

# SHORTENING IN PROCESS TIME OF VARTM AND IMPACT DAMAGE SUPPRESSION FOR FIBRE METAL LAMINATES BY INSERTING POLYAMIDE MESH

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## Introduction

During VaRTM (Vacuum assisted Resin Transfer Molding) a distribution medium which is incorporated on fiber preform as a surface layer is used to shorten impregnation time of resin by increasing the flow rate of resin and is removed after molding. In this study, the distribution medium is replaced what not only improve the flow rate of resin during VaRTM process but also give FRP good property by remaining in the fiber preform after VaRTM process. By distributing particles of polyamide (PA) in the interlaminar of the interlaminar-toughened CFRP (T800H/3900-2, Toray), its impact damage is suppressed [1, 2]. Furthermore, during VaRTM process, in order to increase the flow rate of resin, mesh shape such as distribution medium should be used. Therefore, it is assumed that the distribution medium can be replaced by PA mesh. The objective of this study is to evaluate the increase the flow rate of resin in GFRP and FML (Fiber Metal Laminates) where multi-layer flows occur by inserting PA mesh during VaRTM process.

## Experimental procedure

GFRP laminates examined in this study were manufactured by using plain woven fabric of glass fibers (KS2810J, Kanebo Co., Ltd, 320 $\mu$ m in thickness) and epoxy resin (base resin: 801N, curing agent: 3080, Mitsubishi Chemical Co., Ltd). The thicknesses of PA mesh (NBC Meshtec Co., Ltd) were 87 $\mu$ m, 121 $\mu$ m, 240 $\mu$ m and 520 $\mu$ m. The metal layer of the FML was aluminum alloy (A2017, 500 $\mu$ m in thickness).

Preforms for GFRP were comprised of glass fiber fabrics and two PA meshes inserted so as [GF<sub>3</sub>/PA/GF<sub>3</sub>/PA/GF<sub>3</sub>]. For FML, which is likely to delaminate between the metal and FRP layer [3], two PA meshes with thickness of 121  $\mu$ m were inserted only in upper GFRP layer so as to be adjacent to the aluminum layer to obtain [Al/PA/GF<sub>10</sub>/PA/Al/GF<sub>10</sub>/Al] as shown in Figure 1. In this study, the arrival time of resin is measured by fiber optical sensor. The intensity of reflected light of Fresnel's reflection which occurs at the end of fiber optical sensor decreases by resin arrival. Multipoint measurements for flow rate of resin were carried out.

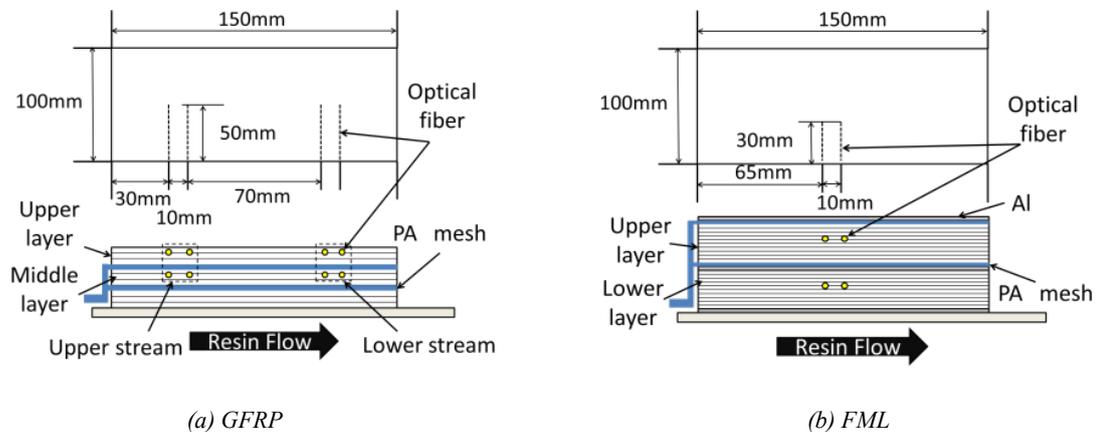


Figure 1: Set-up of fiber optic sensors.

