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MAINTENANCE AND REPAIR OF AIRCRAFT ENGINE TURBINES

Abstract. The turbine is the main part of the aircraft engine responsible for converting fuel into energy to drive the propeller blades. The article is devoted to the maintenance and repair of an aircraft turbine, including the basic procedures and techniques used to detect and correct defects and damage in the turbine. It also describes the process for diagnosing and analyzing turbine failures, and how to prevent such failures from occurring in the future. Turbine maintenance is critical to flight safety, and the article can be useful to both aviation professionals and the general public interested in aviation and technical issues. Reliability and resource, as practice shows, depend more on the number of load cycles and thermal cycles associated with starts, stops and changes in the engine operating mode than on the total number of hours of operation. The turbine is the most important unit of the engine, which determines its service life and reliability of operation. Cooled rotor blades make it possible to increase the working temperature of the gas in front of the turbine or to use less scarce materials for the manufacture of blades. Currently, two types of cooled rotor blades are mainly used: frame and composite blades.

Keywords. Blade, rotor, stator, axial turbine, radial turbine, radial-axial turbine.

Introduction.

Aircraft turbine maintenance and repair are important components of flight safety. The turbine, which is a key part of an aircraft engine, is responsible for generating the thrust required to lift and propel the aircraft. Regular maintenance and repairs are required to keep the turbine running smoothly.

Turbine maintenance includes a number of procedures that must be carried out in accordance with international aviation safety regulations and standards. These procedures help to detect and eliminate possible malfunctions in the turbine before they occur during flight. Turbine repair, in turn, involves the implementation of a number of measures aimed at restoring its performance and guaranteeing flight safety.

Gas turbines offer a number of advantages over other types of engines, including high power, relatively low weight and compactness, and the ability to accelerate quickly. These factors make gas turbines particularly suitable for use in aircraft [1].

However, gas turbines also have their disadvantages, including high cost, complexity and high cost of maintenance, as well as significant noise and emissions.

In this work, we will consider the main aspects of aircraft turbine maintenance and repair, as well as get acquainted with the methods of diagnostics and fault analysis. This information can be useful not only for aviation specialists, but also for anyone interested in technical issues and flight safety.

The gas turbine is a blade installation necessary to ensure the movement of the electric generator (figure 1).

Its main parts are a rotor and a stator with blades.

The blade is a metal part, which is a plate with a shank attached to the disk. As a rule, the width of this plate is a quarter of its length.

Rotor - a movable shaft on which discs with blades are mounted. One disc is called the rotor stage. The number of stages and the size of the blades on each of them depends on the characteristics of the work and the required power of the unit.

The stator is a fixed element of the turbine, which is a blade of a different shape, fixed in a housing around the rotor. It serves to direct the gas to the rotor plates at the desired angle. This increases the efficiency and reliability of operation, and also prevents the disruption of the flow of material [6].

Together with the combustion chamber, the gas turbine is a gas turbine plant.

Figure 1 - Gas turbine plant

With the help of a turbocharger, the incoming air is compressed and fed into the combustion chamber. There it heats up and expands.

Combustion products under pressure are supplied to the turbine blades, which drives the rotor, which is the drive of the electric generator.

With the same power as steam gas plants, they have less weight and dimensions, are put into operation faster, and are easier to maintain [2].

Unlike an internal combustion engine, a gas turbine has fewer moving parts and low vibration during operation, a higher power-to-size ratio, low emissions, and low fuel requirements.

The use of gas turbines is associated with some disadvantages. Among them are high cost due to the complexity of parts production, high power consumption, slow start compared to internal combustion engines, low efficiency at low loads.

