CHAPTER 1 INTRODUCTION

1.1 Background

Thin-walled designs can be seen in many modern fields of engineering and it is significant that they are now formulating a growing proportion of today's engineering design. The need for lightweight, more effective efficient structural structures that provide high strength and rigidity in tandem with low structural weight has helped to promote this development as well as to enhance, the need for continued research, and development in the area of future progress. With an appreciable introduction of thin-walled structural elements and structures in a broad range of areas, the scope of use of thin-walled structures has become increasingly diverse. The structure also has inherent weaknesses. First, it needs to be laminated to improve the resistance to impact or applied forces, without being laminated it became poor resistance to out-of-plane tensile loads. The design also has inherent weaknesses, first it has to be laminated to enhance resistance to impact or applied forces, without being laminated it has become low resistance to tensile loads from outside the aircraft. Then the susceptibility to damage will go unseen and the high potential of internal damage. Through all the disadvantages, based on Agency, 1999 thin-walled still give it benefits almost for all applications due to its lightweight structure.

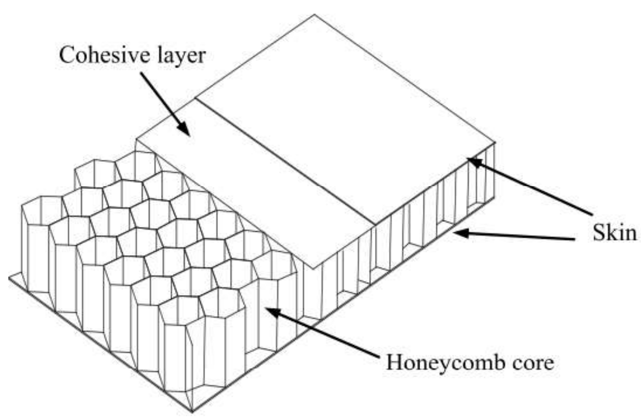

Figure 1 Hexagonal Honeycomb Sandwich Structure(J. Zhang, Lu, Ruan, & Huang, 2019).

Demand for low weight, high performance, and new material design are becoming a new standard and growing rapidly for applications ranging from spacecraft, aviation, automobiles, vehicles, and construction to just a few. Such applications before explaining how to implement sandwich structures that are compatible with all thin-walled composite material structures. A single metal system's advantages are extracted from an adequate mechanical quality paired with lower costs or better durability. However thin-walled structure performance cannot pass the honeycomb-cored sandwich structure (HS). Vinson, 2005 shows that three-layer structure has issues of durability related to water intrusion, delamination, and relatively expensive when the design needs to be curved panels or shells but it is anisotropic.

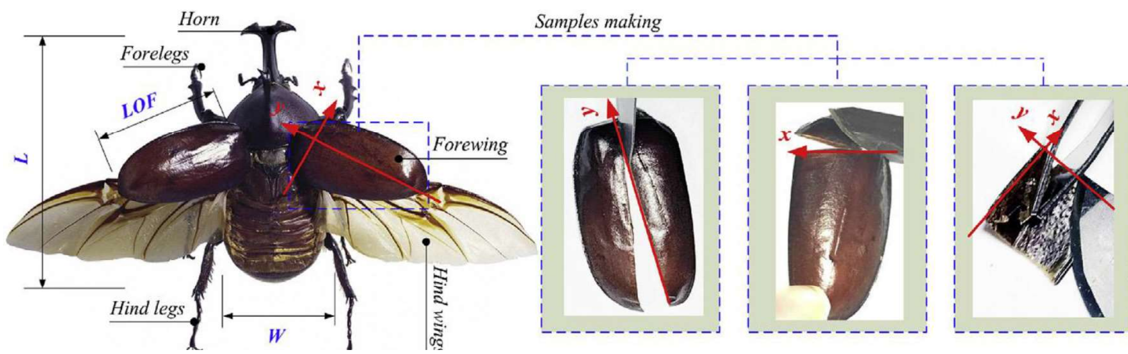

Figure 2 Beetle forewing being taken as a sample(Zhou et al., 2020).

