UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ENVIRONMENTAL IMPACT ASSESSMENT OF THE MILLING PROCESS ON CNC 3D ROUTER

MOHD NAZRIN BIN ZAKARIA

BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (PRODUCT DESIGN) WITH HONOURS

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

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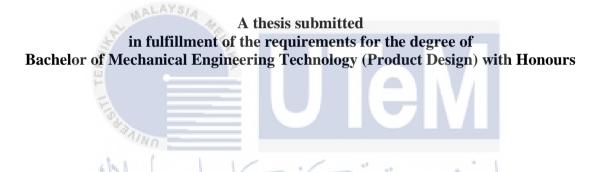## UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this thesis entitled "Environmental Impact Assessment of the Milling Process on CNC 3D Router" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature   : _____

Name   : *Mohd Nazrin Bin Zakaria*

Date   : 10/1/2023

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 Mechanical Engineering Technology (Product Design) with Honours.

Signature :

Supervisor Name : Mrs Umi Hayati Binti Ahmad (Supervisor)

Dr. Hambali Bin Boejang (Co-supervisor)

Date : 10/1/2023

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DEDICATION

This work is wholeheartedly dedicated to all my valuable treasures:

For my beloved parents:

Zakaria Bin Awang Ahmad

Ramlah Binti Hj Hossen

For my supportive siblings:

Mohd Nazri Bin Zakaria

Nadzariah Binti Zakaria

Nazimah Binti Zakaria

Nazarina Bnti Zakaria

Mohd Nazmi Bin Zakaria

Thank you always provide me moral, emotional, financial support and gave me strength when I thought of giving up.

For my respective supervisor and co-supervisor:

Mrs Umi Hayati Binti Ahmad & TS. Dr. Hambali Bin Boejang

For all UTeM lecturers, Engineer Assistance, and my treasured friend:

Who shared their word of advice and encouragement to finish this study.

ABSTRACT

The existing problem is that the machining process has a significant impact on the environment without anyone realize. Therefore, the objective of this project is to construct the life cycle assessment (LCA) to obtain the environmental impact assessment of the milling process on the CNC 3D router and to analyze the relation of environmental impact assessment with the CNC 3D router. To achieve the objective, the literature review is very important to gain as much knowledge and information as possible to help carry out this project. The concept of sustainable development, eco-design, product and sustainability, and life cycle assessment will help generate environmental impact assessment using the GaBi software. Therefore, this GaBi software can help industries to detect what environmental impact of its manufacture. In addition, GaBi software also helps the researchers to get to know extra knowledge regarding the input and output for the LCA process. According to the findings of the study, compressed air consumption during the milling process has an impact on the sustainability of the environment since it scores highly for each possible environmental impact. Controlling environmental sustainability also heavily depends on the materials chosen during component production. In conclusion, modelling life cycle inventories is a reliable and possibly unique method for assessing the environmental effects of items holistically together with the life cycle impact assessment stage—as required by sustainable development.

ABSTRAK

Objektif projek ini adalah membina penilaian kitaran hayat (LCA) untuk mendapatkan penilaian kesan alam sekitar proses pengilangan pada penghala 3D CNC dan untuk menganalisis hubungan penilaian kesan alam sekitar dengan penghala 3D CNC. Untuk mencapai objektif, kajian literatur adalah sangat penting untuk mendapatkan sebanyak mungkin pengetahuan dan maklumat untuk membantu melaksanakan projek ini. Konsep pembangunan mampan, reka bentuk eko, produk dan kemampanan, dan penilaian kitaran hayat akan membantu dalam menjana penilaian kesan alam sekitar dengan menggunakan perisian GaBi. Oleh itu, objektif kajian dihasilkan berdasarkan masalah. Masalah yang wujud ialah proses pemesinan telah menyumbang impak yang besar kepada alam sekitar tanpa disedari oleh sesiapa. Oleh itu, perisian GaBi ini boleh membantu industri untuk mengesan kesan alam sekitar daripada pembuatannya. Di samping itu, perisian GaBi juga membantu penyelidik untuk mengetahui pengetahuan tambahan mengenai input dan output untuk proses LCA. Menurut penemuan kajian, penggunaan udara termampat semasa proses pengilangan mempunyai kesan ke atas kemampanan alam sekitar kerana ia mendapat markah tinggi untuk setiap kemungkinan kesan alam sekitar. Mengawal kemampanan alam sekitar juga sangat bergantung pada bahan yang dipilih semasa pengeluaran komponen. Kesimpulannya, pemodelan inventori kitaran hayat ialah kaedah yang boleh dipercayai dan mungkin unik untuk menilai kesan alam sekitar item secara holistik bersama-sama dengan peringkat penilaian kesan kitaran hayat seperti yang diperlukan oleh pembangunan mampan.

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LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
LCA	-	Life Cycle Assessment
EIA	-	Environmental Impact Assessment
CNC	-	Computerize Numerical Control
GWP	-	Global Warming Potential
D4S	-	Design for Sustainability
IAIA	-	International Association for Impact Assessment
CSR	-	Corporate Social Responsibility

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

In this chapter, the sub-topic that is included are, the project background regarding the environmental impact assessment, sustainable development, life cycle analysis, and computer numerical control (CNC). This chapter also include the problem statement of this research, research objective, the scope of research, and summary for all sub-topics.

1.2 Background

Up to 1970, technical performance and economic costs and benefits were included while evaluating development initiatives. The environmental ramifications were not being carefully looked into. Due to the growing public concern about the quality of the human environment, several development projects that were built and operated that caused significant environmental harm was extensively covered in the media. The unintended negative effects of non-profit initiatives, including spraying DDT to control insect vectors and save valuable crops, were also being apparent at the time. Due to these conditions, there is now an increasing call for decisions about such measures to take into account any potential environmental effects.

Environmental impact assessment (EIA) combines art and science in one process. While technical analysis in the process is founded on scientific concepts, management parts of EIA are an art. EIA offers a methodical analysis of the environmental effects of suggested actions and alternatives to aid in decision-making. The decision-makers

are helped in making choices that are more likely to result in projects that are sustainable by the cost-benefit and trade-off evaluations between the implementation of the project and associated environmental expenses. EIA also serves as a foundation for discussions between regulators, public interest organizations, and developers in order to strike a balance between development and the environment. For attaining sustainable development, EIA has been regarded as a crucial management tool. Figure 1 below shows an example of steps taken to conduct environmental impact assessment.

The previous study regarding the environmental impact assessment was conducted in Nepal. Although development initiatives are crucial to Nepal's economic development, some of the earlier initiatives have undermined the basic foundation of sustainable development by overusing natural resources without regard for the preservation of environmental quality. Without adequate management and the replenishment of Nepal's environmental basis, economic progress cannot be sustained. It must be understood that conservation and development go hand in hand. EIA is likely the most straightforward and efficient method of merging the goals of conservation and development in the current scenario in Nepal, where development is mostly project-led. This was acknowledged in HMG's National Conservation Strategy and Nepal's seven five-year plans, which foresaw the future construction of an EIA system and required the completion of an EIA for any significant development before receiving the appropriate government department's permission. A thorough assessment of the environmental implications of development projects is another requirement of the eight five-year plans (NPC/HMG/IUCN, 1993).

Sustainable development, according to the Brundtland Commission (1987), is "development that satisfies the demands of the present generation without jeopardizing the ability of the future generation to satisfy their own needs." This means that in addition to human and human-made wealth, we should also leave behind natural capital like trees and

clean air for future generations. EIA may positively affect the development of the nations' sustainability by assisting in ensuring that projects are planned in ecologically and sensitive manner.

Life cycle assessment on the other hand, also known as cradle-to-grave or cradle-to-cradle analysis, is a method for evaluating the environmental effects of all phases of a product's life, from the extraction of raw materials to their processing, manufacture, distribution, and consumption (Environmental Management, 2017). The study of the life cycle phases' contributions to the total environmental load, often with the goal of prioritizing changes to goods or processes, and the comparison of products for internal use are the most crucial applications. Figure 1.2-1 below shows the example of life cycle assessment framework.
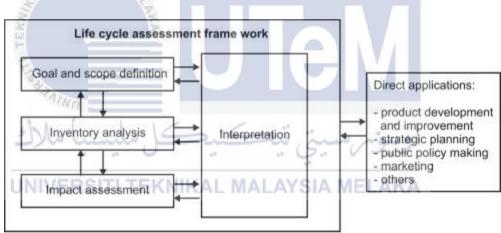
Figure 1.2-1 : Example of life cycle assessment framework

The LCA community learned in the 1990s that data documentation is just as important as data itself. Rarely was meta information supplied on the geographic, temporal, or technical validity of LCI data (neither in a structured way nor otherwise). The creation of a data documentation format was started by the Society for the Promotion of Life Cycle Assessment Development (SPOLD) (Weidema, 1999), which enables thorough documenting of LCI data for processes and services. To promote acceptability and data

format compatibility, many significant LCA software suppliers were involved in the creation of SPOLD. The SPINE data reporting and interchange format was the outcome of a concurrent, largely compatible development (Carlson et al., 1995). This allows for the documenting of meta information using text data fields and was developed concurrently with the construction of the SPINE database. To establish the data documentation format for life cycle inventory data, the International Standards Organization (ISO) decided to produce a technical standard in 2001, (ISO 14048, 2001). The format is divided into three sections namely, modelling and validation, process [Process description, Inputs and outputs (environmental exchanges)], and administrative information.

On the other hand, Computerized Numerical Control (CNC) machines are broadly used all over the world. There are many different types of CNC machines on the market such as CNC Milling Machine, CNC Router, CNC Plasma Cutting Machine, CNC Lathe Machine, CNC Laser Cutting Machine, CNC Waterjet Cutting Machine, CNC Electrical Discharge Machine, and CNC Grinder.

Figure 1.2-2 shows the CNC 3D router made by a group of students developed by Talent Development Program to enhance their design and machining skills as a preparation to face the real-world industry.

Figure 1.2-2 : V2 CNC 3D router

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1.3   Problem Statement

Nowadays, industrial which are using machine as processing is very wide across the world. As the technologies growing rapidly, machines are created to ease the job in many ways. From manufacturing to processing to packaging, machines have been the most reliable things that ever created. On the negative side, the machining process has contributed a large impact on the environment without anyone realized. There are many types of environmental issues that happened nowadays such as air pollution, global warming, deforestation, water pollution, etc. This study could help detecting the type of environmental impact assessment from using the milling machine.

1.4   Research Objective

This research aims to study the type of environmental impact assessment (EIA) from fabricating the aluminum part by using the milling machine. Specifically, the objectives are as follows:

a)   To construct the life cycle assessment (LCA) and obtain the environmental impact assessment of milling process on CNC 3D router.

b)   To analyze the relation of environmental impact assessment with CNC 3D router.

1.5   Scope of Research

To identify and review the inputs needed to conduct appropriate environmental impact assessment at different stages of the product lifecycle. The scope of this research is as follows:

i.   Approach to conducting environmental impact assessment to identify the environmental issues.

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ii. Environmental impact assessment will be conduct by using Gabi software as analysis.

iii. The assessment is only focusing on fabricated part using the milling process.

iv. The result will be only focusing on Global Warming Potential (GWP).

1.6   Summary

To summarize, having an industry with high technology machining is very important but the technology used need to be parallel with good health environment because a true futuristic industry is the one who care with social, economic, and environmental health. Other than that, Computerized Numerical Control (CNC) is an important course that needs to be discovered and learned by every level of students. Usually, the most student knows about CNC machine when they are at the college level. This need to be improved so that even in high school, students are exposed to these particular courses to get a brighter future.

CHAPTER 2

LITERATURE REVIEW

2.1   Introduction

A literature review is a thorough summary of prior research on a particular area of research. The literature review examines academic papers, books, and other materials that are pertinent to a certain study topic. This past study should be included, described, summarized, objectively evaluated, and clarified in the review. This chapter includes the sub-topic about the environmental impact assessment together with its classification which is life cycle assessment. Other than that, this chapter also discusses the environmental impact assessment's benefits and its guideline for the user.

2.2   Milling Machine

Activities related to manufacturing account for 31% of global energy consumption (T. Herzog, 2005) and 19% of global greenhouse gas emissions (Annual energy review, 2008). Due to its magnitude and significance, machining is a manufacturing process that has been heavily targeted for energy reduction. Global machine tool sales alone were predicted to reach $82 billion in 2008 and $71 billion in 2007 (S. Kalakjian, 1997). A workpiece or work (the manufactured item), a tool (which removes material), and a machine can all be thought of as components of the machining process, which is broadly defined as all material removal operations (Metalworking Insider's Report, 2009). A machine tool is the collective term for the machine and the tool. While numerous machine tool types are employed for varied tasks, milling machine tools represent a significant subset.

