INTERNATIONAL RELIABILITY ASSESSMENT PROJECT THROUGH STANDARD PteranoSiC (SiC/SiC)

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Key Words: Reliability Assessment for CMCs, SiC/SiC (PteranoSiC), Multiple Inspection, Physical properties of CMC component, RMI

It is mandatory for CMCs to get a certification of reliability assessment method from the Authority to be implemented into Jet Engines. The international R&D project titled “Reliability assessment methodology for advanced ceramic matrix composites (CMCs)” started in March, 2021 funded by NEDO*. This project has been developing the method that evaluates multiple inspection items for each CMC component using multiple inspection techniques.

The damage tolerance, which is the most important feature of CMC, obtained by the heterogeneity of the composite structure and the diversity of the fracture process, makes it difficult to guarantee the reliability of CMC components, because all the individual components are different. Therefore, in order to guarantee the reliability of CMCs, it is considered necessary to evaluate more items than metals, ceramics and plastics. And it seems important not only to identify the size and location and shape of the isolate defect but also to detect defects comprehensively. For the comprehensive evaluation, it is appropriative to detect physical properties of CMC component such as thermal conductivity (k), elastic modulus (E), dielectric constant (ε), density (ρ), etc. Thermography, X-ray Talbot-Lau interferometer, Laser holography for a vibration, high-frequency dielectric constant measurement, etc. have been evaluated as inspection methods for detecting the physical quantities. Combining these inspection results, CMC reliability can be assessed.

SiC/SiC common test pieces were planned to be provided to international members which would evaluate the pieces by using their NDE equipment. Then we have developed SiC/SiC fabricating by RMI process and named it PteranoSiC. The σ_{ss}, the stress level for shifting from linear deformation to non-linear deformation, of SiC / SiC obtained in this study was ~ 200 MPa. The matrix penetration crack generation stress estimated from the ACK (Aveston-Cooper-Kelly) theory is about 180 to 220 MPa, indicating that the SiC / SiC produced in this study was well compounded.

For multiple inspection criteria, we considered a method of applying a load stress of σ_{ss} or less to one CMC. At this time, it is predicted that damage (hereinafter referred to as matrix crack generation, fiber / matrix peeling and slipping, fiber breakage, etc.) will occur in the CMC. For example, when the design stress is σ_0 ($<\sigma_{ss}$), it is possible to detect the presence or absence of damage generated during CMC and the spread of damage by applying a load of σ_0 or less. In particular, CMC has the characteristic that even if damage occurs, it stays in the material and the compliance of CMC itself changes due to the occurrence of damage. This idea is essentially different from the inspection technique when using materials that do not cause damage below the design stress. As a CMC inspection method, set the load level to σ_0 or less, and apply a method considered to be suitable for detecting damage in the CMC when a load is applied. Further studies are needed on the method of determining σ_0. In addition, this time, the matrix crack penetration stress σ_{ss} obtained from the stress-strain curve is used as the reference, but we think that the applied strain and energy can be used for ranking in the same way. We are still considering this issue.

This presentation is based on results obtained from a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO*).