Aircraft and Aerospace Applications: Part Two

Abstract:
Aluminum alloys are used in transport aircraft as alloys primarily utilized today like 2024-T4, and the alloys having still higher strength (2014-T6, 7075-T6, 7075-T6 and 7178-T6). Where sheet is used, the rolled form is preferred. The upper skins and spar caps of wings often are of 7075-T6 and 7178-T6, because the critical requirement is high compressive strength, and the structure generally is not critical in tension loading or fatigue.

Transport Aircraft
Transport aircraft of the types operated by commercial airlines, by corporations for executive travel, and by the military, including Concordia craft, are generally of semi-monocoque and sheet-stinger aluminum construction. The alloys primarily utilized today are 2024-T4 and the alloys having still higher strength (2014-T6, 7075-T6, 7075-T6 and 7178-T6). Where sheet is used, the rolled form is preferred. The upper skins and spar caps of wings often are of 7075-T6 and 7178-T6, because the critical requirement is high compressive strength, and the structure generally is not critical in tension loading or fatigue.

For wing tension members, sheet webs, and ribs, alloys 2014-T6, 2024-T4, and 7075-T6 are used extensively. For these applications, fatigue performance and fracture toughness, combined with high strength, are the alloy characteristics of chief concern. Although 7075-T6 is stronger than 2024-T3 or 2024-T4, it is more sensitive to notches and has a higher fatigue-crack propagation rate. However, structures designed and fabricated in 7075-T6 have somewhat less weight than is possible in a 2024-T3 or 2024-T4 structure for equivalent performance.

Rolled sheet and plate 0.049 to approximately 0.375 in. thick are employed for wing skins by other manufacturers who prefer as wide and as few pieces as possible. Fail-safe design in this type of construction is achieved by many separate stiffeners, formed from sheet or milled from standard extrusions, or machined from stepped extrusions to accommodate integral end fittings.

Alclad sheet and plate are preferred for wing skins to obtain good corrosion resistance. Rolled alclad sheet and plate provide skins that are structurally efficient without extensive machining. Also, optimum spacing and design of stiffeners are practicable with this approach. Adhesive bonding, instead of riveting, is employed by some designers for attaching doublers and stiffeners to the skin sheet.

Fuselages on virtually all modern commercial airliners and executive aircraft are pressurized. The pressurization cycles and safety requirements dictate the design parameters of high-load, fatigue-resistant and fracture-resistant structures for this application. Although the design is the most important consideration in achieving a desired performance, the fracture toughness of the alloy probably has the most influence on the weight of the structure. Alloys and tempers with good combinations of static strength, fracture toughness, and corrosion resistance are the basis for the alloy selection. Alclad 2024-T3, alclad 7075-T6, and alclad 7075-T6 and 7075-T6 are the primary selections. Aluminum honeycomb core generally is made from 3003-H19, 5052-H19, or 5356-H19 foil. Foil of 2024-T81 is produced and used advantageously for core for long service at high temperatures.

Landing gear structural parts for heavy airplanes are often produced as aluminum alloy forgings. The main cylinders are made on hydraulic presses as conventional closed-die forgings, with the parting plane at the center of the cylinder. In the past, alloy 2014-T6 was employed extensively, but in recent years alloy 7075-T6 or T611 has been used. Alloy 7075 in the new T3 temper and alloy 7070-T7 also should be considered, because of their good resistance to stress-corrosion cracking, and in the case of 7070-T7, its good properties at operating stresses in thick (over 3 in.) sections. Other landing gear members, attached to the main cylinders, also are produced as aluminum forgings, including structural forgings in the fuselage and wings, which distribute the landing gear loads into other structures, and forged parts for the retarding mechanism.

Wheels for heavy civilian or military airplanes generally are designed on a safe-life basis. They are replaced at regular intervals during the life of an airplane, allowing use of lighter-weight designs than are required for long-time fatigue resistance.

High-Performance Aircraft
High-performance aircraft require the application of advanced materials that are discussed in subsequent Oh...
Aircraft and Aerospace Applications: Part Two :: KEY TO METALS Articles

High-performance aircraft require extraordinary materials and design to accommodate to 12g loads (9 to 12 times greater than those imposed by unaccelerated flight). The maximum loads are infrequent, and on some aircraft may never be encountered. Since the high stresses prevalent during most of the flight period are low, and the life of the aircraft in terms of flying hours is also generally low, high-cycle fatigue is not a major problem. However, the high stresses that occasionally may be imposed in maneuvers demand consideration of the high-stress fatigue characteristics of the structure material. Another characteristic of this type of aircraft is high wing loadings, which dictate thick wing skins typically 0.5 to 1.5 in. at the root. Design requirements resulting from aerodynamic heating at high speeds are discussed subsequently, under supersonic aircraft.

