. **Producer**
a) генератор; b) производитель; c) продюсер.
5. **Control plane**
a) контрольный план; b) управление самолётом; c) рулевая поверхность.
6. **Rudder**
a) руль направления; b) покрышка; c) руль высоты.
7. **Aircraft**
a) летательный аппарат; b) самолёт; c) авикоптер.
8. **Alternating current**
a) изменение курса; b) альтернативное направление; c) переменный ток.

9. **Board**

a) панель; b) доска; c) борт.

10. **Single-phase current**

a) постоянный ток; b) однофазный ток; c) кратковременный ток.

III. Вправи на перевірку знань лексики і розуміння вивченого матеріалу на більш високому рівні

1) Translate from Russian/Ukrainian into English:

1. С дальнейшим ростом научно-технического прогресса, подъём в мировой авиационной науке и промышленности стал существенно заметен. / З подальшим зростанням науково-технічного прогресу, підйом у світовій авіаційній науці та промисловості став істотно помітним.

2. Сегодня современные ЛА перевозят огромное количество пассажиров и различных грузов, трудятся в сельском и лесном хозяйстве, нефтяной и газовой отраслях, стоят на вооружении армий многих стран мира. / Сьогодні сучасні ЛА перевозять величезну кількість пасажирів і різних вантажів, трудяться в сільському і лісовому господарстві, нафтовій і газовій галузях, стоять на озброєнні армій багатьох країн світу.

3. На современных самолётах используются различные виды энергии для приведения в действие отдельных элементов и агрегатов. / На сучасних літаках використовуються різні види енергії для приведення в дію окремих елементів і агрегатів.

4. Гидравлическая система является одной из важнейших в применении на современных самолетах. / Гідравлічна система є однією з найважливіших у застосуванні на сучасних літаках.

5. Рабочим телом гидросистемы на большинстве отечественных самолётов гражданской авиации является авиационное гидравлическое масло (гидравлическая жидкость) АМГ-10. / Робочим тілом гідросистеми на більшості вітчизняних літаків цивільної авіації є авіаційне гідравлічне масло (гідравлічна рідина) АМГ-10.

6. Работа гидравлической системы зависит от свойств этой гидравлической жидкости. / Робота гідравлічної системи залежить від властивостей цієї гідравлічної рідини.

7. Гидравлическая система самолета представляет собой сочетание двух частей: первая часть – это сеть агрегатов-источников давления и вторая – это сеть агрегатов-потребителей. / Гідравлічна система літака являє собою поєднання двох частин: перша частина - це мережа агрегатів-джерел тиску і друга - це мережа агрегатів-

споживачів.

8. Как правило, на современных самолётах используют две и более гидросистемы, одна из которых является основной, а вторая – дублирующей или аварийной. / Як правило, на сучасних літаках використовують дві і більше гідросистеми, одна з яких є основною, а друга – запасною або аварійною.

9. В каждой гидросистеме есть основные насосы, создающие рабочее давление. / У кожній гідросистемі є основні насоси, що створюють робочий тиск.

10. Пневматическая система самолёта используется при запуске двигателя, перекладении створок реверса двигателя, уборке и выпуске шасси, управлении посадочным щитком, торможении колёс. / Пневматична система літака використовується для запуску двигуна, перекладення стулок реверсу двигуна, прибирання і випускання шасі, управління посадковим щитком, гальмування коліс.

2) List the components of a hydraulic system.

IV. Додаткові питання (за змістом навчальних відеофільмів)

1. Which parts of the hydraulic system are shown in the video? (based on the film “Parker aerospace hydraulic systems”)

2. What are the functions of these parts? If you do not know, try and guess it.

3. Write down the names of these parts and translate them.

4. Find out the information about the functions of these parts from the books or the internet.

5. Compare the results with your answers and make the necessary corrections.

CHAPTER 6

Aircraft engines

The role of aircraft engines. A modern aircraft needs a special device to fly. This device must create reaction force, which allows the aircraft to fly in airspace with certain adjustable speed at suitable altitude. Such special modern aircraft devices are called engines. They are situated on an aircraft board. It is noteworthy that these engines are traditionally called aircraft engines to distinguish them from other technical devices engines.

Design features of aircraft engines. A modern aircraft engine is a quite complex device, which requires a number of other additional systems, devices and accessories to operate efficiently. Such systems include, for example, an engine fuel supply control system, an engine starting system, engine operating and monitoring systems, lubricating systems, engine fire-protection systems.

Thus, all these systems consist of their own devices, accessories, pipelines, electric circuits etc. Among such additional devices, providing the efficient engine operation, intake systems and exhaust arrangements (or exhaust sections) can be named.

Together with all these devices an aircraft engine composes an **engine unit**.

The engine unit weight is approximately 8-22% of the aircraft take-off weight, depending on the aircraft purpose and performance.

The fuel for a modern aircraft engine is usually situated in fuel tanks on board. The operation principle of an aircraft engine is that it translates molecular fuel energy into caloric and mechanical energy. The major part of the energy derived is used to create thrust force, the remainder powers various aircraft systems and accessories. So, an aircraft engine is a primary energy source of an aircraft.

Aircraft engine types

Since an aircraft engine is one of the basic aircraft constructional units, there is a number of requirements for it to meet. An aircraft engine must provide the necessary maneuvering and runway aircraft performance, necessary flying range, ascensional rate and flying altitude. It must economize fuel in a wide range of flight altitudes and speeds, operate dependably and unalterably, and be fireproof. It must have long operational life without requiring repair. All these complicated and contradictory requirements lead aircraft designers to creating various engine types which operate at different gas-dynamics (Fig. 6.1).

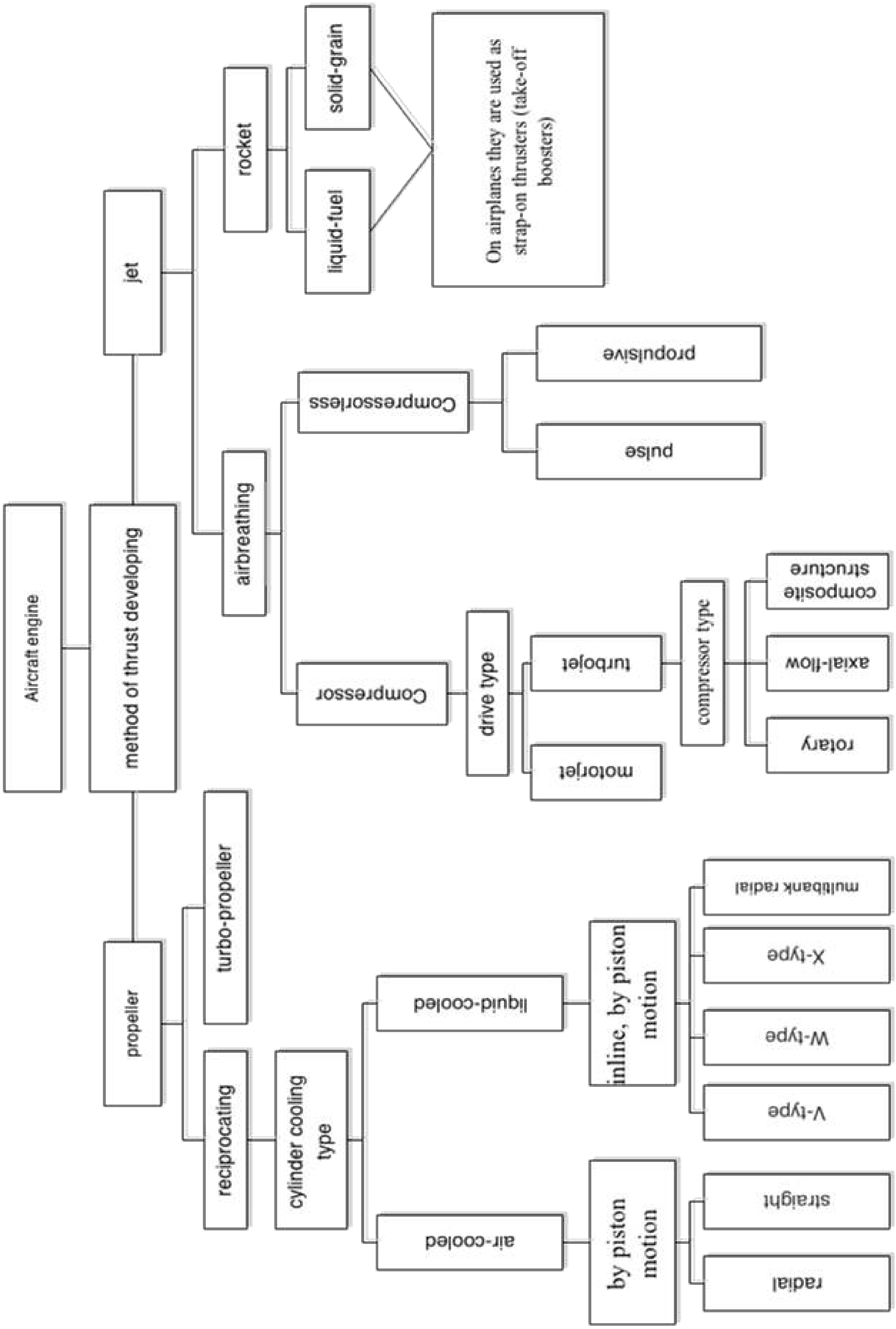


Fig. 6.1. Aircraft engine types

There are propeller engines and jet engines according to the way of thrust force creating.

Propeller engine. A propeller engine uses its propeller (also known as thrust producer) to create the thrust force needed for flying. Propeller engines are divided into reciprocating engines and turbo-propeller engines.

Almost all aircraft models are reported to have been equipped with propeller engines at the outset of aviation development. A reciprocating internal combustion engine had been developed for the propeller engine drive, and it had been used successfully. It is essentially similar to motorcar and motorcycle internal combustion engines. The difference is that a motorcar reciprocating engine transfers energy of its torque effect directly to traction wheels through a number of accessories. An aircraft reciprocating engine transfers its torque effect energy to the propeller.

