МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
АЕРОКОСМІЧНИЙ ФАКУЛЬТЕТ
КАФЕДРА ПІДТРИМАННЯ ЛЬОТНОЇ ПРИДАТНОСТІ ПОВІТРЯНИХ СУДЕН

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
канд. техн. наук, доц.
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«_____»_____________2021р

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ
«МАГІСТР»

ЗА ОСВІТНЬО-ПРОФЕСІЙНОЮ ПРОГРАМОЮ
«ТЕХНІЧНЕ ОБСЛУГОВУВАННЯ ТА РЕМОНТ ПОВІТРЯНИХ СУДЕН І АВІАДВИГУНІВ»

Тема: **“ Методичі основи забезпечення ефективності технічного обслуговування гідравлічної системи середньомагістрального пасажирського літака”**

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Київ 2021

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL AVIATION UNIVERSITY

AEROSPACE FACULTY

AIRCRAFT CONTINUING AIRWORTHINESS DEPARTMENT

PPERMISSION TO DEFEND
Head of the department
Ph. D., Assoc. Professor
_____________ O. V. Popov
«____”_______________2021

MASTER’S DEGREE THESIS

(EXPLANATORY NOTE)

GRADUATE OF EDUCATIONAL DEGREE

«MASTER»

FOR EDUCATIONAL-PROFESSIONAL PROGRAM
«MAINTENANCE AND REPAIR OF AIRCRAFT AND AVIATION ENGENS»

Topic: **“Methodical bases of ensuring the efficiency of maintenance of the hydraulic system of medium-haul passenger aircraft”**

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Kyiv 2021

NATIONAL AVIATION UNIVERSITY

Faculty: Aerospace faculty
Aircraft Continuing Airworthiness Department
Educational and Qualifications level: «Master Degree»
The specialty: 272 «Aviation transport»
Educational-professional program «Maintenance and Repair of Aircraft and Engines»

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Graduate Student's Degree Work Assignment

Semchuk Yan Volodymyrovych

1. The topic of the work: **« Methodical bases of ensuring the efficiency of maintenance of the hydraulic system of medium-haul passenger aircraft »** approved by the Rector's order of October 02, 2021 № 1881/ст.

2. The work fulfillment terms: since October 5, 2021 until December 22, 2021 and since December 21, Graphic materials is represented in the view of presentation Microsoft Power Point

3. Calendar schedule

Task	Fulfillment term	Completion mark
Literature review of materials for degree work	05.10.2021-10.10.2021	
Analysis of technological process of work fulfillment	11.10.2021 – 15.10.2021	
Preparation of necessary equipment for research carrying out	16.10.2021 – 22.10.2021	
Work on a special part of degree work	23.10.2021 – 15.11.2021	
Processing of research results	16.11.2021 – 20.11.2021	
Fulfillment of individual sections of degree work	21.11.2021 – 04.12.2021	
Processing of master's degree work	05.12.2021 - 13.12.2021	

4. Advisers on individual sections

Section	Adviser	Date, Signature	
		Assignment Delivered	Assignment Accepted
Labour precaution	**V.V. Kovalenko**		
Environmental protection	**T.V. Saenko**		

5. Assignment issue date “_____"___________2020.

Degree work supervisor: ______________________________Y.I. Smirnov
(signature)

Assignment accepted for fulfillment ____________________Y.V. Semchuk
(signature)

ABSTRACT

The explanatory note to master's degree work « Methodical bases of ensuring the efficiency of maintenance of the hydraulic system of medium-haul passenger aircraft»

Object of study – hydraulic system of medium-range passenger aircraft.

The purpose of degree work – to find out best and new methodical bases of ensuring the efficiency of maintenance of the hydraulic system of medium-haul passenger aircraft .

Research method – theoretical research.

A complex analysis of methodical bases of ensuring the efficiency of maintenance of the hydraulic system of medium-haul passenger aircraft .

CONTENT

INTRODUCTION

The improvement of aviation technology, the creation of transonic and supersonic aircraft (AC) with an increased payload have led to a significant increase in the requirements for the reliability of their functional systems, the failures of which affect flight safety. Aircraft hydraulic systems also belong to such systems.

The available experience shows that the solution to the reliability problem can be implemented only with an integrated approach to it, the reliability problem should be solved at the stages of design, manufacture, revision and operation of the aircraft.

The practical application of the theory of reliability helps to establish the patterns of occurrence of failures of functional systems of the aircraft, taking into account the influence of external and internal factors and to substantiate the optimal strategy for their maintenance and repair. With the introduction of probabilistic criteria assessing the admissibility of the occurrence of special flight situations, it became necessary to develop more effective methods for ensuring the safety and durability of aviation technology.

Further, a general approach to interrogation of the reliability of aircraft hydraulic systems is presented, as well as attention is paid to the relationship between the reliability and durability of hydraulic units with flight safety hydraulic systems and individual units at the stages of design, manufacture, testing and operation, taking into account the action of various factors and patterns of development of processes leading to malfunctions. The main factors influencing the reliability of the units of the aviation hydraulic system are analyzed. Methods for calculating reliability parameters are illustrated with examples. It is shown that it is promising to introduce progressive strategies for the operation of aircraft hydraulic drive units by technical condition, which are based on the principle of active control, reliability, taking into account the individual physical resources of the units.

Aircraft hydraulic systems consist of devices and assemblies that provide hydraulic power to consumers (hydraulic drives) and control their operation modes from signals from pilots and automatic flight control systems, aircraft engines, etc.

The hydraulic systems, together with the actuators, form, like you, the "muscle" system of the aircraft. They ensure the operation of power devices and drives in control systems of aircraft and helicopters, retraction and release of landing gear, brake flaps, wing mechanization in mechanisms for changing the geometric configuration of the wing in wing rotation systems or aircraft engines on vertical takeoff aircraft, control of engines and propellers in special equipment for agricultural aircraft, in systems for changing the configuration of air intakes for supersonic aircraft.

The use of hydraulic systems simplifies in many cases the equipment of modern aircraft. Hydraulic drives are irreplaceable in guidance systems of radar search systems with homing, for the speed of which especially high demands are made.

The ability to provide large forces with small overall dimensions and weight predetermined the widespread use of steering drives in booster control systems of many types of aircraft. On modern aircraft, hydraulic systems also ensure the operation of such important functional systems as the landing gear retraction and lowering system, braking, the steering system for the front landing gear support. also in various ground equipment serving aircraft, including fueling systems, lifts, winches, conveyors and other devices.

During the operation of the aircraft, their components, systems, assemblies and parts are constantly influenced by a number of factors that affect their technical condition in different ways, and hence their operational reliability and performance.

All the variety of factors that characterize the real operating conditions and affect the technical condition of the aircraft can be subdivided into objective and subjective.

Objective ones include: the influence of the environment, mechanical and other external actions on structural elements and components of functional systems. The subjective ones include those who, in one way or another, depend on the person. This includes the choice of a design solution scheme; selection of materials and design of elements; modes of normal operation; strategy, methods and modes of maintenance, etc. As a rule, these factors are the causes of sudden failures.

On the other hand, the factors that affect the change in the technical state of the aircraft can be divided into design and production, which determine the initial qualities of objects, and operational, which reflect the change in the technical state during operation.

Each company performing or providing technical operation of an aircraft type must have the necessary documentation establishing organizational, regulatory and technical rules for the maintenance and repair of this aircraft type, which guarantee:

- that the maintenance, repairs and modifications of the aircraft are carried out according to the current documentation, within the established timeframe and in accordance with the established procedure;
- technical personnel are properly trained, and the use, accounting and storage of operational documentation is carried out in accordance with the established procedure;
- each aircraft has airworthiness and properly executed operational documentation confirming the continued airworthiness of the aircraft during further operation at the level of established requirements and standards.
- Operational and repair documentation of the aircraft, ensuring the preservation of airworthiness, may include:
- -normative documentation that establishes requirements for the technical condition of the aircraft and its parts and (or) the conditions of technical and flight operation of the aircraft. It’s includes:
- aircraft type certificate, technical delivery conditions, state standards, norms, rules and instructions of state management and control bodies of civil aviation.

Technical documentation that establishes the performance of work during the maintenance of the aircraft and its parts. This includes operational documents for this type of aircraft and its parts, bulletins and airworthiness directives, instructions on safety, fire safety, labor protection and environmental protection related to this type of aircraft and its parts;

- organizational documentation that establishes the procedure for accounting and (or) control over the performance of work during the maintenance of the aircraft and its parts, or the procedure for accounting and control of the flight operation of the aircraft and its parts. This includes statements, acts, maps, certificates, lists, tasks, orders and other documents used in the production activities of operators and other enterprises, production and technical operation of the aircraft and its parts.

Each of the specified types of operational documentation ensuring the technical operation and maintaining the airworthiness of the aircraft and its parts may include:

- general documentation used in flight and technical operation of all types or several types of aircraft;
- standard documentation used in flight and technical operation of only this type of aircraft;
- numbered documentation valid only for a given copy of the aircraft and its component parts and used for registration of state registration and airworthiness of each aircraft for flights, accounting for the operating time and technical condition of the aircraft (engine, component parts), reception and transfer of aircraft to various services within the operator's facility or to another facility.

The distribution of operational documentation into general, standard and number is established by the technical conditions for the contract for the supply of aircraft and the current state and industry regulatory documents (standards, instructions, rules).

PART 1
RESEARCH METODHOLOGY

The successful solution of the problems of improving the maintenance processes and improving the technical and economic indicators of the activities of operational civil aviation enterprises is largely determined by the level of operational manufacturability of aircraft. Therefore, the ability to analyze and evaluate the operational manufacturability of aircraft in order to adjust the scope of maintenance and timely presentation of industry requirements is very important for the activity of operating engineers.

The operational adaptability of an aircraft is understood as a set of properties of its design that characterize its adaptability to perform all types of maintenance and repair work using the most economical technological processes. This, firstly, means the adaptability of the design to such progressive methods of maintenance and repair, such as, for example, the method of servicing with the replacement of units according to the technical, condition and methods of regulated repair, and secondly, the adaptability of the design to perform individual maintenance and repair operations.

Operational manufacturability is determined by a number of factors that are taken into account when creating an aircraft 6, depending on its purpose and operating conditions. Knowledge of these factors is also necessary when choosing a nomenclature of indicators of operational manufacturability.

The level of operational manufacturability of aircraft is decisively influenced by two interrelated groups of factors: design-production and operational

The design and production factors include: availability, testability, ease of removal, interchangeability, continuity of ground service facilities and instrumentation, unification of systems "and assemblies.

The group of operational factors includes the forms of organization of maintenance and repair, the state of production of the military-technical vase, the qualifications of repair service specialists, the completeness of meeting the requirements for spare materials, as well as the completeness and quality of operational and repair documentation.

Design and production factors determine the properties of the structures themselves and must be taken into account when creating an aircraft. Operational factors determine the environment in which the properties of the structure are manifested, and must be taken into account both in the creation and in the operation of the aircraft.

Without diminishing the role and influence on the level of operational manufacturability of operational factors, it should be said that the required properties of the aircraft structure in relation to its suitability for maintenance and repair are laid down and ensured at the design and production stages.

It is at these stages that the necessary operational properties of the aircraft are provided by appropriate design and technological solutions.

Accessibility to the facility for maintenance and repair is an important factor in reducing time and labor costs when carrying out preventive measures, as well as when determining the place of sudden failures and their elimination. When considering the issue of accessibility, they mean the convenience of the contractor when performing basic maintenance and repair operations with a minimum amount of additional work. Depending on the posture that the performer is forced to take during work, his labor productivity changes significantly (on average, in the range from 100 to 30%), and different labor intensity and duration are required to perform the same volume of operations.

In addition to the convenience of the contractor, the concept of accessibility also includes the suitability of the facility for performing various maintenance and repair operations with minimal or no additional work. In this case, additional work is understood as opening and closing panels, manhole covers, dismantling and installing nearby equipment and other work.

The traceability of systems and components is an important factor in monitoring the parameters of systems and components of an aircraft by various means and methods (primarily by means of automated and non-destructive testing). The significance of the problem of testability of aircraft structures is primarily determined by the requirements for ensuring their reliable operation. Naturally, ensuring the suitability of structures for carrying out their checks by various methods and means of control is inevitably associated with additional costs. However, these costs pay off through improved reliability, more efficient use of aircraft and reduced maintenance and repair costs.

Traceability has a decisive influence on the implementation of new, more efficient methods of performing maintenance and repairs and, in particular, the method of maintenance and replacement of products according to technical condition.

Easy removability of components should not be confused with availability. On aircraft there are such parts and products to which excellent accessibility is ensured, but their replacement during operation is difficult. Easy removability means that the product is suitable for replacement with minimal time and labor. And since the usual way to eliminate failures in aircraft operation is to replace the failed product, the requirement for easy removability is important for reducing aircraft downtime and increasing the regularity of their flights. Ease of removal is largely determined by the methods of fastening of products that are replaced in operation, the design of the connectors, the weight and size of removable elements.

