Development of CFRP Aircraft Doors with the Interaction of NDT and Strength Analysis

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Abstract. Within the Airbus Group, Airbus Helicopters is responsible for most of the passenger and cargo doors of the Airbus fleet. The latest, completely new developed aircraft – the A350XWB – consists of a composite structure and the same is true for its doors. For Airbus Helicopters this induced the change from metallic to CFRP door structures. Composite know-how from helicopter business and long-term experience in metallic aircraft doors grew together. This presentation focuses on the interaction between stress department and NDI during the development phase of the composite doors.

One requirement for the structure development was inspectability. The NDI methods to be applied should be mainly ultrasonic pulse echo and visual inspection. The possibilities and restrictions of these methods were explained in an unusual early development phase to the stress engineers. Consequently, several investigations about effect of defect, non- inspectable areas and their relevance for structure integrity were conducted and new acceptance criteria could be established.

As doors in an aircraft are always prone to damage during loading or boarding operations, damage tolerance is the main sizing criterion. And therefore stress engineers have to consider manufacturing imperfections and possible in-service defects as accumulative effects. The inspection results from NDI need to be understood in depth and translated into factors to be applied in stress calculations. Due to these boundary conditions NDI specialists were involved in assessing damage scenarios, also exceeding typical serial inspection.

The common learning phase and experiences led to increased mutual understanding and to new processes which are adapted to the challenges of the new composite aircrafts.

1. Introduction

Airbus Helicopters develops and manufactures helicopters and therefore composites are well known in the company as proven materials for rotorblades and several structural applications. Mainly carbon fibre and glass fibres as processed in monolithic and sandwich laminates. Along with these materials, the NDI competencies and equipment have been established including technologies like CT, µCT and automated UT inspection. Within Airbus Helicopters Germany the NDI, manufacturing and development are centralized in Donauwörth, Germany.

Composite know-how from helicopter business including NDI and long-term experience in metallic aircraft doors have been combined for the A350XWB project. Nevertheless, it was a challenge to adapt the existing technics to latest requirements and a relatively high production rate envisaged for the A350XWB project.

2. Development of Aircraft Doors

2.1 Requirements

Everybody who flies with a commercial aircraft expects that the doors stay safely closed during the flight and of course allow adequate boarding and de-boarding. A quick escape in case of emergency is also mandatory.

From this point of view already two main sources of requirements are visible. There are the legal regulations for airworthiness like the Certification Specification CS25 from the EASA (European Aviation Safety Agency). And there are the customer expectations, where the customer can be the passenger, the airline and the aircraft manufacturer. Additionally, Airbus Helicopter follows economic requirements which lead to industrial boundary conditions in order to develop and produce in an effective way. While the legal and customer requirements are well defined and usually fixed in a contract, some economic and industrial ones are more flexible or even not decently formulated. The needs and limitations of non-destructive inspection are typically an example for the hidden, but highly relevant requirements.

The task of engineering is then to create an optimized product, starting from visions and ideas, down selecting suitable solutions under consideration of all demands. Often a compromise between contradicting requirements has to be chosen. Especially when the design stipulates a composite structure, the NDI becomes more and more relevant. This fact was considered during the development of the A350XWB doors by improved collaboration between engineering and NDI experts in an early stage of the development process.

2.2 Introduction of CFRP Structures

Several research activities were launched at Airbus Helicopters in order to prepare for a full composite commercial aircraft. At the beginning there was a one-shot RTM door and later, around 2006, the first prototype with the size of a typical passenger door has been developed.

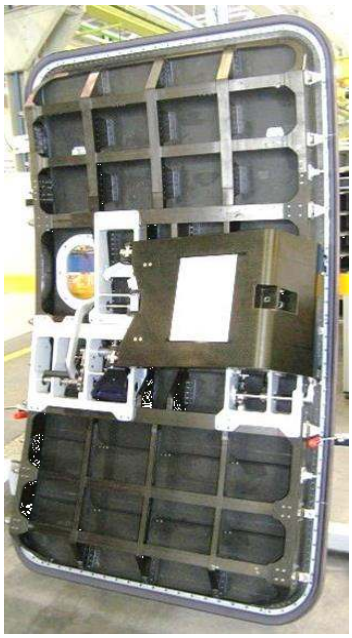

Fig. 1. Full composite prototype for a passenger door

At this time, the focus was on structural optimization, material selection and feasibility of manufacturing concepts. But the NDI responsibles were already aware of the planned future project and the impacts on inspection processes. It was by this time clear, that the production rate for the A350XWB would be significantly higher than for previous products and this induced the need for enhanced processes, but also the agreement with engineering to define relevant and critical inspection scenarios.

2.3 The Interface Stress to NDI

Inside the engineering community it was the stress department which defined most of the quality limits and inspection areas for the composite parts. Material characteristics and structural loads were well known by the stress engineers, but the effects of defects could only be judged on basis of experience from former helicopter and Airbus products. This awareness was well known also before, but now consequent actions were initialized, which are detailed subsequently.

3. Information exchange

3.1 Learning the basics

Beginning with prototypes, which were meant for production feasibility studies, also the information exchange between stress and NDI was started. The main purpose was to investigate and prepare a partially automated inspection concept in order to support the target production rate. But it became obvious that there is much more to learn on the stress and design side considering and being aware of composite affine NDI requirements.

Fig. 2. Demonstrator part for investigation of suitable inspection automation

Non-inspectable areas, respectively areas with limited access like T-sections or corners came into the awareness of stress engineers, who had to find solutions for the missing information due to inspection limits about part quality. For example, the porosity in radii is hard to determine, while a delamination is at least detectable with some uncertainty about the extent of the defect. Consequently, the stress engineer needs to judge about the criticality of porosity and delamination in a different way at the effected locations. This new cognition had an influence on inspection requirements on part drawings and finally on stress certification reports.

4. In-service Challenges

Aircraft door are prone to damages in general. This is mainly due to the frequent loading and unloading operations, usually under time pressure. During development this threat is considered by a suitable robust and damage tolerant design. In spite of this precaution, there will be damages in-service which have to be evaluated and precisely described by means of non-destructive inspection. The In-service requirements at the customer for the non-destructive testing are complete different like the development requirements. Concerning these requirements is an early involvement of the In-service inspection in the development process urgently needed, because in a bad case there is a complete other inspection process needed.

5. The Future

Utilizing composites in large commercial aircrafts has just started. The decision about the best material for next generations of large aircrafts is not yet taken, as in-service experience is small nowadays. But it is also true, that the composite technology has still huge potential, because the first generation, which is flying now, had to have some conservative designs.
New shapes, more composite-like designs will be introduced step by step. Also bonding and welding technologies provide optimisation potential for lightweight aircraft doors.

The Airplane Doors Development department at Airbus Helicopters has implemented a mindset towards industrialization to be prepared for these future tasks and to benefit from the advantages of cooperation between engineering and NDI.