DESIGN IMPROVEMENT OF THE HEATING OVEN FOR HONEYCOMB CORE FORMING PROCESS

This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Sesi Pengajian: **2019/2020 Semester 1**

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2. Hal ini adalah kerana ianya merupakan projek yang ditaja sepenuhnya oleh syarikat luar (CTRM Aero Composites Sdn. Bhd.) dan hasil kajiannya adalah sulit.

Sekian dimaklumkan. Terima kasih.

Yang benar,

Tandatangan dan Cop Penyelia
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I hereby, declared this report entitled “Design Improvement of the Heating Oven for Honeycomb Core Forming Process” is the result of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

…….....

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ABSTRAK

Komposit teras madu (HCC) telah bertambah meningkat dan digunakan secara meluas dalam komponen pesawat, penggunaan ketenteraan, pengangkutan dan pelbagai aplikasi lain. Walau bagaimanapun, hasil pengeluaran panel teras sarang lebah sangat rendah disebabkan oleh keupayaan proses pembentukan. Jurutera perlu berkompromi dengan ketebalan dan proses inti sarang lebah untuk mengurangkan kegagalan. Di samping itu, pemanasan ketuhar juga merupakan salah satu unsur kritikal dalam membentuk komposit teras sarang lebah. Syarikat XYZ telah berusaha untuk meningkatkan pengeluaran mereka dan mengurangkan sekerap mereka yang disebabkan kegagalan ketuhar pemanasan. Projek ini bertujuan untuk meningkatkan reka bentuk ketuhar pemanasan untuk proses pembentukan teras sarang lebah dengan menjalankan analisa aliran haba reka bentuk ketuhar semasa dan asas percubaan untuk memperbaiki parameter proses untuk proses pembentukan. Satu percubaan dan simulasi yang terlibat untuk mendapatkan suhu optimum dan kelakuan ketuhar dan HCC itu sendiri. Keputusan eksperimen menunjukkan bahawa suhu optimum untuk rawatan haba pra-membentuk yang direkodkan ialah 370 ° C. Simulasi yang telah dilakukan terhadap reka bentuk lama dan baru menunjukkan peningkatan yang baik dari segi keseragaman suhu dan aliran haba ketuhar. Selain itu, suhu optimum untuk ketuhar ini juga telah ditentukan dari eksperimen yang dijalankan. Spesimen selepas rawatan panas sebelum pembentukan meningkat dengan ketara dalam nilai ketegangan dari maksimum purata 0.0859 hingga 0.1299 pada tahap tertinggi. Keseragaman haba reka bentuk ketuhar semasa yang ditunjukkan dalam simulasi ini mempunyai jarak 200 °C hingga 370 °C dari suhu purata di seluruh ketuhar. Kesimpulannya, peningkatan ketuhar dan suhu optimum berfungsi sebagai garis panduan kepada jurutera dalam proses HCC dan ini dapat mengurangkan kecacatan yang diketengahkan sehingga meningkatkan produktiviti syarikat.

ABSTRACT

Honeycomb core composite (HCC) has growing increase and widely used in aircraft component, military use, transportation and other wide range of application. However, the production yield of honeycomb core panel is significantly low due to forming process capability. Engineers need to compromise with the thickness and the process of the honeycomb core in order to reduce the failure. In addition, heating oven as well is one of the critical elements in forming process of honeycomb core composite. XYZ Company has been struggling to improve their production and reduce their scrap caused by the heating oven failure. This project aims to improve the heating oven design for honeycomb core forming process by conducting the heat flow analysis of the current oven design and experimental basis on improving the process parameters for the forming process. An experimental and simulation involved to obtain the optimum temperature and the behaviour of the oven and the HCC itself. Experimental results shown that the optimum temperature for the pre-forming heat treatment recorded was 370°C. The simulations that have been done to the old and new design shows great improvement in terms of the temperature uniformity and the heat flow of the oven. Besides that, the optimum temperature for this oven also has been determined from the experiments conducted. The specimen after the pre-forming heat treatment improved significantly in strain value from an average maximum of 0.0859 to 0.1299 at highest. The heat uniformity of the current oven design shown in the simulation has range of 200°C to 370°C from the average temperature across the oven. In conclusion, the improvement of the oven and the optimum temperature serve as guideline to engineers in the process of HCC and this can reduce defects that are highlighted thus increase the productivity of the company.

