ADVANCES AND TECHNICAL CHALLENGES IN DEVELOPMENT OF CMC

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CMCs have been under development for more than 30 years, and the application of CMC parts for commercial aero-engines just started. IHI began to study the development of CMCs at the beginning of 1990, mainly for applying in turbine parts as shrouds, nozzles and blades. For these parts, reduction of cooling air is one of most critical issues. At this moment, CMC has 1300 degree C temperature capability and a development target of temperature limit becomes 1400 degree Celsius.

To achieve this challenging target, IHI has been studying matrix, interphase coating and environmental barrier coating under the sponsored research by NEDO (New Energy and Industrial Technology Development Organization).

3rd generation sintered SiC fibers - Hi-Nicalon type-S and Tyranno SA - and 3D woven fabric were applied for this study. BN interphase coating was optimized to get such a high temperature capability. SiC matrix was infiltrated by CVI process as a primary matrix. After CVI-SiC matrix, seal material is required to achieve oxidation resistance. New matrix was developed to fill large porosities between CVI matrix. Early stage of development, borosilicate glass was used for seal matrix. But the temperature capability of it was not enough. So, new matrix applying rare-earth silicates was studied. Specimens made of new matrix were exposed under steam environment at 1400 degree Celsius. Material tests like tensile, low cycle fatigue and creep were conducted to know the potential of this material. Through these tests, it showed good properties. Then, we conducted engine demo testing of CMC turbine shrouds applying this new material. This test was successfully completed.

Environmental Barrier Coating (EBC) was also developed by applying rare-earth silicates to resist an CMAS corrosion at 1400 degree Celsius. Specimens covered by this coating were exposed at high temperature with CMAS and the micro-structure was evaluated. Reaction phases were formed at the boundary between EBC and CMAS and it became a protection layer to prevent further corrosion by CMAS attack. We will introduce these efforts conducted under NEDO project.