Alcan's Voreppe R&D site in the French Alps serves its aerospace division

Located near Grenoble in the Rhône-Alpes of south-east France at Voreppe is one of Rio Tinto Alcan's two research centres for its Engineered Products division. Surprisingly, Rio Tinto plans to divest itself of this value added division when the market improves.

Aerospace research at Alcan, Voreppe

Alcan Global Aerospace is a business unit within the Engineered Products division of Rio Tinto Alcan. On the eve of the Paris Air show in June it opened the doors of its research centre at Voreppe to a selected number to view its facilities.

Addressed by Christophe Villemin, President, Alcan Global Aerospace, Transportation & Industry, the group was told of the two R&D centres, Voreppe and Nauhausen in Switzerland, and its eight industrial sites serving aerospace, transport and industry, which together employ more than 4000 people of which 360 work in the two R&D centres.

Voreppe is a leader in the development and production of new, high performance aluminium Al-Cu-Li alloys (type 7x75, 7010, 7050 and most recently 7x40 & 7085) and Al-Cu-Li-Ag alloys (2198 & 2050).

With the nature of the aerospace business demanding both quality and innovation, the aim of the R&D centre is to stretch the properties of aluminium alloys to new limits while keeping costs at an acceptable level. Safety; performance; maintenance; and production excellence are the factors driving the R&D work carried out by Alcan.

Customers include Airbus, Boeing, Bombardier, Embraer and Dassault, as well as NASA and ESA.

Safety and the predictability of a material's behaviour are key drivers in the selection of materials for aircraft frames. Additionally, weight reduction by employing lighter alloys or composites and higher strength materials of smaller cross section are increasingly key to the success of an aircraft where operating costs are paramount. Likewise, a need for less frequent maintenance checks by improving the corrosion resistance of alloys, resistance to stress corrosion, achieving better fatigue strength, and greater tolerance to damage in service are all important factors in the selection of a material.

Last, but not least, is sustainability which requires that all machining scrap (typically 90% of the mass is machined away from a structure) and whole aircraft, at the end of life, are recycled (See *Aluminium International Today Vol 21 No 2 March/April 2009 p15 & 18* report on the 'Pamela' recycling project).

Four pillars of innovation are the key drivers, said Christophe Villemin:

- High performance materials; (Low density alloys with improved damage tolerance and corrosion resistance);
- Integrated solutions; (Includes pre-machining, friction stir welding & joining);
- Smart products (eg structural health monitoring using inbuilt sensors, and tailored performance within a single part) and;
- Sustainability (closed-loop recycling of machine chips and end-of-life aircraft frame recycling – the Pamela project).

Friction stir welding can reduce machining by joining plate of different thickness

Voreppe Research Centre

Daniel Marchive, Director, Alcan Voreppe Research Centre explained the facilities provided at both Voreppe and Neuhausen. The latter specialises in automotive solutions, composites and special surfaces while Voreppe's main focus is in fabrication, downstream products, processes and smelting technology.

At Voreppe, R&D capabilities include new alloy development, design and joining, testing and characterisation of airframe alloys and panels. Rapid prototyping of new metallurgical solutions is facilitated by computer aided alloy

Laser beam welding is an alternative to friction stir welding design and a pilot cast house capable of casting full size ingot and billet up to 20t able to mimic plant conditions. This minimises problems when introducing new alloys to commercial production. A 2500kN testing rig capable of cyclic loading and tensile and compressive stressing enables evaluation of design solutions at representative scales.

Voreppe also possesses sophisticated metallographic analysis equipment including transmission and scanning electron microscopy with XRF probe analysis as well as a high resolution FEG-SEM.

Alcan's R&D teams have developed more than 20 new alloys and tempers for the latest Airbus A380 and Boeing 787 aircraft. It has also contributed to broader optimisation of aero structures by using new combinations of aluminium alloys together with innovative design approaches that are specific to aerospace, for example, joining metal and composites together. Weight reductions of 15-20% are typically achieved with this approach, with comparable cost reductions for aircraft builders.

