Superalloys:
Evolution and Revolution for the Future

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Abstract

Ni-base superalloys evolved from forged/wrought alloys to conventionally cast (CC), directionally solidified (DS), and then single crystal (SC) alloys. SC superalloys have also evolved from 1st generation (containing 0wt%Re) to 2nd generation (2-3wt%Re), 3rd generation (5-6wt%Re), 4th generation (5-6wt%Re and 2-3wt%Ru), and then 5th generation (5-6wt%Re and 5-6wt% Ru) alloys. So far 1st to 3rd generation SC superalloys are being used practically, e.g., in the latest fan jet engine Trent 900 on Airbus 380. The highest temperature capability, 1100°C, has been reached by NIMS 5th generation alloys, e.g., TMS-196 (Ni-Co-Cr-Mo-W-Al-Ta-Hf-Re-Ru alloy), while the temperature capability of the current commercial superalloys are around 1050°C. In the 5th generation superalloys, an interfacial dislocation network on the gamma/gamma' coherent interface is designed to be finer (-20nm) to prevent dislocation cutting through the interface and thus prevent creep deformation. A 300mm long and 10kg weight SC hollow blade for an ultra-efficient gas turbine has been successfully cast in a casting house in Japan.

In this paper, the historical evolution and possible future revolution in superalloys are presented. Possible contributions of the superalloys to reduce CO2 emissions are also discussed.

Keywords: Single crystal superalloy; Gas turbines; Aeroengines; CO2 emissions