FABRICATION OF FIBER-STEEL LAMINATES
BY OPTIMIZING MANUFACTURING PROCESS PARAMETERS AND STUDY THE IMPACT BEHAVIOUR

Byung-Jin Park[1], Dong-Woo Lee[1] and Jung-Il Song[1]

[1] Department of Mechanical Engineering, Changwon National University
jisong@changwon.ac.kr

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ABSTRACT

Fiber metal laminates (FML) are multi-component material utilizing metals, fibers and matrix resins. Tailoring their properties is readily achievable by varying one or more of these components [1]. Carbon fiber-reinforced polymers (CFRP) are attractive engineering materials because of their high specific stiffness and strength. These properties make them suitable to applications in the high performance transportation industries. However, their excellent properties are mitigated by a susceptibility to damage from impact events [2]. CFRP, GFRP and steel were used to study the optimization of the manufacturing process using the Vacuum Assisted Resin Transfer Molding (VARTM). The concentration of the etching solution and etching time were set by evaluating the tensile test and the surface roughness in order to optimize the manufacturing process. In order to prevent the delamination between the fiber layer and the steel layer, adhesive film was laminated between the fiber and the steel layer. In this study, in order to confirm the relation between fiber direction and impact damage, FML for the other five laminated patterns was fabricated as shown in Table 1and drop-weight test was conducted. The impact behaviour was explained by comparing cracks and load-displacement curves generated in the lower part of the test specimens by conducting a drop-weight test. Table 2 shows conditions for drop-weight test.

Table 1 Five laminated patterns of FML

Case	1	2	3	4	5
Stacking sequence	S/0/0/S	S/0/90/S	S/0/90/0/S	S/90/0/90/S	S/0/90/90/0/S

Table 2 Conditions of drop-weight test

Impacter weight	4.7kg
Impact speed	4m/s
Impact energy	38J

The cracks generated in the lower part of the specimen, it was found that cracks occurred in the direction in which the fibers were arranged, but cracks were not found on the upper part of the specimen, because the test conditions were set so as not to penetrate FML as shown in Table 2. The

shape of the crack along the fiber direction at the lower part was common to CFRP-Steel FML and GFRP-Steel FML. These FMLs were also common that cracks were not displayed on the upper part of the specimen. The length of the crack did not show a big difference between CFRP-Steel FML and GFRP-Steel FML. The load-displacement curve, the load was slightly different depending on the laminated pattern, and both CFRP-Steel FML, GFRP-Steel FML had the highest load value in case 5, and showed the lowest value in case 2. However, the value of load for each pattern did not show a big difference between CFRP-Steel FML and GFRP-Steel FML. The difference of the crack length and the load value was not large because the thickness of steel occupies about 50% of the thickness of FML. Therefore it was judged that it influenced totally by steel when comparing the load behaviour by each case of CFRP-Steel FML and GFRP-Steel FML, case 1 and case 2 show similar behaviour but case 3, 4 and 5 reliably show other behaviours. In the case of CFRP, the load decreases sharply from the maximum value and decreases with a gentle slope after rapid slope. On the other hand, GFRP shows the opposite behaviour to CFRP. It decreases with gentle slope after the sharp slope to 0 point. It is understood that, due to the process of crack propagation after the impact and progress of cracking at length and thickness direction. Through this study, it was confirmed that cracks occurred depending on the direction of the fibers laminated at the impact test of FML, and the impact load behaviour by the fiber and laminated pattern could be confirmed through the load-displacement curve.

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