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.
______________ О. В. Попов
"____"______________ 2020 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬО-КВАЛІФІКАЦІЙНОГО РІВНЯ
«МАГІСТР»
ЗА ОСВІТНЬО-ПРОФЕСІЙНОЮ ПРОГРАМОЮ
«ТЕХНІЧНЕ ОБСЛУГОВУВАННЯ ТА РЕМОНТ ПОВІТРЯНИХ СУДЕН І АВІАДВИГУНІВ»

Тема: «*Підвищення ефективності технічного обслуговування конструктивних елементів планера літака»*

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Київ 2020

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL AVIATION UNIVERSITY

AEROSPACE FACULTY
Aircraft Airworthiness Continuing Department

PERMISSION TO DEFEND
The Head of the department
Ph.D. (Engineering), Assoc. prof.
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"____"______________ 2020

MASTER DEGREE THESIS

ON THE EDUCATIONAL PROFESSIONAL PROGRAM
"MAINTENANCE AND REPAIR OF AIRCRAFT AND AVIATION ENGINES"
(EXPLANATORY NOTE)

Topic**:** *"Improving the efficiency of maintenance of structural elements of the airframe"*

Fulfilled by: ______________ Avdieienko D.O.

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Kyiv 2020

NATIONAL AVIATION UNIVERSITY

Faculty: The Aerospace Faculty
Aircraft Airworthiness Continuing Department
Educational and Qualifications degree: “Master Degree”
The specialty: 272 “Aviation transport”
Educational-professional program: “Maintenance and Repair of Aircraft and Aircraft Engines”

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“____”_____________ 2020

Graduate Student`s Degree Work Assignment

Avdieienko Dmytro Oleksandrovych

1. The Work (Thesis) topic: “Improving the efficiency of maintenance of structural elements of the airframe” approved by the Rector’s order of October 2, 2020 №1881/ст.

2. The Graduation Project to be performed: Since October 5, 2020 until December 13, 2020 and since December 21, 2020 until December 31, 2020.

3. Initial data for the project: Analysis of methodologies of aircraft preventative maintenance against fatigue stresses and corrosion affecting aircraft airframe components.

4. The content of the explanatory note (the list of problems to be considered): Diploma work assignment; abstract; contents; introduction; analytical part; project part; scientific research part; labour precaution; environmental protection; general conclusions; recommendations; references.

5. The list of mandatory graphic materials: List of tasks: fatigue stress and corrosion cracks; sensor monitoring methods of visual inspection improvement and for stress state evaluation and prediction of fatigue cracks propagation in structure, elements of airframe; conclusions and recommendations.

6. Time and Work Schedule

Stages of Graduation Project Completion	Stages Completion Dates	Remarks
Search for and analysis of reference material	05.10.2020 – 12.10.2020	Completed
Analysis of composite materials	12.10.2020 – 19.10.2020	Completed
Preparation for conducting experiments	19.10.2020 – 26.10.2020	Completed
Conducting necessary experiments	26.10.2020 – 04.11.2020	Completed
Processing of experiments' results	04.11.2020 – 12.11.2020	Completed
Fulfillment of individual sections of degree work	12.11.2020 – 25.11.2020	Completed
Preparation of explanatory note	25.11.2020 – 13.12.2020	Completed

7. Advisers on individual sections of the work (Thesis):

Section	Adviser	Date, Signature	
		Assignment Delivered	Assignment Accepted
Labour precaution	Konovalova O.V.		
Environmental protection	Radomska M.M.		

8. Assignment issue date ______________________________

Graduate Project Supervisor *Smirnov Y.I.* ____________________
(supervisor signature)

Assignment is accepted for performing:

Graduate student *Avdieienko D.O.* ____________________
(graduate student's signature) (Date)

ABSTRACT

The explanatory note to the diploma work "Improving the efficiency of maintenance of structural elements of the airframe"

97 p., 17 figures, 2 tables, 1 diagram, 27 sources

The research object – the estimation of design, and reliability and structural integrity of aircraft structure and components.

The research subject – the development of recommendations directed at improving the workability and maintainability of airframe.

The purpose of diploma work – the development of recommendations, directed on simplifying and improvement of the maintainability and reliability of the aircraft structure.

Method of research – analysis of accident investigations, which identify the accidents and incidents causes, structure defects, and statistical data analysis to find solutions of detected malfunctions.

The main essence of this degree work is to provide that the results of researches have optimal value which could be applied in the practice of aviation in terms of providing quality maintenance efficiency of AC structure.

Diploma work materials are recommended to use in educational process and practical activity of specialists of development laboratory.

STRENGTH, RELIABILITY, OPERATING, AIRFRAME, AIRCRAFT STRUCTURE, MATERIALS, DESIGN, FATIGUE FRACTURE, CORROSION

CONTENT

LIST OF ACRONYMS AND TERMS

AC – Aircraft;

Approx. – approximate;

AW – airworthiness;

CA – Civil Aviation;

NTSB– The National Transportation Safety Board;

ACRO – Aviation Center for Repair and Overhaul;

AMM – Aviation Maintenance Manual;

SSIs – Structural Significant Items;

MSIs – Maintenance Significant Items;

LG – Landing Gear;

MLG – Main Landing gear;

NLG – Nose Landing gear;

CMC – Ceramic Matrix Composite;

CFRP – Carbon Fiber Reinforced Polymer;

QD – Quick Disconnect;

VOCs – volatile organic compounds;

OSHA - Occupational Safety and Health Act.

INTRODUCTION

Aviation industry grows from year to year because of modern aircraft development. The term ‘safety’ is socially made and relative organisational property dependent upon organisational meanings, values and safety practice.

A different aviation technologies and techniques are used to ensure proper level of flights safety. The creation of new airplanes makes it possible, satisfying the customer needs and providing good reliability and safety, for example: Boeing - 737 NG, Airbus - 320, Boeing - 777, Airbus – 330, etc.

Presently, aviation enjoys an enviable rate of reliability, safely transporting millions of passengers each day. However, as the sheer number of passengers and departures increase, accidents will likely experience a similar increase. Though the mishap rate remains exceedingly low, extrapolating upon the current rate of growth in air travel.

Successful operation of modern aviation techniques is possible only at a high level and perfection of system of maintenance service and repair at which the basic purposes of maintenance service and repair are achieved at the minimal labor expenses, costs and an idle time of aircraft at maintenance service [1].

With a view of growth of an air transport overall performance it is needed:

- To provide developing practices and realization of actions on increase of a safety level of flights;
- To optimize the relationship between people and their activities through the systematic application of knowledge about man
- To design new means of ensuring the interaction of man and machine.
- To carry out the further development of optimum schemes of transportation of passengers and cargoes in view of elimination of incomplete transportations;
- To improve technology of the organization of transportations and realization of measures on the fullest use of aircraft carrying capacity;

- The further improvement of management in civil aviation on the basis of applications of the management information system and computer facilities.

It`s obvious that either small human or technical errors can fast lead to accidents, when travelling at high altitudes and high speeds in traffic systems [2]. Consequently, manufacturers and airline companies make efforts to prevent accidents and incidents from occurring. Operating experience of aviation techniques and also the analysis of data on fault detection of aviation techniques which have passed repair after processing a between-repairs resource, have shown, that the scheduled preventive system of maintenance service and repair has a number of lacks. Thus attention should be given to development of the actions directed on improvement of a design of aircraft, development of mechanization and automation of processes of maintenance service of aviation techniques.

The progressive methods of aviation maintenance service should solve the existing problems and meet the main aspects, namely:

- The organizational aspect, related to the development of clear principles and basic concepts for the construction of the structure of the aircraft maintenance system, the establishment of maintenance management processes, etc.
- The scientific and technical aspect of the maintenance problem, related to the creation of theoretical foundations and engineering methods for managing the processes of maintenance of complex systems of aviation engineering. It envisages the development of key scientific positions, the construction of models of different structures, which enable to calculate the effectiveness and evaluate the impact of the maintenance system on the reliability and efficiency of specific systems of aircraft.

Taking into account statistical data of the structure accidents it's possible to insist about necessity, actuality of development and improvement of methods for continuing airframe airworthiness of middle range aircrafts.

The given work on the basis of the analysis of statistical data on failure and malfunctions of the structure elements which took place while operating planes, creates a variety of constructive improvements which allow to increase a level of operational reliability and to provide a high level of safety of flights.

PART 1

ANALYSIS OF FAILURES AND ACCIDENTS

1.1. Statistics of accidents analysis

An accident is determined as an occurrence related with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down, in which:

a) a person is seriously or fatally injured;

b) the aircraft sustains structural failure or damage;

c) the aircraft is missing or is fully inaccessible.

To determine the cause of errors the aviation accident analysis is performed, once an accident has happened. In the modern aviation industry, it is also used to analyze a database of previous accidents to prevent an accident from happening in future. Many models have been used not only for the accident investigation but also for educational purpose [3].

The Bureau of Aircraft Accidents Archives fulfills statistics on aviation accidents of aircraft capable of carrying more than six passengers, excluding helicopters, balloons, and combat aircraft.

I propose to overview and analyze the aircraft accident statistics for 50 recent years recorded by Aviation Center for Repair and Overhaul (ACRO). The detailed graphs are given below:

a) The overall amount of fatalities due to aviation accidents since 1970 is 83,772 (Figure 1.1).

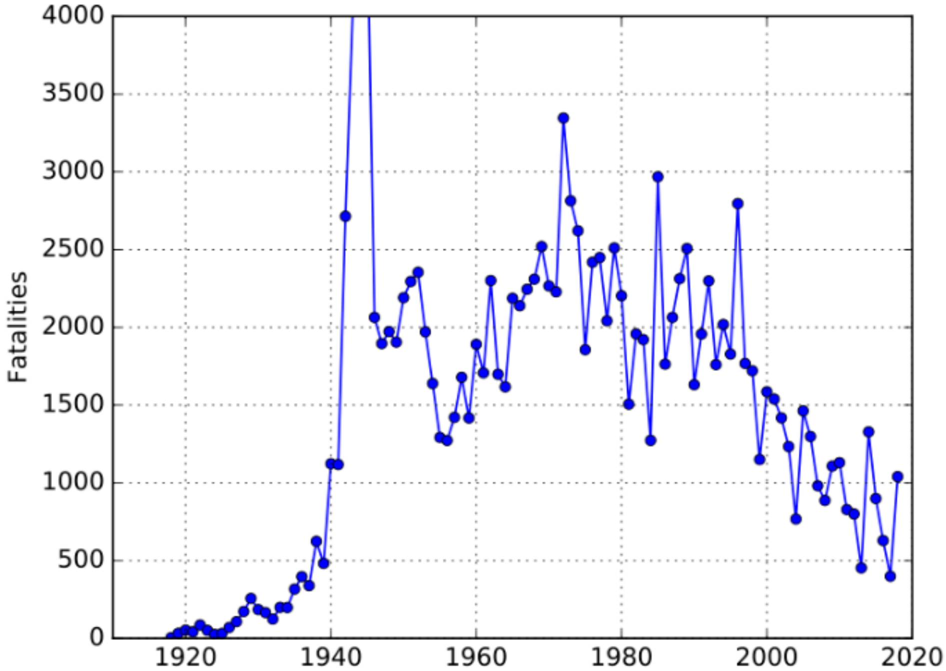


Figure 1.1 – Air accident fatalities recorded by ACRO 1918-2019

b) The total amount of incidents due to aviation accidents since 1970 is 11,164 (Figure 1.2).

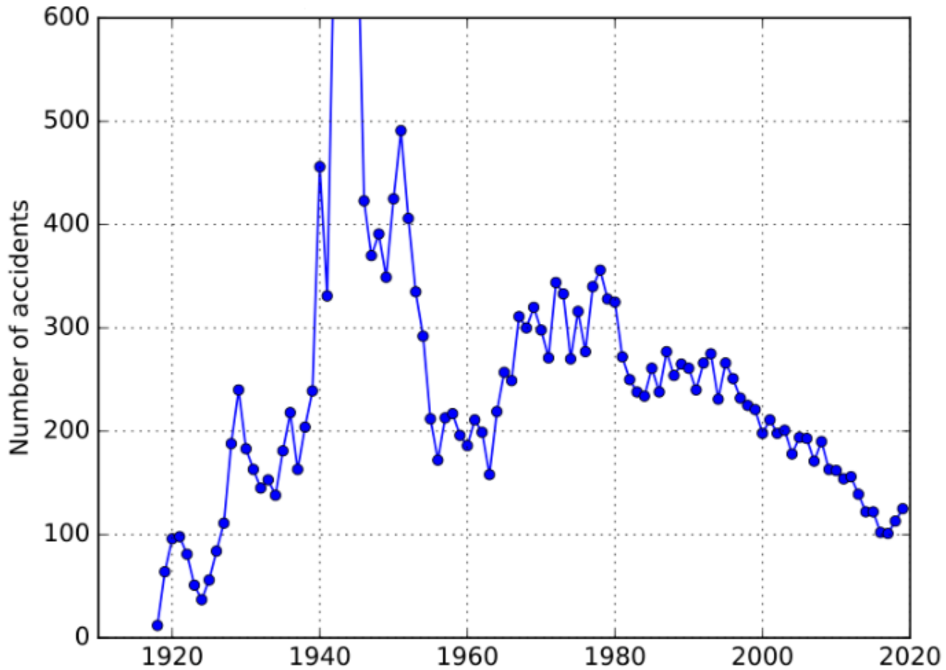


Figure 1.2 – Air accident incidents recorded by ACRO 1918–2019 year

According to ACRO, recent years have been considerably safer for aviation, with fewer than 170 incidents every year between 2009 and 2019, compared to as many as 226 as recently as 1998. Annual fatalities have been less than 1,000 in nine of the fifteen years since 2004, with 2019 experiencing the lowest amount of fatalities, at 399, since the end of 1940`s.

For civil aviation accidents, the National Transportation Safety Board (NTSB) maintains the Accident/Incident Database – the government's official repository of aviation accident data and causal factors. The record for each aviation accident contains infromation about the aircraft, environment, injuries, sequence of accident events, and other relevant topics.

Accidents are classified into four main groups as: (1) human factors, (2) environmental factors, (3) structural failure and (4) system failure. The definitions of these four categories are given below.

1.1.1 Human Factors

Human factors are the biggest contributor to aircraft accidents. In addition to the human cost of accidents, aircraft maintenance issues/errors lead to a significant financial result on airlines.

Accidents classified as resulting from "human factor" were caused by the actions of persons either directly or indirectly responsible for the operation of the aircraft, including passenger and criminal action [4]. The human action types are further broken down as follows:

- Airport Ground Crew
- Airline Procedures
- Mechanic
- Pilot (Captain / First Officer)
- Air Traffic Control
- Flight Crew
- Maintenance Person
- Flight Attendant
- Criminal / Terrorist
- Airport Operator
- FAA

- Pedestrian
- Passenger
- Manufacturer Procedures

1.1.2 Environmental Factors

The forecast and local weather conditions may have significant importance on both the flight conditions and the aircraft performance in general.

Accidents classified under “environmental factors” category were caused by circumstances related to the environment in which an airplane operates. The environmental factors types include thirteen categories as follows:

- Wind shear
- Turbulence
- Fire
- Poor visibility
- Snow
- Heavy Rain
- Rough Landing Surface
- Icing
- Ground Vehicle Failure
- Mountain Wave
- Microburst
- Lightning strike
- Thunderstorms

1.1.3 Structural Failure

An aircraft’s structural failure in midair can have catastrophic consequences, with resultant loss of life and of the aircraft.

Accidents classified as "structural failure" are primarily caused by malfunctions associated with certain parts of the aircraft structure for which the aircraft is usually designed to be admitted. The types of structural failure causes are recognized as follows:

- Corrosion
- Fatigue/Aging
- Overload
- Turbulence
- Maintenance/Pre-flight Inspection
- Design/Manufacturing
- Damages by Foreign Object (eliminate bird strike)
- Other (Passenger Stairs failure, Air-stairs, Door Latch)
- Unknown

1.1.4 System Failure

Accidents classified as “system failure” category were caused by problems with main systems necessary for operation of the aircraft. System failure types are subdivided into four categories, given below:

- Hydraulic system
- Electrical system
- Steering system
- Fuel system

1.1.5 Unreleased cause

Investigating the nature of accidents, I noticed that there are some examples, the cause of which has not been determined by NTSB investigators. That`s why, everyone may familiarize the description of the probable cause in the NTSB website. Furthermore, such accidents with unknown causes are not comprised in our statistical analysis in the following sections.

1.2 Statistics of the Accident Causes

It is very important to analyze the real accident causes and take actions, if the world community trying to decrease and minimize the accident cases in the near future. This section contains statistics on the causes of accidents, classified in the last Section. Firstly, the statistics on the four main groups are presented, after that a detailed analysis of each of these categories is attached. As mentioned at the beginning, there are some categories of accidents, which influencing on aviation safety. The frequency of each of the four main accident causes is shown in diagram (1.1). The set of data includes only accidents for which a cause was released. The NTSB website contains 551 cases of aviation accidents from 1990 to 2015, whereas the causes of 524 accidents were released [5].

Diagram (1.1) shows that 341 accidents (65% of the total accidents for which a cause was released) engaged human factor as a contributing source. Environmental factors took place in 93 (or 17.8%) of total number of accidents. Structural failure accounted for 67 accidents (or 12.7%), and system failure was involved in accidents 23 (or 4.4%) of the total.