The cutting technique known as milling involves moving the tool in relation to the workpiece in a predetermined volume while rotating on one axis. The parts of a typical vertical milling machine tool are shown in Figure 2.2-1. In this illustration, the workpiece is fixed to a table that swivels in a horizontal plane. The tool is rotated by the spindle, and both are moved vertically. A lead or ball screw that is coupled to motors or axis drives, is guided by ways, and is controlled by the machine control unit or controller to give translational motion. The machine tool frame, which offers rigidity and damping, is made up of the bed/base and column. The thermal control unit (reduces thermal errors), the lubrication lines (lubricates the moving elements), and the cutting fluid system (delivers cutting fluid to the workpiece) are additional parts that are not included in Figure 2.2-1.
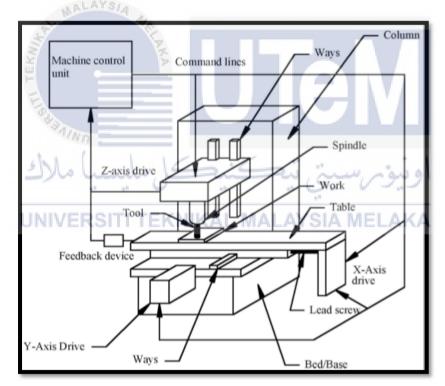

Figure 2.2-1 : Typical vertical milling machine

A machine tool must have a source of energy or relative motion, a way to secure the workpiece, secure and orient the tool, and the ability to regulate the source of energy or motion, the workpiece's orientation, and the tool's orientation (Domfeld & Lee, 2008).

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Machine tools require four input flows to do these tasks: compressed air, water, cutting and lubricating oils, and electric energy. These input flows have all been viewed as inexpensive resources that may be exploited in excess to produce high-quality final goods. But increased environmental consciousness has made it necessary to utilize these resources more effectively.

2.3   Concept of Sustainable Development

The establishment of the idea of sustainable development was preceded by two key component which is the development and sustainability. Sharpley (2000) argues that while neoclassical economics stress that there is no conflict between sustainability and development, development and sustainability may be in opposition, where both may have potential unfavorable impacts (Lele, 1991). According to Sachs (2010), neither progress nor sustainability are possible without the other. The idea of development is connected to the historical western concept of imperialism and colonialism, and during that time it implied the growth of infrastructure, political influence, and economic policy, making it a great tool for imperialists to marginalize and weaken the power of certain countries (Tangi, 2005). The phrase "underdeveloped countries" (also referred to as "Third World Countries"), used by US President Harry Truman in the middle of the 20th century to describe regions with a much lower quality of living than developed areas, is linked by some authors to economic progress (Estevo, 2010).

The principles of sustainable development are founded on the concepts of development or in other words, socio-economic growth within ecological bounds, needs which is redistributing resources to ensure everyone has access to them, and future generations or in other terms, the possibility of long-term usage of resources to ensure the necessary quality of life for future generations (Klarin, 2018). The Triple Bottom Line

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concept, which suggests a balance between the three pillars of sustainability - environmental sustainability, which focuses on maintaining the quality of the environment necessary for conducting economic activities and improving people's quality of life, social sustainability, which works to ensure human rights and equality, preservation of cultural identity, and respect for cultural diversity - is the foundation of sustainable development.

The idea of sustainable development has been subject to various interpretations and critiques since its inception. According to the Brundtland Report, the phrase "sustainable development" has many distinct definitions. It can relate to ecological planning, the adoption of policies, the preservation of cultural assets and biodiversity, and long-term sustainable development (WCED, 1987). Dobson (1996) noted more than 300 definitions and interpretations of the idea of sustainable development a few years after the Brundtland Report. The definitions mainly adhere to the primary idea outlined in the WCED's fundamental definition. According to these definitions, sustainable development primarily refers to a socioeconomic system that meets human needs, but it may also refer to long-term improvements in well-being and general quality of life that take into account environmental restrictions. Table 2.3-1: Chronological overview of the meaning of sustainable development in the period 1987-2015 (Tomislav Klarin, 2018) below shows the chronological overview of the meaning of sustainable development in the period 1987-2015.

Table 2.3-1: Chronological overview of the meaning of sustainable development in the period 1987-2015 (Tomislav Klarin, 2018)

Authors/publication and year	Meaning and understanding of sustainable development
WCED, 1987	Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Pearce et al., 1989	Sustainable development implies a conceptual socio-economic system which ensures the sustainability of goals in the form of real income achievement and improvement of educational standards, health care and the overall quality of life.
Harwood, 1990	Sustainable development is unlimited developing system, where development is focused on achieving greater benefits for humans and more efficient resource use in balance with the environment required for all humans and all other species.
IUCN, UNDP & WWF, 1991	Sustainable development is a process of improving the quality of human life within the framework of carrying capacity of the sustainable ecosystems.
Lele, 1991	Sustainable development is a process of targeted changes that can be repeated forever.
Meadows, 1998	Sustainable development is a social construction derived from the long-term evolution of a highly complex system – human population and economic development integrated into ecosystems and biochemical processes of the Earth.
PAP/RAC, 1999	Sustainable development is development given by the carrying capacity of an ecosystem.
Vander-Merwe & Van-der-Merwe, 1999	Sustainable development is a programme that changes the economic development process to ensure the basic quality of life, protecting valuable ecosystems and other communities at the same time.
Beck & Wilms, 2004	Sustainable development is a powerful global contradiction to the contemporary western culture and lifestyle.
Vare & Scott, 2007	Sustainable development is a process of changes, where resources are raised, the direction of investments is determined, the development of technology is focused and the work of different institutions is harmonized, thus the potential for achieving human needs and desires is increased as well.
Sterling, 2010	Sustainable development is a reconciliation of the economy and the environment on a new path of development that will enable the long-term sustainable development of humankind.
Marin et al., 2012	Sustainable development gives a possibility of time unlimited interaction between society, ecosystems and other living systems without impoverishing the key resources.
Duran et al., 2015	Sustainable development is a development that protects the environment, because a sustainable environment enables sustainable development.

2.4   Design for sustainability

The environment is impacted by technology in many different ways. Some technologies cause environmental contamination, while others utilize non-renewable natural resources like coal or uranium to the point of exhaustion. Environmental issues including the greenhouse effect, overfishing, and ecosystem loss are exacerbated by technology.

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Technology can help with the avoidance or resolution of many environmental issues in the interim. Innovative technologies may reduce energy use; CO_2 collection and storage may help prevent or at least mitigate the greenhouse impact; and it is sometimes difficult to clean up environmental contamination without technology (David M. Kaplan, 2016).

The sort of technology at issue determines in part whether a given technology exacerbates or resolves environmental issues. By their very nature, coal plants have a greater negative impact on the environment than pencils. However, a technology's specific design also affects how it will affect the environment, both positively and negatively (David M. Kaplan, 2016). Different freezers use different amounts of energy. Compared to traditional petrol vehicles, electric vehicles provide a less overall contribution to the greenhouse effect (Hawkins, Gausen, and Stromman, 2012). Paper usage is anticipated to decrease if copying machines default to double-sided printing rather than single-sided printing. Therefore, the way a technology is constructed has an influence on the environment, so it makes sense to design for sustainability.

Now more than ever, engineers are understood to have environmental responsibilities. Engineers are urged to follow the principles of sustainable development in order to preserve the environment for future generations, according to the code of conduct of the US NSPE (National Society of Professional Engineers) (NSPE 2007). Engineers "should carry out their activities so as to prevent and avoidable harmful influence on the environment," according to the FEANI (European Association of National Engineering Societies) Code of Conduct (FEANI, 2006). These widely defined obligations also suggest that engineers have a duty to create technical goods with sustainability in mind.

2.5 Eco design to Design for Sustainability (D4S)

Concepts like Eco design and green product design were presented in the 1990s as tools organizations might use to lessen the environmental effects of organizations might use to lessen the environmental effects connected to their manufacturing processes (Luca, 2005). Additionally, these tactics improved a business's standing and competitive edge in a market where environmental responsibility was becoming increasingly important. Climate change threats have pushed environmental issues to the top of political agendas worldwide during the past 10 years (Beyen, 2002). Many countries have heeded the urgent plea to "act now" in response to these worries.

These nations have put in place policies aimed at lowering greenhouse gas emissions, changing the energy mix to incorporate more renewable energy sources, and improving energy efficiency in order to lessen the negative consequences of climate change. Other environmental difficulties and worries remain on the horizon, notwithstanding the present focus on climate change. These include the accessibility of clean, potable water, increasing deforestation, decreased biodiversity, and ecological degradation. At the process, product, service, and system levels, consumption and production must be drastically altered to reverse these trends.

It is becoming more and more clear in the aftermath of globalization that the existing economic growth and development patterns cannot be maintained without considerable innovation on both the supply (production) and demand (consumption) sides of the market (Borland, 2003). As a result, there is an increasing need for businesses to conduct more research, put more novel methods into practice, and create better goods and services. Governments may assist with this by fostering a supportive policy environment and developing civil society programs that enhance the information distribution to encourage consumer choice of sustainable products.

Many environmental groups have broadened their focus to encompass social and economic issues in order to stay up with the quickly evolving industrial environment. Sustainability is the combination of environmental, social, and economic priorities (Crul, 2006). Eco design, like many other environmental ideas, has developed to take into account both the social and financial aspects of manufacturing and is now known as sustainable product design. According to the idea of "Design for Sustainability" (D4S), the design process and final product must take into consideration social and economic issues in addition to environmental issues. The three pillars of sustainability—people, profit, and planet—are known as the D4S criterion (Bosch & Brezet, 2005). D4S considers how to satisfy customer requirements in a more sustainable fashion rather than just how to create a "green" product. Companies that include D4S into their long-term product innovation plans aim to reduce the detrimental effects on the environment, society, and the economy during the whole supply chain and life cycle of the product.

Companies and intermediate organizations in established and emerging economies can use this step-by-step approach to D4S to get real help for both incremental and radical product innovation. It should be emphasized that gradual product redesign or product greening is still relevant in the market today. According to Johansson, (2005) by creating new goods, services, and systems, D4S fundamentally expands on these ideas and seeks to significantly enhance the productivity and social aspects of production processes.

2.6   Product and Sustainability

The ever-increasing rate of negative environmental and social repercussions makes it clearer that present patterns of consumption and production are unsustainable (Mirata, 2005). The landscape of the private sector in both developed and emerging countries has fundamentally transformed because of the trade liberalization and globalization

processes that are intensifying (Hochschorner, 2003). This has created new chances to increase sustainability. Both large and small corporations have made commendable attempts to tackle environmental concerns while keeping an eye on the bottom line. Through supply chain management, corporate reporting, benchmarking, and the adoption of pertinent international standards, industries are increasing the effectiveness of their present production and the creation of new goods and services.

These internal processes go by various names, including "design for sustainability" and "sustainable product design" (D4S). D4S, which also encompasses the more constrained idea of Eco design, is a widely accepted strategy used by businesses to increase productivity, product quality, and market potential while also enhancing environmental performance, social benefits, and profit margins (Kelly & Tom, 2001). Numerous industrialized economies are well aware of the commercial prospects associated with increased productivity and stricter environmental and social norms. According to Markoff, (2006) D4S initiatives have previously been connected to more general ideas like product-service combinations, system innovation, and other life-cycle-based initiatives.

Numerous organizations have created tools to assist businesses, designers, and consultants in reevaluating how to create goods in a way that increases revenues and competitiveness while minimizing harmful environmental effects. This method, known as Eco design, has grown to address more complex concerns throughout time, including the need to discover less resource-intensive solutions to satisfy customer demands and the social aspect of sustainability (Mcgray, 2006). D4S discusses how to effectively fulfil customer requirements on a social, economic, and environmental level in addition to how to develop a "green" product (Mirata, 2005). This encompasses not only a single product but also a system of goods and associated services that work together to meet consumer requirements more effectively and at a greater value for both businesses and customers.

Social, environmental, and economic sustainability are sometimes known as "people, planet, and profit" and are the three key elements of sustainability of product innovation. According to Nissen, (1997) product innovation needs to take into account a number of frameworks that are connected to people, the environment, and profit, such as social expectations, the equitable distribution of value along the global value chain, and the carrying capacity of the ecosystems that support it, in order to be sustainable.