As the required flight speed and altitude were increasing, further engine-propeller power plant development provided high aircraft efficiency. So called thrust power is one of the parameters showing engine-propeller power plant efficiency. It is the power transferred directly to an aircraft by power-plant propeller. It is also a determinant for thrust force.

Further studying and developing of engine-propeller power plants revealed a number of disadvantages. For example, it was found that a propeller operates efficiently only when the **Mach number** equals to 0.5-0.6.

The Mach number is named after Austrian physicist and philosopher Ernst Mach. It usually represents the ratio of aircraft speed which is equal to the speed of sound or exceeds it. The Mach number at which an aircraft is flying can be calculated by

$$\mathrm{M} = \frac{v}{v_{\mathrm{sound}}},$$

where: ***M*** is the Mach number,

v is speed of the moving aircraft and

$\boldsymbol{v}_{sound}$ is the speed of sound at the given altitude.

At an altitude below 3000 m the speed corresponding to 1 M is approximately equal to 300-330 m/s or 1080-1100 km/h, which corresponds to the speed of sound.

Consequently, flight can be roughly classified in three categories:

Regime	*Subsonic*	*Sonic*	*Supersonic*
Mach	<1.0	1.0	1.0–5.0

The overwhelming majority of modern aircraft flies at the subsonic speed. When the aircraft flight speed is being increased, air compression on the edges of propeller blades is reducing propeller efficiency. That is why the thrust power could not be increased any more as early as in 1950s. It became impossible to increase the flight speed and altitude by increasing the reciprocating engine power, as it lead to unacceptable aircraft weight and dimensions increase. However, developing aerospace technologies further, aircraft designers managed to use power plants along with jet engines, as their thrust power does not reduce when the flight speed is increased. That is how a **turbo-propeller engine** was created.

Anyway, reciprocating engines are widely used nowadays on light low-speed aircraft.

Jet engines create thrust by a direct reaction of an exhaust jet, emitted by engine at a high speed. They fall into jet motors and airbreathing jet engines.

Jet motors are divided into liquid-fuel jet motors and solid-fuel jet motors according to the fuel type. Jet motors are known for their unique properties, such as steady thrust power in a wide speed range, and operating at high flight altitudes including airless space. Plus, their thrust increases with the increase of the flight altitude. Such engines are notable for their relatively simple design and the ability to create high powers in spite of small weight and dimensions of an aircraft. That is why jet motors are unexpendable for aircraft intended to flying in airless space.

However, jet motors have a number of substantial disadvantages. For example, they consume a lot of fuel, they cannot control thrust on wide ranges, and they cannot transfer energy to aircraft systems from main engines which requires additional sources of power supply on board, as well as fuel and oxidizing agent supplies (to keep the fuel burning in the airless space). All these factors reduce the aircraft operating efficiency considerably. Jet motors are not used in power plants of transport aircraft flying within the atmosphere.

Sometimes jet motors are used on high-speed maneuvering aircraft as additional power plants to increase the flight speed or altitude for a short period of time. They are also used as take-off boosters for an aircraft to operate successfully on shorter runways.

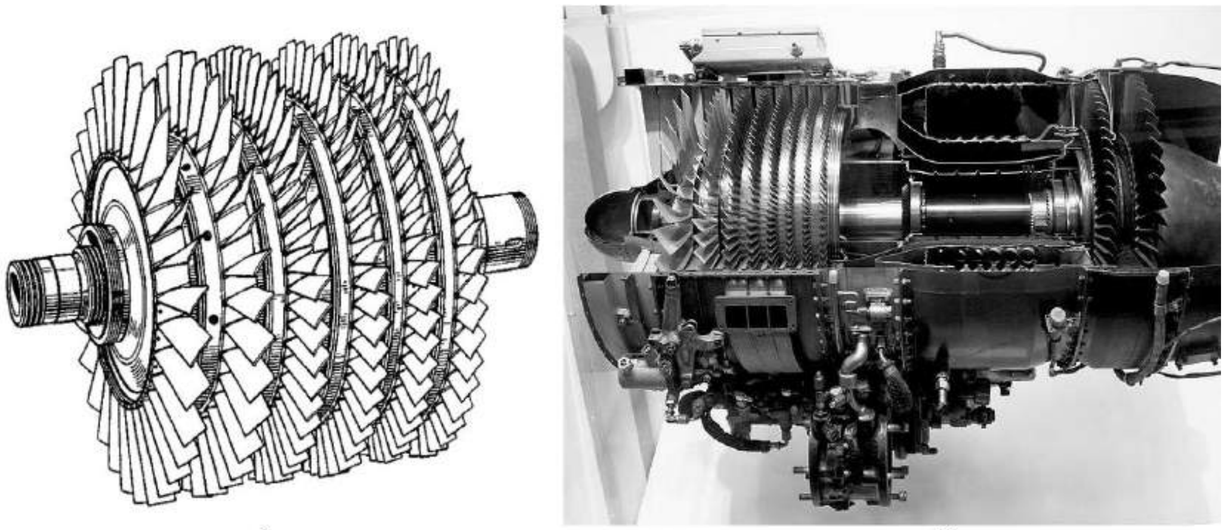
Airbreathing jet engines run on kerosene. As an oxidizing agent they use the atmospheric oxygen. It is known that the air density decreases on higher altitudes, and the oxygen content decreases as well. That is why the mass-flow rate of the oxidizing agent and fuel decreases as the aircraft gains height. Consequently, the thrust decreases as well. Thus, an airbreathing jet engine is a sea-level engine. It operates efficiently at the altitude of 30-50 km. On the other hand, it has a limited flight-speed range. The maximum Mach number of an aircraft with such an engine depends on some design factors. It does not exceed **M = 4 – 6** for airbreathing jet engines of usual schemes and types. However, in their prior use area these engines are much more economizing than jet motors.

Airbreathing jet engines have various designs, schemes and operation principles. According to the way of air compressing they can be divided into compressionless jet engines and compression jet engines.

In ***compressionless jet engines*** air is compressed only by means of wind blast. Propulsive jet engines and pulse jet engines belong to such engines.

In ***compression jet engines*** air is compressed mechanically by means of axial-flow volumetric compressors (Fig. 6.2) or rotary compressors (Fig. 6.3). These compressors are rotated by gas turbines. Such engines are called gas-turbine engines as their major design element is the gas turbine, which is the source of mechanical rotation energy.

A turbojet engine is the most widespread in aviation, as it is a foundation of the whole gas-turbine engine series.



1 2

Fig. 6.2. Axial-flow volumetric compressor

1-axial-flow volumetric compressor rotor;
blade wheels are on the axial drive shaft;
2-an aircraft engine J-85 with an axial-flow volumetric compressor.


1

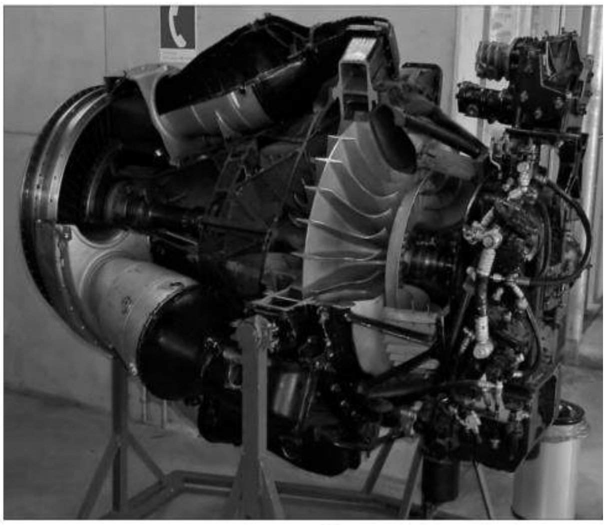

2

Fig. 6.3. Rotary compressor

1-rotary compressor blade wheel;
2-an aircraft engine ВК-1 with a rotary compressor.

Gas-turbine engine types: their major design elements, purposes and design

Aircraft gas-turbine engines are divided into turbojet engines, turbo-propeller engines and by-pass turbojet engines.

Turbojet engine. A turbojet engine is a gas-turbine engine which creates thrust ($\mathbf{P}_{дв}$ is a mathematical indicator for aircraft engine thrust) by translating caloric energy, produced by fuel-burning, into kinetic energy of a gas flow. The reaction caused by this is used as propulsion force. The whole turbojet engine work output goes to increasing the kinetic energy of the test medium, accelerating the flow inside the engine, creating thrust work. It is worth mentioning, that the turbojet engine gas turbine has power equal to that of the compressor. In case of using gas-turbine power to rotate a propeller (1), a fan (2) or an additional compressor in the by-pass duct (3), a gas-turbine engine is called respectively a turbo-propeller engine (1), a turbofan (2) or a by-pass turbojet (3). By-pass turbojets have two thrust producers.

There is a turbojet engine scheme in Fig. 6.4, with the accessories, on the basis of which other turbojet engine types are created:

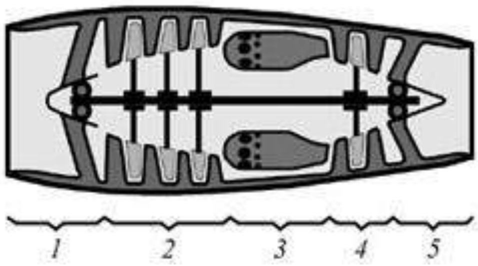


Fig. 6.4. Turbojet engine scheme

1-intake system; **2**-axial compressor; **3-**burner section; **4-**turbine; **5-**nozzle.

Since the turbojet engine is a basis for creating a number of other engine types, its operation principle is also basic (Fig. 6.5).

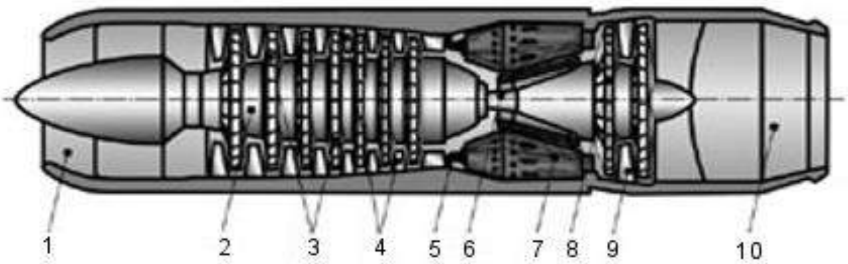


Fig. 6.5. Turbojet engine operation scheme

The airflow is slowed down in the intake engine system (1), which results in the pressure increase in front of the axial compressor (2). Rotor (rotating part) comprises a number of compressor blade wheels (3). A blade wheel is depicted in Fig. 6.5a.

