An Introduction to Metallic Materials for Aeronautics

Philippe Lours
Professor of Materials Science
Vice-director of International Affairs
Head of AeroMat-Innovation Master

Aviation is resilient to crisis. Generally speaking, the world economy continues acceleration, the Gross Domestic Product (GPD) of both advanced and emerging economies being largely positive. They will pursue ascending slopes in the next years, especially in China and emerging countries of the pacific rim. The Compound Annual Growth Rate (GAR) in Asia is forecast to reach about 5% for the 2015-2025 period, much higher than that of the USA and the European Union. The air traffic, as a conjunction of demography, connectivity and economic growths explodes as well, namely through the world development of middle class willing to increase travelling on both domestic and international basis. The Revenue Passenger Kilometres (RPK) is expected to double in the next twenty years, with a prominent contribution in Asia and Pacific. The evolution of the air fleet in service including passengers aircrafts and jet freight aircrafts will go from around 18000 in 2012 to almost 30000 in 2032. Among those 30000 aircrafts, 60% corresponds to pure growth, 30% to replacement and 10% to stay-in-service, remarketed or converted aircrafts.

Among all the technologies allowing the development of the aeronautical industry, materials and structures plays a central role. Materials developed for aircraft manufacturing must obey conflicting objectives related to regulation, safety and performance. Environmental friendly, innovative manufacturing must guarantee as well cost reduction, shortest time-to-market and improve materials index such as engineering specific properties. Competition is fierce between composite and metallic materials and within a same family of materials between various grades, processing, thermal and thermomechanical treatments, coatings techniques, etc.

Following a general introduction on the specificity of metallic materials for aeronautical applications, a general and extensive view of economic issues will be given to highlight the main drivers for developing materials and structures for aircraft applications. General properties and processing of steels, superalloys, aluminium and titanium alloys will be extensively reviewed as well as the principle of material selection by simply illustrating using few comprehensive examples. Both thermal and thermomechanical treatments and their effects on the engineering properties of the various investigated materials will be detailed to assess for the impact of dedicated materials microstructures on the performances of the structures and systems used specifically in aeronautics. The various aspects of materials processing, implementation and characterization will be largely illustrated by multi-scale, multi-physics results of research achievements by the authors, including heat treatments implementation (precipitation hardening, martensitic transformation), mechanical tests (tensile, impact strength, creep, fatigue, crack propagation test), scanning electron microscopy and transmission electron microscopy investigations. Case studies relative to the principle of mechanical and microstructural design of *i)* Ni based turbine blades for creep resistance and *ii)* Ni-based turbine disks for fatigue resistance will be proposed in the shape of tutorials to favour interactivity and get students as much as possible familiar, at ease and comfortable with the subject by practising dedicated calculations and appropriate analysis.
