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"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of
Bachelor of Mechanical Engineering (Design and Innovation)"

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Supervisor: .....
Date: .....

DEVELOPING A LEGO-BOT 3D PRINTER

MOHAMAD TAJUDDIN BIN RAMLI

This report is submitted in fulfillment of the requirement for the degree of Bachelor Degree of Mechanical Engineering (Design and Innovation)

Fakulti Kejuruteraan Mekanikal
Universiti Teknikal Malaysia Melaka

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotation which have been duly acknowledged."

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ABSTRACT

This thesis presents the design and development of the Lego-Bot 3D printer, an innovation machine designed by incorporating Lego technology for the automated construction of solid objects using additive layer manufacturing technology. This project are to design, assemble and analyze the structure of Lego-bot 3D printer. To achieve that, there are phases conducted which is product design and fabrication process. House of Quality and morphological chart have been conducted including the analysis on the Lego-structure design in which resulted an optimum quality value for the design constructed. At the end of this project, the Lego-Bot 3D printer successfully assembled and fabricated with a value 14.29% of errors calculated on the sample product printed from the Lego-Bot 3D printer after comparing with the initial sample designed.

ABSTRAK

Tesis ini membentangkan reka bentuk dan pembangunan pencetak 3D Lego-Bot, mesin inovasi yang direka dengan menggabungkan teknologi Lego untuk pembinaan automatik objek padu menggunakan bahan tambahan teknologi pembuatan lapisan. Projek ini adalah untuk mereka bentuk, memasang dan menganalisis struktur pencetak Lego-bot 3D. Untuk mencapai itu, terdapat fasa dijalankan iaitu reka bentuk produk dan proses pembuatan. Dewan Kualiti dan carta morfologi telah dijalankan termasuk analisis kepada reka bentuk Lego-struktur dimana hasilnya ialah nilai kualiti yang optimum untuk reka bentuk yang dibina. Pada akhir projek ini, pencetak Lego-bot 3D berjaya dipasang dan direka dengan nilai 14.29% kesilapan dicatatkan pada produk sampel yang dicetak dari pencetak Lego-Bot 3D selepas membandingkan dengan sampel awal yang direka.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND PROJECT

This final year project are about the design and development of a Lego-Bot 3D printer. By referring to the project title, the printer should be designed by incorporating the Legos with the 3D printing technology or also known as additive layer manufacturing to produce an innovative 3D printer design. The Legos consist of several parts that can be use in fabricating and in the 3D printer mechanism such as the Lego brick can be use in constructed the 3D printer structure and the Lego servo motor could be use as the mover that drives the 3D printer. Theoretically, the additive manufacturing is a process where a solid object was created by laying down layers of material until the entire object shaped. The ideas to design a 3D printer made from Legos going through several phases and analysis to obtain an optimal final product.

1.2 PROBLEM STATEMENT

The industrial use of 3D printing is not new, several industries have been using it for quite long time. The main applications are rapid prototyping, rapid manufacturing and customization. Generally, there are several types of 3D printing machine available in the market nowadays, such as MarkerBot, Cubify Cube and VentorBot. The question is whether the 3D printing technology could evolve in different directions.

1.3 OBJECTIVES

The main objectives of this project are:

1. To design and assemble the structure for Lego-Bot 3D printer.
2. To design and build hot glue gun extruder.
3. To obtain the analysis for Lego-Bot 3D printer structure and product printed.

1.4 SCOPE OF THE PROJECT

This project are design and build the structure for the Lego-Bot 3D printer including their hot glue gun extruder. Addition to that, the analysis for the structure and the product printed will be conducted.

