High-cycle fatigue characteristics of quasi-isotropic CFRP laminates
Atsushi Hosoi ¹ and Hiroyuki Kawada ²
¹Graduate School of Waseda University, ²Waseda University

Background & Motivation
CFRP is expected to replace for metal materials and aid the expansion of applications in various fields in the future since it has excellent mechanical properties, such as light, high strength and good moldability.

However, machines under serviced load suffer from the fatigue failures, and it’s noted that the high-cycle fatigue fractures are the main factors of the destruction of these machines. Especially, high-speed train, a car used in long-term and the surroundings of a turbine are applied cyclic loadings over $10^9$ cycles. Therefore, it’s demanded that the long-term reliability of CFRP laminates is established.

Moreover, in many applications of CFRP, they are used in the form of multidirectional laminates. Hence, it’s important to investigate high-cycle fatigue characteristics of quasi-isotropic CFRP laminates.

Method & Research

Specimen & Test Condition
The tensile fatigue tests were conducted at the room temperature with a sine waveform under load control conditions using a hydraulic driven testing machine. All tests were run at a stress ratio of $R=0.1$ and the selected maximum stress levels were 20~60% of the static tensile strength.

Observation of Damage Growth
3D Ultrasonic Inspection System
Delamination growth

Evaluation of Damage Growth
To evaluate damage growth, the energy analysis is used as follows.
1. Energy consumed damage growth is calculated.
2. The relationship between the damage growth rate and the energy consumed damage propagation is investigated as shown in left figures.
3. It is investigated whether there is the regime where damage doesn’t grow.

Results & Discussion

It was found that the some plots deviated from a straight line of the modified Paris’s law under the test condition of the low applied stress level. Two points are thought to be the reason that the delamination growth rate was delayed.

1. The implication of threshold of the delamination growth.
2. The suppression of the delamination growth due to the delay of the transverse crack propagation.

Conclusion
It was found that the damage growth behavior was different according to applied stress level.

1. Damage growth behavior was different according to the applied fatigue loading.
2. Long-term durability of CFRP laminates with initial damage, such as impact is researched for the damage tolerant design.

Future work

Acknowledgements
This study is conducted with the support of TORAY and TOSHIBA.