UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ALIGNING NEW PRODUCT DEVELOPMENT WITH REVERSE ENGINEERING METHODOLOGIES FOR HEADLAMP HONDA CITY JIG

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BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PRODUCT DESIGN) WITH HONOURS

2024

Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Manufacturing Engineering Technology (Product Design) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this Choose an item. entitled “ALIGNING NEW PRODUCT DEVELOPMENT WITH REVERSE ENGINEERING METHODOLOGIES FOR HEADLAMP HONDA CITY JIG” is the result of my own research except as cited in the references. Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Name : *Nur Athirah Najwa bt Kamirazaman*

Date : 9/1/2024

APPROVAL

I hereby declare that I have checked this thesis and, in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Product Design) with Honors.

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DEDICATION

This report is dedicated to my amazing parents and loving siblings, whose continuous support and love has served as the foundation for my journey. You supported me during hardship, giving me direction and strength that helped me move forward. Your unfailing faith in me gave me the courage to face difficulties head-on and continue. You have supported me through many sacrifices and never-ending words of inspiration. This accomplishment is equally yours and mine, and I will always be grateful for your steadfast support throughout my life. I appreciate you being my lighthouse and pushing me to new heights.

ABSTRACT

This study explores the combination of reverse engineering (RE) and new product development (NPD) methodologies to enhance the manufacturing process of Honda City headlamp jigs. RE, utilised as a benchmarking technique, aids in regenerating parametric designs or innovating new product concepts. The Honda City's distinctive appearance relies on headlamps with protective coatings cured at high temperatures in UV ovens, necessitating jigs capable of withstanding such conditions. Hence, employing RE becomes crucial to fortifying jig performance.While RE often signifies innovation or refinement, the current headlamp jig encounters deformation issues during manufacturing due to high curing oven temperatures and intense water jet cleaning pressures. The absence of an effective NPD approach exacerbates persistent jig deformation challenges. NPD, encompassing stages like idea generation, concept development, design, testing, and marketing, is crucial. The absence of NPD, along with the complexity of RE, could prolong timelines and escalate expenses in bringing marketable products to fruition.This study aims to propose an NPD model for Honda City headlamp jigs, leveraging RE methodologies to enhance composite jig fabrication processes. The integration of PDCA methodologies within NPD intends to rectify deformation issues while optimizing manufacturing processes for superior Honda City headlamp jigs.

ABSTRAK

Kajian ini meneroka gabungan kejuruteraan terbalik (RE) dan metodologi pembangunan produk baharu (NPD) untuk meningkatkan proses pembuatan jig lampu depan Honda City. RE, digunakan sebagai teknik penanda aras, membantu dalam menjana semula reka bentuk parametrik atau menginovasi konsep produk baharu. Penampilan tersendiri Honda City bergantung pada lampu depan dengan salutan pelindung yang diawet pada suhu tinggi dalam ketuhar UV, memerlukan jig yang mampu menahan keadaan sedemikian. Oleh itu, menggunakan RE menjadi penting untuk memperkukuh prestasi jig. Walaupun RE sering menandakan inovasi atau penghalusan, jig lampu depan semasa menghadapi masalah ubah bentuk semasa pembuatan disebabkan oleh suhu ketuhar pengawetan yang tinggi dan tekanan pembersihan pancutan air yang sengit. Ketiadaan pendekatan NPD yang berkesan memburukkan lagi cabaran ubah bentuk jig yang berterusan. NPD, merangkumi peringkat seperti penjanaan idea, pembangunan konsep, reka bentuk, ujian dan pemasaran, adalah penting. Ketiadaan NPD, bersama-sama dengan kerumitan RE, boleh memanjangkan garis masa dan meningkatkan perbelanjaan dalam membawa produk yang boleh dipasarkan kepada hasil. Kajian ini bertujuan untuk mencadangkan model NPD untuk jig lampu depan Honda City, memanfaatkan metodologi RE untuk meningkatkan proses fabrikasi jig komposit. Penyepaduan metodologi PDCA dalam NPD berhasrat untuk membetulkan isu ubah bentuk sambil mengoptimumkan proses pembuatan untuk jig lampu depan Honda City yang unggul.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to the research platform that allowed me to carry out my research and was provided by Universiti Teknikal Malaysia Melaka (UTeM) and DRB-HICOM Defence Technologies Sdn. Bhd. (DEFTECH). My research has been made easier, and I've had access to the resources and knowledge I need thanks to the partnership between UTeM and DEFTECH. I would also like to thank the Malaysian Ministry of Higher Education (MOHE) for their financial support, which was essential in making this study possible. Their assistance has made it possible for me to conduct research and work towards my academic objectives.

I would especially want to thank Dr. Noor Irinah bt Omar from the Faculty of Mechanical and Manufacturing Engineering Technology at Universiti Teknikal Malaysia Melaka (UTEM), who served as my primary supervisor. Her advice, expertise, and constant encouragement were really helpful to me during this journey. Her passion to perfection and her devotion to my development have been genuinely encouraging. For his invaluable advice and help, I'm particularly grateful to Haji Mohd Suhaimi Omar, senior manager of sales, operations, and production at DRB-HICOM Defence Technologies Sdn.Bhd (DEFTECH). His industry experience and knowledge have made a significant contribution to the accomplishment of this study.

Finally, from the bottom of my heart I express gratitude to my beloved parents for their encouragement and who have been the pillar of strength in all my endeavors. My eternal love also to all my siblings, for their endless support, love, and prayers. Finally, thank you to all the individual(s) who had provided me with the assistance, support, and inspiration to embark on my study.

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LIST OF SYMBOLS AND ABBREVIATIONS

RE	-	Reverse Engineering
NPD	-	New Product Development
PDCA	-	Plan-Do-Check-Action
TQM	-	Total Quality Managment
CAD	-	Computer-Aided Design
CAE	-	Computer-Aided Engineering
CAM	-	Computer-Aided Manufacturing

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CHAPTER 1

INTRODUCTION

1.1 Background

Reverse engineering (RE) is the process of replicating a current product (part or component) by studying its physical measurements, structure, and properties. Reverse engineering (RE) is a benchmarking technique used to regenerate parametric design or for a new product concept. There are many automotive vehicles that use reversed engineering in designing and building parts such as Honda City headlamp Jigs.

Honda City is renowned for its streamlined and fashionable appearance, which boasts eye-catching headlights that heighten its visual appeal. To achieve this standard, the headlamp needs to have a protective coating that will be cured in a curing UV oven at 120-500 degree Celsius. Because of this step a jig that can handle high temperatures is crucial. reversed engineering process needs to be done to the jigs to improve the product performance.

When a company chooses to invest in reverse engineering, it usually means that they want to either build a new product inspired by an existing one or improve an already existing product on the market. For companies embarking on the critical road of new product development (NPD), reverse engineering can be a significant source of insightsand expertise. This NPD process is critical to the smooth and quick development and successful launch of a new product.

- Problem Statement

The current Honda City headlamp jig utilized in the manufacturing process has encountered a challenge of deformation during operation. This has affected production efficiency and compromised the final product quality. This happens due to the high temperature when entering the curing oven, which was 120 degrees Celsius for 100 hours and continued for another 1000 hours, and the high pressure in cleaning process when using high pressure water jet.

Honda City's headlamps jigs are complex structures that require precise design specifications to function correctly in various conditions. Reverse engineering is the process of examining every detail of every structure to choose a better process for making headlamp jigs. The reverse engineering process involved identifying the process, gathering information, maps the steps, computer-aided design (CAD), testing, and continues improvement.

Without incorporating an effective New Product Development (NPD) approach into the manufacturing process, the persistent issue of headlamp jig deformation is likely to continue. NPD is crucial as its tailor products to meet industrial demands, giving the company a competitive edge. NPD involves various stages, such as idea generation, concept development, design, testing and marketing. The complexity of reversed engineering process will elongate the timeline and expenses required to bring marketable product to fruition without NPD approach.

1.2 Research Objective

The aim of this research is to propose a new product development (NPD) model forHonda City headlamp jig. Specifically, the objective are as follows:

a) To use reversed engineering methodology to fabricate composite jig process.

b) To develop NPD model by Using PDCA (Plan-Do-Check-Action)methodology.

1.3 Scope of Research

The scope of this research are as follows:

- Using reversed engineering method and tools to fabricate a composite material Honda City Headlamp jigs process.
- To propose new product development (NPD) Chart in reversed engineering method by incorporate the PDCA methodology to identify every step of development of Honda City Headlamp jigs using PDCA.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The world has witnessed three digital convergences during the past three decades. In the fields of mechanical engineering and industrial manufacturing, RE refers to the method of creating engineering design and documentation data from existing parts and their assemblies. Assessing and evaluating documents and fostering the attainment of the objectives of a RE project Though it traces its roots back to ancient times in history, the recent advancement in reverse engineering has elevated this technology to one of the primary methodologies utilized in many industries, including aerospace, automotive, consumer electronics, medical devices, sports equipment, toys, and jewelry. History REwas often used during the Second World War and the Cold War (Kumar, Jain, & Pathak, 2013). To accommodate this rapid rate of reinvention of modern machinery and instruments, reverse engineering provides a high-tech tool to speed up the reinvention process for future industrial evolution. Reverse engineering involves breaking down or disassembling a product to learn more about it.

