Development of the Defects Detection System for Carbon Fiber Reinforced Plastic by Using Infrared Stress Analysis and Machine Learning

Yuta Kojima[1*], Kenta Hirayama[1], Katsuhiro Endo[1], Kazuya Hiraide[1], Mayu Muramatsu[2], Yoshihisa Harada[3]

[1]Department of Science for Open and Environmental Systems,
Graduate School of Keio University
Hiyoshi 3-14-1, Kohoku-ku, Kanagawa 223-8522, JAPAN
kojimayuta@keio.jp
kenta_hirayama@keio.jp
katsuhiro.endo@keio.jp
kazuya.hiraide@keio.jp
[2]Department of Mechanical Engineering, Keio University
Hiyoshi 3-14-1, Kohoku-ku, Kanagawa 223-8522, JAPAN
muramatsu@mech.keio.ac.jp
[3]National Institute of Advanced Industrial Science and Technology
1-2-1 Namiki, Tsukuba-shi, Ibaraki 305-8564, JAPAN
harada.y@aist.go.jp

Key Words: *Machine Learning, Defect Surveying, Finite Element Method, Infrared Stress Analysis, Carbon-Fiber-Reinforced Plastic*

Carbon Fiber Reinforced Plastic (CFRP) is composite material whose base material is plastic and reinforcement is carbon fiber. CFRP is widely used in various fields by laminating prepregs. Here, laminated plate tends to get damage such as delamination, fiber breakage and base material breakage and we need to conduct high-precision and efficient Non-destructive testing (NDT). Examples of NDT are ultrasonic examination, X-ray tomography and infrared analysis. In ultrasonic exmamination, we need to drip objects in the water. And in X-ray tomography, we need to set object in an analysing room. Hence it is suitable to analyze large structures by means of infrared analysis. However, it is hard to estimate information of defects by means of most of these NDT methods. To solve these problems, some studies propose machine-learning-aided NDT. In this study, we constructed an inverse analysis model that predicts the spatial information of defects from the sum of the principal stress on the surface calculated from the temperature change measured by infrared anlysis in both experiments and numerical analysis, and proposed it as an alternative method to the existing damage analysis. We can calculate the sum of principal stress on the surface through infrared analysis based on Kelvin's theory [1]. Inverse analysis model is composed of two machine learning models. One is for making experimental images closer to Finite Element Method (FEM) results and the other is for predicting spatial information of defects from FEM analysis. Proof of concept for the model which predicts FEM analysis from spatial information of defects is successful [2]. We use Semantic Segmentation for the first machine learning model and CNN for the second one.

REFERENCES

[1] Sakagami, T., Izumi, Y., & Kubo, S. (2010). Application of infrared thermography to structural integrity evaluation of steel bridges. *Journal of Modern Optics*, 57(18), 1738-1746.
[2] Kojima, Y., Endo, K., Hirayama, K., Hiraide, K.& Muramatsu, M. (2021). Estimation of Defects in Carbon Fiber Reinforced Plastic Based on Surface Pressure by Machine Learning. *16th International Conference on Computational Plasticity*.