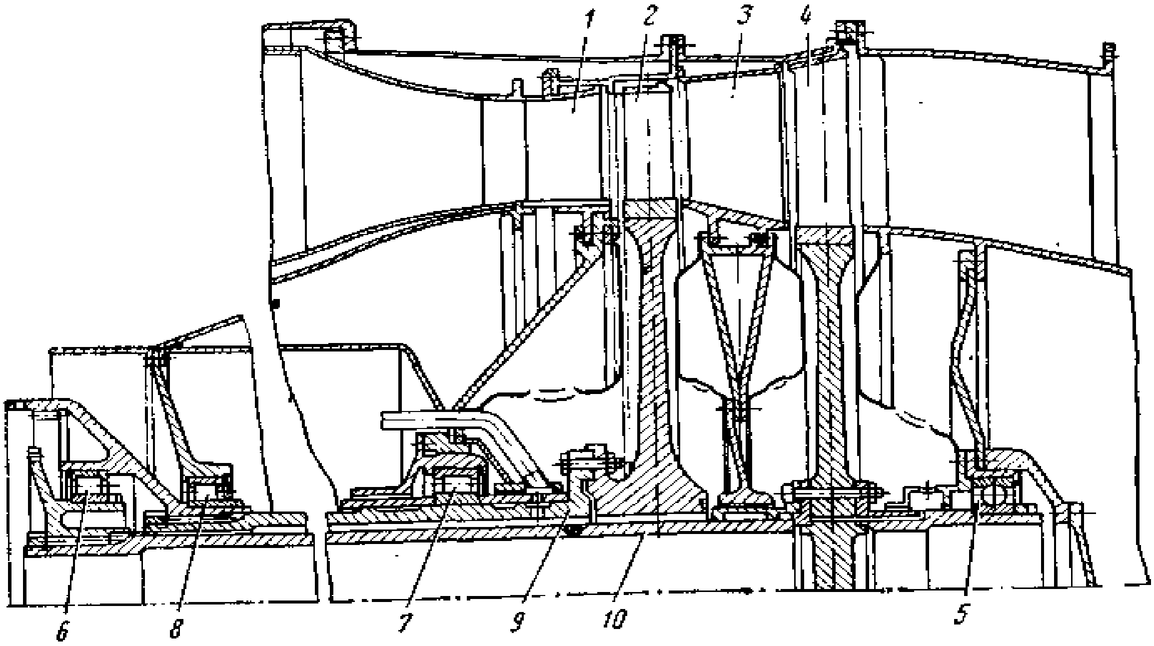
Materials and methods.

Analysis of structures and identification of cracks in the most loaded areas, as well as regular maintenance.

Distinctive features. “The main feature of a gas device in comparison with steam and combined-cycle turbines is the invariability of the aggregate state of the incoming substance throughout the entire working process. This allows them to operate at higher temperatures and increase efficiency.”

According to the direction of the gas flow, gas turbines are axial (most common), radial and mixed.

Axial turbines in modern gas turbine engines are predominantly used. Such turbines approximately retain the axial direction of gas movement at the inlet to the turbine stage and at the outlet from it (figure 2).



1 and 3 - nozzle devices of I and II stages; 2 and 4 - impellers I and II stages; 5 and 6 - bearings of the second rotor; 7 and 8 - bearings of the first rotor; 9 to 10 - shafts.

Figure 2 - Scheme of a two-stage twin-rotor axial turbine

In addition to the axial turbines discussed above, in the flow parts of which the steam flow moves along the rotor axis, radial and radial-axial turbines have found wide application.

Radial turbines are those in which the steam current lines are in a plane perpendicular to the rotor axis. If the steam moves in the direction from the periphery to the axis of the rotor, such turbines are called centripetal; if from the rotor axis to the periphery - centrifugal.

The radial turbine is more reliable in operation and has a longer service life with less maintenance requirements.

Radial-axial turbines are those in which the steam flow in the nozzle blades is directed from the periphery to the axis of the turbine, and the flow in the working blades has a radial-axial direction [3].

Results and Discussion.

Repair of gas turbines: measures to restore performance and ways to reduce wear of parts. Gas turbine equipment operates under extremely difficult conditions: extreme rotational speeds and temperatures (gas heated to approximately +1000 °C is supplied to the blades), high loads, long-term continuous operation lead to corrosion and damage to parts, failures in the operation of units.

Small particles enter the system along with the incoming gas. Air filters cannot cope with a large amount of dust, it moves into the working chamber and stimulates abrasive wear of the elements.

Turbine blade roots are subjected to fretting corrosion - wear due to constant micro-movements of parts relative to each other in a corrosive environment. In addition, they quickly become dirty and require cleaning with a non-abrasive material (figure 3).

