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## Design Innovation in Biocomposite Materials Product Development

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### ABSTRACT

In this paper a design innovation study in biocomposite materials product development is presented. The purpose of this study is to report recent work on the use various design innovation tools and techniques in the development of biocomposite products. The major problem in biocomposite product development is lack of systematic approach in the concept generation of biocomposite products. However, according to design experts, 70% of the cost of development of a product is decided during the conceptual design stage and yet the cost incurred in the conceptual design stage is only 5% of the total product development cost. It is therefore crucial for the designers to focus on proper generation of design concepts using effective tools and techniques. The main methodology adopted in this study is the use of design innovation tools and techniques in concept generation phase of design process for biocomposite product development. The tools and techniques used in concept generation include TRIZ, Why? Why? Why?, gallery method, blue ocean strategy, mind mapping, exploitation of existing technique, biomimetics, brainstorming, cross-industry innovation and morphological chart. These techniques are briefly discussed in terms of design of biocomposite products. The key finding of the study is the results of design concepts obtained by effective use of those techniques, where the techniques have been successfully employed to come up with innovative design concepts of biocomposite products. Out of ten techniques that had been mentioned, few selected techniques such as blue ocean strategy, brainstorming and TRIZ methods are briefly discussed. Results of conceptual design using these techniques had turned out to be very relevant in developing high quality biocomposite products. Innovation in design of biocomposite products is therefore very important if the industries were to remain competitive in marketplace.

*Keywords:* Design innovation, biocomposite material, product development, TRIZ, conceptual design

### Introduction

#### Design Innovation

In mechanical and manufacturing engineering field, innovation in design is an important criterion that determines the success of an engineering product. Creativity and innovation are essential elements of product development. Design engineers work to develop the most effective design concepts early in the design process in achieving this aim (Sapuan and Mansor, 2016). Seventy percents of cost committed during the later stage of the design is decided during the conceptual design state, where design innovation is the emphasis and the cost incurred during conceptual design stage is only five percent of the total product development cost. With design innovation, a lot of new inventions and products will be produced and many problems faced by our society will be solved. Many innovation and

creativity tools and techniques have been created to generate new ideas and concepts for better performance of the products.

### Biocomposites

Biocomposites or natural fibre composites are materials comprise fibre reinforcements from natural fibres and polymer matrices (Sapuan, 2014). Examples of natural fibres used in natural fibre composites include oil palm, kenaf, sisal, ramie, hemp, jute, pineapple leaf, sugarcane bagasse, coconut shell and coir, sugar palm, and water hyacinth. Figure 1 shows an oil palm fruit bunch, and after the removal of oil palm fruits, empty fruit bunches (EFB) can be obtained, which are good source of natural fibres. In addition, natural fibres, not only used as reinforcements for polymer composites, but they also used to make final products such as broom and roof as shown in Figure 2. Natural fibres are mainly used as fibre reinforcements in polymer composites to form natural fibre composites or biocomposites, and they are used in many different industries such as automotive, marine, furniture and building and construction industries. The major advantages of using natural fibre composites over conventional composites such as glass and carbon fibre composites include light weight, can be obtained in abundance, renewable, environmentally friendly, and low cost, in addition to good specific strength and stiffness properties.



Figure 1. Oil palm fruit bunch; potential source of natural fibres from EFB



Figure 2. Sugar palm fibres for making broom and roof

### Biocomposite Design Innovation

Design innovation with biocomposites is normally performed in the manner with design innovation with many engineering products. Innovation in engineering products require the use of different tools and techniques, and it is recommended that product design specification (PDS) to be prepared early in the design process to facilitate this innovation (Sapuan and Mansor, 2016).

### Generation of Design Concepts

In this section, selected design concept generation tools are discussed, which include brainstorming, TRIZ and blue ocean strategy (BOS).

### Brainstorming as a Tool in Design Innovation for Biocomposite Products

Brainstorming is a well-accepted method to generate idea in design innovation of engineering products and it is also an important method of design innovation in biocomposite product development. In biocomposite design, a group of designers sit a meeting room to come up with a final concept of a biocomposite product. In the brainstorming session, a facilitator is selected and he initiates the session, by initially briefing the team on the rules of conducting the session (see Figure 3). A topic is decided, and each member gives the product, one a time. During this session, judgement is suspended until all members give their ideas. A member is in charge to jot down all the ideas and any ‘crazy’ ideas are entertained as these ideas may lead to a better and practical solution.