The centre is a leader in the development and production of new, high performance Al-Cu-Li alloys (7x75, 7010, 7050 and most recently 7x40 & 7085) and Al-Cu-Li-Ag alloys (2198 & 2050). Five such proprietary alloys available in sheet, plate or extruded form are currently produced for customers. Damage tolerant Al-Cu-Li fuselage sheet offers more than a 30% increase in strength and improved damage tolerances as well as increased corrosion resistance and a density saving of 4% compared with previous alloys.

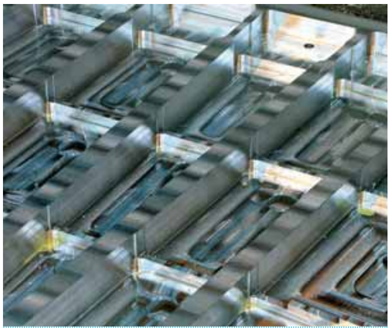
Welded aerospace structures provide new opportunities for cost reduction and more efficient material use, and can enable tailored properties within different parts of an integral section to be produced by using joining techniques such as laser beam or friction stir welding (FSW).

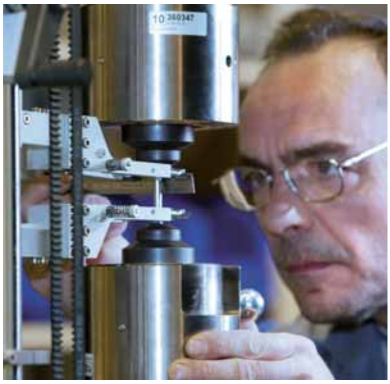
The most recent innovations include Structural Health Monitoring (SHM) where, for example, an optic fibre is incorporated during extrusion which can be monitored optically to detect any crack forming in service large enough to disrupt the transmission of light. This can be used to reduce maintenance costs by decreasing the frequency of major safety inspections. Other SHM applications involve incorporating slots in extruded sections to house sensors such as strain gauges.

Alloy development

Alcan R&D forms joint development teams with its major customers including Airbus, Boeing and Bombardier as well as external laboratories such as European Universities, Beijing AM and the Ecole Polytechnique Fédérale de Lausanne.

One of the first 'modern' aircraft alloys (2618) was conceived for the Concorde in the 1960s. This 2%Cu – Mg- Ni based alloy clad with an Al 1%Zn skin for corrosion resistance was capable of withstanding the frictional heat generated on the leading edges of the wings of up to 127°C as the aircraft flew at speeds of up to Mach 2.05. This alloy had to be capable of preventing creep during the 45 000 hour design life of the airframe. The heat generated is proportional to the square of the speed and Boeing's plans to build a supersonic aircraft travelling at Mach 2.7, which would require an alloy capable of withstanding a temperature of 277°C, never left the drawing board.


Conventionally, 90% of material is machined away to reduce weight


Fatigue tests can be performed on full scale sections in a 2500kN testing rig

Later alloys developed for sub-sonic aircraft such as the A300, B747 and A310 in the 1970s did not require this elevated temperature creep resistance but instead were developed for high toughness, low quench sensitivity and low internal stress (for thick plates). Such alloys were the Al-Zn-Mg-Cu 7475 and 7010 alloys.

In the 1980s, second generation Li-Al alloys 2091 were developed for the B757/767 and A320 as well as alloys 7150 and 7449 (Zn 7.5-8.7, Cu 1.4-2.1, Mg 1.8-2.7) with a yield strength (YS) of up to 600MP, to optimise strength, corrosion resistance and toughness. Earlier Li based alloys had proved unsuccessful as they suffered from thermal stability problems and were difficult to fabricate because of their high Li content (1.8-2.0%), a problem not fully resolved until the current decade with the 2195 and 2098 alloys that contains additions of silver.

In the 1990s aircraft such as the A330/340 and B777 required more damage tolerant alloys and better corrosion resistance for the fuselage which was met by the 2056 alloy and, for the bottom fuselage, by the weldable 6156 (Al-0.9Mg-1.0Si-0.9Cu-0.6Mn) alloy. Alloy 7x40 was developed for ultra thick plate.

