Near-Net Shaping of SiC/SiC Square Tubes Based on Advanced NITE Process

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Introduction

Toward the goal of Accident Tolerant Fuel (ATF) development for LWRs, intensive R & D programs of SiC/SiC composites as ATF components are on-going in OASIS, Muroran Institute of Technology. Typical challenges are the fabrication of all SiC/SiC fuel assembly including clad, channel box, grids, control rods, nozzle and so on. Thus, the development of near net shaping technique for the production of SiC/SiC components with various sizes and shapes is one of the important technical issues. As an representing result, near net shaping for SiC/SiC square tube by DEMO-NITE process is presented. As the main shaping processes, Hot Press (HP) and pseudo-Hot Isostatic Press (Pseudo-HIP) are applied. The results so far are verifying the technological fundamentals for making channel box designed for ATF with sufficient productivity and economical competitiveness. The microstructure and mechanical properties of SiC/SiC square tube fabricated is provided and the remaining issues for improving attractiveness of the products for deployment are discussed.

Background

Characteristics of NITE and other conventional SiC/SiC

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<th>CVI</th>
<th>PIP</th>
<th>RS</th>
<th>NITE</th>
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<td>Crystallinity</td>
<td>●</td>
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<td>Purity</td>
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<td>Gas tightness</td>
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<td>Mechanical Properties</td>
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<td>Thermal Conductivity</td>
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<td>Wear Resistance</td>
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R&D Activities of OASIS, Muroran IT on SiC/SiC Core components for LWR

Concepts of Near Net Shaping for DEMO-NITE SiC/SiC with various shapes and sizes

High Productivity/Low Cost
1. HP (Uni-axial press)
   - Preform sheet or PCR
   - HP Direct Uni-Press by mold
   - Preform is prepared by stacking of prepreg sheets or winding of PCR on square mandrel unidirectionally.
   - Preform is sintered by direct uni-axial press under high temperature.
   - HP is suitable for the fabrication of short square tube with thick wall.

2. P-HIP (Pseudo-3 axial press)
   - Preform is prepared by stacking of prepreg sheets on square mandrel.
   - Preform is sintered by indirect pseudo-3 axial press under high temperature.
   - Solid powder used as a pressure transmitter
   - P-HIP is suitable for the fabrication of medium length square tube with thin wall.
   - Various fiber architecture can be applied.

3. HIP (3 axial press)
   - Preform is prepared by stacking of prepreg sheets or winding of PCR on round mandrel.
   - Preform is sintered by 3-axial press under high temperature.
   - Various fiber architecture can be applied.
   - It is suitable for the fabrication of long round tube with thin wall.

Experimental Results

1. HP (Uni-axial press)
   Before HP: Fiber: PyC coated CeF-NITE
   After HP:
   - Short square tube with thick wall is fabricated by HP.
   - It has well densified SiC matrix and pseudo-ductile fracture behavior.

2. P-HIP (pseudo-3 axial press)
   Before P-HIP:
   - Fiber: PyC coated CeF-NITE
   - Fiber Architecture: 0/90 HP
   - Dimension: 40X40X50mm
   - Density: 2.9 g/cm³
   After P-HIP:
   - Square tube with medium length and thin wall is fabricated by P-HIP.
   - It has well densified SiC matrix but slightly deformed SiC fiber.
   - Further study is needed to optimize fabrication condition.

Summary

- As a representing accomplishment, square tubes have been successfully produced by HP and P-HIP processes.
- DEMO-NITE square tubes fabricated by HP and P-HIP showed attractiveness from high productivity and low cost.
- DEMO-NITE products by HP and P-HIP, other than square tubes, are under development looking for aero-space, energy and environmental applications.