2.7 Life Cycle Assessment

According to Griese, (1997) methods and instruments are needed to measure and contrast the environmental effects of supplying commodities, services, or products to our society in order to achieve "sustainable development." These products are made and consumed because they satisfy needs, whether they be real or imagined. Every product has a "life," which begins with the design and development stage, is followed by resource extraction, production which including the manufacturing and provision of the product as well as the production of materials, use and consumption, and finally end-of-life activities, such as collection and sorting, recycling, and waste disposal (Roozenburg, 1995). Because of resource consumption, substance emissions into the environment, and other environmental exchanges, every action or activity during a product's life has an influence on the environment such as radiation.

Life cycle assessment (LCA) is a tool for evaluating a product's environmental effects throughout the course of its life cycle (Stahel, 2000). LCA is a methodological framework for quantifying and evaluating the environmental effects of a product, including climate change, tropospheric ozone (smog) formation, stratospheric ozone depletion, eutrophication, acidification, toxicological stress on human health and ecosystems, resource depletion, water use, land use, noise, and others. An LCA should not only evaluate the

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environmental impact on certain dimensions but also give an overall comparison of environmental impact to address value conflict (Eekels, 1995). A simplified version of the product life concept, sometimes known as a "life cycle" since it incorporates loops between the various life stages, is shown in Figure 2.7-1. Such loops include, for instance, the recycling of manufacturing scrap or the reuse and recycling of post-consumer items (originating in the end-of-life phase).
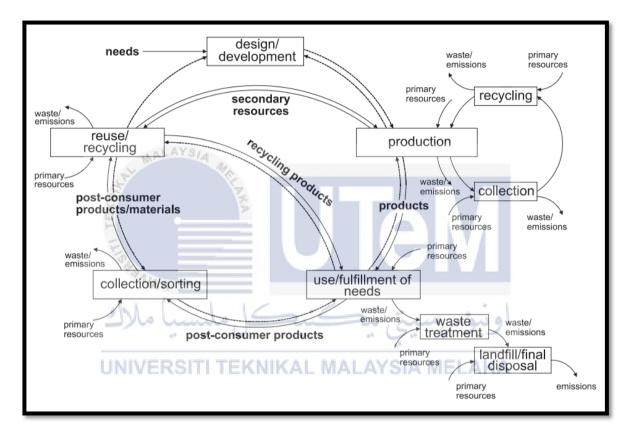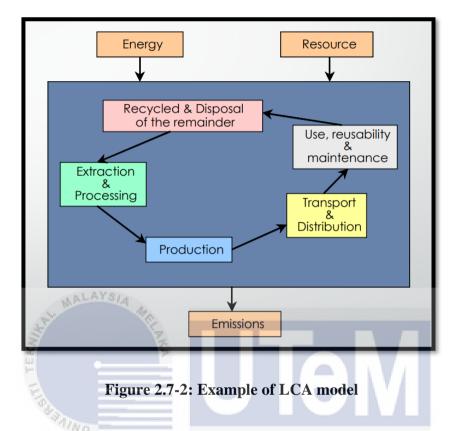

Figure 2.7-1: Example of product life concept

A product or service's life cycle is its whole life, from the extraction of natural resources through its final disposition. In order to assess a product, process, or activity's potential impact, it is also necessary to quantitatively analyze the associated environmental loads (Ryan, 2004). This is done by determining the mass and energy used as well as any discharges into the environment. The life cycle is the collection and assessment of a product

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system's inputs, outputs, and possible environmental consequences during the course of its life cycle (ISO 14040)

Figure 2.7-2: Example of LCA model

Instead of permitting the compensation of a loss in one by a gain in another, LCA aim at an alternative that achieves certain basic requirements with regard to both greenhouse gas emissions and biodiversity. Figure 2.7-2 illustrated the example of LCA model with its cycle. Similar questions include whether a rise in environmental effects would make up for an increase in world hunger, or the opposite. The idea that certain values are incommensurable—that is, that they cannot be stated on a common scale and that a loss un one value cannot be entirely made up for by a gain in another—has been put forth by philosophers and others (Raz 1986; Baron and Spranca 1997; Tetlock 2003).

2.8   Environmental Impact Assessment

2.8.1   Definitions

There are several definitions of environmental impact assessment (EIA). They range from the frequently cited and broad definition of Munn (1979), which refers to the need "to identify and predict the impact on the environment and on man's health and well-being of legislative proposals, policies, programmed, projects, and operational procedures, and to interpret and communicate information about the impacts," to the early UK DoE (1989) operational definition, which is more specific.

According to Beck, (2008) the term "environmental assessment" refers to a method and a procedure by which data on a project's potential environmental impacts are gathered, both directly from the developer and from other sources, and considered by the planning authority when deciding whether to move forward with the development.

A far shorter and pithier description was provided by UNECE (1991): "an evaluation of the impact of a proposed action on the environment." Before a development permit is issued, the EU EIA Directive's procedural requirements call for an evaluation of the consequences of certain public and private projects that are expected to have a substantial impact on the environment. The International Association for Impact Assessment (IAIA) adopted the following definition of EIA in 2009: "The process of identifying, predicting, evaluating, and mitigating the biophysical, social, and other relevant effects of proposed development proposals prior to major decisions being taken and commitments made". It is presently investigated more how this process emphasis.

2.8.2   Environmental Impact Assessment: A Process

EIA is essentially a methodical procedure that analyses ahead of time the environmental effects of development operations (Caldwell, 1988). In contrast to many other

environmental preservation strategies, the focus is on prevention. Of fact, planners have

historically evaluated the environmental effects of projects, but seldom in the systematic,

comprehensive, and multidisciplinary manner required by EIA. The procedure is broken
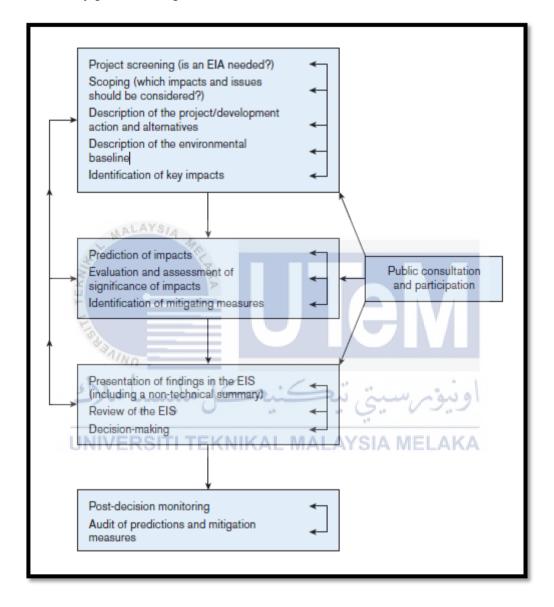
down into many phases in Figure 2.8-1.

Figure 2.8-1: Important steps in environmental impact assessment process (Bartlett, 1999)

Figure 2.8-1 above provides a basic description of the stages. Although the

processes are described in a linear form at this point, EIA should be a cyclical activity with

feedback and interaction between the different steps. It should be noted that the method outlined in the illustration can and often does differ significantly in actuality. For instance, post-decision monitoring is still not required by UK EIA law. The process's steps' ordering is also subject to change.

- The application of EIA is honed to just those projects that may have major environmental implications through project screening. The EIA regulations in effect in a nation at the time of assessment may in part decide screening.

- Scoping is to early identify those that are the most important, major concerns from all of a project's potential repercussions and alternatives that may be handled.

- The goal of the consideration of alternatives is to make sure that the proponent has thought of all viable options, including alternate project sizes, locations, operational conditions, methods, and layouts.

- The description of the project/development activity involves a clarification of the project's goal and justification as well as a comprehension of its many aspects, such as its location, methods, and developmental phases.

- When describing the environmental baseline, it is important to take changes brought on by both natural occurrences and other human actions into consideration when determining the present and future status of the ecosystem.

- The preceding processes are combined in the identification of the key impacts in order to make sure that all potentially important environmental consequences (both negative and positive) are discovered and taken into consideration during the process.

- By contrasting the condition with and without the project or activity, the prediction of impacts aims to establish the scope and other aspects of the change in the environment.

- To enable a focus on the primary negative consequences, the evaluation and assessment of significance evaluates the relative significance of the projected outcomes.

- Implementing actions to avoid, lessen, rectify, or compensate for any severe negative outcomes is known as mitigation. Additionally, improvement requires creating advantageous effects whenever feasible.

- The goal of public consultation and participation is to guarantee the efficacy, quality, and thoroughness of the EIA as well as the proper consideration of the public's opinions during the decision-making process.

- A crucial element in the procedure is the EIS presentation. A lot of the EIA's fine work might be thrown out if it's done poorly.

- Review entails a methodical evaluation of the EIS's quality as a contribution to the decision-making process.

- The decision-making process for the project entails the competent authorities taking into account the EIS (including consultation responses) in addition to other important factors.

- Following a decision to move forward, post-decision monitoring include the recording of results related to development implications. It may help with efficient project management.

- Monitoring leads to auditing. It might entail comparing actual results to expectations, and it can be used to gauge how well predictions are made and how successful mitigation is. It offers a critical stage in the learning process for EIA.

2.8.3   Purposes of environmental impact assessment.

2.8.3.1   An aid to decision making.

EIA is a tool for making decisions. It offers a methodical analysis of the environmental repercussions of a proposed action, and occasionally alternatives, for the decisionmaker, for instance a local government, before a decision is made. The decision-maker may take the EIA into account in addition to other planning-related data (Clark, 1984). EIA often has a broader scope and uses less quantitative methods, such as cost-benefit analysis. It is not a decision-making alternative, but it does aid in the clarification of some of the trade-offs related to a proposed development action, which should result in better organized and informed decision-making. The potential for the EIA process to serve as a platform for negotiations between the developer, public interest organizations, and the planning authority is not always utilized. This may result in a solution that successfully strikes a balance between the needs of environmental preservation and development.

2.8.3.2   An aid to the formulation of development actions

Developers may regard the EIA process as another set of obstacles to cross before they can advance with their different operations; the procedure can be seen as yet another costly and time-consuming activity in the development permit process. However, as it may offer a framework for taking location, design, and environmental problems into consideration simultaneously, EIA can be quite helpful to them. It can help in the creation of development strategies by pointing out potential changes that could be made to a project to lessen or completely remove its negative environmental effects (Faber & Jorna, 2005). Early planning that takes into account environmental effects can result in more environmentally friendly development, better relationships between the developer, the planning authority, and the local communities, a more straightforward development consent

process, and occasionally even a profitable financial return on the additional costs incurred. Such negotiation and redesign ideas are related to the significant environmental topics of "green consumption" and "green capitalism," according to O'Riordan (1990). Developers are responding to the rising customer demand for products that don't harm the environment and the expanding market for clean technology. A developer may utilize the EIA process to negotiate "environmental gain" solutions, which might minimize local resistance, remove or neutralize negative environmental consequences, and prevent expensive public inquiries. Wise developers may use the process to warn a possible problem to the developer. This may be observed in the broader, more modern framework of corporate social responsibility (CSR), which big corporations are increasingly putting into practice (Crane et al. 2008).

2.8.3.3 A vehicle for stakeholder consultation and participation

The environment may be greatly impacted by development activities, affecting a variety of social groups. The necessity of important stakeholders' consultation and engagement in project planning and development is being emphasized by the government at all levels; for examples, see the "Aarhus Convention" (UNECE 2000) and the EC Public Participation Directive (CEC 2003b). EIA may be a very helpful tool for interacting with communities and stakeholders, giving people who could be impacted by a proposed development additional information and opportunities to participate actively in the planning and development process.

