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DEVELOPMENT OF LOW COST 3D PRINTER

NOR AZIRAH BINTI ARIFIN

Thesis submitted in fulfillment of the requirements

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ABSTRACT

Nowadays 3D printer has become a big challenge in technology of prototyping using the printer. This technology is not only used in industries of manufacturing but used for prototyping for an important constraint. This project is to develop low cost 3D printer but not only about the cost budget effective as output but the working process of the 3D printer.

The output of this project expects to give benefit for the common people with the effectiveness cost. 3D printing technologies are available to build a 3D object printing but this project aims to use the 3D manufacturing process that gives the effectiveness solution at low wastage of printing materials. The 3D printer capable of outputting in difference colours and different materials are already exist and will be continue to improve a point of functional product as output products. Now, 3D objects were bought from the online market and assemble the part of 3D printer.

The original 3D printer is used as a reference for the actual position of components in 3D printer. Learn about the 3D printer in spread and research the process from first step until finish used observation through YouTube, website and research paper. The modification of 3D printer made from wood to ensure cost lower. Using the 3D printer modified make the difference design through the CATIA and Thinker cad and printing the product. To ensure the frame in the strength position the Finite element analysis used to simulate the process load that will be force at hot bed surface and frame using fiber wood.

ABSTRAK

Pada masa kini pencetak 3D telah menjadi satu cabaran besar dalam teknologi prototaip menggunakan pencetak barangan. Teknologi ini hanya digunakan bukan sahaja dalam industri pembuatan tetapi digunakan untuk prototaip dengan keadaan penting. Projek ini adalah untuk pembangunan pencetak 3D kos rendah tetapi bukan sahaja tentang kos bajet berkesan sebagai pengeluaran object tetapi proses kerja pencetak 3D.

Selepas projek ini mendapat sentuhan terakhir, ia akan memberi manfaat untuk rakyat biasa dengan keberkesanan kos. Teknologi percetakan 3D yang ada untuk membina sebuah percetakan objek 3D tetapi projek ini bertujuan untuk menggunakan proses pembuatan 3D yang memberi keberkesanan penyelesaian di pembaziran rendah bahan percetakan. Pencetak 3D mampu dikeluarkan dalam perbezaan warna dan bahan yang berbeza sudah wujud dan akan terus meningkatkan titik produk berfungsi sebagai pengeluaran produk. Sekarang, objek 3D telah dibeli dari pasaran dalam talian dan memasang bahagian pencetak 3D.

Pencetak 3D digunakan sebagai rujukan untuk kedudukan sebenar setiap komponen dalam pencetak 3D. Belajar mengenai pencetak 3D dalam meluas melaui proses penyelidikan dari langkah pertama sehingga penamat menggunakan pemerhatian melalui YouTube, laman web dan kertas penyelidikan. Pengubahsuaian pencetak 3D diperbuat daripada kayu untuk memastikan kos yang lebih rendah. Menggunakan reka bentuk pencetak 3D yang diubah suai membuat perbezaan melalui CATIA dan Thinker cad dan mencetak produk. Untuk memastikan rangka dalam kedudukan kekuatan unsur terhingga proses analisis yang digunakan untuk mensimulasikan beban yang akan menjadi kuasa di permukaan katil panas dan bingkai menggunakan gentian kayu.

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CHAPTER 1

INTRODUCTION

1.1   INTRODUCTION

This chapter discusses about the introduction, concepts and overall ideas about low cost of 3D printer. Besides, the background of the project, problem statement, objective of the project, and the scope of the research will be described in detail in this chapter.

1.2   BACKGROUND OF STUDY

Everything around us such as toys, medical tools and buildings are designed can be created by 3D printing, making them a necessity in today's society. Toys companies are often referred to a new technology and the industry is commonly to fulfil the children and all of the age to ensure the products is suitable for different age.

The toy industry is among the biggest beneficiaries of the technology in world. Toys have different type and design such as the toy action figures which is characters of every toy. Kids love the way that Action Figures can bring their favourites characters to life. Toys are already as tend to be small, different design and made out of plastic, making it easy to 3D print them.

3D printing refers as process that used to synthesize a 3D object which successive layers-by-layer of filament or powder are formed using the computer control to create a 3D object or product. The objects produce in any shape or geometry and can be produced from digital model data 3D model or another electronic data source such as an Additive Manufacturing File (AMF) file. The term 3D printing has its

origin sense 3D printing in reference to a process that deposits a binder material with inject heads layer by layer at one layer only one time.

3D printing most commonly uses manufacturing industries to produce the product in small part. This printer can make simple process, to ensure the shape that we need able is processed. Using 3D printer can help to make the complete product and only need to produce using CATIA and using 3D printer to print the small product base on the drawing.

1.3   PROBLEM STATEMENT

The cost to make one 3D printer machine is expensive and need to use a different filament to ensure the product is perfect. The cost to buy the machine 3D printer is higher for personal costumer.

1.4   OBJECTIVE OF STUDY

The research objectives are stated as follows:

- To study the 3D printing process.
- To develop the low cost of 3D printing.
- To produce the 3D part using the 3D printing.

1.5   SCOPE OF STUDY

This project objective is narrowed down by performing scopes of study.

- The project is development of low cost 3D printer. Need study about the process and assemble components of printer ensure full fill requirement of users and cost less than market prices.
- The study will able to make assembly components of 3D printer for a period of FYP 2.
- The product by 3D printer able to be produced by CATIA and Thinker Cad software.

1.6   ORGANIZATION OF WRITING

Thesis writing will be organized by show all the process flow that applied to complete the research, this flow will be discussed in details by listing and describing the chapters need in this thesis as follows:

CHAPTER 1: INTRODUCTION AND GENERAL INFORMATION

This chapter consists of: research background of 3D printing, problem statement, research objective, scope of research, data collection and how organization of waiting.

CHAPTER 2: LITERATURE REVIEW

This chapter about material that uses to producer that product of 3D printing, process of 3D printer, software, and process to convert the 3D cad into STL file.

CHAPTER 3: METHODOLOGY

This chapter explains about flow 3D printer will make to ensure to develop the low cost, Gantt chart, budget plan and the expected outcome.

CHAPTER 4: RESULT AND DISCUSSION

This chapter explains about the result of data collected from 3D printer processed. Data analysis in this chapter using ANSYS to determine the load minimum and maximum from the 3D parts of printer.

CHAPTER 5: CONCLUSION

This chapter will summarize overall of project and recommendation future for printer parts information perform in 3D printer.

CHAPTER 2

LITERATURE REVIEW

2.1   INTRODUCTION

This chapter describes some literature about 3D printer and the principle of 3D printer in general. All information related terms and terminology will be clearly stated.

2.2   INFORMATION OF 3D PRINTER

3D printer is fused deposition modelling (FDM) technique based on deposition of layer-by-layer of plastics ABS filament melting at extruded (Melocchi,2016). This 3D printing is the process for manufacturing the object of three dimension and functional prototyping parts from the 3D drawing using CATIA or CAD software to producer the products (Sachs,1990). The 3D printer uses the ABS filament as the ink-jet to print the parts layer-by-layer and thick of the part product.

2.2.1   3D PRINTER

Three-dimensional (3D) printing is one of the revolution of the additive manufacturing techniques to create the 3D objects product with the unique structure and diverse properties (Weng,2016). There are various techniques to create using this machine such as Stereo lithography apparatus (SLA), fused deposition modeling (FDM), continuous liquid interface production (CLIP) and laser sintering (SLS) (Weng,2016). The Fused Deposition Modelling (FDM) technology it will work with production-grade thermoplastics or the Acrylonitrile Butadiene Styrene (ABS) to make the object or product to be stronger, more durable and dimensionally stable parts with the best accuracy, hardness, tough and repeatability of any 3D printing technology. Figure **2.1** shows the example of 3D printer in market and Figure **2.2** shows the filament from

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Acrylonitrile Butadiene Styrene (ABS). Figure **2.3** shows the process of 3D printer melting filament.

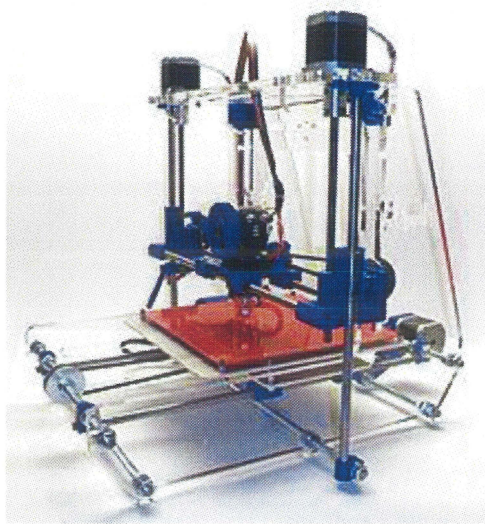Figure 2.1 Example of 3D printer

(Sources: https://en.wikipedia.org/wiki/Fused_deposition_modeling)

Figure 2.2 Example of filament

(**Sources:**https://www.alibaba.com/product-detail/Torwell-FDM-thermoplastics-ABS-PLA-Plastic_60105216284.html)

The filament is normally pushed into the heating block. This can present problems with less ridged filaments.

Filament spool

A heater block melts the filament to a usable temperature. Then the heated filament is extruded through the head of the printer.