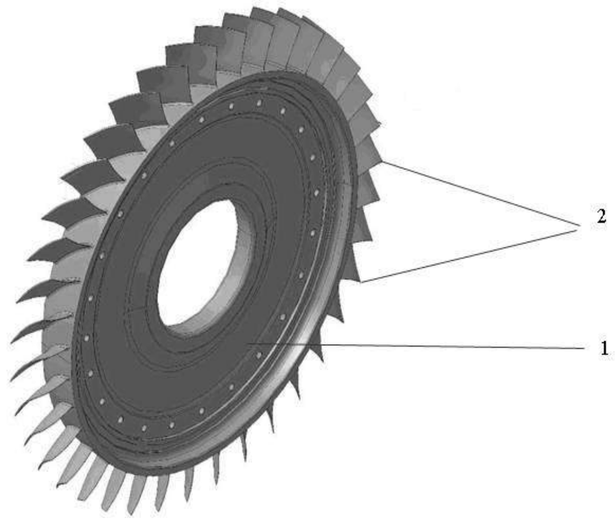


Fig. 6.5a. Axial compressor blade wheel design

1-axial compressor blade wheel disc; **2**-blade wheels.

While rotating, rotor, like a propeller, affects the airflow and makes it move along the engine axes through the row of straightener blades (4) (Fig. 6.5) – hard set circumferentially on the engine body. Each row of straightener blades is situated behind the corresponding blade wheel and forms a stator (fixed part of a compressor). The row of hard set blades, called an outlet straightener, together with the row of working blades is called a compressor stage. The multistage axial compressor compresses air increasing its pressure by 10-40 times. The ratio of compressor delivery air pressure p2 to compressor inlet pressure p1 is called compression ratio: $\pi c= p2/p1$. Compressed air then moves to the burner section, formed by several flame tubes (7) (or an annular tube – see Fig. 6.5b).

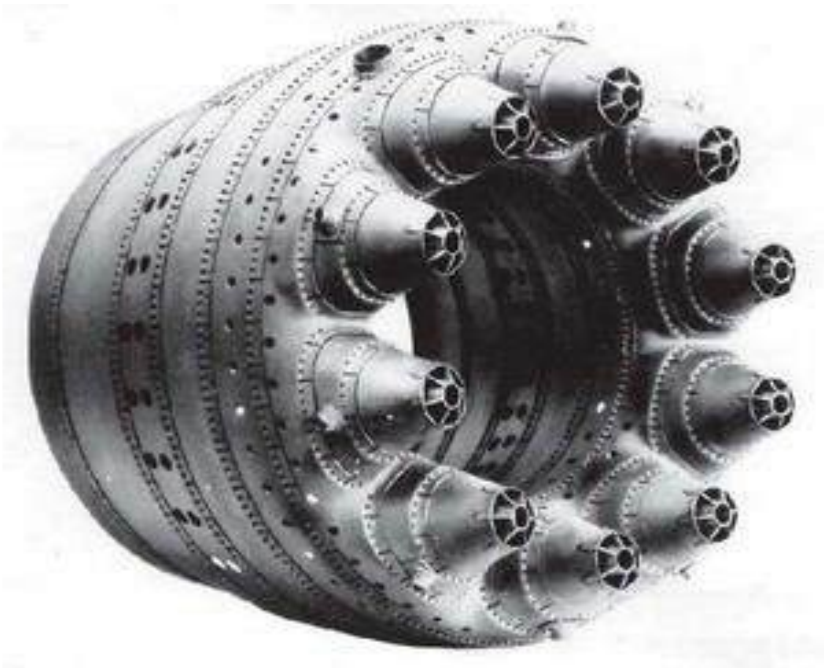


Fig. 6.5b. Burner section formed by an annular tube

About 25-35% of the whole airflow is directed to the flame tubes ***special fuel blow pipes*** *(5)* (see Fig. 6.5. Also see Fig. 6.5c), where kerosene burns. Kerosene inflows here floured through special fuel blow pipes.

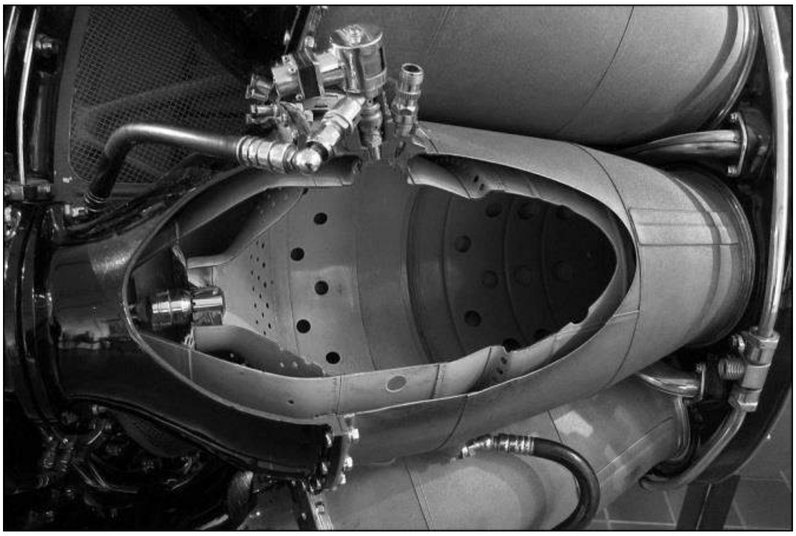


Fig. 6.5c. Burner section formed by a set of flame tubes

The other part of air flows around the flame tubes outer surface cooling them. As it leaves burner section, air blends with combustor discharge to cool them. This keeps the gas-air mixture temperature in the burner section within **Tg** = 1400 - 1900 K (**Tg** – is a mathematical indicator for gases temperature calculated in Kelvins). **Tg** depends on permissible heat resistance of burner section walls, rotor (8) blades (Fig. 6.5) and **turbine outlet straightener blades** (9) (Fig. 6.5) The high-temperature gas-flow with high pressure moves through the exhaust system to the turbine work stages.

A part of gas-air mixture potential energy received by compressing and heating air is translated by gas-turbine rotor into mechanical work of compressor rotor, which is connected to the turbine rotor by a common drive shaft (6) (Fig. 6.5). Moreover, a part of drive shaft (6) mechanical power goes to engine accessories drive (fuel booster pumps, oil bumps etc.), as well as electric power generators drive, which provide various aircraft systems with electrical power. A part of compressed air also goes from compressor to various aircraft systems.

The greater part of combustor discharge is used to accelerate the gas-flow in the propelling nozzle (10) (Fig. 6.5), that is to create reaction force.

Initial drive shaft (5) spin up is carried out by starting the engine with the ground-based or on-board electrical unit. As the engine burns further, drive shaft rotation is maintained by turbine rotor rotation.

When the engine is started, the fuel-air mixture in the burner section is ignited by a special flame igniter. Further burning is maintained by available jet of flame.

The afterburning turbojet engine (Fig. 6.6) is widely used on high-speed combat aircraft.

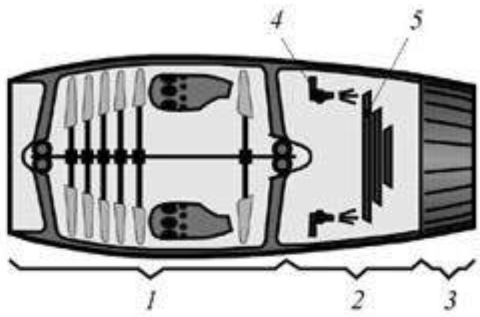


Fig. 6.6. Afterburning turbojet engine scheme

As in turbojet engine, the base of afterburning turbojet engine is a turbo compressor (gas generator) (1), which includes a compressor, a burner section and a turbine. Between the turbo compressor and the nozzle (3) (usually adjustable) there is an afterburner duct (2), where the additional fuel (kerosene) is burned. The fuel is introduced through propulsive nozzles (4) of the afterburner duct. Flame holders (5) provide the stable burning of oxygen-leaned fuel mixture (a part of air oxygen is used while kerosene burning in the turbo compressor burner section). Burning additional fuel increases thrust by 50% or more. This results in an abrupt increase in fuel use. That is why augmentation mode is used only to reduce the runway length while taking-off, as well as to increase the ascensional rate or flight speed during air combats.

Turbo-propeller engine. A turbo-propeller engine is a gas-turbine engine. It has both compressor and turbine (turbo compressor). It is fuel-efficient. A turbo-propeller engine is used on subsonic (600-800 km/h) aircraft (Fig. 6.7). A turbo-propeller engine is essentially a gas-turbine engine. It creates thrust force (85-90%) by the propeller (1), rotated by turbo compressor (3).

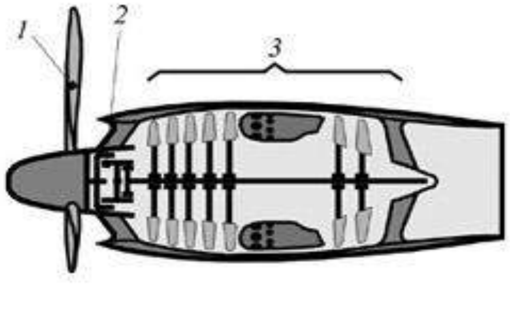


Fig. 6.7. Turbo-propeller engine scheme

The ratio changer (2) decreases the rotation ratio.

By-pass turbojet. Further aircraft fuel efficiency increase results from by-pass turbojets usage(Fig. 6.8), where surplus power of turbo compressor turbine (2) is transferred to an additional low-pressure compressor (1) of so called secondary engine duct.

