Development of composite aircraft components in INCDT COMOTI, Bucharest

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Abstract: *This paper presents the recent research activities within INCDT COMOTI, in the composite materials field. The author makes a short introduction of this field and presents an example of application developed within the composite materials laboratory from INCDT COMOTI, targeting the aeronautic field. The aircraft component is a stator blade made of CFRP composites, integrating new active noise reduction technologies and manufactured by means of the autoclave technology.*

Key Words: *CFRP, aircraft component, autoclave technology, composite material, noise*

1. INTRODUCTION

Considered by many specialists as being the composites age, the late twentieth century was marked largely by changes in the technological concept of industrial production.

The need to develop new materials and unconventional technologies was driven mainly by the fact that giving the exponential growth in terms of production, there was a very strong crisis of raw materials and energy sources, with increased human aggression against the environment.

Also, the development of composite materials in the last century has become a necessity due to several technical and economic reasons, among which we can mention the following: the need for materials with special properties (less weight, greater strength and stiffness), impossible to achieve with traditional materials, the need to increase safety and reliability in operation of various construction equipment or facilities, the need to reduce consumption of scarce materials, precious or expensive; opportunity to reduce labour consumption and shortening the manufacturing processes.

The composite materials domain is considered, an innovative and interdisciplinary one placed between metallurgy, polymer chemistry, powder metallurgy, etc., the continued growth in the consumption of such materials, in the second half of the 20-th century registering a spectacular evolution as compared to traditional materials.

These materials with programmable properties superior to traditional materials and their benefits are well known being already applied in top technique fields, such as aerospace technologies, microelectronics, nuclear technology, medical implants construction technique, but also in the automotive, naval and chemical industry, furniture, construction, and sporting material industry.

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2. MANUFACTURING OF COMPOSITE MATERIALS AICRAFT COMPONENT

Nowadays, when the entire industry presents the "low weight syndrome", which has generated lighter materials, lighter vehicles, lower energy consumption, comfort, reduce pollution, full satisfaction, the composites are the perfect answer for these searches. This materials' benefit enables structural designs that outperform the conventional application limitations improving the system performance such as reducing weight, enhancing aerodynamic efficiencies, lowering manufacturing costs, increasing fuel efficiency or increasing speed [1-3]. The aviation industry was, naturally, attracted by such benefits provided by the composites. For the low-weight metallic alloys, there has been the tendency to extend their use from the interior design elements up to structural parts and the engine of an aircraft [4]. The intensive use of composite materials is reflected by their integration in the aircrafts of the two most important companies on the market, the European Airbus, and the American Boeing. Thus, 25% of the airframe weight of Airbus A380 which is the world's biggest commercial airplane is represented by composite materials. The new Boeing 787 Dreamliner lays claims an even higher percentage: up to 50 % of the structural airframe weight consisting of composites. Carbon-fiber components have a higher strength to weight ratio than comparable aluminium components, so by replacing aluminium with carbon-fiber composites, the overall weight of the aircraft is significantly reduced, while maintaining the same aircraft mechanical properties and flight safety. By using composite materials in the airframe, the overall weight of the aircraft may by significantly reduced, and Boeing claims that airlines using their composite materials based 787 model will achieve a 20% fuel consumption reduction compared to existing aircraft models [5].

This tendency seems to be a long term development, and it can be expected that future aircraft will contain more and more composite structural parts, particularly primary structures as the centerbox, the wing, as well as the fuselage [6]. Composite materials can be classified, depending on their matrix type, in three classes: metallic (MMCs), ceramic (CCMs) or polymer/organic (PMCs). Of the three, the last is the lightest. Although the use of the organic matrix composites for wing and fuselage skins has been steadily increasing to minimize airframe weight, structural metals still account for a very significant part of the aircraft engine, mainly due to the critical conditions of work in the hot regions of the aircraft [7]. Regarding PMCs composites, the most significant advance in the use of these composites in the engine design occurred just over a decade ago, with the entry into service of GE Aviation's GE-90-115B, which powers the Boeing 777 [8]. Its 22 fan blades are composed primarily of IM7/8551 (an amine cured, toughened epoxy system resin with carbon fibers) prepregs from Hexcel [8]. The blades have proven themselves up to the rigorous demands of commercial flight operations — only three blades have been removed from service during more than 12 years of service. Altogether, the 22 blades have a combined weight of about 349 kg of composites. With the inclusion of composite fan blade platforms, spacer bars, acoustic liners and bushings, the front fan section of each GE90 engine carries about 590 kg of composite structures — only 8 percent of the engine's total mass, where an all-metal fan case would account for 30 percent or more of the mass. That represents a significant overall engine weight reduction.