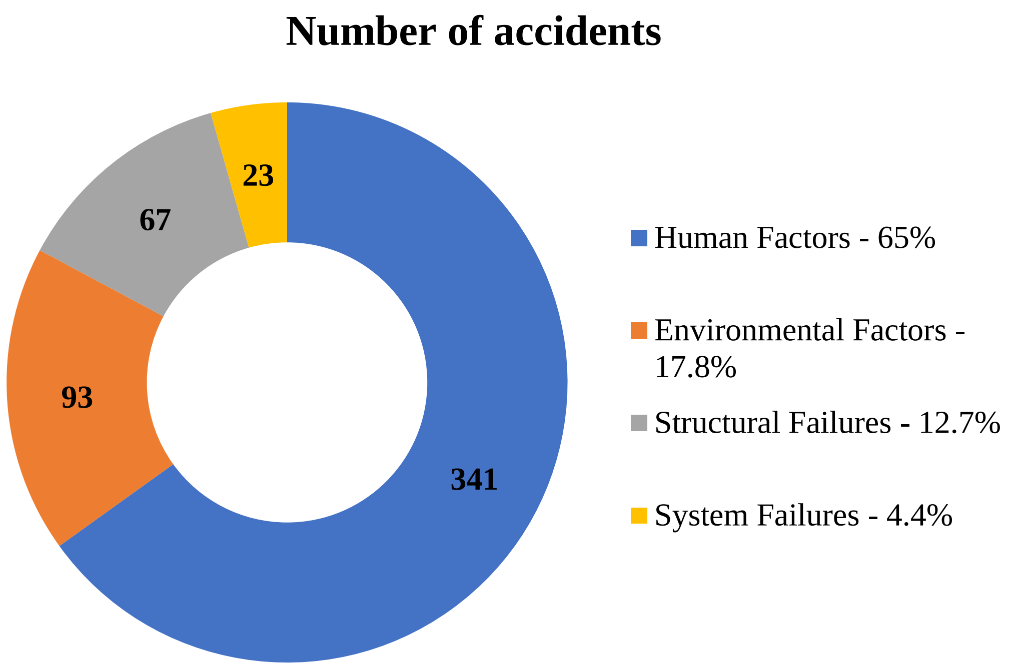


Diagram 1.1 – Accident causes as a percentage of total accidents reviewed for which a cause was released

Each of these general categories is further divided into sub-categories and particularly analyzed in the next subsection.

It should be noticed that the total number of the accident causes given above (551) is greater than the sum of accidents with released cause (524), because some accidents were attributed to more than one cause. Each of these general categories is further classified into sub-categories and analyzed in the following sub-sections [6].

1.2.1 Human Factors

The layout of this category is shown below in Figure (1.3), which shows that the largest contributor to human action accidents was the pilot (Captain/First Officer), which accounted for 37.6% of all human action accidents.

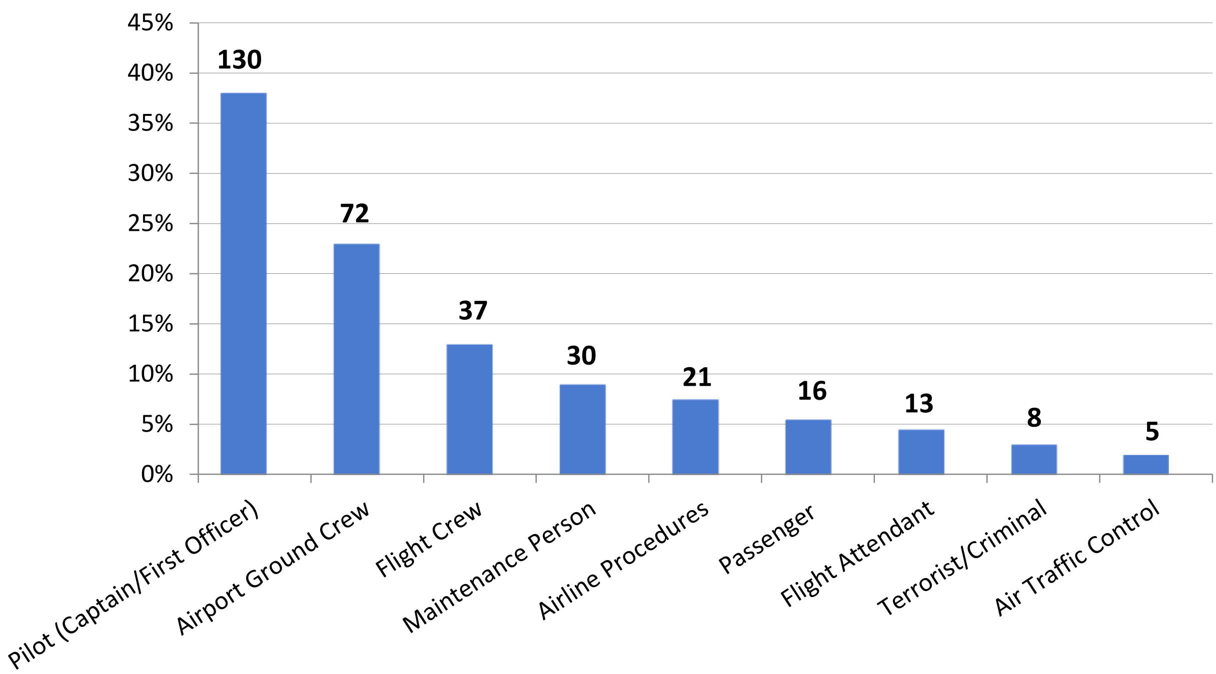


Figure 1.3 – Breakdown of accidents caused by human factors as a percentage of total human factor accidents

1.2.2 Environmental Factors

The accident causes for the accidents due to “environmental factors” as a percentage of the total are shown in figure (1.4), which shows that the overwhelming majority of environmental causes were due to turbulence. This category made up 72% of all accidents involving environmental causes, which amounts to 17.8% of all accidents surveyed with a released cause. Wind gusts were a factor in 9.6% of surveyed accidents with a released cause, and lightning/thunderstorms was involved in 6.4% of these accidents. The remaining categories were each equal to or less than 4.3% of environmental accidents.

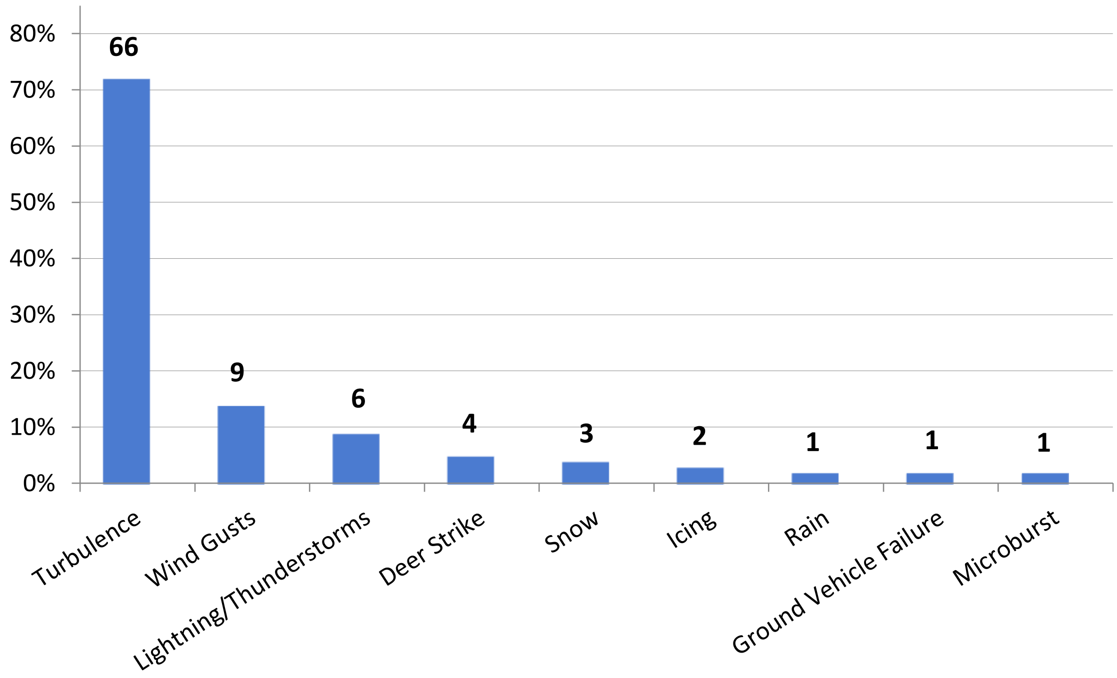


Figure 1.4 – Makeup of the environmental factor accident cause as a percentage of total accidents involving environmental factors as a cause

1.2.3. Structural Failure

In this section, the makeup of the structural failure cause is analyzed more attentively. There are five major structural factors contributing the total number as showed in Figure (1.5).

Recall that human action had two categories with percentages in double digits and environmental had only one such category, structural failure has 5 such categories. The highest of these (approximately 26%) was due to design and manufacturing causes. This was followed by fatigue (20%), overstress (16%), maintenance/inspection (15%), and Aging/Corrosion (13.5%).

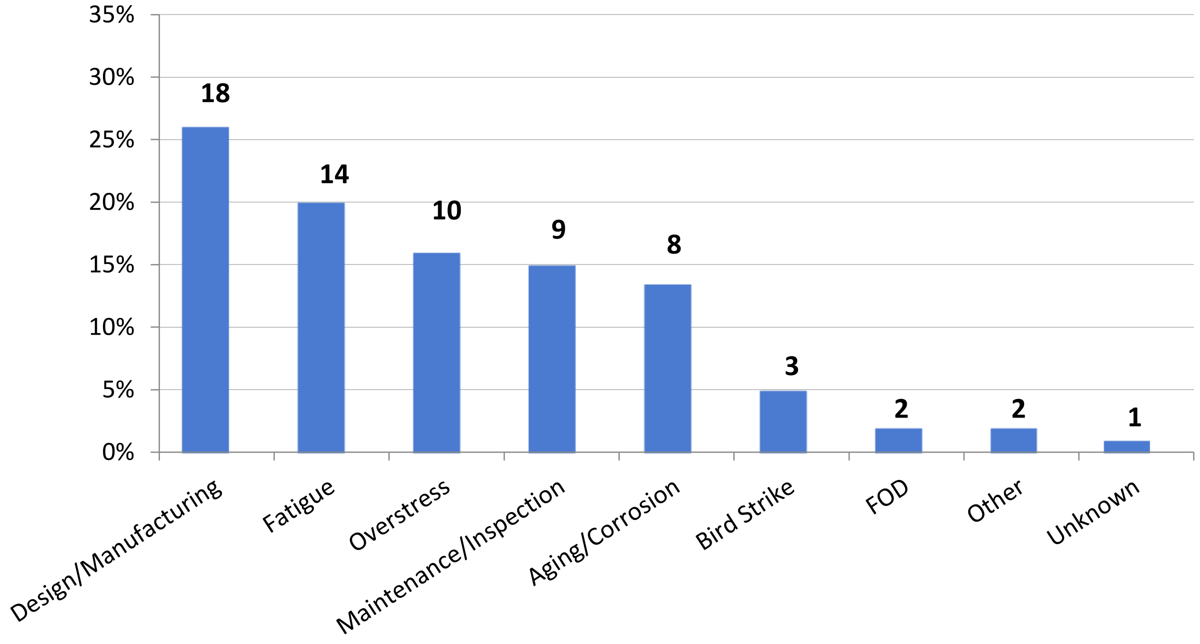


Figure 1.5 – Makeup of the structural failure accident cause as a percentage of total accidents involving structural failure as a cause

1.2.4 System Failure

The sub-categories of system failure as a percentage of all accidents involving system failure are shown in Figure (1.6). The majority of system failures involved an electrical unit, which was related to 55% of all accidents with system failure as a cause.

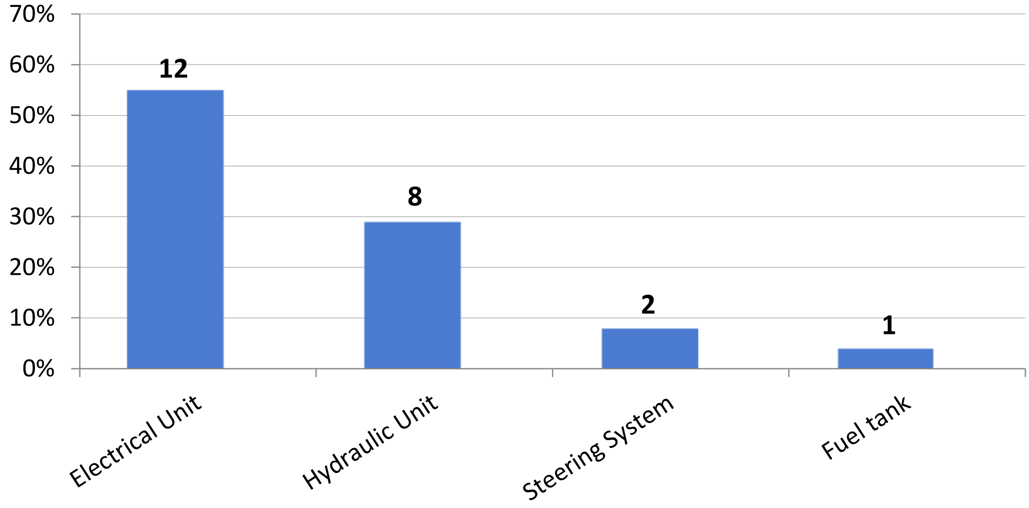


Figure 1.6 – Makeup of the system failure accident cause as a percentage of total accidents involving system failure as a cause

This amounts to 2.3% of all accidents surveyed with a released cause. The hydraulic unit was a factor in 28% of all accident with system failure as a cause, and the steering system and fuel tank were each involved in 1.52% of all surveyed with a released cause.

Conclusions to the Part 1

1. Human factor, poor aviation maintenance, maintenance negligence or maintenance errors are commonly found to be one of the top causes of aviation maintenance accidents.

2. Human errors are result of majority of the accidents (341 or 65%).

3. Turbulence dominated the environmental category, accounting for nearly 72% of this classification.

4. System failure accounted for a relatively small proportion of the accidents (only 4.4%).

5. Structural failure accidents may be more catastrophic than other types of accidents. Structural failure accounted for 12.7% of all accidents, but it was involved in 34.5% of all fatalities.

6. System failure and structural failure leads to serious consequences, so our aim is to prevent possible fatalities by improving the efficiency of maintenance of structural elements of the airframe

PART 2

METHODOLOGICAL BASE OF AIRFRAME MAINTENANCE IMPROVEMENT

2.1 AIRCRAFT STRUCTURES - DESCRIPTION

2.1.1 General

A. The structure of the airplane (figure 2.1) is designed to provide maximum strength with minimum weight. This result was achieved by designing alternate load paths into the structure. It means that a failure of some aircraft segment can not fully threat the airplane. Furthermore, the appropriate use and choose of materials maintaitain the whole strength. The structure consists of some alloys, mainly consists of steel, aluminum and magnesium. Aluminum alloys are widely used and become indispensible part of the structure. Also these alloys are chosen in order to withstand different type of load. Aluminum and fiberglass honeycomb core material is used extensively on secondary areas of structures and many of the flight surfaces [7].

2.1.2 Fuselage

A. The fuselage is a semimonocoque structure with the skin reinforced by circumferential frames and longitudinal stringers. It is comprised of four sections: body sections 41, 43, 46 and 48, of which the forward three together extend from body station 178 to body station 1016 and contain all the passenger, crew, and cargo accommodations. The fourth section of the fuselage is at the aft end and provides support for the empennage. Refer to figure (2.2).

B. The fuselage framework between body stations 178 and 1016 is pressurized with the exception of the cavity enclosing the nose gear wheel well, and the large cutout which accommodates the center wing box and main landing gear well. Structural continuity is provided across this latter area by a keel beam which passes beneath the center wing box and connects to a beam across the main landing gear wheel well. The whole pressurized portion of the fuselage is provided with a floor consisting of horizontal transverse beams attached to the fuselage frames and surmounted by longitudinal seat tracks and floor panels. Local variations in this floor structure include the area over the center wing box, and the main landing gear wheel well across which the floor beams run longitudinally, and the control cabin where the floor structure has to accommodate control gear and other special equipment. The forward air stairs are installed below the floor of body section 41. The fuselage frames at the fuselage stations 540 and 664 include points where the fuselage attaches to the front and rear wing members. The connection between the inner end of the chassis support beam and the fuselage is a mounting fitting that is attached to the frame on the body stations 695 and 706.

C. The part of the hull 48 of the fuselage is not under pressure, but extends from the rear pressure bulkhead at position 1016 of the fuselage at the stern. The vertical design of the ribs and the horizontal structure of the stabilizer are supported by the section 48. The APU is installed in the fire chamber below the horizontal stabilizer.

2.1.3 Wings

A. The wing structure, between left and right tips, comprises generally of the left wing box, the center wing box, and the right wing box. The caissons of the left and right wings are cantilevered from the caissons of the central wing, which carries the fuselage and is located inside it. The thickness and chord of each wing narrows to the top, and when viewed from above, both wings are diverted back from the central box of the wing.

B. Left and right wing surfaces are composed of upper and lower skin panels and front and rear side members. Along the entire left, middle and right wing boxes, the leather panels are reinforced with transverse stringers, and the side members with vertical stiffeners. The left and right fender boxes are reinforced with a series of chordal ribs and are sealed to serve as fuel tanks.

The central wing box is reinforced with spans. The left and right fender flares are attached to the center cowl by the fenders using scuff plates and chords (see figure 2.3).

Another connection is made using the four fittings described in Chapter 57, Wing Terminal Fittings. These different types of connection make the wing structure very reliable.

