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### Composite Structures of C919

Selim Gurgen<sup>1</sup>, Hayati Cakir<sup>1</sup>, Mehmet Alper Sofuoglu<sup>2</sup> and Melih Cemal Kushan<sup>2</sup>

<sup>1</sup>Vocational College of Eskisehir, Eskisehir Osmangazi University, Eskisehir, Turkey.

<sup>2</sup>Department of Mechanical Engineering, Eskisehir Osmangazi University, Eskisehir, Turkey.

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#### ABSTRACT

One of the last products in commercial aviation belonging to China is the C919 passenger airplane. This latest product is a product made by China to enter the market, especially against the series of Airbus A320 and Boeing 737. So it is a modern passenger plane consisting of single corridor and three-row seats like its competitors. In this study, composite structures used in the body of this new aircraft are discussed. Since the A320 and Boeing 737 are older design products, the use of composite materials in their fuselages is very low. At least the aviation use of composites is a surprising fact. The lowest utilization rate of composites is the aviation sector, which is a surprising fact. Because, although composite materials have been developed with aviation and aircraft industry, the rate of utilization in the sector is not very high yet. Especially in terms of weight and cargo we can say that the capacity is still higher in the high-altitude airplanes than in service conditions of metal alloys.

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#### I. Introduction

The C919 (Fig.1), the initial Chinese-built passenger jetliner, consummated its initial flight on May 5 2017 in Shanghai. The C919 seeks to compete against the A320 series and the Boeing 737. Comac's one corridor C919 mercantile airliner was developed to meet growing air freight demand in the zone but is also intended for export sales [1].

The C919 will be equipped with two CFM International LEAP 1C turbines which will have a impulsion of about 25,000lb to 30,000lb. The nacelle, impulsion air flow reverser and outlet layout of the airliner turbine will be ensured by Nexcelle. The airliner will have a range of 2988 mi. The payload of the airliner will be 44,93lbs. The cruise speed of airliner will be 969,32 km/h and the maximum altitude will be 39,360 ft. The range of the airliner varies, from 2532 mi. for the basic version to 3,450 mi. for the prolonged version [2].

According to the Federal Aviation Agency, the composite material has been around since Mundus War II. Over the years, this unique blend of material has become ever more popular, and today can be found in many different kinds of airliners, as well as gliders. Airliner structures are commonly made up of 50 to 70 percent composite material [6].

Aerospace technics pursuit best pershapeance, and traditional materials cannot meet the quiet specialised, for this reason developed composites materials preferred and configurable operational specifications become widely used in airliners structures. Mercantile airliners, military airliners, crafts and all of the others make substantial use of

composites, both for inside and outside structures. Polymer composite structures like aileron-covers, airliner leading sides, and composite body become the standard use in advanced airliners, which not only drop structural weight, but also provide preferable stiffness, toughness, fatigue strength, energy absorption, and thermal stability than traditional materials.

Currently, composite materials represent 50 % of the weight for Boeing 787s and 52 % for Airbus 350XWB airliners. More fibrous reinforced composites are being applied in their airliner structures like by the two giant aerospace companies. China's aerospace industry has developed at an impressive rate over the past two decades [4].



Figure 1. The C919 [3].

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#### II. Fuselage and Materials of C919

Fuselage incorporates new materials, fabrication processing, constructional cost and pershapeance benefits of lighter-weight. Principal "new" airframe materials include metallic alloys and polymer-matrix composites. New materials have been worked out in recent decades. Composite, especially, developed into research hot spot and have applied in several fields. All types of composite materials are used widely on new generation airliner, even as important constructional parts on airliner [5].

Shanghai is centre for designment and outpution of the C919. Like its competitors, the several parts that make up the C919 are produced by other special purpose entities. These are disperse over China, for example: The flaps, ailerons, wing panels, main and outer wing box will be produced in Xi'an.

Tele:

E-mail address: [slm.gurgen@gmail.com](mailto:slm.gurgen@gmail.com)

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The fuselage sections will be made in Jiangxi Province. These sections will all be brought together in Shanghai to consummate the end output C919. Most of the structure of the C919 makes use of Al-alloys, with the main box of wing making use of CFC materials [14].