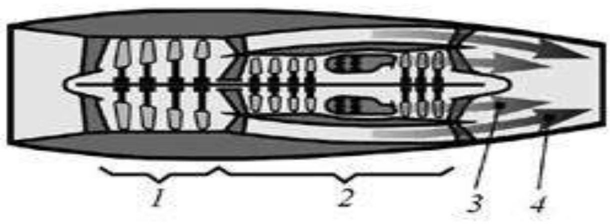


Fig. 6.8. A by-pass turbojet scheme

An airflow inflows into the by-pass turbojet, where it is compressed (1), and a part of the flow (3) moves through the turbo compressor (2), where the operating process is similar to that of turbojet engine.

Another (cold) part of the airflow (4) moves through the secondary low-pressure duct and blends with the hot flow (3) when leaving the duct.

The design of a by-pass turbojet is more complex, which results in its high economic feasibility and good operational characteristics.

By-pass turbojets with reheat are used on maneuvering multimode supersonic aircraft (usually in the secondary duct).

The basic parameters of any engine are the following:

- engine mass $\mathbf{m_e}$ and dimensions;
- engine take-off thrust $\mathbf{P_{e0}}$;
- altitude-speed performance;
- engine service life.

To get the necessary thrust, a pilot must select the corresponding power plant mode. The pilot controls the engine operation mode using a forward thrust lever, which regulates fuel consumption (decelerates).

Purpose and design features of gas-turbine engine additional devices

Engine intake system. To feed the necessary amount of air to the engine, **intakes** are used (Fig. 6.9). Intakes slow down the airflow, increasing its pressure before it moves to the compressor.

Fig. 6.9. Aircraft intakes

1-fixed geometry intake; **2**-aircraft with variable geometry intakes.

On subsonic and sonic aircraft fixed geometry intakes are used. They do not have any moving elements.

On supersonic aircraft variable geometry intakes are used. They have moving parts and elements which affect the airflow and adjusts its feed to the compressor. Using variable geometry intakes on supersonic aircraft results in complexity of the intake system design, its high mass and cost, but it makes engine operation more stable and economically feasible on a wide speed- and altitude-range.

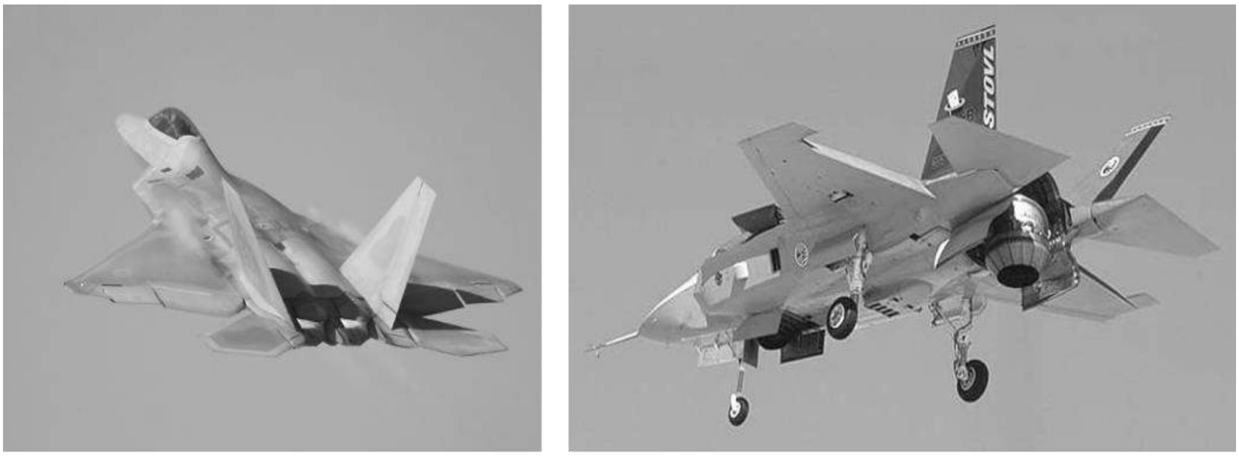
Engine exhaust arrangement. The engine intakes and **nozzles** are adjusted at the same time (Fig. 6.10). Depending on the flight mode, the aircraft engine electronics adjusts the nozzle automatically, providing the necessary aircraft performance (e.g. speed, weight-lift ability, maximum flight altitude) by adjusting engine thrust.

Fig. 6.10 Jet nozzle

In some cases **reverses** (Fig. 6.11) are added to the fixed geometry engine nozzles of transport aircraft, to adjust the thrust vector. Their operation principle makes it possible to deflect the exhaust jet forwards, which shortens the landing distance considerably.

Fig. 6.11 Reverse operation

On supersonic maneuvering aircraft flat and circular nozzles (Fig. 6.12) are also used. They make it possible to adjust the thrust vector in any direction to improve the aircraft maneuvering performance.



1 2

Fig. 6.12 Aircraft nozzles

1-flat nozzles of F-22; **2**-circular nozzles of F-35

Aircraft gas-turbine engines are extremely widespread in aviation due to their economic feasibility, long-term service life, steady long-term operation, and relatively small unit weight. Aircraft gas-turbine engines are wide-range engines, meant for subsonic and supersonic flights. They form a core of nearly whole modern transport aircraft engine-building. It is successful aircraft gas-turbine engines development and the high level of their technical perfection that technical-economic developments of modern civil aviation result from.

Vocabulary notes

№	English	Ukrainian	Russian
1	aerospace engineering	авіакосмічна техніка	авиакосмическая техника
2	aviation	авіація	авиация
3	accessory; aggregate	агрегат	агрегат
4	airless space	безповітряний космічний простір	безвоздушное космическое пространство
5	compressionless jet engine	безкомпресорний ПРД	бескомпрессорный ВРД
6	board	борт	борт
7	aircraft-based system; aircraft system	бортові системи	бортовые системы
8	shaft	вал	вал
9	traction wheels; driven wheels; entry wheels	тягові колеса	ведущие колеса
10	thrust vector	вектор тяги	вектор тяги
11	helicopter	вертоліт	вертолет
12	gross weight; take-off weight	злітна маса ЛА	взлётная масса ЛА
13	runway	злітно-посадкова смуга (ЗПС)	взлётно-посадочная полоса (ВПП)
14	field performance; runway performance	злітно-посадкові характеристики	взлетно-посадочные характеристики
15	propeller engine	гвинтовий двигун	винтовой двигатель
16	engine-propeller combination	гвинтомоторна група	винтомоторная группа
17	engine-propeller power plant	гвинтомоторна силова установка	винтомоторная силовая установка

№	English	Ukrainian	Russian
18	secondary duct	зовнішній контур (двоконтурного двигуна)	внешний контур (двухконтурного двигателя)
19	main duct	внутрішній контур (двоконтурного двигуна)	внутренний контур (двухконтурного двигателя)
20	intake	повітрозабірник	воздухозаборник
21	airbreathing jet engine	повітряно-реактивний двигун (ПРД)	воздушно-реактивный двигатель (ВРД)
22	propeller; windmill	повітряний гвинт	воздушный винт
23	intake system; inlet; air inlet duct; intake area	вхідний пристрій (двигуна)	входное устройство (двигателя)
24	altitude-speed performances	висотно-швидкісні характеристики	высотно-скоростные характеристики
25	altitude engine	висотний двигун	высотный двигатель
26	exhaust arrangement	вихлопні пристрої двигуна	выхлопные устройства двигателя
27	gas turbine	газова турбина	газовая турбина
28	gas-dynamic	газодинаміка	газодинамика
29	gas-turbine engine	газотурбинний двигун (ГТД)	газотурбинный двигатель (ГТД)
30	civil aviation	цивільна авіація	гражданская авиация
31	flying range	дальність польоту	дальность полета
32	engine	двигун	двигатель
33	internal combustion engine (ICE)	двигун внутрішнього згоряння (ДВЗ)	двигатель внутреннего сгорания (ДВС)

№	English	Ukrainian	Russian
34	thrust producer	рушій	движитель
35	propulsion force	рушійна сила	движущая сила
36	subsonic speed; subsonic velocity	дозвукова швидкість	дозвуковая скорость
37	decelerate; throttle down	дроселювати	дросселировать
38	flame tubes; fire tubes	жарові труби	жаровые трубы
39	liquid-fuel jet motor	рідинний ракетний двигун (РРД)	жидкостный ракетный двигатель (ЖРД)
40	flame igniter	запальний пристрій	запальное устройство
41	true airspeed	істинна швидкість у потоці	истинная скорость в потоке
42	burner can; burner section; combustor chamber	камера згоряння	камера сгорания
43	kerosene (JP8 fuel)	керосин	керосин
44	axial-flow volumetric compressor	компресор осьового типу	компрессор осевого типа
45	rotary compressor	компресор відцентрового типу	компрессор центробежного типа
46	compression jet engine; air-injection jet engine	компресорний ПРД	компрессорный ВРД
47	constructional unit	конструктивний вузол	конструктивный узел
48	ducting; duct	контур (двигуна)	контур (двигателя)
49	torque effect	крутний момент	крутящий момент
50	aircraft	літальний апарат	летательный

		(ЛА)	аппарат (ЛА)
51	aircraft performance	льотно-технічні характеристики ЛА	лётно-технические характеристики ЛА
52	drag surface; blade of an oar	лопаті гвинта	лопасти винта
53	manoeuvring ability	маневреність	маневренность
54	maneuvering performance	маневрені характеристики	манёвренные характеристики
55	cruising engine; main engine	маршовий двигун	маршевой двигатель
56	lubrication pump; oil pump	масляний насос	масляный насос
57	mechanical energy; mechanical power	механічна енергія	механическая энергия
58	sea-level engine	невисотний двигун	невысотный двигатель
59	fixed geometry intake	нерегульовані повітрозабірники	нерегулируемые воздухозаборники
60	oxidizing material; oxidising agent	окислювач	окислитель
61	reciprocating engine	поршневий двигун (ПД)	поршневой двигатель (ПД)
62	propulsive jet engine	прямоточний ПРД (ПВРД)	прямоточный ВРД (ПВРД)
63	pulse jet engine	пульсуючий ПРД (ПуПРД)	пульсирующий ВРД (ПуВРД)
64	burning	робота (двигуна)	работа (двигателя)
65	blade wheel	робоче колесо (турбини, компресора)	рабочее колесо (турбины, компрессора)
66	solid-fuel jet motors	ракетні двигуни твердого палива	ракетные двигатели твердого

