Corrosion Characteristics of FeCrW Model Alloys in 360°C High Purity Water

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Introduction

- One of the main candidates for fusion power reactors' structural materials are Reduced Activation Ferritic/Martensitic Steels.
- These iron-based RAFM steels are mainly composed of 8~9% Cr and 1~2% W and replaced high activation minor elements from conventional FM steels to low activation elements like V, Ta etc.[1].
- Water is one of the main candidates for coolant of various fusion reactor designs, and the studies with corrosion characteristics of FM steels showed the Cr concentration dependency on corrosion resistance.
- With reducing Cr concentration below 12%, the corrosion rate increased rapidly, but considering the other mechanical properties like fracture toughness, it appears that the 9% Cr is the most promising Cr concentration[2,3].
- Although RAFM steels are quite vulnerable to PWR conditions due to low Cr concentration, it seems that water-cooled components of RAFM steels can be safely operated, at least under proper coolant chemistry control[4].
- As for the first step of the study, we have investigated corrosion properties of three model alloys in stagnant 360°C high purity water conditions.

Literature Data Analysis

- Before conducting corrosion tests, we collected weight change data from prior studies conducting corrosion tests with RAFM steels or other FM steels, as shown in Fig.1 [5-12].
- As the test temperature increases, the weight change rate becomes higher. It appears that the overall weight gain behavior follows the parabolic law more significantly as the test temperature increases.
- Under flowing water conditions, the weight loss was observed. It seems that the weight loss is suppressed as the dissolved oxygen(DO) concentration of the flowing water becomes high (see Fig. 1) [12].
- To identify insufficient data points of conducted test conditions, we collected corrosion test conditions that had been reported on the prior studies and arranged like Fig. 2.

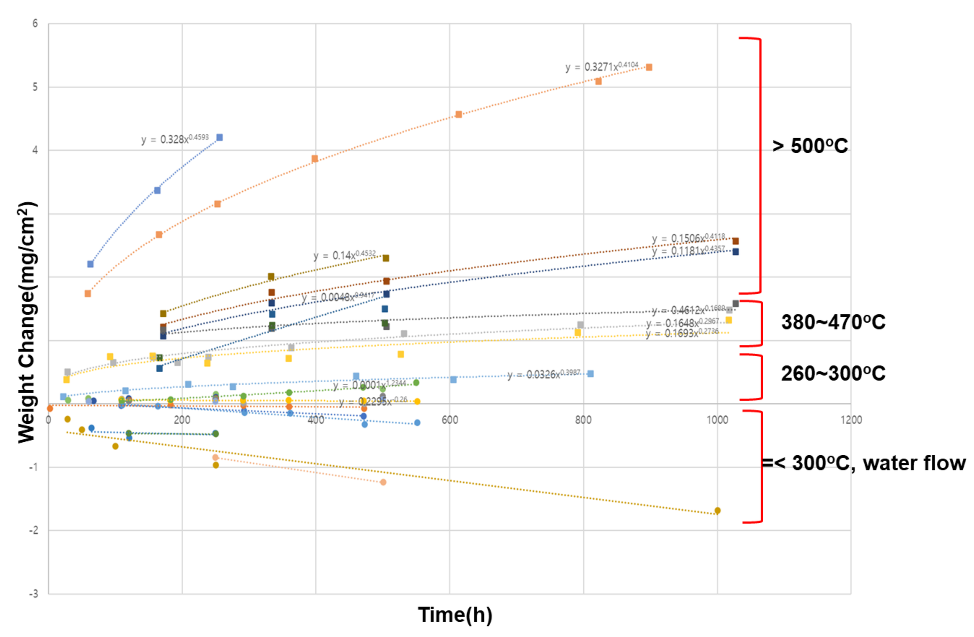

Fig.1. Weight change results from prior corrosion tests studies of FM steels [5-12].