The interchangeability of components and parts means that their property is such that from a multitude of similarly named parts (products) one can take any one without a choice and, without a fit (it is allowed to use technological compensators), can be installed on an aircraft. Depending on the amount of adjustment work, an appropriate degree of interchangeability is established. The less the amount of fitting work when replacing products and parts, the higher the degree of their interchangeability.

Interchangeability is essential to reduce material labor costs and aircraft downtime for maintenance and repair. The successful implementation of the aggregate repair of the method of replacing and repairing aggregates according to the technical condition depends primarily on this factor.

The continuity of ground service facilities and instrumentation means the possibility of using existing facilities for servicing a new type of aircraft. The more the amount of these funds will meet the requirements of maintenance and current repair of a new type of aircraft, the higher its operational manufacturability, this factor has a significant impact on the organization of the workplace and the convenience of the service personnel, the timing and cost of maintenance and repair.

The unification of aircraft systems and products is a very important factor not only for increasing its operational adaptability, but also in solving the problem of increasing the efficiency of operating the aircraft fleet as a whole. The increase in the number of the same products on different types of aircraft greatly simplifies and reduces the cost of maintenance and repair, reduces the range of spare parts in the warehouses of enterprises, and reduces the number of types of required control and measuring equipment.

1.1. Indicators of operational manufacturability and methods of their standardization

To analyze and assess manufacturability, quantitative indicators are required that characterize the design of the aircraft in relation to meeting the requirements of operational manufacturability.The following requirements are imposed on the indicators:

-maximum consideration of the factors that determine the operational manufacturability;

-the possibility of using indicators in the calculations and standardization of indicators and technical requirements for newly created types of aircraft and their units;

- ease of use of indicators in practice when assessing the level of operational manufacturability at the stages of testing and operation;

-sensitivity to changes in factors affecting the level of operational manufacturability.

The completeness of taking into account a large number of the most diverse factors that determine the operational manufacturability is difficult to assess with any one indicator.

Therefore, a set of indicators is used, consisting of generalized (technical and economic) and single (technical) indicators. The main indicators include:

-specific time spent on performing maintenance and repairs (for 1 hour of flight).

This indicator characterizes the adaptability of the aircraft to carry out preventive maintenance and repair measures on it, determined by the reliability characteristics;

- the average time to eliminate sudden failures in the interprophylactic period;
- the intensity of elimination of failures (recovery), characterized by the number of operations performed per unit of time;
- the probability of elimination of the failure (restoration of operability) of the aircraft for a given time interval of its stay. This metric represents the probability that the random time to fix a failure does not exceed a given time. It characterizes the fitness of the aircraft to carry out routine maintenance in the interprophylactic period associated with the detection and elimination of sudden failures with a limited investment of time;
- specific labor intensity of maintenance and repair (man-hours per 1 hour of flight). This indicator characterizes the amount of labor required to maintain the reliability of the operation of the aircraft and all its systems at a given level;
- the specific cost of spare parts and materials when performing maintenance and repairs (rubles for 1 hour of flight). This indicator characterizes the frequency of replacement of components on the aircraft and the cost of their replacement.

The single additional indicators include performance indicators characterizing individual properties of the aircraft design.Their nomenclature is selected primarily taking into account design and production factors, availability, ease of removal, interchangeability, testability, continuity, etc.

1.2. Evaluation of the level of operational manufacturability

This assessment is carried out in two directions, which complement each other: a qualitative analysis of the structure and a quantitative assessment of the achieved level of manufacturability.

When conducting a qualitative analysis, estimates are given for the structure's ability to perform all maintenance and repair operations provided for by the technology; the composition and type of the instrumentation and ground support tools used are determined, and the completeness and quality of maintenance and repair documentation is assessed.

Evaluation of design solutions in the qualitative analysis of the aircraft is carried out by comparing with the best examples of aircraft of this class.

A quantitative assessment of the level of operational manufacturability is the final stage of the analysis and is carried out with the aim of influencing the design, production and operation of aircraft. Based on the results of this stage, a final conclusion on operational manufacturability and recommendations for changing design solutions for this type of aircraft are issued.

Developing simple and reliable ways to quantify the level of manufacturability is a critical task. To solve it, you can use a differentiated method used to assess the level of product quality. In this case, the level of operational manufacturability is understood as a relative characteristic based on a comparison of the set of manufacturability indicators of the evaluated object with the corresponding set of vase (reference) indicators.

As the latter, a real or hypothetical design, similar in purpose, class and operating conditions, can be accepted. Requirements for ensuring the operational manufacturability of aircraft can also serve as a standard.

1.3. Ways to improve maintainability

In the practice of design organizations, there are good examples when systems are installed in compartments, on removable panels. Hydraulic, gas and electrical wiring along the fuselage and wing are laid in special manifolds, which protects them from damage, eliminates the possibility of short circuits, and provides convenience for maintenance and repair. When creating new types of aircraft, great influence is given to the issues of unification and standardization of units and assemblies. However, the designs of some types of aircraft are generally not perfect enough in terms of their operational manufacturability.

At present, general requirements have been developed for ensuring the operational maintainability of structures of newly created types of aircraft, which include the required values of the indicators of operational manufacturability, requirements to the structure in terms of adaptability to progressive methods of performing maintenance and repair, the requirements for the structure in terms of performing lubricating, control and fastening, control and adjustment, refueling and other types of operations, as well as requirements for the design and placement of individual systems, units on the aircraft, their unification and standardization.

Conclusions to the part 1.

The design of new aircraft should provide for the possibility of widespread use of the methods of aggregate-nodal repair, replacement and repair of units according to the actual technical condition, periodic verification of the parameters of units and blocks during their dismantling from the aircraft, etc.

Aircraft components must be able to be as testable, i.e. have built-in sensors and connecting places for periodic checking of their technical condition using control devices.

Work to improve the operational manufacturability of aircraft can be conditionally divided into three stages. The first stage of work is associated with the collection of the necessary information, analysis and systematization of the materials obtained.

At the second stage, the necessary technical guidance materials for operational manufacturability are developed.

The third stage of work consists in monitoring the fulfillment of requirements and assessing the level of operational manufacturability at various stages of aircraft development and testing.

To carry out the analysis and systematization of materials at the first stage, exhaustive initial information is required.The collection of the necessary initial materials is carried out primarily by conducting direct observations separately for each system, a unit or unit installed on various types of aircraft, in the process of performing their maintenance and repair.

Materials on operational manufacturability are also collected during in-depth flaw detection and control bulkheads of aircraft that are part of the so-called hungry groups.

Aircraft of hungry groups are operated with advanced flight time and an increased turnaround time compared to conventional flight vehicles, and as a result, during operation, after a certain flight time, a number of works are performed on them to repair and replace the unit and assemblies, which are usually not performed on scheduled aircrafts.

Valuable information about the manufacturability of structures in a number of cases comes from enterprises and specialists conducting government and operational tests of aircraft. Carefully collected data on the operational adaptability of designs of foreign aircraft, methods and technology of their maintenance and repair.

PART 2.
COMPARATIVE ANALISYS

A feature of the functioning of aircraft repair enterprises (ARP) in a market economy is the struggle for the sales market. Financial stability is achieved through the provision of aircraft repair services at a higher quality level than competitors, and through wide diversification based on the existing production and technological infrastructure.

Achieving this goal is impossible without predicting the market situation and planning investment policy based on modeling the results of marketing research, statistical data, trends in the development of science, technology and technology. The introduction of the latest advances in the field of technological processes, expanding the range of remanufactured parts, mastering the repair of newly commissioned aircraft is associated with a long stage of technological preparation of production in accordance with the technological documentation.

The current regulatory framework does not allow designing repair technological processes by the ARD themselves. At the same time, the "Overhaul Manuals" developed by industrial enterprises are becoming obsolete, and the current mechanism for changing them by the system of bulletins is inertial to the latest achievements of science, technology and technology. ARPs do not have the necessary experimental and testing base for the experimental confirmation of technological developments, but they have qualified personnel and an urgent need to improve the technological base. Industrial enterprises have such a base, but are not always interested in priority research for the needs of the ARP.

The way out of this situation is the maximum use of methods of mathematical modeling of technological repair processes and the creation of computer-aided design systems on their basis. From this follows the relevance of the problem of finding and developing methods for computer-aided design of technological processes for repairing AT. The main difficulty in this is that: until now, no research has been carried out on aircraft repair as a single system, which is the subject of the general theory of aircraft repair production; Due to the complexity of the physical and chemical processes underlying the recovery technologies, the mathematical apparatus has not been developed to fully and adequately simulate them.

In this regard, the main element of the theory of aircraft repair production is the development of theoretical foundations for the design of technological processes for the repair of aircraft as a means of increasing the efficiency of ARP by developing appropriate directions, methods and recommendations in the transition to a market economy.

Achievement of this goal is associated with solving problems: development and analysis of a mathematical model of the system, in order to determine the reserves for increasing the efficiency of the ARP; concretization of the elements of the mathematical model, assessment of adequacy and obtaining design methodological results; presentation of the results as a system of generalized knowledge about the organization of aircraft repair production in a market economy, describing, explaining and predicting the functioning of the objects included in it.

The theoretical foundations for the design of aircraft engine repair in a market economy and the practical recommendations obtained on their basis contribute to the process of increasing the efficiency of aircraft repair production, increasing its economic sustainability and are an essential step towards creating a common theories of aircraft repair production, since they allow:

- to expand the scope of services for the restoration of aircraft engines;
- to solve the problem of a sharp shortage and high cost of spare parts through the introduction of new progressive technological processes for the restoration of aircraft engines;
- to form technologically effective ARP, capable of rapid implementation in the desired "niche" of the market, the perception of revolutionary leaps in technology and technology;

In a market economy, the share of physical and moral wear and tear of aircraft has changed: most of the aircraft fleet is subject to wear and tear; the problem of obsolescence of the main domestic aircraft fleet arose with particular urgency. This, in combination with market competition, has made the problem of expanding the scope of services on the commissioning of long-idle aircraft equipment, the introduction of new progressive technological recovery processes especially urgent.

The formation of aircraft repair enterprises, adapted to rapid adaptation to changing external economic conditions, rapid introduction into a free "niche" of the market, perception of the latest advances in equipment and repair technology, requires a conceptual definition of ways to improve the system of aircraft repair production and repair in a market economy, which is impossible without the development of a general theory of aircraft repair production through the transition to the improvement of repair practice.

The most important element of the general theory is the development of models of different levels in order to develop and implement new repair technologies. "Repair manuals" are becoming obsolete, their update is extremely slow as a result of legal and departmental disunity between developers and users. This does not allow to ensure the effectiveness of the product quality management system, the optimality of the repair technology, the expansion of the range of remanufactured parts, the introduction of new progressive technological processes and equipment. The necessity of temporary, qualitative and quantitative forecasting of defects of the proposed repair fund in order to identify the prospects for the development of new technologies and their timely inclusion in investment programs has been substantiated.

The methodology for the formation of the developed technological processes is shown on the example of the technology of optimal restoration of the quality parameters of aircraft engine turbine elements. The developed plan in the search for optimal conditions and their experimental implementation made it possible to design the technological process and obtain the sought models for obtaining the best parameters of the restoration of the turbine elements. This plan, with its improved repair methods, will increase the resource of the turbine and aircraft engine as a whole by a factor of two or more, while reducing the cost of purchasing new parts.

2.1. Classification of failures and malfunctions

Failures and malfunctions of hydraulic systems arising during aircraft operation can be subdivided according to a number of features, the most important of which are the causes of occurrence, the degree of repeatability, the rate of development in time, the degree of influence on the output parameters of the system, and the degree of influence on flight safety. In fig. 1 shows the classification of aircraft hydraulic system failures according to the listed characteristics.

Due to their occurrence, failures can be subdivided into structural, production and operational. Failures associated with errors in the design of hydraulic units or incorrect setting of the conditions for their operation are considered constructive.

Most of these failures appear at the stage of bench testing of units and are eliminated by design modifications before the start of mass production. If during the design of the units, the conditions for their operation on the aircraft were incorrectly determined. then failures begin to manifest themselves in the operation of all units or a significant part of them. In this case, the actual external influences (vibration, pressure overshoot temperature, etc.) exceed those specified in the design and can have the greatest impact on units with the worst combinations of tolerances.

2.2. Classification of aircraft hydraulic system failures

The randomness of such failures lies in the fact that they can occur only in units with a random worst combination of tolerances or with a random combination of external influences exceeding the levels permissible according to the technical specifications. Such failures are often referred to as "pseudo-sudden" failures.