The extruded material is laid down on the model where it is needed.

The bed often will move in the X and Y axes, and the extruder will move in the Z axis.

Figure 2.3 Process flow of FDM

(Sources:http://machinedesign.com/manufacturing-equipment/3d-printing-tips-and-tech-get-know-those-acronyms)

2.2.2 FDM technology work

This FDM technology used as the model producing the 3D products by extruding the thermoplastics material or ABS filament to form the layer-to-layer as the material hardness after the extrusion from the nozzle (Kun,2016). Plastics that used in this process will be melting from the nozzle after the extrusion, and will heat the filament from the coil and an extrusion will turn the flow on or off the surface of the top print plate.

The print plate consists by two parts, one part called print bottom that mounted on the X-axis smooth rods that are as the base of the surface printed surface. The second part as the top print plate and the top print plate also need to use the heat bed mounted to remain on for the entire duration of the print. The filament hot and after the print and need the support to ensure no affects to the product. The nozzle of 3D printed controlled by the computer aided manufacturing (CAM) software that converts to the STL file and the layer-by-layer one layer at a time. The 3D printer by STL file move the extrusion head rely the object that produced. Figure 2.4 shows the 3D printer FDM process work from the filament to heated nozzle will be product.

The process of FDM technology: (http://www.stratasys.com/3d-printers/technologies/fdm-technology)

1. Pre-processing: Build-preparation software slices and positions of 3D product of figures using a 3D CAD file and convert to STL file to put in 3D printing and calculate a path to extrude thermoplastic and any necessary support material.

2. Production: The 3D printer by extruded will heat the thermoplastic or ABS filament to a semi-liquid state to easily shape the figures and deposit it in ultra-fine beads along the extrusion path. Where support or buffering is needed, the 3D printer deposits a removable material that acts as scaffolding.

3. Post-processing: The user breaks away support material or dissolves it in detergent and water, and the part is ready to use.

Figure 2.4 FDM process work

(Sources: https://www.printspace3d.com/cartesian-vs-delta-printers-work/)
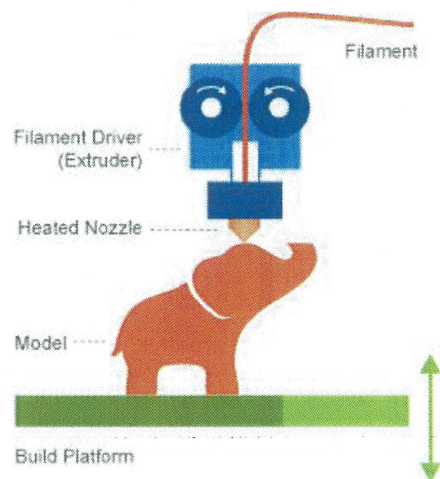
2.2.3 Applications

a) Industrial printing

In industry printing, this technology is used to create prototype designs in simple ways to ensure it has perfect design and also used for traditional manufacturing and research purposes, which is called Rapid Prototyping.

b) Medical Industry

These technologies help the patients around the world able to experience improved quality of 3D printed implants and prosthetics like never before.

c) Aerospace & aviation industries

Develop metal additive manufacturing sector in larger boosted the utilization of 3D printing technology in the aerospace and aviation industries.

d) Automotive industry

This technology is used for building the durable concept models, prototypes, tool and low-volume end-use parts in-house, automotive designers and engineers can work more iteratively, test and move confidently into production.

2.3   INFORMATION OF FILAMENT MATERIALS

The filament used to produce 3D products need have the properties such as; high impact strength, great for mechanical parts fabrications, good post-printing, higher requirements on printing conditions, intended for industrial-grade 3D printers and smooth surface.

2.3.1   Acrylonitrile Butadiene Styrene (ABS).

Acrylonitrile Butadiene Styrene, nanocomposite with the organics modified montmorillonite (OMMT) was preparing by melt intercalation. The ABS filament for fused deposition modelling (FDM) 3D printings were produced by single screw extrude and will print by use 3D printer FDM. The FDM 3D printer is developed by S.Scott Crump in late 1980s and it will commercialized by Stratasys in 1990 (Weng,1990). The use of the FDM 3D printer will make the mechanical strength worse compared with injection moulding.

The thermoplastics materials such as ABS filament, nylon, poly-lactic acid, and blends are used for FDM 3D printer as the filament. The used thermoplastics materials ensure the mechanical properties of the 3D printer thermoplastics and fibre reinforce

composite will be used. To help produce continuous and homogeneous filament the special additive may be necessary extruded.

2.3.2 Poly-lactic acid (PLA)

Poly-lactic (PLA) the popular thermoplastic for fused deposition modelling (FDM). Poly-lactic acid filament is the biodegradable polymer from the new resources. The process need to be carried out of 200°C above the temperature for melting the PLA filament.

2.3.3 Filament melting

Firstly, the acrylonitrile butadiene styrene (ABS) pellets and the different amount of the organics modified montmorillonite (OMMT) powder will physically mixed by the homogenizer and the process will continue after the mixture of the two ABS and OMMT mixed together using the twin screw extrude and the temperature to heat the filament must be 6 times from the chamber that is 200 °C from the funnel to the head of the extrusion head. FDM consists the deposition to build the plate from heat the extrusion move along the x and y axis and z direction while the lower of built and the heat of head extrusion and melted the filament (Melocchi,2016).

By using the FDM 3D printer, there are two nozzles at the extrusion, first the one nozzle extrudes the construction material and the other extrudes material to support the incline surface to again the building direction (Galantucci,2015). The material support is to ensure the part that no bottom support can print and no defect to minimum excess of the filament. The head of the extruded move in x and y direction plane and the deposit of the material deposit according the geometry part use the SLT file of 3D drawing.

In the FDM technology, the plastics filament works from the coil and the material of plastics filament flow into the extrusion nozzle, the nozzle will heat and melt the plastics and be moved in the x and y direction or horizontal and vertical direction by a numerically controlled using the computer aided manufacturing (CAM) software and convert to STL file to read in 3D printer. The product use the plastics and

extruding melted material to form the layer but only one layer process in one time as the material hardens immediately after the extrusion process from the extrusion nozzle. Figure **2.5** shows filament work from the filament will be heat in extrusion nozzle head become solid model.
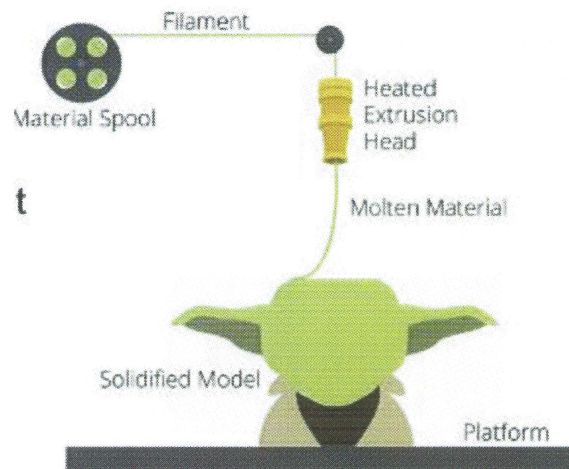
Figure 2.5 Filament work

(Source**s**: http://www.theaxiz.com/3d-printing/3d-printing-processes/)

2.4   SOFTWARE AND PROCESS CONVERT CAD FILE TO STL FILE

This STL format is used to describe the CAD geometry part to change other system that computer can read and performance to ensure the design will be same with the drawing use CAD part (Liu, 2017). In the general Stereo Lithography or STL file is format file that created of CAD software by 3D system. This STL file support by other software packages and used for rapid prototyping in 3D printer or CNC machine.

2.4.1   STL FORMAT

The STL file conceived by use 3D system is created from the database of via for interface the 3D CAD system. The file consists the unordered of every list of the triangular at every facets of surface and to represent the other outside skin of product to ensure the outside of skin is perfect (Junk,2016). The method is represented and

described the CAD geometry from the other system. STL file as facet model derived from the CAD and Thinker-Cad file drawing.

2.4.2   ADVANTAGE AND DISADVANTAGE OF THE STL FILE

The advantages of this file first one: it provides the simple method to represent three Dimensional CAD data. Second, this file is already use the standard of a de facto and this file is commonly used in the most of CAD system. Third, used the STL file contain and provide the small and accurate data file to transfer for STL file using the triangular facets (Chua, 2014). The disadvantages of this file is first: this STL file large than the CAD data file. Second, this file will carriage more redundant information, such as the edges and duplicates vertices.

2.4.3   STL PROBLEM

STL problem that consists of the nature of STL file as file contain no topological data. The type of error by following (Chua,2014):
   (i) Gaps (cracks, holes, punctures) missing the facets.

 • The error at the intersection between the surfaces, leaving gaps and the hole along the edges of the part of product.
   (ii) Degenerate faces (where all its edges are collinear).

 • When all the edges facets are collinear even through all the vertices are district.
   (iii)Overlapping facets

 • Generated represent in 3D but cause the facets to overlap if tolerances are set too liberally.
   (iv)Non-manifold topology conditions

 • Three type of non-manifold namely; a non-manifold edge, non-manifold point and non-manifold face.

