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A Study on Fretting Wear Property of CVD SiC and Sintered SiC

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1. Introduction

Silicon Carbide is broadly used as high temperature structure material because of its high temperature tolerance and superior mechanical properties. After the fukushima nuclear power plant accident, SiC proposed as one of the alternative materials for LWR fuel cladding to provide enhanced safety margin. Grid-to-rod fretting wear-induced fuel failure is known to occur due to flow-induced vibration of the reactor core and grid-to-rod gap. In this paper, wear tests for CVD SiC plate and sintered SiC tube were performed with two types of spacer grids.

2. Methods and Results

2.1 Specimen preparation

CVD SiC supplied by Morgan Advanced Material and Hexoloy SE SiC (Sintered SiC) were used in this experiment. The dimension of CVD SiC specimens were 10mm×10mm×3mm. The outer diameter and the thickness of Hexoloy SE SiC were 12.7mm and 1.6mm, respectively. CVD SiC specimens were polished to 0.25㎛ surface finish to examine the effect of fretting wear on the surface of CVD SiC exactly. CVD SiC, Hexoloy SiC and PLUS 7 spacer grid used in this experiment are given in Fig.1.

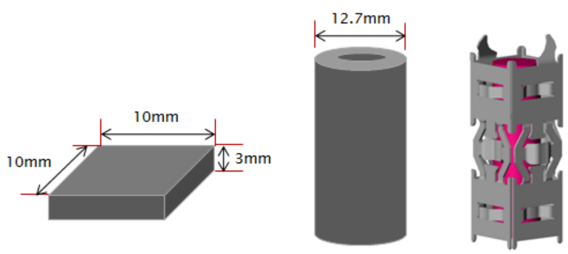

Fig. 1. Schematics of CVD SiC, Hexoloy SiC and PLUS7 spacer grid

2.2 Corrosion test

The corrosion test for CVD SiC plates was performed in an autoclave using water of 3.5ppm LiOH, under a pressure of 15MPa, for corrosion times up to 30days and at a temperature of 360℃.

Fig.2 shows the surface of as-received specimen and corroded specimen observed with scanning electron microscope. It was found that there is no particular feature on microstructure of specimen before the corrosion test. However, the grain boundaries were attacked and penetrated after the corrosion test, as shown in Fig.2 (b), (c) and (d).

Table I: Corrosion test conditions

Specimen	Pressure (MPa)	Temperature (℃)	LiOH (ppm)	Test times (day)
CVD-SiC	15	360	3.5	7
				15
				30

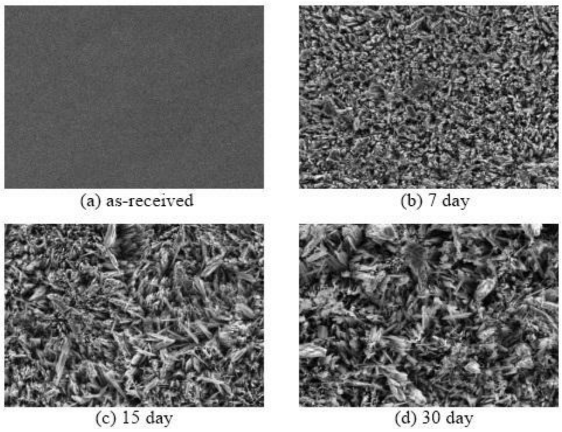

Fig. 2. Scanning electron micrographs of CVD SiC before and after the corrosion tests (x500)

2.3 Fretting Wear test

Fig.3 shows the fretting wear test equipment. The fretting wear test for as-received and corroded CVD SiC plates was performed using sliding amplitude of 1mm, load of 15N and 800rpm for 30 minutes in room temperature water.

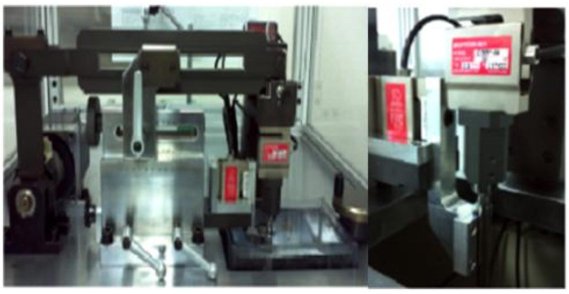

Fig. 3. Fretting wear test equipment

As shown in Fig.4, weight loss caused by the fretting wear increased with corrosion time. In contrast with zirconium alloy which is currently used for cladding tubes, corroded SiC specimen wore more than non-corroded SiC specimen. It can be seen that increase in weight loss shown in Fig.4 is also correlated with the grain boundary attack shown in Fig.2. The surface of as-received specimen was smooth while one of corroded specimen was rough because of grain boundary attack.