Figure 3 - Damaged turbine blade

Nozzle guides are cracked and damaged due to temperature fluctuations. To restore, they are welded.

The turbine shaft can become misaligned due to significant rotational speeds, which leads to increased vibration during operation and accelerated bearing wear.

The plain bearing experiences high pressures and operates under conditions of increased friction. At the start-stop moments of the unit, the risk of damage is maximum. When using low-quality protective materials or with a lack of lubricating fluid, the element quickly fails [4].

Repair of damage to parts of a gas turbine plant. Returning to possible defects in GTU parts and their elimination, we note that the main causes of defects in GTU parts are as follows: high-temperature corrosion, destruction due to vibration, thermal deformation, mechanical and erosive wear, and non-compliance with fuel preparation requirements [7].

The nature of the damage caused by these causes, in most cases, allows them to be detected only by non-destructive testing methods, and eliminated by welding. In more detail about some possible damage to parts of the gas turbine:[5]

Repair of a crack in the turbine nozzle guide vane.

Crack in the turbine nozzle vane (figure 4) - cracking caused by thermal cycles "heating-cooling".

The size of the crack exceeds the allowable limits, and this segment should be replaced in the near future, regardless of the timing of the scheduled inspection.

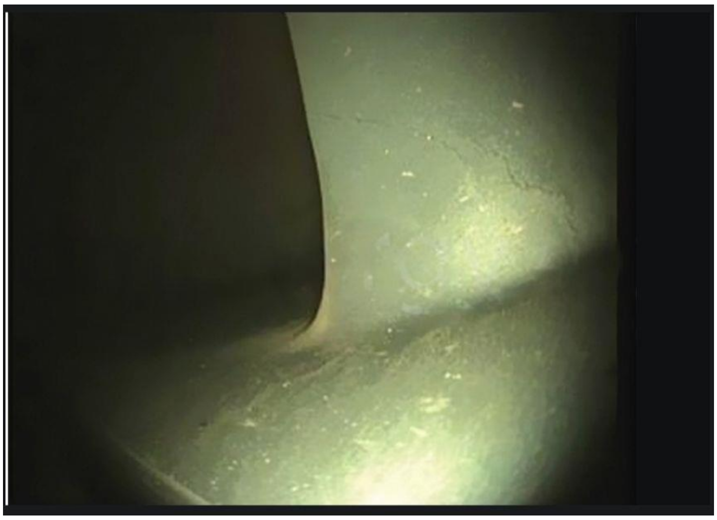


Figure 4 - Crack in the turbine nozzle guide vane

This defect can be eliminated by crack sampling, subsequent welding, mechanical and heat treatment and application of a thermal barrier coating at the final stage. Subsequently, the repaired segment can be used to replace a similar damaged one;

Damage to the blades of the 1st stage of the turbine (Figure 5) - the condition of the rotor blades in the picture is typical for most of the rotor blades of the 1st stages of the gas turbine hot gas path, which have worked out before the next inspection and must be replaced.

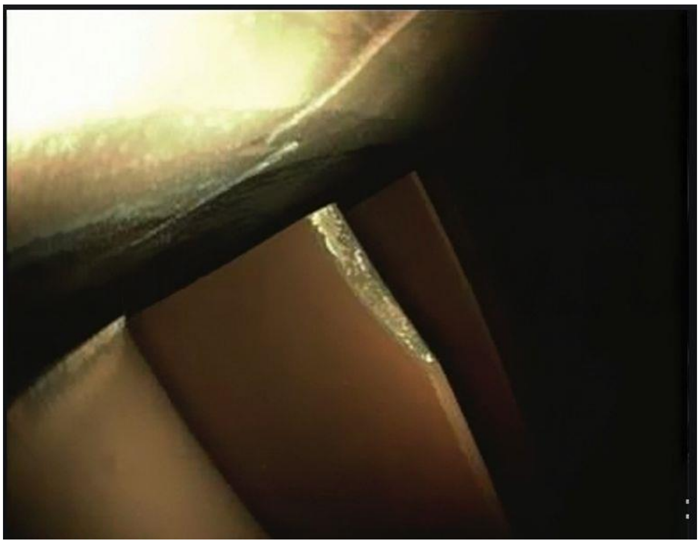


Figure 5 - Damage to the blades of the 1st stage of the turbine (erosive wear of the leading edge)

This condition corresponds to normal wear and tear and is caused by the cumulative effect of the above causes.