		(РДТП)	топлива (РДТТ)
67	rocket; jet-motor; jet motor	ракетний двигун (РД)	ракетный двигатель (РД)
68	jet flame; jet blast	реактивний струмінь	реактивная струя
69	reaction force	реактивна тяга	реактивная тяга
70	jet pipe; propelling nozzle	реактивне сопло	реактивное сопло
71	jet thruster; jet engine	реактивний двигун	реактивный двигатель
72	thrust management; thrust control	регулювання тяги	регулирование тяги
73	variable intake; variable geometry intake	регульовані повітрозабірники	регулируемые воздухозаборники
74	engine endurance	ресурс двигуна	ресурс двигателя
75	operational life	ресурс роботи	ресурс работы
76	rotor	ротор	ротор
77	throttle control lever; forward thrust lever	важель керування двигуном (ВКД)	рычаг управления двигателем (РУД)
78	airplane	літак	самолет
79	supersonic speed	надзвукова швидкість	сверхзвуковая скорость
80	air compressibility	стискуваність повітря	сжимаемость воздуха
81	engine unit; power-unit	силова установка	силовая установка
82	fuel feed system; fuel pumping system; fuel supply system	система подання палива	система подачи топлива
83	ascensional rate	швидкопідйомніс ть	скороподъёмность

84	reversal	створення зворотної тяги (реверс)	создание обратной тяги (реверс)
85	blast pipe; choke tube; exhaust section	сопло	сопло
86	nozzle assembly	сопловий апарат	сопловой аппарат
87	straightener blade; guide vane	спрямовуюча лопатка	спрямляющая лопатка
88	outlet straightener	спрямовуючий апарат	спрямляющий аппарат
89	flame holder; flame stabilisator	стабілізатор полум’я	стабилизатор пламени
90	start unit; starter	стартер	стартер
91	boost for launching; takeoff thrust	стартова тяга	стартовая тяга
92	take-off booster; jato	стартовий прискорювач	стартовый ускоритель
93	stator	статор	статор
94	compression ratio; engine pressure ratio	ступінь підвищення тиску	степень повышения давления
95	turbine stage	щабелі турбіни	ступени турбины
96	compressor stage	щабель компресора	ступень компрессора
97	solid-grain	твердопаливний	твердотопливный
98	caloric energy; thermal power	теплова енергія	тепловая энергия
99	reservoir; tank	паливний бак	топливный бак
100	fuel pump; propellant pump	паливний насос	топливный насос
101	fuel	паливо	топливо
102	fuel priming pump	паливо-підкачувальний	топливо подкачивающий

		насос	насос
103	fuel-air mix	паливоповітряна суміш	топливовоздушная смесь
104	pipeline	трубопровід	трубопровод
105	fan engine; fan jet; fan-type engine; propfan; turbofan	турбовентилятор-ний двигун	турбовентиляторный двигатель
106	jet-prop engine; turbo-propeller engine	турбогвинтовий двигун	турбовинтовой двигатель (ТВД)
107	turbo compressor; gas producer; gas generator	турбокомпресор	турбокомпрессор
108	by-pass turbojet with reheat	турбореактивні двоконтурні двигуни з форсажем (ТРДДФ)	турбореактивные двухконтурные двигатели с форсажем (ТРДДФ)
109	turbojet engine (TJE)	турбореактивний двигун (ТРД)	турбореактивный двигатель (ТРД)
110	afterburning turbojet engine; turbojet engine with reheat	турбореактивний двигун з форсажною камерою згоряння (ТРДФ)	турбореактивный двигатель с форсажной камерой сгорания (ТРДФ)
111	bypass turbojet; by-pass engine; by-pass turbo-jet	турбореактивний двоконтурний двигун (ТРДД)	турбореактивный двухконтурный двигатель (ТРДД)
112	thrust	тяга	тяга
113	motive power; thrust horsepower	тягова потужність	тяговая мощность
114	jet of flame; flame bush	факел полум’я	факел пламени
115	afterburner duct; reheat; augmentor	форсажна камера	форсажная камера

116	augmentation; boosting; forcing	форсування	форсирование
117	propulsive nozzle; blow pipe; discharging jet	форсунка	форсунка
118	molecular energy; chemical energy	хімічна енергія	химическая энергия
119	mach; Mach number	число Маха	число Маха
120	electric circuit	електричне коло	электрическая цепь
121	electrical truck	електроагрегат	электроагрегат
122	generator set electrical generator	електрогенератор	электрогенератор
123	power supply	енергоживлення	энергопитание

Вправи до тексту 6

I. Вправи на перевірку знань лексичного матеріалу

1) Give the definitions to the following words:

a) Engine;
b) Engine unit;
c) Mach number;
d) Supersonic aircraft;
e) Intake system.

2) Fill in the gaps with appropriate words (each word can be used only once):

Density	Subsonic	Thrust	Reverses
Intakes	Propeller	Fuel-burning	Nozzles
Supersonic	Stator	Airflow	Augmentation

1. A propeller engine uses its ____ (also known as thrust producer) to create the thrust force needed for flying.
2. Jet engines create _____ by a direct reaction of an exhaust jet, emitted by engine at a high speed.
3. It is known that the air _____ decreases on higher altitudes, and the oxygen content decreases as well.
4. A turbojet engine is a gas-turbine engine which creates thrust by translating caloric energy, produced by ____, into kinetic energy of a gas flow.
5. Each row of straightener blades is situated behind the corresponding blade wheel and forms a ____.
6. A turbo-propeller engine is used on ____aircraft.
7. To feed the necessary amount of air to the engine, ____ are used.
8. Intakes slow down the ____, increasing its pressure before it moves to the compressor.
9. On ____ aircraft variable geometry intakes are used.
10. In some cases _____ are added to the fixed geometry engine nozzles of transport aircraft, to adjust the thrust vector.

II. Вправи на перевірку знань лексики і розуміння вивченого

1) Choose the right statement, put true (T) or false (F):

1. A turbojet engine is the most widespread in aviation.

2. Jet motors consume little fuel.

3. Sometimes jet motors are used as additional power plants.

4. Jet engines are divided into liquid-fuel engines and solid-fuel engines.

5. The overwhelming majority of modern aircraft flies at the subsonic speed.

6. An aircraft reciprocating engine transfers its torque effect energy to the propeller.

7. Reciprocating engines are not used nowadays.

8. Jet engines create thrust by a direct reaction of an exhaust jet, emitted by engine at a high speed.

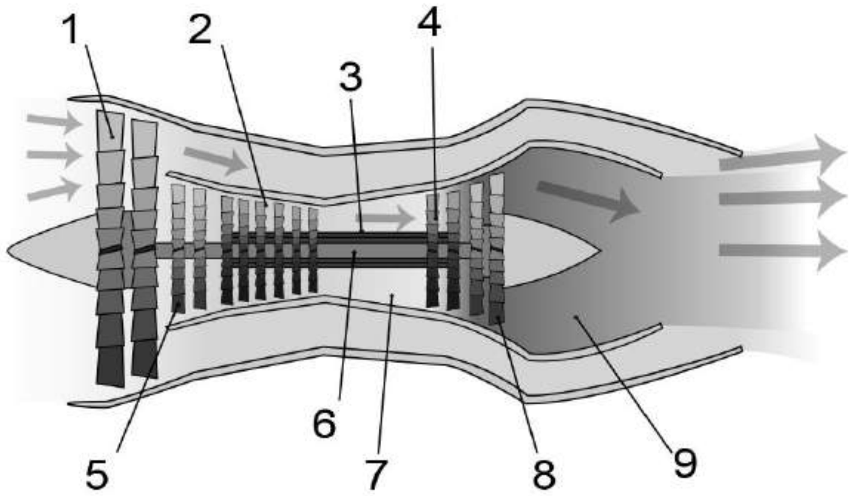
9. Jet motors are used in power plants of transport aircraft flying within the atmosphere.

10. Sometimes jet motors are used as take-off boosters.

2) Name the engine type. Match the engine parts with their names:

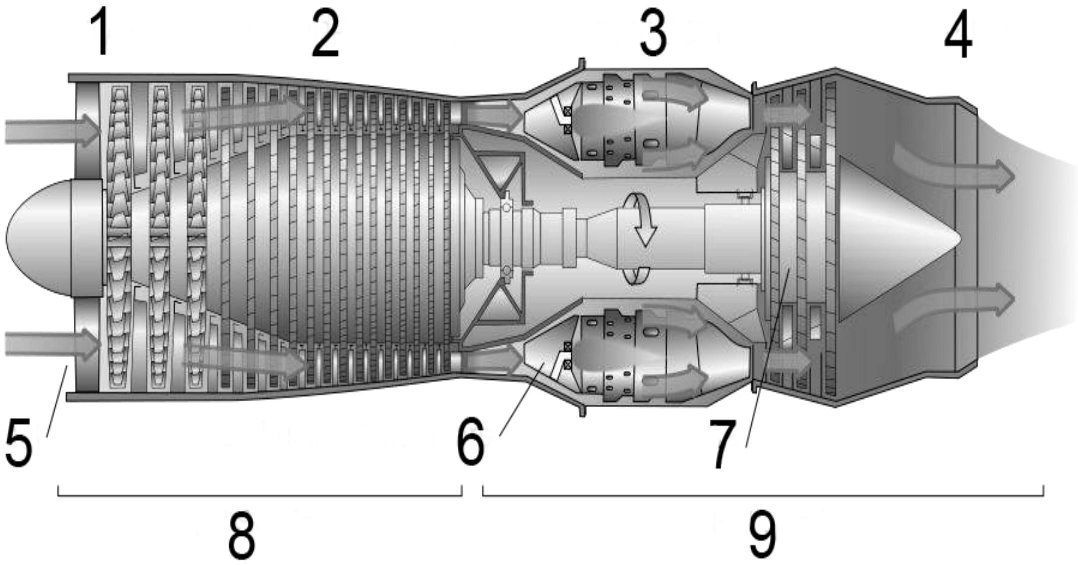
1.

