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Microstructural design of Ni-base superalloys by hot isostatic pressing

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Single crystal Ni-base Superalloys (SXs), used as blade materials, operate at temperatures close to their melting point and have to withstand mechanical and chemical degradation. Casting and extensive solution heat-treatments of such blades introduce porosity, which can only be reduced by hot isostatic pressing (HIP). Recent developments of a HIP unit with a quenching possibility allow performing heat- treatments and eliminate porosity simultaneously. This work gives an overview about the opportunities that such a unique HIP offers for the solution heat-treatment of conventionally cast SXs or directionally solidified Ni-base superalloys fabricated by selective electron beam melting (SEBM).
The influence of temperature, pressure, and cooling method on the evolution of γ/γ′-morphology and on the pore shrinkage is investigated. The cooling method has a strong impact on the γ′-particle size and shape. Slow or natural cooling lead to coarse γ′-precipitate sizes. Quenching after solutioning at 100 MPa leads to a high number density of small γ′-particles, ideal for the subsequent formation of a fine and uniform γ/γ′-microstructure after ageing. Porosity reduction was most efficient at T > Tγ′-solvus. Based on these findings, first, an integrated solution and aging heat treatment for an as-cast SXs is implemented into the HIP unit. Second, short HIP treatments are applied on SEBM parts, generating promising and defect free microstructures. Finally, a HIP treatment is satisfactorily used to rejuvenate the γ/γ′-microstructure of SXs after creep degradation, re-establishing the γ/γ'-microstructure without recrystallization and closing all pores and creep cavities.

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Materials

Primary author(s) : Mr RUTTERT, Benjamin (Ruhr-Universität Bochum)

Co-author(s) : Dr LOPEZ-GALILEA, Inmaculada (Ruhr-Universität Bochum); Dr MUJICA RONCERY, Lais (Universidad Pedagógica y Tecnológica de Colombia); Prof. THEISEN, Werner (Ruhr-Universität Bochum)

Presenter(s) : Mr RUTTERT, Benjamin (Ruhr-Universität Bochum)

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