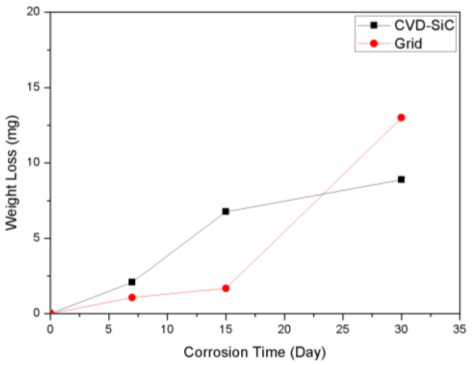

Fig. 4. Variation of weight loss with increasing corrosion time

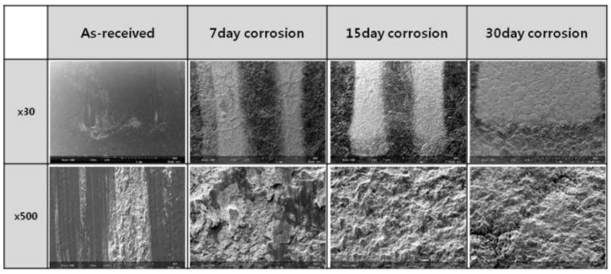

Fig. 5. Scanning electron micrographs of CVD SiC after the wear tests (x30, 500)

Fig.5 shows the scanning electron micrographs of wear surface on the CVD SiC specimens after the wear tests. The wear surface becomes wider with the increase in corrosion time. It can be seen that corrosion depth affect wear loss. The grain boundary attack was increased over the corrosion time and it increased corrosion depth.

The fretting wear test for Sintered SiC tubes was performed using sliding amplitude of 1mm, load of 15N and 800rpm for 15, 30, 90, 150 minutes in room temperature water. Fig.6 shows wear behavior of Hexoloy SiC tube. It can be seen that the wear rate increased with time in the early stage of the test. However, after 30minutes, the wear rate reduced and remained consistent. As shown in Fig.7, the specimen tested for 30 minutes generated larger wear trace than the specimen tested for 15 minutes.

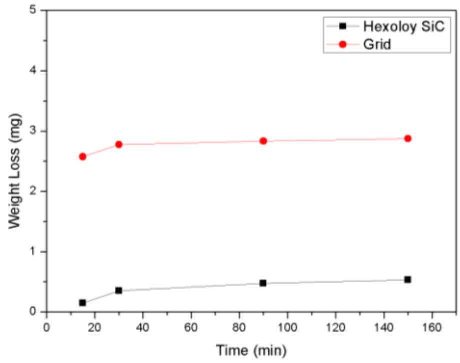

Fig. 6. Wear behavior of Hexoloy SiC tube with increasing wear test time

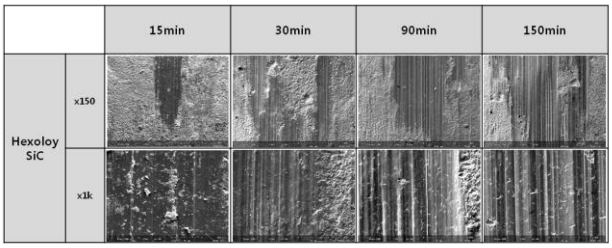

Fig. 7. Scanning electron micrographs of Hexoloy SiC after the wear tests (x150, 1k)

3. Conclusions

Wear test of corroded and non-corroded CVD SiC plates indicate that wear resistance of corroded specimen is lower than one of non-corroded specimen in contrast with zirconium alloy cladding tube. It may be affected by rough surface of corroded specimen caused by grain boundary attack. Wear test of Hexoloy SiC tube shows that wear rate increased with time in the early stage of the test and decreased after 30 minutes.

REFERENCES

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