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Development of press moulding preform fabrication and moulding method with unfolded diagram for CFRP

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Abstract

In the study, a novel design and fabrication method, which are simple and optimized press moulding for CFRP on the basis of CAD data was proposed. CFRP has been come into widespread use for weight reduction of transportation equipment in recent years. However, in order to expand range of their purpose, reduction of the production cost is required. The authors have focused on the press moulding techniques. In the case of the CFRP moulding, partial buckling or fracture of the fibre could occur due to the drawled fibre by the deforming force. As a solution for these problems, the authors have proposed a design and a fabrication method for CFRP preform, which has unfolded diagram shape for the objective of three-dimensional model using a tow prepreg. In the previous report, the authors had proposed the unfolding methodology of a three-dimensional shape to a plane surface based on CAD/CAM system, which enables generating an unfolding diagram with maintaining continuity of the fibre tow. And validity of unfolded diagram had been confirmed by reproducing the objective three-dimensional shape from the unfolded diagram. Provided that fabricating a preform with the unfolded diagram, it could be necessary to steer the tow prepreg since the fibre on the unfolded diagram is curved. In order to steer the tow while conserve the stiffness and characteristic as the composite material after moulding, the tow prepreg must be steered by movement of the fibres in the longitudinal direction with maintaining the fibre orientation parallel each other. Also, strategy of tow placement on the preform is important in moulding -free-formed surface to avoid interference with each other of the tows. In the report, steering capability of the tow prepreg was verified and the steerability was evaluated. Besides, strategic fabrication method of the prepreg and forming method of the objective shape was proposed.

CFRP, Press moulding, Preform, CAM, Polygon mesh, Unfolded diagram

1. Introduction

In the study, a novel design and fabrication method, which are simple and optimized moulding method for CFRP (Carbon-Fibre-Reinforced-Plastics) has been proposed.

CFRP has been come into widespread use as high specific strength material for weight reduction of transportation equipment in recent years. On the other hand, there are not many adoption examples except aircrafts and high-performance vehicles. In order to expand range of purposes, reduction of the production cost is required. The reduction of cycle time and process automation enable to reduce production cost.

In order to satisfy these requirements, the authors focused on the press moulding technique. If the continuous fibre CFRP was formed by press moulding, partial buckling or fracture of the fibre occur due to drawled fibre by the deforming force. For this reason, the formability and the rigidity of the moulded product could be deteriorated. Preforms which have optimized fibre orientation for moulding are necessary to avoid these defections. By the RTM method, 3D preform has been used intended to solve the problem. Instead of that, advanced skills to layout the fabrics on the 3D shape are required to fabricate the 3D preform.

As a solution for these problems, the authors have proposed a 2D CFRP preform, which is often utilizing unfolded diagram used to the paper crafting technique [1], based on 3D CAD data.

In our previous report, unfolding method using 3D CAD data had been proposed [2]. In the article, fabrication method and moulding experiment of 2D preform is reported.

2. Fabrication of preform

The 2D preform has been planned to fabricate by the two-dimensional ATL method. Practically, the preform fabricated by hand lay-up. Owing to use of the two-dimensional ATL method, the preform fabrication without 3D mould is realized. The procedure of fabrication method of the 2D preform is consisted by two parts. First is optimization of an unfolded diagram for ATL method. Second is laying-up of a tow prepreg.

2.1. Optimization of the unfolded diagram

In many cases, an unfolded diagram has overlapped tapes. The tapes represent trajectories of the tow prepreg. Therefore, If the tapes were overlapped, tows were stick each other in the area and reconstruction of the objective shape could be impossible.

In order to avoid that, the authors tried to split a ply of unfolded diagram into several layers. Fig. 1 shows an objective shape including free-formed surface of the moulding experiment and the fibre orientation. In this case, unfolded diagram is split into two layers. Fig. 2 shows the unfolded diagram and split diagrams. The overlap parts are decreased obviously.