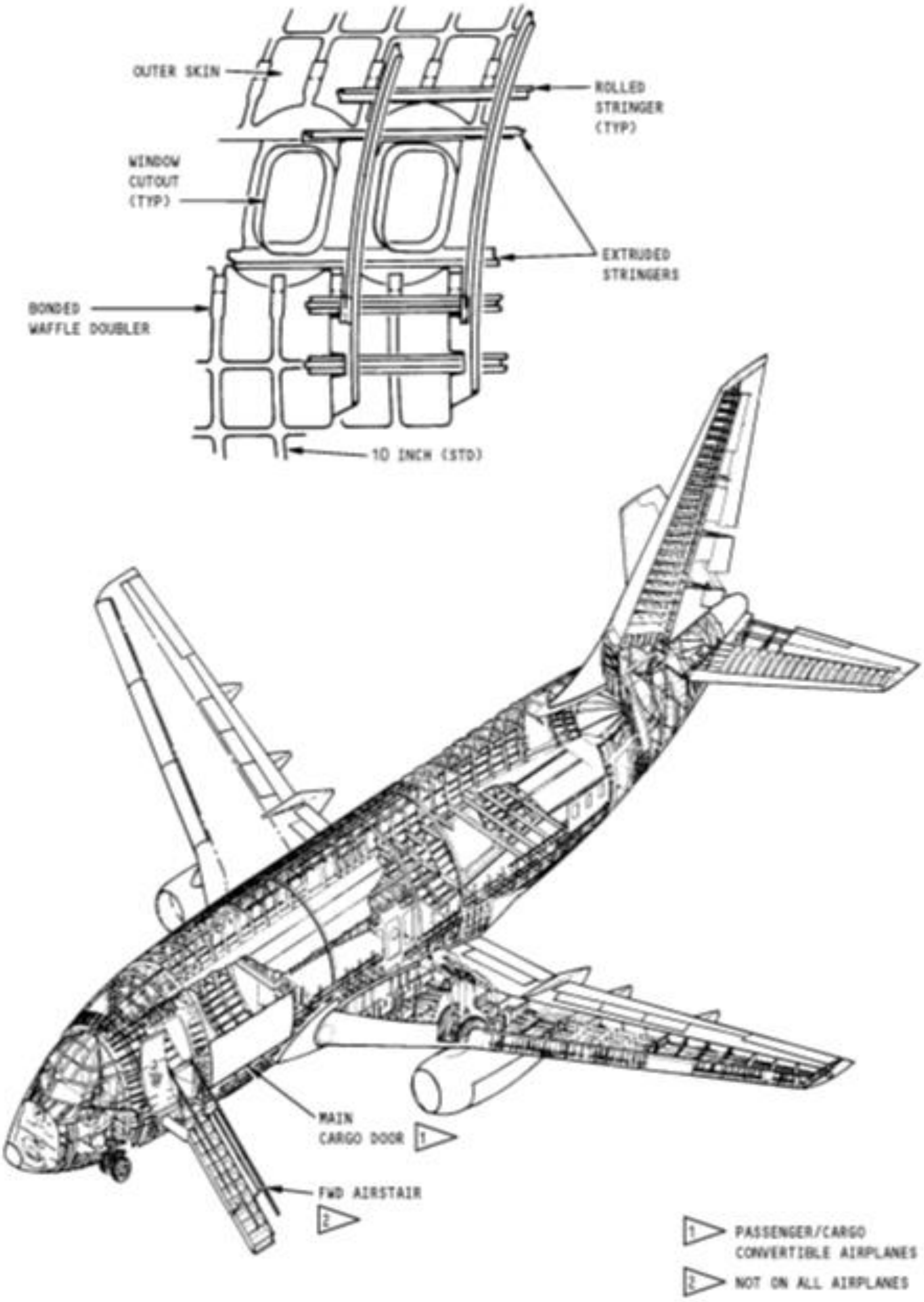
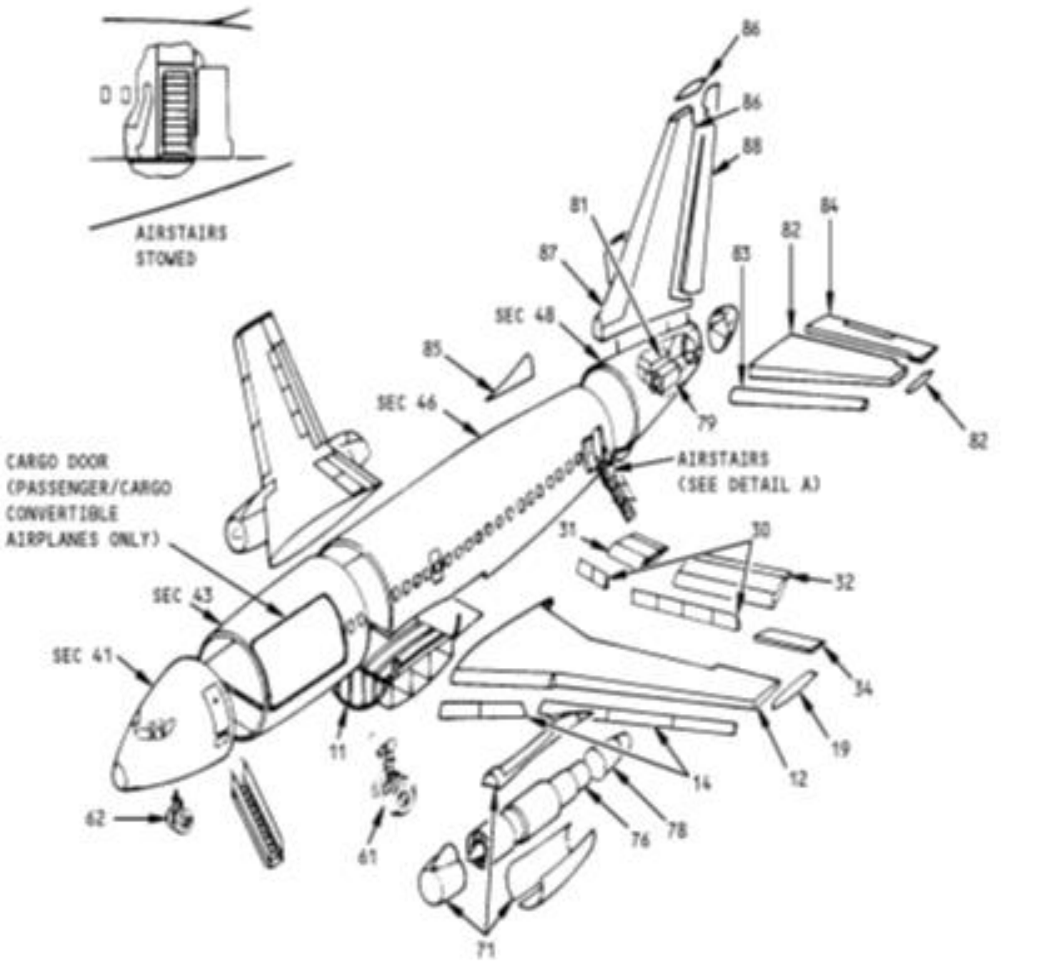


Figure 2.1 – Training manual Boeing 737 NG



STRUCT	NONSTRUCT	TITLE	STRUCT	NONSTRUCT	TITLE
	09	TOTAL AIRPLANE	60	65	LANDING GEAR
10	20	WING	61	66	MAIN GEAR
11	21	WING STUB	62	67	NOSE GEAR
12	22	WING, OUTBOARD	70	75	POWERPLANT
14	24	SLATS AND FLAPS, L.E.	71		COWLING
19	29	WING TIP		76	ENGINE
30	35	SPOILERS	78	78	THRUST REVERSER, TAIL PIPE
31	36	FLAP, INBOARD	79	79	AUXILIARY POWER UNIT
32	37	FLAP, OUTBOARD	80	90	EMPENNAGE
34	39	AILERON	81		STABILIZER CENTER SECTION
35		FLAP, CENTER	82	91	STABILIZER
40	50	BODY	83	91	STABILIZER L.E.
41	51	SECTION 41	84	91	STABILIZER ELEVATOR
43	53	SECTION 43	85		DORSAL FIN
46	56	SECTION 46	86	92	FIN
48	58	SECTION 48	86		FIN TIP
			87	92	FIN L.E.
			88	92	RUDDER
				93, 94	PASSENGER ACCOMODATIONS

Figure 2.2 – Training manual Boeing 737 NG.

Aircraft sections

The chords are four longitudinal elements passing between the septa at stations 540 and 664, and on the buttocks line of the body 70.85 along the upper and lower edges of the wing. The two upper chords have six flanges to which are attached the fuselage skin, wing skin and stringers, center skin and wing box stringers, and wing root ribs. The bottom two chords are T-sections. The fins of the wing root are attached to the membranes of these chords, and the heavy sculptural plates are attached to the flanges. The skins of the center box of the wing and wing boxes are attached to the scaffold plates. Stringers are attached to both sides of the T-section web in the welding plates using fittings. There is no connection of the fuselage skin with the lower chords.

C. On each wing, the leading edge structure is cantilevered forward of the front wing spar. The trailing edge structure is cantilevered aft of the rear wing spar and is additionally supported at the inner wing end by a landing gear support beam. This beam is attached at its inner end to the fuselage frame at body stations 695 and 706, and at its outer end to the rear of the rear wing spar. The bearings are roughly midway along the landing gear beam along with the rotation of the landing gear and are the points at which landing loads are transferred to the wing structure.

D. Five control surfaces are supported by the front edge structure of each wing: two flaps are thrown from the inner third of the notch span and three retractable strips are installed along the suspended two-thirds. Control surfaces along the trailing edge of each wing consist of inboard and outboard flaps, an aileron and a total of four spoilers.

2.1.4 Wing to Fuselage Attachment

A. A connection exists between the wing and the fuselage by means of six flanged chords running between the bulkheads at stations 540 and 664, and at buttock line 70.85 along the upper edges of the wing. Refer to figure (2.3).

B. The bulkhead at body station 540 and the center wing box front spar are integrated into one piece and the bulkhead at body station 664 and the center wing box rear spar are also integrated into one piece.

C. A connection exists between the lower surface of the center wing box and the fuselage keel beam which passes beneath it.

D. Other points of attachment between the fuselage and the wings include the main landing gear support beams, the longitudinal floor beams, and the wing to body fairings. The wing to body fairings are attached to the fuselage and to the left and right wing upper surfaces.

2.1.5 Empennage

A. The empennage consists of a dorsal fin, a vertical fin, an adjustable horizontal stabilizer, rudder and elevators.

B. Left and right horizontal stabilizers are removable from the adjustable center section truss located within the fuselage. This center section is movable, pivoting on two hinge joints attached to a bulkhead in the fuselage. Each stabilizer consists of two spars with interconnecting ribs and skin. The leading edge is removable.

C. The elevators are skin covered, spar and rib structures, containing balance panels, stabilizer actuated elevator tab and elevator control tab.

D. The vertical fin is composed of front and rear spars, interconnecting ribs and skin. The leading edge is removable. The fin and rudder may be removed.

E. The rudder is a skin covered, spar and rib structure.

2.1.6 Engine Fairing

A. The engines, one on each wing, are supported from fittings attached to wing structure. The engine fairing covers the area between the engine nacelle and the wing.

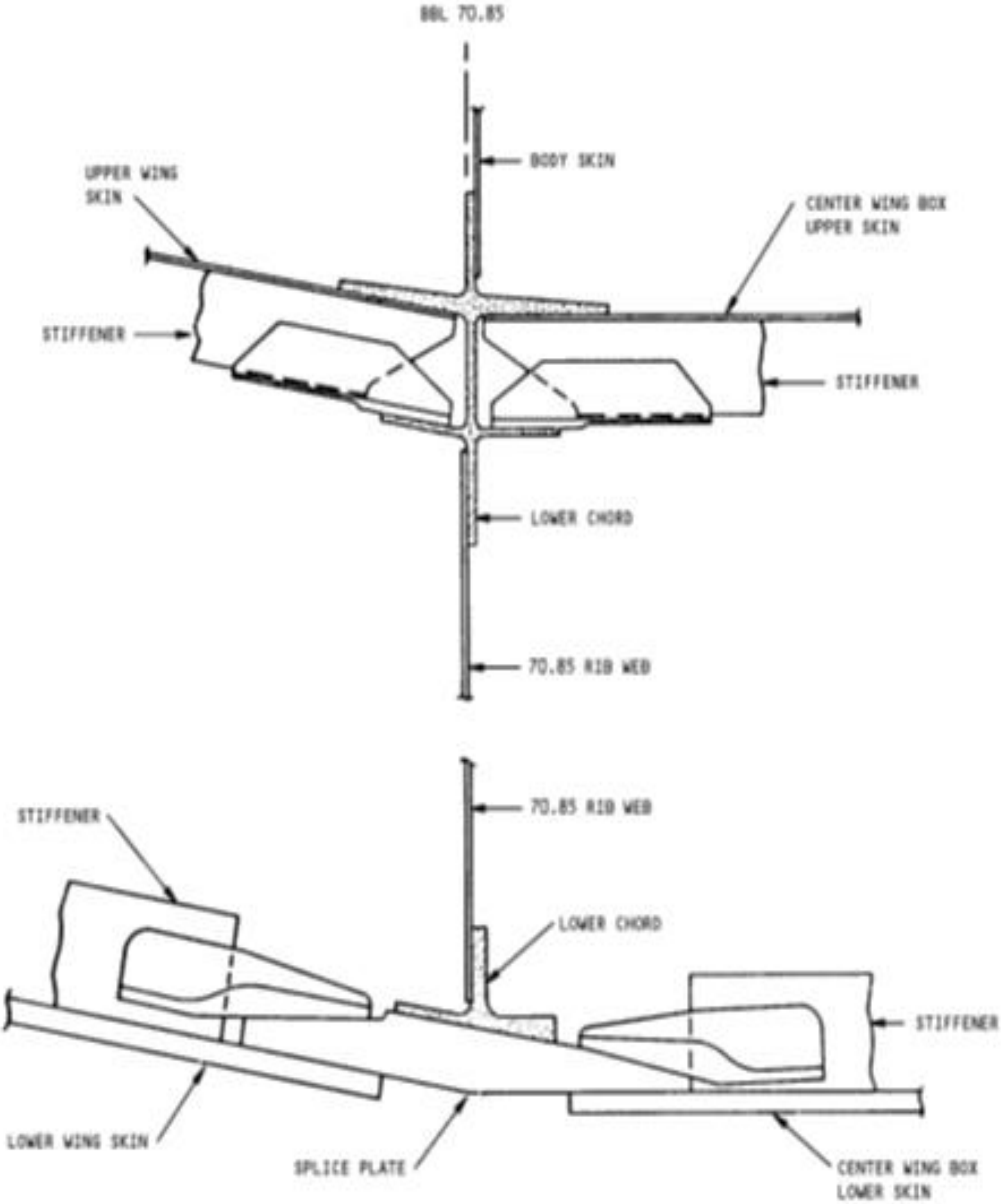


Figure 2.3 – Wing to fuselage attachment

2.2 The enhanced aircraft maintenance practices and procedures

The definition of aircraft maintenance usually includes the tasks required to restore or maintain the aircraft's systems, components, and structures in flight conditions. Three main reasons for maintenance:

- Operational: maintaining the aircraft in good and reliable condition in order to generate income.

- Cost preservation: maintaining the current and future value of the aircraft by reducing physical wear and tear over the entire life of the aircraft.

- Regulatory requirements: the condition and maintenance of aircraft are regulated by the aviation authorities. Such requirements set standards for maintenance, repairs, major repairs and reconstruction, and require the operator to develop an airworthiness maintenance program, which must be performed by certified personnel.

The efficiency of aircraft use largely depends on the improvement of maintenance programs (MP). In the context of a constant increase in the volume of air traffic, the complexity of the design of nuclear power plants, and increasing requirements for the intensity of their operation, the impact of the programs used on efficiency is becoming more and more significant.All users confirm that these aircraft in the MP are serviced under this program, which is reviewed and updated at least once a year.

Maintenance methods and procedures that meet the requirements of the MP must comply with the standards specified in the type certificate holder's maintenance manual (aircraft maintenance manual, structural repair manual, service bulletins, etc.).

To ensure and demonstrate affectivity, the MP is periodically reviewed by the MP (at least annually):

- Experience in the service sector;

- Repeated maintenance consequences that occur due to the requirements of the type certificate holder or the authorized body;

- The need for aircraft maintenance.

The term "inspection / inspection", which is used in MP, if applicable, refers to maintenance that requires careful study of an element, component, system or structure in general, with particular attention to the following areas:

Correct fasteners, protective DROs, attachments, fasteners, clamps, latches, pipes, plumbing, DROs and connection connections, connection connections, bearings, grinding, cleaning, lubrication, obvious damage, cracks, delamination, Wear, operating pressure, liquid leaks, excessive wear or reverse wear, petukhia, overheating, friction, signs of aging, preservative coating or finish, cleanliness and overall appearance.

In addition, this check does not require special measurements, removing the input panels with each specific check.

Checking emails and per checks are defined as follows:

* PRE-FLIGHT FIRE (PFI);

* TRANSIT CONTROL (TR);

* CHECK THE ARRIVAL PILA (AA);

* PRE-FLIGHT INSPECTION (BD);

* 48-HOUR VERIFICATION;

* CHECKING A, C, SI;

* AN HOUR OF SILENCE.

Even the simplest type of aircraft maintenance, such as transit fire, involves visual fire from the glider, landing gear, and engines.

Thus, the main method of detecting damage and defects during glider maintenance is visual fire returned to the glider.

Depending on the size of the glider and its main frequency, the time spent on visual fire increases.

Based on the modern management group MP-3 maintenance (MSG-3) Principles, service station (SS). The On-Condition condition requires periodic inspection of the device or part, or verification by any appropriate physical standard, to determine whether it can continue to work. The purpose of the standard is to decommission the device before it appears during normal operation.

The group consisted of Representatives from various aviation authorities, including the Air Transport Association (ATA), Airlines, aircraft manufacturers, suppliers, and FAA representatives.

When the condition is released, no services or checks are planned to track integrity or fitness, but mechanical characteristics are contrasted and analyzed. According to MSG - 3 logic, the service is evaluated not at the component level, but at the system level. According to them, if it can be proved that the functionality of a non-specific system does not affect the safety of work or that the economic consequences do not matter, then there is no need for scheduled maintenance.