Cooled rotor blades make it possible to increase the working temperature of the gas before the turbine or to use less scarce materials for the manufacture of blades. The blades are mainly cooled by air taken from the compressor, although cooling is also possible with liquid coolants (water, fuel, molten metals, such as sodium, etc.). Creating a successful design of cooled blades is associated with great design and technological difficulties, since it is necessary:

- ensuring a uniform temperature field over the cross section; unevenness leads to the appearance of thermal stresses, which can nullify the cooling effect;
- maintaining the necessary strength and vibration resistance;
- design manufacturability.

Cooling the blades by removing heat to the disk rim is the simplest method, but its effectiveness depends on the type of blade fastening lock and the thermal conductivity of the blade material.

Currently, two types of cooled rotor blades are mainly used: frame and composite. The frame blade consists of a supporting frame-frame and a thin-walled shell covering it. Between the frame and the shell there are channels for the passage of cooling air. In terms of their aerodynamic properties, such blades are not much inferior to solid, uncooled ones, but the presence of transverse grooves on the rods greatly reduces their strength. Composite blades are made of two separate parts. Each part is made separately, and then channels are milled on the joined surfaces. After connecting both parts, cavities are formed inside the blade for the passage of cooling air. (Fig. 6) In addition to the listed methods of cooling the rotor blades, cooling with a protective film (barrage cooling) is possible. This method is based on the principle of creating a protective coolant layer between the hot gas and the blade surface. In this case, there are a number of slots in the blade walls through which the coolant is blown into the gas boundary layer near the blade**.**

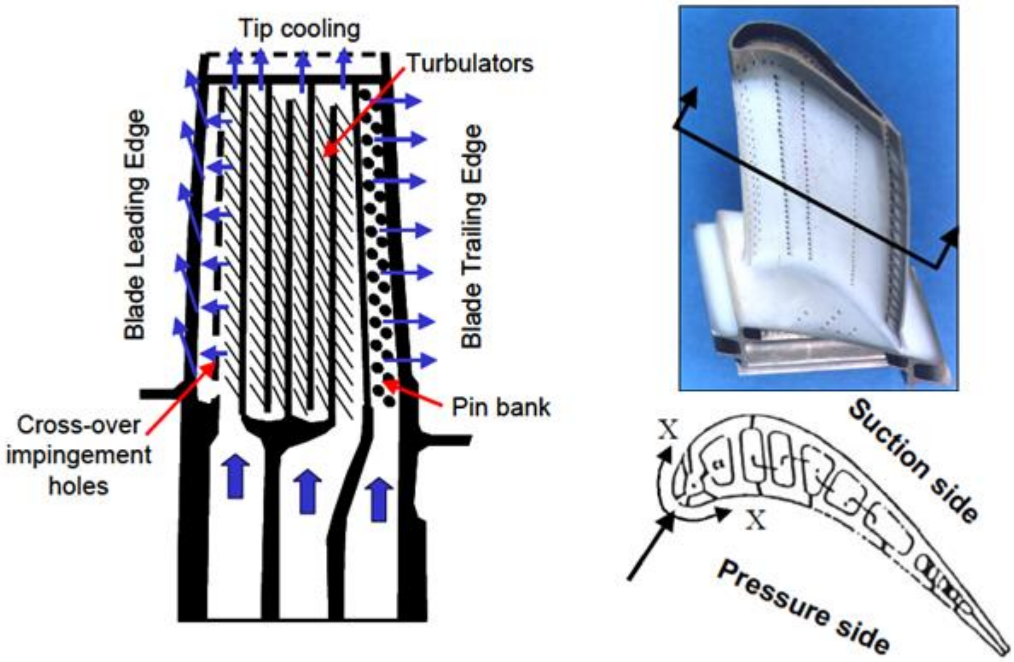


Figure 6 - Scheme of cooling of rotor blades

Conclusion.