STL solution
   (i) Generic solution

   I.   Solve the missing facets problem

   II. Solve the wrong orientation of facets

2.4.4   CONVERT SOLID MODEL TO STL FILE

Convert the 3D drawing to STL file first, by using the 3D modelling drawing created using the computer aided design (CAD) software package for example AutoCAD, CATIA, Solid work and the other different of software. Second, the CAD model is converted into STL (Standard Tessellation Language) file format. The file can translate the 3D model into a collection of triangular facets to easily to 3D printer read. If necessary, some adjustments are carried out to 3D printing and build the real model.

For example, if we convert 3D drawing used CATIA to STL file. The procedures:

Save CAT Product files as CAT Part Files for 3D printing:

1.   File Menu > Open > source file selected imported CAT Product file save
2.   Select File > New > Part > Name the new part
3.   Select one component from your master CAT Product File and copy it
4.   Component paste in a new part window
5.   Repeat steps and until you have copied all
6.   Select File > New Part
7.   Individual component copy
8.   The new part ready to exported as an STL file
9.   Select Tools > Generate CAT Part from Product
10. Select File > Save as type: STL

2.5   CATIA SOFTWARE

3D CAD advance in modelling to general prerequisite rapid prototyping processes usually the time-consuming part mostly of the entire process chain. One key that need to use the CATIA in design that makes the analysis to carry out product modelling, management, state control, and assembly based on design product structure (Li,2013). This CATIA commonly as 3D Product Lifecycle Management software suite, CATIA supports multiple stages of product development, including conceptualization, design (CAD), engineering (CAE) and manufacturing (CAM). CATIA facilitates collaborative engineering across disciplines around its 3D experience platform, including surfacing &

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shape design, electrical fluid & electronics systems design, mechanical engineering and systems engineering.

3D printer, process for the industries in manufacture of tooling and functional prototyping parts using the direct computer modelling using CATIA software. 3D printing function by deposition the filament will melting in extruded in layers and performed the product. The process uses PLA filament as the ink in order to build the product.

2.5.1   ADVANTAGE OF CATIA

- Simple to reference and reuse exist 3D and 2D drawing data.
- New concepts in 3D can be quickly generated from existing 2D layouts.
- Faster to build the products by using CATIA.
- Full product can be reviewed by using multiple views from side, front, top and bottom.
- Manufacturing and other downstream activities benefit from direct integration and access to the full 3D product definition.
- Downstream users can create their own specialized views and improve decision making with accurate data.
- On-demand blueprint creation allows documentation to be easily produced for the extended enterprise.

2.6   DESIGN 3D PRINTING EXISTING (REP RAP)

RepRap is the humanity's first for the general purpose to build by self-replicating of manufacturing machine. From the RepRap website shows how to make the simple ways by used the all material to make the 3D printer step by step. The materials and other components can buy used online and it freely available for the benefit of everyone. In RepRap at RepRap.org is the space that community to ask the question about the machine that means to welcome to edit most pages on that site. The reference website RepRap: (http://reprap.org/). Figure **2.6** and Figure **2.7** shows the market design of 3D printer.
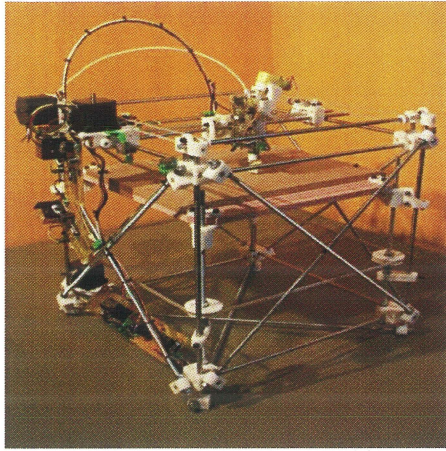
Figure 2.6 Example of exist 3D printer

(Source: https://all3dp.com/history-of-the-reprap-project/)

Figure 2.7 Example of exist 3D printer

(**Source:** http://shop.prusa3d.com/en/3d-printers)

CHAPTER 3

METHODOLOGY

3.1   INTRODUCTION

In this chapter, strategy and the methods to make the low cost 3D printer will be explained. The aim for this chapter as the technique to ensure that the methods of 3D printing to assembly will be perfect and the analysis use the flow chart till the end of the project. The material used to replace plastic for frame 3D printer is composite wood or fiber because the cost buy the material is cheaper than plastics cost. The composite woods contain the other materials such as wood fiber and some type of binding agent. These ingredients are put together to form a material that is denser, stronger, and heavier than wood alone. The existing cheap Reprap 3D printer (pursa i3) buys after compare the price with other 3D printer market and cost to buy each component separate is higher. The 3D printer modification is less the price because the frame that use from the wood is lower cost than other materials.
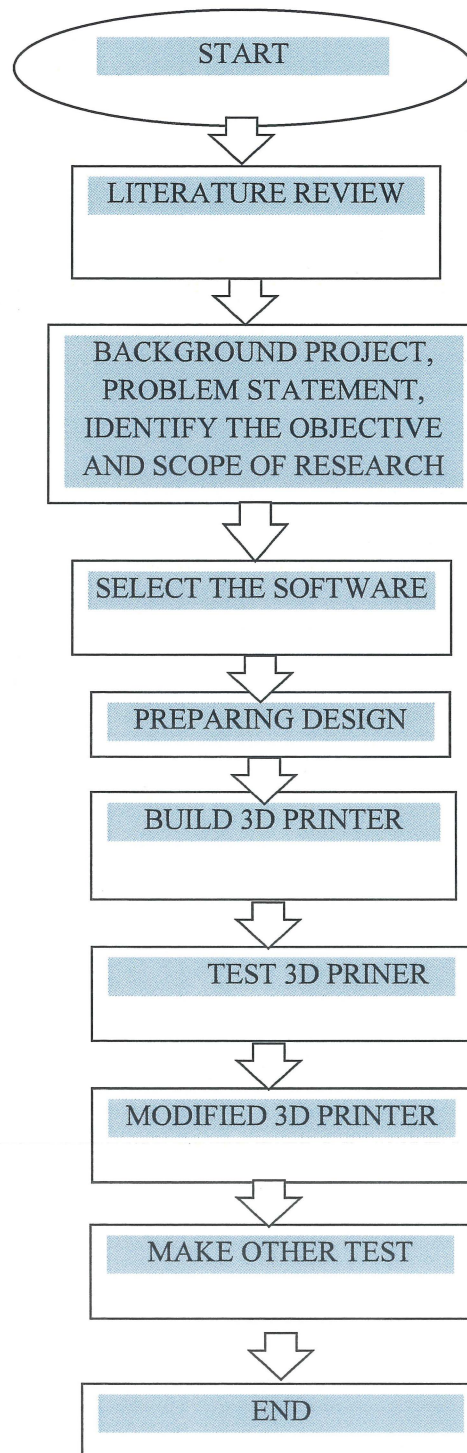
3.2   PROCESS PLANNING FLOWCHART

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                    ┌──────────────────┐
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                    └──────────────────┘
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                   │ LITERATURE REVIEW │
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                   ┌──────────────────────┐
                   │ BACKGROUND PROJECT,   │
                   │ PROBLEM STATEMENT,    │
                   │ IDENTIFY THE OBJECTIVE│
                   │ AND SCOPE OF RESEARCH │
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                   │ MODIFIED 3D PRINTER│
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Figure 3.1 Process of flowchart

Figure 3.1 shows the process planning flowchart of 3D printer from the Final year project 1 and 2.

3.3 ASSEMBLY 3D PRINTER SETUP

3D printer can produce a lot of parts and also the 3D printer has higher cost. So, used the assembly 3D printer will make the cost lower and can buy the cheap part after make the survey from different market. The output quality of 3D printer will be the same with the market but we build our own with reference from the original 3D printer.

3.3.1 COMPONENTS OF 3D PRINTER

Main component in 3D printer part that use depends on the type of project. The melting of the nozzle is important in 3D printer because the filament need melting at 200-230°C make the product. Figure 3.2 show the list and part of 3D components.

3.3.1.1 FRAME

The frame consists with the threaded rods with connected together with the printed part called as the vertices and the place to hold the printed part and controlled the y-axis and z-axis.

3.3.1.2 Y-AXIS AND BUSHING

Y axis control by a belt attached to a stepper motor with the pulley. The pulley will control by the motor and y axis move at the bottom.

Bushings is actually the plain bearing that will slide over smooth rods when move along the y axis and this bushing ensure no friction when the pulley pull the rods up or down.

3.3.1.3 Z-AXIS AND X-AXIS

The z-axis and y-axis are the part to move up down and right or left move. This axis is the part of the construction.

3.3.1.4   EXTRUDER

This extruder consists of two parts, the top part or cold part that feed the filament of plastics. The bottom part or the hot place, that will melt and extruder the plastics to become the other objects it depend the design.

3.3.1.5   X-CARRIAGE

X- Carriage can be use the bushing or linear bearing. This x carriage controls the motor and the belt.

3.3.1.6   PRINT PLATE

The x, y and z axis move together to build the product so will move the nozzle above the plate and the finish product by 3D printer will cold at print plate.

This plate actually consist the two plates, first bottom print plate that mounted as the x-axis smooth rods use the bushing or the linear bearing. The top print plate is a mounted on x-axis and to form the finish product or as the print surface.

3.3.1.7   ELECTRONICS PART

The electronics board connected with the Personal Computer (PC) by the USB-to-serial converted. Other than, use the Arduino with the RAMPS board such as the converter build-in.