In the current decade, a new generation of low density Li-alloys 2198 and 2050 have been developed and are starting to be applied on the A380 and B787. 2x98 fuselage sheet is an Al-Cu-Li-Mg-Ag alloy (wt % Al- Cu 2.9-3.5; Li 0.8-1.1; Mg 0.25-0.8, Ag 0.1-0.5) with a minimum yield strength (YS) of 407MPa and a density of 2.7g/cm^3. As a result of its low density, increased stiffness and high damage tolerance properties compared to conventional alloys, weight reductions of over 15% can be achieved. Alloy 2050 is produced in plate form and is also an Al-Cu-Li-Mg-Ag alloy but with a higher Cu content (3.2-3.9%) and contains 0.2-0.7%Ag. Yield strength, which also depends on the thickness of the plate, is 476MPa for 12.7mm plate and 448MPa for 101mm plate. The addition of silver improves damage tolerance while maintaining high strength by the precipitation of the T1 (Al2CuLi) hardening phase shortening the ageing time and increasing peak strength while maintaining damage tolerance.

Each step from conventional alloys to the next generation has improved performance by 10-20% by increasing strength, modulus, corrosion resistance and decreasing density.

Fabrication

Bruno Chenal, Director Technology & Innovation provided examples of how the


Casting and forging are also researched at Voreppe. A precision cast door for the Dassault Falcon

best weight – to-cost balance can be obtained by optimising material, manufacturing process and design. An example of innovation in the manufacturing process is the joining of rolled plate of differing thickness by friction stir welding (FSW) to 'tailor' the section to where the strength is needed. FSW uses a rotating tool which traverses along the joint to create a solid state weld – no melting takes place, the joint being achieved by a combination of heat generated by friction and pressure applied to the tool. Alcan has produced a 17m long weld by this means, a world record.

An example of a design innovation is the replacement of the conventional 'J' shape stiffening stringer by a 'top hat' shape with slots cut at regular intervals to enable inspection of the internal surfaces for corrosion (**Fig 1**). The stringer can be either riveted or bonded to the plate, the latter providing a weight reduction of 15% and a strength increase of 14%. Test sections are currently flying. Also, it has been found that machining a rib with a local overthickness on the plate parallel to the stringers increases strength and damage tolerance without weight penalty as the remaining plate can be machined to a thinner gauge than before.

As the use of composite materials such as carbon fibre reinforced polymer (CFRP) increase in airframes, so alloys need to be developed to be more compatible to join with these non-metallics in particular to improve the corrosion and thermal fatigue properties of the joint. Again, the Al-Cu-Li-Mg-Ag alloys prove to be more compatible with composites than other alloys.

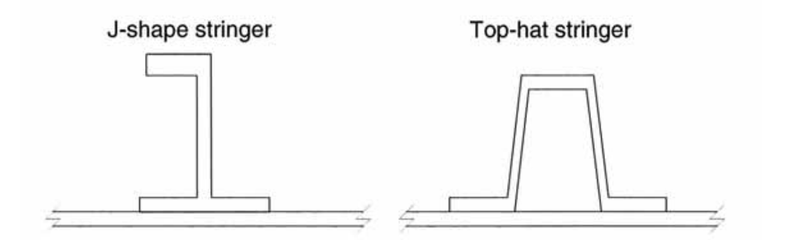


Fig 1 Changing from a traditional J-shape stringer to a Top-hat stringer reduces weight and increases strength

Divesting value

With 15 000 employees in 34 countries and a commercial presence in 65 markets across Europe, the Middle East, Africa, the Americas and Asia Pacific, Alcan Engineered Products is organised into seven businesses covering rolled products, extrusions, cable, composites, automotive and international trade.

Therefore, possibly the most surprising element of the day was that Rio Tinto, which acquired Alcan at the end of 2007 for $40bn, a move which loaded the company with such debt that it has been forced to seek a joint venture with its rival, BHP Billiton, is to divest itself of its high value added Engineering business leaving its remaining interest in Alcan to focus on primary metal and alumina production alone. ■

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