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HIGH TEMPERATURE CHARACTERISTICS OF ZIRCONIUM CARBIDES-STRENGTHENED COBALT-BASED AND IRON-BASED ALLOYS SPECIFIED USING DIFFERENT THERMAL ANALYSIS METHODS

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► **To cite this version:**

Jérémy Peultier, Valentin Kuhn, Patrice Berthod, Mélissa Ritouet-Léglise, Thierry Schweitzer, et al.. HIGH TEMPERATURE CHARACTERISTICS OF ZIRCONIUM CARBIDES-STRENGTHENED COBALT-BASED AND IRON-BASED ALLOYS SPECIFIED USING DIFFERENT THERMAL ANALYSIS METHODS. 1st Journal of Thermal Analysis and Calorimetry Conference, Jun 2017, Budapest, Hungary. hal-03229273

HAL Id: hal-03229273

<https://hal.science/hal-03229273>

Submitted on 18 May 2021

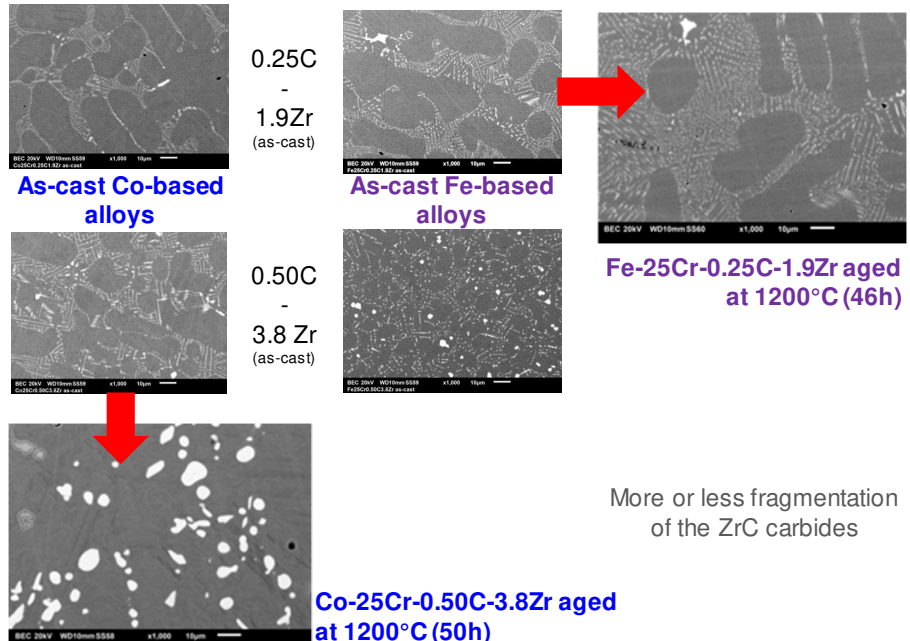
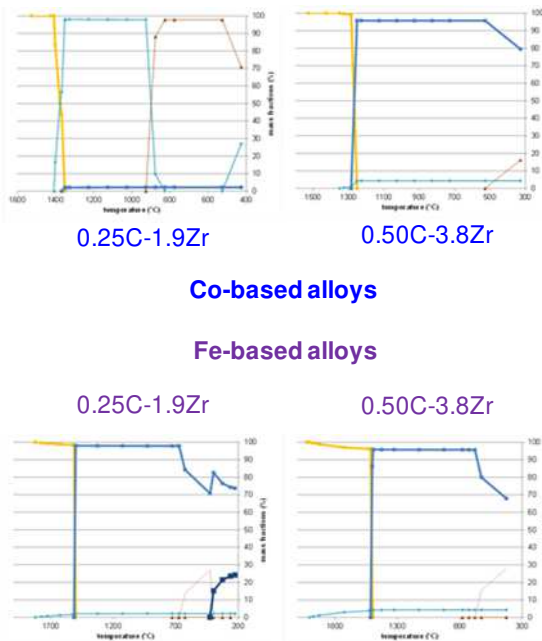
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Some of the conventionally cast alloys based on cobalt or on iron can be potentially very interesting high temperature materials. Their strengthening by interdendritic carbides morphologically favourable and stable enough at elevated temperature may allow them challenging gamma/gamma prime nickel-based single crystals for applications at temperatures exceeding 1100°C. Such carbides may be MC-types ones, for example TaC, HfC or ZrC. This is this last carbide which was under interest in this work. Four 25wt.%Cr-containing alloys, two based on cobalt and containing (0.25C, 1.9Zr) or (0.50C, 3.8Zr) and two other containing the same chromium, carbon and zirconium quantities but based on iron, were elaborated by foundry. Parts were exposed to 1200°C and the as-cast and aged microstructures were characterized. In parallel the four alloys were also subjected to DTA (differential thermal analysis) to specify their solidus and liquidus temperatures when possible. In parallel again calculations were carried out with Thermo-Calc N to help understanding the microstructure formation during cooling from the liquid state and to know the theoretical melting ranges and stable microstructures at 1200°C.

THERMODYNAMIC CALCULATIONS

AS-CAST AND 1200°C-AGED MICROSTRUCTURES



More or less fragmentation of the ZrC carbides

DIFFERENTIAL THERMAL ANALYSIS RESULTS

Co-based alloys

Mushy zone temperature range

Fe-based alloys

0.25C-1.9Zr

0.25C-1.9Zr

Fusion over: 1330 → 1445°C
Solidification over: 1350 ← 1400°C

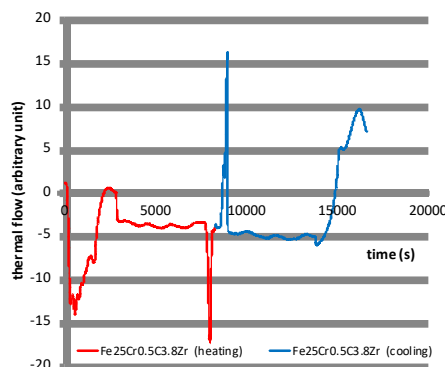
Fusion over: 1445 → > 1500°C
Solidification over: 1450 ← > 1500°C

0.50C-3.8Zr

0.50C-3.8Zr

Fusion over: 1340 → 1420°C
Solidification over: 1350 ← 1385°C

Fusion over: 1445 → > 1500°C
Solidification over: 1445 ← > 1500°C



The as-cast microstructures, observed by Scanning Electron Microscopy, appeared as being dendritic with script-like ZrC carbides forming a eutectic compound with the matrix in the interdendritic spaces. In three out of four alloys other ZrC carbides appeared too, obviously of a hypereutectic origin since blocky and not located between the matrix dendrites generally. This was confirmed by Thermo-Calc calculations realized for successive decreasing levels of temperature for simulating solidification. The DTA experiments showed that the two cobalt alloys start melting and finish solidifying near 1340°C while their liquidus temperatures were of about 1400°C or slightly above. The two iron alloys appear significantly more refractory with solidus temperatures around 1445°C and liquidus temperatures higher than 1500°C, measurement not achievable with the used apparatus. The experimentally determined temperatures were globally consistent with Thermo-Calc predictions. After several tens hours spent at 1200°C the ZrC carbides appear more or less fragmented and their volume fractions (assessed by image analysis assuming equivalence between surface and volume fractions), converted using the volume mass of both ZrC and matrix, were globally consistent with the mass fractions issued from Thermo-Calc calculations for 1200°C.