3.3.1.8   STEPPER MOTOR

There are five stepper motor in build 3D printer:

- To control the y axis
- To control the x axis
- To control the z axis (2 motor)
- To control extruded

3.3.1.9   FILAMENT

- ABS Filament

- PLA Filament
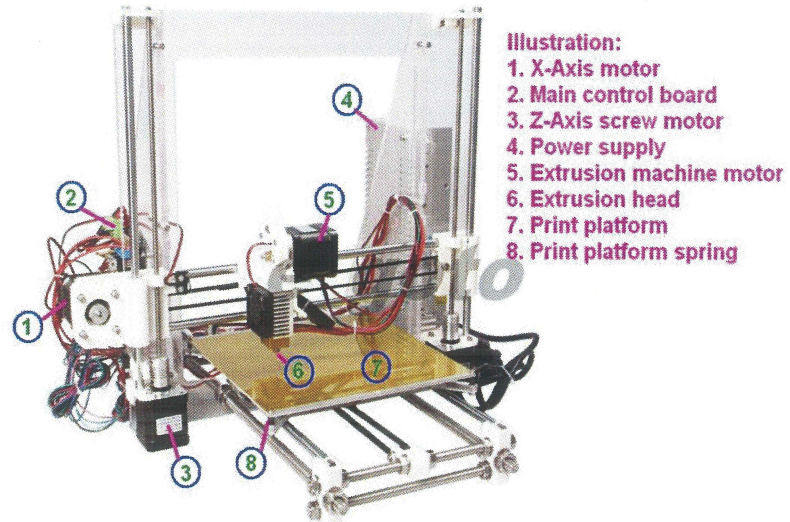
Figure 3.2 List of components

(Source: http://www.ebay.ca/itm/3D-Printer)

3.3.2 ELECTRONIC PART

Based those components mentioned in pervious part, there are some electronics components uses as shows in Figure **3.3** and Figure **3.4**.
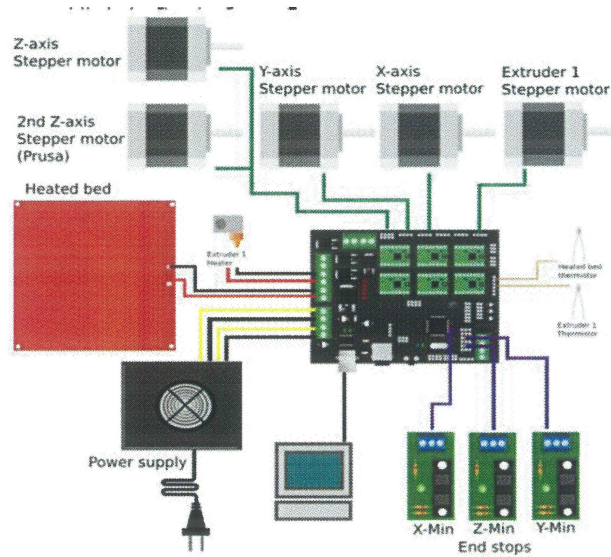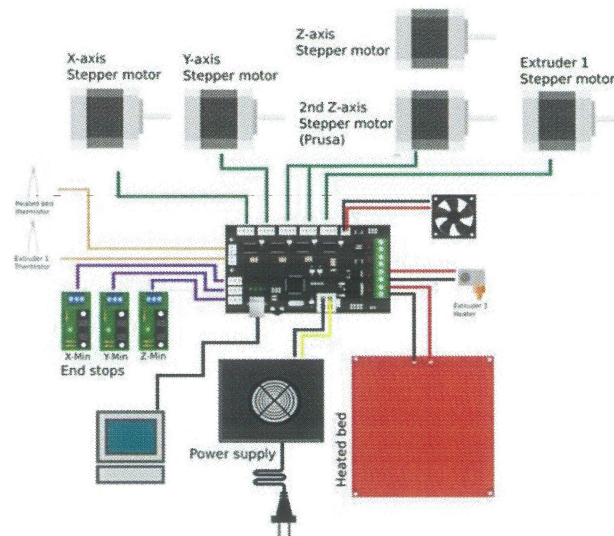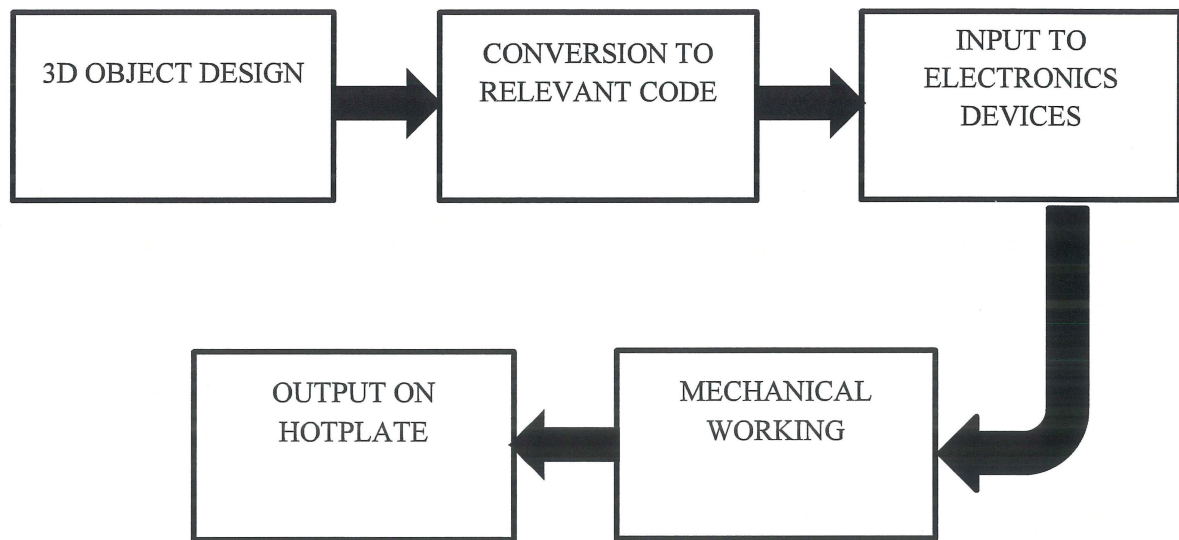

Figure 3.3 Boards with Minitronics1.0

Figure 3.4 Boards with Minitronics2.0

(Source:https://print3d.com.pk/wp-content/uploads/2015/09/Prusa-i3-Build-Manual.pdf)

3.4   SIMPLIFIED BLOCK DIAGRAM

Figure 3.5 Simplified block diagram

3.5   BUILD 3D PRINTER

Assembly design of 3D printer is the process to reduce the assembly cost and the time taken to assembly the part. The assembly, act of combining component in the manufacturing makes the machine or product. Figure **3.6** to Figure **3.19** shows the components or parts to be used to build the 3D printer.
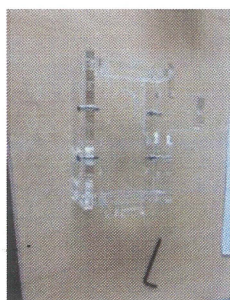
Figure 3.6 Hold x-axis motor

Figure 3.7 Stepper motor X-axis
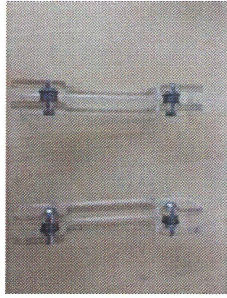
Figure 3.8 Hold filament

Figure 3.11 Stepper motor z-axis (2parts)
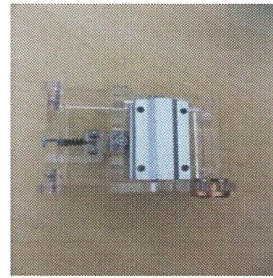
Figure 3.12 Hold the feed rod z-axis

Figure 3.9 Hold hot bed

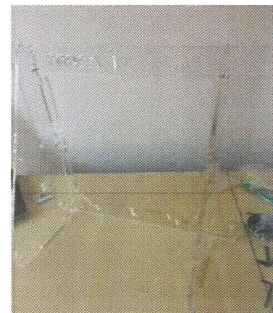Figure 3.13 Frame of 3D printer
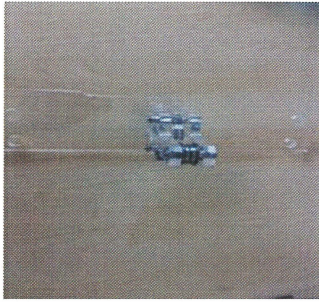
Figure 3.10 Stepper motor y axis

Figure 3.14 Pulley to hold the belt y-axis
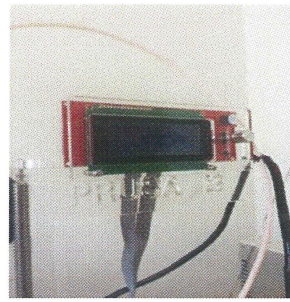

Figure 3.16 LCD red boards

Figure 3.15 Extruder nozzle
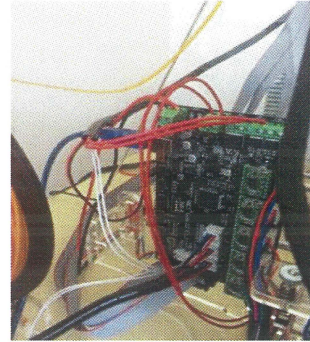

Figure 3.17 Main board
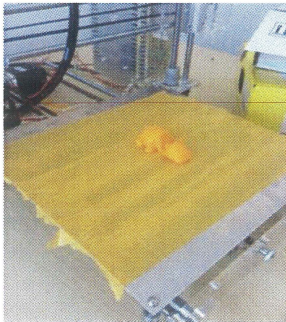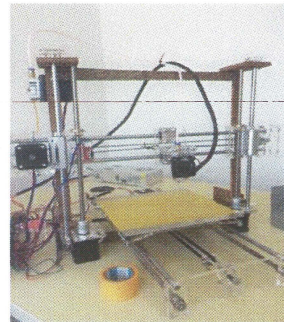

Figure 3.18 Hot bed

Figure 3.19 Assemble component

CHAPTER 4

RESULTS AND DISCUSSION

4.1   INTRODUCTION

This chapter will discuss the result of the study and presented the results of the 3D printer build. This chapter will also show the information and the data that analyse and discuss.