Low-pressure rotor drive shaft	Fan	Burner section
High-pressure turbine	Nozzle	High-pressure compressor
High-pressure rotor drive shaft	Low-pressure compressor	Low-pressure turbine



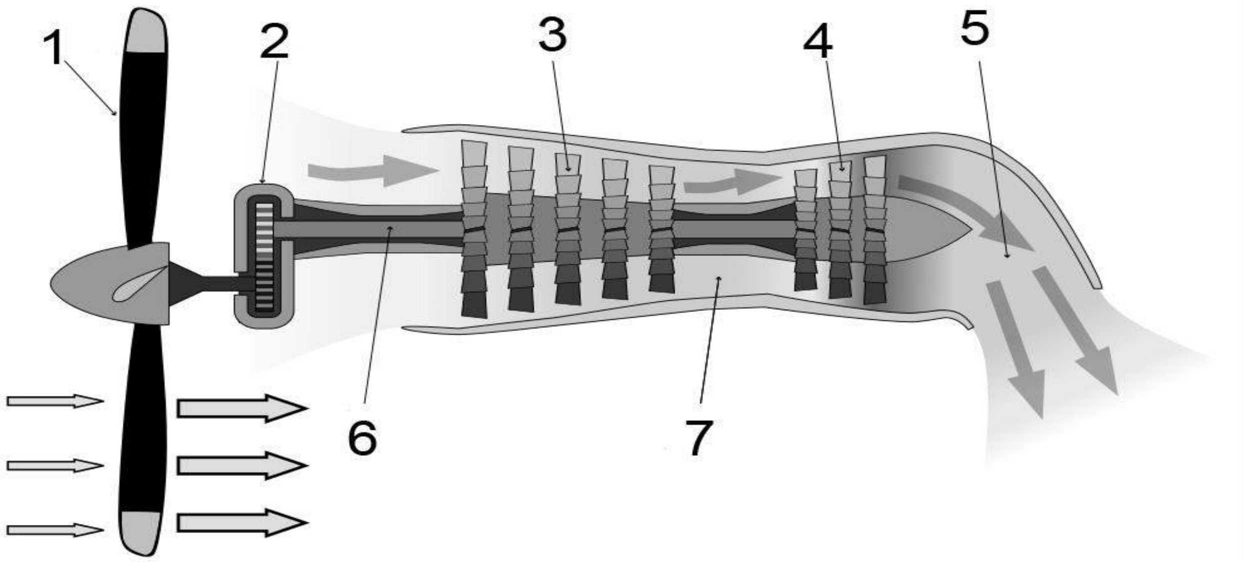
2.

Compression	Air inlet	Burner sections
Combustion	Intake	Exhaust
Turbine	Hot section	Cold section



3.

Exhaust	Burner section	Compressor
Propeller	Turbine	Transmission
Drive shaft		



III. Вправи на перевірку знань лексики і розуміння вивченого матеріалу на більш високому рівні

1) Translate from Russian/Ukrainian into English:

1. На начальном этапе развития авиации почти все модели летательных аппаратов были оснащены винтовыми двигателями. / На початковому етапі розвитку авіації майже всі моделі літальних апаратів було оснащено гвинтовими двигунами.

2. Одним из основных параметров, характеризующих эффективность винтомоторной силовой установки с ПД, является так называемая тяговая мощность. / Одним з основних параметрів, що характеризують ефективність гвинтомоторної силової установки із ПД, є так звана тягова потужність.

3. Дальнейшее изучение и усовершенствование винтомоторных силовых установок с ПД выявило ряд недостатков. / Подальше вивчення й удосконалення гвинтомоторних силових установок із ПД виявило ряд недоліків.

4. Обычно в числах Маха измеряют скорость полета самолета равную или превышающую скорость звука. / Зазвичай у числах Маха вимірюють швидкість польоту літака, що дорівнює або перевищує швидкість звуку.

5. Реактивные двигатели создают тягу за счет прямой реакции струи выхлопных газов, вырывающихся с большой скоростью из двигателя. / Реактивні двигуни створюють тягу за рахунок прямої реакції струменю вихлопних газів, що вириваються із великою швидкість з двигуна.

6. Весовой расход окислителя и горючего по мере увеличения высоты полета летательного аппарата уменьшается. / Вагові витрати окислювача та палива із набором висоти літального апарата зменшуються.

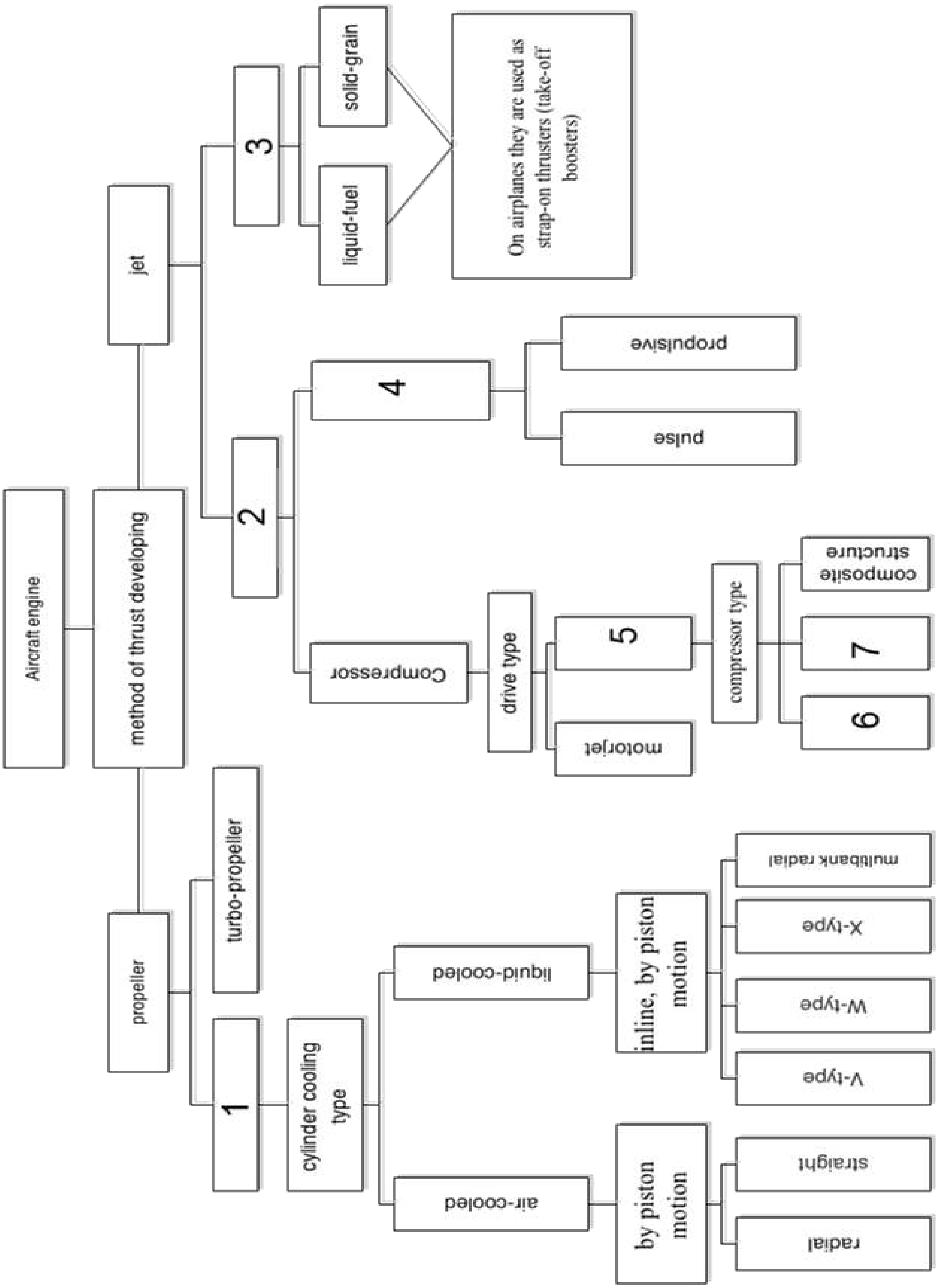
7. Эффективность работы воздушно-реактивного двигателя ограничена высотой полета в 30-50 км. / Ефективність роботи повітряно-реактивного двигуна обмежена висотою польоту у 30-50 км.

8. Мощность газовой турбины турбореактивного двигателя равна мощности компрессора. / Потужність газової турбіни турбореактивного двигуна дорівнює потужності компресора.

9. Поток воздуха, попадающего в двигатель, тормозится во входном устройстве, в результате чего давление воздуха перед осевым компрессором повышается. / Потік повітря, що потрапляє в двигун, тормозиться у вхідному пристрої, в результаті чого тиск повітря перед осьовим компресором підвищується.

10. Стабилизаторы пламени обеспечивают устойчивое горение обедненной кислородом топливной смеси. / Стабілізатори полум’я забезпечують стійке горіння збідненої киснем паливної суміші.

2) Add the missing engine types:



IV. Додаткові питання (за змістом навчальних відеофільмів)

1. Describe the operation of the airbreathing jet engine. (based on the film “Airbreathing jet engine”)

2. Describe the operation of the gas-turbine engine. (based on the film “Gas-turbine engine”)

3. Describe the operation of the internal combustion engine. (based on the film “Internal combustion engine”)

4. Describe the operation of the turbopropeller engine. (based on the film “Turbopropeller engine”)

5. What is the Mach number? What is it used for? (based on the film “Mach numbers”)

CHAPTER 7

Cockpit

***Cockpit interior*.** A cockpit or flight deck is the area, usually near the front of an aircraft, from which a pilot controls the aircraft. Most modern cockpits are enclosed, except on some small aircraft.

The cockpit of an aircraft contains flight instruments on an instrument panel, and the controls that enable the pilot to fly the aircraft. In most airliners, a door separates the cockpit from the passenger compartment.

In the modern electronic cockpit, the electronic flight instruments usually regarded as essential, which are MCP, PFD, ND, EICAS, FMS/CDU, and back-up instruments.

