Self-Healing Concept for Damaged Composite Structure of Automobile Bonnet

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Abstract. In this work, a structural design and analysis on automobile bonnet using natural flax fiber composite is performed. Through the structural analyses using commercial FEM software, it is confirmed that the designed automobile bonnet using natural composite is acceptable for structural safety. And also, the damage is a critical problem in composites during their service in structural applications. Therefore, study on self-healing concept of bonnet structure was performed.

1 Introduction

For last several years, the interest to use natural fibers has been increased due to environmental problems of man made fibers in the composite materials. Natural fibers have some advantages such as cost effective, recycling and low energy consumption due to obtainable from nature rather than man made fibers by using high energy consumption.

In this work, a structural design on automobile bonnet using natural flax fiber composite is performed. The structural design results of flax/epoxy composite blade are compared with the design results of metal structure. In order to evaluate the structural design results of the composite bonnet, the structural analysis was performed by the finite element method. And also, the damage is a critical problem in composites during their service in structural applications. Therefore, study on self-healing concept of bonnet structure was performed.

2 Investigation on Natural Fiber

The growth of use of natural composite is indicative of their wider application due to the favorable mechanical performance of natural fibers. Among them, flax, hemp, jute and sisal are most popular composite fibers in natural composites [1~3]. Through comparison of mechanical strength and stiffness, it is found that the flax fiber has the best properties. The vinyl ester is selected due to cheap price even though somewhat low mechanical properties compared to epoxy. The tension test of specimen is shown as Fig. 1 and the stress-strain curves are shown as Fig. 2.

Figure 1. Manufactured flax/vinyl ester panel.

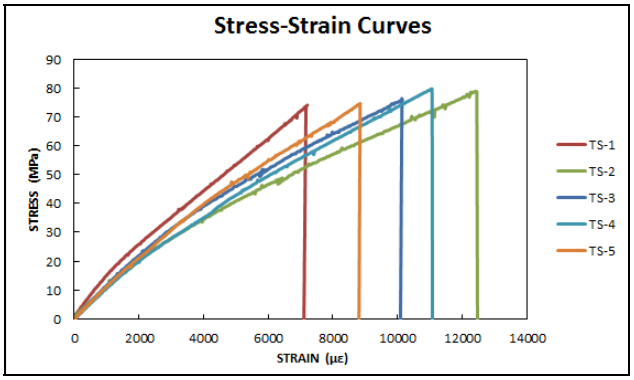

Figure 2. Stress-strain curves of tension specimen.

3 Structural Design and Manufacturing

After investigation on mechanical properties of flax/vinyl ester composite, the design of eco-friendly structure using flax/vinyl ester was performed. The selected target structure is bonnet panel for automobile. In order to evaluate the structural design results of bonnet, the

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structural analysis was performed by the finite element method. Through the structural analyses, it is confirmed that the designed bonnet using natural flax composite is acceptable for structural safety and stability. Figure 3 shows structural configuration of automobile bonnet.

The resin flow analysis of VARTM manufacturing method was performed after structural design and analysis. According to flow analysis results, the prototype bonnet was manufactured. Figure 4 shows the process of resin flow analysis. Figure 5 shows 3-D modeling of mould for prototype manufacturing.

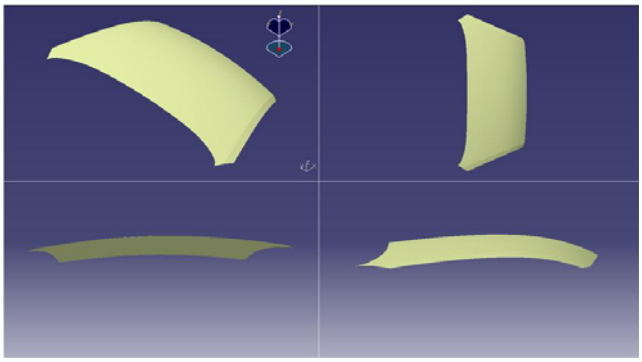

Figure 3. Structural configuration of automobile bonnet panel.

