

## Nickel Base Alloys (Superalloys)

Nickel base alloys (Superalloys) are the typical materials for the hot parts of the engine, starting with the rear stages of the HPC being too hot for Ti-alloys. For combustors special sheet alloys (e.g. Hastelloy X , C263) have been developed with relative low strength, high oxidation resistance, good formability and suitable weldability. For turbine applications there are basically two groups of superalloys, one for wrought disks and rings and the other one for cast blades and vanes. Both owe their elevated temperature properties to two different strengthening mechanisms :

- ◆ Solid solution strengthening by cobalt, chromium and refractory metals such tungsten and molybdenum.
- ◆ Precipitation hardening by the intermetallic  $\gamma'$ - phase  $\text{Ni}_3(\text{Al,Ti})$  or  $\gamma''$ -phase  $\text{Ni}_3\text{Nb}$ . Therefore the most heat resistant superalloys contain up to 10 weight-% (Al+Ti) or some % Nb.

Superalloys for disk applications are tailored for high static and dynamic strength properties at temperatures below 750 °C. Special emphasis is laid on optimum low-cycle fatigue (LCF)-properties being most important for disk design.

Table 2 shows some of the most important Ni-alloys for disks and rotating rings. The most widespread alloy is IN 718. It covers a wide range of applications both in the rear section of the HP-compressor and in the turbine.

Waspaloy has a higher temperature capability as compared to IN 718. Waspaloy, however, is very critical concerning metallurgical behaviour. It is difficult to achieve a uniform fine grained structure in forging. Therefore both machining and welding of Waspaloy is critical. For many years disk alloys with higher temperature properties than Waspaloy could be manufactured only via powder metallurgy, e.g. Udimet 700, Rene 95 or IN 100. Some of them have very high strength even at high temperatures, however, fracture mechanical properties are critical. Since about one decade it is possible to produce similar alloys like Gatorized Waspaloy or Udimet 720 Li (Li = low interstitial) via the conventional route casting plus forging”, in a quality level being sufficient for disk applications.