The process of creating a mirror copy of an object or retrieving a past event involves measuring, assessing, and testing. Reverse engineering (RE) is the process of replicating a current product (part or component) by studying its physical measurements, structure, and properties. Reverse engineering (RE) is a benchmarking technique used to regenerate parametric design or for a new product concept. RE tools are programmed to generate free-form shapes from scanned data, and surface features are identified from the cloud of data points. Reverse engineering is a digital technology of CAD models, reconstruction technology of geometric models, and manufacturing technology that isdifferent from the creation of traditional geometric models. It involves the design of new parts, the replication of existing parts, the restoration of damaged or worn parts, improving the accuracy of the model, and the detection of digital models. The process consists of three phases: scanning, point processing, and the generation of a CAD model from the point cloud data. This review is based on the latest research done on parameter optimization in reverse engineering technology. Reverse Engineering has dramatically evolved from making the initiations for the manual redesign procedure and capturing technical product data while also permitting efficient concurrency benchmarking to abetter-extravagated process (Fares et al., 2021).

2.2 Purpose of Reversed Engineering

Reverse engineering is a technique used by manufacturers to compress product development times and shorten lead times to market a new product. It is used to capture a three-dimensional product or model in digital form, remodeled, and exported for rapid prototyping, tooling, or rapid manufacturing. It is often used when a manufacturer is faced with long-term issues, such as lost suppliers for critical spare parts or inadequate documentation of the original design. RE can also be used as a cost-effective alternative to having no future parts to maintain a production capability (Kolar, 2008). RE is the process of duplicating an existing part by capturing the component's physical dimensions, features,and material properties.

RE a part or product is often necessary due to the fact that the original manufacturer no longer producing it, the original design documentation being lost or never existed, some bad features needing to be designed out, the need to strengthen the good features of a product based on long-term usage, analyze the good and bad features of competitors' products, explore new avenues to improve product performance and features, gain competitive benchmarking methods, lack of the original CAD model, the supplier unable to provide additional parts, and the original equipment manufacturers being unable or unwilling to supply replacement parts. It is also important to update obsolete materials or antiquated manufacturing processes with more current, less-expensive technologies. It istypically cost-effective only if the items to be reverse engineered reflect a high investment or will be reproduced in large quantities (Kolar, 2008). RE begins with the product and works through the design process in the opposite direction to arrive at a PDF. It uncovers as much information as possible about the design ideas used to produce a particularproduct. Reverse engineers generally consider whether the financial risk of such an endeavor is preferable to purchasing or licensing the information from the original manufacturer.

2.3 Key Faced of Reverse Engineering Process

The reverse engineering method consists of three major parts. The first phase is an overview, in which reverse engineers become acquainted with the programme and identify areas of interest (Votipka, 2020). In the second phase, known as the sub-component scanning phase, they examine specific sections to discover potential vulnerabilities or topics for additional inquiry. The final step is the focused experimentation phase. They apply dynamic strategies to improve their grasp of the programming and test hypotheses. The study also found that reverse engineers typically use static methods in the first two phases but switch to using dynamic methods in the last phase. Experience plays a large role in each phase, helping reverse engineers prioritise where to search, recognise implemented functionality and potential vulnerabilities, and select which simulation method to employ (Votipka, D., 2020).

2.4 Reverse Engineering Process

Reverse engineering is a systematic process that involves analyzing the design of existing products or systems to create representations of them in higher abstraction levels. It involves four stages: data evaluation and verification, data generation, design verification, and design implementation (Lamba, K. ,2006). In the data evaluation and verification stage, raw data is collected for economic and logistics calculations. In the data generation stage, technical data is developed using traditional devices for high-precision measurements. In the design verification stage, prototypes are developed and tested to ensure design adequacy and accuracy. Finally, in the design implementation stage, the design is implemented into the final product through fabrication, procurement, assembly, and testing to meet specifications and quality standards (Lamba, K. ,2026). The process presents both challenges and benefits, such as product complexity, rapid obsolescence, and the gestation period required for product development. It is crucial for addressing the complexities and demands of developing heavy-duty line printers and other products.

2.5 Method Of Making Reversed Engineering

Different methods and scanning principles are used by reverse-engineering systems to collect data. The methods and sensors used to collect data may differ even among thetwo different reverse engineering systems that are categorized. Similar to how two separatecontrol systems could employ various strategies, ideas, and sensors for data collection. Themethods of digitization can be categorized into two large groups: Contact techniques and non-contact techniques (Chen, 2015).

The contact RE method refers to the digitizing process, where it is the most common, accurate, but time-consuming conventional approach that involves making physical contact with a measuring device's stylus or contact probe on a component surface (Zhao, G., 2017). The contact RE moves at a slow speed that depends on CMM's speed. The accuracy is good, and the point cloud volume is low at hundreds or thousands of points

Non-contact methods do not make physical contact with the object that is being measured and take less time to scan and derive component surface information. by utilizinga medium (light, laser, sound, magnetic fields, or X-rays) with measurement limitations on hollow structures on the surface of transparent materials and are further classified into active and passive techniques (Joshi et al., 2012). The non-contact RE has an extremely fast speed, up to 10,000 per second or more. but the accuracy is low even though the point cloud is extremely high with hundreds of thousands of points.

2.6 Honda City Headlamp

The Honda City is a subcompact car produced by Honda in 1981. It was originally a 3-door hatchback/convertible for the Japanese, European and Australasian markets (Arif,2020). The seventh-generation model features significant size growth and the introduction of the 5-door hatchback model. It was also sold as the Honda Fit Aria in Japanand the Honda Ballade in South Africa. Dongfeng Honda sold a remodeled version of the city called the Honda Greiz and its 5-door liftback counterpart.

The Honda city car's headlamp, which offers illumination for driving at night and inpoor visibility circumstances, is one of its essential components. To ensure the quality and durability of the Honda City headlight, production engineering professionals must be aware of its components and construction process. The Honda city car's headlamp, which offers illumination for driving at night and in poor visibility circumstances, is one of its essential components. To ensure the quality and durability of the Honda City headlight, production engineering professionals must be aware of its components and construction process. Typically, plastic, glass, and metal materials are used to create the Honda City headlamp. While the glass component allows light to pass through it, the plastic component serves as the headlamp's major structural support. The metal component often comprises of brackets or screws that secure the headlamp to the car's body. Injection molding is a step in the construction process when melted plastic material is injected into a mold cavity under intense pressure to create intricate designs.

2.7 Honda City Headlamp Jig

Honda City headlight manufacturing entails several delicate steps that necessitate precision and accuracy. To ensure that the product fulfils the needed quality requirements, jigs must be used during the production process (H. Radhwan et al,2019). Jigs are essential for holding the workpiece in place during machining or assembly operations, allowing for accurate placement and reproducible part manufacturing. This essay will discuss the many types of jigs used in Honda City headlamp manufacturing procedures, the materials used tomake them, and their benefits and drawbacks. Jigs are tools that anchor a workpiece while executing a specific job such as drilling, cutting, or welding. Depending on the activity, numerous types of jigs are used in the Honda city headlight production process. Plate jigs, box jigs, channel jigs, and angle plate jigs are some examples.

Curing is an important aspect of the Honda City headlights manufacturing process, which necessitates the use of specialized jigging equipment to support them while curing inside tunnel ovens. By chemically reacting with other molecules to generate cross-linked polymers, the curing process increases strength and endurance (Pandit,2021). Various types of molds can be used at this stage, ranging from metal substrates covered with release agents such as silicone rubber coatings or Teflon-like coatings.

2.8 Total Quality Managment (TQM)

Total quality management is defined as a continuous effort by all levels of a particular organization to ensure long term customer loyalty and customer satisfaction (Dale H, 2003). The combination of top-level management and employees of an organization is the formula to achieve efficient methods and guidelines to produce high-quality goods that not only satisfy butalso surpass client expectations.

Quality is considered to be the principal determinant of competitiveness and is assessed by determining whether a product or service answers customers' needs, and whether it can be sustained under current market conditions. To manage quality, TQM tackles changing leadership and personnel management practices, better utilizing information and analysis, understanding the needs of customers, and improving processes in a planned way within the strategic goals of the organization (Connolly, 2018). An effective TQM can potentially change the situation such as from result-oriented to process-oriented, personalized to process-led and product-oriented to customer-centered (D.R. Kiran, 2016).

2.9 Six Sigma

Six Sigma is a quality-boosting process improvement technique that entails trainingseveral key personas in the firm in the techniques to monitor, measure, and improve processes and eliminate defects. Six Sigma has been widely applied across industries, from retailing to financial services

(Fred R, 2009). Six sigma's main objective is to implement measurement- based strategy that is focused on purposes improvement variation reduction.

The criteria of six sigma are critical to quality it is the most important to customer, defect is about failing to delivered to customer needs, process capability is about process that can be delivered, variation is what customer sees and feels, stable operation is to ensure consistent, predictable process to improve the customer sees and feel and design for six sigma is a design that can meet customer need and process capability (Yusliza,2015).

The Six Sigma methodology involves identifying the need for an improvement project, conducting a financial analysis to estimate expected financial savings, and measuring current process performance for critical causes for improvement. Solutions are implemented, and the achievement is proven at the end of the project. Antony (2008) found that Six Sigma helped organizations reduce defect rates, operational costs, and increase value for customers and shareholders. Welch of GE reported savings of hundreds of millions of dollars due to Six Sigma implementation. Six Sigma principles include aligning key processes with strategic goals, identifying champions, establishing a standard measurement system, training improvementteams, and setting stretch improvement goals (Souraj, 2009).

