SiC Coating Process Development Using H-PCS in Supercritical CO_2

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1. Introduction

Due to hydrogen explosion in the Fukushima nuclear power plant, analysis of fuel cladding became one of important issues.

The purpose of this experiment is to see the possibility of the production of a metal cladding that contains SiC composites as a protective layer.

To make SiC composites, the current process needs high temperature (about 1100℃) for infiltration of fixing materials such as SiC.

So, we need a low temperature process to make a metal cladding with SiC composites as a protective layer. We tried SiC coating using supercritical fluids.

Supercritical fluids are the substance exists over critical temperature and critical pressure. It is hard to expect that there would be a big change as single-solvent as the fluid is incompressible and the space between the molecules is almost steady. But the fluid which is being supercritical can bring a great change when it is changed its pressure near its critical point, showing its successive change in the density, viscosity, diffusion coefficient and the polarity.

We have tested the 'H-PCS into SiC' coating experiment with supercritical CO_2 which has the high penetration, low viscosity as well as the high density and the high solubility that shows the property of the fluid.

2. Methods and Results

In this section some of the techniques used to supercritical CO_2, coating method 'H-PCS into SiC' are described.

2.1 Apparatus used in the experiment

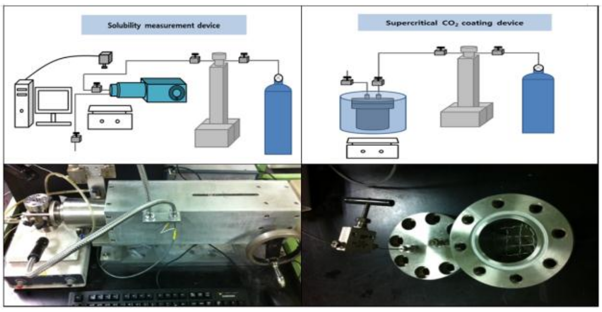

Fig. 1. Solubility measurement, Supercritical CO_2 coating device

2.2 Experimental Procedures

As we mentioned earlier, we have used supercritical CO_2 because of its high speed of diffusion, the powerful penetration and its easy property that can be changed only with the pressure and the changing degree. Also it is harmless to humans and has a weak influence on the environment. Table I is properties representative in accordance with CO_2's state

Table I: Properties representative in accordance with CO_2's state

	Gas P=1bar T=15~30℃	Supercritical Fluid		Liquid P=1bar T=15~30℃
		T_c, P_c	T_c, $4P_c$	
Density (g/cm^3)	0.0006 ~ 0.002	0.2 ~ 0.5	0.4 ~ 0.9	0.6 ~ 1.6
Viscosity (μPa·s)	10 ~ 30	10 ~ 30	30 ~ 90	200 ~ 3000
Diffusion Coefficient (cm^2/sec)	0.1 ~ 0.4	0.7×10^{-3}	0.2×10^{-3}	$(0.2~2) \times 10^{-5}$

Figs. 2 and 3 These are the pictures and the graphic charts being taken with the camera to measure the H-PCS solubility of CO_2 before it is coated.