4.2   DATA COLLECTION

The data that collect after finish build the 3D printer and print the part to ensure the machine is function. The data information obtains from observation and pictures take during build the 3D printer.

4.2.1   COMPARISON BETWEEN 3D PRINTER MARKETS

The total price of 3D printer is less than RM1310, price to make a 3D printer is cheaper than the market price refer to Figure **4.1** and Figure **4.2** market price and table 4.1 for total cost of components. The frame used from wood to ensure the cost is less than the Perspex and metal. The advantage of wood is easily to shape, machining and assemble. The other components in 3D printer is used because the components were function such as motor to move the extruded and hot bed, power supply current, hot bed hold the product and fan for cool the extruded. To minimum the cost of 3D printer need to ensure the cost lower than market price. The frame change to fiber wood need replace to ensure the 3D printer strength and low cost.
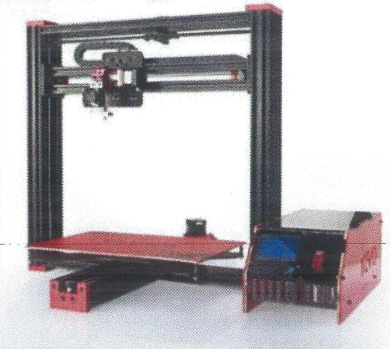
Figure 4.1 Market price of 3D printer (http://www.lazada.com.my/)

Figure 4.2 Market price 3D printer (https://www.lelong.com.my/)

Table 4.1 Price of components

No.	Component	Quantity	Price per unit	Price
1	Stepper motor	4	RM89.90	RM359.60
2	Limit switch	3	RM15.00	RM45.00
3	LCD display	1	RM69.00	RM69.00
4	Fan	1	RM22.00	RM22.00
5	Head hot end	1	RM79.00	RM79.00
6	Rod	6	RM5.00	RM30.00
7	Lead screw rod	2	RM21.50	RM49.00
8	Power supply	1	RM100.00	RM100.00

9	Metal Bowden Extruder	1	RM40.00	RM40.00
10	Hot bed	1	RM80.00	RM80.00
11	Belt	1	RM10.00	RM10.00
12	Pulley 16 tenth	1	RM14.00	RM14.00
13	Flexible coupling	2	RM20.00	RM40.00
14	Ball bearing	7	RM7.00	RM49.00
15	Control board	1	RM180.00	RM180.00

16	Spring ==Gadgets==	7	RM1.50	RM10.50
17	Filament	1	RM79.00	RM79.00
18	Frame	1 set	RM50.00	RM50.00
TOTAL COST				RM1306.1

The price of 3D printer is less than RM1310 for the components that needed to build the 3D printer show in Table 4.1 Price of components.

4.3   COMPARISON OF 3D PRINTER

The original 3D printer is used as a reference for actual position of the part components in 3D printer. Figure **4.3** and Figure **4.4** is the 3D printer original and modified.
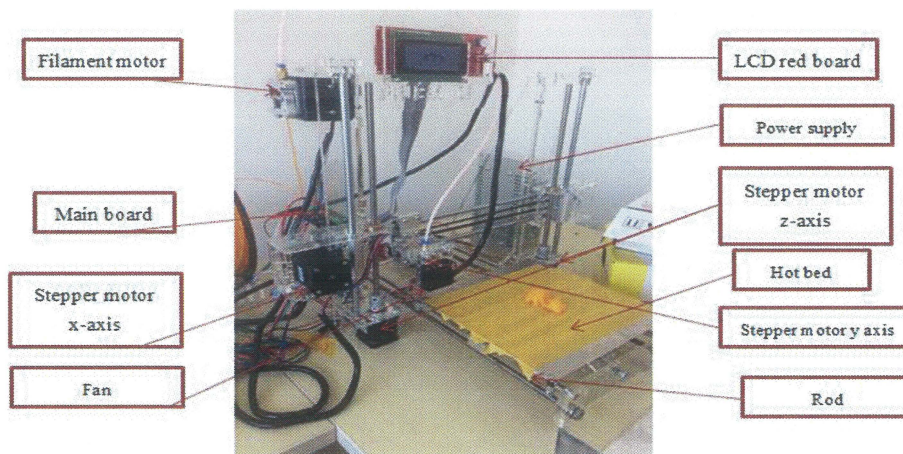

Figure 4.3 Original 3D printer Pursa i3

4.3.1 Modified design 3D printer
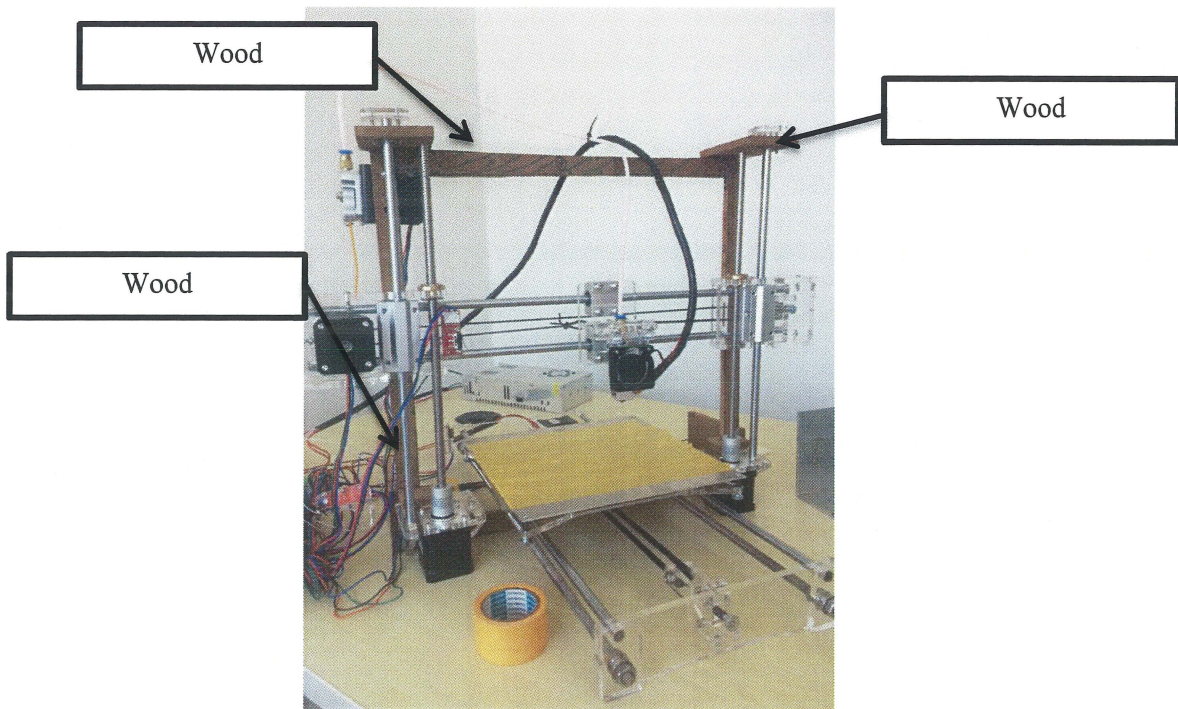
Figure 4.4 Modified 3D printer.

4.4 DRAWING OF 3D PART

The 3D printer models that been scanned, design in CAD software and printer are requirement product.

4.4.1 Drawing product "CATIA"

Computer aided three-dimension interactive application or CATIA is software that suitable for designing the drawing 3D product and develop the design to print in 3D printer after save as STL file. This software provides the advanced technologies to design the complex drawing to print. CATIA enables the creation of 3D parts from the 3D sketches to develop the 3D drawing. In this project, simple toys assembly is produced. Figure **4.5** Part 1 to Figure **4.9 Assemble part** shows the design created in CATIA software.