Production failures include failures due to imperfection or violation of the production technology of the units. In this case, the failure rate of units of the same type may be different depending on the manufacturer or batch of approved products. Operational failures arise as a result of violations of the operating rules and technology for performing maintenance regulations or the occurrence of off-design situations, for example, a heap of aircraft landing. Sometimes the reason for operational failures is the imperfectly operating procedure for the maintenance of the hydraulic system of the aircraft or the technology for its implementation, as well as the imperfection of the technology for repairing units that have worked out the overhaul life or the resource before the first repair. In these cases, in order to eliminate failures, a change in the regulations or technology for its implementation is required, as well as the technology for performing repair work.

According to the degree of repeatability, hydraulic system failures are subdivided into single and repeated ones. If there are repeated failures, it is necessary to determine the cause of their occurrence and take measures to eliminate them.

Loss of performance of a hydraulic system or its individual subsystems can occur both as a result of going beyond the technical conditions of its output parameters, and as a result of a malfunction of its units and elements due to the destruction of hoses or pipelines, jamming of spool valves, destruction of hydraulic cylinder rods, breakage of electrical circuits of electromagnetic valves, etc. In accordance with this, parametric and functional failures of the hydraulic system or its individual units are distinguished. Functional failures can lead to complete or partial loss of system performance.

During operation, reversible and irreversible changes occur in the elements of hydraulic units. Reversible changes occur under the action of operational factors and disappear after the termination of their action. Irreversible changes, due to the accumulation of damage in the structural elements of the units, persist even after the termination of the action of operational loads. According to the rate of breakdown of the malfunction in time, failures of the hydraulic system units are divided into gradual and sudden. Gradual parametric failures are a consequence of irreversible changes occurring in the elements of units of gradual wear and aging. Failures of electromagnetic valves due to failure of the electrical part account for a small proportion of all failures (no more than 2%) and are the result of moisture ingress into the electrical cavity of the unit and the action of vibration overloads. They are random in nature and cannot be predicted, but can lead to serious consequences, since in some cases they are a kind of active failures. Typical distribution of failures by units for the hydraulic system of a modern aircraft is shown, respectively, in Fig. 3. From the analysis shown in Fig. 3 of the failure diagrams of the hydraulic system of a heavy transport aircraft with several independent hydraulic systems, it can be seen that up to 40% of all failures are accounted for by the distribution and control equipment units, which in most cases are sudden and sometimes intermittent. They often lead to deterioration of the characteristics of the functional subsystems of the aircraft hydraulic system, and sometimes to their complete failure.

Failures of hoses and pipelines account for a significant part (up to 34%). In most cases, hose failures lead to external leaks, loss of working fluid, pipelines to flight accidents and prolonged downtime of aircraft, thereby reducing efficiency.Failures of hydraulic pumps, depending on the type of aircraft, account for 58% of the total number of destruction of the pumping unit due to its robots in case of insufficient pressure in the suction line, due to failures in the pressurization system of the hydraulic tank or temperature overheating of the pump due to clogging dividing the minimum flow. There are also cases of shear of the drive roller, leaks of its seals and some other types of failures.

2.3. Requirements for the reliability and reliability of hydraulic systems

Aircraft hydraulic systems included in the category of "essential" functional systems must fully meet the above requirements for reliability and reliability, taking into account the impact of the consequences of failures on flight safety. This is achieved by the appropriate choice of the circuit design of the hydraulic system, the constructive solution and production execution of the units and components included in it. In general, the hydraulic system must be designed in such a way that, under the expected operating conditions, reliable power supply of the hydraulic actuators included in other aircraft systems is provided in all operating modes.

The power of the pressure sources of the hydraulic system must be sufficient to ensure the operability of the consumer systems under the most unfavorable the possible combination of their simultaneous operation and the corresponding counteraction of external loads, during any minimum specified periods of time. If the functioning of the actuating hydraulic mechanisms of the consumer systems is partially provided by hydraulic accumulators, their energy capacity should be sufficient to perform the required number of working cycles (operations) with the required time intervals between them.

Reliability of power supply of the executive power drives is ensured due to the implementation of the hydraulic system of the aircraft on the principle of redundancy. The redundancy rate of the hydraulic system and its individual subsystems is determined by the requirements for the reliability of robots of its consumers, taking into account wide-body passenger aircraft, any failure in the hydraulic system should not lead to a situation more serious than the complication of flight conditions. If it is necessary for any consumer systems to continue to operate after the failure of any source of hydraulic power, measures should be taken to ensure that these systems are sufficiently powered from the remaining power sources, and such power should not be consumed, but the activation of secondary systems of influence of failures on flight safety.

To protect the hydraulic system units from failures and malfunctions due to contamination of the working fluid, the cleaning filters of the required capacity are installed in the hydraulic system, designed for the nominal fluid flow under various operating modes of the system.

Hydraulic systems must have devices that could limit the maximum attainable pressure in the system under various modes of operation, including transition processes, during the volumetric thermal expansion of a liquid or gas in the event of failure of any of the elements of the hydraulic system, as well as during its check. Typically, the maximum allowable pressure in the system corresponds to the crimping pressure of its elements. This requirement is met by the presence of one or more pressure relief valves.

The hydraulic system and its components must not cause or increase the risk of fire or explosion on the aircraft and must meet the applicable fire safety requirements.

It is desirable that low flammability fluids are used in the hydraulic system. A hydraulic system that uses a flammable fluid must be segregated or protected from potential ignition sources so that the risk of fire due to fluid leakage from the system or due to system failure is reduced to an acceptable level.

Units and elements of the hydraulic system must withstand the operating loads and pressure increases, limited by safety devices within the design tolerances, without detecting cracks or ruptures, leaks or permanent deformations. These requirements are met by conducting appropriate tests of units, fittings and pipelines of hydraulic systems for tightness and strength.

Conclusions to the part 2.

At present, general requirements have been developed for ensuring the operational manufacturability of structures for newly created types of aircraft, which include the required values of the indicators of operational manufacturability, requirements for the structure in terms of adaptability to progressive methods of performing technical service and repair; design requirements in terms of lubrication, control and fastening, control and adjustment, refueling and other types of operations, as well as requirements for the design and placement of individual systems and assemblies on the aircraft, their unification and standardization.

PART 3.
DEVELOPMENT AND INSTALLATION OF PARAMETERS CONTROL

SENSORS IN HYDRAULIC SYSTEM

3.1. Parameterized maintenance application

The increasing complexity of the design of aircraft systems and products has led to an increase in the variety of units (blocks) included in them by the nature of the physicochemical processes used, the nature and degree of loads and, as a consequence, to different levels of their reliability. Therefore, there is practically no optimal timing of maintenance and repair for a complex object as a whole. Performing a predetermined amount of preventive work on time for most removable products does not reduce the likelihood of failures, and for some equipment, for example, electronic equipment, it increases the flow of post-repair failures.

The rate of consumption of the actual resource (rate of aging, wear) of an object is random and varies widely depending on operating conditions, climatic conditions, operating modes, duration of flights, organization and quality of maintenance and repair, storage and transportation conditions. The current level and prospects for the development of means of technical diagnostics, flaw detection and automated control open up real possibilities for applying the strategy of servicing and repairing aircraft systems and products based on the state of control of parameters.

To identify the pre-failure state of products, the principle of assigning anticipatory tolerances to diagnostic parameters can be used. In this case, anticipatory tolerance is understood as a set of parameter values between the limit and pre-failure levels of a parameter. If a parameter goes beyond the limit level, it means a failure, and reaching a pre-failure level requires preventive maintenance or product replacement.

The diagnostic mode is a set that determines the composition of the diagnostic parameters, the frequency of their checking and anticipatory tolerances on the parameter. The diagnostic mode provides for the establishment of quantitative relationships between the values of the anticipatory tolerances for the diagnostic parameters of the product and the frequency of monitoring its technical condition.

Diagnostics Regulations - a single document that directively approves the mode of technical diagnostics. Obtaining initial information about the technical condition of the product is carried out by measuring its functional and diagnostic parameters. The following measurements are carried out at a certain frequency in flight and when performing various forms of maintenance, on board the aircraft and with the removal of equipment from the aircraft, using standard instruments, automated control means, technical diagnostics and non-destructive testing, with registration in flight logs and on board tapes and ground recorders.

From the point of view of management, the technical condition is of significant importance for the technical diagnostics of products on the ground and, in particular, during operational control carried out in the preparation of aviation equipment for flights.

Operational control of the technical condition should provide signaling about the presence of a failure; operational status alarm; signaling about the need for preventive work to ensure the extremum of the selected quality criterion; short-term forecasting of performance for a given time interval in the event of an alarm about the need for preventive work; search for a removable functional element to be replaced; assessment of the technical condition of products.

The degree of application of technical diagnostics determines the depth and quality of determining the technical condition of products, and therefore the correctness and effectiveness of the decisions made and the strategy itself. The traditional and most common approach to determining the technical state is that a certain set of parameters is selected, measurements are taken, the results of which are compared with the specified boundaries of the operability area. When the conditions for belonging to each of the parameters of the specified area are met, a decision is made on the performance of the product. If this condition is not met for at least one of the parameters, then the object is recognized as inoperative.

Despite the apparent simplicity of this approach, its implementation encounters a number of significant difficulties. This applies, first of all, to the selection of a set of parameters and the determination of operability areas for each of the selected parameters. Significant difficulties arise in the hardware implementation of this strategy, due to the need to use a large number of heterogeneous primary converters and switches. A characteristic feature of the considered maintenance and repair strategy is the absence of overhaul life of products. The decision to continue operation until the next check or the need to replace (adjust) the product is made based on the results of continuous or periodic monitoring of the parameters that determine the technical condition.

The prerequisites for the application of a performance-based maintenance and repair strategy arise from the requirements for flight safety, regular departures and economy of operation. Flight safety is achieved as a result of ensuring: a given level of reliability of structures with increased survivability, assessing and predicting the level of operability during operation; detecting failures and malfunctions at the early stages of their development by ensuring the required level of testability, indicating failures and pre-failure states, using methods and means of technical diagnostics.

The regularity of dispatches is achieved due to: rapid detection of emerged failures and malfunctions; ensuring the required levels of operational manufacturability (testability, availability, easy removability of interchangeability), allowing you to quickly restore the operability of a system or product.

The economic efficiency of operation is achieved by choosing the optimal maintenance and repair strategy that provides extreme values of the objective function at a given level of reliability of functional systems and products.

It is advisable to limit the scope of the strategy of maintenance and repair with control of parameters to systems and products that, for reasons of flight safety, cannot be allowed to operate to failure. with a high functional significance, having an insufficient degree of redundancy and, at the same time, having a high level of operational adaptability and controllability.

3.2. Parameters of the technical state of objects and their changes

Determination of the technical condition of aviation equipment is one of the most difficult tasks in the field of aircraft technical operation. As a rule, the most laborconsuming part of the work of the ITP of civil aviation enterprises is to perform work to check the serviceability, the correct functioning of objects, and also to search for faults that arise in them. For example, most of the downtime when troubleshooting failures is spent identifying (finding) a faulty element in a failed system. This is a consequence of the fact that since the present time, when designing an aircraft, no deep study has been made on the issue of organizing effective procedures for determining its technical condition. In this connection, when operating an aircraft, it is often necessary to use intuitive methods and manual methods for determining the technical condition.

The use of such methods in conditions of continuous complication of aircraft structures and an increase in the intensity of their use cannot guarantee obtaining objective information about the actual technical condition of objects. A successful solution to this problem can be obtained only through the use of modern scientific methods of technical diagnostics, which is a branch of knowledge that studies the technical condition of objects for diagnostics and the manifestation of technical conditions, develops methods for their determination, as well as principles of construction and organization of the diagnostic system.

Technical condition - a set of object properties subject to change during production or operation, characterized at a certain point in time by the characteristics established by the technical documentation for this object. Qualitative and (or) quantitative characteristics of its properties can be signs of a technical condition. The actual values of these characteristics determine the technical condition of the object.

It is necessary to distinguish between the concepts of "technical condition" and "type of technical condition". The set of technical conditions that satisfy (do not satisfy) the requirements that determine the serviceability, serviceability or correct functioning of the object forms the corresponding types of technical conditions of the object. To determine their type, it is necessary to know the technical state, determined by diagnostics, and the requirements that determine the serviceability, operability, correct functioning of the object, for example, in the form of a task in the technical documentation of the nomenclature and the permissible values of the quantitative and qualitative characteristics of the object's properties.

With one and the same objectively existing technical condition, an object can be operable for some conditions and unworkable for others. So, after the onset of an inoperative state on an aircraft, an aircraft engine may turn out to be efficient as a source of mechanical energy in installations for various purposes on the ground.

3.3. Object structure and structural parameters

The subject of research in technical diagnostics is real technical systems (objects of diagnostics). The study of objects to be diagnosed covers two aspects: the study of the properties and characteristics of real physical objects; methods of constructing their mathematical models.