2.10 The concept of six sigma in the context of TQM

Total Quality Management (TQM) is a leadership approach that focuses on quality through the participation of all members. It seeks constant improvement and introduces new processes to achieve higher levels of excellence. Success in TQM is based on compliance with clear performance criteria determined by reference models like Total Quality Management and Six Sigma (Gabriela, 2019). After analyzing these models, a new approach to conceptualizing quality management in the online context was established. This concept fosters an employee- centered culture by adjusting to the needs of the primary beneficiaries as well as the external environment.

TQM and Six Sigma are powerful continuous improvement methodologies that share common goals and complement each other. They can be integrated to create a better methodology that overcomes individual shortcomings. Despite their differences, they intersect in many areas, and one may excel in helping the other (Souraj, 2009).. The integration of TQM and Six Sigma is possible and beneficial. Both methodologies share numerous values and aims and can benefit from each other's advantages. TQM can be a holistic umbrella for all stakeholders, while Six Sigma provides a strong structure for achieving greater process improvements.

In the last two decades, the public interest in Total Quality Management (TQM) has declined, while the Six Sigma improvement method, particularly implemented by General Electric, has become a popular management tool. Factors contributing to TQM failure include the diffuse nature of the concept, lack of graspable definitions, and the misconception thatTQM implementation requires cultural change. Additionally, academic discussion of TQM and its implementation has also declined in recent years (Tauseef, 2012).

2.11 New Product Development

The New Product Development (NPD) process is important for developing goods that suit the needs of industrial clients while also distinguishing companies from competitors. It has a distinct character for the industrial sector, taking into account product customization and partnerships with the end user. The traditional sequential process, based on concept, development, validation, and manufacturing phases, has been replaced by an integrated approach that integrates stages and functions (Kazimierska,2017). Product design is now a crucial element of the NPD process, with the expertise of industrial designers providing significant support at various stages of development.

IT technology, such as computer-aided design, engineering, and manufacturing (CAD/CAE/CAM) tools and advanced prototyping technology, allows for support from concept to detailed designs and ultimately manufacturing (B. Cimatti, 2016).

The New Product Development (NPD) process involves companies producing and launching new goods in a series of steps that begin with an initial concept and progress through evaluation, development, testing, and launch. This process can be seen as a series of information gathering and evaluation stages, allowing management to become more

knowledgeable about the product and assess its initial decision. This process can lead to improved new product decisions, limiting risk and minimizing resources committed to productsthat fail. The NPD process varies from industry to industry and firm to firm and should be adapted to meet specific company resources and needs. The Booz, Allen, and Hamilton (1982) model, also known as the BAH model, is the best-known model, based on extensive surveys, interviews, and case studies, and is considered a good representation of prevailing industry practices (Bhuiyan, 2011).

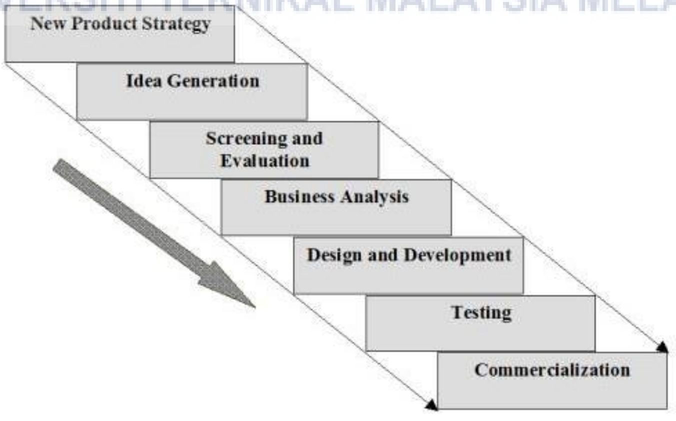

Figure 2.1 Stages of New Product Development (NPD) by Booz, Allen & Hamilton, 1982

New Product Strategy Will Connects the NPD process to the company's goals and gives direction for idea/concept generation as well as instructions for creating screening criteria. Idea generation looks for product ideas that suit the company's goals. Screenings are an early review to discover which concepts are relevant and warrant further investigation. Business Analysis Assesses ideas further using quantitative parameters like earnings, return-on- investment (ROI), and sales volume. Development will convert a concept on paper into a demonstrable producible product. Testing conducts commercial experiments required to validate previous business judgments. Commercialization is the process of launching things (Bhuiyan, 2011).

2.11.1 Type of NPD

Cristian (2010) identifies several types of New Product Development (NPD) based on their focus and goals. These include cost reductions, new uses, new markets, productimprovements, line extensions, new entries, and new to the world products. Experts argue that the easiest types of NPD are those aimed at reducing costs or improving existing products, as these technologies and markets are well-known. However, new entries and new to the world products require significant time and effort.

Companies can receive new items in two ways, internally or outside. Internally managed NPD entails businesses producing new products with their own resources and competencies, which can have both positive and bad consequences. Strategic partnerships, strategic alliances, joint ventures, and licensing arrangements, on the other hand, include numerous enterprises working together to generate winning products. Companies can benefit from experience and knowledge using this strategy.

2.11.2 New Product Development(NPD) Process

The first step in new product development is idea generation, which involves searching for new ideas to enhance existing products or develop new ones. This can be done through customer feedback, analysis of consumer trends and employees, and research into competitors' new services and products. Idea screening is the next phase, where the product concept is evaluated for both external and internal acceptance. The company may end up with several concepts that fulfil customer needs, creating opportunities for radical innovations (Faisa, 2016).

Concept development and testing is the transition from ideas to final products, where the team, including project managers, technical experts, and marketing experts, transforms the concepts into physical products. The selected concept should consider three inputs: customer benefits, production technology, and product form. The marketing strategy formulation is the next step, where the product manager designs and develops a marketing plan for introducing the new product into the marketplace. The plan consists of three segments: market behavior, structure, size, marketing budget, planned price distribution, profit goals, and long-term sales (van,2006). Business analysis is the review of costs, sales, and profit projections with respect to the new product to determine if these aspects satisfy the organization’s goals. Management also makes decisions regarding the technical feasibility, market share potential, and financial contribution to the organization.

Product development requires in-depth technical analysis to evaluate the product's production costs and attractiveness to customers. A prototype or working model is developed to identify all the intangible and tangible attributes of the product. A product protocol is drawnand handed to the R&D department for production. Market analysis is an expensive but crucial step in the global product development process. If the product passes the development and pretest stages successfully and seems to be a profitable prospect, it is tested in the market. This involves physical prototype testing, testing the product and packaging in normal usage situations, conducting focus groups, making necessary adjustments, and producing and sellingin a test market to explore customer acceptance.

In conclusion, the final step in global product development is the decision to introduce the product in all markets being considered. Continuous monitoring is necessary to maximize the product's contribution to the overall company portfolio (Millward,2005)

2.12 Plan-Do-Check-Action (PDCA)

The PDCA cycle, also known as the Deming cycle or Shewhart cycle, is a continuous improvement methodology that can be applied to any small-scale industry, school, or hospital.It involves a four-stage checklist, Plan-Do-Check-Act, to coordinate an organization's efforts towards continuous improvement. The PDCA cycle is more effective than other techniques and aims to address both temporary and permanent issues. Temporary action focuses on addressing and fixing problems, while permanent action investigates and eliminates root causes, ensuring the sustainability of the improved process (Nonxuba, 2010). The PDCA cycle emphasizes that continuous improvement is a never-ending process, making it a valuable tool for organizations to implement.

The PDCA cycle consists of four major components, as shown in Figure 2.0. each of which can be subdivided into the necessary step-by-step problem-solving activities.

Figure 2.2 PDCA Cycle

Firstly, the "Plan" phase. Before any corrective action is taken on the problem at hand, several activities should be undertaken. The problem must be defined, relevant information must be gathered, and the root cause of the problem must be identified. identified, possible solutions developed and considered, and the best alternative selected for implementation. All this needs to be done by people carefully selected based on their association with the process involved and their special relevant knowledge, skills, experience,

Secondly, the "Do" phase is the first step in implementing a plan for improvement, following the comprehensive learning from the "Plan" phase. This phase allows for further learning, adjustments, and further improvements in the "Check" and "Act" phases. The team implements the chosen solutions one by one, requiring support from concerned parties to ensurethey are understood and followed (Patel,2017). Data is collected and documented, including problems, unexpected observations, lessons learned, and knowledge gained. The goal is to ensure the improvement is fully understood and followed.