In sum, 9 prepreg features and 7 adhesive features were skilled with Solvay produces for the C919 program and were used across the airliner's structure. Solvay's CYCOM 977-2 and CYCOM X850 prepreps, toughened epoxy materials ideal for principal and secondary structure technics were utilised on the horizontal stabilizer, rear pressure bulkhead, aileron and flaps. CYCOM 970 and CYCOM 7701, two epoxy prepreps output void-free honeycomb sandwich and monolithic structures were seriatim used on the rudder, elevator, winglets, spoiler, wing-to-body fairings and on the radar dome (nose). Several adhesives for metal and composite bonding were also chosen [1].

On the other hand, Al-alloys have been the principal material for the constructional sections of airliner for more than eighty years because of well known pershapeance of Al-alloys. Using composite materials dropd the quality of aluminum up to some extent, high strength Al-alloys remain important in airframe construction. Lower manufacturing and maintenance costs of Al-alloy are important advances can effectively compete with modern composite materials. New aluminum lithium alloy used on large airliner of China was provided by Alcoa [5]. But it is not easy to put new materials into practice in the aviation industry aluminum lithium alloy is one of these alloys.

Al-alloy is estimated to contribute 61.4% of weight of Mercantile airliner C919, while composite 15% Titanium and Ti-Alloys are largely used in airliner technics because of high strength/weight ratio of Ti-Alloys and excellent corrosion resistance. Ti-alloys ideal materials for weight savings. Welding property of Ti-Alloys is usually much more than that of Al-alloys. Titanium welding can be generated with almost 100 percent joint proficiency for strength and slight decreases in crack and durableness pershapeance. Comparatively low quotient of thermoexpansion and thermal conductance of Ti-Alloys prone to minimalise probable for distortion during welding processes. It is reported that volume of titanium alloy used on C919 is 9.3%, slightly higher than that of the Boeing 777 (7%~8%). Whereas mount of titanium alloy on A380 is 10% [5].

Fibrous-hardened polymer composite materials with high mechanical force and fatigue resistance, light heaviness, and perfect elevated temperature features are the combin of several polymer matrix and fibrouss. Hence finest mechanical properties of fiber composites, they are the up-and-coming solutions to the different mercantile execution, particularly in the weight-critical airliner industry [4].



**Figure 2. Horizontal stabilizer of C919 [9].**

The regional COMAC C919 airliner is under research and development, and the technic of composite materials will approve two grades strategy. The initial grade is to use nearly 15% of composite materials mainly on main tank, pressure bulkhead, tail unit, and control plates etcetera, and the secondary grade is to use almost 23% of composite materials plus on composite wing and wing fuel tank. Besides, Boeing 787 and Bombardier C Series airliner are being handled the contemporaneous type affirmation by "Civil Aviation Administration of China" with "Federal Aviation Administration" and "Transport Canada Civil Aviation" seriatim. In case farther comprehend the influence introduced by large scaled composite application on airliner structures for the designment and certification of COMAC C919 airliner or other coming regional airliners, as well as relieve type affirmation of Boeing 787 and Bombardier C Series airliner, it is immediate to have a study on the certification troubles introduced by extensive use of composite on airliner structures [7].

### III. Horizontal Stabilizer

One of the most important sections of an airliner is the horizontal stabilizer. Highly important moving sections are on the horizontal stabilizer. On Dec. 17, 2010, sample piece of horizontal stabilizer section (Fig. 2) for C919 was succeededly rolled out. The development of horizontal stabilizer composite section is one of critical tasks in development work of C919 Program in 2010. The success achieved in the development of the sections farther verifies related engineering designment and manufacturing processing schemes, accumulates lots of designment and technique experience and valuable data, and lays a solid foundation for enhancement of capability of composite manufacturing processing and succeeded conduction of detailed designment of composite horizontal stabilizer and subsequent development work for C919 Program. This is another significant progress made for the development of composite parts of C919 Program [8].