1.5 FLOW CHART

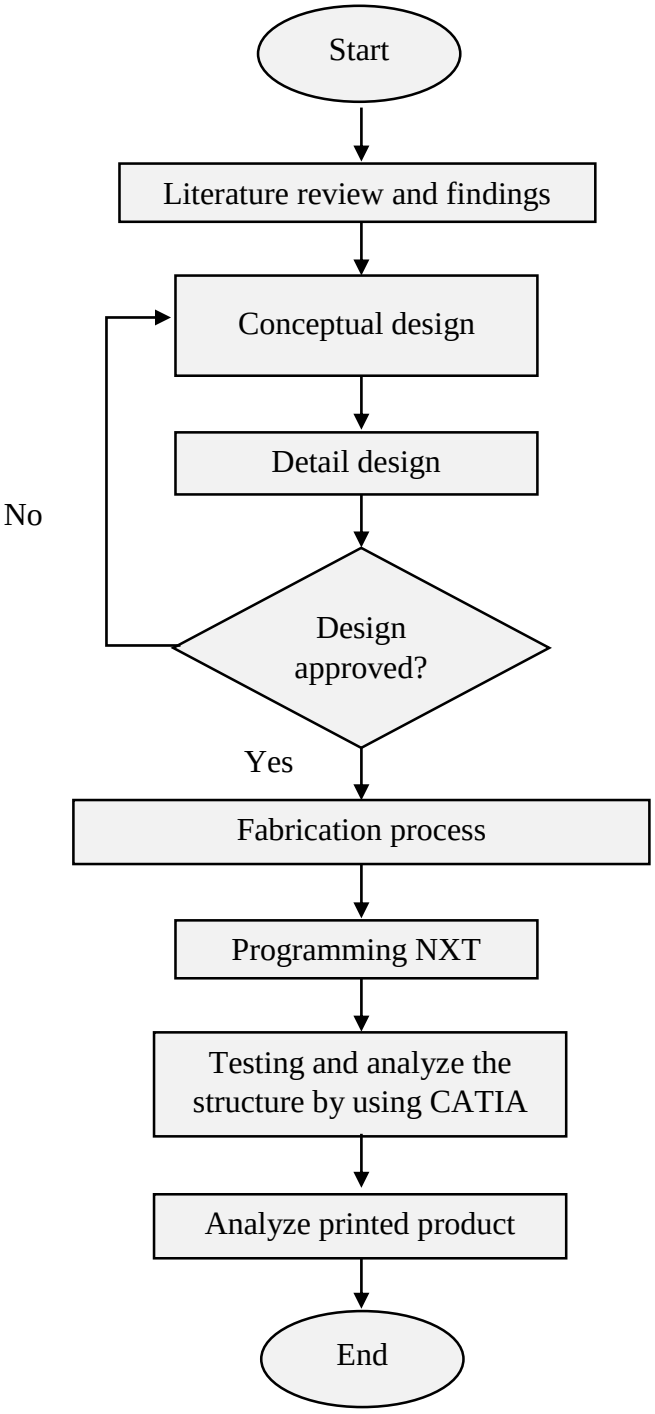

Figure 1.1: Flow chart PSM

CHAPTER 2

LITERATURE REVIEW

2.1 DEVELOPING A LEGOBOT 3D PRINTER

The 3D printing technology has been introduced since 1984 by Charles Hull. During that year, that machine was based on a technique and using stereo lithography method. Nowadays, the technology has progressed so much so that there are various version of 3D printing hardware and also transformation in the 3D printer design. This project is one of the developments in additive manufacturing technology in which the construction for the 3D printer structure are made from Legos and fabricated Lego-shaped that manufactured by using Kossel 3D printer. Besides making the Lego-Bot 3D printer to be functioning, the structure and product printed analysis were also included as the main objectives for this project.

2.2 3D PRINTING TECHNOLOGY

In manufacturing industries, the using of the additive technology in manufacture or fabricate certain product are not new. Other than reducing the production time and manufacturing cost, this technology can fabricate almost every designed product by converting the design in Computer Aided Data (CAD) into STL then import the file to a g-code format to be printed by using the 3D printer machine. In the future, this advances in crafting technology can provide individuals and families with the ability to make objects easier, or even to make entirely new types of objects (Amy Hurst, 2014). Imagine that each families have their personal 3D printer at home, they would be no need to find opened hardware store to replace a broken door knob when they can fabricate it them-self. There are many types of 3D printer available in the market today, as for examples in figure 2.1, figure 2.2 and figure 2.3.