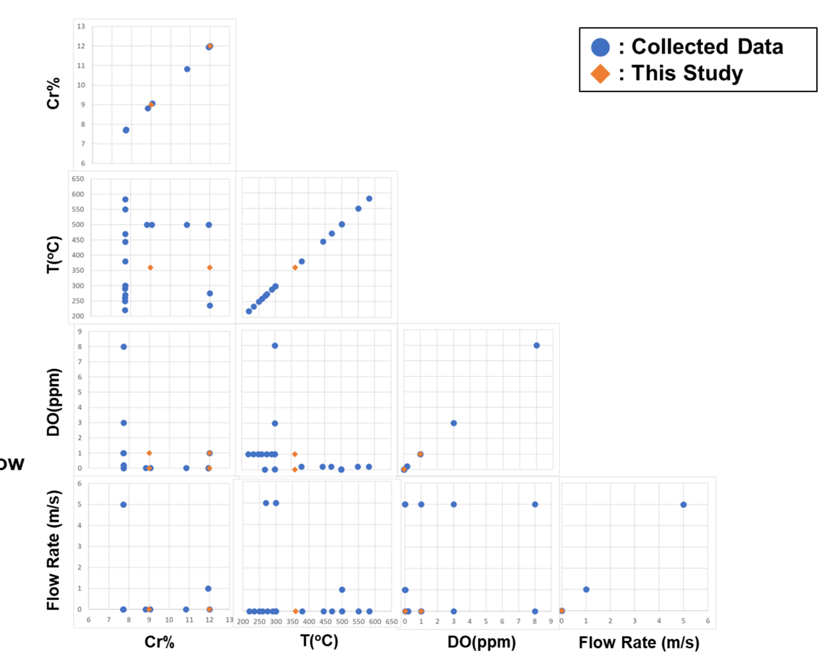

Fig.2. Corrosion test conditions of prior studies. The Orange dots are the conditions of this study.

Experimental Methods

▪ Experimental conditions

Parameter	Value
Material	Fe – 9, 12% Cr – 0, 1% W
Temperature	360°C
Water Chemical Condition	Dissolved Oxygen(DO) : Deaerated, 1ppm
Water Flow	Static
Exposure Time	50, 100, 150, 300h

▪ Alloys chemical compositions (wt%)