The air advance notice was only delivered from the conservative maintenance program for the original equipment manufacturer (OEM). Because these programs were resource-intensive and expensive, the user's share of the win was not enough to implement an effective maintenance program. Airlines wanted to participate in the development of scheduled maintenance programs for the aircraft they operate to improve safety, reliability, availability, stability, and reduce maintenance costs.

The MSG-3 instructions will provide jamming-oriented logic for the corresponding jams scheduled maintenance. The goal-setting program consists of specific requirements selected for this functional failure effect based on the specific reliability characteristics of the equipment recognized for the protection action. Below is a list of basic tasks:

1. Lubrication / Servicing (LU/SV or LUB/SVC) – to preserve the innate abilities of the structure.

2. Operational / Visual Check (OP/VC or OPC/VCK) – the task of eliminating fidgets.

3. Functional Check / Inspection (FC /IN) – functional verification of quantitative verification to determine one or more functions of the analysis element, taking into account certain restrictions. There are three levels of verification to determine whether a subject is fulfilling their goal.

- General Visual Inspection (GVI)
- Detailed Inspection (DI)
- Special Detailed Inspection (SDI)

4. Restoration (RS) – reworking, replacement of parts or cleaning necessary to return an item to a specified standard.

5. Discard (DS) – the removal from service of an item at a specified life limit.

According to MSG-3, maintenance work is divided into three programme groups: (a) systems and power plants, (B) structures and (C) regional.

The purpose of warm-up Systems & powerplants is to conduct functional and / or operational inspections of typical aircraft systems, such as flight control, pneumatics, electrics, etc.

The purpose of warming up regional control is to assess the overall state of closing of all elements of systems and sprud in each region using certain regional control tasks. The tasks of regional control include visual control of electrical wiring, hydraulic pipelines, water supply / sewerage, pneumatic pipes, components, fittings, brackets, etc.

The Design View program is designed to ensure timely detection and elimination of structural damage during commercial operation. Visual and / or non-destructive methods are used to detect Roosters, stressed Roosters, unfamiliar injuries, and fatigue cracks.

The process of improving the maintenance program requires the aircraft manufacturer and users to work together to identify blockages that can be optimized. For each identified maintenance task, the aircraft manufacturer reviews the data obtained and analyzes the positive and negative results of operation. The adopted amendments are submitted to the regulatory authorities for approval. The document "aircraft maintenance planning data" (MPD) contains planning information necessary for each user to develop an epidemic-specific scheduled maintenance program [9].

Maintenance program advanced maintenance programs developed using MSG-3 have all the jams set at different intervals (i.e. flight hours, flight cycles, and calendar time). Most of these confluence blocks connect the two of these intervals. This process allows operators to group maintenance workloads into packages for the most efficient formation. This process allows you to maximize the use of task intervals.

The purpose of some of the general visual control tasks of the systems developed under the MSG-3 process is met by the regional control program.

The chapter MP (MP structure) will set out the task of scheduled maintenance for structural maintenance programs. This program is designed to ensure timely detection and repair of structural damage to the airframe, as may occur during commercial operation. Detection of petuhia, live petuhia, unfamiliar accidental damage, and fatigue cracks is considered using visual and/or non-destructive testing (Non-Destructive Testing). It is believed that large accidental injuries, such as bird impacts or large ground equipment, are easily detected. In addition, such symptoms as fuel leaks, loose fasteners, loss of tightness in the cabin, etc. are easily detected and leave an important part of the structure maintenance program.

2.3 Zonal Analysis Procedure

The regional control programme is a visual control zavannya that translates system components, including connected wires, pipeline, air ducts, etc., as well as the state and structure of security in public access areas to be checked in terms of the overall condition and safety of the system installation and overall design control.

The regional inspection programme contains a number of gaps that have been identified as inspection-regional. This check is defined as a visual inspection of the installation or assembly to detect internal or external areas, obvious damage, defects, or damage. This level of control is performed from a touch distance, unless otherwise specified. The mirror could know to improve visual access to all exposed surfaces in the field of view. This level of inspection is performed under normal lighting conditions, such as daylight, hangar light, lamp or drip light, and may require the removal or opening of entrance panels or doors.

General visual reviews included in the regional program are GV reviews that show poor unsatisfactory condition, damage, failures, breakdowns / inconsistencies in the visible structure, systems and installations or nodes of electrical spaces. "General visual" inspections / inspections are not included in the regional programme and are listed as separate in the relevant sections of the programme of systems, power plants or facilities. Inspection details and special details are not included in the regional inspection programme [10].

Excessive dust, debris, or excessive dispersion of compounds that inhibit Petunia detected during any inspection are considered unsatisfactory, which can reduce the fire resistance of the glider structure. The maintenance program's actions include blockage requirements that meet the following requirements: so-called "interconnect wire systems" (EWIS). This right requires the development of aircraft maintenance and inspection tasks, intervals, and procedures. The analysis was performed for each service area using the "advanced region analysis procedure" (EZAP). Then the purpose of the ezapi analysis is to determine the requirements for maintenance and control:

1) reducing the accumulation of combustible materials.;

2) detection of defects in the EVIS component;

3) detection of inconsistencies in the ewis installation that cannot be reliably identified with inversions in the glass of existing MP.

2.4 Composite Materials

A "Composite" material is defined as a mixture of different materials and substances. This definition is so general that it can refer to metal alloys made of several different metals to improve their strength, ductility, conductivity, or any other characteristics. Similarly, the composition of composite materials is a combination of reinforcing elements such as fiber, whiskers, or parts that are surrounded by the resin that forms the structure and are in place.

As a relatively new technology, the development and practice of composite materials is developing. The lack of public good standards is reflected in the lack of educational standards, as a result of which institutions and educational organizations often focus on certain areas of composite materials technology. This sacrifices balance and breadth and usually removes valuable information from the course curriculum.

Some aircraft designs and details are made of composite materials rather than aluminum. Composite materials are lighter and more resistant to corrosion than aluminum. Composite materials are layers (layers) of carbon or fiberglass in a plastic resin mixture. They include the following materials:

1) Carbon fiber reinforced plastic
2) Toughened carbon fiber reinforced plastic
3) Fiberglass
4) Carbon fiber reinforced plastic/fiberglass hybrid.

Composite technologies are evolving in real time, with next-generation design and manufacturing technologies for large composite structures being researched and developed. Coupled with property developments, manufacturing techniques are also changing. Evolving composite technologies are frequently considered proprietary and are not available in the public domain. As a result, composite property standards are in the early stages of development and are in flux, requiring special skills and awareness of safety implications of composite maintenance and repair [11].

There are a number of factors affecting the continued airworthiness of composite structure. Unlike metal structures, where fatigue cracking can be a primary threat to structural integrity, accidental damage (e.g., foreign object impact) is a critical threat for composites. Hidden deficiencies incurred in manufacturing also need to be considered. For example, weak bonds caused from surface contamination may not be detected by initial inspection methods. As a result, other procedures and redundant design features are needed to ensure the continued airworthiness of bonded structures.

2.4.1 Advantages/Disadvantages of Composites

The main advantages of using composite materials are:

- High strength-to-weight ratio (Tensile strength 4 to 6 times that of steel or aluminum)
- Fiber-to-fiber transfer of stress allowed by chemical bonding
- Bonded construction eliminates joints and fasteners
- Longer life than metals
- Higher corrosion resistance
- Reduced aircraft drag
- Good heat resistance
- Greater design flexibility
- Easily repairable

The disadvantages of composites include:

- Inspection methods difficult to conduct, especially delamination detection (Advancements in technology will eventually correct this problem)
- Lack of long-term design database, relatively new technology methods
- Highly Cost (especially processing equipment)
- Lack of standardized system of methodology
- Lack of visual proof of damage
- General lack of repair knowledge and expertise
- Products often toxic and hazardous
- Lack of standardized methodology for construction and repairs

The increased strength and the ability to design for the performance needs of the product makes composites much superior to the traditional materials used in today’s aircraft. As more and more composites are used, the costs, design, inspection ease, and information about strength-to-weight advantages help composites become the material of choice for aircraft construction.

2.4.2 Composite Materials Maintenance and Repair

Carefully inspect any damage that may require thorough cleaning of the part before a detailed inspection. If there is a small puncture in the honeycomb panel that is within a certain permissible damage limit (ADL) for this component, it should be dried according to the specified requirements of the repair documentation, and then filled with filling compound and sealed with tape. This prevents the damage condition from getting worse, and the part must be scheduled for permanent repairs within the time limits specified in the original documentation. If the damage needs to be repaired before the next flight, the part must be replaced either during the removal of the original repair part, or the original part must be repaired before the next flight in accordance with the instructions contained in the authorized repair documentation.

The full extent of damage to the composite part must be mapped using visual and non-destructive Research Institute methods. If the damaged part is a honeycomb sandwich panel, a coin tap test can be used to map the damage. If the damage occurs in a hard layered area of the sandwich panel (for example, in the edge strip) or in a hardened layered part, the coin tap test will detect delamination only in the first few layers, and an ultrasonic method will be required to establish the damage boundary.

It is necessary to read the permitted documentation for the permissible amount of maintainable damage. The acceptable size of repairs depends on the type of repair. For example, repairs using room-temperature curing adhesives or resins are usually limited in size. If a hot - cured adhesive or resin is used at 65-93 ° c (150-200°F), the permissible repair size becomes larger. If repairs are made at the initial curing temperature, then larger repairs are allowed, and sometimes repairs of unlimited size.

When preparing the repair surface, it is important to make sure that it is clean, dried to the required size, and the repair fabric has the necessary treatment. Use careful abrasion with aluminum oxide or silicon carbide abrasive paper.

Repair of composite or bonded metal parts may require equipment ranging from a flat stand for Vacuum Bonding of flat panels to extremely expensive tools, approaching those used in the original production for very large repairs and autoclaved bonding of complex shaped parts. The curing temperature should not distort the tool, and ideally the tool should be made of a material with the same coefficient of thermal expansion as the part. This is especially important for profiled parts that must be made to the exact shape.

2.4.3 The Differences between Repairing Composite and Metal Structures

Metal surfaces need special treatment to increase their surface energy and ensure good adhesion. Aluminum alloys require anodizing with phosphoric or chromium acid to produce a high-energy oxide layer with a porous structure that promotes good adhesion. There are other methods, but they are not as effective. Titanium and corrosion-resistant steel can be glued together, but always check the processing recommendations. Good surface preparation is most important for good, strong connections when repairing metal parts. Primers are often used for bonding metals. The primers must be compatible with the adhesive used. Primers do not significantly increase the adhesion strength, but they do increase corrosion resistance and, consequently, durability. Metals have the same properties in all directions. The metal repair patch must be the same thickness as the original leather, or one caliber thicker, but not more; otherwise, too much load will be applied to the patch.

Composite coatings are quite porous. If wet styling is done at room temperature or up to about 95°C, or if a Prepreg is used, some gas and air can be drawn through the resin to create binding pressure to hold the skin on the honeycomb and repair area of the skin. The area surrounding the repair can be damaged if there is water in the honeycomb and an attempt is made to harden at the initial temperature. To avoid this problem, all repairs to cellular panels should be carried out at a temperature significantly lower than the initial manufacturing temperature. If this is not allowed, a higher pressure must be provided by a press or autoclave. Metals almost always use primers to minimize corrosion and increase the durability of the joint. Similarly, composites use a primer to protect the first layer of fiber. This coloring system is also used for metals when Brig.

Teamwork is essential to composite maintenance, particularly as associated with the steps involved in aircraft structural inspection, disposition, and repair. Team members should have some awareness of the different skills needed to successfully perform each step. This awareness serves to better understand personal skill limits and where to get help.

Types of repair are related to damage assessment and location on the aircraft. For instance:

• If a low-observability repair is required, a flush bonded repair will have to be made.

• In areas where the airflow is critical, such as the leading edge of a wing or an engine nacelle, a flush bonded repair is required.

• If damage occurs to a heavily loaded, stiffened laminate structure, bolted repairs are most likely to be used, sometimes in conjunction with adhesive bonding. For example, wing skins, stiffened by stringers, are likely to be repaired using bolts or blind fasteners.

• When these scenarios are considered, the number of occasions when there is a choice, bolting is less likely to be chosen.

• In general, if the panels are of sandwich construction, bonded repairs are usually chosen.

• If the parts are heavily loaded, stiffened laminate structures, bolted repairs are quite often used.

2.5 Corrosion Prevention Maintenance

The ability to recognize corrosion in its early stages is important and necessary for taking corrective measures, as well as before expensive repairs or replacements become necessary. Any structural part exposed to corrosion should be carefully examined to determine its structural integrity. Rusty parts should be removed and, if they can be saved, recycled. Apply the same type of protective treatment that was previously applied to the parts. If it is not possible to remove a structurally strong part, special treatment must be carried out depending on the type of material and the degree of corrosion.

The following types of corrosion are those most identified in airframe structures:

- Anodic (Galvanic) corrosion
- Stress Corrosion Cracking
- Pitting
- Intergranular and Fretting corrosion Micro-Biological
- Filiform surface corrosion
- Uniform surface corrosion Exfoliation
- Exfoliation
- Crevice (Deposite) Corrosion
- Intergranular and Fretting corrosion

Non-metallic materials (plastics, elastomers, paints and adhesives) are not subject to electrochemical corrosion. The use of unauthorized maintenance chemicals and procedures can accelerate degradation and ultimately lead to material failure resulting in leakage, corrosion, electrical shorts, crazing, and/or mechanical failure.

The Corrosion Prevention and Control Program (CPCP) is an integral part of the Structural Maintenance Program. The objective of the CPCP is to control corrosion found on all structure listed in the Structural Maintenance Program to Level 1 or better. Structural maintenance requirements are determined on the basis of continual maintenance to preserve or restore the inherent corrosion preventive measures and structural surface finishes [12].

Corrosion preventive maintenance includes the following specific functions:

1) Proper cleaning

2) Provide periodic lubrication

3) Detailed checks for elements corrosion and failure of protective systems

4) Prompt treatment of corrosion and touch up of damaged paint locations

5) Accurate record keeping and reporting of material or design deficiencies to the manufacturer and the NAA

6) Use of necessary materials, equipment, technical publications, and adequately-training personnel

7) Maintenance of the basic finish systems

8) Keeping drain holes free of obstructions

9) Daily draining of fuel cell pumps

10) Daily wipe down of exposed critical areas

11) Sealing of aircraft against water during foul weather and proper ventilation on warm, sunny days

12) Replacing deteriorated or damaged gaskets and sealants to avoid water intrusion and/or entrapment

13) Maximum use of protective covers on parked aircraft

In addition to the above assumptions, there are metal processing techniques that can stop the metal from corroding before it starts; for example, an oil or oil coating that remains on the metal surface. Painting is another way to prevent metal corrosion. Also consider using cathodic protection to prevent corrosion on the main metal parts. Carbon fiber coatings are another great way to prevent metal corrosion. In this process, carbon fiber sheets are compacted around a metal pipe and often on a metal surface or any metal surface. This not only prevents corrosion, but also strengthens the metal, prevents the formation of cracks and prevents leakage [12].

2.6 Aircraft Maintenance Improvement against Corrosion Corrosion Prevention and Control Program

Inspection for Corrosion must be a scheduled maintenance task in MP. The MP should include inspection for corrosion followed by correct treatment of affected areas. The areas should be inspected for not only actual corrosion damage but also for conditions that could cause corrosion (such as damaged finishes or blockage of drain holes). Because corrosion is a problem that will not go away, frequent inspection of the problem areas is recommended.

In instances where loading of nonstandard cargo (i.e. livestock or fish) or cargo spillage of harmful products (i.e., mercury) occur, specific inspection requirements are initiated.

Visual or nondestructive inspection (NDI) procedures are used as methods of inspection for identifying the existence of corrosion. For general inspection, the visual means aided by magnifying glasses, borescopes, etc., is used extensively. The NDI techniques have limited capability to locate or detect corrosion because of complexity of instrumentation, complexity of areas being inspected and time consumed to make the inspection. In specific localized areas where inspection by visual means is impossible or where extent of corrosion has to be determined after visual detection, the NDI technique may be used.

Corrosion can be removed by mechanical procedures or chemical procedures. The details and the selection decision will be different for different amounts of corrosion and different types of metal. The mechanical corrosion removal procedure is recommended for most cases of corrosion damage. Some examples of this procedure are: hand sanding with abrasive paper or metal wool, power sanding with abrasive mats, grinding wheels, wire brushes or rubber mats. The chemical corrosion removal procedure can be used on the airplane where chemical flow can be controlled and the area can be fully washed with water.

In order to preclude the occurrence or recurrence of corrosion after corrosion removal or corrosion damage repair, the exposed surfaces of most metals must be immediately treated after rework. These treatments include conversion coating, plating or the application of thin protective film, i.e., oil or primer, over the base metal. The conversion coatings and primer application also enhance the surface adhesion qualities for painting, if required. Applying of corrosion inhibiting compound to the inner skin surface and structure also is used.

Sealing compounds are used to obtain aerodynamic smoothness on exterior surfaces of the fuselage, wing and empennage.

During the course of structural or component inspection seals are to be examined for deterioration of compound and non-adherence. Any air leakage throughout the pressurized fuselage can normally be detected aurally when carrying out a fuselage pressure check. Fluid leakage can be detected by presence of fluid or fluid stains on the dry side of structural elements. Structural Repair Manual includes all information concerning determination whether any structural repair is necessary [13].

2.7 Airframe Drainage

1 . General

A. External drain holes and internal drain paths are provided to prevent water and other fluids from collecting within the airplane which could become a possible fire or corrosion hazard. Drain paths and drain holes must be inspected periodically to ensure they are clear of obstructions.

B. In the electronics compartment, moisture shroud panels on all airplanes and waterproof fabric moisture shields on some airplanes protect equipment on the electronic equipment racks.

2 . External Drains

A. Drain ports are located on exterior surfaces of body, wing, and empennage to dump fluids overboard. Leveling compound is used to ensure proper drainage in sloping areas. Rubber flapper seals are used in pressurized areas. The seals close off parts when the airplane is pressurized and allow ports to remain open when the airplane is not pressurized. Drain ports in non-pressurized areas are always open.