DEDICATION

Only

my beloved father, Ajid Salleh

my appreciated mother, Masiah Misron

my adored sister and brother, Bazli, Ain, Afifah and Muizz

for giving me moral support, money, cooperation, encouragement and also understandings

Thank You So Much & Love You All Forever

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3D	-	Three-Dimensional
ANOVA	-	Analysis of Variance
CAD	-	Computer Aided Design
CFD	-	Computational Fluid Dynamic
CTT	-	Classical Test Theory
DOE	-	Design of Experiments
FKP	-	Fakulti Kejuruteraan Pembuatan
HCC	-	Honeycomb Core Composite
UTeM	-	Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

This chapter brief introduction on the project's background base on the general information regarding the honeycomb core forming process and heating oven that used for the heating process. Problem statements, objectives and scope will also be explained in this chapter.

1.1 Project Background

Heating oven has been widely used as one of the tools in the manufacturing industry for brazing, heat treating, hardening, annealing, tempering and stress relieving to pre heating and shrink fitting, and more general purpose heating like crystal pulling, sintering, bonding, material testing, drying, soldering, curing, degassing and sealing. Even though there is a lot of heating operations in the industry, conventional heating oven are still the most dominant method due to the technical limitation in the current induction heating technology (Frogner *et al,*, 2015). Heating oven plays important role in the forming process of honeycomb core composite, not only in curing process of the composite but the preparation of the material itself before its go to the shaping process. Any failure for the heating oven caused defects to the final product that could jeopardize the overall mechanical strength of the honeycomb core panel.

In producing of honeycomb core, heating in the forming oven as well as shaping is an important step in order to obtain a high quality product. Forming process of a honeycomb core composite is a huge challenge for the manufacturing companies. With the growth of the honeycomb core composite technology, the applications of it have widened for not only used in the airspace industry. Military and transportation industry also have been implementing the used of honeycomb core panel to increase efficiency and reduced weight.

There are 3 main elements involved in the forming process of the honeycomb core. Figure 1.1 below shows the 3 main elements in the forming process of honeycomb cores in the industry.