In the "Check" phase, significant learning can be achieved by observing newlyimplemented processes and partnering with associates to understand what worked well and what new learning has taken place. This allows for the development of comprehensive plans to elevate the process, rather than just fixing what went wrong in the "Do" phase. After implementing improvements, the achieved state is analyzed to verify the solutions. If negative results occur, the improvement work will need to start again at the planning phase (Patel,2017). If positive results occur, the tested solutions will continue to the act phase. Comparing new datato baseline data can help determine if improvements were achieved and if the aim statementwas met. Reflecting on the analysis and considering additional information can help document lessons learned, knowledge gained, and surprising results

Finally, the “Act” phase. If the check step confirms that the problem has been eliminated and that it is not likely to recurrence, then the job is done. If, however, it is found that the solution has not accomplished the intended result or that there is still a possibility of recurrence, then it will be necessary to “adjust” the implemented solution. Adjustment can also mean discarding the implemented solution and trying a different approach. Whether the implemented solution has failed completely or does not quite measure up. According to expectations, the conceptual adjustment will be carried forward to the next step of another PDCA cycle. This cycle can be repeated as many times as is necessary to eliminate the problemsuccessfully. If progress is not evident after several cycles, however, it would be a good idea to stop (David L,2014)

2.13 When to Used of PDCA Cycle

The PDCA cycle is an effective problem-solving tool. The cycle can be applied to repeated PDCA cycles when Kaizen (continuous improvement) is used, and the Continuous Improvement tool can be applied to new areas for improvement. Next, it can also be applied to exploring a range of possible new solutions to problems, trying them out, and improving themin a controlled way before selecting one for full implementation. The cycle for planning data collection and analysis so as to verify and prioritize problems or root causes. Finally, for avoiding the large-scale waste of resources, daily routine management for the individual and/or the team (D.R. Kiran, 2016). Other fields where PDCA can be used are project management, continuous development, vendor development, human resources development, new product development, and process trials.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This methodology will be the explanation on how new product development (NPD) process related to reversed engineering of Honda City headlamp jigs. The reverse engineering method consists of deconstructing a process flow and thoroughly analyzing the component. Analyzing and understanding the Honda City Headlamp Jig's design, process and problem are the objectives of reversed engineering in this project. From the information gathered in the reversed engineering process, the new product development (NPD) can be built.

New Product Development (NPD) is a research-driven process aimed at creating and introducing innovative products to the market. By integrating reverse engineering into NPD by utilizing PDCA method, it harnesses the power of a creative and data-driven approach to produce market-ready products. This integration not only enhances production timelines but also optimizes manufacturing processes for maximum efficiency.

3.2 Proposed Methodology

This proposed methodology will help to guide the process of reversed engineering(RE) using a new development process (NPD) with PDCA method in beta testing Proposed Methodology.

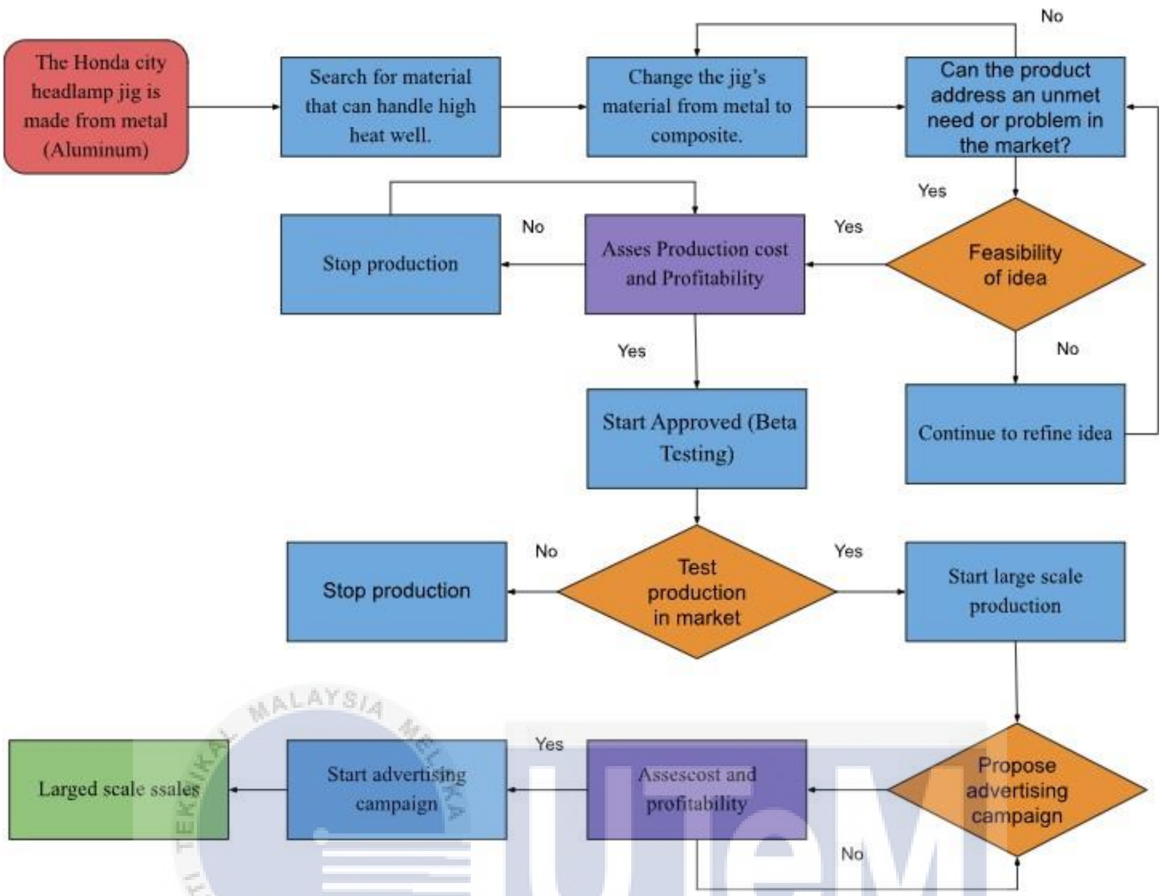

Figure 3.1 New Product Development (NPD) Flowchart

3.3 Integration of PDCA with Reverse Engineering

The PDCA method will be focusing on the Start Approved (Beta Testing) from the new product development (NPD) flowchart as shown in figure 3.1. This process will explained step by step of making Honda City headlamp jig using PDCA method with reverse engineering process.

3.3.1 Plan

The PDCA (Plan-Do-Check-Act) technique will begin with the planning phase, with a focus on the deformation issue noticed in Honda City headlamp jigs because of their constant exposure to the curing oven. Concerns have been raised about the jigs' repeated thermal cycling within a temperature range of 120°C to 125°C during testing for durations of 100 hours and 1000 hours. Furthermore, the cleaning process, which uses high water pressure, compromises the jig's integrity.

Furthermore, the Honda City headlamp's intrinsically elongated dimension increases its sensitivity to deformation, slowing the curing process. These elements all lead to deformations, which reduces the overall efficacy of the headlight curing method.

3.3.2 Do

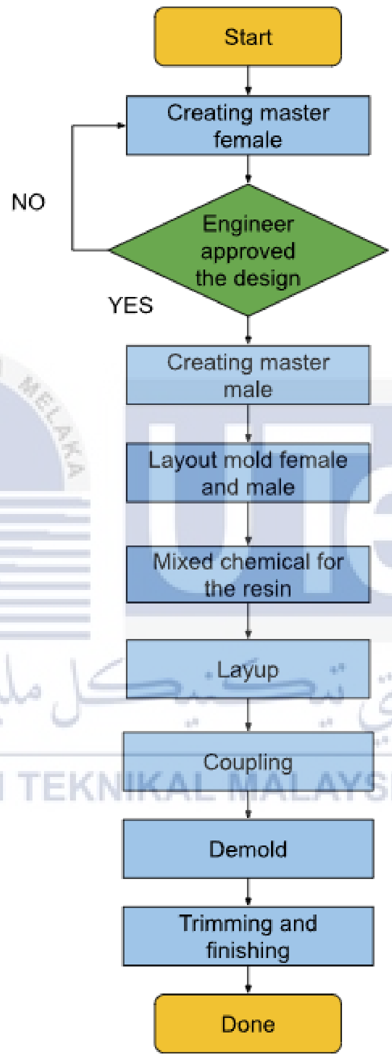

Figure 3.2 Reversed Engineering Stage (Beta Testing Flowchart)

Continuing with the PDCA (Plan-Do-Check-Act) technique, the 'Do' step entails the execution of the Honda City headlamp jig production process. Figure 3.2 depicts the entire flowchart of the beta testing segment inside the New Product Development (NPD) structure, outlining the intricate details of this phase. This graphical representation shows the stages followed during the beta testing phase of the headlamp jig production process.

Figure 3.3 Master Female for Honda City Headlamp Jig

The process starts by producing master female as shown in figure 3.3. The master female is produced by developing inner platform on surface of the Hando City headlamp lens by using foe foam or any material available such as cardboard or plywood. After the inner lens is produced, the second step is to produce the outer platform on the surface of the lens. After that, the platformis filled with filler patty to produce the desired shape and let it dry for few hours and send the surface for smooth finishing.

Master male will be created once master female is complete and the engineer has approved the design. The first step is to mix 100 grams of resin with 30 grams of hardener for the laminating process. The mix resin and hardener are then applied on top of the masterfemale. Then, 8 layers of fiber glass and fiber carbon are placed alternately, the mold will be cured overnight. The secondary laminating process will be carried out once the mold has cured. The mold will be demolded and trimmed to finish after the resin is cured.