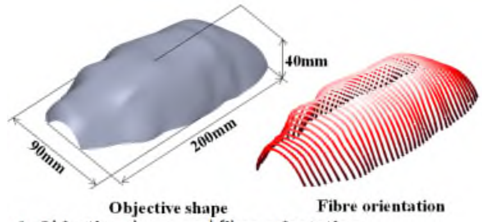

Figure 1. Objective shape and fibre orientation

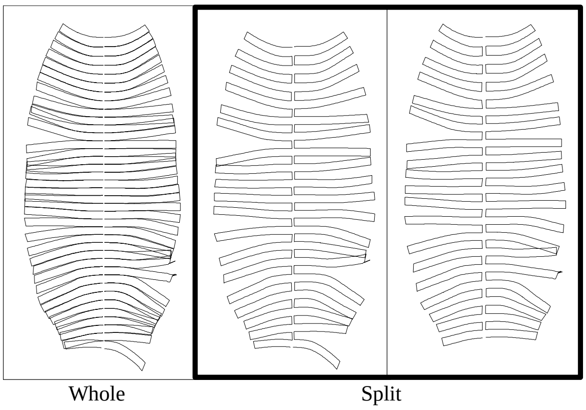

Figure 2. Example of the split unfolded diagram

2.2. Placement of tow prepreg

The preform has an unfolded shape of the objective shape surface. Tow prepreg is arranged in a curved line along to the unfolded diagram. Fabrications of variable–stiffness laminates using tow prepreg with curved trajectory had been reported [3-4]. The matrix of the prepreg has tackiness and the tow prepreg are placed utilizing its tackiness.

Fig. 3 shows fabricated 2D preforms. In order to prevent deterioration by distortion of the unfolded diagram shape of 2D preform, the tow prepreg was placed on a support film. Owing to adhesion of the support film, the fibre deformation and displacement on the plane of unfolded diagram were suppressed and that realize similar easiness of assemble as paper crafts.

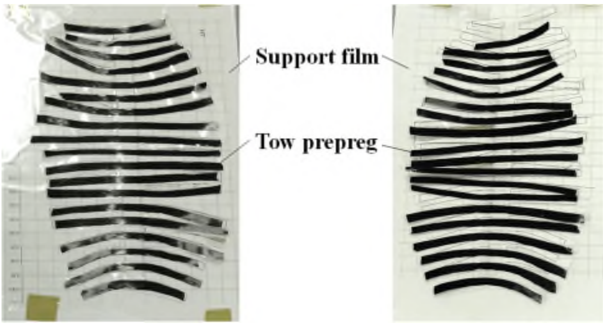

Figure 3. Fabricated 2D preforms

3. Moulding experiment

3.1. Experimental condition

The objective of the experiment is confirmation of effectivity to fibre orientation of a formed workpiece by applying 2D preform and only 1 ply with parallel fibre orientation was moulded in each time. Therefore, the stiffness or the tensile strength shall be ignored to evaluate.

Commonly, the tow prepreg has been used for filament winding with the autoclave treatment. The autoclave treatment enables to realize high specific strength of moulded workpiece. However, the treatment requires a huge kiln, lot of resources and time. Hence, the 2D prepreg has been moulded using conventional vacuum bag and oven intended to ease of experiment.

Curing temperature condition is 423 K in 1 hour. Width of the tow prepreg is about 5 mm.

3.2. Result

Fig. 4 shows 2D preform placed on mould and moulded workpiece. Fibre orientation close to the design has been obtained in moulded workpiece.

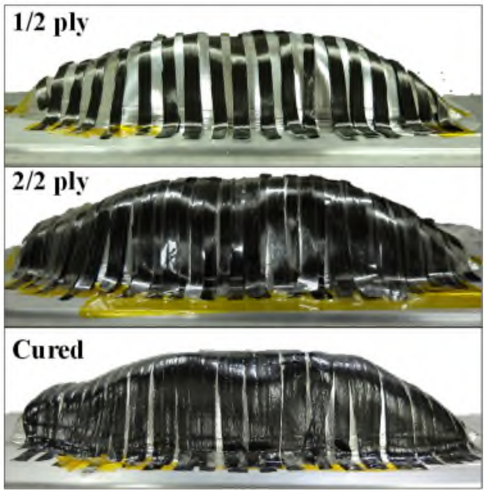

Figure 4. Placed preform and moulded workpiece

4. Discussion

From the experimental result, the effectiveness of the 2D preform was confirmed. However, distortions of fibre orientation occurred in several parts, due to dragging of the fibre by deformation of the bagging film while evacuating. In order to prevent the distortion of unfolded shape of 2D preform, improved moulding procedure need to be contrived.

5. Conclusion

In the study, a moulding method using 2D preform has been proposed and the effectiveness of 2D preform has been confirmed by the moulding experiment.

As the next plan, moulding experiment with another objective shape using improved moulding procedure and a quantitative evaluation on the fibre orientation of moulded workpiece are scheduled.

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