The first aspect is associated with solving the problems of studying the normal functioning of an object, highlighting the elements of the system and the connections between them, i.e. system structure; highlighting possible states of the system, i.e., possible combinations of failures of elements; analysis of the technical capabilities of the control of signs characterizing the state of the system; collection and processing of statistical data, allowing to determine the distribution of probabilities of possible states of the system, patterns of manifestation of failures of its individual elements, the costs associated with diagnostics. All these tasks imply for their solution empirical research of specific technological systems and procedures for their diagnosis.

The second aspect is related to the construction of mathematical models of objects. Theoretical analysis always presupposes a certain idealization, in which some essential (for technical diagnostics) features of real objects are singled out and the secondary ones are discarded, i.e. a real technical system is replaced by some model. This model must be abstract enough to be applicable to the analysis of a whole class of technical systems. At the same time, it must take into account all the essential features of specific systems and methods of searching for failed elements in them. Replacing real systems with appropriate models makes it possible to widely use the formal apparatus of modern mathematics (probability theory, mathematical logic, dynamic programming, etc.) to solve problems of technical diagnostics.

The object of technical diagnostics, whether it is an engine, a hydraulic system

or an aircraft control system, has a certain structure, i.e., an ordered set of complexes of jointly working elements (parts) that form the structure of the object's structure ensuring the performance of specified functions.

The structure of an object is characterized by the relative position, shape and size of interacting parts (macrostructure), the nature of the mates, surface cleanliness (microstructure) and other characteristics. The structure of the object as a whole predetermines the set of certain technical and operational properties laid down in it during design and production, which determine the degree of the object's fitness to perform specified functions in certain operating conditions.

The structure of an object is characterized by quantitative parameters, which are called structural. The object, entering into operation, has a certain structure and a set of technical and operational properties, depending on the structure. In this case, the numerical values of the structural parameters correspond to those established according to the drawings and specifications. Such parameter values are called initial or nominal.

Taking into account the change in the structure of the object, we can talk about the technical state of the object at any given moment in time, characterized by a certain set of specific values of the structural parameters of parts and assemblies. Changes in the structural parameters of an object are reflected in the totality of its technical and operational properties. Changes in structural parameters have quite definite patterns that have not been fully studied. These changes, constantly accumulating, can reach such a quantitative limit at which abrupt changes occur.

3.4. Selection of parameters for control

The monitored parameters of various units of the hydraulic system are given in table. 2

Unit	Monitored parameter
Hydraulic tank	Liquid level Temperature Boost pressure
Filter	Pressure Chips in liquid
Safety valve	Pressure
Accumulator	Nitrogen pressure Temperature
Hydraulic Pump	Pressure Temperature Leakage rate in the case System leak rate
Pulsation damper	Nitrogen pressure
Steering Surface Control Cylinders	Fluid Flow Stem position Pressure
Reducing valve	Pressure
Drain tank	Liquid
Wheel braking system	Brake pressure Anti-theft vending machines
Wheel Steering System	Steering Angle Pressure in the ACC
Chassis control system	Electromagnetic crane Limit switches
Inner spoiler control system	Solenoid valve Limit switches

Table 2.

Parameter control sensors in flight and on the ground implements the following operations:

a) in flight:

- automatic quantitative control of the parameters of the equipment of the control object with the recording of information about the control results on the magnetic tape of the control information rescue device;

- issuance of voice messages to the crew through the intercom in case of emergencies at the controlled object;

- the content of the information recorded on the magnetic tape in the event of a flight accident;

b) on the ground:

- automatic quantitative control of the parameters of the equipment of the control object with the issuance of information about the results of control on a light board, with the recording of information about the results of control on the magnetic tape of the control information rescue device and with the issuance of voice messages to the crew through the intercom;

- Logical troubleshooting (the location of the fault is determined using the catalog of solutions);

- selective control of individual systems and units at the request of the operator;

- manual adjustment of the parameters of the equipment of the controlled object by standard means of adjustment available in the controlled equipment.

Composition of the parameter control system.

The monitoring system hardware consists of the following functional devices:

a) device switching and parameter conversion;

b) central processing unit;

c) indication and registration devices;

d) power supply and protection devices.

The functional devices include the following blocks:

1. Device for switching and converting parameters:

- primary switches;

- switching control unit;
- signal (parameter) conversion block.

2. Central processing unit:

- arithmetic unit;
- measurement unit;
- signal selection block;
- storage block;
- Control block;
- power unit;
- communication unit with external devices;
- control and display panel;
- Remote Control.

3. Display and recording device:

- control unit for indication and registration;
- device for recording parameters;
- display control panel;
- indicator panel.

Switches are designed to select and connect control points, match the outputs of signal sources with subsequent targets. In modern control systems, the addresses of the check points are sent to the switch in the form of a serial code, and then, using a shift register, are expanded into a parallel (or parallel-serial) code. Test point switching is usually two-wire. Each switch is powered separately from the system power supply. The central processing unit contains the following control units (programming unit), signal selection (switching, normalization and conversion of signals into constant voltages), a measurement and calculation unit consisting of analog-to-code converters and a computing device, a power supply unit that can include the device output control and indication

Basic principles of robotic sensors control parameters

From sensors and primary converters installed in the units and systems of the controlled object, the monitored parameters are fed to the inputs of the primary switches of the monitoring equipment.

According to the control program, at the command of the control device, the corresponding primary switch is installed, the parameter conversion unit is installed according to the type and measurement range, the signs are installed, the time sensor is installed to form a time interval between measurements. The monitored parameters in the form of an electrical signal through the primary switch and the switching control unit are fed to the input of the parameter conversion unit, where the analogue electrical signal is converted into a numerical binary-decimal code. This code is the result of measurement in the given units and is transmitted to the arithmetic unit.

The arithmetic unit compares the measurement result with the nominal parameter value stored in the memory, performing mathematical operations according to the control program. The deviation of the measured parameter from the nominal is determined by the standard processing formula:

$$\frac{\mathrm{Pch} - \mathrm{Pnom}}{\Delta P} = P\%$$

where Pch is the measured value of the parameter; Pnom - the nominal value of the parameter,

ΔP - permissible deviation, P% - percentage deviation in the field.

To find out whether the parameter is in the limits, use the formula:

$$[P\%] - 100 = A$$

This formula is used to subtract the modules of the numbers P% and the tolerance field taken as 100% is determined in the tolerance parameter (A <0) or not in the tolerance (A> 0). The result of the logical operation (A <0 - signals "In limits", A> 0 - signal "Not in tolerance") is used to form a condition for performing a conditional jump operation, which provides a logical search for a malfunction. The result of the control is transmitted to the control and registration unit, which prepares and transmits the received information to the executive devices, an automatic printing device, a parameter recording device, an extension and display panel. At the same time, in accordance with the result of the control, control signals are transmitted from the control unit to the voice message device for issuing voice messages, which are reproduced as follows: control signals are stored in the memory of the voice message device, the most important voice message is played first, the least important second, etc.

During ground control of aviation equipment, according to the commands of the control device, in accordance with the operator's desire and the type of control, it performs the following operations:

a) control with a stop to perform manual settings;

b) control in standby mode (continuous control until the parameter value is established within the tolerance range);

c) control with a stop at a parameter out of the tolerance range and without stopping at the request of the operator;

d) selective control of single and group parameters, at the request of the operator;

e) manual regulation.

Operators are connected with control equipment using a control panel, on which a control body and a dial-up field for manual input are located constants and addresses of the beginning and end of the selected section of the control program in the storage device of the equipment, where it is entered using a ground input device and from where it naturally enters the control unit

Self-control of the equipment is carried out according to the program by measuring and processing the parameters of self-control according to the standard formula and performing special test tasks.

3.5 Calculation of the characteristics of built-in control systems

3.5 (1) The main malfunctions of hydraulic pumps

The correct operation of the hydraulic units depends on the pressure supplied to the actuators. Nicknames, dents, clogging of pipelines and units increase the pressure loss, which can affect the work of individual consumers, the operation time, etc.

During operation, disturbances in the system may occur, leading to increased pressure fluctuations, changes in operating modes of units and devices and other malfunctions. These malfunctions can occur when parts of the units are worn out (loss of internal tightness in units), frequent triggering of automatic unloading devices or frequent switching on of pumping stations, as well as failure of hydraulic accumulators or pulsation dampers, violation of adjustment of units, etc. All these malfunctions can lead to the appearance in hydraulic systems, pressure pulsations (often in this case pressure overshoots occur above the maximum) and hydraulic shocks. The manifestation of pulsating loads in the system can cause the development of fatigue cracks in pipelines and unit casings.

Long-term operation of pumps under load causes premature wear of their parts, a decrease in flow, and the appearance of fatigue-type cracks is possible. In addition, continuous pumping operation under load and pressure pulsation leads to overheating of the liquid, more severe conditions of robotic seals, and more contamination of the liquid. Overheating of the liquid from prolonged operation of the pumps under load causes a decrease in it viscosity, and this increases the frequency of operation of the automatic unloading machine. Such mutual influence aggravates the malfunction, requires timely finding and eliminating its cause.

External tightness is checked by inspecting the units and pipelines of the hydraulic system. Internal - by sequential shooting of the units from the aircraft and checking their tightness on the stands. Or by checking the tightness of the units without shooting them by disconnecting the drain line pipeline and measuring the leakage values (the pressure in the system is created by a hand pump or a ground source of energy).

Therefore, of particular interest is the issue of using built-in failure detection and recognition systems to monitor the technical state of the hydraulic system in flight and on the ground.

The main characteristic of a hydraulic pump is the dependence of its performance on pressure. Initial data:

- diameter of the cylinder block (Dcb = 125 mm.);
- plunger diameter (Dpl = 12 mm);

- number of plungers (Z = 9);
- the number of revolutions of the hydraulic pump shaft (n = 4000 rpm);
- tilt angle of the cylinder block (γ = 20 °);
- pressure behind the hydraulic pump (P);
- coefficient taking into account leaks in the hydraulic pump (β = 0.95);
- kinematic viscosity (μ = 20).

The theoretical flow rate of the hydraulic pump (Θt) is determined by the formula:

$$\Theta_T = \frac{\pi d_{pl}}{4} Z n D_{cb} tg\gamma; \text{ litres\min;}$$

$$\Theta_T = \frac{3{,}14 * 12^2}{4} * 9 * 4000 * 125 * tg20^\circ * 10^{-7} = 18{,}5 \text{ litres\min;}$$

Leaks in the pump are accounted for by the formula:

$$\Theta_{lks} = \beta \frac{P}{\mu};$$

The actual flow of the hydraulic pump is determined by the formula:

$$\Theta_{fact} = \Theta_{\text{Т}} - \Theta_{\text{УТ}};$$

All data are summarized in table. 4.

P, MPa	*ӨУТ,* litres\min	*О,*litres\min
2	*0,095*	*18,4*

4	0,19	18,31
6	0,3	18,2
8	0,38	18,12
10	0,48	18,02
12	0,57	17,9
14	0,66	17,84
16	0,76	17,7
18	0,85	17,65

Table 4.

Based on these data, the characteristic of the hydraulic pump is built (see Fig. 1). Sensors monitor the parameters of the hydraulic pump in flight and on the ground. The built-in control system processes signals and solves the following tasks of providing early warning of incorrect operation of the hydraulic pump or its failure, monitoring the critical and vital parameters of the hydraulic pump, issuing a signal to ground personnel about the need for maintenance.

3.5 (2). Calculation of the reliability of the hydraulic pump

The reliability of the hydraulic pump is characterized by the probability of failure (P), which is determined by the formula:

$$P = 1 - e^{-\lambda_i t};$$

where λ is the failure rate (λ = 10^{-3});

t is the operating time of the hydraulic pump to failure, h.