2.8.3.4 An instrument for sustainable development

Environmentally damaging developments already in place must be controlled as effectively as possible. Even if they are shut down in extreme circumstances, they may continue contribute to environmental issues decades later. It would be far preferable to lessen the negative impacts in advance, during the planning stage, or, in certain circumstances, to

completely prevent the specific development. Prevention is preferable to treatment (Downey, 2005). This is the basic tenet of the groundbreaking EIA laws from the US and the EC. For instance, "the greatest environmental strategy consists in avoiding the formation of pollutants or nuisances at source, rather than afterwards seeking to mitigate their consequences" as stated in the preamble of the 1985 EC EIA Directive (CEC 1985).
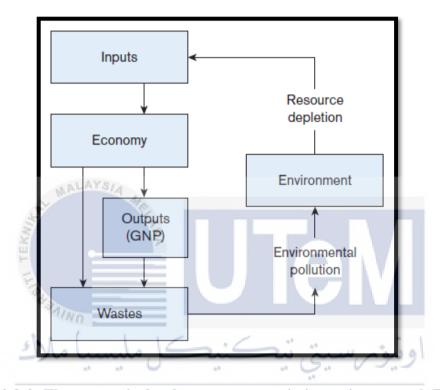
Figure 2.8-2: The economic development process in its environmental (**Boulding, 1966**)

It is important to consider how social and economic growth fit into their respective environmental environments. The classic paper by Boulding (1966) eloquently illustrates the contrast between the "spaceship economy" and the "throughput economy." As in Figure 2.8-2 above Increased gross national product (GNP), which is achieved by employing more resources to generate more products and services, includes the seeds of its own demise. Along with more goods and services, increased output also produces more garbage. Higher inputs call for additional resources. The "source" of resources and the "sink" for trash are both the natural environment. Economic progress is almost always accompanied

by environmental damage and resource depletion. Governments at all levels, from local to worldwide, have acknowledged the relationship between economic and social growth and the environment as well as the reciprocal effects of human actions on the biophysical world. Efforts have been made to manage the relationship more effectively. The European Environment Agency report, European Environment State and Outlook 2010 (EEA 2010), however, showed some good progress toward the end of the first decade of the twenty-first century mixed with enduring fundamental challenges, with potentially very serious consequences for the quality of the environment.

2.8.4 The Benefits of Environmental Impact Assessment

Environmental impact assessment is required to:

i. Development initiatives should be ecologically responsible.

ii. Lessen negative environmental effects.

iii. Prior to development initiatives, evaluate environmental effects on ecologically vulnerable terrain.

iv. Analyze how development pressures affect both the socio-cultural and natural resource bases.

v. Lower the total financial and environmental costs of projects.

vi. Maximize the advantages of the project.

2.9 GaBi Software

Product sustainability software called GaBi comes with a number of tools for assessing a product's possible environmental effect. It is a top modelling and analytical tool for Life Cycle Assessment (LCA) and reporting software, content databases with user-friendly tools for data collecting and reporting. The databases in the programmed give information on the advantages and disadvantages of the industrial processes in terms of the

environment. It is defined as the release or decrease of emissions into the air, water, or land as a result of the use or conservation of resources energy. An LCA model must be built in accordance with the stated system boundaries in order for the program to create the data. The fabricate part to build the CNC 3D router technology by using the milling process will be examined in this study's manufacturing process analysis to determine its potential environmental effects.

When the database is connected to the program, GaBi software may be used. The software must be launched with an Internet connection since it needs to produce inputs and outputs from spherical databases. The required process is manually created, and if it cannot be accessed, it is allocated to the correct process categories. All of the information about the input and output data is included in the database setup as well. The plan includes all of the chosen processes, including the manufacturing process, and all of the processes are connected appropriately. This is done to make sure that the software connects the system boundaries and the process chain. We looked at the printing process' possible environmental effects as well as other information including the machine's diesel and power usage.

2.10   Summary

The industry must simultaneously generate new concepts due to the expanding market potential and rising competition. Business choices are made with sustainability as their primary consideration. It is difficult to put sustainability into practice by integrating it into day-to-day corporate operations. The businesses are having several problems putting the planned approach into practice. The company was efficiently placed on a sustainable structure thanks to careful planning and creative concepts. In a company, the harmony of the sustainability components is important. Thus, adopting sustainable practices inside an enterprise gives it a competitive edge in the marketplace.

CHAPTER 3

METHODOLOGY

3.1   Introduction

This chapter will go through the study's methodology as well as the process flow
chart that was utilized to arrive at the final outcome. This chapter will also cover life cycle
assessment and its details, as well as data analysis. The procedure for reaching the outcome
will be more structured and efficient.

3.2   Flow Chart

The process flow as illustrated in Figure 3.2-1 shows the overall project
direction. It starts with a literature review and ends up with the life cycle analysis part.
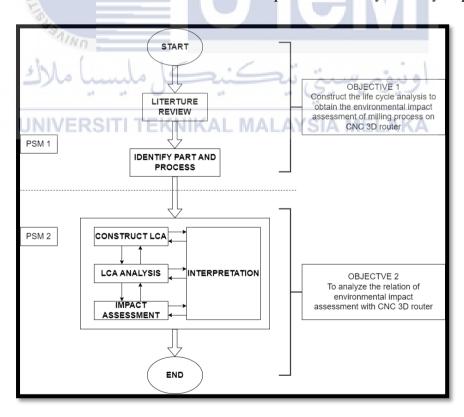
Figure 3.2-1: Flow chart of project methodology

This thesis analysis was conducted using the Gabi software. The analysis is applied on the CNC 3D router machine. Before the analysis started, it is very crucial to identify which part and process of the CNC 3D router that needed to key in the data in the Gabi software. After having discussion with the supervisor and the co-supervisor, it has been decided, the part that are needed to be analyze in the Gabi software is the fabricated part which is only going through the milling process. There are 15 parts of aluminum that has been fabricated using the milling machine. This is because the only machining process that were frequently used to fabricate the CNC 3D router is the milling process. Some other machining processes were also involved such as lathe, welding, and laser cutting process but this process only going through one or two time only. In the end, it is very important to choose a process that are repeatedly used to gain the accurate result of Gabi analysis. Table 3.2-1: Fabricated aluminum part below shows the fabricated aluminum part by using the milling machine. In the table there is also include the mass of every part that were gain from the SolidWorks software mass properties.

Table 3.2-1: Fabricated aluminum part

No.	Aluminum Parts	Mass
1.	LEVELING MOUNT PLATE	0.15kg
2.	MOTOR MOUNT	0.07kg
3.	TOP BLOCK MOUNT	0.176kg
4.	SIDE ANGLE MOUNT	0.065kg

No.	Aluminum Parts	Mass
5.	 MOTOR MOUNT	0.069kg
6.	 ANGLE BLOCK MOUNT	0.067kg
7.	 MAIN PLATE	0.991kg
8.	 TOP PLATE	0.222kg

No.	Aluminum Parts	Mass
9.	LINK PLATE	0.083kg
10.	BUSH PIPE	0.006kg
11.	SPACER PLATE	0.076kg
12.	SPINDLE MOUNT PLATE	0.734kg

No.	Aluminum Parts	Mass
13.	 CABLE CHAIN SPACER	0.015kg
14.	 BLOCK SPACER	0.446kg
15.	 MAGNET HUB	0.038kg
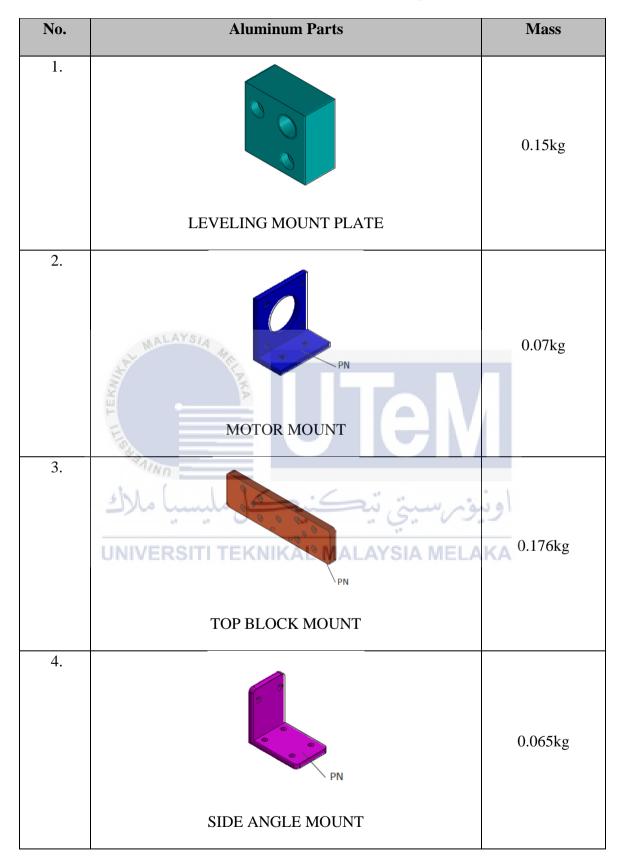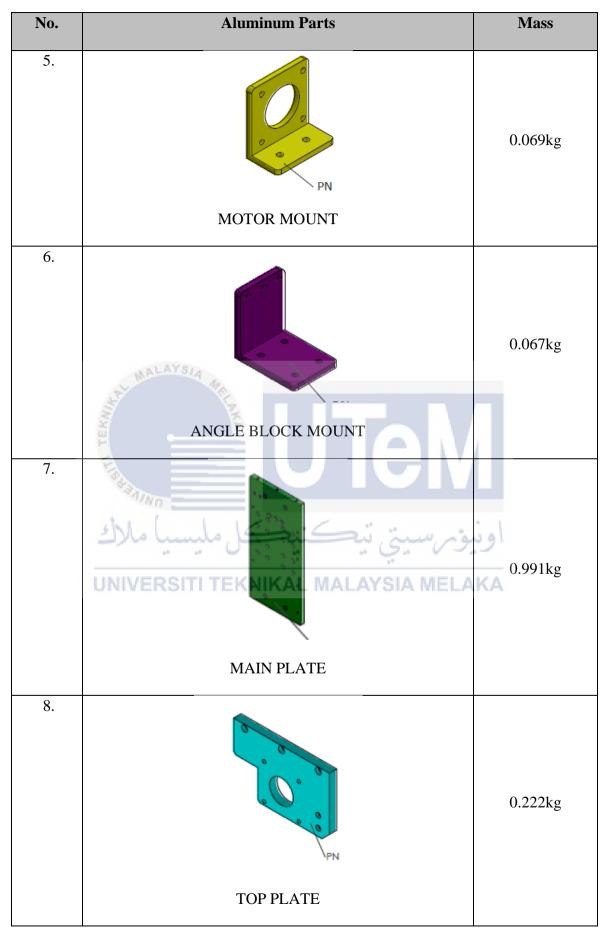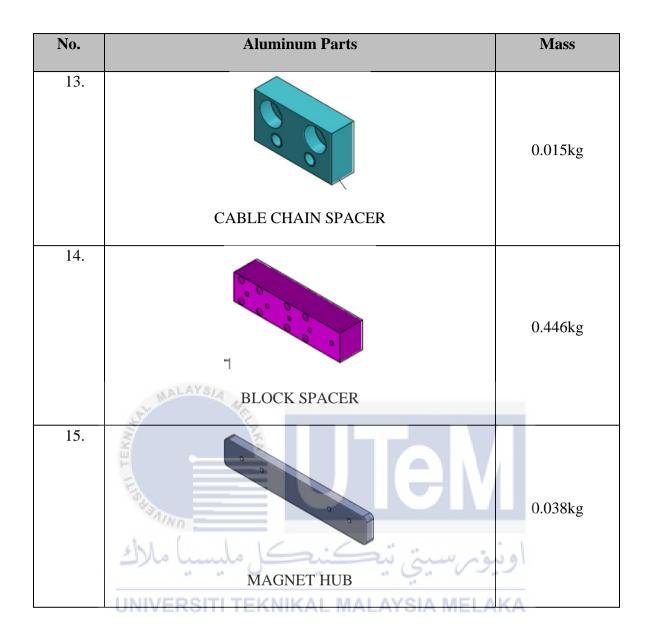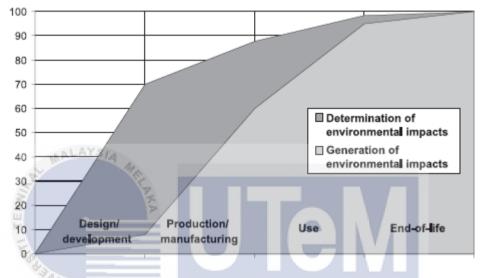
3.3   Life Cycle Assessment.

The term "life cycle assessment" (LCA) refers to a methodology for quantifying and evaluating the environmental effects of a product, including those related to climate change, ozone depletion in the stratosphere, production of tropospheric ozone (smog), eutrophication, acidification, toxicological stress on ecosystems and human health, resource depletion, water use, land use, noise, and others.