3 . Internal Drain Paths and Drain Holes

A. Internal structure is provided with tubes, channels, dams, and drain holes, to direct the flow of fluids toward external drainage points.

(1) Primary body drain paths are provided in the forward lower body area, in the overwing and wheel well area, and in the aft lower body area.

(2) Secondary body drain paths are provided to all stringer splice locations. Drain ports in the floor permit fluids to flow to the lower body skin where they drain overboard.

Caution: if structural repair is accomplished, ensure drain holes and drain pathways are not inadvertently blocked with sealant.

EXTERNAL DRAINAGE - INSPECTION/CHECK

1 . General

A. All external drains must be checked at regular intervals to ensure proper drainage and prevent a possible fire or corrosion hazard (figure 2.5).

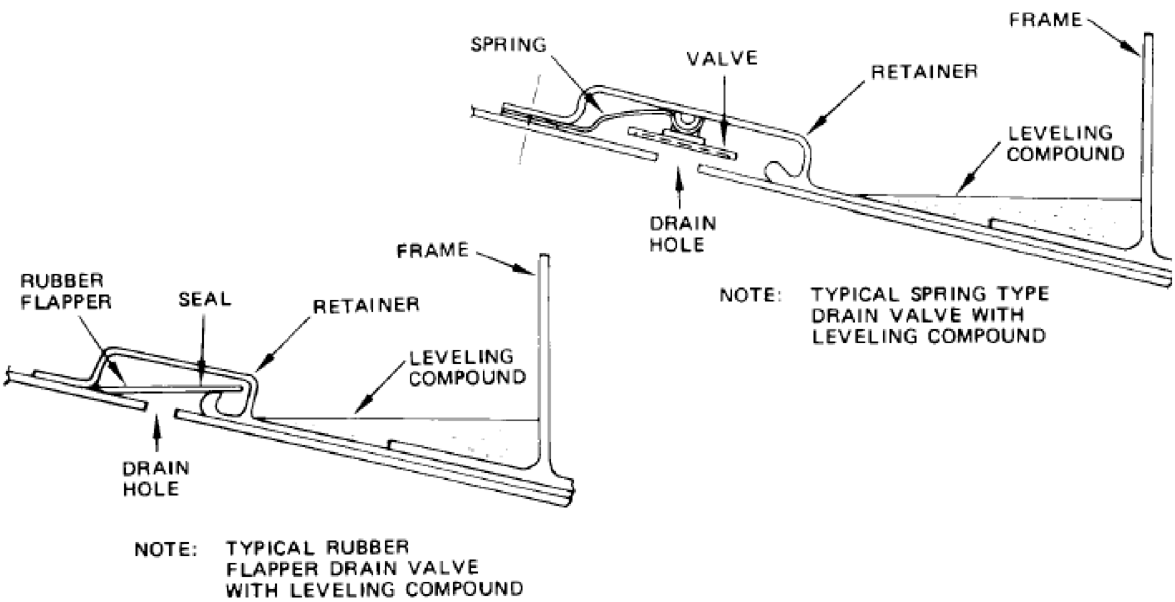


Figure 2.5 – Airframe drainage structure

2 . Equipment and Materials

A. Wiping cloths

B. Mild Cleaner

3 . Check External Drains

A. Check external drains frequently and keep free from obstructions. If required, clean drains per par.

B. Repair leveling compound.

(1) Check drain holes with and without valves in areas of body, wing, empennage, nacelle, and control surfaces.

C. Clean Drains

(1) Using cloth moistened in water-cleaner solution, if required for set soils, remove all soils and obstructions from drains.

(2) Carefully raise rubber seals or valves from drain ports in pressurized areas and remove soils and other obstructions. Replace defective or deteriorating seals or valves.

INTERNAL DRAINAGE - INSPECTION/CHECK

1 . General

A. All internal drains must be checked at regular intervals to ensure proper drainage and prevent a possible fire or corrosion hazard.

2 . Equipment and Materials

A. Wiping cloths

B. Mild Cleaner

3 . Check Internal Drains

A. Check internal drains frequently and keep free from obstructions. If required, clean drains per par.

B.(1) Gain access to upper surface of wing center section by removing floor panels as required (Ref AMM 53-21-0, Removal/Installation).

(2) Check drain openings through aft lower corner of ribs at pressure deck beam.

B. Clean Drains

(1) Using cloth moistened in water-cleaner solution, if required for set soils, remove all soils and obstructions from drains.

(2) Check and clean horizontal drain hole.

Conclusions to the Part 2

In this chapter, after careful analysis of the various airframe structure and typical damages like (corrosion and fatigue fracture,), the structural maintenance improvements were suggested.

In this thesis, it was offered to improve a system of maintenance by material selection, early inspection, corrosion prevention, new technology of inspection.

PART 3

AIRFRAME MAINTENANCE ENHANCEMENT BY USAGE OF SENSOR SYSTEMS FOR CONDITION MONITORING

3.1 Organization of maintenance and repair of the aircraft airframe

Regarding civil aircraft, the following types of maintenance are installed: operational, periodic, seasonal, special, during storage. The main of these types are operational and periodic. Each type of technical services differs in the volume and complexity of work required in time and frequency of their implementation.

Maintenance of civil aircraft consists of the following periodic inspections of the technical condition of aircraft, which must be performed by airlines (service companies) after a certain time or certain flight hours (specified in the airline maintenance program): Transit check, Daily Check, Weekly check, A- check, C-check and D-check.

When servicing a airframe, the main method of detecting damage and malfunctions is simply a visual inspection of the airframe's surface.

Depending on the size of the airframe and its main parts, the time spent on visual inspection increases. And depending on the form of maintenance the complexity and complexity of visual control of the airframe of the plane and its separate parts changes.

Maintenance of the airframe is to check the condition of its body, power elements (frames, spars, stringers, ribs) and their connections, as well as checking the surfaces of the steering, wing mechanization and their adjustment.

Typical airframe failures are:

- deformation and destruction of the body and power cell;
- loosening and riveting rivets;
- loosening of screws for fastening of covers of hatches;
- wear of joints in hinged joints;
- weakening and destruction of bolted connections;

- staining disorders;

These faults are very dangerous for the aircraft, as they lead to increased vibration of the aircraft and especially its plumage, which, in turn, leads to a significant increase in the load on the tail of the aircraft.

When monitoring the condition of the airframe, special attention is also paid to prevent corrosion damage to elements and parts. Occurrence of corrosion damages of details can be connected with destruction of apaint and varnish covering, poor-quality oil. Most often, corrosion damage occurs at the junction of elements (especially from dissimilar metals or unstable from corrosion), not protected by paint, in places of possible accumulation and ingress of moisture and salts. An external sign of corrosion is the appearance on the surface of steel parts of brown-red coating, and on parts made of aluminum and magnesium alloys - grayish-white coating in the form of soot. When parts with a protective paint coating are subject to corrosion, the coating swells (swells) in the form of small bubbles [13].

To sum up, the use of unmanned sensor systems for visual inspection of the aircraft airframe during all types of maintenance can potentially increase the efficiency of the aircraft maintenance, as well as facilitate the work of the operator and maintenance.

3.2 Selection of approach to maintenance and restoration of the airframe

The algorithm of the airframe inspection process includes:

1) Beginning of the inspection;

2) Identification of the area, upon the presence of the object in the inspection area;

3) The ratio of the unmanned sensor system to a number of segments of the field of view;

4) Generation of data on the surface of the object by an unmanned sensor system;

5) Checking the surface for damages or other violations;

6) If the damages are identified – selection of maintenance works;

7) End of review. Issuance of results.

The process begins by identifying the area of space that contains the object, upon the presence of the object in the viewing area. The space area has many segments.

The process then compares multiple sensor systems with multiple area segments. Each sensor system of multiple sensor systems is mapped to multiple segments from a plurality of area segments on the basis that the sensor system is able to generate data on the surface of the object in a particular segment from a plurality of segments with the required level of quality.

After that, the process generates data on the surface of the object using a number of sensor systems mapped to multiple segments of the area. The process then determines the presence of a certain number of violations on the surface of the object, using this data.

If there are no violations on the surface of the object, the process ends. On the other hand, if the violation is on the surface of the object, the process determines the maintenance work to be performed on the object with the subsequent completion of the process.

Maintenance work may include, for example, restoring the surface of the object, repairing the surface of the object, replacing the part associated with the surface of the object, performing additional inspection of violations and / or other relevant operations. For example, if an additional inspection identifies a number of violations as a result of a maintenance identification operation, the process may send commands to a mobile test system to move that mobile test system to those violations.

Thus, a method and apparatus for inspecting objects such as an airplane are proposed. Upon the presence of the object in the viewing area, the area in which the object is located is identified. This area has many segments. A number of sensor systems are aligned with many segments of the area. Each sensor system of this number of sensor systems can be compared with a number of segments in many segments of the area. This comparison of a certain number of sensors is based on whether each sensor can generate with the required level of quality data on the surface of the object in a separate segment of many segments. Then data on the surface of the object is generated using a number of sensor systems, aligned with the many segments of the area. To detect the presence of a number of violations on the surface of the object, the detection process is carried out. This information can then be used to perform maintenance or other work on the site.

Thus, the proposed system reduces the time, cost or equipment required to inspect an object such as an aircraft. Using a number of sensor systems compared with the generated data of the required quality for specific segments of the area in the viewing area in which the object is located, the view of the object can be performed more easily, in less time, more accurately or more consistently than existing methods.

Moreover, various embodiments may be presented in the form of a computer software product that provides program code for use with or in combination with a computer or any device or system that executes instructions. A data processing system suitable for storing or executing program code includes one or more processors connected directly or indirectly to memory elements via a fiber communication line, such as a system bus. Memory items may include local memory used during the current execution of the program code, external memory and cache memory, which provide temporary storage for at least some amount of program code so that the number of reads of the part can be reduced. code from external memory during code execution.

Input /Output (I / O) devices can be connected to the system either directly or via I / O controllers. These devices may include, but are not limited to, such as keyboards, touch screens, and pointing devices. Various communication line adapters can also be connected to the system to enable the data processing system to connect to other data processing systems, remote printers or storage via private or public networks.

3.3 Conceptual aspects of the use of unmanned sensor systems (drone usage) for airframe inspection

The aircraft and its parts are inspected at different stages of the aircraft's life. For example, when an aircraft is in the process of being assembled, different parts of the aircraft are inspected at different stages of assembly. In addition, during the inspection and certification of an airplane, an inspection is performed to determine whether the various parts of the airplane are operating in accordance with the design.

Currently, the inspection of the aircraft is carried out by a person using instructions that identify the parts and integrity violations that the person must find. This person is also a repair and maintenance operator. The results of this inspection are recorded or entered into the database by the repair and maintenance operator.

For example, for some types of inspection, the aircraft can be placed in a hangar. The repair and maintenance operator may walk around the aircraft to determine if there are any integrity violations on the surface of the aircraft. These integrity violations may include, but are not limited to, potholes, holes, missing rivets, or some other type of integrity breach. Thus, a certain advantage would be provided by a method and apparatus that take into account one or more of the problems described above, as well as other possible problems.

When considering the various options for maintenance processes, it can be concluded that when inspected by repair and maintenance operators, it may be difficult to see the upper segments of the aircraft, such as the upper part of the aircraft. As a result, some violations may not be detected or identified by repair and maintenance operators.

The repair and maintenance operator may need to climb stairs or use a lifting device to see the upper segments of the aircraft. This process increases the time required to inspect the aircraft and also requires equipment that allows repair and maintenance operators to see higher segments of the aircraft that cannot be easily seen from the ground.

This provides a system for using unmanned aerial vehicles that can be used to review an airframe. Upon the presence of the object in the viewing area, the area of space in which the object is located is identified. This area of space has many segments. The sensor system moves in many segments of the space.

3.3.1 Design of unmanned sensor system (drone usage)

An unmanned aerial vehicle (drone), as a sensor system, contains many cameras. Many cameras are configured to generate data in the form of many images. The plurality of images may, for example, be at least one of the types of photo, video and / or other types of corresponding images without restrictions.

Cameras can generate many images from a specific area of the aircraft. The cameras can be fixed or can move around several axes.

This movement on several axes is controlled by a motor system and a controller. In addition, in these demonstrations, the movement around several axes can be called rotation and tilt.

Multiple cameras above the zone are able to generate multiple images, but data can only be generated for the zone segment. In the zone segment, you can generate many images with the required level of quality.

In the presented example (figure 3.1), the control system is a mobile control system. As shown, the mobile control system includes a platform, a power plant, a controller and a non-destructive testing unit. The platform provides a framework for other components in the mobile control system. The power plant, controller and non-destructive testing unit are connected to the platform.

The power plant is configured to move the mobile control system. The power plant can move a mobile control system over the ground, through the air or in both environments.

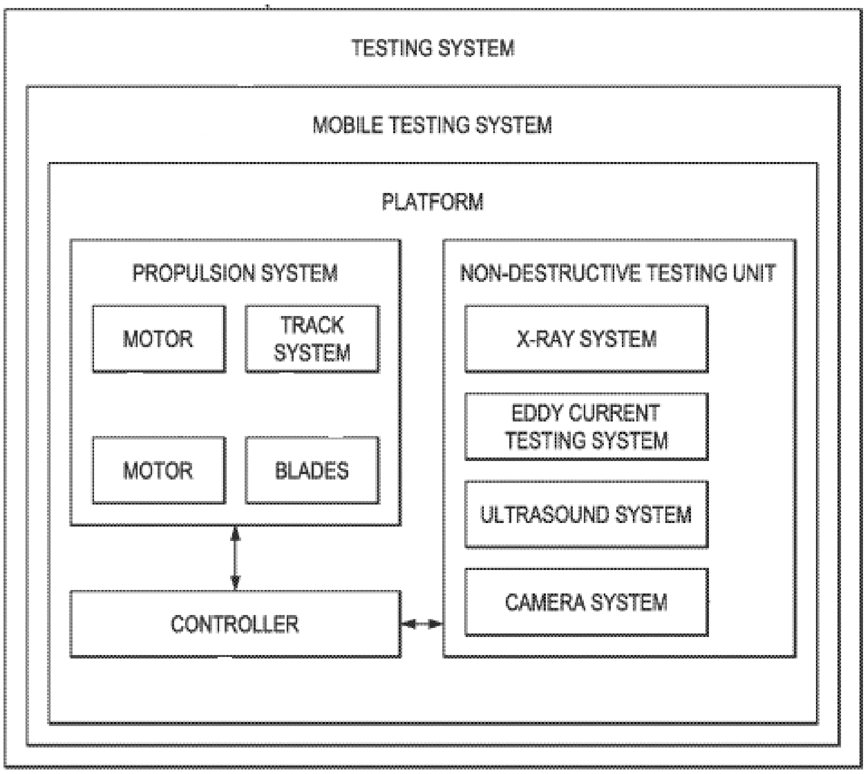


Figure 3.1 – Design of unmanned sensor system

The non-destructive testing unit may comprise at least one of the systems: an X-ray system, an ultrasound system, a chamber system, or other suitable types of non-destructive testing systems.

The controller may be a data processing system, such as a data processing system or a processor unit. The controller is configured to control a mobile control system.

Motion and data generated by the mobile control system can be controlled by instructions or commands received from the inspection process.

3.3.2 New drone airframe inspection technology

The aircraft is inspected to identify a number of violations and damage. As an example, these violations may include at least one hole, crack, hole or some other type of violation.

In this demonstration example (Figure 3.2), the aircraft is inspected at a special location. In particular, such a place may be in the hangar. The place in the hangar forms the viewing area for the inspection of the aircraft.

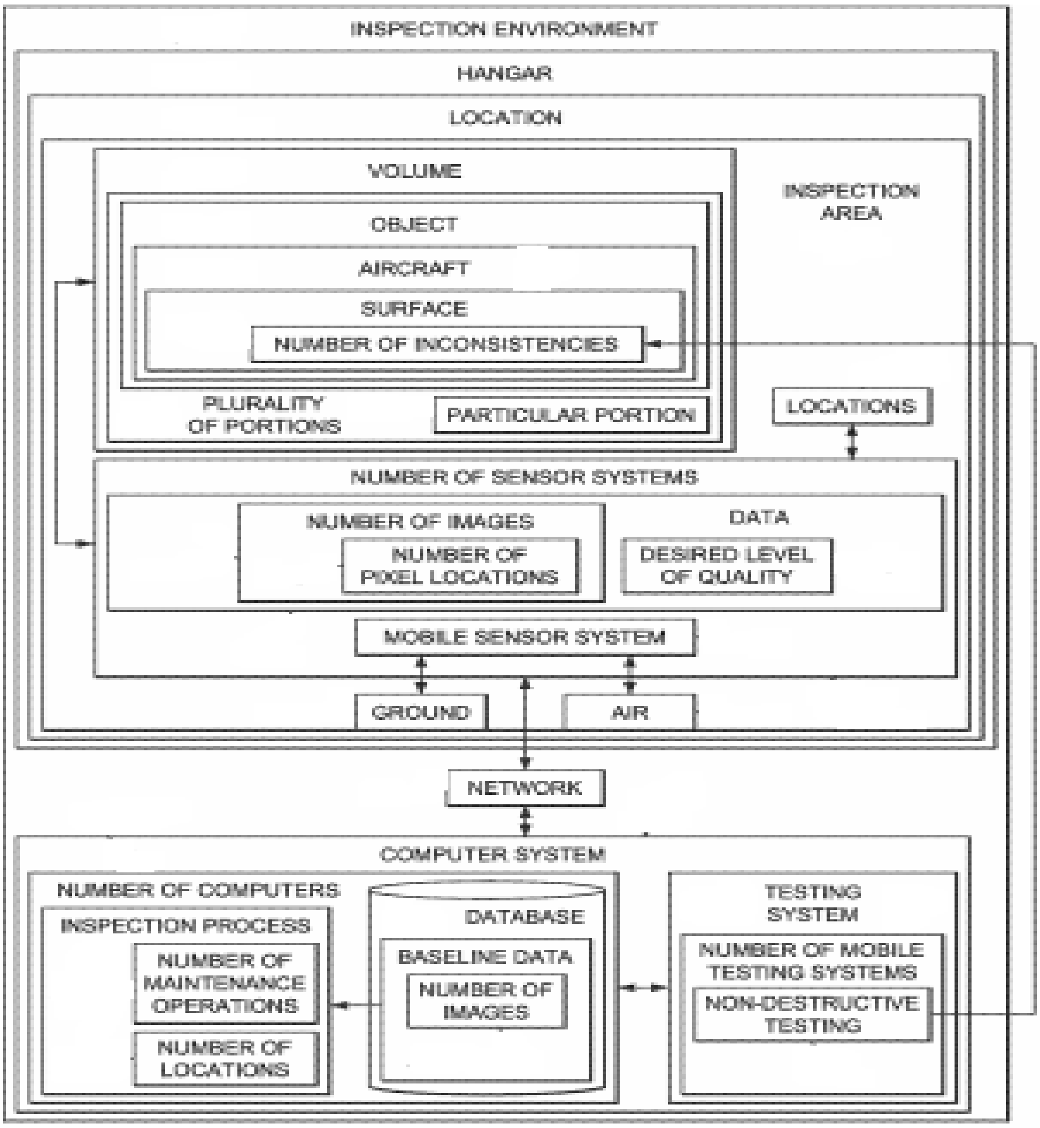


Figure 3.2 – New inspection technology by drone usage

In the illustrated examples, many sensor systems may include a portable (mobile) sensor system. The mobile sensor system is configured for air in the viewing area in the hangar.