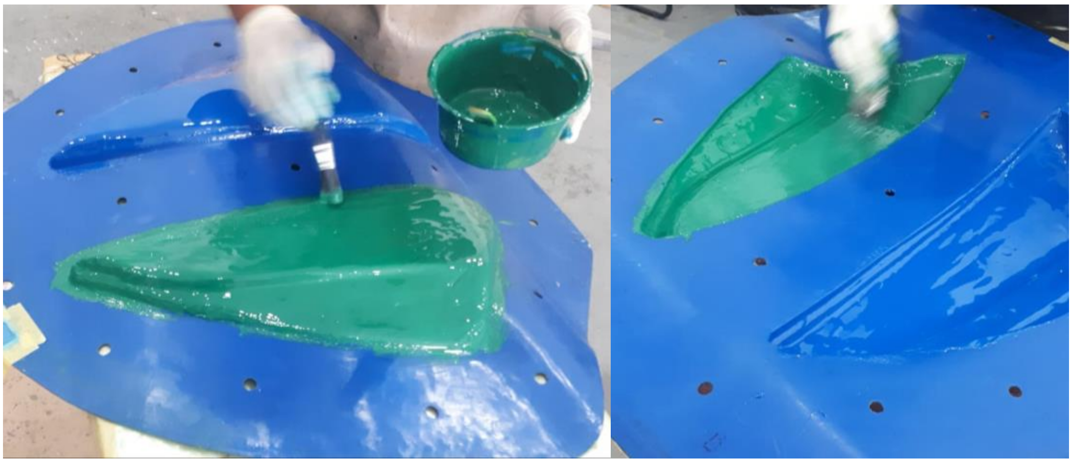

Figure 3.4 Layout Process

The layout process can be done by using epoxies resin or polyester, in this process epoxies resin have been chosen as the binding solution, shown in figure 3.4. The mold female are produces by preparing the master female using wax as the releasing agent. The wax will help to avoid the mold from sticking to the master female and smooth demolding process. Then, 100 grams of resin with 30 grams of hardener are mixed for laminating process. Mix resin then, place on top of the wax surface and8 layers of fiber glass and fiber carbon are placed alternately. After the mold is cured, the mold will be demolded, and finishing. The same process will be repeated using mold of master male. In this process, the thickness of the jigs is determined. Thethickness is determined by material data sheet (MDS). MDS information includes the fiber material, resin, and vacuum process.

Figure 3.5 Chemical Mixture Process

In the formulation of the chemical mixture shown in figure 3.5, a precise combination of 100 grammes of Epoxy 2051, complemented by 20 grammes of hardener, is used. Notably, the resin exhibits a dark blue hue, while the hardener presents a light amber coloration. The density of the resin registers between 1.25 and 1.35 at a temperature of 25 degrees Celsius, while the hardener maintains a density range of 1.05 and 1.09, also at 25 degrees Celsius. Enhancing the mixture's viscosity for a more robust bond involves the incorporation of fumed silica. This powder material acts as an agent to thicken the blend when combined with the resin and hardener, thereby fortifying the overall strength of the mixture.

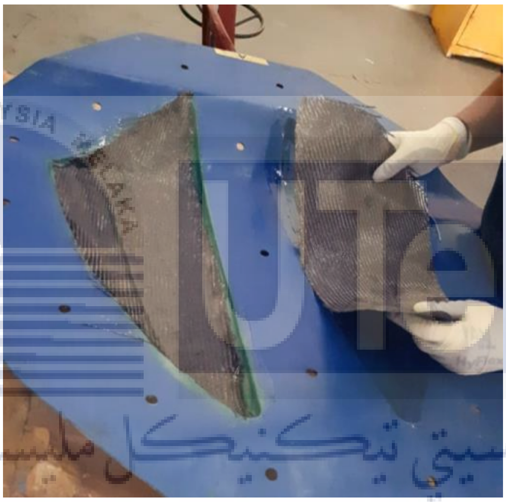

Figure 3.6 Layup Process

In the layup process shown in figure 3.6, the finished male and female mold will be wax to make sure the jigs can be demolded smoothly. Then, fiber glass and fiber carbon will be cut using the template provided by the engineer. After that, the chemical that have been mixed are place on top of the wax surface, then, two layer of fiber carbon are placed on top of both male and female mold. The fiber carbon on the female mold needs to fit nicely, do not have many extra surfaces to make sure the mold doesn’t break. After that, 2 layers of fiber glass were placed on top of the fiber carbon and lastly two more fiber carbon are placed on top of the fiber glass. Thelayup must be smothered with the resin mixture and all layers need to apply the resin mixture tomake sure the fiber carbon and fiber glass stick together. Before continuing with coupling process, the final layers need to be layered with thick resin that has been mixed with fumed silica.

Figure 3.7 Coupling Process

Bolts and nuts are used to attach the male and female molds during the coupling process shown in figure 3.7. After the last layers are positioned, this important step needs to be done right away to avoid the resin drying out too soon. After the molds are sealed, the next step is the curing process, which takes place over night. This process guarantees the best possible adherence of the molds, giving enough time for the resin to cure and solidify inside the small mold structure, resulting in the integrity and quality of the final product that is required.

Figure 3.8 Demold Proces

Figure 3.9 Trimming Process

In the demolding process as shown in figure 3.8, the cured composite jigs are by unscrewing the mold and carefully detaching the mold from the jigs. This process can be done by using a spatula. Diamond edge cutting tools are used in the trimming process to avoid any burr defects as shown in figure 3.9. To make sure all the jigs have smooth surfaces, the sanding and drilling process will be done at the finishing stage as shown in figure 3.10. Then, to ensure that the fiber does not come out of the edge, edge seals will be placed for safety purposes.

Figure 3.10 Sanding Process

3.3.3 Check

In the PDCA cycle, the Honda City headlight jig at DEFTECH is examined closely by the quality department during 'check' step. The customer and DEFTECH both performed extensive internal and external reviews during this period. While DEFTECH thoroughly examines the jig to make sure it complies with their standards, the customer offers crucial third-party confirmation. The dedication to client happiness and superior products is highlighted by this cooperative approach. An important point that can be emphasized in this current progress report is that this stage's rigorous inspection guarantees that the headlight jig satisfies strict quality standards.

Multiple tests are carried out as part of DEFTECH's meticulous verification procedure to guarantee a thorough evaluation. The main exam concentrates on surface finish, stressing the need to carefully inspect every surface for possible flaws such as holes, scratches, fractures, dents, or surface bulging. By closely examining every part for flaws, this rigorous inspection guarantees that the Honda City headlamp jig satisfies the highest quality standards. Being the first step, the surface finish test demonstrates DEFTECH's dedication to accuracy and quality during the project's inspection phase.

The dry fit test is the second crucial test in DEFTECH's thorough review. Making sure the sample lenses fit the fixture precisely and securely is a crucial part of this inspection. Additionally, it carefully confirms that any gaps found in important areas are within tolerance limits. Through the implementation of the Dry Fit Test, DEFTECH thoroughly evaluates the accuracy and operation of the Honda City headlamp jig, confirming that the lenses fit with a smooth appearance while upholding the required tolerances in particular regions. This test is essential to ensure that the fixture works and meets the requirements.

The tap test is the third essential step in DEFTECH's checking procedure for Honda City headlamp jig. To check for delamination or debonding in the composite material, a careful inspection entails tapping the Honda City headlight jig sporadically on all of its surfaces. DEFTECH intends to confirm the structural integrity of the composite components by putting the jig through these carefully calibrated taps. This will guarantee that all composite materials stay firmly bonded without sacrificing any structural quality. This examination protects against possible material flaws that can jeopardize the headlamp jig's overall longevity and performance.

The headlight jig's hole diameters are thoroughly examined as the last step of scrutiny. Each hole's size and location are carefully examined to make sure they exactly match the tolerance levels that have been stipulated. The care with which this inspection is conducted ensures that each hole is precisely positioned and meets the precise measurements needed to ensure the headlight jig operates as intended.

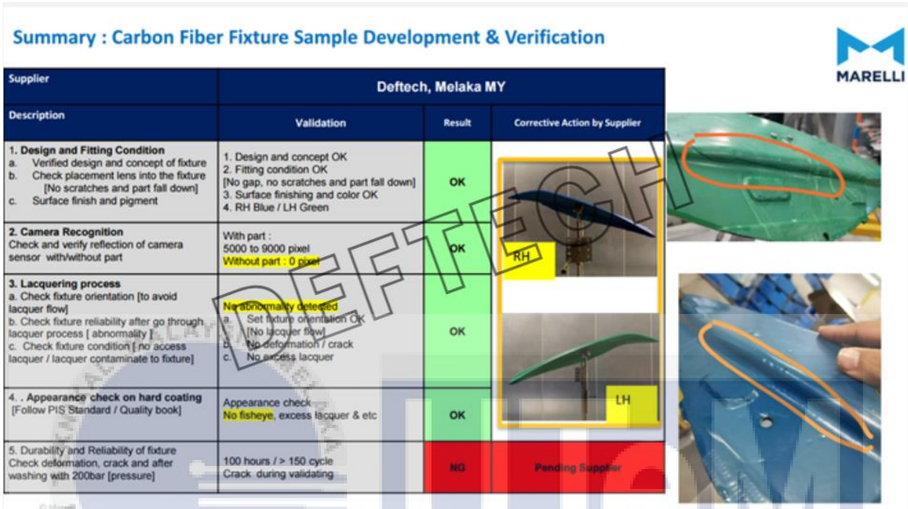

Figure 3.11 Customer Method of Testing

For the customer, the method of testing the product is by several critical evaluations are undertaken to ensure the impeccable quality and functionality of the Honda City headlamp jig as show in figure 3.11. The "Design and Fitting Condition" evaluation starts with a detailed review of the fixture's design and conceptual integrity. It also checks the precise placement of lenses in the fixture to ensure a perfect fit with no scratches or parts slipping out. Furthermore, this inspection rigorously inspects the fixture's surface polish and pigment to ensure that it fulfils the set criteria without any flaws.

Another critical examination is the "Camera Recognition" test, which thoroughly evaluates and confirms the camera sensor's reflection both with and without components. This assessment assures that the camera recognition capabilities are accurate as requested by the customer, as well as the fixture's performance in sensor detection. Next, the "Lacquering Process" examination has several components. First, it evaluates the fixture's orientation to avoid lacquer flow. It then assesses the fixture's reliability after lacquering to identify any anomalies that may develop. Finally, this examination guarantees that the fixture is not contaminated by lacquer or residue, allowing it to remain intact throughout the lacquering process.

