PREDICTIVE ASSESSMENT OF AN AIRCRAFT STRUCTURE BEHAVIOUR FOR PASSENGER AND CREW SECURITY

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Abstract

In the aerospace industry one of the most important requirements in the aircraft design and operation is the high level of fiability under various atmosphere and environmental conditions. The design and validation of such a system is a great challenge. It must meet several requirements such as: high resistence, low weight and a small occupied volume. The stresses that occur during the aircraft operation are extremely complex, being the result of the interaction of different systems.Consequently, in order to obtain an optimal design of the whole system, the design, testing and operating processes require a combination of laborious analysis and experimental data. As up to 90% of the structure failures are du to the fatigue, high performance methods of fatigue analysis are needed to estimate the aircraft ressources. These methods must enable a precise determination of the static and dynamic strains inder to correctly estimate the aircraft ressource. The project proposes an approach of some aspects of the aircraft/ aircraft subassemblies simulation and testing and develop o calculation methodology of experimental data and high performance numeric methods integration in order to establish the ressource.

Introduction

Generally, the fatigue analysis comprises one of the following methodologies: The method stress-life or N-S known as life duration as it doesn't make a difference between the initialistion and the propagation of a crack and the method of local specific deformations or life specific deformation, known as the method of the crack initialisation beacause it reffers to the crack initialisation and propagation.

The adequate determination of the strains variation is very important to obtain an estimation as accurate as possible.

The strains can be defined by time variation or spectrum depending on the type of the empoyed fatigue analysis.

Reliability and safety assessment of structures is nowadays very much based on global approach, either deterministic or probabilistic.

Statistical analysis (per component or per system) of failures caises is insufficient to provide in advance responses to the questions like „what is the safety level of a given component /product".

The project aims to develop a methodology to establish the fatigue endurance limit and reliability criteria for airframes and main systems of a certain type of operational aircraft, methodology which can be afterwards extended to all types of operational aircraft. The models used to calculate general aspects of fatigue strain are analytical

models, numerical models, finite-element models or similar in functionality, meant to solve the partial derivative equations used in integrated design.

The results obtained through calculations associated with the data obtained from an operational aircraft in service for at least 15-20 years will lead to the development of a methodology for the flight safety assessment.

The experimental data analysis is carried out using specific probability calculation techniques defining objective functions and risk weight. These will be specific to each subassembly and failure type and they are defined taking into account cascading failure propagation.

Aeronautics plays an important part within the European strategy for the increase of the economic and scientific competitiveness. Several aviatic catastrophes occured lately in the civil aviation worldwide.

Reliability and safety assessment of structures is nowadays very much based on global approach, either deterministic or probabilistic.

Statistical analysis (per component or per system) of failures cases is insufficient to provide in advance responses to the questions like „what is the safety level of a given component /product". Moreover, the current solutions based on detailed structural analysis usually cover the general stress state and globally assume the failure scenario.

The real failure is, on the other hand, generally linked to manufacturing technologies and to local conditions and environment, for which the modelling is still virtually inexistent.

This is particulary true for the metallic structures exposed to complex loads leading to fatigue damage, which appear to be the most important cause of failures in industry in terms of associated risks (probability of combined failures multiplied by environmental, safety and economic consequences), in particular in the aerospace industry where significant exemples can be found.

Main Activities of the Project

The methodology and techniques utilized are based on the drawing up of fatigue resistance calculus, using models developed within resistance analysis programs and informational processed data collected form flight testing and aircraft operation.

Main directions to be developped are:

- To establish a new methodology to analyse the structures locally supporting random complex loadings which could generate catastrophes.
- To establish and to promote an equivalence rule, related to fatigue failure, between two complex loads. This rule will provide a simple equivalent load which will be illustrative for any complex load, including the multiaxial loads with „ random amplitude".

The main advantage of this rule is that it has a real physical significance unlike the majority of the present techniques utilized in standards and codes.

- To establish some new determinative design rules for structures under fatigue loads that are cvasi-independent of the structure net and easily applicable.

The survey of the structural fiability assessment, for instance the probability of failure (POF), taking into account the uncertainities on loadings, geometries, various material types, properties and initial conditions.

- Improvements of the „global" approach of the fatigue state:
  - a better knowledge of the local loads real situation;
  - a better correlation to operational data;
  - a better asessment of the failure during complex loads

Reliability and safety assessment of the aircraft is nowadays very much based on global approach, either deterministic or probabilistic.

Operating safety of an aircraft must begin in the design stage and it is ensured during the fabrication process and continued throughout the aircraft operation.

The main issues regarding the operational safety assessment are the following: to establish the failures occurance laws, to study the internal and external factors upon operational safety, to establish the operational safety assessment and calculus methodology, to draw up the methods to ensure the design and manufacture reliability, to maintain this characteristic throughout the operation based on operational data and to provide a technological response to the acute need of probability prediction of materials and structures failure under complex loads break-down, such as aircraft.

Reliability and safety assessment of structures is nowadays very much based on global approach, either deterministic or probabilistic. Furthermore, current solutions based on detalied structural analysis cover usually general component stress states and assume global failures scenarios.