Enter all calculations in table. 5.

t	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
$e^{-\lambda_i t}$	0,37	0,14	0,05	0,02	0,004	0,003	0,001	0,0004	0,0002	0,0001
P	0,63	0,86	0,95	0,98	0,996	0,997	0,999	0,9996	0,9998	0,9999

Based on this data, we build a graph:

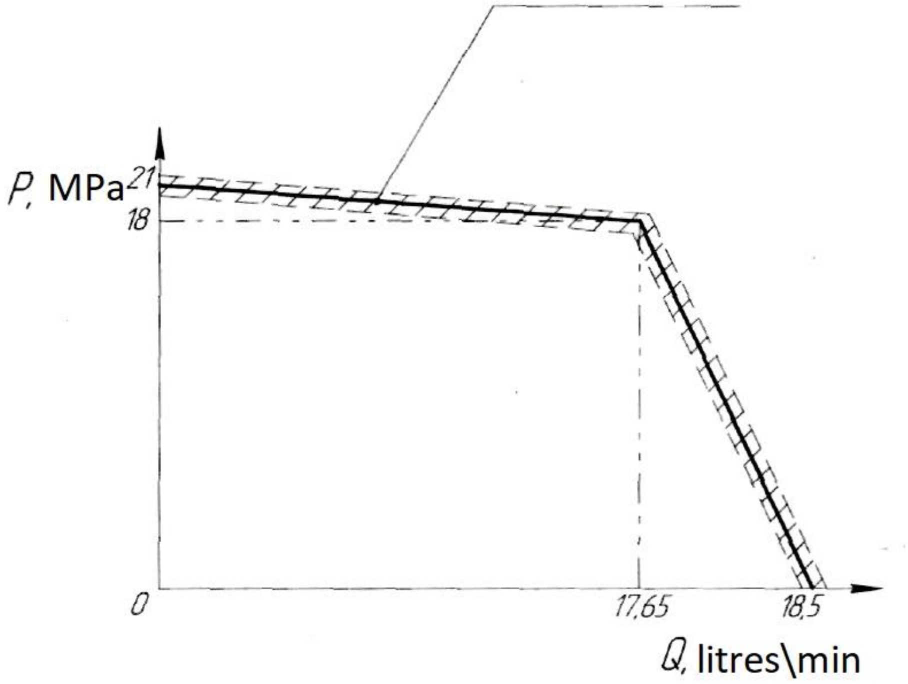


Fig. 3.1 Hydraulic pump characteristic.

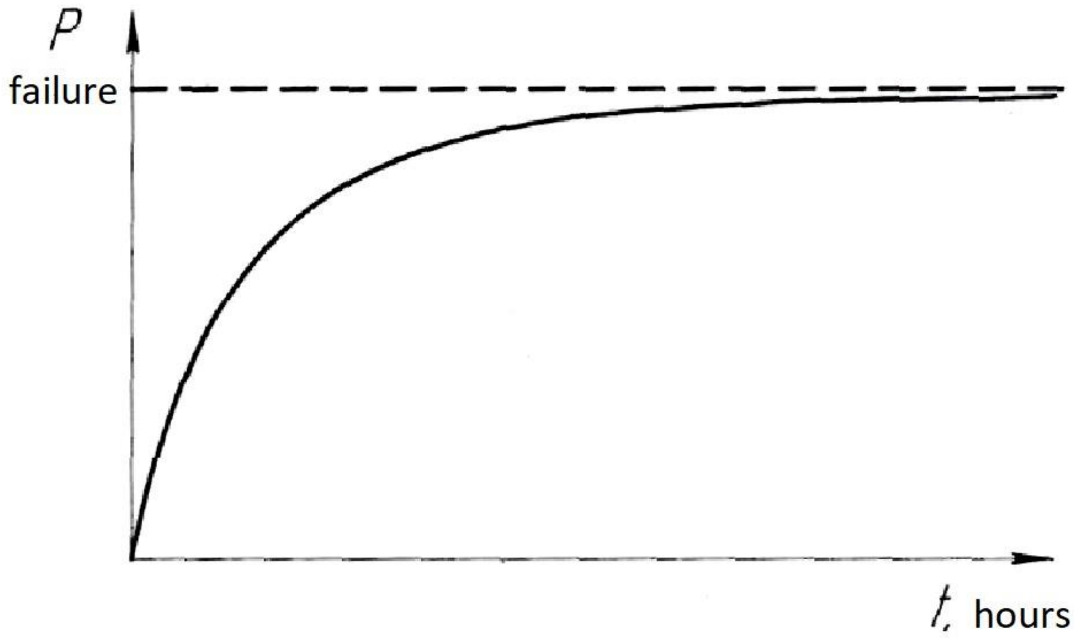


Fig. 3.2. Failure probability

Maintenance of the hydraulic system

On modern aircraft, in most cases, mixed systems are used, which include system elements: a hydraulic system (energy sources and consumers), electric (control of command electric-hydraulic units) and gas (charging hydraulic accumulators, emergency and other systems). The reliability of such mixed systems depends on the serviceability of all very complex aggregates of various types included in them. Unlike the structural elements of the airframe and other systems, the performance of the hydraulic system is influenced not only by the external climatic conditions (outside air temperature, pressure, etc.), the duration of the operation of the system units, but by a number of specific factors: the properties of the working fluid and their changes during the operation of the system , regularities of pressure changes in the system, duration of operation of pumps under load, correct adjustment of units, etc.

Of the external conditions, temperature affects the operation of the hydraulic system to a greater extent. Temperature changes affect the elasticity of the sealing cuffs, the viscosity of the liquid, and the size of the gaps in the joints. All this leads to a violation of the external or internal tightness of the system. Small clearances in spool-type units (within 2-10 microns) impose special requirements on the quality and purity of the working fluid of the hydraulic system.

To a large extent, the service life of the units of the pressure source network depends not only on the duration of their operation, but on their operating time under load, which in turn depends on the serviceability of the units and units regulating the unloading of the pumps that ensure the duration of this load.

The reliability of a hydraulic system depends on the presence of air in it, which can be in the liquid in the form of small bubbles, in dissolved form and in the form of air locks. The presence of air in the system contributes to liquid oxidation, a decrease in pump performance or unit failure (cavitation may occur, for example, if the pressurization system of hydraulic tanks fails). The correct operation of the hydraulic units depends on the pressure supplied to the actuators. Nicknames, dents, clogging of pipelines and units increase the pressure loss, which can affect the work of individual consumers, the operation time, etc.

During operation, disturbances in the system may occur, leading to increased pressure fluctuations, changes in operating modes of units and devices and other malfunctions. These malfunctions can occur when the parts of the units are worn out (loss of internal tightness in the units), the automatic unloading machines are often triggered or pumping stations are turned on frequently, as well as the failure of hydraulic accumulators or pulsation dampers, a violation of the unit adjustment, etc. All these malfunctions can lead to hydraulic systems, pressure pulsations (often in this case pressure overshoots occur more than the maximum) and hydraulic shocks. The manifestation of pulsating loads in the system can cause the development of fatigue cracks in pipelines and unit casings.

The main work during maintenance (regardless of the type of hydraulic system) include checking the presence of fluid in the system and the absence of external leaks.

The liquid level in the tanks is usually checked with the landing gear extended, the flaps retracted, the accumulators charged, and when the operating pressure in the system is present (sometimes taking into account the outside air temperature). If necessary, refueling is carried out using a ground installation (through the onboard suction fittings) or an onboard hand pump .. In addition, to check the purity of the working fluid and its compliance with its technical conditions, remove filters and drain the sludge from the tanks. In case of detection of mechanical impurities, water or contamination, the working fluid is replaced. In this case, it is also required to flush the tanks and their filters, for which special stands and installations are used.

In case of defects in hydraulic systems, the condition and fastening of the pipelines is checked, on which there should be no dents, nicks, scratches, scuffs and other stress concentrators, as well as loosening of the pipelines in the clamps and flanging blocks.

The use of damping gaskets increases the reliability of pipelines, reduces the stress in the pipe by 4-6 times. At the same time, the observance of the required distances between pipes and other parts of the aircraft is also checked.

Hydraulic pipelines are subjected to a complex load spectrum due to deformations and vibrations of aircraft parts, water hammer and fluid pressure fluctuations, and a number of other factors. These phenomena can cause transverse and longitudinal fatigue cracks in pipelines. Transverse cracks appear, as a rule, at a distance of 10-15 mm from the nipples, in places of bends with a large curvature contributing to stress concentration.

Violation of the cylindricity of the cross-section of the pipeline contributes to the appearance of longitudinal cracks. The reliability of pipelines largely depends on the correctness of the dismantling and installation work.

Frequent dismantling of pipelines leads to thread wear and loosening of the connection.

During maintenance, they check the serviceability and operation of individual units and sections of the system (energy consumers), charging accumulators and pulsation dampers with compressed nitrogen, which is done with a device with a pressure gauge or using the pressure relief method (for accumulators).

In a number of systems (for example, brake systems), the fluid pressure is checked and, if necessary, adjusted when the valves of the main, emergency and parking braking are pressed. In the case of using a fly-by-wire pressure control, the brakes are checked for serviceability and adjustment of inductive pressure sensors, feedback, an electro-hydraulic converter and other units.

Sometimes a general assessment of the health of the hydraulic system is made by the number of activations by individual consumers, for example, brakes, when the pressure in the system drops from working to zero, the correct operation of the safety valve, the serviceability of the pressure relief valve of the pressure tank pressurization system and the serviceability of hand pumps are checked.

After replacing a faulty unit of a pipeline section or performing other dismantling and installation work, it is necessary to check the robot of the hydraulic system and those units that it serves.

In some cases, this is done during a test flight.

It is very important to remove air locks from the system using ground-based installations after performing the installation work, and before removing the units, it is imperative to relieve the pressure in the system.

In order to increase the reliability of hydraulic systems, various types of unloading of pressure sources are used: unregulated supply systems with an automatic unloading (unloading with non-operating consumers by pressure), systems with variable supply pumps (unloading by supply) and systems with an autonomous or frictional pump drive (unloading by pressure and filing).

In systems with variable displacement pumps, an increase in internal or external leaks will cause the pump washer to rotate until the displacement equals the system leaks. The operability of such a system is checked when starting the aircraft engine on which the pump is installed, by measuring only the value of the maximum pressure created by the pump, since the pressure during unloading of the pumps remains maximum (with non-operating consumers). An additional criterion for the serviceability of such systems is the absence of pressure pulsations, overheating of the fluid and the unit. Pressure pulsations can appear when the pulsation dampers are incorrectly charged with compressed gas, when their rubber diaphragm is destroyed. Overheating of the liquid with non-operating consumers is possible due to clogging (clogging) of the constant flow throttle, therefore it is periodically removed and flushed, and the initial charging of the pulsation dampers with compressed gas is checked.

In systems with fixed flow pumps, after reaching the maximum pressure, the pumps are switched to idle by the automatic unloader, that is, their pressure lines are connected to the return lines. The working pressure of the pump is determined by hydraulic losses in the pipe (usually no more than 0.5-1.5 MPa). With a decrease in the pressure in the system below the minimum value, but which is adjusted by the automatic unloading machine, the pump again switches automatically to pumping into the system. Typically, the parameters of the hydraulic accumulator of the automatic unloading machine and other units are selected so that the time interval between turning off and turning on the pump is as long as possible (15-30 minutes).

The serviceability of systems with fixed-flow pumps is also checked when the corresponding aircraft engine is started. The compliance of these parameters with the technical conditions depends on the serviceability of hydraulic pumps, automatic unloading machines and a number of other units. The time period between activation of the automatic unloading machine is a function of many variables.

Long-term operation of the system, its units and especially pumps under load causes premature wear of their parts, a decrease in flow, parts of automatic unloading machines, check valves also wear out prematurely, fatigue-type cracks may appear on pipelines and units. In addition, prolonged operation of pumps under load and pressure pulsation leads to overheating of the fluid, more severe operating conditions of the seals, and more contamination of the fluid. Overheating of the liquid from prolonged operation of the pumps under load causes a decrease in its viscosity, and this increases the frequency of operation of the automatic unloading machine. Such mutual influence aggravates the malfunction, requires timely finding and eliminating its cause.

For systems with automatic unloading devices, a violation of the frequency of operation of the automatic device in flight or the presence of a rapid spontaneous drop in pressure on the ground is one of the main signs of a system malfunction. To determine the cause frequent operation of the automatic unloading machine, it is possible to recommend the search for faulty units using the "labor intensity probability" method, taking into account the design features of each system.

Fluid purity and compliance can be verified by draining sludge from the hydraulic tank. In case of contamination of the fluid, replace it. In this case, the tank and its filters must be removed and washed.

The serviceability of the automatic unloading machine can be checked from a ground installation, with the help of which it is possible to determine the values of Dmax and Ptin, as well as the time t of the pressure drop from the value Pmax to Pmin (with idle consumers and onboard pumps).

External tightness is checked by inspecting the units and pipelines of the hydraulic system, internal - by sequentially shooting the units from the aircraft and checking their tightness on the stands or checking the tightness of the units without shooting them by disconnecting the drain line pipeline and measuring the leakage values (the pressure in the system is created by a hand pump or a ground-based source of energy). Typically, the limits of permissible internal leaks in the units are 5-20 cm 3 / min.

Hydraulic systems with an autonomous pump drive, the so-called pumping stations, are automatically controlled after the initial forced activation of the electric motor during the entire flight. When the pressure max is reached, the electric motor and, accordingly, the pumping station are turned off; when the pressure in the system drops to Pmin, the pumping station is put into operation. In the event of pipeline rupture (when the pressure drops below 3-6 MPa), the pumping station is turned off. In addition, when the pressure drops below the Pmin value, the corresponding signal lamp automatically turns on.