## Experimental results

The measured flow rate of resin in case of GFRP is shown in Figure 2(a). It is obvious that by inserting PA mesh the flow rate increased, in addition, the thicker PA mesh was, the higher the flow rate of resin was. The experimental results of the flow rate in case of FML were shown in Figure 2(b). When the PA meshes were not inserted both in the upper and lower layer, there was little difference in flow rate between upper layer and lower layer as shown by blue columns. Therefore, it was confirmed that same flow rate in each layer was achieved during VaRTM process in case of FML. Then when PA mesh was inserted only in the upper layer, the flow rate in upper layer was faster than that in lower layer which has no PA mesh. From the above, it was founded that the flow rate of resin was increased by inserting PA mesh as the role of a distribution medium.

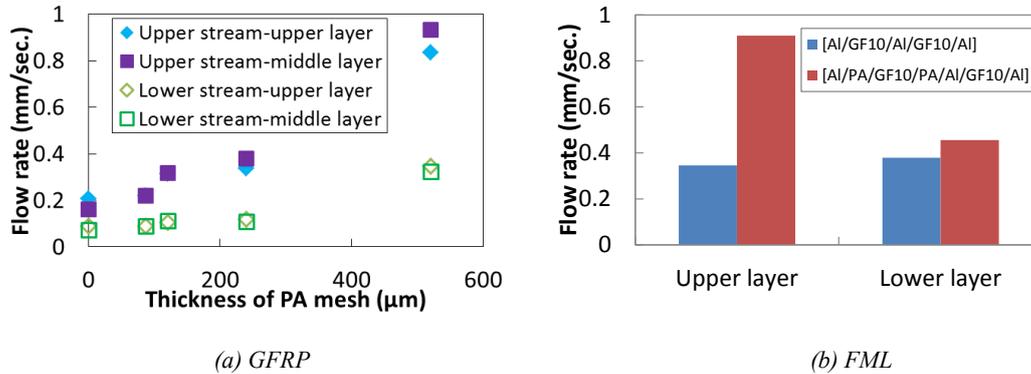


Figure 2: Results of flow rate of resin during VaRTM process.

## The simulation of resin impregnation behavior

To evaluate the resin impregnation behavior in the preforms with PA mesh inserted, the simulation of resin impregnation behavior was carried out. In this study, the simulation utilized the finite element analysis to evaluate resin pressure, using equation of continuity and Darcy's law.

Figure 3(a), (b) and (c) show simulated results of resin flow in GFRP without PA mesh and with PA mesh of  $520\mu\text{m}$  in thickness, and FML, respectively. These figures indicate the shape of the flow front every 45 seconds from the resin injection. In case of not inserting PA mesh, the shape of the flow front was perpendicular to the traveling direction of resin. On the other hand, in case of inserting PA mesh, the shape of the flow front was the ahead in PA mesh layer. Therefore, it was considered that resin is impregnated into fiber preform through the PA mesh. In case of FML, the shape of the flow front was the ahead in PA meshes that are placed on top and under the glass fiber fabrics. However, the analysis results did not correspond with the experimental results in flow rate of resin. It was assumed that the wettability of the metal layer adjacent to the FRP layers may affect resin flow.

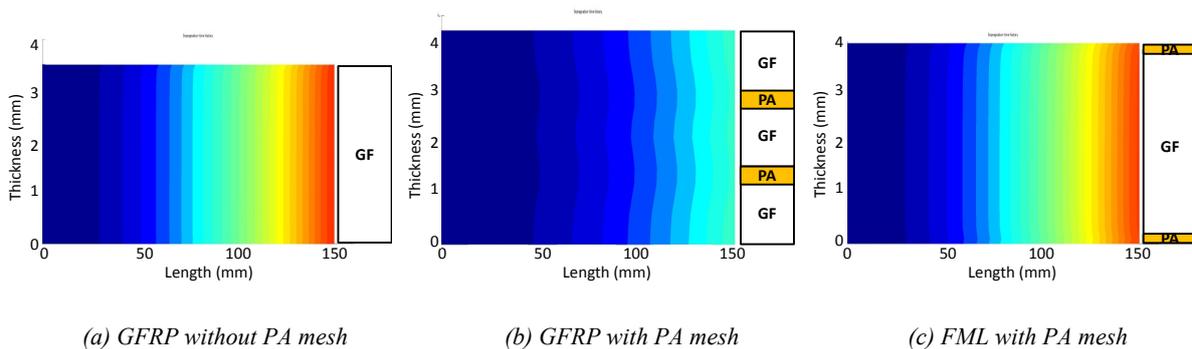


Figure 3: Simulation results of the shape of the flow front.

## References

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