The installation should be moved in places in the inspection area in the hangar so that essentially all the required surfaces of the aircraft airframe can be detected by the number of sensor systems installed on the mobile installation. Thus, it is possible to inspect the entire object more carefully compared to currently used methods. This improvement can be especially evident when the object has the shape and size of an aircraft.

The computer system is connected to the sensor system. The network may include wired broadcasting, wireless communication, or a combination thereof.

A computer system contains many computers. Computers from many computers (servers) can be connected to each other via a network or part of another network, depending on the specific implementation [27].

The inspection process is started on the computer of the maintenance operator. In addition, the review process can be implemented in the form of software, hardware or a combination thereof on multiple computers on the network. Sensor systems generate data that is transmitted during the review process.

During the inspection, identifies the area of space upon the presence of the object in the inspection area. This initialization of the review process can be done automatically upon the presence of the object. also, the inspection process may start inspecting the object when the object is in the inspection area, and input data is received to start the inspection process. This input may be user data or some other suitable type of input data.

The area of the space contains the object of review. In other words, the object is located inside the area of space. The review process compares many data from sensor systems with many area segments. Comparison of multiple sensor systems with multiple segments is based on the ability of the sensor system to generate with the required level of quality data on the surface of the object, in particular the segment of the plurality of segments.

The data generated by the sensor systems is represented as a set of images. The plurality of images may include photographs, video images, combinations thereof, or some other suitable image type.

Sensory systems can create many images in visible light, in infrared rays and / or in other suitable types of rays. In addition, multiple images can also be created using a laser beam aimed at the surface of the object, with data forming values of the distance to the surface, to generate images from multiple images. Of course, you can use other types of images.

The review process compares the data with the original data in the database. The source data for the object is obtained before the formation of the survey data. In other words, the source data for the object is obtained by inspecting the object for the presence of many violations.

The original data can be represented as a set of images generated after the manufacture of the object. Also, the plurality of images may be images of the object obtained before the active operation of the object. The data generated by the sensor systems is represented as a set of images. Many images may include photographs, video images, combinations thereof, or some other suitable image type. Sensory systems can create many images in visible light, in infrared rays and / or in other suitable types of rays.

The review process compares the data with the original data in the database. The source data for the object is obtained before the formation of the survey data. This data can be represented as a set of images generated after the manufacture of the object. Also, the plurality of images may be images of the object obtained before the active operation of the object.

For example, the review process may compare the data with the original data to identify multiple pixel positions in the plurality of images, where the data does not match the original data within the selected threshold. Thus, many violations are identified by many positions of the pixels in the images.

Comparison between data and source data can be obtained in different ways: image segmentation, contour selection, image enhancement, comparison of geometric shapes, frequency conversion, photogrammetry method, graph-oriented algorithm and other appropriate methods.

Upon detection of a number of violations on the surface of the object, the inspection process may determine the maintenance work to be performed on the object. These maintenance works may include, but are not limited to, for example, replacement of parts, restoration of parts, additional inspection, and / or other appropriate types of maintenance work.

Thus, an improved compared to current inspection systems is a method and device for identifying violations in objects such as aircraft. In these demos, the time and amount of work for objects such as an airplane can be saved. In particular, the inspection of the object in the form of an aircraft can be performed quickly and with greater accuracy through the use of multiple sensor systems installed on the unmanned aerial vehicle and the inspection process than a human operator.

3.4 Sensor monitoring of stress state and prediction of the fatigue cracks propagation in structural elements made of composite materials

During aircraft operation their units, aggregates and parts are subjected to constant influence of some factors that affect their operational state.

Cracks are the typical damages and malfunctions of airframe structural components. Cracks, deformations and destructions occurred as a result of repeated stress and vibration. As a rule they are fatigue cracks in aircraft skin, ribs, frames, longerones, stress raisers and points of concentrated load (landing gear hinges, wing flaps and so on)

A fatigue crack propagates like a wear in the general case; three zones of crack development can be defined for this process [14].

The first zone is characterized by high initial speed of crack propagation and decrease of this speed in increments (see figure 3.3). The stationary crack development is observed in the second zone. The catastrophic crack development following by destruction of airframe structural components starts in the third zone.

The widespread use of composite materials in aviation is due to high strength and low weight compared to metallic materials. Analysis of the fatigue fracture of structures from composite materials shows that the fracture mainly begins at the junction of the elements (holes, places of application of concentrated loads, etc.).

For aviation constructions, the most important characteristic is fatigue durability. Increasing the efficiency of structures, improving their characteristics, resource extension, is impossible without solving the problems associated with assessing the fatigue durability of structural elements [15].

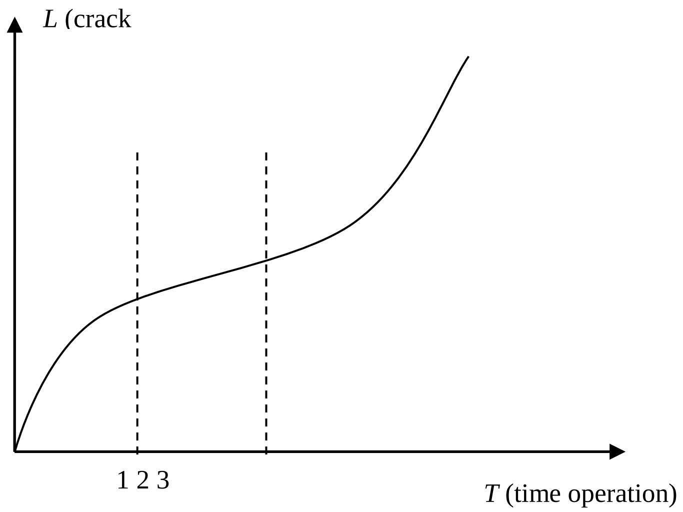


Figure 3.3 – Typical character of fatigue crack propagation in aircraft

For composites, it is also advisable to use the strain gage (tensometric) method of stress state control proposed in the work [15].as an element of the sensor monitoring system.

In accordance with [15] two types of Carbon Fiber Reinforced Polymer (CFRP) plates were used for investigation, while the study of fatigue cracks growth process was carried out. These plates have a hole and two radial cracks. To simulate a bolted / riveted connection of elements, type 2 loading is considered. In the first variant, the cracks spread perpendicularly to the load direction, in the second case – through the hole**.** The cyclic load was uniformly applied to the ends of the plate type 1 (see figure 3.4).

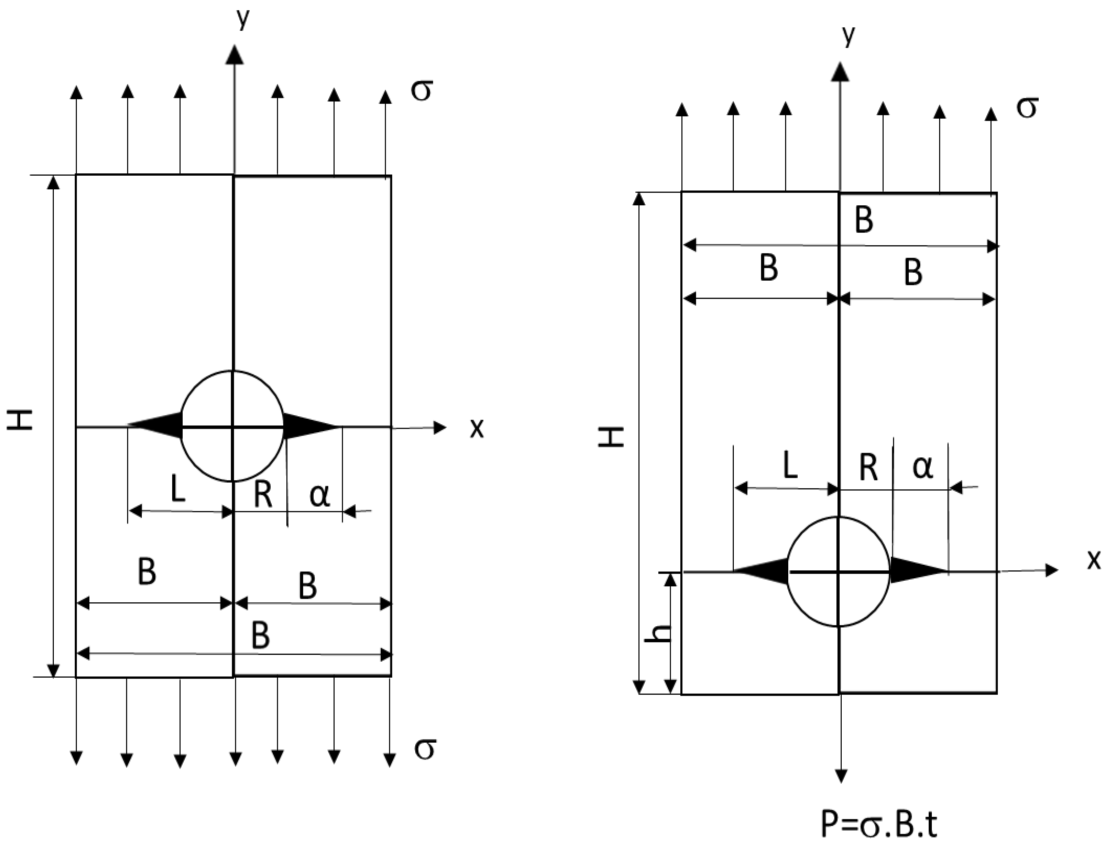


Figure 3.4 – Shape, size and mode of loading of the structural elements with radial cracks

During the structural inspection of airframe components in line with [16] the stress state could be investigated by tensometric method which used glued strain gages (tensoresistors).

For determination of the stress field in the vicinity of the crack tip the mentioned method uses stress intensity factor (SIF) – K which is determined by the formula:

$$K = \alpha\sigma a1/2 \qquad (3.1)$$

The differential equation transformed from the Forman`s formula for crack propagation is used:

$$dN = \frac{dL[(1-R)Kc-\Delta\sigma L^{0.5}\alpha]\ \ )}{C5*\Delta\sigma^{n}*(\sqrt{L})^{n}*\propto^{n}} \qquad (3.2),$$

where: N – the number of stress cycles,

C_5 and n – experimentally determined constants,

$\Delta K = (K_{max} - K_{min})$ – range of stress intensity factor (SIF),

K_c – critical SIF,

L = a + R

$\Delta\sigma^n = (\sigma_{max} - \sigma_{min})$ – range of stress intensity.

The initial conditions in this case have the form:

$N = N_0, L = L_0$

(L_0 – corresponds to the number of cycles). When the critical crack length is reached $L = L_k$, the value of L_k is determined from the condition that K reaches the critical value Kc

Integrating equation (1) with allowance for the initial conditions and replacing the variable λ = L /b, we can determine fatigue durability (the number of cycles up to fracture).

$$N_k - N_0 = \frac{(1-R)*Kc}{C5*\Delta\sigma n*b^{0.5n-1}} * \int_{\lambda 0}^{\lambda k} \frac{d\lambda}{\propto^{n}\lambda^{0.5n}} - \frac{1}{C5*\Delta\sigma n*b^{0.5n-1}} * \int_{\lambda 0}^{\lambda k} \frac{d\lambda}{\propto^{n-1}\lambda^{0.5(n-1)}} \quad (3.3)$$

The integrals entering into formula (3.3) are computed numerically (in the present paper by the Simpson formula). The critical value of the SIF, the correction function α, and the constants C_5 and **n** are determined by the results of the experiment.

Representing the results of the experiment in the form of the function L = f(N), we determine the growth rate of the crack V = dL/dN. Further, using formula (1) and the crack growth rate V, we can determine the constant C_5

$$C_5 = \frac{V[(1-R)Kc - \alpha\Delta\sigma(\lambda b)0.5}{\Delta\sigma^{0.5}\alpha b^{0.5}\lambda^{0.5n}} \quad (3.4)$$

Critical SIF (K_c) is determined by equation 3.5. Where σ_c and K_c the stress and SIF at the moment of the plate fracture with the crack length L..

$$K_c = \alpha*\sigma_c*L^{0.5} \quad (3.5)$$

Thus, if the value of $\boldsymbol{\sigma}_c$ is found for the material, then for any crack length, in obedience to the dependence (3.5), it is possible to obtain the value of the critical CIF.

Experimental research was carried out on samples of carbon fiber with an arrangement of layers ($0^o{}_3/90^o{}_2$) with geometric dimensions H = 210mm, 2b = 105mm, R = 5.2mm, t =2.3mm. The tests were carried out by dynamic loading frequency of 10.9 Hz with a σ_{max} = 68Mpa, σ_{min} = 29Mpa. Therefore, between the theoretical and experimental results a good agreement was found [15].

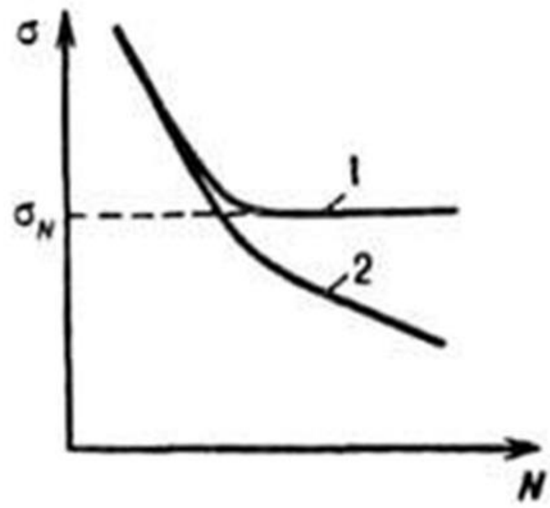
Thus, usage of this tensometric sensor method for the various types of structural elements allows predict a crack propagation until fracture.

3.5 Corrosion fatigue

Corrosion fatigue is the mechanical degradation of a material under the joint action of corrosion and cyclic loading in a corrosive environment. It. Nearly all engineering structures experience some form of alternating stress, and are exposed to harmful environments during their service life. The environment plays a significant role in the fatigue of high-strength structural materials like steel, aluminum alloys and titanium alloys.

Corrosion fatigue, expressed in the simultaneous impact of cyclic (alternating) stresses and aggressive media on the metal; one of the most common types of stress corrosion. This is characterized by a decrease in the ultimate strength of the metal (at maximum stress, when the metal has not yet been destroyed under the influence of variable loads or given cycles of the test base) [17].

The metal fatigue curve in an aggressive environment is shown in the figure. (3.5). As the number of cycles increases, it constantly decreases, unlike the fatigue curve in air, the edge has a cross-section corresponding to the tolerance limit.



S – stress; N – number of loading cycles; σ_N – endurance limit in air

Figure 3.5 – Metal fatigue curves in air (1) and in corrosive environment (2)

Materials with high specific strength are developed in accordance with the requirements of advanced technologies. However, their usefulness largely depends on how resistant they are to corrosion fatigue.

The environment affects corrosion fatigue. For example, the fatigue force of Xi3 type steel in vacuum is significantly higher than in air, in fresh water the fatigue threshold decreases by 1.5-3 times, and during the transition from fresh water to sea-by 2 times.

Heat treatment of alloys changes the threshold of their corrosion fatigue. As a result of solidification with subsequent release, the abrasion strength increases significantly compared to the state after annealing or normalization.The combination of severe corrosion and fatigue damage can have a significant impact on the resistance to damage, reduce residual strength, increase damage in several areas, accelerate the growth rate of cracks, and the design provides for an increase in the initial size of damage. The spread of rust in the fleet under unforeseen circumstances significantly reduces the Safe damage period when fatigue damage is detected. A significant impact on the structural integrity of the aircraft can be provided by reducing the possibility of detecting damage to exceeding the safe permissible limits.

However, the presence of an aggressive environment during fatigue eliminates this stress advantage, since the fatigue limit is not sensitive to the strength level for a particular group of alloys.

This effect is schematically shown for several steels in diagram (3.6), which indicates the effect of an aggressive environment on the performance of high-strength materials under fatigue.