To check the serviceability, it is necessary to turn on the electric motor and check the compliance with the technical requirements of the values. In the presence of malfunctions in the system, the pump is often turned on in flight or even its constant operation with the consumers turned off.

Analysis of the system's operation and methods for finding faulty units with frequent triggering of the automatic unloading machine can be used in systems with an autonomous pump drive to find the reasons for the frequent switching on of the pumping station.

3.6 Economic justification

Reducing maintenance burden with monitoring sensors

In the general case, the average statistical time required for maintenance without using flight information can be expressed as the sum:

$$T_{1\Sigma} = T_{t.p.} + T_f + T_w, \qquad (1)$$

where Tt.p. - the average burden on the ground spent on detecting an unacceptable state of an object;

Tf - the average time to find other malfunctions;

Tw - the average time for other maintenance work.

When using automated control, after landing the aircraft, with a certain probability, the RP has on board data on the occurrence (or absence) of states from a set of unacceptable states, then we find the average burden on maintenance by the expression:

$$T_{2\Sigma} = T_{t.p.}(1-P_{П}) + T_f + T_w + T_t, \qquad (2)$$

Where Tt - the average time for decryption.

We find the reduction in maintenance time from the use of control sensors as the difference between expressions (1) and (2):

$$\varDelta T_r = T_{1\Sigma} - T_{2\Sigma}\,. \qquad (3)$$

The economic effect of reducing the time spent on ground maintenance, as a result of the use of automated control, can be found if the cost of the aircraft downtime is known.

Let's set the following calculated data:

Cao - the cost of additional onboard equipment installed on one aircraft;

Cag - the cost of additional ground equipment for decoding flight information;

Ct is the total cost of operating additional onboard equipment, decoding flight information and losses from reducing the payload of one aircraft;

Coa. - the cost of operating additional ground equipment;

Lop - loss of profit due to downtime of one aircraft per unit of time;

M - is the number of forms of TO, on which automated control is used;

Kuf - aircraft utilization factor;

N - is the listed number of aircraft equipped with an automated control system.

Parameters Cao, Cag and t are related to one calendar time τ.

The costs of using automated control for one aircraft are found by the formula:

$$3 = C_{ao} + \frac{C_{ag}}{N} + C_{ag}\tau + \frac{C_{oa.}}{N}\tau. \qquad (4)$$

Cost savings from using control sensors:

$$E = \Delta T_{p;}\, Lop\, m\, K_{uf}\, \tau. \qquad (5)$$

The condition for the payback of the on-board automated control system is the inequality:

$$\mathbf{Ag > Ao} \qquad \mathbf{(6)}$$

Substituting formulas (3) and (4) into inequality (5), we find the minimum calendar time τmin, during which the costs are recouped:

$$\tau \frac{Cao+\frac{Cag}{N}}{\Delta T_p Lop m K_{uf} \tau-(Coa+\frac{C_t}{N})}_{min} \qquad (7)$$

We find the loss of profit due to the downtime of one aircraft based on the results of processing statistical data. For long-haul aircraft, it is approximately 200-500 conventional units per hour.

Equipment cost for one aircraft:

$$C_{ao}+\frac{C_{ag}}{N}\tau = 150000 \text{ conventional units}$$

Sum of Ct $\frac{C_{oa.}}{N}$= 90000 conventional units, multiplication of $\Delta T_p Lop\, m\, K_{uf}\tau = 300000$ conventional units.

Substituting the values of ΔTp= 45 min, Lop = 300 conventional units / hours; t = 1500; Kuf = 0.89 into the formula (7) we find that the costs of installing and operating the automated control system pay off in 8 ... 10 months.

Saving equipment items during maintenance on condition

We will evaluate the effectiveness of the maintenance and repair program with control of the parameters of functional systems by comparing it with the baseline performance indicators for a traditional aircraft maintenance and repair program. As a result of the implementation of the maintenance and repair program for the functional system, a significant part of the elements of the functional system will be serviced as per condition. When servicing by condition, the average individual resource of the elements of the functional system is significantly increased in comparison with the overhaul life. As a result, the required number of replaceable elements is reduced. Required number of items of a certain type for a traditional maintenance program per year:

$$n_{i1} = \frac{W_1}{t_{pi}}, \quad (8)$$

where W1 is the annual flight time during the traditional program of maintenance and repair of the functional system, hours;

tpi - overhaul life of the i-th unit, hours.

$$n_{i1} = \frac{1752}{500} = 3{,}5$$

Assuming that the average individual resource of the elements when servicing them according to their state will be equal to the failure operating time Tf, then for the elements serviced with parameter control, the expression will be written as follows:

$$n_{i2} = \frac{W_2}{\mathrm{T}_f \Theta_i}, \quad (9)$$

where Θi is a coefficient that takes into account the decrease in the operating time of the i-th element due to the removal of the element when its defining parameter falls into the pre-failure tolerance.

$$n_{i2} = \frac{2277}{1{,}5 * 1000} = 1{,}5$$

We determine the number of "saved" elements of the functional system of the i-th type, serviced with control of the parameters:

$$\Delta n = 3{,}5 - 1{,}5 = 2.$$

Conclusions to the part 3.

According to the calculation data, the use of the built-in on-board system for detecting and recognizing failures of the functional system of the aircraft gives a tangible economic effect.

PART 4.
LABOR PROTECTION

Work on labor protection during maintenance and repair of aircraft must comply with the requirements of regulatory requirements (Law "On labor protection" - Effective from 1992-10-14 .: - K .: Council Of Ukraine, 1992.) for its organization and be aimed at:

- compliance with labor laws;
- creation of safe and healthy working conditions in production, the necessary hygienic and sanitary facilities;
- mechanization and automation of processes with difficult and hazardous working conditions, the introduction of effective safety measures;
- training employees in safe methods of performing labor operations and their timely and qualified instruction at the stages of work established for this;
- ensuring effective control over the observance of rules, norms and instructions on labor protection;

Responsibility for the management of labor protection work, for its general and specific condition, for daily supervision and control over compliance with applicable standards and rules and labor protection requirements in organizations and enterprises of civil aviation, in subdivisions and units, in teams and groups that carry out maintenance and repair of AT, are borne by their managers (including direct supervisors of work performed at AT), as well as regular workers on labor protection within the established for each (company documents and in accordance with regulatory enactments) responsibilities and authorities.

This responsibility applies to the processes of maintenance and repair of aircraft in places of permanent and temporary basing of aircraft.

Employees of all categories and levels are obliged to comply with the established norms, rules and labor protection requirements. Specific labor protection duties are indicated in the labor protection instructions developed by the enterprise for each type of AT, for specific operations, work or specialty (profession).

Control over the technical condition of lifting devices and vehicles, pressure vessels, electrical installations, protective devices for special ground and technological equipment is carried out by officials whose composition is determined by the enterprise on the basis of current documents of state bodies of special supervision.

Each participant in work at the AT is provided for the time of direct participation in their production with special clothing, special shoes and personal protective equipment. The procedure and norms for the provision, storage and use of the specified property and funds are determined by separate regulatory acts.

The composition of officials of the enterprise (organization) of civil aviation responsible for the development of safety instructions for specific objects, types of activities and functions, conducting briefings and issuing permits (admission) for the production of work, as well as those carrying out the preparation and placement of signal (pointers, signs, inscriptions, etc.) and protective equipment on the production territory and objects - is determined by the documents of the enterprise.

The regulation and regulation of the work regime of the airline employees, including the processes of maintenance and repair of aircraft, is carried out on the basis of the requirements of target instructional documents on this issue for the civil aviation and in accordance with the norms of labor legislation.

For employees of the IAS divisions of the airline, briefings on labor protection are carried out, the types and terms of which are determined by the relevant regulatory documents.

All management and engineering and technical workers are required to pass exams in accordance with labor protection rules at least once every three years, and upon admission to work - within the first month of work.

4.1 Fire safety

Responsibility for managing work to ensure fire safety for its general and specific state, for day-to-day supervision and control over the observance of current norms, rules and requirements for fire safety in organizations [Rules of fire safety in Ukraine: NAPB A.01.001-04; effective from 2014-12-30. - Kyiv: Ministry of Internal Affairs of Ukraine, 2014. - 47 p. - (Normative act of fire safety)] and enterprises of civil aviation, in subdivisions and links, in teams and groups that carry out maintenance and repair of AT, are carried out by their managers (including direct supervisors of the work performed at AT), within the limits established for each (by the documents of the enterprise and in accordance with regulatory enactments) responsibilities and authorities. This responsibility applies to the processes of HE production and repair of aircraft in places of permanent and temporary basing of aircraft.

[Rules of operation and standard norms of belonging of fire extinguishers - B.03.001-2004; valid from 2018-02-23. - Kyiv: Ministry of Internal Affairs of Ukraine, 2018. - 23 p.]

Employees of all categories and levels are obliged to know and comply with the norms, rules and requirements of fire safety established by regulatory documents. Specific duties and powers of each employee for these interrogations are included in his job description.

In a typical case, for the purpose of comprehensiveness of fire-prevention work in enterprises, fire-technical commissions are created to develop and monitor the implementation of relevant measures.

Permanent fire prevention measures include:

- organization and control of the implementation of the current norms, rules and requirements of fire safety by all categories of workers;
- ensuring a strict fire safety regime in production, administrative, warehouse and auxiliary premises. In this case, in each case, places for smoking should be determined, the procedure for conducting hot work, inspection and closing of premises after the end of work;
- a clear definition by the documents of the enterprise of the composition of specific persons responsible for the fire safety of specific facilities;
- provision of personnel with instructions on fire safety of facilities and works, evacuation of people, aircraft and equipment in case of fire;
- provision of fire safety briefings with all employees and training on fire-technical minimum programs, including practical training in the use of primary fire extinguishing

equipment;

- constant preventive work to effectively prevent violations of fire safety rules.

The composition of employees responsible for the fire safety of specific facilities is determined by the documents of the enterprise. The service details of these persons are given in the corresponding signs installed at the facilities. Typically, the employee responsible for the fire safety of the facility is obliged to:

- ensure compliance with the established fire regime at the facility;
- to conduct fire-prevention briefing of personnel and classes on the fire-technical minimum;
- monitor the serviceability of technological equipment, fixtures, heating devices, means of communication with units and duty officers of the fire department;
- in all production and service premises in prominent places to place schemes for the evacuation of people, aircraft, documentation, equipment and property and other actions necessary in the event of a fire.

It is prohibited to smoke at workplaces in production facilities, hangars, warehouses, storage facilities, near and inside the aircraft, on ground equipment storage areas, in other fire hazardous places. Smoking is allowed in specially equipped areas equipped with fire extinguishing equipment. Standard signs are posted in places where smoking is permitted or prohibited.

During storage, maintenance and repair of aircraft in open areas and indoors, it is prohibited:

- start work without checking the grounding of the aircraft, the presence and serviceability of fire extinguishing equipment;
- allow special vehicles and vehicles to the aircraft that do not have fire extinguishing, grounding and spark extinguishing means provided for them;
- use faulty electric heating and electric lighting devices and installations when working on an aircraft;
- to carry out work on painting, washing and rinsing parts in rooms that are not equipped for this;
- store containers with flammable materials, kindle blowtorches, make fires, burn

garbage, burn grass near aircraft, industrial buildings and other objects (at distances less than established by the relevant documents);
- store flammable and combustible liquids, oxygen cylinders, oiled rags, motor vehicles in hangars, docks;
- pour oil products onto the soil (concrete, asphalt) and into unsuitable containers,
- when working in a hangar (room), place electric wires in the path of movement of intra-hangar vehicles;
- to misuse fire-fighting equipment (equipment).

Upon detection of a fire that has arisen, the employee is obliged to immediately inform the fire brigade duty officer, dispatcher, any manager about it and start extinguishing the fire with the available means.

4.2Fire extinguishing means and rules of their application

Laboratory rooms should be provided with primary fire extinguishing means. Alllaboratory workers must know the location of the fire extinguishers and know how touse them.

One of the most effective primary means of extinguishing is the fire extinguisher.

Extinguishers, as a primary means of fire fighting, take one of the main places in the system of fire protection. On the effectiveness and reliability of fire extinguishers, as well as their skillful using depends not only on the nature of the further development of the fire, the amount of damages that they can cause, but also people's lives. Fire statistics show that most fires are usually extinguished before the arrival of fire brigade units.