Figure 3. Brainstorming session (Sapuan, 2017)

### TRIZ as a Tool in Design Innovation for Biocomposite Products

TRIZ is one of the design innovation tools in solving design problem based on logic and data, and it was developed in Russia. It emphasized on the use of the same solution for a large number of similar problems. The idea of developing TRIZ was because, after studying hundreds of thousands of patents, he discovered that the solution for many different problems were almost the same. He came up with limited lists of potential solutions for different engineering problem. For instance, one of the solutions proposed to solve problem is to use composite material. So for biocomposite problem, the solution based ‘composites’ is applicable. In composite, what a designer wants is light weight (positive impact) but doing so, the strength of the part may be sacrificed (negative impact).

### Blue Ocean Strategy (BOS) as a Tool in Design Innovation for Biocomposite Products

BOS is a power tool in business field and it aims at achieving uncontested market by creating one’s own niche in business. It makes competition irrelevant. In conceptual design for composite product an attempt is made to use two tools in BOS, i.e. four-action-framework strategy canvas methods.

This four-action framework from BOS for conceptual design application uses the following actions in generating innovative design of a biocomposite component, i.e:

- Eliminate – to remove dysfunctional components.
- Raise- to raise the component well above the current design.
- Reduce- to reduce the component d well below the current design.
- Create- to create new design

A BOS tool called strategy canvas was used to analyse the potential of hybrid biocomposites as candidate materials for an automotive anti-roll bar. The data are compared with the data of steel and synthetic fibre composites in terms of the voice of customers and voice of environment (Figure 4).

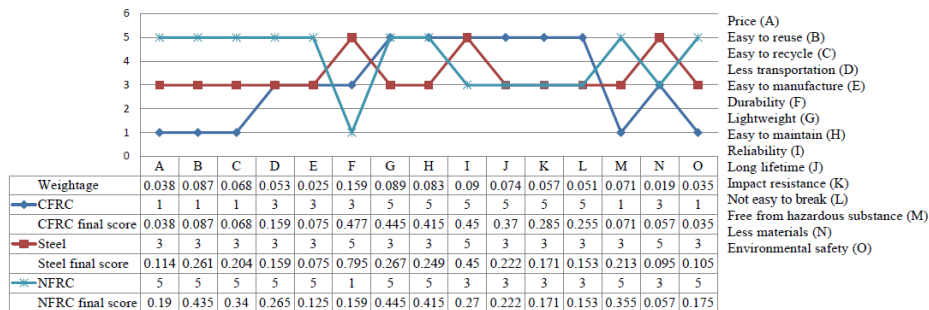


Figure 4. Strategy canvas from BAS for hybrid composite automotive anti-roll bar (Mastura, 2017)

**Other Methods and Tools in Design Innovation for Biocomposite Products**

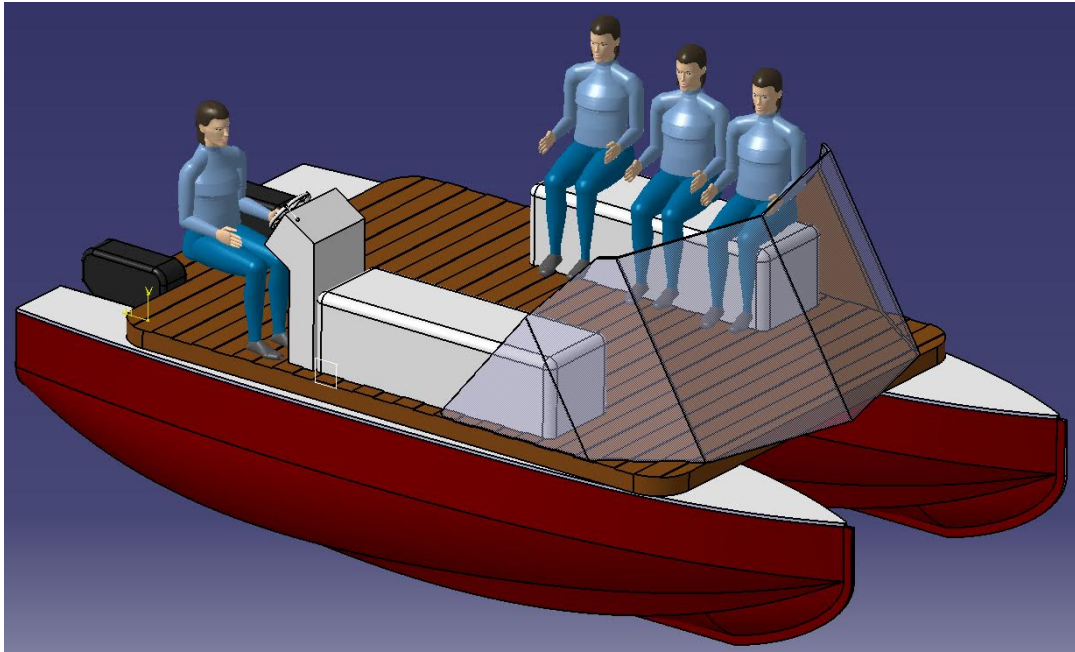
Other methods reported to be used in design innovation of biocomposite products include mind mapping, exploitation of existing technique, biomimetics, brainstorming, cross-industry innovation and morphological chart, Why? Why? Why? and gallery method (Sapuan, 2017).

