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Casting and characterization of Ni-, Fe(Ni)- and Fe-based 30%Cr-containing alloys strengthened by TaC; comparison with thermodynamic calculations



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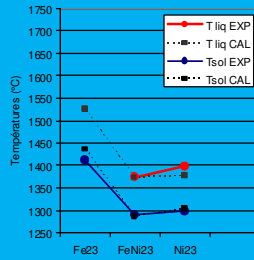
Faculté des Sciences et Technologies



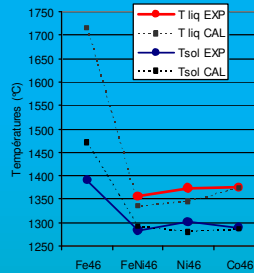
Interdendritic carbides of chromium or tantalum are among the main reinforcing phases in superalloys. They allow them being used at high temperature under mechanical stresses. However the presence of such carbides can be detrimental for the refractoriness. In addition the morphologies and volume fractions of these carbides may evolve to better correspond to the thermodynamic equilibrium at the service temperature, with possible consequences on the properties of the alloys. The study aims to better know the fusion temperature ranges, the metallurgical stable states at high temperature of several foundry chromium-rich alloys based on iron-nickel and nickel and reinforced by chromium or tantalum carbides. The set of studied alloys will be also enriched with a TaC-containing cobalt alloy. Thereafter the metallographic observations and quantitative measurements will allow testing the accuracy of thermodynamic calculations in the (Fe and/or Ni)-Cr-C-Ta before using this tool for identifying new chemical compositions allowing to improve refractoriness without too important loss of strengthening carbides.

elaboration of 7 alloys by high frequency induction melting under argon

| % mass. | base | Cr | C | Ta |
|---------|--------|----|-----|----|
| Fe23 | Fe | 30 | 0.2 | 3 |
| Fe46 | Fe | 30 | 0.4 | 6 |
| FeNi23 | Fe=Ni | 30 | 0.2 | 3 |
| FeNi46 | Fe=Ni | 30 | 0.4 | 6 |
| Ni23 | Ni | 30 | 0.2 | 3 |
| Ni46 | Ni | 30 | 0.4 | 6 |
| Co46 | Co-9Ni | 30 | 0.4 | 6 |

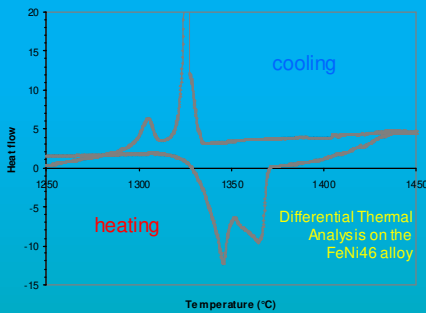
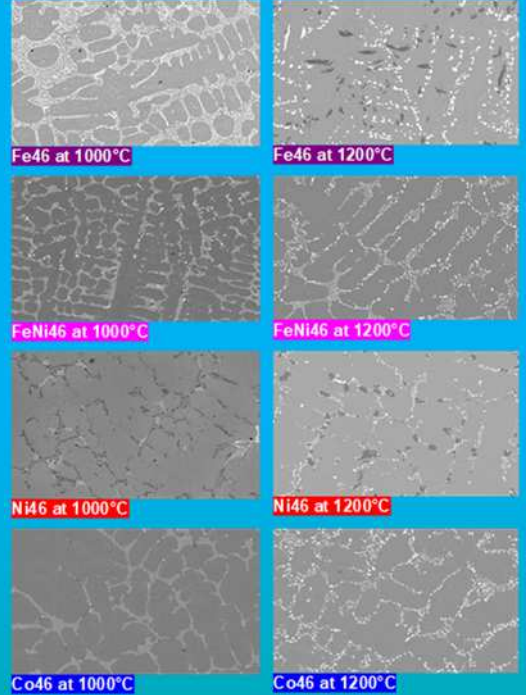


Alloys containing 0.2%C and 3%Ta

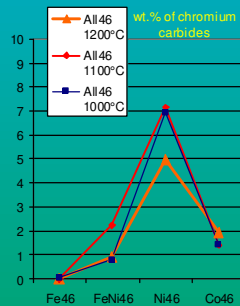
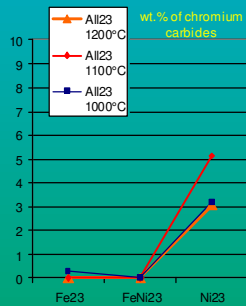


Alloys containing 0.4%C and 6%Ta

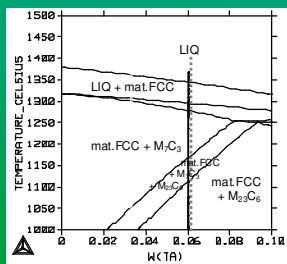
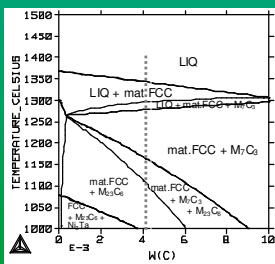
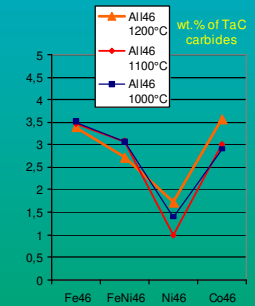
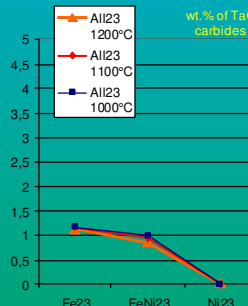
Stables microstructures of the alloys with equal atomic contents of Ta and C



solidus and liquidus temperatures measured by DTA and issued from Thermo-Calc calculations

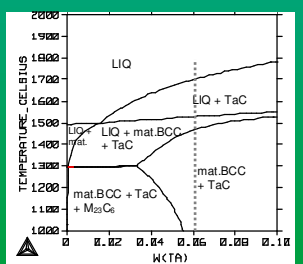
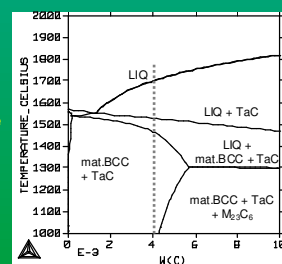


Carbide mass fractions deduced from the Cr and Ta contents in the matrix (WDS microprobe measurements)



Sections at 0.4%C and 6%Ta of two of the calculated phase diagrams

(ThermoCalc)



Ni-based alloys

Fe-based alloys

For the same carbon and tantalum contents the alloy microstructures vary versus the nature of the base element. Globally they were well predicted by thermodynamic calculations performed here. Among the alloys with equal atomic tantalum content and carbon content it is possible to obtain only tantalum carbides as interdendritic strengthening particles in the chromium-rich Fe-based, (Fe + Ni)-based and Co-based alloys. In contrast this is obviously not the case of the Ni-based alloys which necessarily also contain chromium carbides. With their solidus temperature higher than 1400°C, the best refractoriness is given by the iron-based alloys. Their melting point may increase again by a simple modification of the carbon and tantalum contents. Unfortunately the refractoriness of the other alloys cannot be really improved since thermodynamic calculations showed that they have already the chemical compositions which lead to the maximal solidus temperatures.