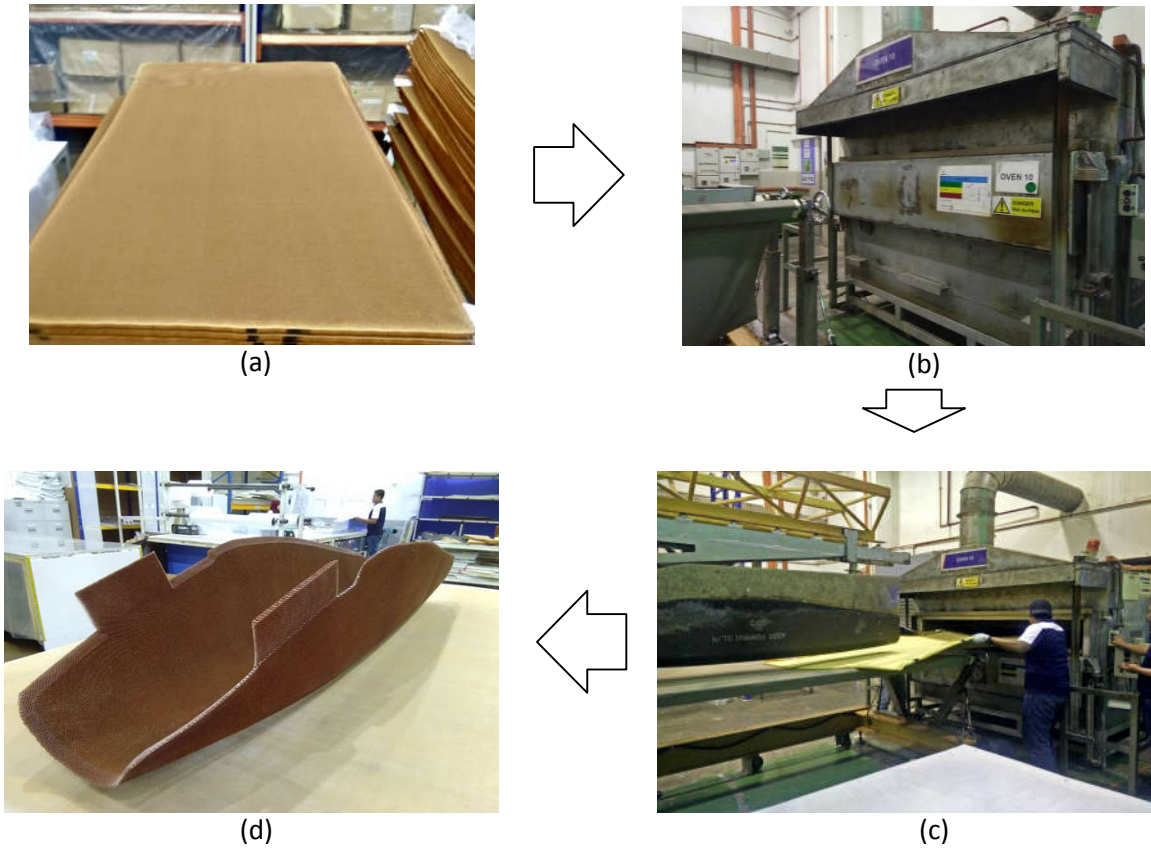

Figure 1.1: Elements involved in the forming process. (a) Sheet Honeycomb Core (b) Pre-Forming Heat Treatment Using Convection Oven (c) Forming Process Using the Forming Machine (d) Final Product

1.2 Problem Statement

Manufacturing of honeycomb core composite panel is highly impacted by poor production yields caused by the core defects that occur during the curing process (Hsiao *et al.*, 2006). Defects that happen during the manufacturing process leads to high cost part rejects because the defects are non-reworkable (Aziz, 2019). This constrains the aircraft engineers, limiting the design range for the core density and core thickness in order to avoid the failure (Hsiao *et al*., 2006). Moreover, the heating oven is the single point failure in the forming process line of company XYZ. Having the heating oven to fail caused the overall line to halt and increased the cost of production. The heat observation done to the oven also shows that the oven only capable to achieve the heat uniformity after 5 hours of operations. With the oven closed its operation for one day in a week, the forming process line would loss 5 hours of production hour until the oven sustain its heat uniformity. Over or under the temperature caused defects on the honeycomb core final product. With the defects could not be rework, the cost for manufacturing the honeycomb core increased significantly. Figure 1.2 shows the defects occurred during the process of forming pre and post heating.