Just a few reports have been published scientifically over the past year on the design and optimization of sandwich structure parameters. Some of them adopted bio-inspired designs and generated beetle forewing sandwich structure (BFS). Beetle has been observed on its physical characteristics, in particular on its forewing in figure 2, which can be defined as an integrative sandwich layer with higher, lower lamination layers and a core layer with honeycomb cells and trabecula in figure 3. It is identified as the main component which helps beetle to endure most impact either force. Stable performance of the beetle forewing aid by the bio-composite of chitin fibre-enhanced keratinized protein which is low density and good toughness (Zhou et al., 2020). Regarding it good performance, many researches in this novel structure emphasis only on optimizing the common HS by using the beetle forewing bio-characteristic and material features, it is not clear whether the design of the core geometry is linked to the sandwich structure quality itself.

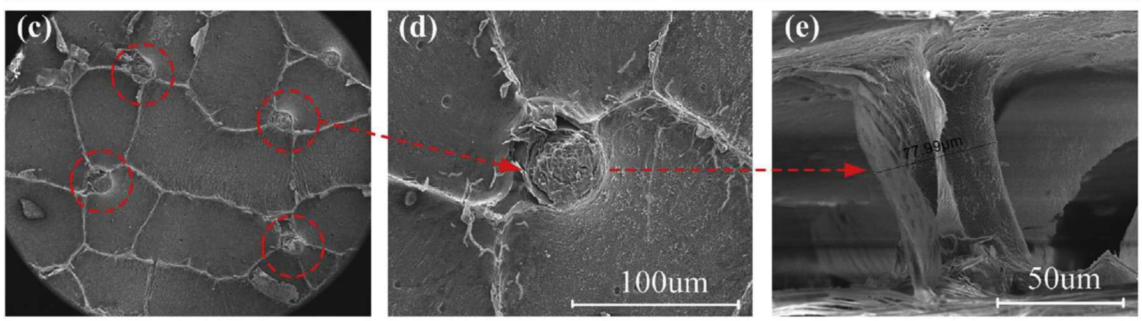

Figure 3 Scanning electron microscopy photographs(Zhou et al., 2020).

Chen et al., 2017 as the first BFS research found a good compressive deformation mode and a higher energy absorption ability compared to the traditional HS. Common HS performance depends on the material used to increase the capacity and weight of energy absorption due to the high density used in the structure. BFS not only provides HS with a possible advantage by the design of a beetle forewing which uses trabecula on the core surface but also helps to achieve the perfect combination of lightweight material and structure to achieve better mechanical properties for HS reinforcement and to keep the main function as the thin-walled structure enhanced with the sandwich structure purpose.

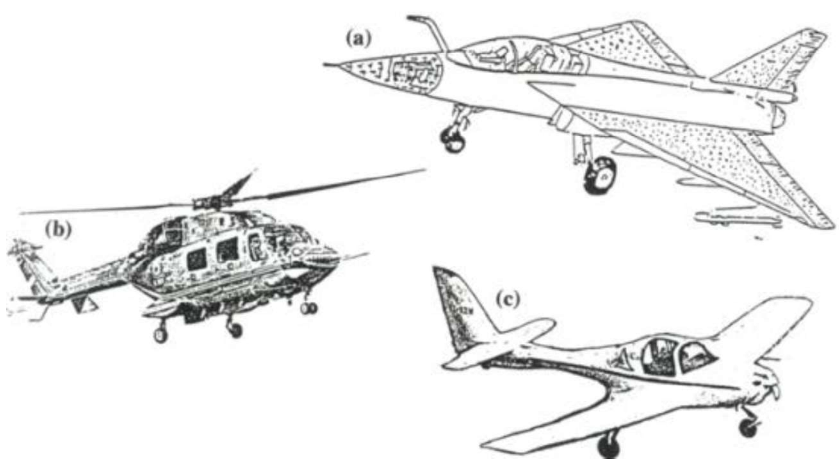

Figure 4 Implementation of Sandwich Structure Used in Aerospace (Agency, 1999)