There such fire extinguishers:

1) ОХП–10, ОП–М, ОП–9ММ – hand chemical foam fire extinguishers. ОХП-10 is intended for extinguishing of inflammation and small fires of hard materials and combustible liquids. ОХП-10, is shown in the figure 4.1, it is the steel welded cylinder the mouth of which is closed with a plug-forming device. The charge of fire- extinguisher consists of acid and alkaline part. Distance of stream is 6 – 8 meters. For

applying of fire-extinguisher it is needed to bring him to the place of inflammation, to turn the handle of the valve on 180 degrees completely, to invert a fire-extinguisher upwards by a bottom and to point the stream of foam to the fire. It is strictly forbidden toextinguish by foam fire-extinguishers to the electrical wiring and electrical equipment;

2) ОУ–2, ОУ–5 and ОУ–8 – hand carbon dioxide fire extinguisher. They are intended for extinguishing of small initial inflammation of different matters and materials, except that matters burning of which takes place without access of air. Carbon-dioxide fire-extinguishers, shown in the figure 4.2, are steel cylinders, in the mouths of which the brass valves are screwed with siphon tubes, the fly-wheels of valves must be sealed. For extinguishing of fire it is necessary to direct the fire-extinguisher to the fire and unscrew completely the valve anticlockwise. During work of fire-extinguisher it is not recommended to hold a balloon in horizontal position because such position obstructs the output of carbonic acid through a siphon tube;

3) ОВП–10 and ОВП–5 – hand air-foam fire extinguishers;

4) ОУБ–3 and ОУБ–7 – hand ethyl bromide, carbon-dioxide fire extinguishers are designed to extinguish small sources of fire of fuel materials.

ОХП-10 ОУ-8 ОУ-2

Figure 4.1 – Different fire extinguishers types

Primary means of extinguishing fire may be placed on boards. Manual fire tool on the boards should be periodically cleaned from dust, dirt and traces of corrosion and repair needs sharpening angles and painting tool for use after fire or during practice.

All requirements used in this chapter meet the standards [Code of Civil Protection of Ukraine - Effective from 2012-11-21. : condition on 01.01.2018 - Kyiv: Verkhovna Rada of Ukraine, 2012. - (Law of Ukraine)].

4.3 Electromagnetic fields and radiation

According to the [“Державних санітарних правил і норм роботи з візуальними дисплейними терміналами електронно-обчислювальних машин” ДСанПІН 3.3.2.007-98,] , rules which are written in there are designed to forestall unfavourable consequences on staff member of harmful factors that go along with work with VDT, related to visual and emotional accentuation that performed in a strained working position at local voltage upper extremities on the background of limited overall muscle activity under the influence of a complex of physical factors of electrostatic field, non-ionizing and ionizing electromagnetic radiation. These Rules incorporate hygienic and ergonomic requirements for establishment of workplaces, and workplace parameters working environment, compliance with which will avert disorders in the health condition of computers and PCs users. Primary preventive measures that ought to be satisfied, according to the document mentioned above, to arrange safe and harmless working conditions for an operator: • the area per workplace should be at least 6 sq. m. and a volume of not less than 20 cubic metres.

The space for work with VDT must have natural and artificial source of light

- The area is to be equipped with heating, air conditioning, or supply and exhaust ventilation
- working area must be equipped with first aid kits
- levels of positive and negative ions in the air VDT premises must comply with sanitary and hygienic standards N 2152-80
- the value of the electrostatic field strength mustn’t exceed the maximum value allowed by the book.

Labor protection instructions for aircraft technician

Individuals who are at least 18 years of age, have special training, have passed a medical examination and have no contraindications for health reasons, who have undergone introductory and primary labor safety briefings at the workplace, trained in safemethods and techniques of work, have been trained in workplace and testing knowledge oflabor protection requirements, as well as training in fire safety rules and testing knowledgeof fire safety rules in the scope of job duties; training in electrical safety rules and testingof knowledge of electrical safety rules in the scope of job duties with the assignment of an appropriate group.

Conclusion to part 4

1) The different harmful and dangerous production factors for the mechanic in the laboratory room were identified and described. The measures of fire and explosion safety in laboratory room were considered. Lightning calculations of working environment were carried out.

2) On the basis of carried out analysis of dangerous and harmful production factors that can take place during application of coatings on aircraft details in laboratory room the measures are developed for increasing the labour safety during work in laboratory room.

Part 5. Environmental protection

5.1Methods for reducing the negative impact of thermo-chemical processing (nitriding) on the environment

Thermal processing and operation of electrical facilities in a varying degree have a harmful impact on environment, as it is accompanied by the forming of great quantity of harmful gasses, dust, contaminated water. That is why it is necessary to account the degree of negative impact of these factors on the environment.

To the main factors, which have the harmful impact on the environment, in the thermal production relate:

1) release of heat into biosphere – almost all electrical energy, used by furnaces, transform into the heat and dissipate in biosphere in the form of losses or during the cooling of heated details. The more powerful electrical furnaces, the more essential this factor. In order to decrease the useless heat dissipate it makes sense: improving of heat isolation and reduction of all kinds of losses, using of heat of exit gases and cooling water for the technological and municipal purposes;

- pollution of water reservoirs by the industrial wastewater – acids, alkali and salts solutions, used for the etching processes of details, and water, used for the cold hardening and details wash and cooling of furnaces, get to the wastewater in the thermal sections.
- For the wastewater sterilization the next measures are accepted: wastewater before its rejection should pass different kinds of sewage treatment, which ensures the maximum permissible concentration in water; after the processing, settling and filtration the wastewater is thrown down to the common sewerage system;

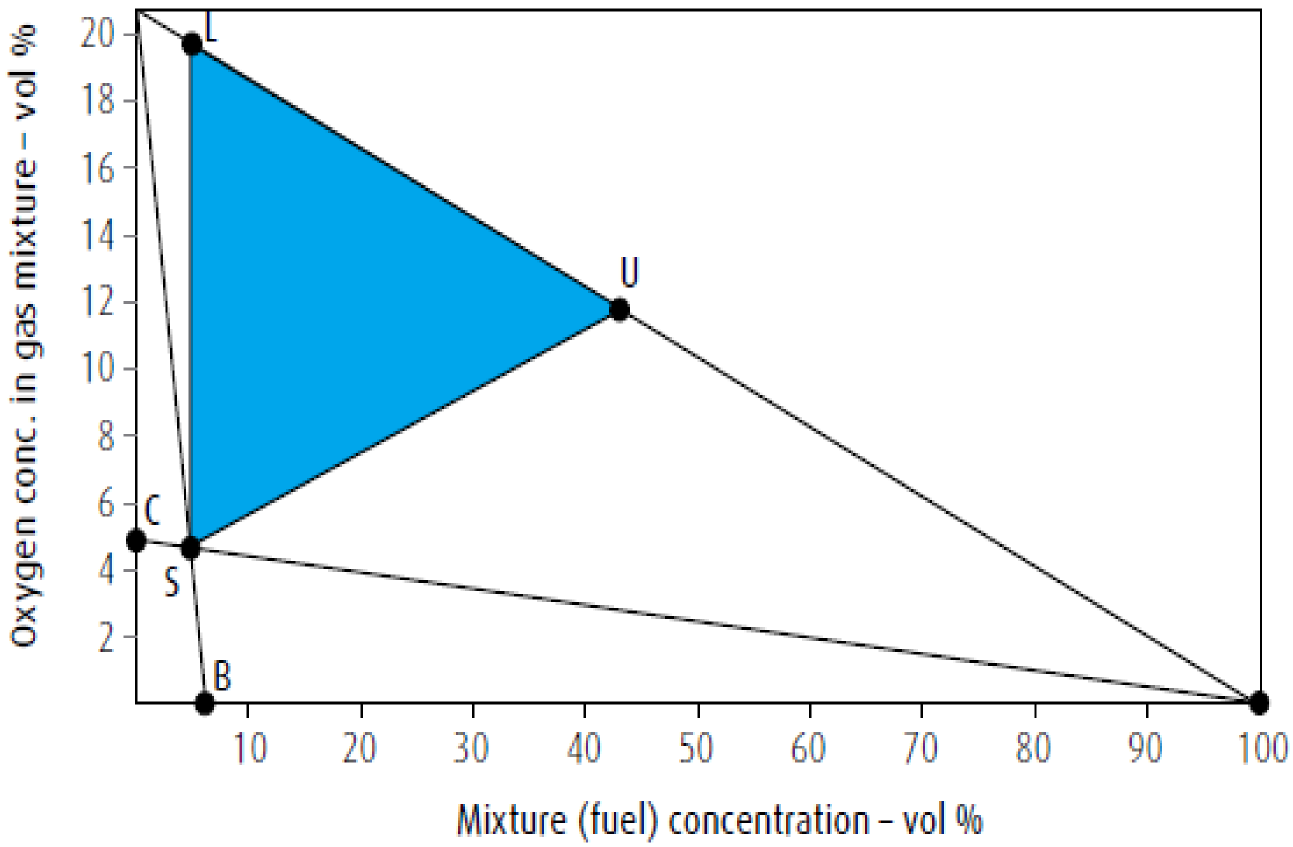
2) using of water resources – electrical equipment is a large consumer of water, expendable to the cooling of furnace units and devices. The high requirements are made for it: in order to decrease of water, taken away from the sources, and providing of its quality it is necessary to use the recirculated water system;

3) release of harmful gases – the gassing takes place in the thermal sections at

the heating, drying and some other operations. For the reduction of the atmosphere pollution the next measures are applied: using of gas trapping system and fume-cleaning plant, replacement of technological processes with the great gas evolution to another, which are more perfect.

As it was written before, ammonia – is one of the dangerous gases. Safety Triangle is proposed below, with the help of which it is possible to avoid or at least decrease the influence of harmful gases on the atmosphere.

The Safety Triangle in figure 5.1 shows how to operate safely. The flammability triangle is depicted in the area L-S-U and this area should always be avoided. This is done as follows. When starting up a process, where the furnace is partly or wholly filled with air, ammonia must not be introduced until the oxygen concentration has been lowered to point C. This may be done by purging the furnace with nitrogen. When point C in figure 5.1 is reached, ammonia can be safely introduced.



L – Lower flammability limit in air (5.1 volume percentage mixture);

U – Upper flammability limit in air (43.5 volume percentage mixture);

S – Minimum concentration of O_2 for flammability (4.6 volume percentage mixture) and Fuel (5.1 volume percentage mixture);

C – Start up (maximum 4.9 volume percentage mixture);

B – Shut down (maximum 6.5 volume percentage mixture)

Figure 5.1 – For mixture in air at 200 °C:

If nitrocarburising is performed in a furnace that will be opened to air access after nitriding or nitrocarburising, i.e. in a pit furnace, a reversed sequence is required before closing the process and opening the furnace. By purging with nitrogen the ammonia concentration must now be lowered to point B in figure 5.1 before the furnace can be opened and exposed to air.

Measures that should be involved in order to prevent the negative impact of thermochemical processing on environment

Technological processes of metals thermo-chemical processing should provide:

1) removal of direct contact of workers with the chemical substances, materials, details and production waste, affecting on them negatively;

2) replacement of operations, at which the harmful and dangerous productive factors arise, by the operations, where the mentioned factors are absent or have less intensity;

3) using of automated methods for the determination of substances concentration of the first class of danger in air;

4) applying of comprehensive mechanization and automation, remote control of setting and adjustment of technological processes parameters (temperature, pressure in the working area of furnace, content of components in gas medium, etc.);

5) using of blockers (with the purposes of elimination of accidents occurring) and means of warning lights and chime about the violation of technological process;

6) equipment capsulation, from which the harmful substances separate into the atmosphere;

7) timely moving off and sterilization of production waste, which are the sources of dangerous and harmful productive factors;

8) maintenance of prescribed periodicity of cleaning of hardening tank,

reservoirs and heating furnaces;

9) at the operation of the flow gages of alternate overfall pressure it is necessary to provide the rejection of the expulsion products into the drain or effluent disposal line for the prevention of air pollution;

10) at the work on electrothermal equipment with the controlled atmospheres it is prohibited to mix the burning gases, used at the preparing of controlled atmospheres with air, in order to avoid the formation of explosive mixture;

11) for the furnaces expulsion the rare gas should be used;

12) removing of gases from the working area that have the strong smell should be accompanied by the local ventilators with the suction.

5.2Laws requirements in Ukraine in ensuring of environmental protection

Environmental protection, rational use of natural resources, environmental safety of human life – is an essential condition for sustainable economic and social development of Ukraine. For this purpose Ukraine carries on its territory environmental policy aimed at the preserving for the existence of living and inanimate nature safe environment, for protection the lives and health from the negative impact, caused by the environmental pollution, achieving of harmonious interaction between the nature and society, protection, rational use and reproduction of natural resources.

At present, the main regulations governing the organization of environmentalprotection in Ukraine are:

1) the Law of Ukraine "About Environmental Protection";
2) Agrarian Code of Ukraine;
3) Water Code of Ukraine;
4) Law of Ukraine "About Air Protection";
5) Law of Ukraine "On objects of assigned risk";
6) Law of Ukraine "On State Program of Toxic Waste";
7) Law of Ukraine "On the area of environmental emergency";
8) Law of Ukraine "On Wastes";
9) Law of Ukraine "About management Radioactive Waste Management" and

many others.