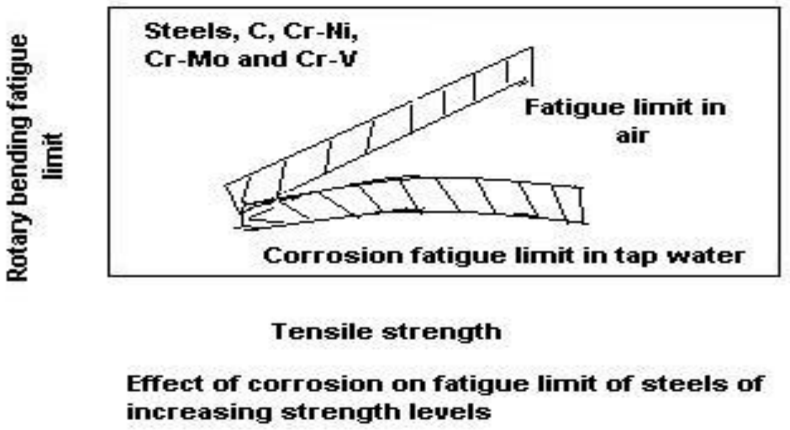


Figure 3.6 – Effect corrosion on fatigue limit of increasing strength

Corrosion fatigue in an aquatic environment is an electrochemical behavior. Fractures start with pinpoint or permanent sliding bands. Corrosion fatigue can be reduced by using alloys, inhibition, and cathodic protection, all of which reduce pitting. Since corrosion-fatigue cracks form on the metal surface, surface treatments such as coating, coating, nitration, and explosion have been found to increase the resistance of materials to this phenomenon.

Conclusions to the Part 3

A sensor system for the inspection of the condition of the airframe skin based on the use of drones is proposed.

In this chapter, sensor method for stress state monitoring and prediction of the crack grows in structural elements made of composite materials have been proposed.

For corrosion crack the S-N diagram has been studied to meet the needs of advancing technology, higher-strength materials are developed through heat treatment or alloying.

PART 4

OCCUPATIONAL SAFETY

4.1 Analysis of harmful and dangerous production factors

Aviation mechanics perform repair and maintenance work wherever the aircraft are located: in the hangar, production building, on the platform, etc. in addition, technical specialists must be able to work in harsh conditions, such as bad weather, thunderstorm failure, or an unequipped workplace. Therefore, it is very important to organize the work area with appropriate conditions that meet the needs of mechanics and contribute to the performance of professional tasks, since they are responsible for the safety and health of both employees and passengers of the aircraft.

4.1.1 Aircraft technician working conditions

Initially, it is obvious that the technician is responsible for compliance with the aircraft's safety standards. Service personnel work in hangars or other enclosed areas where the amount of physical movements and postures associated with these activities is required. They can work outdoors, sometimes in hot or cold weather. There are potential risks associated with working around the aircraft, electricity, compressed air, hydraulic systems, the use of hand and electric tools, solvents, lubricants and other combustible substances (aviation fuel).

Tools such as welding torches, drills, grinders, or rivets are required for manufacturing and repairs. There is a chance of getting an average injury from the equipment, so properly maintain your tools and follow the safety rules. You should wear protective equipment such as glasses and face masks, as well as face and eye protection glasses [18].

4.1.2 Work features of maintenance personnel

During the maintenance, the mechanics:

- work at a steady pace, because rushing increases aircraft turnaround and chance of accidents;
- work in a moderately competitive atmosphere where daily and weekly deadlines must be met;
- often make decisions without consulting someone else first. For complex tasks, they may consult with others;
- avoid a fall, watch for ground lines to the aircraft. Well-lit work areas are safer. Watch sharp leading edges like wing tips and pointy antennas, probes, and "Remove Before Flight" flags that stick out from the aircraft. Colliding with hard, sharp surfaces or protrusions causes bumps, bruises, and cuts;
- may work evenings or nights because shifts are scheduled around the clock, when aircraft are not in use. Also some work in remote locations for long periods, overtime and being on call are common.

4.1.3 Harmful and dangerous production factors for aircraft technician according to the standard ГОСТ 12.0.003-74

Dangerous and harmful production factors are subdivided by the nature of action into the following groups [19]:

1) physical;
2) chemical;
3) biological;
4) psychophysiological.

Let`s determine the characteristics of each group separately:

1) Physical:
   a) moving machines and mechanisms; moving parts of production equipment; moving products;
   b) the increased dustiness and gassiness of air of a working zone;
   c) increased or decreased temperature of surfaces of equipment, materials;
   d) increased or decreased air temperature of the working area;
   e) increased noise in the workplace;

f) increased vibration level;

g) increased voltage in the electrical circuit, the short circuit of which can occur through the human body;

h) increased level of static electricity;

i) lack or absence of natural light;

j) insufficient lighting of the working area;

k) sharp edges, burrs and roughness on the surfaces of workpieces, tools and equipment;

l) location of the workplace at a significant height relative to the ground (floor);

2) Chemical:

- by the nature of the impact on the human body on:

a) toxic;

b) carcinogenic;

c) affecting reproductive function.

- by penetration into the human body through:

  - respiratory organs;
  - skin and mucous membranes.

3) Psychophysiological:

a) physical overload

  - static;
  - dynamic.

b) neuropsychiatric overload

- monotony of work;
- emotional overload.

4.2 Measures to reduce the impact of harmful and dangerous production factors

Within the aviation maintenance industry, there are at least three major categories of workplaces, namely hangars, ramps, and shops. Of these, ramps are the least controllable in terms of workspace and environmental factors such as lighting and noise.

First, you need to evaluate the content and location of the entire workspace, which can be a hangar or ramp. Second, you need to take into account devices, tools, and work platforms that are stored in the shared workspace or are part of it. Third, you need to describe the atmospheric, light, and sound environment (and its controls). Therefore, it is necessary to evaluate individual jobs in the overall workspace. While most aviation maintenance is done at night, people don't tend to work exactly when there's little light. To perform visual inspection tasks that make up a significant part of routine aircraft maintenance, it is very important that workers have sufficient levels of the correct type of lighting.

The ability of workers to perform various types of maintenance and inspection largely depends on the appropriate lighting in their work areas.

In the field of aviation maintenance, proper lighting of the object is important. Most scheduled repairs are carried out at night in the hangar.

Light intensity is measured in lux, which is the metric equivalent of a foot lamp (ft-c). Each foot lamp is approximately 10 lux. The light level that will be" sufficient " will depend on the type of task being performed. To give an idea of the" sufficient " lighting range, consider:

a) OSHA requires that EXIT signs be illuminated with no less than 5 ft-c (about 50 lux).
b) Difficult inspection tasks or fine bench work can require illumination of up to 500 ft-c (5000 lux).

In figure 4.1 are shown some recommendations related to lighting.

Lighting Levels

Lowest recommended level:	15-20 ft-c (150-200 lux)	Should be used only for infrequently used areas
Normal recommended level:	75-100 ft-c (750-1000 lux)	Adequate for many normal maintenance tasks

Figure 4.1 – Light level recommendations on workplace

Even for general lighting of an object, there is no minimum lighting that can be called acceptable. Some experts recommend lighting rare rooms, such as storage rooms, that are only 15-20 feet (150-200 Lux) sufficiently lit. However, if we believe that there is no need to provide additional lighting for each task performed in the hangar, the overall light level should be maintained in the range of 75 to 100 feet (750-1000 Lux).

It is important to maintain a uniform light level in all work areas. The most common recommendation is to maintain the ratio of maximum and minimum illumination in and around the work area at a level of 3 to 1 or less.48 in general, we want to provide uniform, diffused, shadow-free, dim lighting in all areas of the object used by people. The best way to diffuse light and reduce shadows is to use many small light sources, rather than several large lamps. However, placing bulbs does not remove shadows or bright spots. Regardless of the location of the lamps, the floor under the wing of a large transport aircraft can be completely protected from direct light.

Calculation of artificial light needed for comfortable work using the ramp in required space of hangar.

It should also be noticed that the duration of the visual inspection is more than half of the working day. And depending on the software used can be dealt with, both directly and with reverse contrast and contrast the nature of the object and the nature of the background can be anything: light, medium, dark.

To calculate the required number of illuminators that shall be symmetrically distributed in working space the following details must be given:

1. The required medium illuminance depending on the visual task;
2. Colour of the ceiling and walls;
3. Surface of the definite place of hangar (dimensions);
4. Suspension height of the illuminators;
5. Measuring plane (height of ramp);
6. Cleaning cycle, degree of getting dusty;
7. Type of illumination;
8. Type of light source.

The calculation of an interior space illumination shall be demonstrated by an example of the luminous flux method. The result is of sufficient accuracy. A hangar shall be illuminated by LED lamps. The LED illuminators are distributed in the working area.

<u>Parameters</u>

Ceiling reflection – 80%

Wall reflection – 60%

Required illuminance – 800 lx

Type of illumination - direct

Depreciation factor (V) – 0.8

Length of workplace (L) – 5 m

Width of the workplace (B) – 2 m

Measuring plane (ME) – 1.6 m

Suspension height (hA) – 4 m

<u>Solution: Calculating steps</u>

1. Surface of the room

A = L x B = 44m x 36m =10 square metres (4.1)

2. Useful height

hN = hA - ME = 4 m – 1.6 m = 2.4 m (4.2)

3. Workplace factor

$$K = \frac{width(x)\times 0.8 + length(x)\times 0.2}{useful\ height} = 2\times 0.8 + 5\times \frac{0.2}{2.4} = 3.84 \quad (4.3)$$

K = 3.84

4. Determination of lighting efficiency. The ceiling display period selects a column that is located about 70% (about 80%) of the wall display, i.e. 60%. This column goes down until it reaches the value K = 4.

Here you will find a value of 0.45 (45%). This is the degree of efficiency of the room. Since the degree of efficiency of the irradiator should be equal to 1, the lighting efficiency will be equal to (0.45) the level of efficiency of the workplace.

5. Determination of the total luminous flux

$$PHlges = \frac{Em\times A}{etaB\times V} = \frac{800\times 10 sq.m}{0.45\times 0.8} = 22\ 223 \quad (4.4)$$

PHIges approximately 22 223 lm

6. Calculation of the number of lamps

$$n = \frac{totallum.flux}{lamp.luminous\ flux} = \frac{22\ 223}{2700} = approx. 9 \quad (4.5)$$

The result is that double-lamp illuminators have to be evenly distributed in the ramp workplace area [20].

4.3 Occupational Safety Instruction

4.3.1 General safety requirements

1) persons who have reached the age of 18, who have passed a mandatory medical examination, introductory instruction, primary instruction at the workplace, are trained in safe working methods and have an electrical safety group of at least II are allowed to work independently on drilling machines;

2) perform only the work specified in the job description,

provided that it is approved by the company's administration and the employee is well aware of safe ways to implement it;

3) comply with labor protection requirements. Proper use of personal and collective protective equipment;

4) immediately inform your direct or senior supervisor about any situation that poses a threat to people's lives and Health, about every accident at work or about the deterioration of your health, including the appearance of signs of acute occupational disease (poisoning));

5) complete training in safe methods and techniques of performing work and providing first aid to victims at work, instruction on labor protection, testing of knowledge of labor protection requirements;

6) the employee must be able to provide first aid to victims of electric shock and other accidents. Ability to use primary fire extinguishing equipment;

7) when performing maintenance, workers must be provided with special clothing, special footwear and other personal protective equipment and a collective agreement for the free issuance of special clothing, special footwear and other personal protective equipment in accordance with standard industry standards;

8) Employees who perform work at height are obliged to:

- know and comply with the requirements of the Rules of labor protection when performing work at height, other regulations and this instruction on labor protection when performing work at height;
- take care of personal safety, as well as the safety of others while performing any work;
- perform work with the use of helmets, seat belts, other means of individual and collective protection;
- undergo a medical examination in the prescribed manner.

9) The main danger when performing work at height is the location of the workplace at a significant height relative to the ground (floor). In this regard, there is a high risk of the worker falling from a height or falling objects on workers who are at the bottom in the immediate vicinity;

10) In cases of injury or discomfort, it is necessary to stop work, notify the supervisor of the work and contact a medical institution.

4.3.2 Safety requirements before starting work

1) Check and verify that the stationary equipment, tools, devices and protective equipment are working well. Position the tool as comfortably as possible to avoid unnecessary items in the work area;

2) control over the condition of stairs in an educational institution is carried out by the head of the farm, responsible for the safe performance of work related to lifting and height;

3) adjust the local lighting so that the work area is sufficiently illuminated, but the light does not blind the eyes;

4) before starting work, make sure that the lifting device is stable, make sure that the ladder or ladder does not slip or move accidentally by checking and testing;

5) in case of detection of defects in equipment and means of collective protection, notify the person responsible for carrying out this work, and do not start work until the identified defects are eliminated. ;

6) The employee is prohibited from:

- use improper and incorrectly sharpened tools and devices;
- touch to live parts of electrical equipment, open doors of electrical cabinets. If necessary, contact the operational maintenance personnel;

7) All shortcomings and malfunctions of the tool, devices and protective equipment found during the inspection should be reported to the work supervisor for taking measures to eliminate them [21].

4.3.3 Safety requirements during airframe maintenance

1) The equipment must meet the requirements of the rules for the use of personal protective equipment and the means and means used, depending on the type of work performed;

2) follow the maintenance instructions with details on how to " complete each task and any specific tools";

3) installation and disassembly of heavy parts and devices should only be carried out using lifting equipment;

4) Use a safety protocol, such as wearing seat belts, safety flags, and other warning signs when working on the wings and fuselage;

5) the entrance to the scaffolding and decking should be better from the inside, and the entrance to each landing should be equipped with a hatch;

6) scaffolding and other access equipment must be permanent;

7) when performing maintenance work on aircraft:

- engage in extraneous matters that are not related to the assigned work;
- admission of unauthorized persons to the place of work;
- Do not clean accidentally spilled fuel, oil, working fluids, etc. ;
- dispose of used oils on the floor (on the ground, artificial turf);
- cluttering of workplaces and driveways with equipment, spare parts, and waste;
- use used napkins, rags, etc. write down the workplace (plot, parking lot).;
- selection, disassembly, hitting, throwing of unknown units, mechanisms and components, as well as ignition, testing and sniffing of unknown objects.

8) When performing work on high-lying objects, it is prohibited:

- work without safety devices; use non-standard ladders (ladders);
- use dirty, oily or ice-covered equipment (ladders, ladders, safety devices);
- use stepladders or ladders installed unstably or at an angle to the horizon of more than 60 °, or on an inclined plane, or on intermediate additional structures;
- overload the working platform of the ladder (stepladder) with a load above the norm, the value of which must be indicated on the surface of the platform.

9) Works on cleaning of windows, lamps, light lanterns, etc., performed at height, are works with increased danger and must be provided:

- the choice of detergent;
- method of cleaning (dry, semi-dry, wet);
- the choice of methods of protection of glasses from aggressive pollution;
- choice of cleaning method (manual, mechanized);
- workplace organization;
- choice of overalls, footwear and other personal protective equipment.

10) When performing other work at height, the same safety requirements should be observed when organizing and performing work as for work when wiping glass;

11) If malfunctions are detected during work at the workplace, in equipment and means of collective protection, stop work, switch off equipment and devices. Notify the supervisor and do not resume work without instructions.

4.3.4 Safety requirements after work

1) Remove the means of performing work, fences and lifting equipment to the places provided for their storage;

2) Place devices and tools in the designated places

3) for the purchase of personal protective equipment and auxiliary equipment;

4) if deficiencies in the operation of equipment and means of collective protection are identified, inform the direct supervisor or other official about this;

5) inform the work manager about all malfunctions detected in the operation of the equipment during the performance of work. Describe the actions taken to solve the problems that arise [22].

4.3.5 emergency safety requirements

1) if malfunctions of the tools and equipment used are detected or an emergency situation occurs, then:

- Immediately stop the maintenance process and inform the work manager about it;

- Take measures to prevent the development of an emergency situation and the impact of dangerous factors on other employees ; ;;
- Performing procedures for notifying emergency services as soon as possible and starting evacuation;
- Providing procedures for providing assistance to victims and providing first aid;
- Make sure that there is an effective connection between the manager and all people in the workplace to coordinate emergencies.

2) Thus, to prevent possible emergencies in the future:

- Development of test plans for emergency procedures, including the frequency of testing;;
- Providing information, training and instruction to the relevant service personnel to carry out emergency procedures.

Conclusions to the Part 4

One of the major issue during preparation of the diplo work deals with labor precautions safety in workplaces. Every aviation enterprise should pay attention to harmful and dangerous production factors and take measures to reduce their impact. Supervisors must provide acceptable working conditions to minimize dangerous situations to occur. Every worker must observe the safety rules and recommendations. Also workers and their supervisors must follow the requirements of Occupational Safety Instruction to prevent emergency situations and personnel injurie.

PART 5

ENVIRONMENT PROTECTION

5.1 Environmental Protection Overview. Modern Practices

Aviation must be environmentally sustainable, operating harmoniously within the constraints imposed by the need for clean air and water, livable climate and, a limited noise impacts. Aviation sphere affects the environment in following ways: people are exposed to noise from aircraft; streams, rivers, and wetlands may be exposed to pollutants discharged in storm water runoff from airports; and aircraft engines emit pollutants to the atmosphere. Also the aircraft manufacture processes are not eco-friendly, as much it is needed, for example dangerous materials can be used for aircraft structures. That`s why, the main task of modern aviation community is to minimize all the dangerous and harmful factors, which can worsen the environment situation in the whole world.

Efficient processes plus a shared commitment to responsible business practices and to environmental performance are a must. Suppliers and industrial pratners are also assessed on the basis of environment criteria, which are part of contractual agreements. They are expected to comply with environmental policy, provide reliable environmental data on the products delivered and, wherever possible, deploy an Environmental Management System. Tracking and managing hazardous materials is also crucial and manufacturersare working towards a systematic inventory of such materials. The company will uphold these standards and will continue to evaluate its suppliers accordingly. There are some 4,000 aircraft due to reach end-of-life by 2023; hence the need for decommissioning, dismantling and recycling aircraft in an environmentally-responsible manner.

