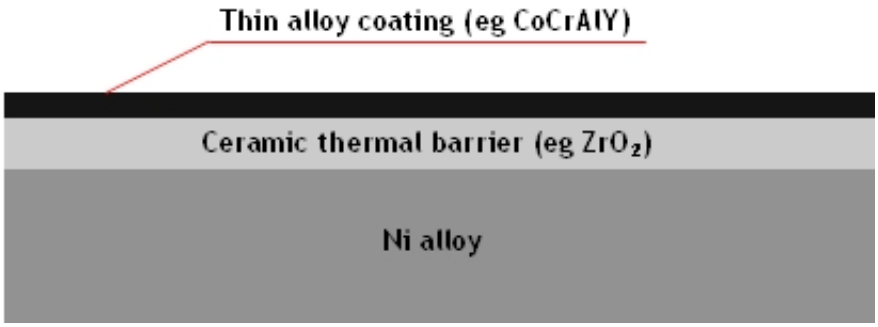
Nickel-based alloys

Nickel and nickel-based alloys have a wide range of applications including aerospace, medical, nuclear, chemical, etc. They are best known for their corrosion and heat resistance because of their high melting points and high strength. Nickel is FCC and has good formability. When Copper is added to Nickel, maximum strength is obtained near 60% Ni. These alloys are called **Monel alloys** and are used to provide oxidation resistance at temperatures above 760°C. Al & Ti are sometimes added to Monel alloys to improve strength by age-hardening (they nearly double the tensile properties).

Superalloys are metallic alloys which can be used at high temperatures, often in excess of 0.7 of the absolute melting temperature. **Nickel superalloys** or **Inconel** are Ni alloys that contain large amounts of alloying elements (such as Cr, Mo & Fe) intended to produce a combination of high strength at elevated temperatures, resistance to creep at temperatures up to 1 000°C and resistance to corrosion. Solid solution strengthening, carbide dispersion strengthening and precipitation hardening are generally employed.

Material	**Tensile strength [MN.m^{-2}]**	**Yield strength [MN.m^{-2}]**	**% Elongation**
Pure Ni (99.9% Ni):			
Annealed	345	110	45
Cold-worked	655	620	4
Ni-Cu alloy: Ni-31.5% Cu	540	270	37
Ni superalloy: Ni-15.5% Cr-8% Fe	620	200	49
Fe-Ni superalloy: Ni-46% Fe-21% Cr	615	258	37
Co superalloy: Cr-4.5% W	1 220	710	4

Strength of most metals decreases adversely with increasing temperature because dislocations can surmount obstacles easier with the assistance from thermal activation, and even though superalloys have a higher threshold than most metals and alloys, they are no exception. That's why in gas turbines where Ni alloys are used, an extra layer is coated over the alloy to provide additional thermal protection. The coating aids in the reduction of oxidation allowing the gas turbine to operate at higher temperatures and greater efficiency. It's a thin (1mm) coating of a different alloy covering a thermal barrier ceramic coating.



References

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