**Biocomposite Product Development**

Design innovation in biocomposite product design eventually lead to total development of a biocomposite product (i.e. design concept evaluation, detail design, fabrication, assembly, and maintenance). Once design concepts are developed, they evaluate against design requirements, and using appropriate tools such Pugh selection method or weighted objective method.

**Selected Design Concept after Concept Evaluation Presented in CAD Model**

After concept development, concept evaluation is performed and once a final concept is selected, it is presented in three dimension using computer aided design (CAD) tool (see Figure 5).



*Figure 5.* Final design concept developed using CAD software for biocomposite boat

### **Interface between Design and Manufacture**

Once design has been established, the next step is to fabricate the biocomposite products. In doing so, designers discussed their design with mould maker in order to plan for fabrication process (Figure 6).

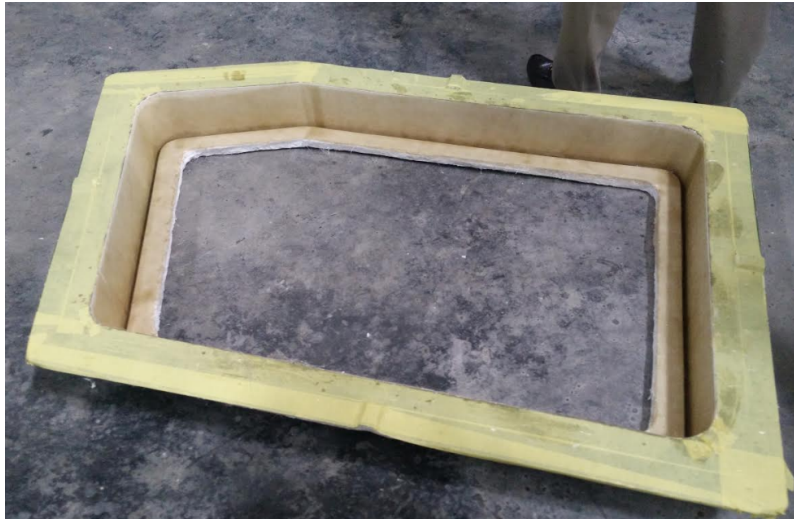


*Figure 6.* Designers and mould maker in developing biocomposite frame

### **Fabrication**

Fabrication is performed using different techniques depending on the nature of the products. For product like boat component, hand lay-up process can be employed (Figure 7). Figure 8 shows a car seat fabricated from hand lay-up process made from jute fibre composites.





*Figure 7.* Composite boat component (Courtesy of Brazen Composite Sdn. Bhd. Melaka, Malaysia)



*Figure 8.* Biocomposite Go-Kart car seat

### **Conclusions**

In this paper, design innovation study for biocomposite products is presented. Brief discussion on design innovation is presented, followed by the description of biocomposite materials. Design innovation with biocomposite products is presented by giving three examples of innovation tools used in biocomposite product development (brainstorming, TRIZ and BOS). After the innovation stage, the product development proceeds with CAD model, design and manufacturing interface and fabrication of biocomposite products.

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