Figure 2.1: Ultimaker
(source: www.toptenreviews.com)

Figure 2.2: Cubify CubePro
(source: www.toptenreviews.com)

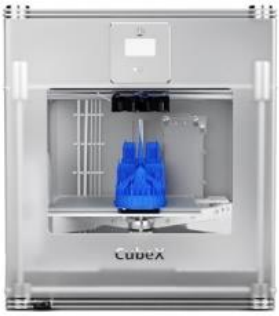

Figure 2.3: Cubify CubeX
(source: www.toptenreviews.com)

2.3 LEGO TECHNOLOGY

Lego is an old classic and also a giant in a toy business. Lego Classic in figure 2.4, Lego Technics in figure 2.5 and Lego Mindstorms in figure 2.6 shows that the Lego of the past has expended into multiple different branches in which it seems more into inserting the latest technology in this era into their toys. Lego Classic contains the original Lego toys such as Lego blocks or brick, green bases, flat connector pieces and a simple embellishments. The original Lego system is too simple and heavy but still an interesting and educated toys for 90s kids.

The next level is Lego Technics system. This system of gears, motors, connectors and joints can be used to build almost any mechanical device. In fact, in engineering laboratories, the Technics system is routinely used for building and testing simple models. The latest Lego toys are the Mindstorms in which ranked as the most advanced toys of the Lego family. Mindstorms can be used to build autonomous robotic inventions, which are fully programmable to respond to sensory inputs. These robots are tremendously useful and the programming language they use is so intricate that even the most complex action patterns can be programmed (Chris M and Rebecca Taylor, 2001).

Figure 2.4: Lego Classis model

(source: www.flickr.com)

Figure 2.5: Lego Technics model

(source: www.flickr.com)

Figure 2.6: Lego Mindstorms model

(source: www.itp.net)

The Lego components, such as beams can be use as a support columns for a model construction. Figure 2.7, Figure 2.8 and Figure 2.9 shows the steps to built a Lego column base by using Lego beams with difference techniques. In the mean time, figure 2.10 shows the example house frames made from Lego beams.

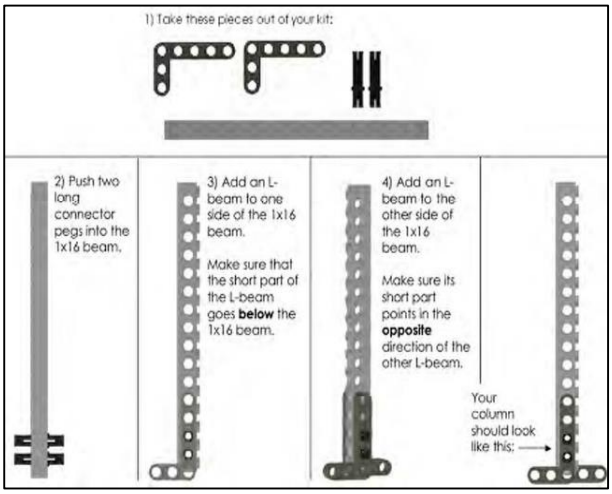

Figure 2.7: step-by-step building instructions for simple Lego column base (source: G. Michael Barnett, 2009)

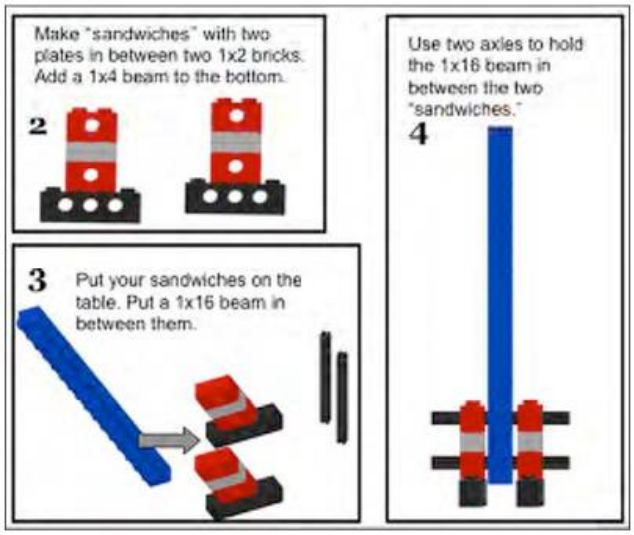

Figure 2.8: step-by-step building instructions for complex Lego column base (source: G. Michael Barnett, 2009)

