# Cyclic Fatigue Behaviour of Impact-Damage for GFRP composites

J. I. Kim[1], Y.-H Huh[1*], J.H. Park[2] and Y. H. Kim[3]

[1]Division of Industrial Metrology, Korea Research Institute of Standards and Science, Daejeon, South Korea
[2]Department of Mechanical & Automotive Engineering, KyungSung University, Busan, South Korea
[3]School of Mechanical Engineering, Chungnam National University, Daejeon, South Korea

[*]Corresponding author: yhhuh@kriss.re.kr

## 1. Introduction

Several types of defects and damages in GFRP(Glass Fiber Reinforced Plastics) composites, such as fiber-matrix debonding, delamination, and matrix cracking et al, can be introduced during fabrication and processing, and at in-field or during service. Impact failures of FRP laminates, which can be generated by dropped objects or fragments from a nearby accidental explosion, also are a major concern because impact damage in the composites can result in significant strength and stiffness loss. Therefore, impact damage tolerance design is an important consideration for composite structures.

In this study, fatigue behavior of the GFRP composites with impact damages was investigated. Cyclic fatigue tests using two GFRP composites with different fiber directions were carried out, and from the tests, the effect of impact patterns and dependency of the fiber direction for the respective impactors were examined.

## 2. Experimental Program

In this study, two GFRP laminates with different fiber directions, UD(unidirectional, [0°2]s) and TRI (three directional, (±45°/0°)2]s) laminates, were prepared. 25 mm wide and 3.5 mm thick tensile and fatigue specimens were machined from the laminates. A low-velocity impact damage was introduced at the centre of the respective specimens using a drop-weight impact system at three different energy levels of 4, 6 and 8J. In this study, in order to examine the effect of the impact damage patterns, two different impact tups, semi-hemispherical and pyramidal impactors, were used.

Tensile and fatigue load were applied to the impact damaged specimens using servo-hydraulic machine (MTS810), as shown in Fig. 1, and fatigue loads were imposed on the specimen at a frequency of 3 Hz and with load control.

Stress distribution around the respective impact damage was measured by DIC(Digital Image Correlation) measurement.

Impact damage propagation under cyclic fatigue loads also was measure by back light scattering technique.

## 3. Results and Discussion

S-N curves for the respective composites were determined. The fatigue lives for the UD and TRI composites with different impactors were dependent on the fatigue load levels, and the S-N curves for the impact damaged composites shows a remarkable reduction of the fatigue strength, compared to the composites without damage.

Impact damage propagation was measured with cyclic fatigue loading. Propagation rate of the pyramidal impact damage for the TRI laminate was considerably faster than the rate of the semihemispherical damage. For the UD composite, the effect of the two impactors on the damage propagation was not considerable.

Stress concentration near the impact damage during the cyclic fatigue damage propagation also was measured using DIC measurement technique. The stress evolvement with cyclic loads could be visualized.

Cyclic fatigue failure mode could be observed. The cyclic fatigue failure for the UD laminates was extended along the fiber direction, which could be compared to the TRI laminates.

.

**Fig.1 Experimental setup for cyclic fatigue load test and DIC measurement**

**Acknowledgment**

This work was supported by the KETEP(Korea Institute of Energy Technology Evaluation and Planning) granted by the Korea government (MSIT No. 20153010024470) and KRISS