	Fe	Cr	W
Fe12Cr1W	Bal.	11.4 %	1.04 %
Fe9Cr1W	Bal.	9.2 %	1.07 %
Fe9Cr	Bal.	8.8 %	-

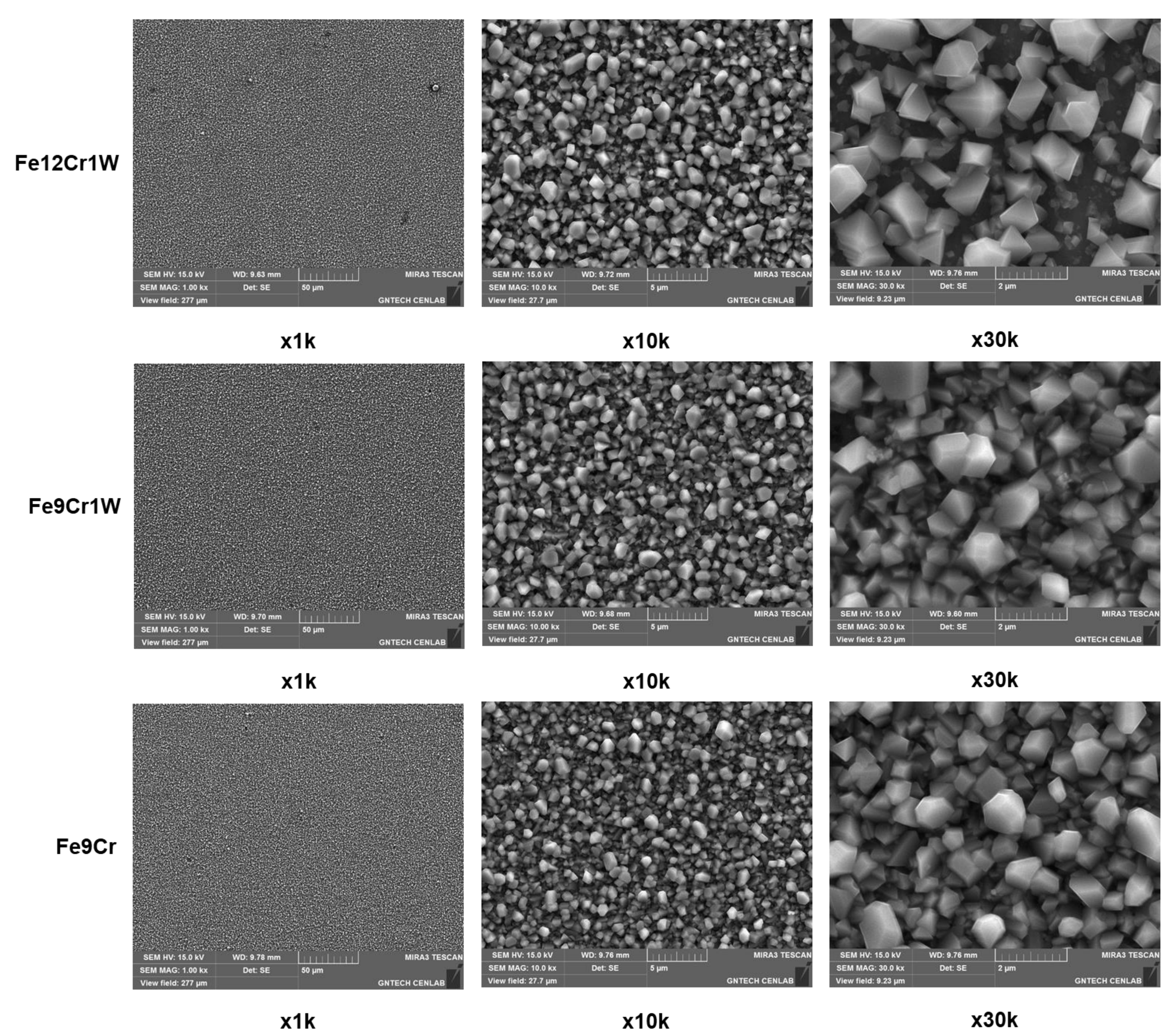

Fig.4. Surface oxide morphology results of FeCrW model alloys (SEM SE image). Test conducted in DO level of 1ppm for 50h.

Results

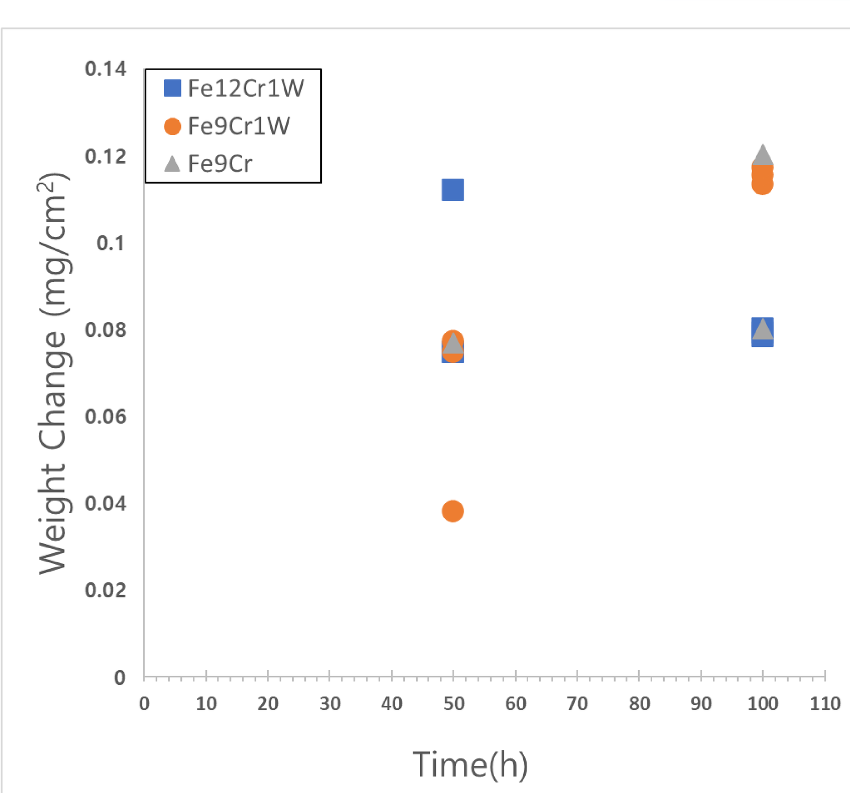

Fig.3. Weight change results of FeCrW model alloys in DO 1ppm condition

- Until 100h of corrosion test in DO level of 1ppm, the weight change rate does not seem to be affected by Cr concentrations (see Fig. 3).
- After 50h of corrosion test conducted in DO level of 1ppm, the surface oxides were examined by SEM (see Fig. 4).
- The blocky oxides were formed on the surface of the specimens.
- There was no significant difference in surface oxide morphology until the 50-hour corrosion test.

Future Work

- The continuous corrosion tests up to 300h is on going and additional corrosion test in DO level of 0ppm will be conducted.
- The results of the corrosion tests will be combined and compared with the prior corrosion studies.
- In addition to weight change measurement and surface morphology analysis, measurement of dissolution rate of the alloys, XRD surface analysis and oxide film cross-section analysis will be conducted to study FeCrW model alloys' corrosion characteristics in high temperature, high purity water.

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