An "appearance check" in accordance with the PIS Standard or Quality Book is an essential component of the assessment. This thorough inspection confirms that the fixture's hard coating satisfies the required standards, is free of any fisheye effects or excessive lacquer, and strictly adheres to set appearance rules. The last assessment, "Durability and Reliability of Fixture," looks at the fixture's ability to tolerate deformation and cracks, particularly after being washed at 200 bars of pressure after going into a curing oven for 100 hours and another 1000 hours. This comprehensive inspection assesses the fixture's resistance and endurance, ensuring that it stays intact and reliable even in harsh situations.

The only feedback indicating failure in quality testing for the Honda City headlamp jig comes from the customer's durability and reliability assessment. The jig exhibited cracks or deformities after undergoing the curing oven and a pressure wash for over 100 hours or more than 150 cycles, revealing vulnerabilities during validation.

3.4 Summary

This chapter presents the process of making a Honda City headlamp jig using composite material with the PDCA (Plan-Do-Check-Action) method from the New Product Development (NPD) process. The plan part identifies the problem that has occurred at the Honda City Headlamp Jigs after entering the curing oven for an amount of time, and the jigs then undergo high water pressure in the cleaning process. In this chapter, all the step-by-step processes to produce Honda City headlamp jigs using composite material have been identified. They start with building a female and male master mould, follow the layout process, and continue with the chemical mixture and layup process. Every step-by-step process is crucial to making sure the jig is produced in good condition. The next step is compling, demolding, trimming, and finishing.

This chapter also talks about the checking process or quality control procedure. There are several tests that have been done, including one from DEFTECH, the company that produces the Honda City jigs, and one from the customer to make sure the jigs meet customer standards.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

The project's outcome will primarily focus on the 'Action' phase within the PDCA cycle, aiming to address solutions arising from the 'Check' step evaluations. This phase involves proposing and implementing solutions to rectify issues identified during the assessment. It encompasses strategies and recommendations derived from a thorough examination of the headlamp jig's performance and quality, particularly emphasizing improvements to mitigate or resolve concerns detected in earlier testing stages. From the testing stage, the jig did not pass the customer final testing phase, that is durability and reliability assessment. The 'Action' phase serves as a pivotal aspect of the PDCA methodology, facilitating the refinement and enhancement of the Honda City headlamp jig's design and functionality.

4.2 Action

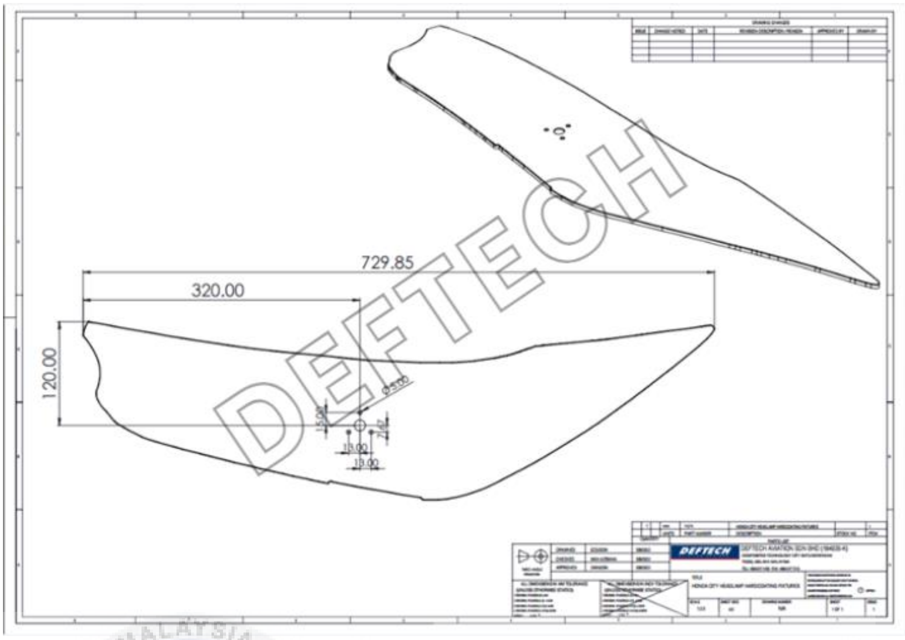

Figure 4.1 Original Drawing of Honda City Headlamp Jig

As seen in Figure 4.1, the headlight jigs designed for the Honda City have a notable feature in their design: an extended and large body layout. This elongation in the jig's structural makeup increases its vulnerability to deformation or fracture. This structure's large length and scale make it intrinsically less stable when exposed to external influences, increasing the possibility of structural breakdown. While the elongated design has some advantages, it makes it difficult to retain structural integrity, especially when subjected to large external stresses, increasing the likelihood of deformation or fracture.

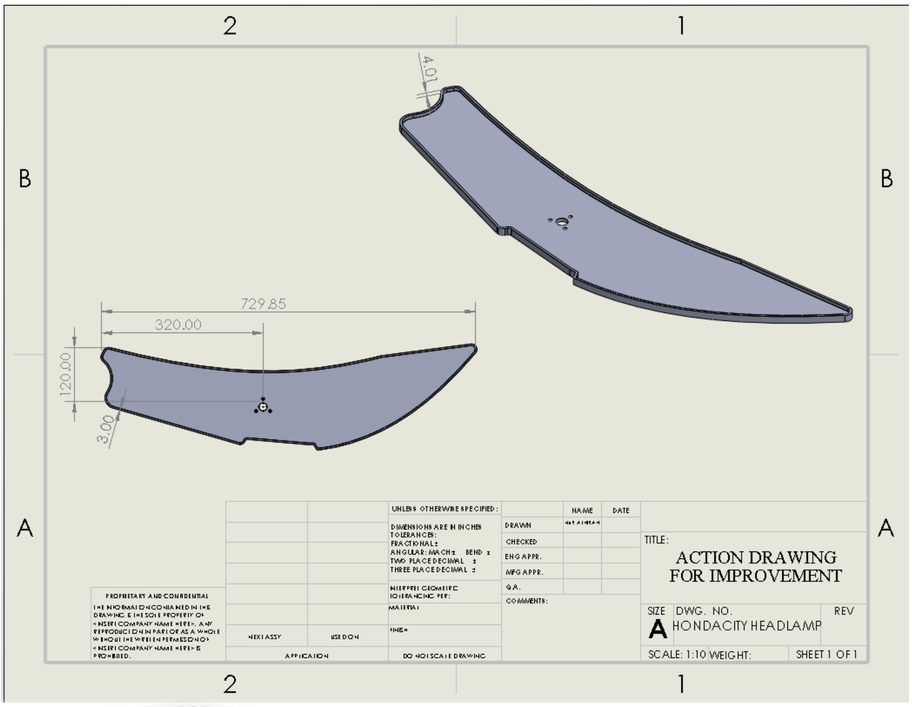

Figure 4.2 Action Drawing for Improvement

The action that can be taken is by adding a stiffener to the Honda City headlamp jig body. This suggestion is because Honda City headlamp is already a big and long body that make it more prone to break or creak. By adding a stiffener, it will support the body and make it stronger and harder to break into half. Figure 4.2 show the added stiffner. After the design is approved by the engineer and manufacturer can begin to do the process of making the Honda City headlamp jig. Considering that composites are generally non-reusable once they've undergone the setting process, a proposed approach to optimize both time and cost efficiency involves repurposing the existing finished mold. This suggestion entails modifying the mold to accommodate the stiffener, thereby avoiding the need to create an entirely new mold from scratch. The process of making these changes is suggested as the flow chart below:

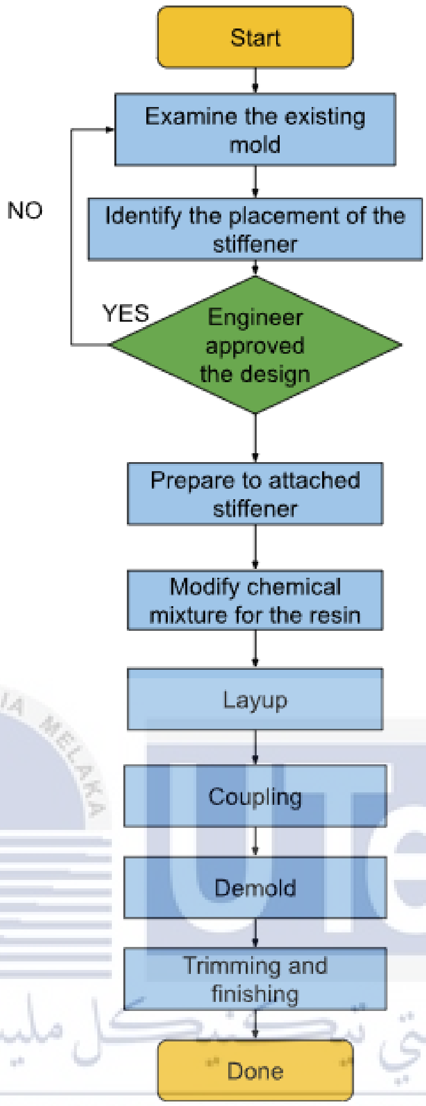

Figure 4.3 Improvement Suggestion for Beta Testing Flowchart

Figure 4.3 shows the flow chart of suggested improvements to the process of making a Honda City headlamp jig. The flowchart starts with an examination of the current mold to discover potential areas for integration or modification. Examine the structural integrity and dimensions of the existing mold thoroughly to establish appropriate places and methods for adding the stiffener. This examination verifies that the stiffener's intended attachment is compatible with the composition of the mold. After the examination process, the flowchart continues with identifying the placement of stiffeners. The marking of the placement of the stiffeners can be determined by a systematic approach such as finite element analysis (FEA) or stress analysis. Finite Element Analysis (FEA) can be used to determine the effects of forces or pressures applied to a structure or system. By modelling the structure or system using discrete elements, the FEA can provide insight into how it will behave under different loading conditions. This can be particularly useful in engineering applications, where it is important to understand how a structure or system will respond to external forces or pressures (Vishal, J., 2013). For stress analysis, the suitable analysis technique provides reasonably accurate and reliable results in terms of the magnitude and distribution of stresses or strains in the structure of interest that is subjected to a specific load and boundary condition. The information from the analysis will enable the engineer to predict the strength of the structure (R. Haghani, 2014).