The Boeing pioneered the creation of the International Aviation Environment Group in 2011. The group's mission is to help the industry develop common standards for chemicals management and other environmental issues to work with the global supply chain. For example, aerospace companies are required to identify and report the chemicals and other substances that are used in the manufacture of their products. The group has developed a standardized approach that companies can use to collect information from suppliers on a voluntary basis. A common approach improves efficiency, reduces costs by eliminating the need for each company to develop its own system, and encourages more sustainable alternatives for these chemicals. Boeing is also an industry leader in initiatives aimed at finding replacements for hazardous materials used in the manufacture and operation of aircraft.

Airbus has committed to continuously work on limiting the environmental impact of the production processes specific to the aeronautical industry, on all sites. Considerable efforts are made to contain, reduce and, if possible, eradicate the local industrial effects of working metals and composites, polishing and treating surfaces, assembling components and parts, and then assembling the entire aircraft. Cleaner technologies are being continuously introduced. Manufacturing inputs and outputs are reduced to the greatest extent. Regular inspections are run. Material quantities, toxicity and usage are evaluated and related to how waste, water discharge [23].

5.2 Aircraft Manufacture Processes

A lot of high-skilled aviation engineers aimed to develop and improve structural phenomena of the aircraft. Some workers determine and analyze the importance of some characteristics such as durability and strength of aircraft structural components. The manufacturing process is developing from year to year.

Manufacturing is a very important process and contains a large amount of interconnected processes. The first manufacturing step is fabrication, it inlolve making some parts using raw materials. Tools and fixture making, different types of processing are included as the main fabrication features. Plastic and composite working has significant influence of structure manufacturing.

Special tools are applied as specimens and other surfaces. Using these templates the metal or composite parts may be constructed.

Such main aircraft parts like fuselage, wings, panels and skins of tail unit are created from shaped aluminium sheets, which are previously cut and treated using some chemicals. A single sheets made of aluminium are used in forging process, that the wing spars are made. Other parts, which have small size are cut and the shape is forming due to milling, turning and grinding machines.

Composite materials and metal sheet are used in ducting production. They are put (into shaped layers, maintaining carefull arrangement) using machine and then cured in autoclave. The next step is detail assembling. This process begins with the component parts assembling into sub-assemblies comprising such structures: wings, fuselage sections, landing gear, stabilizers, etc. Special intensivity are noticed during wing assembly. Cleaning and sealing are important procedures to provide the safety level of fuel compartment, when the wing is assembling.

As usual, final assembly may be performed using large halls or assembly places, some locations that are among the world`s biggest buildings for manufacturing. Numerous assembly operations take place simultaneously at each position, creating the potential for cross exposures to chemicals.

The final step of assembling includes riveting of fuselage sections together. The adoptable structure serves like a support. Structural stringers and beams comprise anti-corrosive elements. Nose and aft sections of fuselage are connected to the wings. Also a wing stub is used like a general fuel tank. It serves, for instance, as the structural center of aircraft. Manual assembly is an expensive method that is well suited for the production of individual parts or very small batches. As the number of identical parts to be manufactured increases, fiber winding, resin transfer casting, and weaving become cost-effective alternatives. The winding of the thread consists of winding tapes of continuous fiber or braids or rovings on the mandrel in one operation controlled by the machine. Several layers of the same or different patterns are placed on the mandrel.

Fibreglass insulations are used as the main material for interior fuselage blankets. The inner part of the fuselage surface is covered with decorative skin.

Powerplants and landing and nose gear are mounted, and avionic components are installed. The functioning of all components is thoroughly tested prior to towing the completed aircraft to a separate, well-ventilated paint hanger, where a protective primer coat (normally zinc-chromate based) is applied, followed by a decorative top-coat of urethane or epoxy paint [24].

Restoration work should reduce the risk of failure to a level that ensures safe operation of the product. The organization and execution of works must be such as to achieve the highest level of reliability and safety that can be expected from aircraft and which is embedded in its design. To this end, appropriate recovery processes are identified, developed and implemented. Technological processes of manufacturing and restoration of aircraft should ensure the stability of obtaining the necessary quality characteristics of components and products of aircraft in general in accordance with requirements of technical documentation on a typical design of aircraft.

5.3 Environmental hazards during aircraft manufacture

Aircraft manufacturing produces many health and environmental hazards, High influence has engine manufacture, because materials used in the process conduct harm and dangerous due to toxicity and exposure potential for lives.

The most toxic products are exhausted from nickel, chromium and cobalt. The aluminium and iron are less dangerous and complicated.

In traditional methods of machining, it is important to minimize vapour of fumes and dust. These substances are reduced by coolants or other appropriate fluids. In general, the metals are not serious hazard, except of dry sanding, but the mists of the coolant create danger during inhalation. It is needed to provide the additional ventilation, when the process of grinding is preformed using potentially hazardous alloys, such as nickel-, chromium, cobalt-based, etc.

Composite plastic parts fabrication contains chemical exposure to unreacted resin components and solvents those are major hazards related to the fabrication during wet lay-up operations. Aromatic amines are concerned and used as reactants in polyimide resins. Besides, hardeners also influence in epoxy resin gathering. Such compounds are detected and confirmed to those harmful for human substances.. They also promote other toxic effects with bad consequences. Such resin materials has very reactive nature, especially epoxies. They influence on the skin and respiratory path.

Most of machining processes promote high noise level due to vibration and tool chatter. This can be controlled to an extent through more rigid tooling, dampening materials, modifying machining parameters and maintaining sharp tools. It is important to determine if the hazardous material / substance may be replaced with eco-friendly one. In some cases it is hard to find another material to replace the existing one. In such situations, the solution is to consider the variant of using a new technological process – alternative with less content of hazardous substances.

Currently, it increasingly provides specifications for the production of products such as paints and varnishes, for the use of water-based instead of solvent. Instead of using powdered materials that form hazardous dust, the same materials can be produced in the form of granules. Stopping the whole process seems to be the most effective way to reduce the risks of air pollution. If this is not possible, polluted air should be removed. Hood and sealing must be supplemented by intensive aeration.

In the aerospace industry there are more than 5,000 chemicals and compounds that comprise a combination of several ingredients, most of them – with multiple suppliers. The chemical types, which are spreadly promoted in manufacturing listed in Table 5.1.

Table 5.1 – Typical chemical hazards of manufacturing processes for environment

Common processes	Type of emission	Chemicals or hazards
Coatings, including temporary protective coatings, mask and paints	Overspray of solids and evaporation of solvents	Volatile organic compounds (VOCs) including methyl ethyl ketone, toluene, xylenes Ozone-depleting compounds (ODCs) (chlorofluorocarbons, trichloroethane and others) Organic toxins including tricholorethane, xylene, toluene Inorganic toxins including cadmium, chromates, lead
	Solid waste, (e.g., wipers)	VOCs or toxins as above
Solvent cleaning	Evaporation of solvents	VOCs, ozone depletersor toxins
	Solid waste (wipers)	VOCs or toxins
	Liquid waste	Waste solvent (VOCs) and/or contaminated water
Paint removal	Evaporation or entrainment of solvents	VOCs such as xylene, toluene, methyl ethyl ketone Organic toxins (methylene chloride, phenolics) Heavy metals (chromates)
	Corrosive liquid waste	Caustics and acids including formic acid
	Dust, heat, light	Toxic dust (blasting), heat (thermal stripping) and light
Anodizing aluminium	Ventilation exhaust	Acid mist
	Liquid waste	Concentrated acid usually chromic, nitric and hydrofluoric
Chemical milling	Liquid waste	Caustics and heavy metals, other metals
Sealing	Evaporated solvent	VOCs
	Solid waste	Heavy metals, trace amounts of toxic organics
Alodining (conversion coating)	Liquid waste	Chromates, possibly complexed cyanide
	Solid waste	Chromates, oxidizers
Corrosion-inhibiting ompounds	Particulates, solid waste	Waxes, heavy metals and toxic organics
Composite fabrication	Solid waste	Uncured volatiles
Vapour degreasing	Escaped vapour	Tricholorethane, trichoroethylene, perchloroethylene
Aqueous degreasing	Liquid waste	VOCs, silicates, trace metals

VOCs – volatile organic compounds, ODCs – ozone-delpeting compounds

5.4 Usage of Composite Materials in Airframe Manufacture

Many materials used in manufacturing processes do not become part of the final airframe. Manufacturers may have tens of thousands of individual products approved for use, although far fewer are used at any time. A large number and variety of solvents are used, with environmentally harmful options such as methyl methyl ketone and freon being replaced with more environmentally friendly solvents. Chromium and nickel-containing steel alloys are used in equipment, and hard metal bits containing cobalt and tungsten carbide are used in cutting tools. Lead, which was previously used in metalworking processes, is rarely used today, replacing it with kirxite.

Airframe production is usually carried out in large integrated factories. New plants often have large volume exhaust ventilation systems with controlled supply air. Local exhaust systems can be added for specific functions. Chemical milling and painting of large components is now routinely performed in closed automated rows or booths containing escaping steam or fog. Older manufacturing facilities can provide much poorer control of environmental hazards.

In aerospace manufacturing areas, workers, materials and work processes change frequently. Therefore, hazard reporting should be an ongoing process. The most difficult chemical environments are typical for airframe production facilities, especially prefabricated areas. An intense, responsive and well-planned industrial hygiene effort is required to recognize and characterize the hazards associated with the simultaneous or sequential presence of large amounts of chemicals, many of which may not have been adequately tested for health effects. The hygienist must be wary of contaminants that are released in physical form, are not anticipated by suppliers, and therefore are not listed on the safety data sheet. For example, repeated application and removal of strips of partially cured composites can release solvent-resin mixtures as aerosols that will not be effectively measured by vapor control methods.

The concentration and combinations of chemicals can also be complex and highly variable. Delaying work in a non-standard sequence may result in hazardous materials being used without proper engineering controls or proper environmental protection.

The aviation industry is designed with carbon fiber reinforced polymer (CFRP) to reduce greenhouse gas emissions and fuel combustion in aircraft. The Boeing 787 Dreamliner is a fully composite aircraft with a modern life cycle assessment (LCA). It is estimated that an architecture using the global transition of such composites contributes 20-25% of industrial CO2 reduction targets. The secondary analysis phase from cradle to grave extends research from private jet to the world fleet. [25]

The new era of composite architecture aircraft has significant environmental and life-long health benefits over conventional aluminum composites, especially in terms of CO2 and NOx as a result of reduced fuel burnup. In this case, there is a broad reduction in CO2 emissions of 14-28 15% compared to an individual aircraft by 20%.

5.5 General Recommendations. Reduction Measures of Aircraft Manufacture Impacts on Environment

And the market has grown for the aerospace industry to change the product development hour, immediately vicious materials and various deadly, and the clock is ultra-precise performance criteria. Accelerating the development of products and production can lead to the development of materials and processes in the form of parallel development of environmental and medical technologies. The result can be a bulletproof, inverted, and hardened product, although there is no reward from the health and Nutrition Center. Regulations such as the Toxic Substances Control Act (TSCA) in the United States require:

- Testing of new environmentally friendly production materials;
- Development of rational laboratory experience for research and development;
- Restrictions on the import and export of certain chemicals;
- Monitoring research in the field of occupational health, safety and environmental protection, as well as taking into account the significant effects of chemical exposure on human health in the company's workplace.

The widespread use of material safety data sheets (MSDSs) has helped provide healthcare professionals with the information they need to control chemical exposure (see table.5.2). However, only a few hundred of the thousands of materials used have complete toxicological data, which is a problem for industrial hygienists and toxicologists.

Emissions and wastewater from maintenance facilities shall be treated to a level that meets the requirements of the local sewer network or, if discharged into surface water, comply with the guiding values in the guidelines of an environmentally sound standard for metal, plastic and rubber products providing guidance values for treated wastewater used for machining, purification, packaging and processing, including metal painting. Discharge levels for a given site may be determined on the basis of state requirements for the collection and treatment of wastewater or on the basis of the use of receiving water, as described in the general environmental guidelines, if they are discharged directly into surface water.

Potential hazards should be identified and described, and necessary controls should be implemented before materials or processes arrive at the workplace. It is also necessary to develop, establish and document safety rules that must be followed before starting work. In case of incomplete information, it is advisable to take a high predicted risk and take appropriate measures to protect the environment. To ensure proper control and reliable operation, it is necessary to check industrial hygiene regularly and frequently. Precise production of aerospace products requires a clear, organized and well-controlled working environment. Containers, barrels and tanks with chemicals should be marked about the potential danger of materials [26].

Table 5.2 – Typical emission-control practices

Processes	Air emissions	Water emissions	Land emissions
Coating: overspray	Emission control equipment for overspray (VOCs and solid particulate)	Onsite pretreatment and monitoring	Treat and landfill paint-booth waste. Incinerate flammables and landfill ash. Recycle solvents where possible.
Solvent cleaning with VOCs	Emission controls and/or material substitution	Onsite pretreatment and monitoring	Incinerate and landfill used wipers
Solvent cleaning with ODCs	Substitution due to ban on ODCs production	None	None
Solvent cleaning with toxins	Substitution	Onsite pretreatment and monitoring	Treat to reduce toxicity and landfill
Paint removal	Emission controls or substitution with non-HAP or mechanical methods	Onsite pretreatment and monitoring	Treatment sludge stabilized and landfilled
Anodizing aluminium, plating hard metals, chemical milling and immersion conversion coating (Alodine)	Emission control (scrubbers) and/or substitution in some cases	Onsite pretreatment of rinsewaters. Acid and caustic concentrates treated on or off site	Treatment sludge stabilized and landfilled. Other solid waste treated and landfilled
Sealing	Usually none required	Usually none required	Incinerate and landfill used wipers
Corrosion-inhibiting compounds	Ventilation filtered	Usually none required	Wipers, residual compound and paint-booth filters treated and landfilled
Vapour degreasing	Chillers to recondense vapours Enclosed systems, or Activated carbon collection	Degreasing solvent separation from wastewater	Toxic degreasing solvent recycled, residual treated and landfilled
Aqueous degreasing	Usually none required	Onsite pretreatment and monitoring	Pretreatment sludge managed as hazardous waste

VOCs – volatile organic compounds, ODCs – ozone-delpeting compounds,

HAP – Hydroxyapatite Coating

Nowadays, aerospace industries have been perfectly influenced by the rapid growth in environmental and noise regulations passed primarily in the United States and Europe Legislation such as the Clean Water Act, the Clean Air Act and the Resource Conservation and Recovery Act in the United States and companion Additionally, universal issues such as ozone depletion and global warming are forcing changes to traditional operations by banning chemicals such as chlorofluorocarbons entirely unless exceptional conditions exist. Directives in the European Union have resulted in voluminous local regulations to meet environmental quality objectives. These regulations typically promote the use of modernized current technology, whether new materials or processes or end of stack control equipment.

The increasing developmentof the industry and the concentration of working possibilities around airports and industrialized locations made new regulation attractive. The industry underwent a revolution in terms of programmes required to track and manage toxic emissions to the environment with the intent to ensure safety. Wastewater treatment from metal finishing and aircraft maintenance became standard at all large facilities existing.

Conclusions to the Part 5

According to my diploma project task as an aircraft designer to make it environmentally friendly during manufacture processes.

Main our task is mitigation of global environmental problems. For this we have to do the following issues:

1) use fuel efficiency measures reduces the impact of aviation on greenhouse gas emissions;

2) improve aircraft design and manufacture process

3) develop eco-friendly composite materials

4) implement aviation noise legislative controls;

5) make taxes for noise and emission violations.

6) improve existing and develop new manufacture processes to reduce environmental emissions.

GENERAL CONCLUSIONS

Due to rapid development of aviation industry it is important to increase the efficiency of aircraft maintenance. The risks connected with the human factor influence and inappropriate airframe maintenance may lead to serious consequences. However, the modern level of safety is much greater than in previous years, but some solutions and improvements need to be investigated.

In this project thesis, there is a careful review of aircraft structure components, which caused various accidents. Thus leading to the development and modification of the maintenance system as well as a modification in the material use in manufacturing and construction of the airframe.

A sensor monitoring methods of visual inspection improvement and the reliability of these modifications are shown in the Part 3 of this thesis. A change in the material used in construction of some parts of the airframe will increase the efficiency and durability making it more reliable.

Here is a brief review of the overall thesis:

1) Aircraft maintenance is a highly dynamic and regulated industry characterised, for example, by complex and mutually dependent systems and technologies, detailed and legally binding task procedures and documentation, highly publicised accident rates and highly regulated management systems to ensure reliability, efficiency and safety at all. MSG-3 is intended to facilitate the development of initial scheduled maintenance.

2) The structure of the airplane is designed to provide maximum strength with minimum weight. As more and more composites are used, the costs, design, inspection ease, and information about strength-to-weight advantages help composites become the material of choice for aircraft construction. Changes in the materials used in parts can also improve fatigue life. Much has been done to improve the corrosion resistance of aircraft, such as improvements in materials, surface treatments, insulation, and modern protective finishes. All of these have

been aimed at reducing the overall maintenance effort, as well as improving reliability.

After careful analysis of the various airframe structure and typical damages like (corrosion and fatigue fracture,), it was offered to improve a system of maintenance by material selection, early inspection, corrosion prevention, new technology of inspection.

3) The use of unmanned sensor systems for visual inspection of the aircraft airframe during all types of maintenance can potentially increase the efficiency of the aircraft maintenance, as well as facilitate the work of the operator and maintenance. The algorithm of the airframe inspection process was suggested by using unmanned sensor system (drone usage).

In spite of these improvements, corrosion and its control is a very real problem that requires continuous preventive maintenance. The sensor methods for stress state monitoring and prediction of the crack grows in structural elements made of composite materials have been proposed. Furhermore, for corrosion crack the S-N diagram has been studied to meet the needs of advancing technology, higher-strength materials are developed through heat treatment or alloying.

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