The design/development phase is typically not included in an LCA since it is frequently believed to have a minimal impact. One must keep in mind, nevertheless, that

choices made during the design and development phase have a significant impact on how the environment is affected during the subsequent life cycle stages. A product's behavior at later stages is heavily influenced by its design (e.g., the design of an automobile more or less determines the fuel consumption and emissions per kilometer driven in the use phase and has a high influence on the feasible recycling options in the end-of-life phase).

Figure 3.3-1: Generalized representation of the (pre)determination and the generation of environmental impacts in a product's life cycle (Rebitzer, 2002).

This relationship between design/development and the other life cycle phases is shown in Figure 3.3-1. Therefore, the research should be conducted as early in the design process as is practical and simultaneously with the other design procedures if the goal of an LCA is the development of goods and services, one of the most significant LCA applications. The design or enhancement of a process within the life cycle of a product is akin to this, particularly if interactions with other processes or life cycle phases are possible.

3.3.1   Life Cycle Assessment (LCA) Construction

Once the materials were done selected with its mass, it was place inside the manufacturing process since the raw materials are manufactured to get the product. Each of

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the part has its own process. From the source to the manufacture to the product itself. Basically, the machine needs power source such as electricity and compressed air to start processing. Next, it is also need raw material which in this project that were using are aluminum only. Other than that, as a design engineer student who applied sustainable development, a post process is important to include in the plan. For example, if there is raw material to be processing, there will be product part and there are also waste material that were created during the machining. It is critical to have knowledge so those waste material could be less and be recycle.
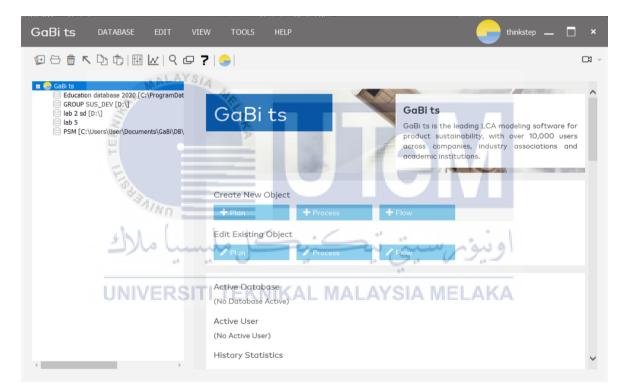
Figure 3.3-2: GaBi Software

Figure 3.3-2 above shows the Gabi software that has been used for the environmental impact analysis in this project. The user interface displays the flow of how to make a plan and obtain a result in several forms. To make a plan, it is very important to have knowledge on how to create a process and as well as the flow. Incorrect flow will lead to choosing the wrong

process. Thus, this will affect the plan either it could not link the process or the results unobtainable.

Figure 3.3-3: Manufacturing Process

Figure 3.3-3 above shows the example of manufacturing process created by Nazrin, 2022. For this project, it would be more process since the analysis involve 15 parts to be total with different mass. For each of the parts, there will be different mass of the raw material, different mass of part production and different mass of waste material created. All this data needs to be considered and get a precise quantity. On the other hand, Figure 3.3-4 below shows the example of disposal process where to create a sustainable development, a right way to dispose the waste material is very important for the environment. As for the aluminum milling process, the chip created were collected in one place to send back to the factory for recycle purpose.

Figure 3.3-4: Disposal Process

3.3.2   LCA Plan

Figure 3.3-5: Life Cycle Plan

In Figure 3.3-5 above shows the example of life cycle plan made by Nazrin, 2022. It is very crucial to create the right plan to get a precise environmental impact assessment result. The user may construct as many plans as necessary, and all of the plans may ultimately be combined to form a single plan for analysis. The more process plan involves, the more detail the data filled, the higher the accuracy of the result obtain. Figure 3.3-6 below shows the example of life cycle analysis (LCA) model for the fabricated part using the milling process. This project consists of 15 types of LCA model due to 15 different fabricated part but using the same milling process.
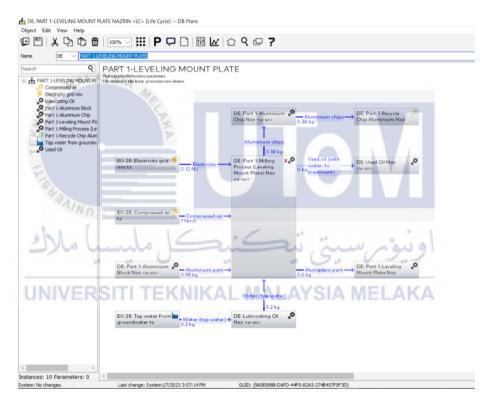
Figure 3.3-6: The LCA model for leveling mount plate.

3.3.3 Impact Assessment Results

An all-in-one tool, GaBi software may be used to create product models, input and output processes, and to produce data for calculating possible environmental emissions. It includes databases that PE International created using data and information gathered from industry sources and academic studies. Before using GaBi Software, the framework for LCA

methodology must be standardized using a methodical technique called Life Cycle Assessment (LCA) that adhered to ISO 14000 norms. The ISO standard specifies the following procedures for creating an LCA framework:

i. ISO 14040 (1997) – Introduction of a general framework for LCA

ii. ISO 14041 (1998) – Provides guidelines to determine goal and scope of LCA study

iii. ISO 14042 (2000) – Deals with life cycle impact assessment (LCIA) step

iv. ISO 14043 (2002) – Provides statements to interpret results from LCA.

All of these processes are used as a way to analyze a product's life cycle from raw materials to the manufacturing phase known as cradle-to-gate as a system boundary to assess how producing a product affects the environment. GaBi software is used to create an LCA model of an aluminum component that was milled in order to produce probable environmental consequences and calculate impact values. The example value of possible environmental effects from the milling technique used to fabricate aluminum parts is shown in Figure 3.3-7 until Figure 3.3-10.

The results come in many types such as environmental footprint, CML, ReCiPe, and TRACI. There are 18 graphs in environmental footprint, 15 graphs in CML, 19 graphs in ReCiPe, and 11 graphs in TRACI. In this project, the results that are accounted for is in terms of global waring potential (GWP).
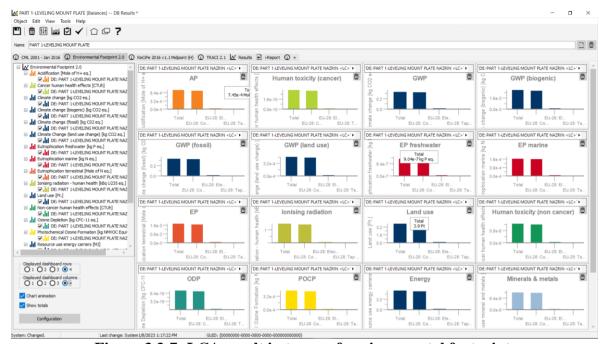
Figure 3.3-7: LCA result in terms of environmental footprint.
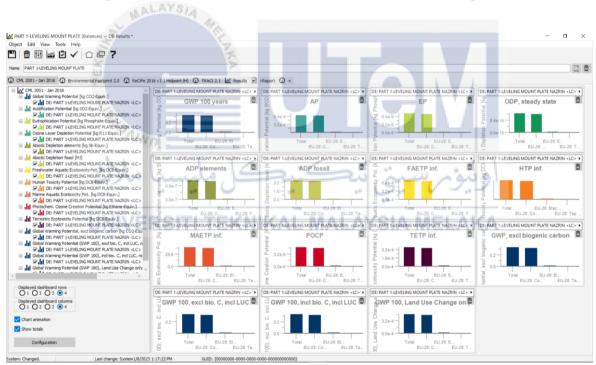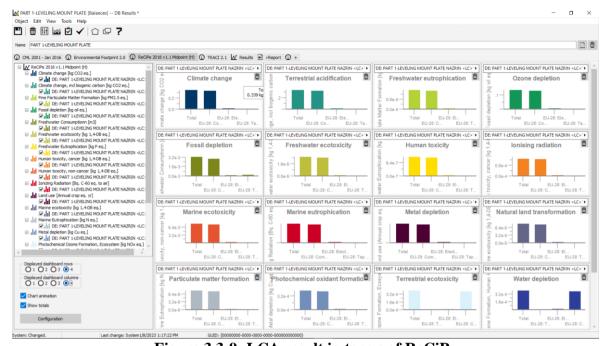
Figure 3.3-8: LCA result in terms of CML.

Figure 3.3-9: LCA result in terms of ReCiPe
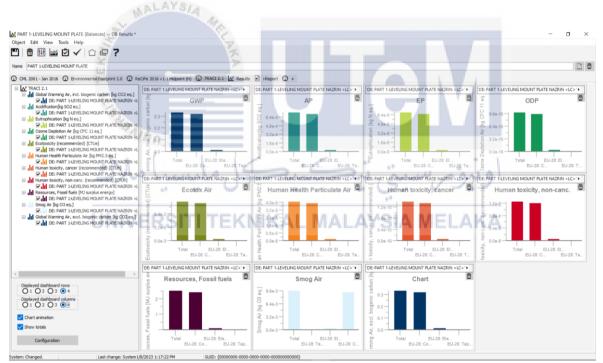
Figure 3.3-10: LCA result in terms of TRACI.

3.4   Summary

To summarize, this chapter presents the proposed methodology in order to analyze the environmental impact assessment of fabrication aluminum part using the milling process. This study has demonstrated that the use of GaBi software is crucial in identifying potential environmental effects throughout a product's life cycle. The information gathered by the program enables future research to take measures while creating the aluminum part, particularly with regard to environmental factors. Due of its extensive database, this program may also be used in other fields like economics and building. As a result, the GaBi software program in this case study serves as a very effective validation and optimization tool.

CHAPTER 4

RESULTS

4.1   Introduction

This chapter present the detailed description of every process and the result gain from the analysis. This chapter also described the processes that were necessary to create a major outcome. To make sure the information gathered is reliable enough to do the GaBi analysis, more research was conducted. Every input and output are fill in detail with its mass properties that were gain from SolidWorks software properties.

4.2   Process Flow

It is very crucial to have knowledge regarding the process flow. Research needs to be done to find the exact or at least the most significant data to fill in the process flow. Even though every element in this project has the same input and output, the only thing that differs between each component is the mass, even if each process might not contain the same element in real industry. The mass of raw material, the mass of product part and the waste material created from the milling process has different mass for each part. Table 4.2-1: Input & Output for each fabricated part. below shows the input and output for each part including their mass.

Table 4.2-1: Input & Output for each fabricated part.

No	Part name	Input	Mass	Output	Mass
1.	Leveling mount plate	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	0.98kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.6kg 0.38kg 0.38kg 0.4kg
2.	Motor mount	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	0.36kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.14kg 0.22kg 0.22kg 0.4kg
3.	Top block mount	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	0.66kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.352kg 0.316kg 0.316kg 0.4kg
4.	Side angle mount	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	0.29kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.13kg 0.16kg 0.16kg 0.4kg
5.	Motor mount	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	0.19kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.069kg 0.124kg 0.124kg 0.4kg
6.	Angle block mount	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	0.16kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.067kg 0.095kg 0.095kg 0.4kg
7.	Main plate	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	1.61kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.991kg 0.621kg 0.621kg 0.4kg

No	Part name	Input	Mass	Output	Mass
8.	Top plate	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	0.47kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.222kg 0.253kg 0.253kg 0.4kg
9.	Link plate	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	0.14kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.083kg 0.06kg 0.06kg 0.4kg
10.	Bush pipe	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	0.03kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.024kg 0.008kg 0.008kg 0.4kg
11.	Spacer plate	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	0.27kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.152kg 0.12kg 0.12kg 0.4kg
12.	Spindle mount plate	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	1.2kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.734kg 0.47kg 0.47kg 0.4kg
13.	Cable chain spacer	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	0.04kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.015kg 0.025kg 0.025kg 0.4kg
14.	Block spacer	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	1.27kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.892kg 0.386kg 0.386kg 0.4kg

No	Part name	Input	Mass	Output	Mass
15.	Magnet hub	- Aluminum part - Compressed air - Electricity - Lubricating oil - Water	0.09kg 7Nm3 0.12MJ 0.2kg 0.8kg	- Aluminum part - Aluminum chip - Industrial waste for municipal disposal - Used oil	0.038kg 0.056kg 0.056kg 0.4kg

Figure 4.2-1 below shows one of the complete processes where it contained the right input and output. This process is for top block mount part. For more detail and more process can refer to APPENDIX C.

