Microwave Electromagnetic Field Characteristic Inside Carbon Fiber Reinforced Plastic Structures—Evaluation Based on Reverberation Chamber and Human Phantom

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The usage of carbon fiber reinforced plastics (CFRP), which include primary materials in passenger aircrafts, has rapidly increased in recent years. With regard to electromagnetic compatibility issues, the electromagnetic field (EMF) characteristics of a metallic-body aircraft are well understood. However, the detailed characteristics of aircrafts based on CFRP materials require further investigation. In previous research, we measured the microwave EMF characteristics of CFRP materials, including the shielding and polarization characteristics (S. Futatsumori et al., IEICE Electronics Express, vol. 9, no. 6, pp. 531-537, 2012). We also evaluated the stored EMF energy and quality factors (Q-factors) of a CFRP reverberation chamber.

In this study, the microwave EMF characteristics inside CFRP structures with an internal human phantom is investigated using the reverberation chamber method. The Q-factor of the CFRP reverberation chamber is measured with and without a human phantom to examine the EMF characteristic dependence on the presence of passengers. Firstly, an aluminum reverberation chamber whose size is 1.45 m × 2.1 m × 1.8 m (width × depth × height) is employed for the measurement. The four sidewalls and the ceiling, except for the floor, can be replaced with CFRP laminates. Second, the transmission characteristics of the two antennas are measured between 500 MHz and 6 GHz using a network analyzer. Finally, the Q-factors of the reverberation chamber are calculated based on the equation in the IEC 61000-4-21 document.

Fig. 1(a) shows the Q-factors of the aluminum and the CFRP structures without a human phantom, which means under unloaded conditions. The material constant of the phantom is adjusted to be similar to that of an actual human body, in the 2 GHz band. The measured relative permittivity and loss tangent are approximately 43 and 1.1, respectively. The Q-factor with the CFRP structures between 2.5 and 6 GHz is almost one-half (S. Futatsumori, 2017 International Symposium on Electromagnetic Compatibility, pp.1-4, 2017). However, Fig. 1(b) shows the Q-factors with an internal human phantom. The difference between the aluminum and CFRP structures at 2.5–6 GHz is reduced by approximately 30%, which means that the difference in the aluminum and CFRP structures is reduced by the internal electromagnetic lossy materials.

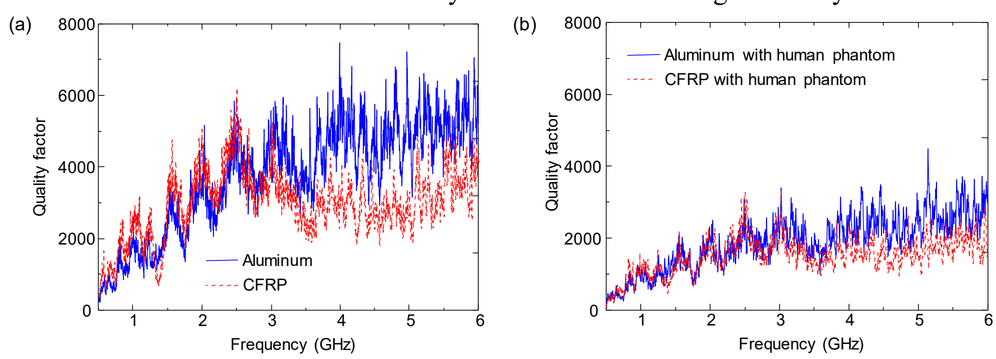

Figure 1. Measured Q-factor (a) without and (b) with a human phantom