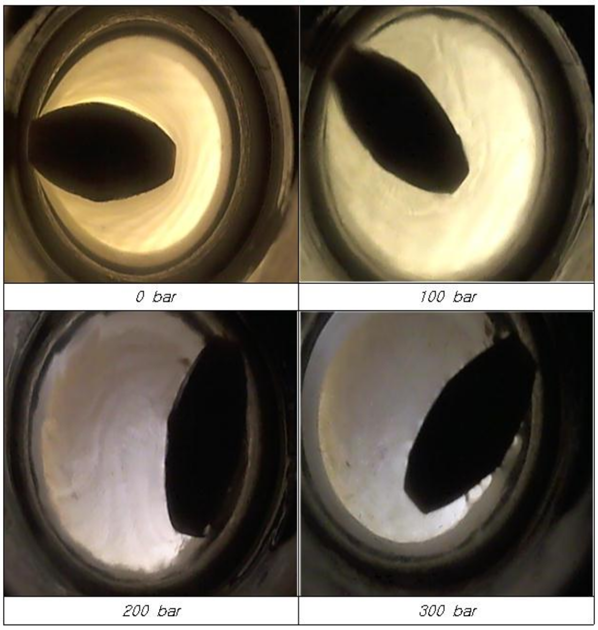

Fig. 2. H-PCS solubility measurement to Supercritical CO_2

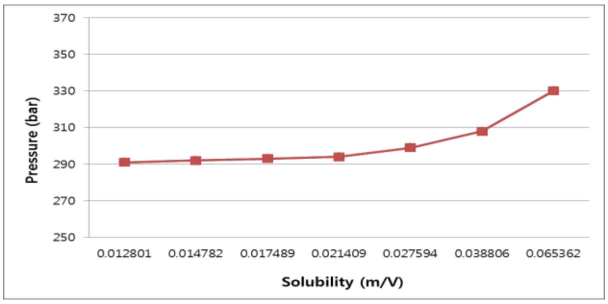

Fig. 3. H-PCS solubility measurement to supercritical CO_2

It was tested under the constant temperature and time condition, with the changing pressure to get permeated H-PCS into SiC.

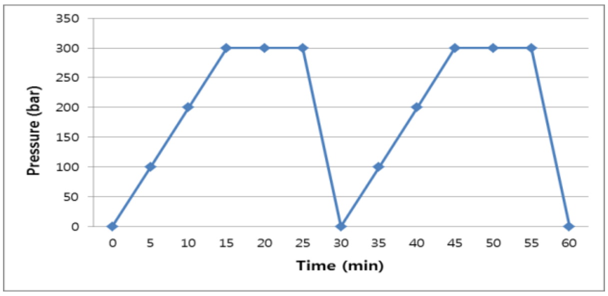

Fig. 4. Experiment condition

2.3 Experimental Result

It can be seen from the OM(optical microstructure), SEM(Scanning Electron Microscope) below, that the penetration of H-PCS into the SiC between is different the atmospheric pressure and the supercritical CO_2

It is certain that the result in the left picture which was tested in the atmosphere pressure has a lot of remaining empty space but the supercritical CO_2 shows that the H-PCS permeated perfectly between SiC fibers.

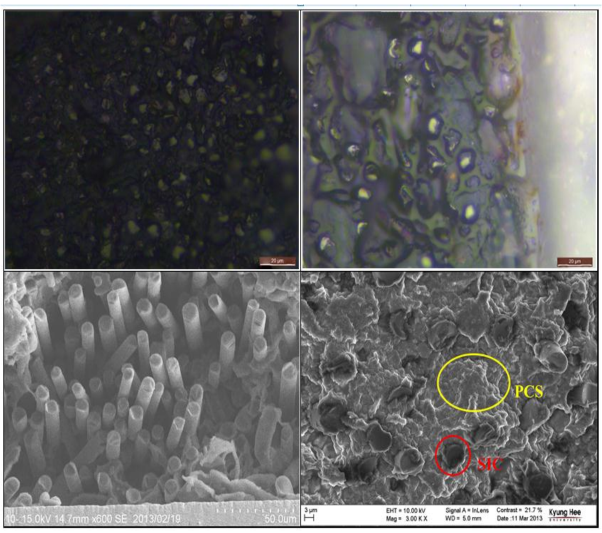

Fig. 4. Experimental result (Dip coating, Supercritical CO_2)

3. Conclusions

This experiment is for SiC coating using H-PCS in supercritical CO_2.

It shows the clear difference that the penetration of H-PCS into the SiC between dip coating method and using the supercritical CO_2

If we can make a metal cladding with SiC composites as a protective layer, the use of the cladding will be very broad and diverse.

Inherent safe nuclear fuels can be possible that can stand under severe accident conditions.

SiC is known to be one of a few materials that maintain very corrosion-resistant properties under tough corrosive environments.

The metal cladding with SiC composites as a protective layer will be a high-tech product that can be used in many applications including chemical, material, and nuclear engineering and etc.

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