Aerospace:
economic and environmental impacts

While time and experience have helped composites become established in the aerospace industry, these materials continue to be closely monitored, with extra efforts on the part of aircraft manufacturers.

By

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Today, it is generally acnowledged that every passenger who makes the round trip from Paris to New York by plane in normal travelling conditions "produces" one metric ton of CO_2. One can easily calculate the per-passenger fuel consumption at about 400 litres of kerosene.

That may seem like a lot, but given the distance between Paris and New York (about 5,850 km, or 11,700 km round trip), 400 litres of fuel to go 12,000 km comes out to an average per-passenger consumption of about 3.5 litres per 100 km. Certainly better than any car!

Environment and economy

We are faced with a twofold problem, both environmental and economic. These two notions cannot be addressed separately. With more than two billion passengers per year, the CO_2 production for travel by aircraft adds up to impressive quantities of CO_2 emissions – more than 600 million metric tons per year! And yet, all these tons account for only 5% of annual global human-induced production. On the economic side, the aerospace industry generates more than 30 million jobs worldwide and the equivalent of 7.5% of global GDP. So once again for this issue, the environmental and economic aspects are crucial.

New objectives

Aware of the problem, the Advisory Council for Aeronautics Research in Europe (ACARE) has set progress objectives to be reached by 2020:

- reduce CO_2 production (including aircraft fuel consumption) by 50%;
- reduce NOx production by 80%;
- reduce perceived noise levels by 50%;
- reduce the environmental impact of aircraft manufacturing, maintenance and use.

Underlying these objectives is the fact that we must significantly reduce the environmental impact of aircraft for the duration of their service lives, even if it requires introducing innovations that could lead to higher aircraft prices.

Given that an aircraft's fuel consumption obeys a slightly exponential law as a function of the airborne weight, lowering the weight of airplanes

