Evaluation of FP Chemistry under Severe Accident Conditions with Focus on the Effects of BWR Control Material
(6) Oxidation behavior of B_4C/SS/Zry mixed melts phases

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This work describes the oxidation and vaporization behaviors from simple Fe-B phases (Fe_2B, FeB) under steam conditions, which contributes to the experimental determination of boron (B) release kinetics from B-containing complex melts (B_4C/SS/Zry) during a severe accident. The oxidation and vaporization behavior of these samples was found to be influenced by their B/Fe ratio and by the formation of Fe-B-O compounds.

Keywords: B_4C-SS-Zry, Oxidation, Steam, Severe Accident, Boron Release Kinetics

1. Introduction

During a BWR Severe Accident (SA), B-containing complex melts (B_4C/SS/Zry) can be formed due to the interaction of the control rods with the cladding and structural materials. This can affect B release kinetics, decreasing it by the formation of less volatile Fe-B (or Zr-B) compounds, and could consequently influence the fission product behavior [1]. While reliable set of data and models exist for the behavior of B_4C under SA conditions, those for B_4C/SS/Zry melts are limited and only qualitative [2]. The aim of our studies is to acquire kinetic data for the B release and oxidation of these complex phases. Such results will provide data to improve SA codes models. In this work, the oxidation and vaporization behaviors were investigated on simple representative Fe-B compounds [1].

2. Experimental

The B-ReK (Boron Release Kinetics) facility was applied for these experiments, which consists of a TGA (ThermoGravimetric Analyzer) connected to a customized steam generator. FeB and Fe_2B samples were prepared by powder metallurgy from commercial materials. Weight changes were measured by TGA under steam conditions (70°C dew point) at different temperatures (1073-1373 K). The oxidation and vaporization behavior was interpreted based on the characterization of the samples before and after the tests by XRD measurements.

3. Results and Conclusions

The XRD patterns (Figure 1) after the TGA tests at 1173 K showed the possible presence for both samples of B_2O_3, as an amorphous phase presenting a broad hump. B_2O_3 was completely vaporized in the tests at 1373 K, after which Fe_2O_3 was detected for the FeB sample, indicating its complete oxidation. While for Fe_2B at 1373 K, Fe-B-O compounds (such as Fe_3BO_5, $Fe_{21.34}O_{32}$) were found, indicating only its partial oxidation. The lower weight gain and higher weight loss for FeB respect to Fe_2B (Figure 2) are mainly related to the higher B/Fe ratio which can lead to enhanced formation of B_2O_3. From these results, it can be concluded that the oxidation and vaporization kinetics of Fe-B compounds are influenced by the B/Fe ratio. Finally it was demonstrated that the B release is suppressed by the formation of Fe-B-O compounds.

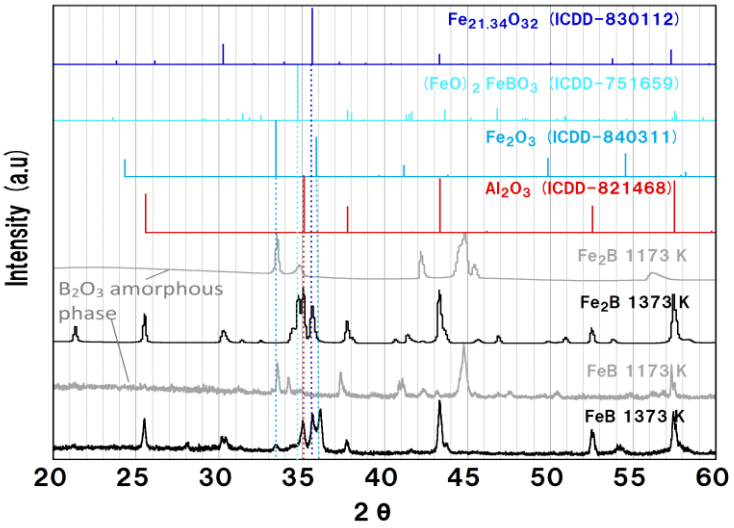

Figure 1 – XRD analyses of the samples at 1137 and 1373 K. Al_2O_3 present in the samples are impurities from the sample holder.

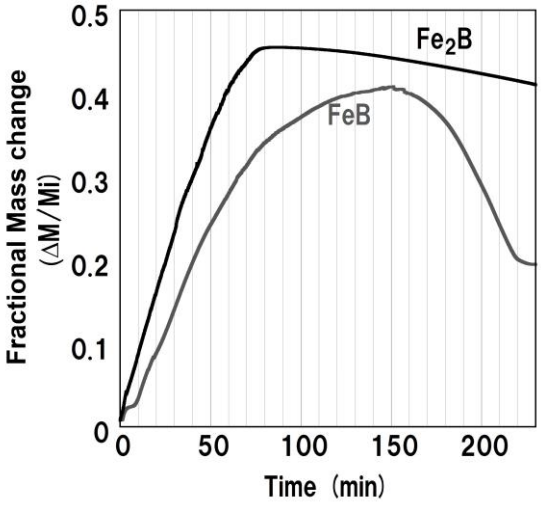

Figure 2- Mass change in the TGA tests at 1373 K in steam for the FeB and Fe_2B samples.

References

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