MCP. A mode control panel, usually a long narrow panel located centrally in front of the pilot, may be used to control heading, speed, altitude, vertical speed, vertical navigation and lateral navigation. It may also be used to engage or disengage both the autopilot and the autothrottle. The panel as an area is usually referred to as the "glareshield panel".

PFD. The primary flight display is usually located in a prominent position, either centrally or on either side of the cockpit. It will in most cases include a digitized presentation of the attitude indicator, air speed and altitude indicators (usually as a tape display) and the vertical speed indicator

ND. A navigation display, which may be adjacent to the PFD, shows the current route and information on the next waypoint, current wind speed and wind direction. It may be pilot selectable to swap with the PFD.

EICAS/ECAM. The Engine Indication and Crew Alerting System (used for Boeing) or Electronic Centralized Aircraft Monitor (for Airbus) will allow the pilot to monitor the following information: values for N1, N2 and N3, fuel temperature, fuel flow, the electrical system, cockpit or cabin temperature and pressure, control surfaces and so on. The pilot may select display of information by means of button press.

FMS. The flight management system may be used by the pilot to enter and check for the following information: flight plan, speed control, navigation control, and so on.

***Back-up instruments*.** In a less prominent part of the cockpit, in case of failure of the other instruments, there will be a battery-powered integrated standby instrument system along with a magnetic compass, showing essential flight information such as speed, altitude, attitude and heading.

Aircraft flight controls

A conventional fixed-wing aircraft flight control system consists of flight control surfaces, the respective cockpit controls, connecting linkages, and the necessary operating mechanisms to control an aircraft's direction in flight. Aircraft engine controls are also considered as flight controls as they change speed.

Primary controls. Generally, the primary cockpit flight controls are arranged as follows:

- a control yoke governs the aircraft's roll and pitch by moving the ailerons when turned or deflected left and right, and moves the elevators when moved backwards or forwards;
- rudder pedals are used to control yaw, which moves the rudder; left foot forward will move the rudder left for instance;
- throttle controls are used to control engine speed or thrust for powered aircraft.

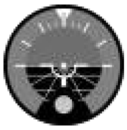
Secondary controls. In addition to the primary flight controls for roll, pitch, and yaw, there are often secondary controls available to give the pilot finer control over flight or to ease the workload. The most commonly available control is a wheel or other device to control elevator trim, so that the pilot does not have to maintain constant backward or forward pressure to hold a specific pitch attitude. Many aircraft have wing flaps, controlled by a switch or a mechanical lever or in some cases are fully automatic by computer control, which alter the shape of the wing for improved control at the slower speeds used for takeoff and landing. Other secondary flight control systems may be available, including slats, spoilers, air brakes and variable-sweep wings.

Basic flight instruments

Flight instruments are the instruments in the cockpit of an aircraft that provide the pilot with information about the flight situation of that aircraft, such as altitude, speed and direction. The flight instruments are of particular use in conditions of poor visibility, such as in clouds, when such information is not available from visual reference outside the aircraft.
Most regulated aircraft have these flight instruments:

Altimeter. The altimeter shows the aircraft's altitude above sea-level by measuring the difference between the pressure in a stack of aneroid capsules inside the altimeter and the atmospheric pressure

obtained through the static system. It is adjustable for local barometric pressure which must be set correctly to obtain accurate altitude readings. As the aircraft ascends, the capsules expand and the static pressure drops, causing the altimeter to indicate a higher altitude. The opposite effect occurs when descending. With the advancement in aviation and increased altitude ceiling the altimeter dial had to be altered for use both at higher and lower altitudes. Hence when the needles were indicating lower altitudes i.e. the first 360 degree operation of the pointers was delineated by the appearance of a small window with oblique lines warning the pilot that he is nearer to the ground. This modification was introduced in the early sixties after the recurrence of air accidents caused by the confusion in the pilot's mind. At higher altitudes the window will disappear.



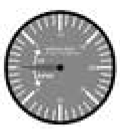
Attitude indicator. The attitude indicator (also known as an artificial horizon) shows the aircraft's relation to the horizon. From this the pilot can tell whether the wings are level and if the aircraft nose is pointing above or below the horizon. This is a primary instrument for instrument flight and is also useful in conditions of poor visibility. Pilots are trained to use other instruments in combination should this instrument or its power fail.

Airspeed indicator. The airspeed indicator shows the aircraft's speed (usually in knots) relative to the surrounding air. It works by measuring the ram-air pressure in the aircraft's Pitot tube. The indicated airspeed must be corrected for air density (which varies with altitude, temperature and humidity) in order to obtain the true airspeed, and for wind conditions in order to obtain the speed over the ground.

Magnetic compass. The compass shows the aircraft's heading relative to magnetic north. While reliable in steady level flight it can give confusing indications when turning, climbing, descending, or accelerating due to the inclination of the Earth's magnetic field. For this reason, the heading indicator is also used for aircraft operation. For purposes of navigation it may be necessary to correct the direction indicated (which points to a magnetic pole) in order to obtain direction of true north or south (which points to the Earth's axis of rotation).

Heading indicator. The heading indicator (also known as the directional gyro, or DG; sometimes also called the gyrocompass, though

usually not in aviation applications) displays the aircraft's heading with respect to magnetic north. Principle of operation is a spinning gyroscope, and is therefore subject to drift errors (called precession) which must be periodically corrected by calibrating the instrument to the magnetic compass. In many advanced aircraft (including almost all jet aircraft), the heading indicator is replaced by a horizontal situation indicator (HSI) which provides the same heading information, but also assists with navigation.



Vertical speed indicator. The VSI (also sometimes called a variometer, or rate of climb indicator) senses changing air pressure, and displays that information to the pilot as a rate of climb or descent in feet per minute, meters per second or knots.

Course deviation indicator. The CDI is an avionics instrument

used in aircraft navigation to determine an aircraft's lateral position in relation to a track, which can be provided by a VOR or an instrument landing system (ILS).

Radio magnetic indicator. An RMI is generally coupled to an automatic direction finder (ADF), which provides bearing for a tuned non-directional beacon (NDB). While simple ADF displays may have only one needle, a typical RMI has two, coupled to different ADF receivers, allowing for position fixing using one instrument.

Communication equipment. In aviation, ACARS (ARINC Communications Addressing and Reporting System) is a digital datalink system for transmission of short messages between aircraft and ground stations via airband radio or satellite.

ACARS as a term refers to the complete air and ground system, consisting of equipment on board, equipment on the ground, and a service provider.

On-board ACARS equipment consists of end systems with a router, which routes messages through the air-ground subnetwork.

Ground equipment is made up of a network of radio transceivers managed by a central site computer called AFEPS (Arinc Front End Processor System), which handles and routes messages. Generally, ground ACARS units are either government agencies such as the Federal Aviation Administration, an airline operations headquarters, or, for small airlines or general aviation, a third-party subscription service. Usually government agencies are responsible for clearances, while airline operations handle gate assignments, maintenance, and passenger needs.

The ACARS equipment on the aircraft is linked to that on the ground by the datalink service provider. Because the ACARS network is modeled after the point-to-point telex network, all messages come to a central processing location to be routed. ARINC and SITA are the two primary service providers, with smaller operations from others in some areas. Some areas have multiple service providers.

Flight crew*.* Flight crew are personnel who operate an aircraft while in flight. The composition of a flight's crew depends on the type of aircraft, plus the duration and purpose of the flight.

Some flight crew position names were originally derived from nautical terms, and also indicated a rank, or command structure similar to that on an ocean-going vessel, quickly allowing for executive decision making during normal operations or emergency situations. Historical flight deck positions include:

- Captain, the pilot designated as the Pilot-In-Command (PIC), and the highest ranking member or members of a flight crew;

- First Officer (FO, also called a co-pilot), another pilot who is not the pilot-in-command, and is normally seated to the right of the captain;
- Second Officer (SO), a person lower in rank to the First Officer, and who typically performs selected duties and also acts as a relief pilot;
- Third Officer (TO), a person lower in rank to a Second Officer, and who typically performs selected duties and can also act as a relief pilot;
- 'Relief Crew' members in the present day are fully licensed and trained Captains and First Officers who accompany long-haul airline flights, and who relieve the primary pilots during designated portions of the flight to provide them with rest or sleep breaks. The number of relief crew members assigned to a flight depends in part on the length of the flight and the official air regulations the airline operates under;
- Flight Engineer (FE), a position originally called an 'Air Mechanic'. The Flight Engineer's position is commonly staffed as a Second Officer.

Materials and components. Aircraft covering

Aircraft fabric covering is a term used for both the material used and the process of covering aircraft open structures. The purposes of the fabric covering of an aircraft are:

- to provide a light airproof skin for lifting and control surfaces;
- to provide structural strength to otherwise weak structures;
- to cover other non-lifting parts of an aircraft to reduce drag, sometimes forming a fairing;
- to protect the structure from the elements.

With the development of modern synthetic materials following World War II, cotton fabrics were replaced in civil aircraft applications by Polyethylene terephthalate, known by the trade-name Dacron or Ceconite. This new fabric could be glued to the airframe instead of sewn and then heat-shrunk to fit. Grade A cotton would typically last six to seven years when the aircraft was stored outside, whereas Ceconite, which does not rot like cotton, can last over 20 years.

Vocabulary notes

№	English	Ukrainian	Russian
1	aircraft covering	обшивка літака	обшивка самолёта
2	airspeed indicator	покажчик швидкості	указатель скорости
3	altimeter	висотомір (альтиметр)	высотомер (альтиметр)
4	altitude	висота над рівнем моря	отметка над уровнем моря; высота над уровнем моря
5	attitude indicator	авіагоризонт	авиагоризонт
6	autothrottle	автомат тяги	автомат тяги
7	cockpit	кабіна екіпажу	кабина экипажа
8	communication equipment	обладнання зв'язку	оборудование связи
9	course deviation indicator	покажчик відхилення курсу	индикатор отклонения курса
10	flight crew	льотний екіпаж	лётный экипаж
11	flight management system (FMS)	обчислювальна система літаководіння	вычислительная система самолётовождения
12	heading indicator	вказівник курсу	указатель курса
13	mode control panel (MCP)	пульт керування режимами літака	пульт управления режимами самолёта
14	navigation display (ND)	навігаційний дисплей	навигационный дисплей
15	pitch	тангаж	тангаж
16	pitot tube	датчик(сенсор) швидкості	датчик скорости
17	primary flight display (PFD)	авіагоризонт	основной пилотажный дисплей
18	radio magnetic indicator	радіомагнітний вказівник	радиомагнитный указатель
19	roll	крен	крен
20	rudder pedals	педалі обертання	педали поворота
21	throttle; throttle control	дросель; важіль керування двигуном	дроссель; рычаг управления двигателем (РУД)
22	vertical speed indicator	варіометр	вариометр
23	yaw	рискання	рыскание

Вправи до тексту 7

I. Вправи на перевірку знань лексичного матеріалу

1) Give the definitions to the following words:

a) Cockpit;
b) Flight instruments;
c) Flight crew;
d) Captain;
e) ACARS.