Figure 4.5 Part 1

Figure 4.7Part 3
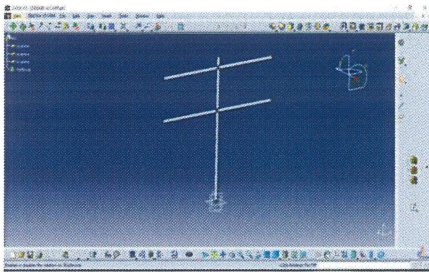
Figure 4.6 Part 2
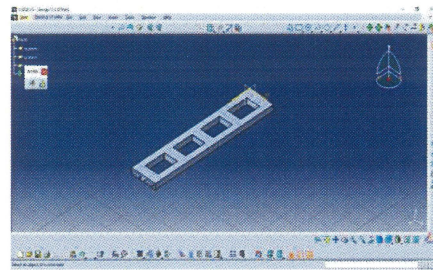
Figure 4.8Part4 (2 pieces)
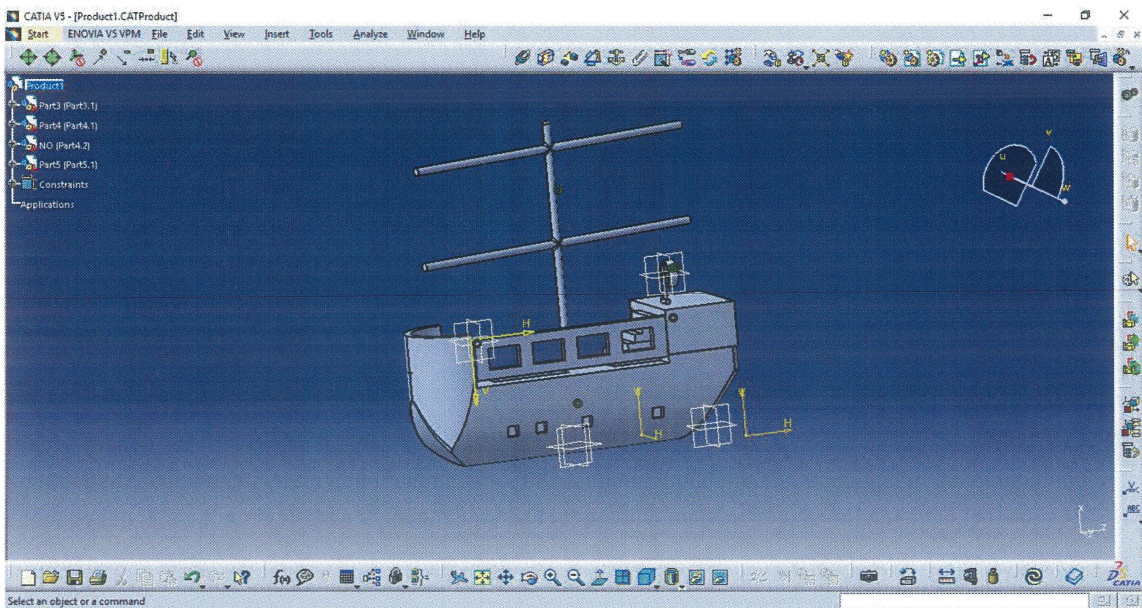
Figure 4.9 Assemble part

4.4.2 Drawing product using Thinker cad
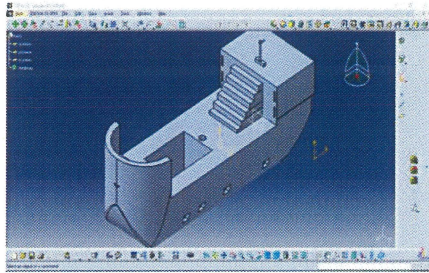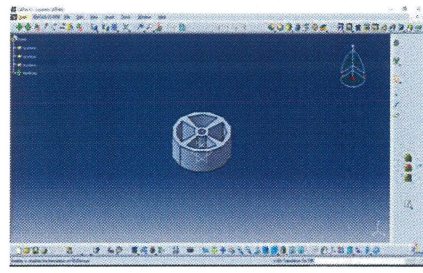
Thinker cad is browser-based 3D design and modelling tool, easy to make perfect design with simple design in minutes. 3D designs that thinker cad can produce such as toys, prototypes, home decor figures, case phone and other. Thinker cad was founded by Kai Backman and Mikko Mononen in 2011 that can bring the first Brower-based 3D design in the platform.

The thinker cad is easy to learn and incredible used for make the simple and complex design. The 3D modelling is the process to develop of any three-dimension surface of an object. It displays the two dimensional image to three dimensional. 3D modelling software is the 3D computer graphical software that used to produce the 3D models that can print through 3D printer. Figure **4.10** 3D model thinker-cad bowser-based. show the design used the Thinker Cad software.
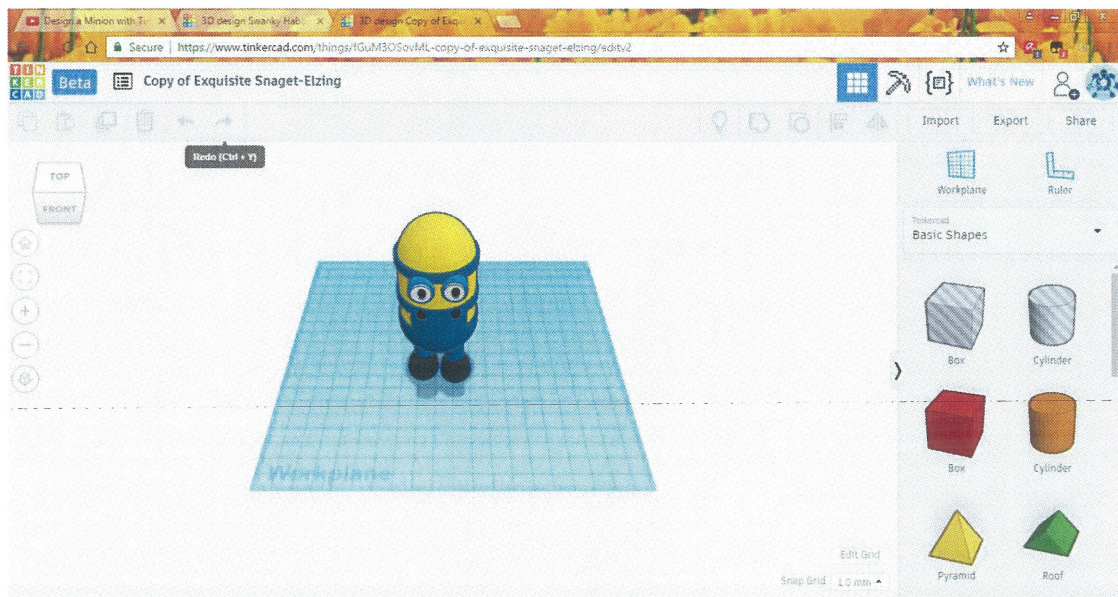
Figure 4.10 3D model thinker-cad bowser-based.

(Source: https://www.tinkercad.com/)