In conclusion, it can be noted that aircraft gas turbines are one of the most important components of aircraft, which provide the necessary thrust for their movement. Maintenance and repair of gas turbines is critical, as any failure in their operation can lead to dangerous situations that can lead to an accident.

To ensure the reliable and safe operation of aircraft gas turbines, regular maintenance is necessary, which includes checking and replacing components, as well as repairs if necessary. It is also necessary to observe the correct mode of operation of gas turbines, including optimal load conditions, fuel quality control and other factors.

In general, the correct maintenance and repair of gas turbines are important factors for the safety and reliability of air transport.

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ӘУЕ ҚОЗҒАЛТҚЫШТАРЫНЫҢ ТУРБИНАЛАРЫН ЖӨНДЕУ ЖӘНЕ ТЕХНИКАЛЫҚ ҚЫЗМЕТ КӨРСЕТУ

Аңдатпа. Турбина - әуе винтінің қалақтарын қозғау үшін отынды энергияға айналдыруға жауапты ұшақ қозғалтқышының негізгі бөлігі болып саналады. Мақалада әуе кемесінің турбинасына техникалық қызмет көрсетуге және жөндеуге арналған, оның ішінде турбинадағы ақаулар мен зақымдануларды анықтау және түзету үшін қолданылатын негізгі процедуралар мен әдістер көрсетілген. Бұл мақалада сондай-ақ турбиналық ақауларды диагностикалау және талдау процесін және болашақта мұндай ақаулардың алдын алу жолдары сипатталған. Турбинаға техникалық қызмет көрсету кезінде ұшу қауіпсіздігі үшін және авиация мамандары үшін де өте маңызды, мұндағы ақпараттар авиациялық және техникалық мәселелерге қызығушылық танытқан көпшілік үшін де пайдалы болуы мүмкін. Тәжірибе көрсеткендей сенімділік пен ресурс, жұмыс уақытының жалпы санына қарағанда, қозғалтқыштың жұмыс режимін іске қосу, тоқтату және өзгертуге байланысты жүктеме циклдары мен жылу циклдерінің санына көбірек байланысты. Турбина қозғалтқыштың қызмет ету мерзімін және жұмыс сенімділігін анықтайтын ең маңызды бірлігі болып табылады. Суытылған ротор қалақтары және пышақтар турбина алдындағы газдың жұмыс температурасын жоғарылатуға немесе газ өндіру үшін тапшы материалдарды азырақ пайдалануға мүмкіндік береді. Қазіргі уақытта салқындатылған ротор қалақтарының негізінен екі түрі қолданылады: рамалық және композитті қалақтар.

Түйінді сөздер. Қалақша, ротор, статор, осьтік турбина, радиалды турбина, радиалды-осьтік турбина.

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ТЕХНИЧЕСКОЕ ОБСЛУЖИВАНИЕ И РЕМОНТ ТУРБИН АВИАЦИОННЫХ ДВИГАТЕЛЕЙ

Аннотация. Турбина является основной частью двигателя самолета, отвечающей за преобразование топлива в энергию для привода лопастей воздушного винта. Статья посвящена техническому обслуживанию и ремонту турбины самолета, включая основные процедуры и техники, используемые для обнаружения и исправления дефектов и повреждений в турбине. Она также описывает процесс диагностики и анализа неисправностей турбины, а также методы предотвращения возникновения таких неисправностей в будущем. Обслуживание турбины является критически важным для безопасности полетов, и статья может быть полезна как авиационным специалистам, так и широкой аудитории, интересующейся авиацией и техническими вопросами. Надежность и ресурс, как показывает практика, больше зависят от числа циклов нагружения и теплосмен, связанных с запусками, остановками и изменениями режима работы двигателя, чем от общего количества часов наработки. Турбина является важнейшим узлом двигателя, определяющим его ресурс и надежность работы, Охлаждаемые рабочие лопатки позволяют увеличивать рабочую температуру газа перед турбиной или применять для изготовления лопаток менее дефицитные материалы. В настоящее время применяют в основном два типа охлаждаемых рабочих лопаток: каркасные и составные

Ключевые слова. Лопатка, ротор, статор, осевая турбина, радиальная турбина, радиально-осевая турбина.

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