It is reported that the C919 horizontal stabilizer iron bird specimen is the initial full-scale full-composite horizontal stabilizer constructional component, and is an important constructional specimen of C919 iron bird test rig. The delihighly of the horizontal stabilizer represents an important milestone and guarantee for starting iron bird test within the year. At the same time, the trial manufacture of the C919 horizontal stabilizer iron bird specimen which has gone through related designment and manufacture procedures lays a solid foundation for the subsequent optimization designment [9].

### IV. Rear Pressure Bulkhead

The pressure bulkhead is usually located on the tail of the airliner. Separates passenger cabin and APU chamber. On Avic's Shenyang plant has consummated a composite aft-pressure bulkhead test piece for the Comac C919 airliner, using materials and techniques that are new to China. The bulkhead is the initial large composite specimen to be made for the C919 program [10].

Polymethacrylimide rigid foam named ROHACELL is being used on the rear pressure bulkhead archetype of COMAC's initial big mercantile airliner, C919. This is the initial time in China that a mercantile airliner applies composite material to its principal load-carrying structure [12].

The rear pressure bulkhead archetype is the initial big-sized composite section consummated in C919, of which structure ROHACELL is used in the stringers to enhance the



stiffness and buckling properties of the section. The manufacturing of this archetype was finished approximately in 5 months after the Computer Aided Designment files were released, and the fast delivery of a state of art ROHACELL shape from Evonik ensured its realization. The succeeded roll-out of the rear pressure bulkhead archetype in October has further certificated the engineering designment and outpution processing; it also guarantees the plane development processing of other composite sections on the airliner [11].



**Figure 3. Rear pressure bulkhead of C919 [11].**

#### V. Centre Wing Box

The centre wing box is the most important psection of the main wing. So far this section was made of metal alloys like Al and Ti alloys. On Avic's Shenyang plant has consummated a composite aft-pressure bulkhead test. The body structure of the airliner will be made of an aluminium alloy. The centre wing box will be made from CFC [13]. The main wing box (Fig. 4) was originally intended to use of CFC, but the designment was changed to an Al-materials designment to drop program complications [15].



**Figure 4. Main wing box of C919 [15].**

Carbon composite has been chosen for the critical centre wing box plus engine nacelles and impulsion reversers. Although outpution nominally began in December 2011, certification delays the Chinese have experienced with another airliner project, the ARJ21 zonal jet, have delayed progress on the C919, pushing back initial flight and delighly milestones for an unspecified time. This will not please the would- be customers, mostly Chinese, who have placed orders for almost 400 airliner so far [16]. A composite wing development since 2012 was revealed years after abandoning it for a metal-alloy one, as static and damage tolerance tests were finished in May 2018, verifying the constructional designment and strength before full-size composite wingbox tests [17]. The wing is supercritical, increasing aerodynamic proficiency by 20% and reducing drag by 8% compared to a non- critical one[18].

The main wing box was originally intended to use CFC [19]. It was changed later to an Al material designment to drop designment complications [20].



**Figure 5. The vertical tail section of the initial C919 airliner [22].**

#### VI. Vertical Tail

The rear vertical tail is the most important part of the tail. The C919 vertical tail comprises a vertical stabilizer and a rudder, made mostly of composite materials, except major attachment fittings which are Ti based alloy (Fig. 5). COMAC indicates that composite materials have preferable fatigue resistance and corrosion resistance, which can greatly drop the constructional weight, improve the pershapeance, lifetime, safety and maintainability of the airliner and extend the time interval for field maintenance. All of this helps to drop the airliner operational maintenance cost and the life-cycle operating cost [21].

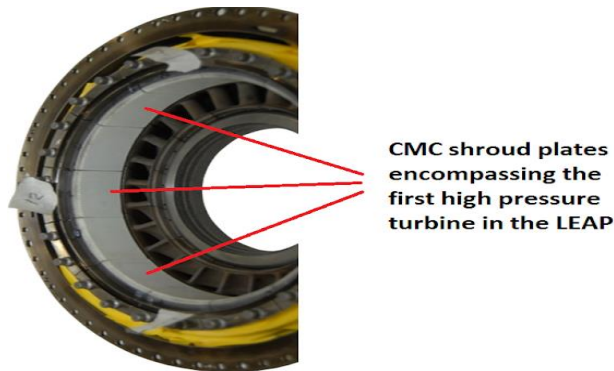
The vertical fin comprises a vertical stabilizer and a rudder. Most of the parts are made of composite materials that make the airliner lighter and more fuel efficient, improving the pershapeance and safety of the airliner and reducing maintenance costs [22].