After the engineer has approved the design, the process will be continued with preparing to attach the stiffener. The preparation is by cutting carbon fiber and fiberglass material. The amount of fiberglass and fiber carbon need to be adjusted to incorporate the stiffener. Following the preparation phase, the chemical mixture requires adjustments in its measurements to accommodate the inclusion of stiffeners. The quantities of resin and hardener are modified in accordance with the dimensions and size of the stiffener, ensuring a tailored mixture that aligns with the specific requirements of the stiffener's incorporation.

During the composite layup process, selected locations that require reinforcement will receive additional layers of composite material to act as built-in stiffeners. The area that is reinforced is completed in the second stage, "identifying the placement of the stiffener." This technique offers intrinsic fortification without the need for separate components. By deliberately adding these supplemental layers during the composite layup, structural integrity and strength are improved, reducing possible weaknesses or flex points without introducing new parts or pieces into the assembly. This technology simplifies the fabrication process while effectively increasing the structural resilience of the composite without requiring additional stiffening components.

For the coupling, demold, trimming and finishing will be the exact same process as the old process, where the male and female mold will be attached together for coupling. After the resin has cured overnight, the demolding process continued by using a spatula to separate the jig with the mold. After that, the trimming process is applied by using diamond cutting tools and finally the finishing process using sandpaper.

Once the new design for the Honda City headlamp jigs is finished, it will be sent to the customer for checking. This step is really important because the customer will carefully look at the designs to make sure they meet the standards and requirements they've set. Their review will focus on how well the designs work and if they fit with what the customer needs. This check by the customer is crucial because it ensures the designs match their specific demands before moving ahead with producing the jigs. The jigs will undergo validation by the customer, where the jigs will undergo a curing process in the tunnel oven at 120 to 125 degrees Celsius for 100 hours, and after that, another 1000 hours, and the jigs will also undergo a cleaning process with high-pressure water.

4.3 Summary

This chapter presents the original drawing of the Honda City headlamp jigs and the potential cause of the problem after the curing and cleaning process made the jigs deform. This chapter also states the potential solution to overcome the problem. The solution is to add stiffener around the Honda City headlamp jigs as support to help the jigs support themselves when faced with harsh environments.

This chapter also stated the potential step-by-step flowchart on how improvements can be made without rebuilding the master female and master male molds. The improvement that is suggested is to add an extra layer at the selected locations that require reinforcement. These locations will receive additional layers of composite material to act as built-in stiffeners. This process will not only reduce the cost of producing new mold, but it will also help save time for the company.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The incorporation of the Plan-Do-Check-Act (PDCA) technique into the framework of New Product Development (NPD) has shown great potential for improving product quality and efficiency. PDCA, with its iterative cycle of planning, execution, assessment, and refinement, provides a systematic approach to problem solving and continuous improvement.The PDCA method allowed for an organized review of design defects and vulnerabilities during the development of the Honda City headlight jig. Iteratively discovering, analyzing, and implementing solutions improved the jig's structural integrity, notably in terms of sensitivity to deformation during thermal cycling and high-pressure washing.

Moreover, the PDCA method integrated within the NPD process encourages a data-driven approach to innovation. It aligns well with reverse engineering methodologies, enabling a detailed examination of existing designs and processes. This iterative approach fosters adaptability and agility, ensuring that refinements and improvements are driven by insights gained from the evaluation phase.

In conclusion, the PDCA method integrated into the NPD process serves as a powerful tool for continual enhancement. Its cyclical nature encourages flexibility and responsiveness to changing demands, promoting the creation of superior, market-ready products through a structured and iterative approach to problem-solving and innovation.

5.2 Recommendations

For future improvements, accuracy of the new product

i) Maintain adaptability and flexibility when applying the PDCA cycle. Be willing to revise plans and methods when circumstances change or new problem emerge during the cycle.

ii) Invest additional time and resources in the planning stage to thoroughly analyse and identify potential concerns prior to execution.

iii) Create a mechanism for continuously monitoring the jig's performance following the stiffener addition. Regularly monitor its functionality, looking for signs of wear, stress spots, or potential flaws. Use this information to improve the design if needed.

5.3 Project Potential

The study findings could be applied to manufacturers that have problems or defects in their process flow. By applying PDCA to the new product development (NPD) process, the error can be detected in an early stage and improved quickly. The PDCA cycle is a closed-loop system where the process of improvement will always be determined when applying it. Any company can use the PDCA method to increase their company's efficiency.

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APPENDICES

APPENDIX A List Of Interview Question And Answer From Deftech Employess According To Department

QUESTION FOR COMPANY INTERVIEW FOR IMPROVEMENT OF MANUFACTURING COMPOSITE

HOD Engineer

1. How are decisions made regarding the implementation of changes in the manufacturing process for the composition of Honda City Headlamp Jig products?

   DAV:

   1. Customer request for changes
   2. Conduct brainstorming meeting to generate an idea, and screen the ideas
   3. Develop the concept and produce sample for First Article Inspection.
   4. Production test, feedback from customer & approval

2. What specific changes have been introduced in your manufacturing system to improve productivity in composite of Honda City Headlamp Jig manufacturing?

   DAV:

   1. Materials – At the early stage, we used polyester resin to produce the sample FAI unit. However, the jig deformed after the production test. We decided to use epoxy resin instead of polyester to withstand temperatures up to 120 deg C during lacquering process.
   2. Design – Initially, we copied the design based on sample fixture made of metal, consigned by customer. However, this concept not suitable for composite materials where deformation occurred after several series of production run. We change the design by adding a stiffener at the edge of the jig to support its strength.

HR

1. How do you ensure everyone on the team gets the right training and support for these new processes in composite manufacturing of Honda City Headlamp Jig?

   DAV:

   Conduct Training Need Analysis for all staff, perform assessment & issue proficiency card

Engineer

1. How do you manage production continuity while implementing these manufacturing changes for Honda City Headlamp Jig?
   - We will inform any current status/situation through Engineering Notice Form to Production line. It might need to be hold, proceed with requirement quantities or stop the production line.
2. How does the company currently assess the performance and quality of headlamp jigs, and what metrics are used to evaluate the effectiveness of the manufacturing process for Honda City Headlamp Jig? How about Proton X50 and Vinfast model?
   - Each model requires its specific design, concept and requirements. For Honda city jig, its require to have a deep fitting and thin at tip's fixtures. While for X50, its require to have close fit to the lens without any gap occur during assembly and for Vinfast its require to have stiffener to prevent deformation occur. All these specific design, concept and requirements are to be validate by our customer by performing run-processing test on their production line. If there any problem occurs to their product quality, our jig requires to change as per required by customer. Once the designs are all fit, DAV will proceed to the manufacturing process and DAV need to maintain its design as per accepted by customer. We will inspect the bubble occur after lay-up and delamination (standard composite inspection), thickness control, trimming line and fitting test.

3. How does the company select materials for manufacturing Honda City Headlamp Jig, and what factors are considered in this selection process? How about Proton X50 and Vinfast model?
   - The materials for all models will be selected according to requirements need by customer such as temperature resistance, the complexity of fixture design, and its durability. The temperature resistance needs to be known by understanding the customer's production line process where they have curing process that is 120°C. The design complexity of the fixtures requires to have flexible carbon fabric thus require to have low gsm (gram per meter square) and its durability need to use high durable resin that is epoxy type.
4. What level of detail is considered appropriate in production specifications to ensure consistent manufacturing processes for composite of Honda City Headlamp Jig products?
   - The trimming line need to have high details due to have exactly end-point as per sample design accepted by customers.
5. How does the company address the challenges associated with manual manufacturing processes in composite of Honda City Headlamp Jig manufacturing?
   - We require to have high monitoring activities to each process and manage the skillful workers to fabricate the fixtures.
6. What are the key factors considered when evaluating the scope and cost of proposed changes in the manufacturing system for the composition of Honda City Headlamp Jig products? How about Proton X50 and Vinfast model?
   - All models undergo same key factors to evaluate the scope and cost of proposed changes. We will look to our capability by looking at our staff's skills, tools and facilities to perform any changes.
7. Can you identify any bottlenecks or areas of inefficiency in the current composite production workflow?
   - Mostly inefficient on the chemicals used like resin or gelcoat.
8. Are there any emerging technologies or techniques in composite manufacturing that you think we should explore?
   - Yes, you may explore in advance composite technology such as Infusion system, prepreg and autoclave process.