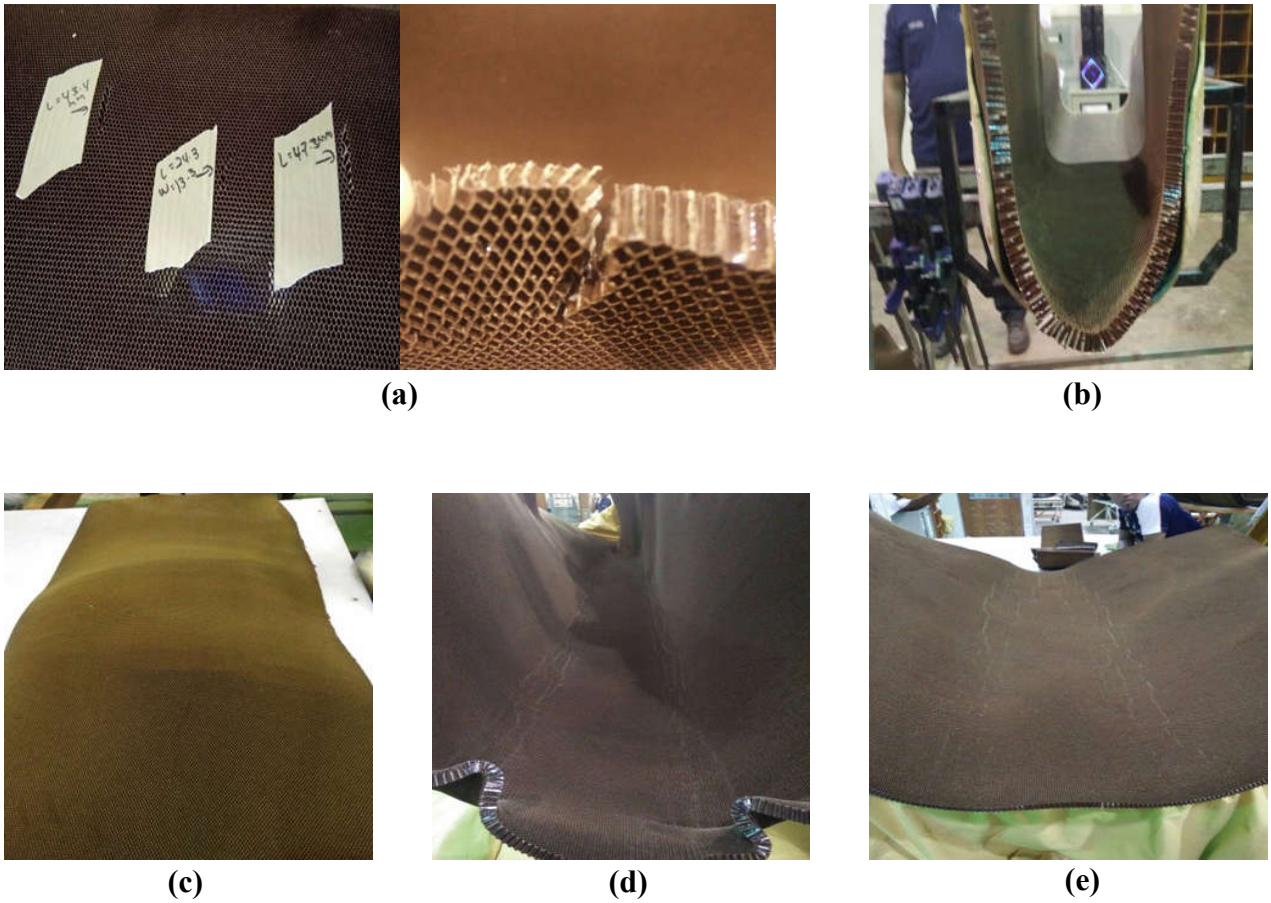

Figure 1.2: a) Cell Tear b) Gap from CTT c) Unformed core d) Buckled line e) Unformed core and buckled line.

Therefore, this research intends to propose comparison study using experiment and physical analysis method to evaluate the temperature of the oven that would be optimum for the oven and for the HCC. The outcome of this study is a valuable input that assists engineers and the company in designing and choosing the best configuration oven and reduces the failure scrap.

1.3 Objectives

In order to solve the issues, the objectives of this project are as follow:

1) To analyse the heat flow of the current oven design using a 3D simulation software.
2) To optimize the heating temperature of the honeycomb core using experimental analysis.
3) To compare the heat uniformity between current oven design and proposed oven design using optimized temperature.

1.4 Scope

This project is focusing on the oven design of the oven, labelled as Oven 10 that used in the forming process of honeycomb core composite at XYZ Company as well as the process parameters of the forming process itself. The scopes of this project include the use of commercial 3D modelling Design software Solidworks, analysis software SolidWorks Flow Simulation to analyse the current oven design and proposed oven design. Next is to run the experimental based analysis in order to determine the process parameters that are most suitable for the forming process of a honeycomb core composite. Fresh HCC specimens with the cell size of 3 mm and thickness of 12.75 mm had a 3-point bending and compression test using Shimadzu Universal Tensile Machine located at FKP, UTeM.

1.5 Organization of Report

This final year project report consists of five chapters namely introduction, literature review, methodology, results, discussion, conclusion and recommendation. The first chapter briefly explains on the project's background base on the general information regarding the honeycomb core forming process and heating oven that used for the heating process, problem statements, objectives and scopes.

In chapter two more about literature of honeycomb core composite, its mechanical properties and heat treatment process by other researchers. The design of the oven for heat treatment of the honeycomb core composite is reviewed. An overview of the heat treatment process covers theory of heat treatment, and the parameters that govern the heat treatment process. Besides that, this chapter provides a short review on the use of SolidWorks as the tools to analyse the capabilities, limitation and the effectiveness of the current oven design with the proposed design.

In general chapter three is the methodology on how this project will be conducted, software analysis and experiment setup, testing technique and how the data analysis obtain from the experiment is done.

Chapter four is about the results of the study that have been done in this project according to the methodology that have been stated in the previous section.

Finally, chapter five concluded about the overall project that has been finished, as well as future recommendation, which could not be established in this project at the time.

CHAPTER 2
LITERATURE REVIEW

This chapter discusses literature of honeycomb core composite, its mechanical properties and heat treatment process by other researchers. The design of the oven for heat treatment of the honeycomb core composite is reviewed. An overview of the heat treatment process covers theory of heat treatment, and the parameters that govern the heat treatment process. Besides that, this chapter provides a short review on the use of SolidWorks as the tools to analyse the capabilities, limitation and the effectiveness of the current oven design with the proposed design.

2.1 Honeycomb Core Composite

Honeycomb core structures are known to highly improve stiffness at lower weight and having high flexural rigidity. Wide applications in aerospace as part of the primary structure as well as the interior panel and floors have been found. Typical materials used for the purpose of honeycomb core are high performance aluminium and aramid. Materials such as fibre glass, carbon fibre, Nomex and also reinforced Kevlar are used by other industries (Manan *et al*., 2016). Honeycomb core composite panel is considered as one of the latest invention that boosts the development of transportation technologies especially in the aerospace sector. With the capabilities of being lightweight while giving the same if not better performance as the traditional materials.