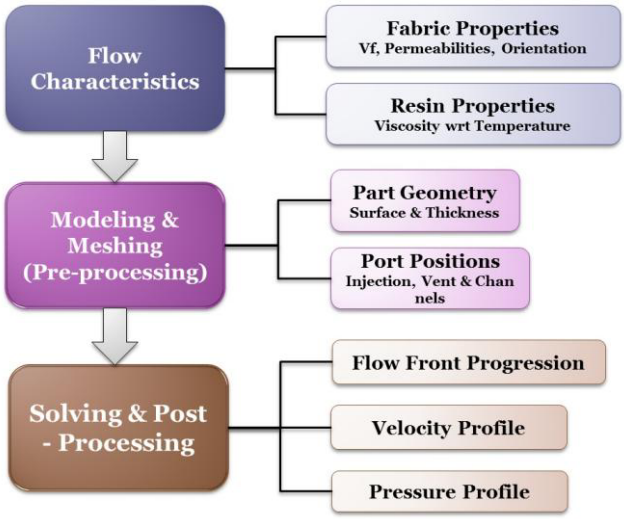

Figure 4. The process of resin flow analysis.

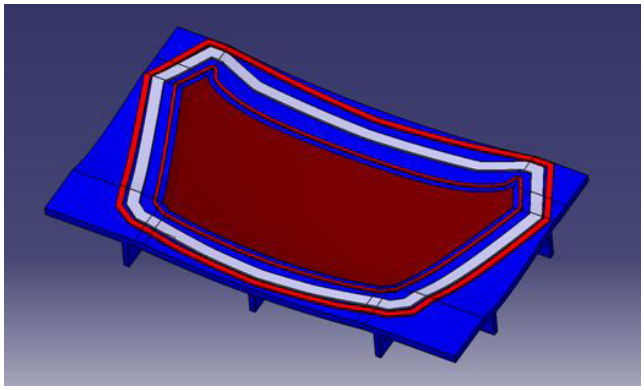

Figure 5. Design of mould for prototype manufacturing.

4 Investigation on Self-Healing of Composite Structure

The cracks in the structure are a critical problem in composite materials during their service in structural applications. The development of cracks brings about serious failure of the structures and then reduces their lifetimes. Therefore, early diagnosis of damage becomes necessary for removing the catastrophic failure. Recently, Self-healing composite structures have attracted increasing research interests. This study was performed investigation on self-healing of composite structure. Figure 6 shows the concept of self-healing epoxy based composite with epoxy loaded microcapsules. The self-healing concept using embedded microcapsules is shown in Fig. 6. A microencapsulated liquid monomer healing agent is embedded in a structural polymer matrix containing a catalyst capable of polymerizing the healing agent. When the material is damaged cracks occur, rupturing the microcapsules and releasing the healing agent into the crack plane through capillary action. The healing agent contacts the catalyst, triggering polymerization that bonds the crack faces closed[4, 5]. The target composite blade structure will be applied with the self-healing concept.

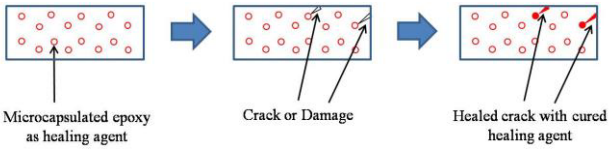

Figure 6. The concept of self-healing epoxy based composite with epoxy loaded microcapsules

5 Conclusions

In this study, an investigation on mechanical properties of flax/vinyl ester natural fiber composite is performed as a precedent study on the design of eco-friendly structure using flax/vinyl ester composite. The Vacuum Assisted Resin Transfer Molding (VARTM) manufacturing method is adopted for manufacturing the flax fiber composite specimen. The mechanical properties of the manufactured flax composites specimens are compared with flax composite data cited from some references. The experimental data show that the flax/vinyl ester composites using the proposed VARTM manufacturing method have much better mechanical properties than the reference test results. Based on this, structural design of automobile bonnet was performed using flax/vinyl ester. After structural design and analysis, the resin flow analysis of VARTM manufacturing method was performed. Through the structural analyses, it is confirmed that the designed bonnet is acceptable for structural safety and stability. Finally, study on self-healing concept of bonnet structure was performed.

Acknowledgments

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