4.5 PROCEDURE TO PRINT PRODUCT (REPETIER HOST)

Repetier-Host works with almost all 3D FDM printers. Repetier-Host is easy to use for beginner to control the printer, slider and printing process. This software is easy multi-part printing in one time, can load duplicate of many models and print them simultaneously. Figure 4.11 to Figure 4.13 show the Repetier-host software to control the heat and motor of 3D printer.
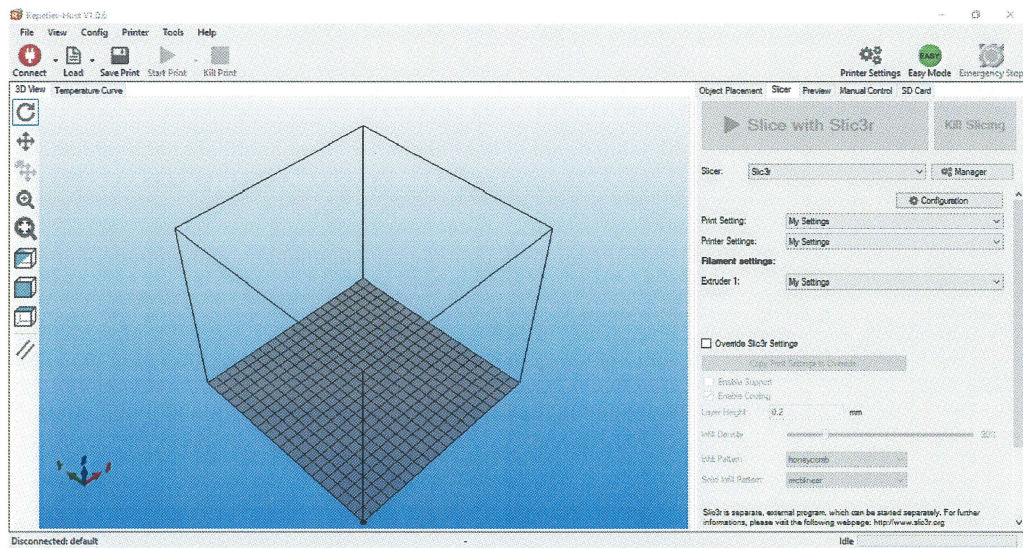
Figure 4.11 'Repetier–Host' software
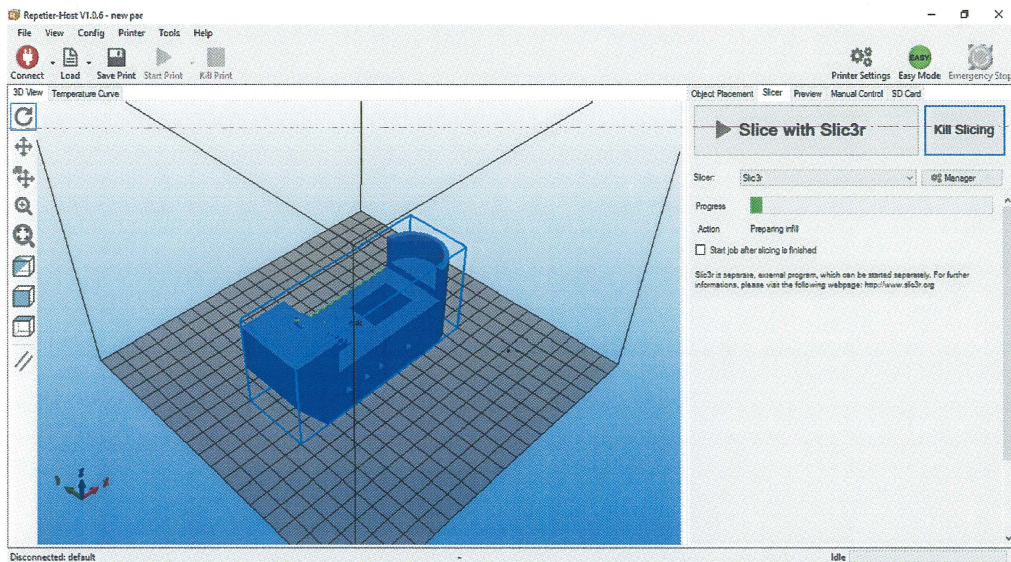
Figure 4.12 Inside part in Repetier-Host
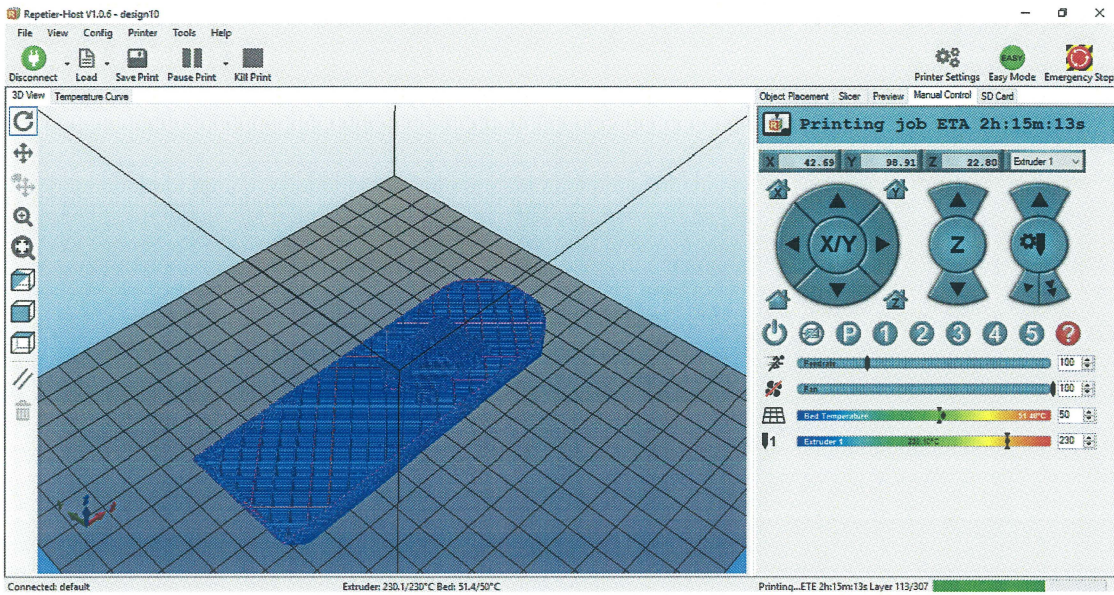
Figure 4.13 Controller 3D printers.

4.6   PRODUCT OF 3D PRINTING

3D printer allows faster innovations design and the manufacturing timing to produces product are shorter. 3D printer changes the face of products with easy to use online apps and software that people can create the unique product. In designing the toy need to put some ideas into the virtual files. Figure **4.14** to Figure **4.19** show the product printed of 3D printer.
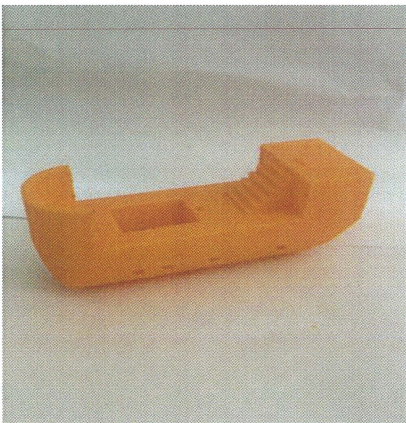
Figure 4.14 Model part 1
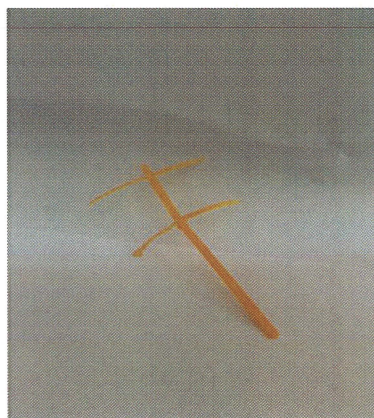
Figure 4.15 Model part 2

Figure 4.16 Model part 3

Figure 4.18 Assemble part model
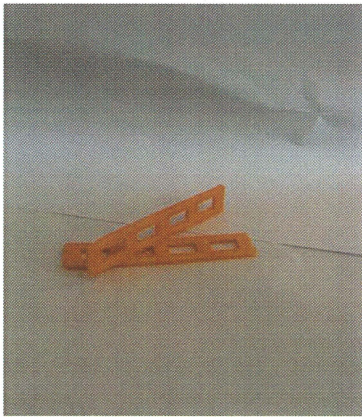
Figure 4.17 Model part 4

Figure 4.19 Tinker-Cad products.

4.7   PATTERN INSIDE THE PRODUCT

The printer uses that some patterns, that can be controlled Repetier-Host software to choose such as rectilinear, line, concentric, honeycomb, Hilbert curve (slow), Archimedean chords (slow), and actogram spiral (slow). Figure 4.20 shows the pattern controller and Figure **4.21** and Figure **4.22** show the design of pattern.
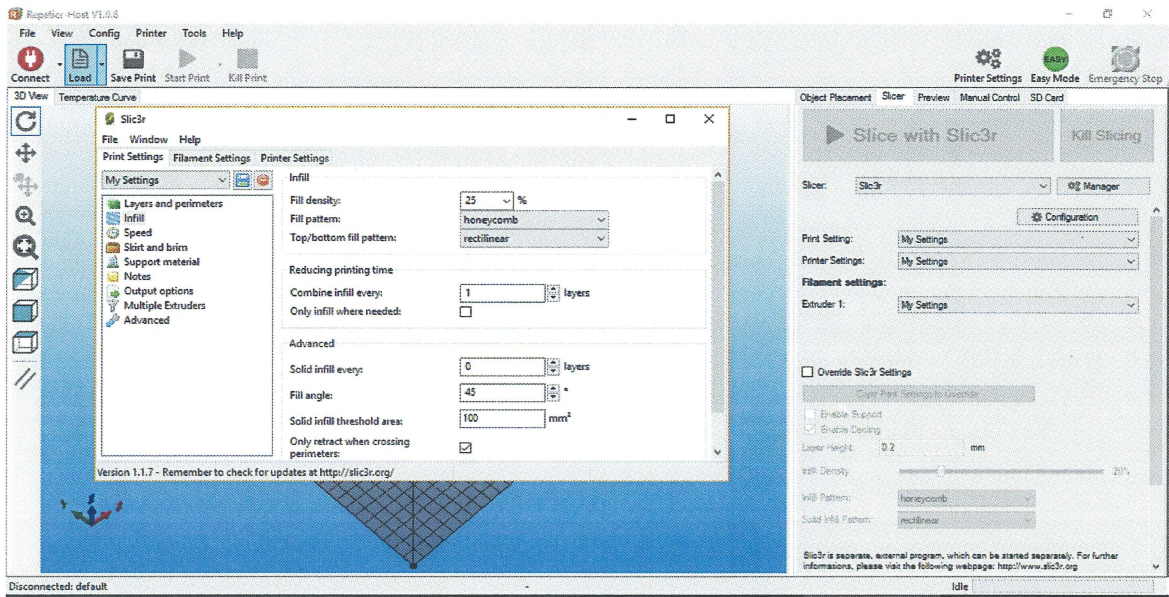
Figure 4.20 Fill pattern chose "Repetier-Host"
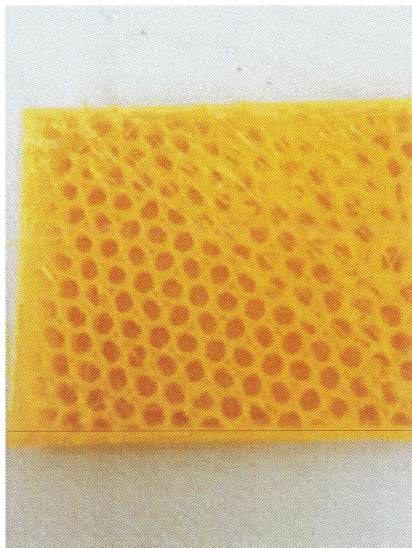
Figure 4.21 Honeycomb
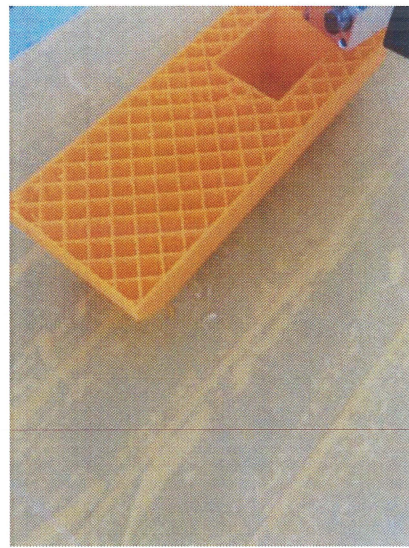
Figure 4.22 Rectangle

4.8   ANSYS DATA

ANSYS software with modular structure gives opportunity for taking only necessary features. ANSYS enables to simulate testing or working condition for test the product before virtual environment of manufacturing prototyping product. ANSYS imports the CAD design to igs file and enables to build the geometry preprocessing abilities.

