【Grant-in-Aid for Scientific Research (S)】
Science and Engineering (Engineering)

Title of Project : Intelligent Manufacturing Science of Innovative Composite Structures Based on Optical-Fiber Life Cycle Monitoring

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Keyword : Composite Materials, Optical Fiber Sensor, Process Monitoring

【Purpose and Background of the Research】

Carbon Fiber Reinforced Plastic (CFRP) composites have been used as aircraft primary structures recently. However, the potential of CFRP has not been fully utilized due to difficulties in manufacturing and assembly as well as uncertainty of strength after accidental damage. An innovative approach is necessary for next-generation aerospace CFRP structures to balance both high manufacturability and performance.

Both thermoplastic CFRP and Out-of-Autoclave (OoA) CFRP have attracted much attention as such new material systems. Manufacturing process of these CFRP are much more difficult and complicated, and the quality control and assurance of CFRP structures are a big issue to be overcome.

Manufacturing process of such new materials often relies on trials and errors and workers' skills. However, the authors believe an innovative intelligent manufacturing sciences is necessary for CFRP quality assurance by combining advanced process monitoring technologies and multi-scale and multi-physics computational science.

In the present research, embedded optical fiber sensor systems are used to monitor the material behavior of CFRP materials during the manufacturing process and then during assembly and in practical operation environments, throughout the CFRP life. Then such characterized properties are fed into the process modeling based on multi-scale and multi-physics computational science. Through such efforts, intelligent manufacturing science is established to enable innovative design concept suitable for next-generation CFRP structures (Fig. 1).

【Research Methods】

Multi-point FBG and distributed optical fiber sensor strain and temperature measuring systems are improved and utilized to measure strain and temperature throughout the manufacturing process to the practical operations. Concurrently, a new theoretical and numerical process modeling is developed to explain the experimental data based on multi-scale and multi-physics approach. Then, the developed approach is used to establish a novel design methodology of CFRP bolt-less structures.

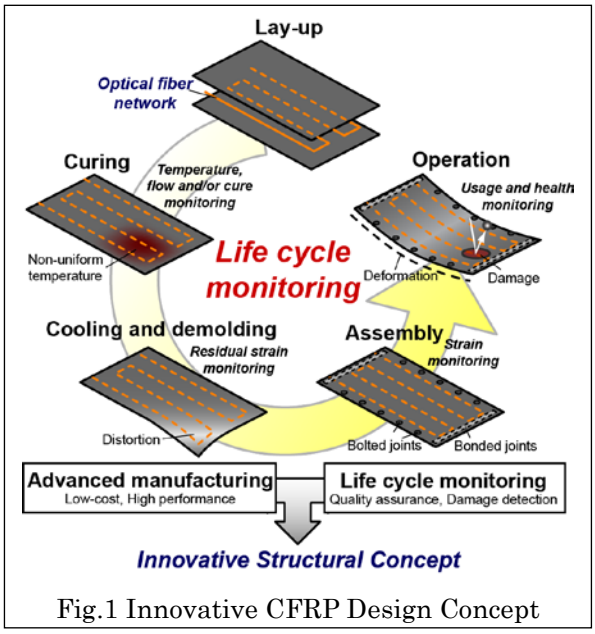

Fig.1 Innovative CFRP Design Concept

【Expected Research Achievements and Scientific Significance】

Innovative low-cost and high-performance CFRP design concept is highly demanded for next-generation single-aisle commercial aircraft. International competitiveness of Japanese aircraft manufacturers can be improved with such continuing efforts. The current study is one of the fundamental but practical approaches to support development of CFRP materials and structures.

【Publications Relevant to the Project】

・S. Minakuchi et al., "Life Cycle Monitoring and Advanced Quality Assurance of L-Shaped Composite Corner Part Using Embedded Fiber-Optic Sensor", Composites Part A, Vol. 48, 2013, pp. 153-161.

【Term of Project】 FY2014-2018

【Budget Allocation】 117,800 Thousand Yen

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