Detection of Disbond in Honeycomb Sandwich Structures based on Laser Ultrasonic Visualization

Osamu Saito[1], Weikun Chen[1], Zeyu Dong[1], Yoji Okabe[1]

[1]Institute of Industrial Science, University of Tokyo, Japan

Owing to the lightweight and the high bending rigidity, honeycomb sandwich structures (HSS) are widely used in various industries such as aviation, automotive, and marine industries. If a disbond occurs between the honeycomb core and the face sheet, the superior performance of HSS is degraded. Hence, reliable and efficient non-destructive inspection technique is needed to detect the disbond. One of the viable candidates is laser-ultrasonic visualization technique, in which ultrasonic guided waves are generated by scanning a pulsed laser and are received by a piezoelectric sensor. In this research, we attempt to detect the disbond area through the change in the dispersive property of the guided waves. Firstly, we tried to calculate the dispersion relation of guided waves in HSS. Since the honeycomb core is complicated, we assumed the honeycomb core to be replaced with a homogeneous material which has equivalent elastic properties; the elastic parameters were derived by Gibson's method. Considering the HSS as a three-layer homogeneous plate, we used global matrix method to clarify the dispersive behavior of fundamental anti-symmetric mode. Comparing with the result for the single face sheet, we found that the wavenumber is enhanced in the disbond area at low frequency. Then, we conducted the experiment using an aluminum HSS. A disbond was artificially prepared with knife insertion to the HSS specimen. Using the wave data acquired during the laser scanning, we calculated the wavenumber at each point in the inspected area. The wavenumber was evaluated by taking the ratio of Fourier components of time-series wave data between adjacent points. Averaging the wavenumber over some frequency ranges, the fluctuation was reduced. On the obtained two-dimensional wavenumber map, the disbond area was clearly detected due to the enhancement of the wavenumber. Besides, in the disbond area, we found the disappearance of the cell walls, which can be seen in the intact area. In addition to aluminum HSS, we conducted experiment with the composite HSS made by CFRP face sheet and Nomex honeycomb core. We successfully detected a Teflon sheet inserted as an artificial defect on the wavenumber map. Thus, in this research, we showed the effectiveness of the wavenumber evaluation for disbond detection of HSS based on laser-ultrasonic visualization technique. In the future, our method will be applied to more practical structures such as curved HSS and tapered HSS.