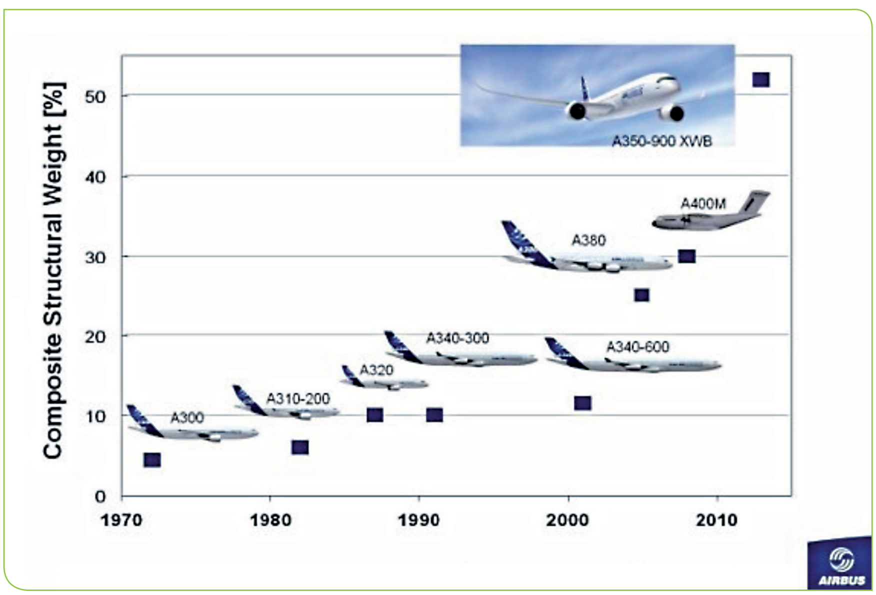

Fig. 1: Composite structural weight development

More information

Airbus qualification scope

- AITM 2-0002-A/B: Resistance of materials when tested according to the 12s or 60s vertical Bunsen burner test.
- AITM 2-0003: Resistance of materials when tested according to the 15s horizon tal Bunsen burner test.
- AITM 2-0004: Flammability of non-metallic materials - Small burner test, 45° - Deter mination of the resistance of material to flame and glow propagation, and to flame penetration.
- EN 2377 (ISO 14130): Glass fibre reinforced plastics - Determination of apparent inter laminar shear strength.
- EN 2562: Carbon fibre reinforced plastics - Unidirectional laminates - Flexural test Composite parallel to the fibre direction.
- EN 2563: Carbon fibre reinforced plastics - Unidirectional laminates - Determination of apparent interlaminar shear strength.
- EN 2746: Glass fibre reinforced plastics - Flexural test - Three point bend method.
- AITM 1-0007-A/B/C/D: Fibre reinforced plastics - Determination of plain, open hole and filled hole tensile strength.
- EN 2561: Carbon fibre reinforced plastics - Unidirectional laminates - Tensile test parallel to the fibre direction.
- ISO 527-5: Determination of tensile proper ties - Part 5: Test conditions for unidirectio nal fibre-reinforced plastic composites.
- AITM 3-0004 (EN 6043): Determination of gel time and viscosity.
- EN 2564: Aerospace series - Carbon fibre laminates - Determination of the fibre, resin and void contents.
- ISO 1183-1: Plastics - Methods for deter mining the density of non-cellular plastics - Part 1: Immersion method, liquid pyknometer method and titration method.
- AITM 1-0003: Determination of the glass transition temperatures (DMA).
- AITM 3-0002: Analysis of non metallic material (uncured) by differential scanning calorimetry (DSC).
- AITM 3-0008 (EN6064): Determination of the extent of cure by differential scanning calorimetry (DSC).
- ISO 11358 (ASTM D3850/ASTM E1131): Plastics - Thermogravimetry (TG) of polymers.

significantly has to be an important component of any industrial solution that is applied to reach these objectives – without, of course, losing any performance in terms of safety, speed, flight range, comfort, or life span, among others.

Innovating to succeed

The new specifications soon crystallized once manufacturers set out to examine all the ways in which to approach the objectives. Their studies addressed a range of very different and complementary methods, including:

- the massive use of composite materials and new lightweight metal alloys;
- replacing hydraulic systems by electrical systems;
- increasing engine performance;
- improving aircraft aerodynamics,
- using biofuels and synthetic fuels;
- administering an overall weight reduction “treatment”.

The brainstorming also touched on operational aspects such as flight path optimization (continuous descent), airspace management, airport/airport congestion management and passenger load optimization.

The appeal of composites

We know intuitively that any metal is much heavier than a composite. Practically speaking, we can establish that titanium has a density of about 5 and aluminium, about 2.7. A standard aerospace-grade carbon-fibre/epoxy composite material with a 60% fibre content by volume has a density of 1.8, which is 33% lower than that of an aluminium alloy, although in certain ways the mechanical properties of both are equivalent. They both have an elastic modulus of 70 GPa, for example.

As a result, the rate at which composite materials are gradually being introduced in aircraft has been increasing exponentially over the past years. As the graph below shows, Airbus has gone from lower than 10% in 1978-80 (A300 and A310 series) to 25-30% for the airplanes currently in operation (A380, A400M) and 53% for the future A350 XWB.

The same trend has been observed with the other leading aircraft manufacturer, Boeing, whose first 787 is already flying with more than 50% composites by weight. But an airplane will never be built exclusively from composite materials. The A350 XWB,

interview

José Alcorta
Manager of Rescoll

JEC Composites Magazine: How did Rescoll get started?

José Alcorta: Rescoll grew out of the one of the first French technology transfer departments at the University of Bordeaux. Back in 2001, we decided to give it the legal status of a company so as to get closer to our customers.

JCM: How would you characterize the entity?

J. A. : It is innovative even in its legal structure, because it is both a commercial and a non-profit company. All its profits are reinvested in the business, making it possible for the company to develop rapidly.

JCM: So that is one of the factors in your success?

J. A. : Without a doubt. But there are others. For example, the employees are company shareholders, which both motivates and helps to preserve know-how.