2) Fill in the gaps with appropriate words (each word can be used only once):

essential	surfaces	altitude	cockpit	humidity	airproof
yaw	back-up	north	compartment	enclosed	disengage
linkages	roll	temperature	engage	throttle	nautical
horizon	controls	ground	direction	visibility	Pitch

1. In the modern electronic cockpit, the electronic flight instruments are usually regarded as ___ and ___ instruments.
2. MCP may be used to ___ or ___ both the autopilot and the autothrottle.
3. A conventional fixed-wing aircraft flight control system consists of flight control ___, the respective cockpit ___, connecting ___, and the necessary operating mechanisms to control an aircraft's ____ in flight.
4. A control yoke governs the aircraft's ___ and ___.
5. Most modern cockpits are ___, except on some small aircraft.
6. Rudder pedals are used to control ___.
7. In most airliners, a door separates the ___ from the passenger ___.
8. ___ controls are used to control engine speed.
9. The flight instruments are of particular use in conditions of poor ___.
10. The attitude indicator shows the aircraft's relation to the ___.
11. Air density varies with ___, ___ and ___.
12. The compass shows the aircraft's heading relative to magnetic ___.
13. The ACARS equipment on the aircraft is linked to that on the ___ by the datalink service provider.

14. Some flight crew position names were originally derived from ___ terms.

15. The fabric covering of an aircraft provides a light ___ skin for lifting and control surfaces.

II. Вправи на перевірку знань лексики і розуміння вивченого матеріалу

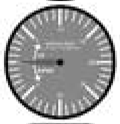
1) Choose the right statement, put true (T) or false (F):

1. Grade A cotton would typically last ten to fifteen years.
2. The Second Officer is lower in rank to the First Officer.
3. The term “gyrocompass” is widely used in aviation applications.
4. The “RMI” stands for “radio magnetic identificator”.
5. The airspeed indicator works by measuring the ram-air pressure in the aircraft's Pitot tube.
6. A mode control panel is located behind the pilot.
7. Ceconite does not rot like cotton and can last over 20 years.
8. Polyethylene terephthalate can be glued to the airframe instead of sewn.
9. The pilot may use the flight management system to check the flight plan.
10. A co-pilot is normally seated to the left of the captain.

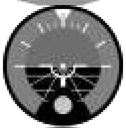
2) Match the names of instruments with their pictures:

1) 

2) 

3) 

4) 

5) 

6) 

7) 

8) 

a) airspeed indicator

b) vertical speed indicator

c) radio magnetic indicator

d) altimeter

e) course deviation indicator

f) attitude indicator

g) magnetic compass

h) heading indicator

III. Вправи на перевірку знань лексики і розуміння вивченого матеріалу на більш високому рівні

1) Translate from Russian/Ukrainian into English:

1. Часть самолёта, из которой пилот управляет им, называется кабиной экипажа. / Частина літака, з якої пілот керує ним, називається кабіною екіпажу.

2. Пульт управления режимами самолёта может использоваться для контроля направления, скорости, высоты, вертикальной скорости, навигации в вертикальной и горизонтальной плоскостях. / Пульт керування режимами літака може використовуватися для контролю напрямку, швидкості, висоти, вертикальної швидкості, навігації у вертикальній і горизонтальній площинах.

3. Навигационный дисплей показывает текущий маршрут, а также информацию о следующей точке маршрута, текущей скорости ветра и его направлении. / Навігаційний дісплей показує поточний маршрут, а також інформацію про наступну точку маршруту, поточну швидкість вітру і його напрям.

4. В дополнение к основным органам управления полётом часто также присутствуют вспомогательные органы управления, дающие пилоту возможность более точного контроля над полётом. / На додаток до основних органів керування польотом часто також присутні допоміжні органи керування, що надають пілотові можливість більш точного контролю над польотом.

5. Приборы контроля особенно полезны в условиях плохой видимости, например в облаках. / Прилади контролю особливо корисні в умовах поганої видимості, наприклад у хмарах.

6. Указатель скорости показывает скорость летательного аппарата (обычно в узлах) относительно окружающего воздуха. / Покажчик швидкості показує швидкість літального апарата (зазвичай у вузлах) відносно навколишнього повітря.

7. Во многих современных самолётах указатель курса заменяется навигационным плановым прибором, который предоставляет ту же информацию о направлении, а также помогает с навигацией. / У багатьох сучасних літаках покажчик курсу замінюється навігаційним плановим приладом, який надає ту ж інформацію про напрям, а також допомагає з навігацією.

8. Состав лётного экипажа зависит от типа самолёта, а также длительности и цели полёта. / Склад льотного екіпажу залежить від типу літака, а також від тривалості та мети польоту.

9. На большинстве авиалайнеров кабина экипажа отделена от пассажирского салона дверью. / На більшості авіалайнерів кабіну екіпажу відокремлено від пасажирського салону дверима.

10. На случай отказа остальных приборов, имеются запасные приборы, показывающие основную информацию о полёте. / На випадок відмови інших приладів є запасні прилади, що показують основну інформацію про політ.

2) Write the full names for the abbreviations given:

1. MCP;
2. EICAS;
3. PFD;
4. ECAM;
5. ND.

IV. Додаткові питання (за змістом навчальних відеофільмів)

1. Which crew members did you see in the video? What are their duties? (based on the film “B777-300ER Air Austral Cockpit”)
2. Which devices did you see on the control panel? (based on the film “B777-300ER Air Austral Cockpit”)
3. What information about the flight did the pilot share? (based on the film “B777-300ER Air Austral Cockpit”)
4. Which airport was shown in the video? (based on the film “B777-300ER Air Austral Cockpit”)
5. Was the landing successful? (based on the film “B777-300ER Air Austral Cockpit”)

Ббліографічний список

1. Авиастроение [Электронный ресурс] // Режим доступа: http://www.aerokzn.ru/
2. Александров, В. Г. Справочник по авиационным материалам и технологии их применения / В. Г. Александров, Б. И. Базанов. – М. : Транспорт, 1979. – 241 с.
3. Андриевский, Ю. А. Авиационное оборудование / Ю. А. Андриевский, Ю. Е. Воскресенский. – М. : Воениздат 1989. – 249 с.
4. Андриенко, А. И. Конструкции летательных аппаратов и их систем / А. И. Андриенко, В. В. Кириченко. – Харьков : ХАИ 2004. – 177 с.
5. Безуглый, С. В. Агрегаты систем авиационных двигателей / С. В. Безуглый, А. И. Скрипка, Б. Г. Нехорошев. – Харьков : ХАИ 2007. – 90 с.
6. Вульф, Б. К. Авиационное материаловедение (Изд. 3-е) / Б. К. Вульф, К. П. Ромадин. – М. : Машиностроение, 1967. – 394 с.
7. Гарькавый, А.А. Двигатели летательных аппаратов : учебник для авиационных техникумов / А. А. Гарькавый, А. В. Чайковский. – М. : Машиностроение, 1987. – 287 с.
8. Гильзин, К. А. Воздушно-реактивные двигатели / К. А. Гильзин. – М. : Воениздат, 1956. – 172 с.
9. Гончаренко, В. В. Как люди научились летать / В. В. Гончаренко. – Киев : Веселка, 1986. – 195 с.
10. Егер, С. М. Основы авиационной техники : учебник / С. М. Егер, А. М. Матвеенко, И. А. Шаталов. – М. : МАИ, 1999. – 576 с.
11. Жабров, А. А. Почему и как летает самолет / А. А. Жабров. – М. : Физматлит, 1959. – 56 с.
12. Конструкция самолетов [Электронный ресурс] // Режим доступа : http://aeroconstruction.ru/
13. Кравчик, Н. И. Развитие воздушных летательных аппаратов и авиационных двигателей / Н. И. Кравчик, Т. Н. Кравчик. – М. : МАИ, 2002. – 100 с.
14. Шевелюк, М. И. Теоретические основы проектирования жидкостных ракетных двигателей / М. И. Шевелюк – М. : Оборонгиз, 1960. – 689 с.
15. Baker, A. Composite Materials for Aircraft Structures / A. Baker, S. Dutton, D. Kelly. – Blacksburg, Virginia : Virginia Polytechnic Institute and State University, 2004. – 602 c.
16. Hull, D. G. Fundamentals of Airplane Flight Mechanics / D. G. Hull. – Berlin : Springer-Verlag 2007. – 310 c.

Навчальне видання

Рижкова Вікторія Василівна
Рижков Сергій Васильович

ІНЖЕНЕРНІ ОСНОВИ АЕРОКОСМІЧНОЇ ТЕХНІКИ

(Англійською мовою)

Редактор Л. О. Кузьменко

Зв. план, 2018
Підписано до видання 16.07.2018
Ум. друк. арк. 6,3. Обл.-вид. арк. 7,06. Електронний ресурс

Видавець і виготовлювач
Національний аерокосмічний університет ім. М. Є. Жуковського
«Харківський авіаційний інститут»
61070, Харків-70, вул. Чкалова, 17
http:// www.khai.edu
Видавничий центр «ХАІ»
61070, Харьків-70, вул. Чкалова, 17
izdat@khai.edu

Свідоцтво про внесення суб'єкта видавничої справи
до Державного реєстру видавців, виготовлювачів і розповсюджувачів
видавничої продукції сер. ДК № 391 від 30.03.2001