Unfortunately, all these legal documents have a serious drawback. They are formed for the separate regulation of land, water, mining, forestry, atmosphere protection. This approach does not provide the regulation of relations on the environment as a single organism.

Ukraine's Law “About Environmental Protection” is the fundamental legal act, it defines the concept of environmental protection and measures for their security, environmental requirements for the disposition, designing, engineering, reconstruction, putting into the operation of enterprises and other objects, on the application of fertilizers; provides measures for protecting the environment from harmful biological effects, harmfuleffects of physical factors and radioactive contamination, from contamination by industrial, household and other wastes. This law not only states, but also provides the guarantee system of human ecological protection, makes certain orderliness in the management system in branch of the nature use, and it affirms the right of Ukrainian citizens on safe for human life environment.

Responsibility for managing work on environmental protection, for its general and specific state, for day-to-day supervision and control over the observance of current norms, rules and requirements for the protection of the natural environment in organizations and enterprises of civil aviation, in subdivisions and units, in teams and groups, carrying out maintenance and repair of vehicles are carried out by their supervisors (including the immediate supervisors of the work performed at the vehicles) within the limits established for each (by the documents of the enterprise and in accordance with regulatory enactments) duties and powers. This responsibility applies to the processes of maintenance and repair of aircraft in places of permanent and temporary basing of aircraft.

Employees of all categories and levels are obliged to comply with the established norms, rules and requirements for environmental protection. The specific duties and powers of each employee on these issues are included in his job description.

Harmful production factors include:

- noise and vibration during the operation of aircraft engines, ground and technological equipment;

- exhaust gases of aircraft engines, cars, heaters, air conditioners;

- spilled fuels and lubricants (POL) and poisonous liquids;

- scattered and sprayed pesticides;

- contamination of the air space with azrozols from materials used in paintwork, galvanic and flushing processes;

- waste (discharge) of liquids when washing aircraft and units;

- electromagnetic radiation of high and ultrahigh frequencies from airborne and ground radar installations;

- the ionizing effect of equipment with appropriate radiation sources;

- other factors specified in the relevant safety standards.

To eliminate or reduce to safe levels the harmful effect of production factors, civil aviation organizations and enterprises that carry out maintenance and repair of aircraft ensure the introduction of protective devices, the creation of sanitary security zones, the dispersal of objects that have a harmful effect on the environment, the development of internal documents on the rules for handling toxic materials, testing of engines, work with radars.

Do not place on the ground, bury or spray radioactive substances, pesticides, release toxic gases into the atmosphere, pour into the soil (into gutters), into water (when operating seaplanes, deck helicopters) samples, waste and residues of acids, electrolyte, other toxic and corrosive liquids, as well as oil products, their waste , other substances specified in the relevant regulatory documents.

Chemicals and aggressive liquids are rendered harmless or disposed of in accordance with the applicable sanitary regulations. The drained waste oil products are collected in containers located at the parking areas.

Washing, degassing and decontamination of aircraft is allowed only at special sites equipped with devices for collecting and removing (flushing) waste. After washing and degassing aircraft engaged in aviation chemical works, the waste is subject to neutralization. It is prohibited to wash seaplanes on water using gasoline and chemicals.

Checking the performance and correct functioning of the aircraft radar equipment at the aerodrome is carried out in such a direction of its radiation, which excludes the harmful effect on people and the natural environment, and when checking in buildings, the radiation is shielded as much as possible.

When operating isotope devices, it is necessary to exclude the possibility of irradiation of people, as well as the ingress of ionizing materials into waste. The procedure for receiving, recording, storing and transporting sources of ionizing radiation is regulated by the sanitary rules for working with radioactive substances and other sources of ionizing radiation.

Testing of gas turbine engines is allowed only on sites specially equipped for this. Technical equipment and preparation of such sites is determined by the relevant regulatory documents.

The heads of organizations and enterprises of civil aviation that carry out maintenance and repair of aircraft are obliged to assist representatives of sanitary supervision and environmental control authorities in carrying out chemical analyzes of atmospheric air, soil, water in nearby reservoirs and drains, as well as when measuring noise and vibration levels, radiation doses.

Inspection safety

The basic safety rules for monitoring the technical condition of aircraft provide for strict compliance with the requirements for the use of technical means of control, appropriate stands, equipment. In this case, the controlling person must:

- know the design of equipment and stands, instructions for their use and have an appropriate permit to work;
- own operational documentation on the use of controls;
- to know the standard values of the measured parameters when checking the functioning of systems, products and mechanisms.

For instrumental monitoring of the state of the aircraft, portable, mobile, built-on aircraft and stationary means are used. In this case, the use of faulty controls is unacceptable.

Modern wide-body aircraft of large passenger capacity require additional rules and safety instructions when performing maintenance and monitoring the technical condition of systems and high-level structural elements. To avoid injury when working on hot sections of the aircraft systems pipelines, ensure that they cool beforehand.

During control and dismantling for laboratory testing of heavy units, special care should be taken and special tools and devices should be used. It is forbidden to undo and connect plug connectors, open covers of panels of electrical units and repair damage when the power supply is on. It is also forbidden to leave open electrical panels and terminal panels and blocks that are energized. In all cases, when performing control operations and eliminating identified malfunctions, use the complete tool and equipment. After completing the work, check the compartments where the work was carried out and make sure that there are no tools, fasteners, consumables or other foreign parts.

Particular care must be taken when checking the performance and correct functioning of the aircraft's radar equipment. In these cases, it is necessary to ensure all measures to exclude the harmful effects on people and the natural environment of high- and ultra-high-frequency radiation. The technology for performing such work provides for compliance with special instructions.

The management is obliged to provide assistance to the bodies of the State Sanitary Inspection, the State Committee for Hydrometeorology and Environmental Control in carrying out chemical analyzes of atmospheric air, soil and water in nearby reservoirs and drains, as well as in measuring noise levels, vibration and radiation doses.

Thermo-chemical processing (nitriding) as the source of pollution

At the thermo-chemical processing of metals the action of different hazardous and harmful production factors is possible. They can be:

1) aerosols of fibrogenic action (dust);
2) unfavourable microclimate;
3) increased level of electromagnetic radiation (ultraviolet, visible, infrared, laser, microwave, radio-frequency);
4) increased tension of magnetic field;
5) increased level of noise;
6) chemical factors of general toxic, irritative, carcinogenic influence, etc.

It is necessary to give the permanent attention to these factors, as they direct affect not only a person, but also on climate change.

At the thermal sections the content of harmful substances is usually higher than the permitted level: nitric oxide is approximately 20 mg/m^2, according to the norm of Maximum Permissible Concentration this value must be 5 mg/m^2; barium chloride is approximately 1.8 mg/m^2, according to the norm of Maximum Permissible Concentration – 0.3 mg/m^2; hydro-potassium oxide is approximately 2.5 mg/m^2, according to the norm of Maximum Permissible Concentration – 0.5 mg/m^2; potassium nitrate is approximately 15 mg/m^2, according to the norm of Maximum Permissible Concentration – 5 mg/m^2; industrial oils (И–12А, И–20А) is approximately 25 mg/m^2, according to the norm of Maximum Permissible Concentration – 5 mg/m^2.

In the diploma work one of the methods of surface hardening of aircraft parts is nitriding. Ammonia is used at the nitriding processes. Ammonia is a corrosive gas attacking moist skin, mucous membranes and eyes. Ammonia at 100 ppm causes irritation of the eyes and nose after a few minutes' exposure and at 700 ppm causes severe eye and nose irritation but no permanent effects, if the exposure is lower than half an hour. Concentrations above 1700 ppm cause serious coughing, bronchialspasm, acute pulmonary oedema and asphyxia and at these levels death can occur within half an hour.

Supply of ammonia is usually performed from the cylinders, which are installed in the special ramps. Handling with ammonia requires special care because it is toxic and explosive. Transportation of cylinders with the ammonia takes place in the horizontal position in the special wooden containers. Also it is necessary to provide the elimination of any cylinders' pushes or bumps into each other. Storage of cylinders is carried out in vertical position at the continuous cooling with water, as at the increasing of temperature the liquid ammonia vaporises, and it leads to the dangerous increasing in pressure.

The salt bathes are used for the thermal processing at the section, which in case of overheating can be the reason of explosion, fire dangerous situation and, of course, separation of hazardous substances in the atmosphere, occurance of blast wave. Furnaces for the nitriding are equipped with the devices for the removal and post-combustion of the exit gas and absorption of undecomposed ammonia.

Increased level of ammonia also has consequences for the climate changes. Excess of nitrogen can influence on the temps of climate changes in different and opposite directions. From one hand it leads to the greater warming through the greenhouse gases of nitrogen protoxide, but on the other hand it can decrease the warming through the expanding the additional growth of the plants by forming the substances that are called reflected aerosols in the atmosphere. Excess of nitrogen also has great and unclear consequences for some air and water pollution.

Conclusion to part 5

1) According to the Law of Ukraine on Environmental Protection (from 26.06.91) the degree work has been complied with all requirements, summarized above and proposals, concerning reduction of hazardous influence of thermochemical processing for the ecosystem.

2) During the hardening of details by the thermo-chemical processing the safety requirements about the prevention of environment pollution by the productive waste must be executed (collection and neutralization or necessary dilution of gaseous, liquid and solid, including dust waste, and they removing in accordance with the established rules).

3) Nitriding coating is one of the most dangerous sources of pollution, mainly surface and groundwater reservoirs, due to large volume of wastewater, as well as large quantities of solid wastes, especially from the reactive method of sewage disposal. The creation of a complete water cycle should not be an end in itself, because both in terms of environmental safety and economic feasibility the main goal should be the rationalization of water consumption and optimization of treatment systems.

4) During working to reduce environmental hazards of thermo-chemical processing first it is needed to analyze the range of applicable solutions and chemical substances, and possibly to replace the toxic solutions to less toxic or reduce the concentration of toxic components in the applied solutions. If the replacement of toxic substances to less toxic is limited by the requirements of the coatings obtained, then reduction of water consumption for washing is possible in a wide range. In this case, great importance has where the reduction of water consumption is carried out: in the existing, reconstructed or under construction shop.

CONCLUSIONS

In general, the diploma project is fully disclosed, fulfilled with the requirements of the aviation industry for diploma design.

In conclusion, it should be noted that in order to optimize the process of technical operation of hydraulic systems of the aircraft, to increase their reliability and durability, an important place also belongs to the issues of improving organizational structures and production and technical base of operating and repair enterprises of civil aviation. This primarily refers to the improvement of the organization of the information service of the operating enterprise and the forms of management of the reliability of aviation equipment, to the further development of laboratories and diagnostic centers designed to ensure the widespread implementation of strategies for the operation of aviation equipment as per condition.

LITERATURE

1. Ripinsky A.I., Chebotareva I.V. Technical Operation of Aircraft and Engines Graduation Design. - Mn., 2007.

2. Bashta T.M. Calculations and designs of aircraft hydraulic devices. - M: State Scientific and Technical Publishing House Oborongiz, 1961.

3. Bashta T.M. Hydraulic drives of aircraft - M .: Mashinostroenie, 1962.

4. Birger I.A. Technical diagnostics. - M .: Mechanical Engineering, 1978.

5. Gamynin N.S. Hydraulic drive of control systems. - M .: Mechanical engineering, 1972.

6. Elistratov V.N. Airworthiness and civil certification standards aircraft. - Riga: RKIIGA, 1983.

7. Komarov A.A. Reliability of hydraulic systems. - M .: Mechanical Engineering, 1969.

8. Methods for determining quantitative indicators of the reliability of hydro-gas systems, their functional subsystems and assemblies according to the data of operation on airplanes. - M .: MGA USSR, GosNII GA, 1977.

9. Operation and maintenance manual for TU-154M aircraft (hydraulic system).

10. Smirnov N.N. Maintenance and repair of aviation equipment as it is. Air transport, v. 11 (Results of science and technology). - M .: VINITI AN SSSR, 1983.

11. Technical operation of aircraft and aircraft engines (Collection of scientific works, issue 2), ed. A.I. Pugacheva. - Riga: RKIIGA, 1976.

12. Operational reliability and modes of aircraft maintenance. N.N. Smirnov, A.I. Andronov, N.I. Vladimirov, Yu.I. Levin. - M .: Transport, 1974.

13. Law "On labor protection" - Effective from 1992-10-14 .: - K .: Council Of Ukraine, 1992

14. (Rules of fire safety in Ukraine: NAPB A.01.001-04; effective from 2014-12-30. - Kyiv: Ministry of Internal Affairs of Ukraine, 2014. - 47 p. - (Normative act of fire safety)

15. Rules of operation and standard norms of belonging of fire extinguishers [Text] - To replace B.03.001-2004; valid from 2018-02-23. - Kyiv: Ministry of Internal Affairs of Ukraine, 2018. - 23 p.