



Metals in the World of AVIATION

Part 7 – Nonferrous metals & alloys in Aircraft and Engines other than Aluminium & Titanium alloys

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It is fascinating to note that the High Pressure Turbine blades in an aircraft engine operate at temperature very close to its melting point with a centrifugal load equivalent to that of the weight of a double decker bus acting on its roots (the mounting region). Modern day engineering has stretched the limits of use of these alloys by ingenious ways like, applying an insulating thermal barrier coating on the turbine blades, internal cooling channels, formation of a thin layer of air cooling film on the surface of these blades as extremely hot gases of combustion rush past them.

Aircraft and aero engines are

complex mechanical systems where it is necessary for components and parts to perform one or more functions. This requires that these parts are manufactured from alloys that are suitable to impart the properties required to fulfill their intended function in service. The properties required could be diverse and entirely different and sometimes a combination of many. For example, parts like Turbine blades, Nozzles, Combustors must withstand higher temperatures beyond 1100 Deg C. and some others, must be light in weight with adequate strength.

No alloy alone can meet all the engineering properties required in a complex system like an aircraft or its engines. Hence different alloys are used.

Many of these alloys are surface

engineered for better wear, to provide lubrication, improve corrosion, protection of mating part etc...

The most commonly found Nonferrous alloys other than Aluminium and Titanium used in the manufacture of an aircraft or engine with are given in Table 1.

Nickel & Magnesium alloys are the most widely used non-ferrous alloys after Aluminium & Titanium alloys. The present day engines rely heavily on the Nickel alloys for their improved performance. The unique property of the Nickel alloys is to withstand high temperature with retention of their useful strength up to approx. 85% of their melting

List of Non Ferrous alloys other than Aluminium & Titanium used in the manufacture of Aircraft & Engine parts.

S.No	Non Ferrous Metals	Alloys Commercial / Common Names	Key properties	Application in Aircraft/Engine
1	Nickel	<p>INOCNEL625, INCONEL718, INCONEL 925, X-750, NIMONIC 75, NIMONIC 80, NIMONIC 90, NIMONIC 115</p> <p>MAR-M-200, RENE5, DS142 CSMX100</p> <p>HASTE ALLOY X, HASTE ALLOY W HAYNES ALLOY C-276</p> <p>MONEL K500, 400</p>	Excellent strength at high temperatures (ie above 800C – 1200 C). Highest creep strength for Single crystal Alloys	Fire walls, heat shields, high strength bolts, pins, lugs struts, mounts , in engines. Discs of HP compressor , Turbine, seals, housing, stator vanes in compressors and turbines, exhaust nozzles, Shafts, Rivets, pins etc. Plasma spray powders.. Transition ducts, Combustor cans, spray bars and flame holders as well as in afterburners, tailpipes.
2	Cobalt	HAYNES 188, UDIMET, MP35N, WASPALLOY	High temperature resistant alloys with good creep strength	Combustors, combustor parts, diffusers, Seal tip segments, wear resistant coatings by plasma. repair
3	Magnesium	AZ91E, AZ31B	Light weight combined with strength & weldable	Housings, Casings, pump cases, gear box casing, oil coolers/IDG etc, Thrust reverser cascade casting
4	Zinc	SAE 921/903/925	Easy to cast complex shapes and cheap	Die castings, struts, housings etc
5	Gold	99.99 % pure gold & alloys with Copper, Nickel are also used	Vacuum brazing, Good strength of joints	Braze joints high integrity barze joints on tubes seals etc.
6	Silver	Silver with Copper, Nickel , Cadmium in varying proportions	Easy wetting & application	Braze joints used on tubes and non critical areas
7	Molybdenum	NICKEL BASED WITH HIGH Mo CONTENT	High strength	High strength hot section parts like bolts
8	Copper	Aluminium bronze, Phosphor bronze, Copper Beryllium	Highly corrosion resistant, Resist wear provides due to good frictional characteristics	Widely used in the electrical wiring, Bushings, Sleeves, inserts, Springs Bronze – bellows, springs, bushings, Piston pump housings, sleeves, electrical harness, earthing conductors etc.

point makes it an indispensable alloy for Engine design. Nickel alloys are used for fabrication of parts in the vicinity where temperature exceeds approx. 400 Deg C to meet the strength requirements. These alloys are also used on aircraft where high strength coupled with corrosion resistance is required.

Magnesium alloys are lighter than Aluminum and ease of casting intricate shapes makes it a choice for almost all the Gear box housings, Pumps, Integral Drive generator etc. These castings have numerous lubricating oil feed and scavenge passages cast into the housings. However, the susceptibility of magnesium alloys to environmental condition requires that these casting are adequately protected and is usually achieved by coating with Epoxies after pretreatment. Many parts like strutcovers, thrust reverser cascade castings are also made from Magnesium alloys.

Copper alloys like Aluminium Bronze, Phosphor Bronze, Copper Beryllium alloys are extensively used for fabrication of bushings & sleeves of fitting in aircraft. These are used due to their resistance to wear.

Zinc is used where parts are required in large numbers, are complex & intricate in shape and are non critical. Silver and Gold are widely used for brazing purposes. Gold brazing is used for joints requiring higher strength. Molybdenum is not used as common as those stated above but is used in some cases where high strength is required.



Fig. 05 Aluminium & Phosphor Bronze (Copper Alloys) bushings used in an Aircraft Fitting

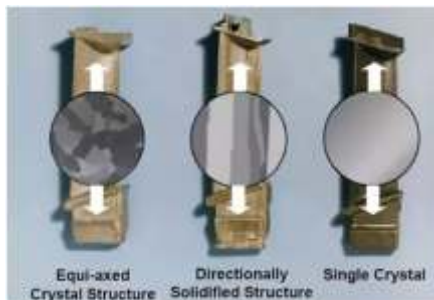


Fig 1. The present day Single crystal Blades in Nickel Alloy which can withstand Higher temperatures making engines more efficient



Fig. 2 . Low Pressure Turbine (LPT) Case of an Aeroengine made from Nickel alloy Inconel 718



Fig. 07 Aircraft Landing gear with Bronze Bushing



Fig. 06 Impellers brazed with Gold fillers



Fig. 03 A typical Gear Housing casting made of Magnesium Alloy



Fig. 04. Thrust reverser cascade casting made of Magnesium alloy