Flight safety is a complex and current problem, the life of the crew, passengers and environment security depending on its succesfull solving. During the aircraft operation, various fatigue factors caused by wind gusts, manoeuvres, shocks and vibrations loads along with oscillating atmospheric temperature and humidity act upon its structure.

Under the influence of these factors, the structural elements of an aircraft must not lead to remanent deformations, that impede its safe operation.

Current stage of lifespan prediction is also non-unitary and several methods are available in different countries, according to their technical culture. The project is following the diagram shown in Figure 1.

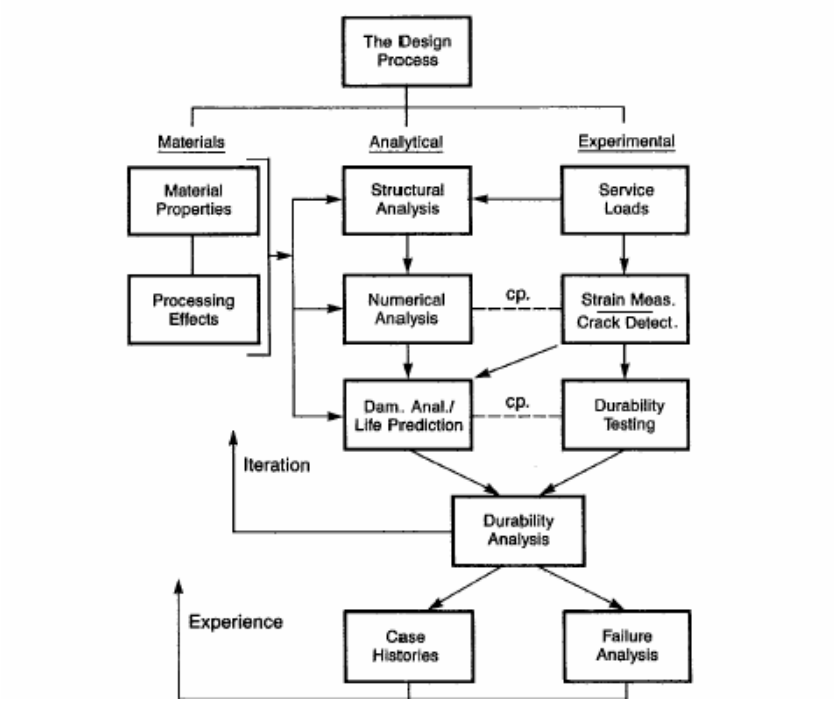

Fig. 1

The main and specific project objectives are:

- To compare and combine the conventional/global practice-based solutions to the innovative local approaches.

- To ensure the procedures to be in conformity with the accepted/applied standards

- To provide a technological response to the acute need of probability prediction of materials and structures under complex loads (such as aircraft) break-down.

- To ensure the methodology compatibility with current practices, standards and regulations

- To identify and quantify the risk key-parameters regarding the airframe and main systems exposed to complex loads.

- To perform a functional analysis of data and information, used in aviation risk management, in order to predict the user requirements.

- To evaluate the structural and system design, at both a national and international level

- The warnings calculus reports shall be detailed; the main components such as the fatigue-control elements shall be identified and described; To create an interactive database which allow:

- o gather information from various sources

- to classify the information by: generating causes, gravity of effects, other criteria.

The database installed on a portal of public interest represents a valuable tool both for the accident /flight incidents prevention even in the design phase and for elucidation of futher flight events.

- Drawing up of a technical mesures breviar to reduce the aircraft susceptibility and vulnerability to the hazard factors, a very useful tool which could be part of the confidential documentation of some aeronautical companies and that is not available to us.
- The compliance of the project to the proposed methodology and procedure shall be checked**.**
- The project compatibility with the proposed methodology and procedures shall be checked.
- The software's detailed functionality shall be defined as follows:
- gathering of random complex loads- related data and information
- calculation of the equivalent load/stress
- assessment of cumulative damages
- gathering of failure or accident
- related data and information to support the decision taking process as well as the failure and post- accident situation assessment
- The assessment process will imply industrial partners and users that will conduct the strain risk methodology testing procedures, supervised by the project's development team.

The main activities of this project are:

Activity 1: Current problems reffering to aircraft flight safety-general assesment. On overview of the current stage of the results in the field both at the national and international level will be made and specific analyse programs are elaborated.

Activity 2: Organizing of an operational database for prediction and data gathering.

Activity 3: Fatigue state analysis of airframe – lifting surfaces.

Activity 4: Fatigue state analysis of airframe – fuselage.

Specific calculation programs for the aircraft design are used in the activities 3 and 4, the program manager having an 38 years of experience in the field.

Activity 5: Analysis of a critical aeronautic structure element under an extreme load-impact with a body of significant mass.

Activity 6: Unyfying and completing of the existent theoretical and experimental databases obtained from flight and ground tests along with the utilization of operational data of other aircraft.

Final analysis and correlation of the existent theoretical and experimental results to establish the risk factor per aircraft / subassembly according to its specific and importance. For the time being only the first two activities are developped.

Conclusion

The strategic goal of the project is to develop operational safety assessment capabilities of high novelty degree, unique at the national level, concerning the validation of

methodologies and techniques utilized in the fatigue resistance calculus for complex aeronautical structures according to the international regulations requirements in the aeronautical field.

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