Although at international level the development in this field is a major priority [9-11], in Romania, the share of composite materials in research is too low. In this context, INCDT COMOTI answers this challenge, considering this field, one in which the opportunities of development and technological, scientific progress remains crucial. The Composite Materials

Laboratory for Aeronautic Field, from INCDT COMOTI has the necessary expertize to achieve a complete technological cycle of manufacturing for laminates / composite parts starting from design, selection of materials (fibers, resins, prepregs, cores for structures, metal inserts etc.), structural/mechanical characterization of composite materials, manufacturing parts / composite laminates using autoclave advanced technology, laboratory testing (mechanical tests in static and dynamic regime, structural tests, microscopy, etc.). The capabilities of INCDT COMOTI allow not only the material development and characterization, but also the stress analysis, design and manufacturing of moulds required within the manufacturing process for the targeted part. INCDT COMOTI is equipped with a unique equipment in Romania: an autoclave for polymerization of composite materials, which is a Scholtz product, with a useful sizes of 1.5 m in diameter and 2.5 m in length that allows the composite polymerization process using vacuum, pressure up to 20 bar and temperatures up to 400 ° C. The research activities in the field of composite materials of the INCDT COMOTI laboratory are underlined by the internal collaborative projects with businesses Romanian aircraft industry: Aerostar Bacau, Craiova SA Airplanes but also European projects in which it was recruited.

Within the European project Openair "Optimization for Low Environmental Noise Impact Aircraft" FP7-234313 (2009-2013), coordinated by the French company SNECMA, INCDT COMOTI was one of the 46 partners from 17 countries of the European Union and beyond, including Airbus, Bombardier, Dassault, EADS, Rolls-Royce, Volvo, DLR, ONERA, NLR, Imperial College of London, EPFL and the University of Cambridge, Rome and Madrid, which is in principle, the elite of European aviation. The project is part of the X-NOISE program, which, according to ACARE goal, aims to the reduction of civil aircraft noise by a factor of 2 (representing about 10dB), until 2020. The involvement of INCDT - COMOTI in the project consisted in achieving a series of demonstrators, representing fan stator blades made of composite materials lighter than conventional metallic materials, for next generation engines. The composite components were manufactured by means of the autoclave technology, using CFRP composites, integrating actuators elements in their structure for lowering noise level coming from the engine. The final composite prototype, provided also solutions for integration of the part in the stator case and ensuring the mechanical resistance in both nominal but also critical functioning conditions (FBO-fan blade out case), by using special designed and advance materials metallic insertions. These demonstrators represents a premiere both at national and international levels, because they incorporate top technologies aimed to reduce civil aircraft weight, thus reducing fuel consumption and therefore lowering environmental impact but also active noise technologies to reduce the impact of aircraft noise on surrounding communities airports. The activity of INCDT COMOTI in this project was successfully completed in May 2011, providing final prototypes – carbon fiber reinforced polymer composite stator blade, to the project coordinator, group SNECMA, France, which is currently being tested at Airbus and Snecma, France. The quality of research results was clearly appreciated, INCDT COMOTI being invited to be involved furthermore in future activities related to the testing campaign on the composite prototypes.

3. CONCLUSIONS

COMOTI results of the project were appreciated at national level and the General Association of Engineers in Romania awarded COMOTI with the AGIR price 2010 in the "Materials Engineering" field. Likewise, the INCDT COMOTI research team's success

within Openair program has not gone unnoticed by the European Commission. The later sponsored a film presenting the Openair project results, and for this only 4 of 47 partners were selected to present their research results within this project, DLR-Braunschweig, Snecma-Villaroche, CNRS-Poitier and INCDT COMOTI-Bucureşti. . INCDT COMOTI was one of these 4 partners. The filming within the INCDT COMOTI composite materials laboratory were made in January 2011, and the movie was presented at the sixth edition of the European Aeronautics Days "Aerodays 2011" in Madrid, Spain. Also, INCDT COMOTI was invited to present the composite stator blade prototype of the project Openair at the 49th edition of the International Air Show at Le Bourget, France, 20 to 26 June 2011.

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