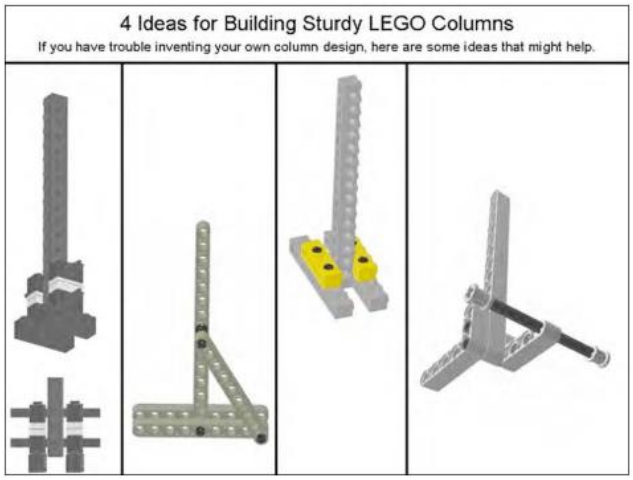

Figure 2.9: less detailed building instructions for Lego column bases
(source: G. Michael Barnett, 2009)

Figure 2.10: Sample house frame
(source: G. Michael Barnett, 2009)

2.3.1 Lego characteristics properties

Initially, Lego was a simple wooden hand crafted toys made by a Danish carpenter in 1932 (encyclopedia.com, 2001). Todays, Lego was made by using thermoplastic, acrylonitrile butadiene styrene (ABS), which is valued for strength, resilience and a shiny, impervious surface (Eamon Murphy, 2011). ABS is the polymerization of Acrylonitrile, Butadiene and Styrene monomers. The combination of these three different monomers form a single material that draws from the properties of all three. Figure 2.11 shows properties and characteristics of acrylonitrile, butadiene and styrene and Figure 2.12 shows the ABS facts.

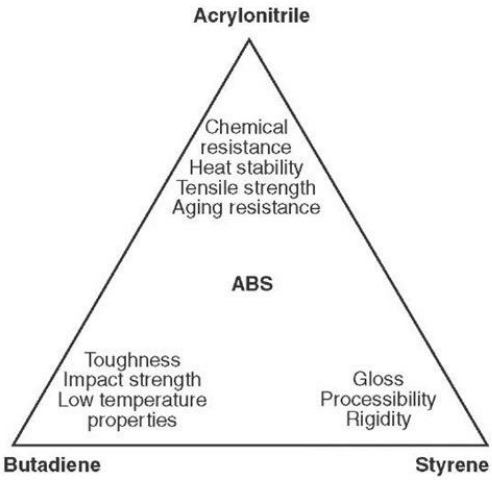

Figure 2.11: Properties and characteristics of ABS

(source: www.what-when-how.com)

Figure 2.12: ABS facts

(source: www.dynalabcorp.com)

2.3.2 Lego NXT

In this project, the using of Lego Interactive servo motor in the design may be considered since it is related to the project title. Lego Mindstorms NXT programmable brick is the operator to drive the motor by entering the commands into the simulator's interface (Mohamed Hamada, 2010) than upload it into the NXT. Figure 2.13 shows the Lego Mindstorms NXT programmable brick. There are three motors input on the NXT programmable brick labeled A, B and C. Each motor is equipped with an integrated encoder that can be used to determine the current position of the motor. Figure 2.14 shows the connection between NXT and Interactive servo motor including the others available sensors.

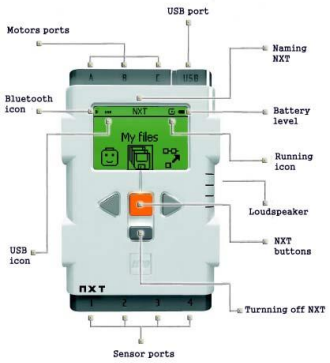

Figure 2.13: Lego Mindstorms NXT programmable brick

(source: www.Legostorms.com, 2006)

Figure 2.14: NXT sensors assembly

(source: www.Legostorms.com, 2006)