Since about 1945, all high-performance aircraft have been manufactured of the highest-strength aluminum alloys approved by the military services. Alloy 7075-T6 has been the workhorse, complemented in specialized applications by 2014-T6, 2024 in both naturally and artificially aged tempers, 7075-T6, and 7178-T6. In one large Navy carrier aircraft, 2020-T651 plate is used for wing and tail surfaces to obtain the advantages of its low density and high modulus of elasticity (11.4 million psi). The notch sensitivity of 2020-T6 requires care in design and fabrication to minimize stress concentrations and to realize the full structural capabilities of the alloy.

Extrusions 1 to 5 in. thick in alloys 7075-T6 or 7079-T6 are utilized as machining stock for spar caps, which in some designs are continuous from one side of a wing to the other. Appreciable sweepback and dihedral angles present forming problems for continuous spars; therefore, in some swept-wing aircraft, stepped extrusions are employed as machining blanks for spar caps with integral attachment fittings. These are attached to carry-through members, machined from thick plate, hand forgings, or die forgings. Alloys 7075-T6, 7075-T73 and 7079-T6 predominate.

The primary disadvantage of the machined-plate skin is its elimination of the use of an alclad exterior surface for greater corrosion resistance, thus requiring effective coating systems for adequate corrosion protection.

In general, the military services approve systems involving a conversion coating, one or two coats of zinc chromate primer, and one or two coats of high-quality organic coating. If the coating fails or is damaged, aircraft operating in very severe and tropical salt atmospheres may encounter exfoliation corrosion on top surfaces of 7075-T6 and 7178-T6, Alloy 7075-T73 and the artificially aged tempers of the 2000 series alloys do not exfoliate, but they have lower yield strengths than the 7000 series alloys in the T6 temper. A more recent development is 7178-T6, which approaches the structural capability of 7075-T6 and the exfoliation resistance of 7075-T73.

Premium-strength aluminum alloy castings are used in some high-performance airplanes. They are employed in structural components such as canopy supports and frames, fuselage members, and heavily loaded pylons that support external loads. Alloys 354-T6 and A597-T6 are usually specified for these premium-strength castings. New alloys of the 2000 series, not yet in production, show a capability of 20% increase in mechanical properties for simple shapes.

Supersonic Aircraft

Supersonic aircraft, designed to withstand aerodynamic heating to 250°F for over 100 hr (the time in service is accumulated in small increments), generally utilize the 2000 series alloys in artificially aged tempers for skin sheet. Alloys 2024-T31 and T6 are the most extensively employed. 2014-T6 and 2024-T62 or T81 are used for extruded members. Alloys 2014-T6 and 2681-T6 are employed for forged products located in heat-affected areas; alloy 2024, which can be forged, also can be considered for parts of this type. Alloy 2219 has had limited application in engine pods as shroud, nacelle, and forgings.

The designers of one supersonic bomber have made extensive use of honeycomb core sandwich construction for wing panels, to achieve a stiff structure that does not buckle when stressed in compression near the yield strength of the material. The honeycomb in these sandwich panels is 5052 aluminum foil, except where fiber glass is applied to further insulate the fuel from aerodynamic heating.

Honeycomb panel frames are predominantly 7075-T6, machined from plate to eliminate corner joints. Aluminum honeycomb is also used in the beaded areas of skin doublers, to help stiffen the fuselage skin. At elevated temperatures, 2024-T61 foil provides higher strength than is obtained in work hardened alloys, such as 5052-H39 and 5056-H39.

The supersonic transport being developed by British and French interests makes general use of alclad and bare 2618-T6 for the structure. This alloy, which has served many years in forged engine parts, is available also in other wrought forms. Alloy 2219-T81 or T87 has approximately the same tensile strength for design purposes as 2618-T6, however, limited data show 2618-T6 has higher creep strength.

Helicopters

Helicopters have critical structural requirements for rotor blades. Alloys 2014-T6, 2024-T3, and 6061-T6, in extruded or drawn hollow shapes, are utilized extensively for the main spar members. The blade skins, typically 0.020 to 0.040 in. thick, are primarily alclad 2024-T3 and 6061-T6. Some blades have a 3003-H19 or 5052-H39 honeycomb core; others depend on ribs and stringers spaced 5 to 12 in. apart to prevent excessive buckling or warping of the thin trailing edge skins. Adhesive bonding is the most common joining method.

The cabin and fuselage structures of helicopters generally are of conventional aircraft design, utilizing foam or sheet bulkheads, extruded or rolled sheet stringers, and doublers or chemically milled skins.

List of Articles - Knowledge Base

http://www.keytometals.com/Article96.htm 2/3