In figure 4, one example from Agency, 1999 is the application of a sandwich structure in the aerospace field. Because one of the advantages of a sandwich structure is that it is strong but still lightweight without having a very heavy period. The function becomes the opportunity for the utilization of these structures due to the need for aerospace which requires strong but also lightweight materials and structures. In use, there are how many parts that use this structure but have not been fully implemented as in the use of wings, tails, and muzzles of the aircraft. Due to the needs multi-factor experiment design provide the solution involving several factors that affecting the result due to any outputs. The previous BFS research represents a major advancement and is promising to be extended to new energy-absorbing sandwich structures but does not declare a specific combination of each bio-characteristic of the beetle forewing to optimize the work and energy absorbed. The aim of this study is to find out more about geometry design parameters to maximize the sandwich structure of the beetle forewing.

1.2 Problem Definition

Based on the background explained before, the problem define is obtained as follows:

1. What is the significant parameter to optimize and reinforce the honeycomb sandwich structure in order to increase the structure mechanical properties under three-point bending test?
2. How is the interaction of implemented bio-characteristic beetle forewing to the honeycomb sandwich structure?

1.3 Research Objectives

In this research there are several objectives, as it follows:

1. Knowing the significant parameter implemented on propose design to enhance the honeycomb sandwich structure to increase the energy absorption capacity
2. Knowing the interactions of implemented parameter from beetle forewing bio-characteristic to honeycomb sandwich structure mechanical properties

1.4 Research boundaries

In this research there are boundaries as follows:

1. The beetle sandwich structure hexagonal diameter will remain as the same for all type.
2. The material will be used to test the specimen structure is Aluminium 6061 Alloy (UNS A96061).
3. Specimen dimension adjusted to ASTM D 790-17 as standard reference for three-point bending test.
4. Simulation done without the nose and support and replace with line as a reference point for applied force and fixed support.
5. The study only analyses the optimization of design parameters based on structure mechanical properties, and the selection of design concepts using predetermined methods.

1.5 Benefits of research

Based on the background, problem formulation, research objectives, and research limitations above, the benefits of this study are as follows.

1. Knowing how to determine the design concept and optimal design parameters using the multi-factor experimental design method.
2. Producing a proposed beetle forewing sandwich structure design that can be used for bio-inspired sandwich structure research.
3. Apply industrial engineering, especially in product design and development regarding parameter optimization and concept selection.
4. Give references to readers who want to develop design concepts from this study.

1.6 Writing systematics

The systematic writing use in this research are:

- **Chapter – 1 Introduction**

This chapter contents the research background, problem definition, research objective, research boundaries, and also benefits of the research

- **Chapter – 2 Literature Review**

  This chapter contains references to the study of literature taken from previous studies relating to the topic of the issue raised. This chapter also discusses the relationship between the concepts studied and the elaboration of contributions by previous researchers, as well as explaining the reasons why the chosen theory is included in the study.

- **Chapter – 3 Research Methodology**

  This chapter contains an explanation of the methods used and the steps in the study work in detail from the initial stage to the final stage. What needs to be done is to describe the conceptual model of the study scheme and also the systematic problem solving that addresses issues ranging from problem identification, data collection, data processing, data analysis, to drawing conclusions

- **Chapter – 4 Data Collection and Processing**

  This chapter contains the collection of data needed to measure design parameters, make 3D models of design concepts, and perform steps according to the method used. Data collection is carried out using static structural simulations and the results will be tested and processed statistically.

- **Chapter – 5 Analysis**

  This chapter contains an analysis of the results of data processing. This analysis will discuss in detail the results of the design concept selection along with the related reasons and references that can be responsible for the results of the data obtained.

- **Chapter – 6 Conclusion and Suggestion**

  This chapter contains the conclusions drawn from the results of the analysis and discussion. Where these results are associated with the initial objectives of the study, whether the research objectives have been achieved or not. Then there are also suggestions for further study.