#### VII. Other Applications

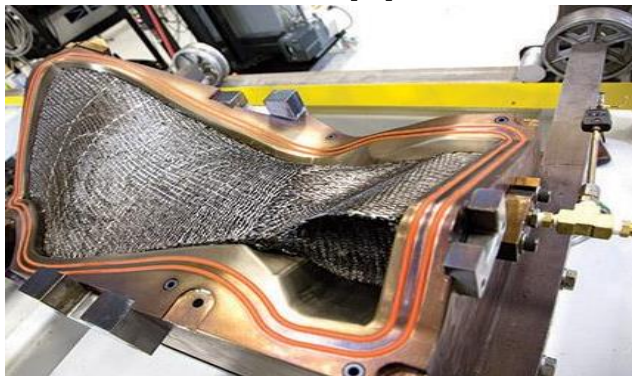
The increase in the composite rate of materials for new airliners is quite slow. Even the goals at the design stage cannot be reached. In this section we will see the composite materials used in the General Electric turbine engine of C919

Preferable yet is to use materials that need highly trace of cooling like CMC (Ceramic Matrix Composites). "General Electric" is a pioneer in the use of Ceramic Matrix Composites in turbines. General Electric has extensived it in their fixed jet engines in years and the LEAP now shapes the premier for expansion of Ceramic Matrix Composites in airliner jet engines. The technic is on the external coat of the initial high pressure turbine (Fig. 6).

Coating in turbine are applications that are often used in engines. Based on the technic type, coats are projected to surpass nozzle and become the largest technic of Ceramic Matrix Composites in airliner engines, driven by their usage in the LEAP engines. LEAP engine is certified for the B737 Max, A320neo, and C919 airliner. Farthermore, development of Ceramic Matrix Composites based coats in upcoming airliner engines, like GE9x, would farther accelerate the demand over the next five years. All major technics (combustor liner, coats, blades, and nozzles) are projected to witness healthy growth rates during the forecast period [23].



**Figure 6. Initial jet engine cove which uses CMC lining elements [24].**



**Figure 7. AEC (Albany Engineering Composite) resin infusion vane blade shape with the interlocked textured carbon fibrous in place [24].**

CFM International will provide a model of the LEAP engine, the LEAP-1C, to power the airliner. The engine's nacelle, impulsion reverser and outlet system will be provided by Nexcelle, with such features as an developed inlet version, the large scaled use of composites and acoustic operation and an electrically operated impulsion reverser. Michelin will provide Air X radial tyres.

"General Electric" is the mundus pioneer in CFRP-based vane s and vane covers. LEAP is now takeover this technics farther. The GE90 and GENx vanes are laid by hand up from CFRP pre-impregnated fabric. Snecma, which has liability for the vane and low pressure sections in CFM, has shaped a jointly venture, Albany Engineered Composites Inc. (AEC, Rochester, N.H.) with one of US high tech weaving companies, Albany International. AEC get the technics to knit the Carbon fibrouss into a 3D mesh which when placed in a shape get soaked in injected resin (Fig.7) [24].

## VIII. Conclusion

Although the C919 is the latest developed airliner of china, at the present the large airliner C919 use of 12% of the composite material [25]. In other words, the rate of use for land and sea vehicles is much higher. As you can see, although the composite materials have been developed with aviation and airliner industry, the usage rate in the sector is not highly high yet. Especially in terms of weight and cargo we can say that the capacity is yet higher in the high-altitude airliners than in service conditions of metal alloys [26].

Today the most used composite material is in Boeing 787 with 50% utilization rate. Boeing 787 seriatim; Others followed by A400 (39%), A380 (23%), A340 600 (13%) and Boeing 777 (11%) [26].

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