Figure 4.2-1: Top block mount process flow

4.3   Life Cycle Assessment (LCA) Model
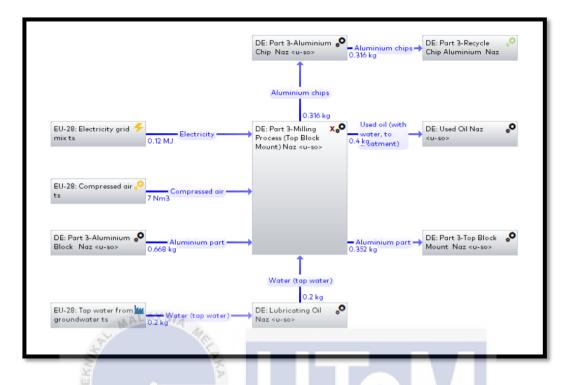
Figure 4.3-1: The LCA model plan for top block mount

After developing the process, the life cycle analysis (LCA) plan has to be made. It is crucial to determine which parts are input and output, based on Figure 4.3-1 above, and which parts need to be connected. The primary requirements for the milling process are an electrical power supply and compressed air, both of which are crucial. Other than that, the project's raw material is aluminum, and coolant is required throughout the milling process to keep everything running properly. The coolant utilized for this LCA type is a mixture of water and lubricating oil. The waste material was also formed into chips in addition to the parts that were produced in accordance with the specifications. Following some investigation, a firm will recycle the chips produced during the milling process.

Figure 4.3-2: Total 15 parts of LCA model

The entire LCA model is displayed, as depicted in Figure 4.3-2 above. To obtain a thorough result analysis, the 15 components of the LCA model must be combined into one. Scaling factor is a variable in this stage since it depends on the expected output. In this research, each LCA model's scaling factor has been set to 1, 50, 100, 250 and 500 for the purpose of comparing the outcomes of the various environmental impact assessments.

4.4   GaBi Results

The program generates results in accordance with the inputs and outputs that have been previously established in the constructed LCA model, and it may also be updated in accordance with the supplied data or to account for changes in the manufacturing process, techniques, and technology. Raw material flows, energy flows, and emissions are all included in the statistics. software displays the environmental implications of the milling machine's production of 15 aluminum parts in terms of their Global Warming Potential (GWP) value.

Table 4.4-1: Value of GWP environment impacts from GaBi software

No.	Scaling factor	Global Warming Potential (GWP)					
		100 Years (Kg CO2 eq)	Climate change (Kg CO2 eq)	Biogenic (Kg CO2 eq)	Fossil (Kg CO2 eq)	Land use (Kg CO2 eq)	Air (Kg CO2 eq)
1.	1	1.31	1.34	0.0109	1.33	1.92e-3	1.3
		0.554	0.568	0.0046	0.563	0.815e-3	0.552
2.	50	65.4	67.1	0.543	66.4	0.0962	65.1
		27.7	28.4	0.23	28.1	0.0408	27.6
3.	100	131	134	1.09	133	0.192	130
		55.4	56.8	0.46	56.3	0.0815	55.2
4.	250	327	335	2.72	332	0.481	326
		139	142	1.15	141	0.204	138
5.	500	654	671	5.43	664	0.962	651
		277	284	2.3	281	0.408	276

	Total value
	Highest part value

This project only includes the result in terms of Global Warming Potential (GWP) environment impact. From the result in Table 4.4-1: Value of GWP environment impacts from GaBi software above, it is shown that the highest impact from fabricating the aluminum part by using the milling process is the GWP in terms of climate change. According to National Geography Society, 2022, the gradual changing of a region's temperature and usual weather patterns is referred to as climate change. Climate change might apply to a certain area or the entire world. Weather patterns might become less predictable as a result of climate change. Because projected temperature and rainfall levels can no longer be depended upon, these unexpected weather patterns can make it challenging to sustain and develop crops in areas that rely on farming. Other harmful weather occurrences including more frequent and more powerful hurricanes, floods, downpours, and winter storms have all been linked to climate change.

In this project, the scaling factor of fabricated aluminum part is only 1. To show a significant result due to manufacturing industry nowadays produce a large amount of product or so-called mass production, the scaling factor was change to 50, 100, 250 and 500. Figure 4.4-1 until Figure 4.4-5 below shows the results of input and output with different scaling factor. From the result, it is shown that the highest value is emission to fresh water. Emission to water is a water that is brought in needs to be treated before it can be used in the process, and it needs to be treated once again when the process is complete before it can be discharged as effluent to a receiver. Following wastewater treatment, the chemicals found in the effluent are listed. All mills have some method of treating the effluent water, whether it is mechanical treatment through sedimentation, further biological anaerobic and aerobic treatment, or chemical treatment.

Inputs	
	DE: TOTAL 15 PARTS ALUMINIUM MILLNG NAZRIN <LC>
Flows	**6.17E003**
Resources	**6.17E003**
Energy resources	0.627
Land use	
Material resources	6.17E003

Outputs	
	DE: TOTAL 15 PARTS ALUMINIUM MILLNG NAZRIN <LC>
Flows	**6.44E003**
Deposited goods	5.53
Emissions to air	38.8
Emissions to fresh water	6.38E003
Emissions to sea water	22.2
Emissions to agricultural soil	2.13E-007
Emissions to industrial soil	1.51E-005

Figure 4.4-1: Results of input and output with scaling factor 1

Inputs	
	DE: TOTAL 15 PARTS ALUMINIUM MILLNG NAZRIN <LC>
Flows	**3.09E005**
Resources	**3.09E005**
Energy resources	31.3
Land use	
Material resources	3.09E005

Outputs	
	DE: TOTAL 15 PARTS ALUMINIUM MILLNG NAZRIN <LC>
Flows	**3.22E005**
Deposited goods	276
Emissions to air	1.94E003
Emissions to fresh water	3.19E005
Emissions to sea water	1.11E003
Emissions to agricultural soil	1.07E-005
Emissions to industrial soil	0.000756

Figure 4.4-2: Results of input and output with scaling factor 50

Figure 4.4-3: Results of input and output with scaling factor 100

Figure 4.4-4: Results of input and output with scaling factor 250

Inputs	
	DE: TOTAL 15 PARTS ALUMINIUM MILLNG NAZRIN <LC>
Flows	3.09E006
Resources	3.09E006
Energy resources	313
Land use	
Material resources	3.09E006

Outputs	
	DE: TOTAL 15 PARTS ALUMINIUM MILLNG NAZRIN <LC>
Flows	3.22E006
Deposited goods	2.76E003
Emissions to air	1.94E004
Emissions to fresh water	3.19E006
Emissions to sea water	1.11E004
Emissions to agricultural soil	0.000107
Emissions to industrial soil	0.00756

Figure 4.4-5: Results of input and output with scaling factor 500

4.5   Summary

To summarize, this chapter showing the result of the GaBi analysis in terms of Global Warming Potential (GWP) environment impact. The reason for these circumstances is due to the world right now is having a serious case of global warming impact due to human factor mostly. Even though what are the industry applying right now will give bad impact for a long term, our future generation might be the victim for what we were doing today. So, with this result analysis, manufacturing industry might reconsider and emphasize more regarding the environment health. According to the study's findings, compressed air consumption during the milling process has an impact on the sustainability of the environment since it scores highly for each possible environmental impact. Controlling environmental sustainability also heavily depends on the materials chosen during component production. This conclusion, however, was only supported by the production and materials. In order to obtain precise values, a high level of analysis and evaluation is needed to verify the full life cycle process.

CHAPTER 5

CONCLUSION

5.1   Conclusion

This study has demonstrated that the use of GaBi software is crucial in identifying potential environmental effects throughout a product's life cycle. Due of its extensive database, this software can also be used in other fields like economics and building. As a result, the GaBi software program in this case study serves as a very effective validation and optimization tool.

The Life Cycle Assessment (LCA) approach is introduced in this project. LCA is evolving as a crucial element in most organizations' toolkits as a result of the push for sustainable development. An effective set of techniques for estimating, assessing, comparing, and improving products and services in terms of their possible environmental implications is life cycle assessment (LCA). LCA encourages the identification of potential for resource conservation and pollution prevention through methodical studies, avoiding dogmatic goals that may be intuitive but nevertheless erroneous even in their broad strokes. In essence, modelling life cycle inventories is a reliable and possibly unique method for assessing the environmental effects of items holistically together with the life cycle impact assessment stage—as required by sustainable development. However, there are still a lot of unanswered problems to be fixed and communication plans to be developed. These include dissemination of this relatively new methodology around the globe, which calls for education, awareness-raising, and mutual learning as well as acceptable and conveniently accessible technologies and relevant international databases.

5.2 Recommendation

Based on this study, there are many things that any industry can improve to get a better result in environmental impact assessment. First and foremost, industry can use a composite material in exchange for the existing materials due to its effect towards the environment and human health. There are many studies and research regarding the composite material which has a higher material properties and lower effect to the environment. Next, industry also could use another initiative to replace the coolant for the milling process running smoothly. For example, use a coolant with less chemical content or try to avoid using the coolant. In addition, industry also need to make sure the machine that they are using consume less enough energy resources such as electricity and compressed air. Last but not least, set a limitation for the manufacturing process because the longer the machine operate the higher the effects towards the environment and human health.

This analysis has certain errors that could be fixed in subsequent research. For instance, from what have been describe in this research, the production of a machine tool is far more intricate and involves several phases that are harder to define. Since each component of a machine tool is made up of several materials, aggregate effects also had an impact on the extraction and processing of materials. Even while machine tools need operators and maintenance professionals and the widget itself is simpler than many manufactured parts, labor was overlooked in the use phase due to its intrinsic complexity.

Additionally, due to resource constraints, it is likely that the process parameters used in the studies to calculate the energy required to create a widget were not representative of a real production run. In spite of these potential sources of inaccuracy, the study was created to offer a thorough first evaluation of energy consumption over the course of a machine tool's lifetime. Future research will aim to enhance the data utilized in this analysis and to polish the analysis itself by adding in additional possibly important variables.

5.3 Project Potential

Every project or research has its own potential and limitation. For this kind of research, it is very helpful in developing a sustainable industry. GaBi software should be use by every industry as a guidance to ensure their product manufacture and even their machining process performing a sustainable product with sustainable process. Once every industry obliges the sustainable development, the machining activities will be less responsible in producing pollution such as greenhouse emission, etc.

REFERENCES

- Abu, Rozieana & Ab Aziz, Muhammad Arif & Hassan, Christoper & Noor, Zainura & Jalil, Rohaya. (2021). LIFE CYCLE ASSESSMENT ANALYZING WITH GABI SOFTWARE FOR FOOD WASTE MANAGEMENT USING WINDROW AND HYBRID COMPOSTING TECHNOLOGIES. Jurnal Teknologi. 83. 95-108. 10.11113/jurnalteknologi.v83.17199.

- Aissa Assia, Zakaria. (2019). Introduction to Environmental Impact Assessment.

- Diaz-Elsayed, Nancy & Helu, Moneer & Jayanathan, Stephen & Chen, Yifen & Horvath, Arpad & Dornfeld, David. (2010). Environmental analysis of milling machine tool use in various manufacturing environments. Proceedings of the 2010 IEEE International Symposium on Sustainable Systems and Technology, ISSST 2010. 1 - 6. 10.1109/ISSST.2010.5507763.

- Faber, N., Jorna, R. and van Engelen, J. 2005. A Study into the conceptual foundations of the notion of 'sustainability'. Journal of Environmental Assessment Policy and Management, 7 (1).

- G. Rebitzer, T. Ekvall, and R. Frischknecht. (2003). Life Cycle Assessment Part 1: Framework, goal and scope definition, inventory analysis, and applications. 30(2004) 701-702

- Laxmi, Santhana & Samydoss, Chandramohan. (2020). Sustainable development. 10. 69-73.

- Poel, Ibo. (2016). Design for Sustainability. 10.7551/mitpress/9780262035668.003.0008.

- P R, Arun. (2013). Environmental Impact Assessment; Challenges and opportunities.

- Roy, Rabindra. (2001). Environmental Impact Assessment: a tool for sustainable development. 7.

- Senusi, Farasyafinaz & Mahmood, Salwa. (2022). Application of GaBi software in identifying potential environmental impacts in fabrication of 3D bone tissue engineering.

