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Development of high chromium ferritic steels strengthened by intermetallic phases

B. Kuhn[a,*], M. Talik[a,b], L. Niewolak[a], J. Zurek[a], H. Hattendorf[c], P.J. Ennis[a,1], W.J. Quadakkers[a], T. Beck[a], L. Singheiser[a]

[a] Forschungszentrum Jülich GmbH, Institute for Energy and Climate Research (IEK), Microstructure and Properties of Materials (IEK-2), 52425 Jülich, Germany
[b] Czech Technical University in Prague, Zikova 4, 160 00 Praha 6, Czech Republic
[c] Outokumpu VDM GmbH, Kleffstraße 23, 58762 Altena, Germany

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ABSTRACT

Microstructural features, mechanical and steam oxidation properties of ferritic 18-23 wt% chromium model steels, strengthened by the precipitation of intermetallic phases, were investigated. The behavior of the commercially available ferritic steel Crofer® 22 H [1-4], originally developed for the application in automotive solid oxide fuel cell (SOFC) powered auxiliary power units (APUs) [5-7], was compared with that of optimized model alloys with systematic variations in Cr, Nb, W and Ti content. The main aim of the studies was the estimation of the potential suitability of these steels as construction materials in power plants with live steam temperatures around 600 °C.

Some of the optimized trial alloys demonstrated remarkable characteristics at 600 °C. Results of constant load creep experiments and steam oxidation tests indicate the potential of these alloys as candidate materials for application in highly efficient steam power plants with steam temperatures above 620 °C. At high stress levels some of the presented alloys, especially those containing enhanced levels of W and Nb, even exhibit higher creep strength than standard ferritic-martensitic steel P92. The amount of strengthening $(Fe,Si,Cr)_2(W,Nb)$ – Laves phase particles is found to correlate well with the level of W- and Nb-alloying and in contrast to ferritic-martensitic steels, the formed Laves phase particles are highly stable at elevated temperature. Owing to the high contents of chromium, the model alloys have excellent steam oxidation resistance. A way to preserve favorable steam oxidation properties and diminish undesirable (Fe,Cr)-σ-phase formation is outlined.

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*Corresponding author. Tel.: +49 2461 61 4132; fax: +49 2461 61 8284.
E-mail address: b.kuhn@fz-juelich.de (B. Kuhn).
[1] Now visiting Professor at University of Leicester, University Road, Leicester LEl 7RH, United Kingdom.

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