But there are two major factors that helped the company take off: developing an effective quality system and working with competitive clusters. From the very beginning, we caught on that having a lot of test machines would serve no purpose if we didn't back up these investments with an internationally recognized quality system. So, we made significant efforts to obtain accreditations like ISO17-025 and NADCAP NMMT, and from prime manufacturers like Airbus or Safran.
Competitive clusters also played a key role. They allowed us to sit down with the prime manufacturers to get an idea of their needs, share our experiences and launch projects together. An incredible chance.

JCM: Anything to add?

J. A. : Just to mention that, compared to other European countries, France has a great lack of medium-sized professional technological structures.

We are midgets next to the Basque, English, Dutch and German centres. Everything remains to be done, and we are looking ahead.

for example, contains more than 50% composites by weight, but also about 20% aluminium, 15% titanium, 10% steel and 5% miscellaneous materials.

A unique process

Unlike for a metal, which can be machined, folded, etc., a composite part is produced at the same time as the material is being manufactured. The currently used thermoset composites need to be cured in autoclave after the moulding process in order to obtain a cohesive, homogeneous material. Therefore, manufacturing the part in the finished shape has a direct influence on the manufacturing of the material, and vice versa, so it is important that the composite manufacturer have perfect control over the manufacturing chain in order to obtain reproducible parts that meet aircraft manufacturer specifications.

Validation and certification

Aware of how important it is to control these parameters, one thing Airbus did was to set up a rigorous, comprehensive characterization programme for the composites designed for its aircraft, aiming to verify that the manufacturing processes of all subcontractors and partners are sound. In this way, process validation and initial parts certification are subject to very precise characterization procedures to ensure control over the curing cycles – specifically through fibre content analysis and through differential scanning calorimetry (DSC) to characterize the curing rate – and over the characteristics of the parts obtained (thermomechanical analyses by dynamic mechanical methods (DMA), and compression, tensile and interlaminar-shear mechanical tests, in particular). Mass manufacturing processes for parts are also subject to strict monitoring, with verification of each batch.

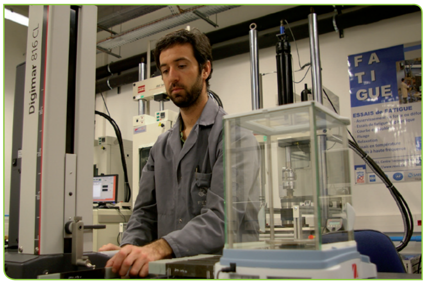

Fig. 2: Mechanical test

For greater accountability and optimum safety, these tests are not done by the parts manufacturers themselves, but by qualified independent laboratories in each country. Rescoll is one of the rare European laboratories to be certified by Airbus to carry out tests on composite materials both for the validation stage and the manufacturing stage.

Composite testing with the highest of quality standards

Rescoll is a research company that specializes in innovation studies on industrial applications for polymer materials (resins, composites, adhesives, lacquers, etc.) and related fields such as adhesive bonding, surface preparation and coating, and material fire behaviour.

To carry out its studies, the company created a characterization laboratory that also provides direct on-site services for its customers. As a result, the laboratory has developed significant expertise in the characterization of polymers and composites, and now performs a broad range of mechanical, thermomechanical and physiochemical tests, among others, on this type of materials.

The company first set out to obtain ISO 17-025 accreditation for tests on plastics and organic-matrix composites, then reinforced that by obtaining NADCAP's Non Metallic Materials Testing (NMMT) certification. Once NADCAP had delivered a number of consecutive «zero non-compliance» audits, it granted Rescoll good laboratory performance status. The laboratory is also Safran group qualified for testing composite materials, and Airbus has qualified the company for a very broad range of about twenty tests (see box).

Comprehensive services

To provide its customers with a full line of turnkey services, Rescoll endeavours to cover all stages: machining of specimens, conditioning specimens, NDT using ultrasound (one technician is certified for Level 1 COSAC/COFREN), bonding shoulders and strain gauges, testing in lead-time, quality and cost conditions that are compatible with the application. As a result, the company receives business from Airbus' European, American and Indian subcontractors. ■

More information:
www.rescoll.fr