- Tomislav Klarin. (2018). The Concept of Sustainable Development: From its Beginning to the Contemprorary Issues.
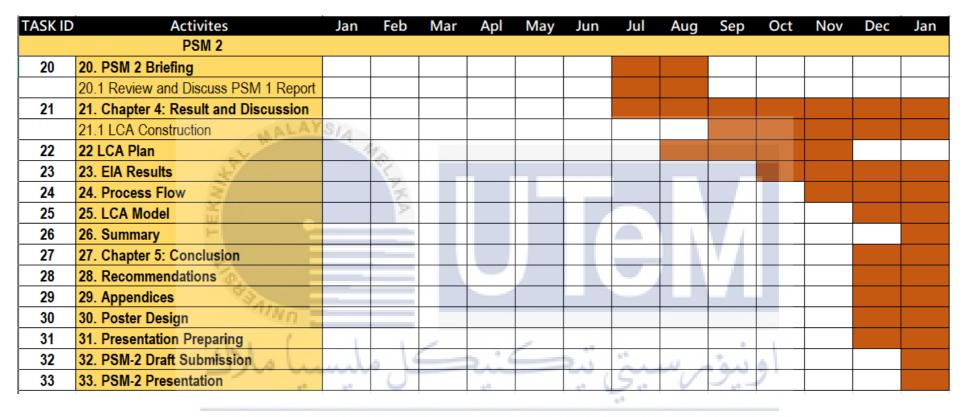
APPENDICES

APPENDIX A   Gantt Chart PSM 1

TASK ID	Activites	2022										2023		
		Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
	PSM 1													
1	1. Topic Selection													
2	2. Discussion With Supervisior													
3	3. PSM Planning													
4	4. Research Information													
5	5. Finding and Reading References													
6	6. Define the Problems Statements													
7	7. Chapter 1: Introduction													
8	8. Logbook Submission													
9	9. Draft Submission Chapter 1													
10	10. Chapter 2: Literature Review													
12	12. Environmental Impact Assessment													
13	13. Draft Submission Chapter 2													
14	14. Chapter 3: Methodology													
15	15. Draft Submission Chapter 3													
16	16. Renew Report Draft													
17	17. Report Submission													
18	18. Slide Presentation													
19	19. Video Presentation													

APPENDIX B   Gantt Chart PSM 2

TASK ID	Activites	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
	PSM 2													
20	**20. PSM 2 Briefing**							X	X					
	20.1 Review and Discuss PSM 1 Report							X	X					
21	**21. Chapter 4: Result and Discussion**							X	X	X	X	X	X	X
	21.1 LCA Construction									X	X	X	X	X
22	**22 LCA Plan**								X	X		X	X	
23	**23. EIA Results**										X	X	X	
24	**24. Process Flow**											X	X	
25	**25. LCA Model**											X	X	
26	**26. Summary**												X	X
27	**27. Chapter 5: Conclusion**												X	
28	**28. Recommendations**												X	
29	**29. Appendices**												X	
30	**30. Poster Design**												X	
31	**31. Presentation Preparing**												X	
32	**32. PSM-2 Draft Submission**													X
33	**33. PSM-2 Presentation**													X

APPENDIX C Process Flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	Mass	0.98	kg	X	0 %	(No statement)	
⇄ Compressed air [Mechanical ene	Standard volu	7	Nm3	X	0 %	(No statement)	
⇄ Electricity [Electric power]	Energy (net ca	0.12	MJ	X	0 %	(No statement)	
⇄ Lubricating oil [Operating mater	Mass	0.2	kg	X	0 %	(No statement)	
⇄ Water [Operating materials]	Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	Mass	0.6	kg	X	0 %	(No statement)	
⇄ Aluminium chips [Waste for recovery]	Mass	0.38	kg	*	0 %	(No statement)	
⇄ Industrial waste for municipal disposal	Mass	0.38	kg	*	0 %	(No statement)	
⇄ Used oil (with water, to treatment) [W	Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Leveling mount plate process flow

Inputs
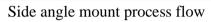
Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	Mass	0.36	kg	X	0 %	(No statement)	
⇄ Compressed air [Mechanical ene	Standard volu	7	Nm3	X	0 %	(No statement)	
⇄ Electricity [Electric power]	Energy (net ca	0.12	MJ	X	0 %	(No statement)	
⇄ Lubricating oil [Operating mater	Mass	0.2	kg	X	0 %	(No statement)	
⇄ Water [Operating materials]	Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	Mass	0.14	kg	X	0 %	(No statement)	
⇄ Aluminium chips [Waste for recovery]	Mass	0.22	kg	*	0 %	(No statement)	
⇄ Industrial waste for municipal disposal	Mass	0.22	kg	*	0 %	(No statement)	
⇄ Used oil (with water, to treatment) [W	Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Motor mount process flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	Mass	0.668	kg	X	0 %	(No statement)	
⇄ Compressed air [Mechanical ene	Standard volu	7	Nm3	X	0 %	(No statement)	
⇄ Electricity [Electric power]	Energy (net ca	0.12	MJ	X	0 %	(No statement)	
⇄ Lubricating oil [Operating mater	Mass	0.2	kg	X	0 %	(No statement)	
⇄ Water [Operating materials]	Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	Mass	0.352	kg	X	0 %	(No statement)	
⇄ Aluminium chips [Waste for recovery]	Mass	0.316	kg	*	0 %	(No statement)	
⇄ Industrial waste for municipal disposal	Mass	0.316	kg	*	0 %	(No statement)	
⇄ Used oil (with water, to treatment) [W	Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Top block mount process flow

71

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	⫶ Mass	0.29	kg	X	0 %	(No statement)	
⇄ Compressed air [Mechanical ene	⫶ Standard volu	7	Nm3	X	0 %	(No statement)	
⇄ Electricity [Electric power]	⫶ Energy (net ca	0.12	MJ	X	0 %	(No statement)	
⇄ Lubricating oil [Operating mater	⫶ Mass	0.2	kg	X	0 %	(No statement)	
⇄ Water [Operating materials]	⫶ Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	⫶ Mass	0.13	kg	X	0 %	(No statement)	
⇄ Aluminium chips [Waste for recovery]	⫶ Mass	0.16	kg	*	0 %	(No statement)	
⇄ Industrial waste for municipal disposal	⫶ Mass	0.16	kg	*	0 %	(No statement)	
⇄ Used oil (with water, to treatment) [W	⫶ Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Side angle mount process flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	⫶ Mass	0.193	kg	X	0 %	(No statement)	
⇄ Compressed air [Mechanical ene	⫶ Standard volu	7	Nm3	X	0 %	(No statement)	
⇄ Electricity [Electric power]	⫶ Energy (net ca	0.12	MJ	X	0 %	(No statement)	
⇄ Lubricating oil [Operating mater	⫶ Mass	0.2	kg	X	0 %	(No statement)	
⇄ Water [Operating materials]	⫶ Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	⫶ Mass	0.069	kg	X	0 %	(No statement)	
⇄ Aluminium chips [Waste for recovery]	⫶ Mass	0.124	kg	*	0 %	(No statement)	
⇄ Industrial waste for municipal disposal	⫶ Mass	0.124	kg	*	0 %	(No statement)	
⇄ Used oil (with water, to treatment) [W	⫶ Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Motor mount process flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	⫶ Mass	0.162	kg	X	0 %	(No statement)	
⇄ Compressed air [Mechanical ene	⫶ Standard volu	7	Nm3	X	0 %	(No statement)	
⇄ Electricity [Electric power]	⫶ Energy (net ca	0.12	MJ	X	0 %	(No statement)	
⇄ Lubricating oil [Operating mater	⫶ Mass	0.2	kg	X	0 %	(No statement)	
⇄ Water [Operating materials]	⫶ Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	⫶ Mass	0.067	kg	X	0 %	(No statement)	
⇄ Aluminium chips [Waste for recovery]	⫶ Mass	0.095	kg	*	0 %	(No statement)	
⇄ Industrial waste for municipal disposal	⫶ Mass	0.095	kg	*	0 %	(No statement)	
⇄ Used oil (with water, to treatment) [W	⫶ Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Angle block mount process flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
Aluminium part [Metal parts]	Mass	1.61	kg	X	0 %	(No statement)	
Compressed air [Mechanical ene	Standard volu	7	Nm3	X	0 %	(No statement)	
Electricity [Electric power]	Energy (net ca	0.12	MJ	X	0 %	(No statement)	
Lubricating oil [Operating mater	Mass	0.2	kg	X	0 %	(No statement)	
Water [Operating materials]	Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
Aluminium part [Metal parts]	Mass	0.991	kg	X	0 %	(No statement)	
Aluminium chips [Waste for recovery]	Mass	0.621	kg	*	0 %	(No statement)	
Industrial waste for municipal disposal	Mass	0.621	kg	*	0 %	(No statement)	
Used oil (with water, to treatment) [W	Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Main plate process flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
Aluminium part [Metal parts]	Mass	0.475	kg	X	0 %	(No statement)	
Compressed air [Mechanical ene	Standard volu	7	Nm3	X	0 %	(No statement)	
Electricity [Electric power]	Energy (net ca	0.12	MJ	X	0 %	(No statement)	
Lubricating oil [Operating mater	Mass	0.2	kg	X	0 %	(No statement)	
Water [Operating materials]	Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
Aluminium part [Metal parts]	Mass	0.222	kg	X	0 %	(No statement)	
Aluminium chips [Waste for recovery]	Mass	0.253	kg	*	0 %	(No statement)	
Industrial waste for municipal disposal	Mass	0.253	kg	*	0 %	(No statement)	
Used oil (with water, to treatment) [W	Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Top plate process flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
Aluminium part [Metal parts]	Mass	0.143	kg	X	0 %	(No statement)	
Compressed air [Mechanical ene	Standard volu	7	Nm3	X	0 %	(No statement)	
Electricity [Electric power]	Energy (net ca	0.12	MJ	X	0 %	(No statement)	
Lubricating oil [Operating mater	Mass	0.2	kg	X	0 %	(No statement)	
Water [Operating materials]	Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
Aluminium part [Metal parts]	Mass	0.083	kg	X	0 %	(No statement)	
Aluminium chips [Waste for recovery]	Mass	0.06	kg	*	0 %	(No statement)	
Industrial waste for municipal disposal	Mass	0.06	kg	*	0 %	(No statement)	
Used oil (with water, to treatment) [W	Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Link plate process flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	.::: Mass	0.032	kg	X	0 %	(No statement)	
⇄ Compressed air [Mechanical ene	.::: Standard volu	7	Nm3	X	0 %	(No statement)	
⇄ Electricity [Electric power]	.::: Energy (net ca	0.12	MJ	X	0 %	(No statement)	
⇄ Lubricating oil [Operating mater	.::: Mass	0.2	kg	X	0 %	(No statement)	
⇄ Water [Operating materials]	.::: Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	.::: Mass	0.024	kg	X	0 %	(No statement)	
⇄ Aluminium chips [Waste for recovery]	.::: Mass	0.008	kg	*	0 %	(No statement)	
⇄ Industrial waste for municipal disposal	.::: Mass	0.008	kg	*	0 %	(No statement)	
⇄ Used oil (with water, to treatment) [W	.::: Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Bush pipe process flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	.::: Mass	0.272	kg	X	0 %	(No statement)	
⇄ Compressed air [Mechanical ene	.::: Standard volu	7	Nm3	X	0 %	(No statement)	
⇄ Electricity [Electric power]	.::: Energy (net ca	0.12	MJ	X	0 %	(No statement)	
⇄ Lubricating oil [Operating mater	.::: Mass	0.2	kg	X	0 %	(No statement)	
⇄ Water [Operating materials]	.::: Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	.::: Mass	0.152	kg	X	0 %	(No statement)	
⇄ Aluminium chips [Waste for recovery]	.::: Mass	0.12	kg	*	0 %	(No statement)	
⇄ Industrial waste for municipal disposal	.::: Mass	0.12	kg	*	0 %	(No statement)	
⇄ Used oil (with water, to treatment) [W	.::: Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Spacer plate process flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	.::: Mass	1.2	kg	X	0 %	(No statement)	
⇄ Compressed air [Mechanical ene	.::: Standard volu	7	Nm3	X	0 %	(No statement)	
⇄ Electricity [Electric power]	.::: Energy (net ca	0.12	MJ	X	0 %	(No statement)	
⇄ Lubricating oil [Operating mater	.::: Mass	0.2	kg	X	0 %	(No statement)	
⇄ Water [Operating materials]	.::: Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	.::: Mass	0.734	kg	X	0 %	(No statement)	
⇄ Aluminium chips [Waste for recovery]	.::: Mass	0.47	kg	*	0 %	(No statement)	
⇄ Industrial waste for municipal disposal	.::: Mass	0.47	kg	*	0 %	(No statement)	
⇄ Used oil (with water, to treatment) [W	.::: Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Spindle mount plate process flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	..∷ Mass	0.04	kg	X	0 %	(No statement)	
⇄ Compressed air [Mechanical ene	..∷ Standard volu	7	Nm3	X	0 %	(No statement)	
⇄ Electricity [Electric power]	..∷ Energy (net ca	0.12	MJ	X	0 %	(No statement)	
⇄ Lubricating oil [Operating mater	..∷ Mass	0.2	kg	X	0 %	(No statement)	
⇄ Water [Operating materials]	..∷ Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	..∷ Mass	0.015	kg	X	0 %	(No statement)	
⇄ Aluminium chips [Waste for recovery]	..∷ Mass	0.025	kg	*	0 %	(No statement)	
⇄ Industrial waste for municipal disposal	..∷ Mass	0.025	kg	*	0 %	(No statement)	
⇄ Used oil (with water, to treatment) [W	..∷ Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Cable chain spacer process flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	..∷ Mass	1.27	kg	X	0 %	(No statement)	
⇄ Compressed air [Mechanical ene	..∷ Standard volu	7	Nm3	X	0 %	(No statement)	
⇄ Electricity [Electric power]	..∷ Energy (net ca	0.12	MJ	X	0 %	(No statement)	
⇄ Lubricating oil [Operating mater	..∷ Mass	0.2	kg	X	0 %	(No statement)	
⇄ Water [Operating materials]	..∷ Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	..∷ Mass	0.892	kg	X	0 %	(No statement)	
⇄ Aluminium chips [Waste for recovery]	..∷ Mass	0.386	kg	*	0 %	(No statement)	
⇄ Industrial waste for municipal disposal	..∷ Mass	0.386	kg	*	0 %	(No statement)	
⇄ Used oil (with water, to treatment) [W	..∷ Mass	0.4	kg	*	0 %	(No statement)	
Flows							
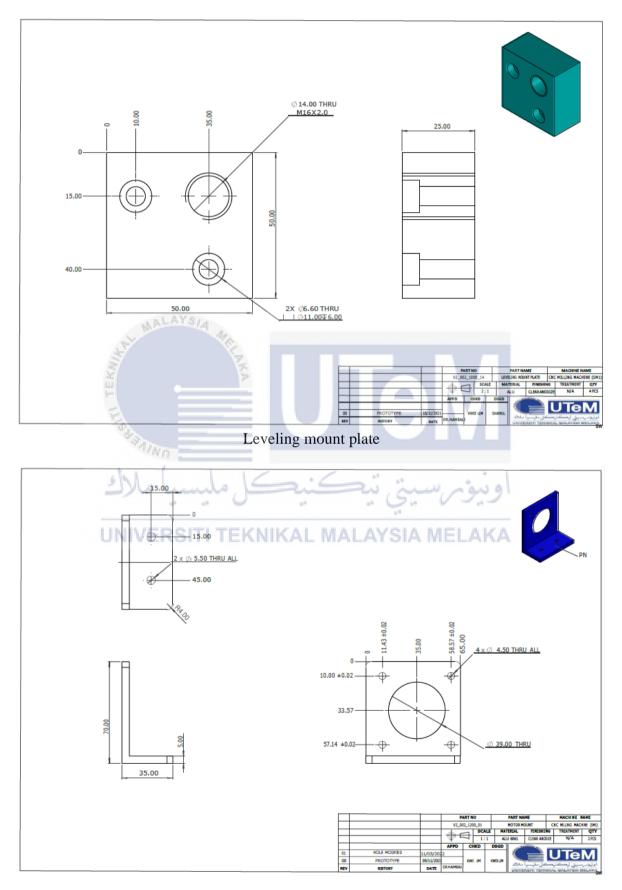
Block spacer process flow

Inputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	..∷ Mass	0.092	kg	X	0 %	(No statement)	
⇄ Compressed air [Mechanical ene	..∷ Standard volu	7	Nm3	X	0 %	(No statement)	
⇄ Electricity [Electric power]	..∷ Energy (net ca	0.12	MJ	X	0 %	(No statement)	
⇄ Lubricating oil [Operating mater	..∷ Mass	0.2	kg	X	0 %	(No statement)	
⇄ Water [Operating materials]	..∷ Mass	0.8	kg	X	0 %	(No statement)	
Flows							

Outputs

Flows	Quantities	Amount	Units	Tra	Standar	Origin	Comment
⇄ Aluminium part [Metal parts]	..∷ Mass	0.038	kg	X	0 %	(No statement)	
⇄ Aluminium chips [Waste for recovery]	..∷ Mass	0.056	kg	*	0 %	(No statement)	
⇄ Industrial waste for municipal disposal	..∷ Mass	0.056	kg	*	0 %	(No statement)	
⇄ Used oil (with water, to treatment) [W	..∷ Mass	0.4	kg	*	0 %	(No statement)	
Flows							

Magnet hub process flow

APPENDIX D FABRICATE PART DRAWING
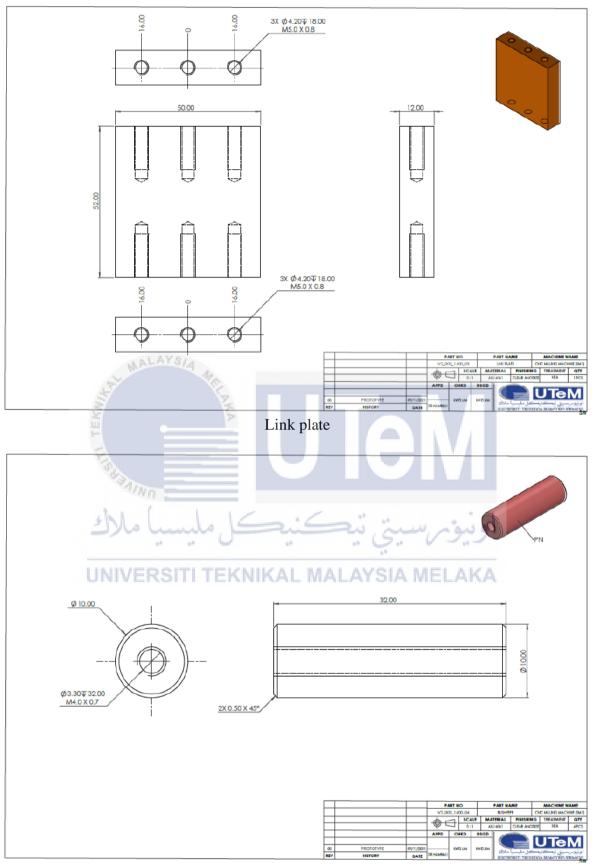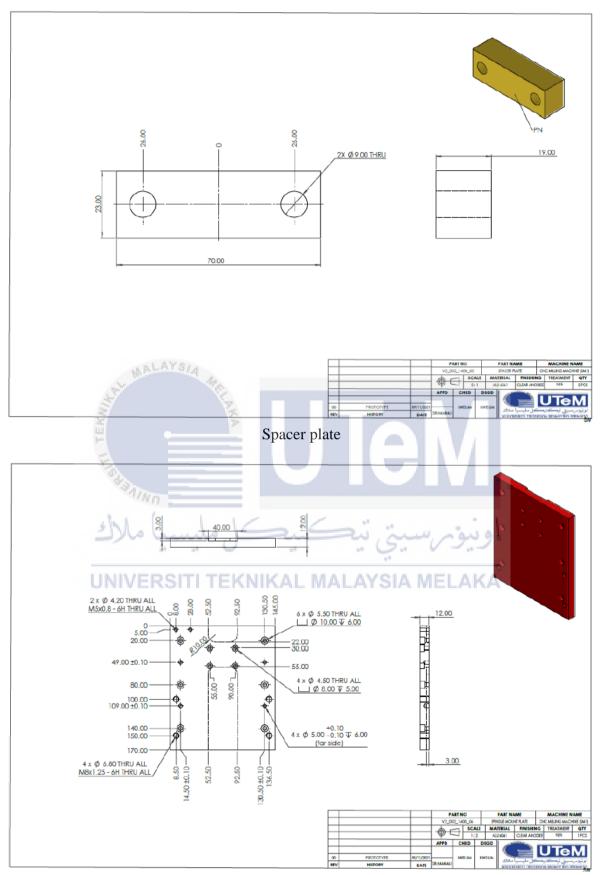
Leveling mount plate

Motor mount

Top block mount

Side angle mount

Motor mount

Angle block mount

Main plate

Top plate

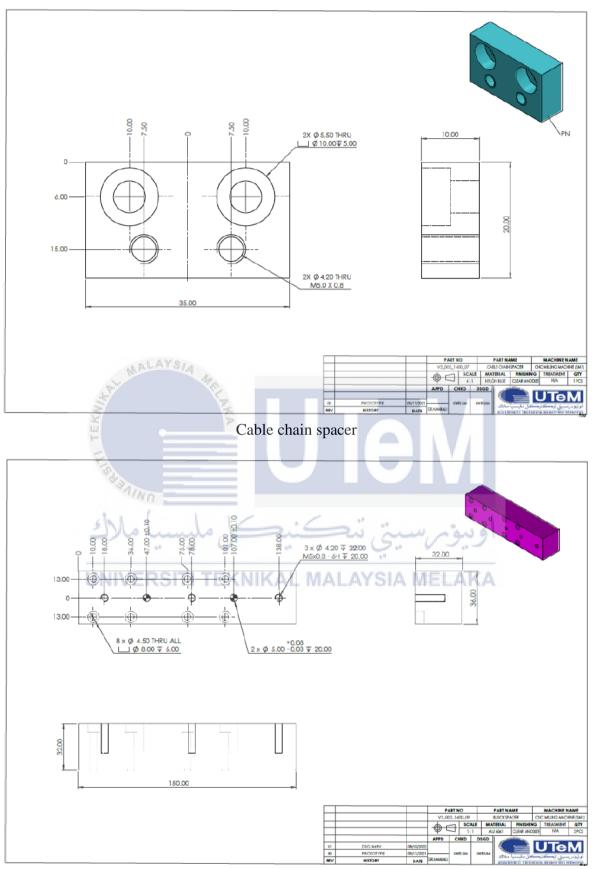**Link plate**

Bush pipe

Spacer plate

Spindle mount plate

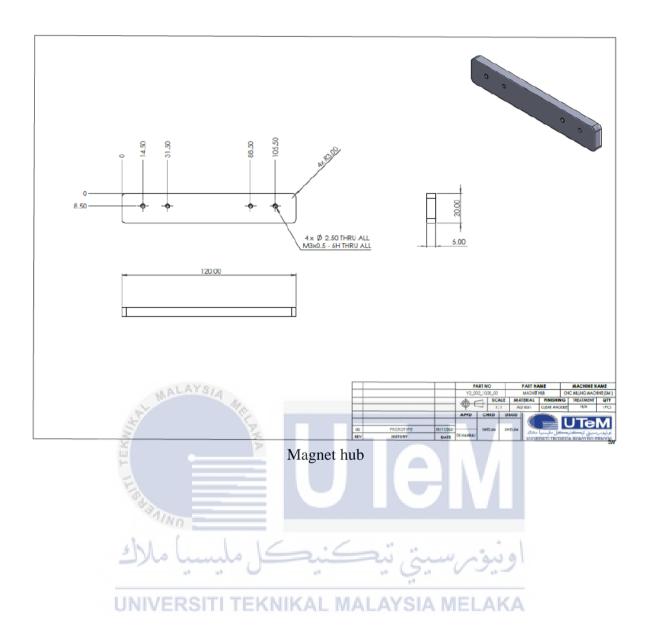Cable chain spacer

Block spacer

Magnet hub

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Tuan

PENGKELASAN TESIS SEBAGAI TERHAD BAGI TESIS PROJEK SARJANA MUDA

Dengan segala hormatnya merujuk kepada perkara di atas.

2.   Dengan ini, dimaklumkan permohonan pengkelasan tesis yang dilampirkan sebagai TERHAD untuk tempoh **LIMA** tahun dari tarikh surat ini. Butiran lanjut laporan PSM tersebut adalah seperti berikut:

Nama pelajar: MOHD NAZRIN BIN ZAKARIA
Tajuk Tesis: ENVIRONMENTAL IMPACT ASSESSMENT OF MILLING PROCESS ON CNC 3D ROUTER

3.   Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"
"KOMPETENSI TERAS KEGEMILANGAN"

Saya yang menjalankan amanah,

UMI HAYATI BINTI AHMAD
Pensyarah
Jabatan Teknologi Kejuruteraan Pembuatan
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
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