9. How, in your opinion, can we maximize the utilization of raw materials to cut down on waste throughout the headlight jig x50 production process? How about Honda City and Vinfast model?
   - To fully utilize raw materials, we need to calculate the exact size of cutting fabric and control its using accurate cutting. Besides, the resin application used need to determine the requires time to perform mixing and lay-up before the resin become gels. Once its become gel, the resin cannot be used.

APPENDIX B Technical Data Sheet For The Chemical Mixture:

AXSON TECHNOLOGIES

EPOLAM 2051

LAMINATING SYSTEM FOR TOOLING

Tg 140°C

MECHANICAL PROPERTIES at 23°C [(1)]			
Final hardness	ISO 868 :2003	Shore D	86
Flexural modulus	ISO 178 :2001	MPa	3200
Flexural strength	ISO 178 :2001	MPa	130
Tensile strength	ISO 527 :1993	MPa	65
Compressive strength	ISO 604 :2002	MPa	110

THERMAL AND SPECIFIC PROPERTIES [(1)]			
Glass temperature transition	ISO 11359 : 2002	°C	140
Demoulding time at room temperature		hr	24 - 36
Complete hardening time at room temperature		d	5

(1) : Average values obtained on standard specimens after 15 hours at 120°C curing

HANDLING PRECAUTIONS

Normal health and safety precautions should be observed when handling these products :

- Ensure good ventilation
- Wear gloves, safety glasses and waterproof clothes.

For further information, please consult the product safety data sheet.

STORAGE CONDITIONS

Shelf life is 12 months for in a dry place and in original unopened containers at a temperature between 15 and 25° C. Any open can must be tightly closed under dry nitrogen blanket.

PACKAGING

RESIN	HARDENER
1 × 8 kg	1 × 2.4 kg
1 × 20 kg	1 × 6 kg

GUARANTEE

The information of our technical data sheet are based on our present knowledge and the result of tests conducted under precise conditions. It is the responsibility of the user to determine the suitability of AXSON products, under their own conditions before commencing with the proposed application. AXSON refuse any guarantee about the compatibility of a product with any particular application. AXSON disclaim all responsibility for damage from any incident which results from the use of these products. The guarantee conditions are regulated by our general sale conditions.

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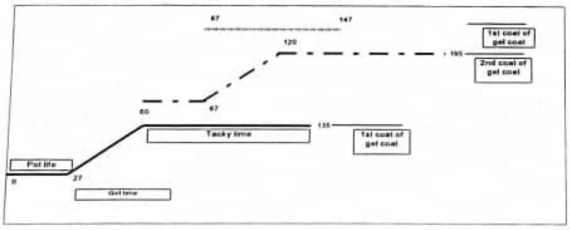
Axson TECHNOLOGIES

TECHNICAL DATA SHEET

GC1 150 / GC 15

PHYSICAL PROPERTIES				
		RESIN GC1 150	HARDENER GC 15	MIXING
Mixing ratio by weight		100	20	
Aspect		paste	liquid	thick liquid
Color		dark blue	light amber	dark blue
Brookfield LVT viscosity at 25°C (mPa.s)	-	thixotrope	850	thixotrope
Density at 25°C Density of the cured product	ISO 1675-85 ISO 2781-88	1.25 – 1.35 -	1.05 – 1.09 -	- 1.25 – 1.26

Application diagram of GC1 150/GC 15
(Application temperature : 23°C Mass 390 g)

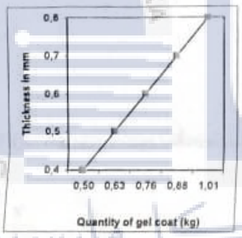


Time (mn)

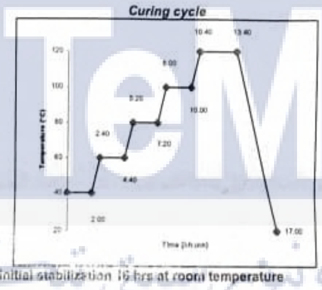
PROCESSING CONDITIONS

- *Apply DEMOLDING AGENT 841 or WAX 827 on a non porous pattern.*
- *Back-up : EPOLAM 2050 and reinforcements*
  EPO 4030

Quantity of gel coat for production of 1 m² surface
(for information only)



Curing cycle



Initial stabilization 16 hrs at room temperature

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Axson TECHNOLOGIES

GC1 150 / GC 15

TECHNICAL DATA SHEET

EPOXY GEL COAT

CAN BE SANDED – GLOSS RECOVERY
GOOD TEMPERATURE RESISTANCE
GOOD CHEMICAL RESISTANCE

USE

Molds : Polyester RTM, polyurethane foaming.

MECHANICAL AND THERMAL PROPERTIES AT 23°C(1)			
Hardness	ISO 868-85	Shore D1 / D15	87 / 86
Compressive modulus	ISO 604-97	MPa	6000
Compressive yield strength	ISO 604-97	MPa	120
Flexural modulus	ISO 178-93	MPa	4800
Flexural strength	ISO 178-93	MPa	103
Glass transition temperature after curing	T.M.A.-Mettler	°C	130
Glass transition temperature without curing (24hrs at room temperature)	T.M.A.-Mettler	°C	100

(1) : Average values obtained on standardized specimens / Hardening 16 hrs at 25°C + curing described in processing conditions

STORAGE CONDITIONS

Use before 24 months according to the manufacturing date. Expiration date indicated on the packaging.

HANDLING PRECAUTIONS

Normal health and safety precautions should be observed when handling these products :

- *ensure good ventilation*
- *wear gloves, safety glasses and clothes.*

For further information, please consult the product safety data sheet.

PACKAGING

Resin	Hardener
1 x 8.69 kg	*1 x 1.740 kg*
12 x 0.326 kg	*Carton de 12 x 0.065 kg*

GUARANTEE

The information of our technical data sheet are based on our present knowledge and the result of tests conducted under precise conditions. It is the responsibility of the user to determine the suitability of AXSON products, under their own conditions before commencing with the proposed application. AXSON refuse any guarantee about the compatibility of a product with any particular application. AXSON disclaim all responsibility for damage from any incident which results from the use of these products. The guarantee conditions are regulated by our general sale conditions.

The technical data sheet and the safety data sheet are also available on our website : www.axson.com

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AXSON TECHNOLOGIES

EPOLAM 2051

LAMINATING SYSTEM FOR TOOLING

Tg 140°C

APPLICATIONS

Production of tooling for high temperature resistance requirement used by laminating. Used in concrete back-up or in casting by addition of fillers.

PROPERTIES

- Product free of MDA
- Good thermal resistance
- Good wetting of fabrics and fillers
- Low exothermy
- Low shrinkage
- Easier curing cycle

PHYSICAL PROPERTIES				
Composition		**RESIN**	**HARDENER**	**MIXED**
Mix ratio by weight Mix ratio by volume at 25°C		100 100	30 37	
Aspect		liquid	liquid	liquid
Colour		Colourless	Amber	Light amber
Viscosity at 25°C (mPa.s)	BROOKFIELD LVT	2700	55	1200
Specific gravity at 25°C Specific gravity of cured product at 23°C	ISO 1675 : 1985 ISO 2781 : 1996	1.19 -	0.96 -	- 1.12
Pot life at 25°C on 260 g (min)	Gel Timer TECAM			70 - 90

PROCESSING

LAMINATING: After mixing according to the indicated ratio, impregnate the reinforcements by the different laminating processes. Demould after 24 hours polymerisation at room temperature. Then cure (see thermal treatment).

CASTING: Thoroughly mix the resin before use and ensure a homogeneous mix according to the mixing ratio (100 g resin+30g hardener+100-120g RZ1350) and then cast.

CONCRETE BACK-UP: In order to produce an aluminium concrete, use 120 g to 150 g of EPOLAM 2051 mix for 500 g of RZ 1019 granulate + 500 g of RZ 1021 granulate. Mix the whole together with a planetary agitator and tamp down the concrete on to the laminate.

THERMAL TREATMENT

A good rate of polymerisation is obtained at room temperature. A curing is not necessary when using a tooling at a temperature under 50°C.

On the other hand a thermal treatment is necessary for applications requiring a good thermal resistance until 140°C. This is the reason why the tooling or the part must be cured for 8 to 12 hours at an inferior temperature of 20°C to 30°C than its working temperature. Then the processing of the tooling will allow to finish the thermal treatment.

Caution: When curing tooling of high dimension it is necessary to use suitable supports in order to avoid any risk of distortion.

Laminating thickness must not exceed 12 mm in only one operation.

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APPENDIX C Fixture Quality Inspection Report

DEFTECH Aviation

FIXTURE QUALITY INSPECTION REPORT

Section A : Detail

Project :		
Part No. :		
Description :		
Tool No.* :		
Remarks :		Batch Serial No:

Section B : Quality Inspection

No.	Item Descriptions	Remarks/Comments
1.	Surface Finish: Ensure all surfaces are free from any defects (Example: holes/scratch/cracks/dent/surface bulging)	
2.	Dry Fit Test: Ensure sample lenses fit firmly onto the fixture. Ensure gaps on critical areas are still within tolerance.	
3.	Tap Test: Tap test randomly on all surface to ensure no delamination or debonding of composite material.	
4.	Holes Dimensions: Check holes dimensions and positions are all within tolerance.	
5.	Others:	

Name:	Signature & Stamp:	Date:

QA/QC personnel will only sign and stamp this form once all defects listed have been rectified.

Note : (*) - If applicable
Original - Quality
Copy - MPP and/or Originator

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Form No. EA 029