4.8.1   ANSYS hot bed plate

ANSYS generally is a software that can be used to simulate interactions of all disciplines of structures, physics, vibration, fluid dynamics, load, heat transfer and electromagnetic for engineers. ANSYS load used to know the deformation for surface of hot bed plate and the min deformation occurs in middle and the max deformation ends of plate. Figure **4.23** shows the deformation by using ANSYS. So, 3D printer of product will produces in the middle of plate because the minimum load.
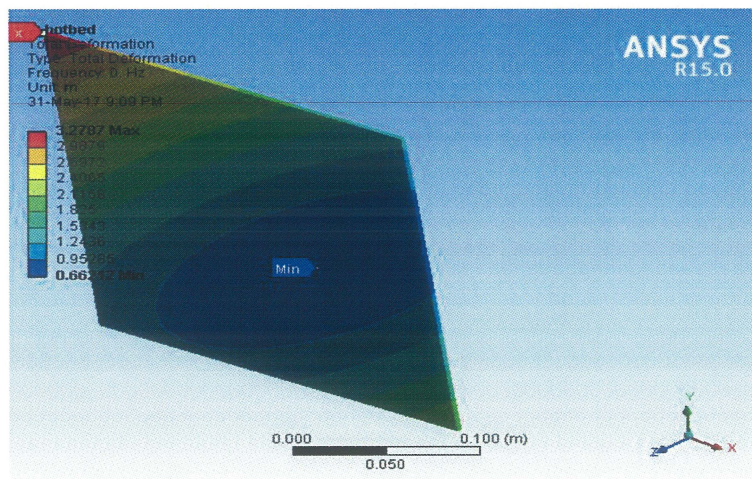
Figure 4.23 ANSYS of hot bed plate.

4.8.2 ANSYS frame

Frame holds all the components together. The frame made out of fiber wood. The minimum load for the frame occurs on bottom because support part and the maximum load above. Figure **4.24** shows the deformation of the fiber wood frame.
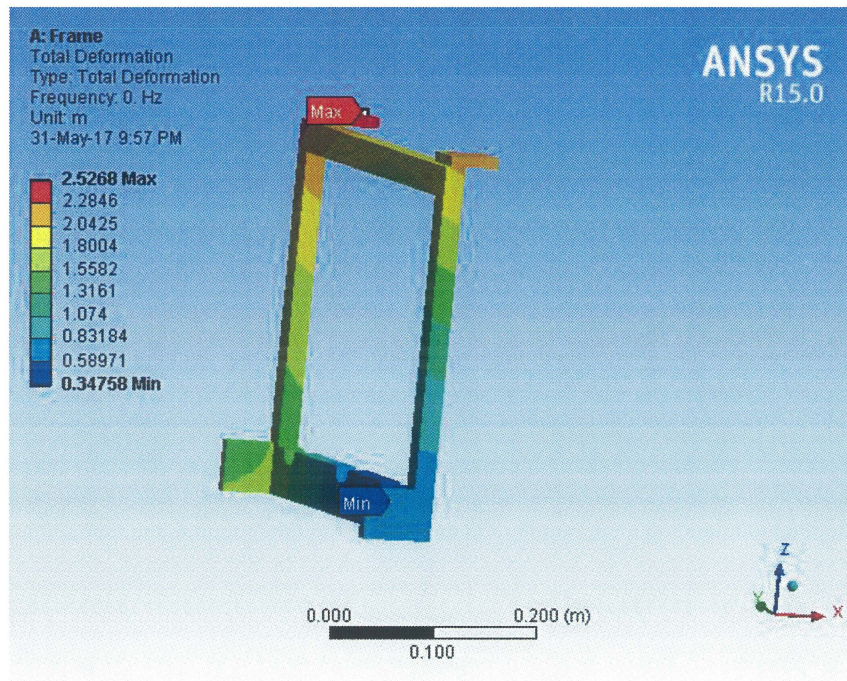
Figure 4.24ANSYS of frame

4.9 COMPARISON OF DIMENSION

Comparison between dimensional actual products with design used CATIA software. Figure **4.25** and Figure **4.26** shows dimension of product and design. The tolerances mean amount of number that allowable amount of variation of a specified quantity, especially in the dimensions of the product. The CATIA design dimensional 40

millimeter but after make the 3D printer for product the dimension is bigger 0.05 millimeter from the design. The tolerance of product is +0.05 but accept because small than 1.0 millimeter. The cause effects of tolerance such as molten filament excessive, no support material and other.
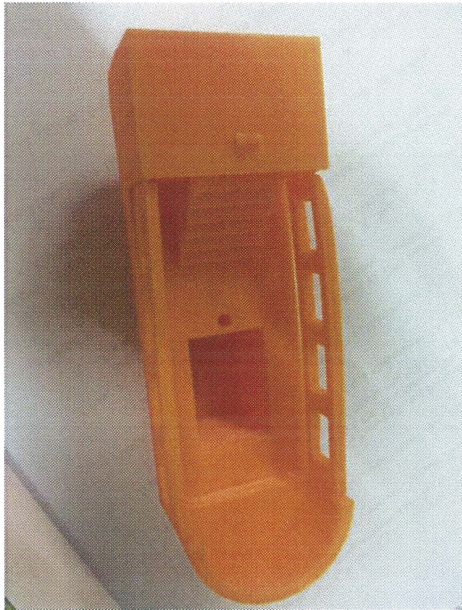
Figure 4.25 Actual dimensions
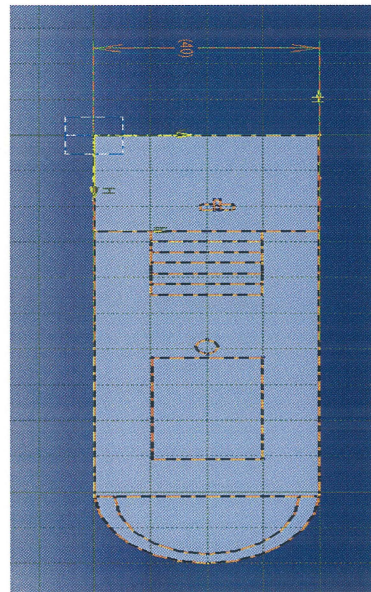
Figure 4.26 Drawing dimension

CHAPTER 5

CONCLUSIONS

5.1 INTRODUCTION

In this chapter, conclusions from this study make based on the previous chapter and the recommendation suggested improving the performance in low cost 3D printer and 3D part produce.

5.2 CONCLUSIONS

1. The 3D printer process has been studied in this project. 3D printer process used Fused Deposition Modelling (FDM) technique by melting layer-by-layer of plastics filament at nozzle used temperature 200°C for Poly-lactic acid (PLA) filament. The type of filament used in FDM technique such as Poly-lactic acid and Acrylonitrile Butadiene Styrene heat difference temperature to melting the filament.

2. Low cost of 3D printer has successfully been developed. The low cost of 3D printer is successful build by changing the material of frame. The frame made of the fibre wood is cheaper than aluminium or Perspex.

3. 3D parts have been produced using low cost of 3D printing. The parts are designed using the CATIA and Thinker Cad and were printing using the low cost of 3D printer and the parts have successfully finish. The toys and assemble toys are produced using the printing.

4. The finite element analysis (FEA) is the numerical method for solving problem of manufacturing product. The typical solving methods for this project include load for support the machine, structural analysis and the deposition force for 3D printer.

5.3 RECOMMENDATION

Problem solving recommended in order overcoming the 3D printer work properly such as adjustable manual of nozzle extruded by touch the hot bed before make the printer because if the nozzle not touch the hot bed it not function and the printing are damaged. Before printer make sure the filament in the nozzle and 3D part can printing. The low cost of 3D printer is ensure the entire component to assemble are ready and the Board with Minitronics assemble correctly with wire ensure the current not explode.

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FYP1		SEPT			OCT				NOV			DEC			
No.	Project Activity	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1	Identify task analysis	██	██	██											
2	Identify problem statement			██	██										
3	Identify design of 3D printer			██	██										
4	Select design needed				██	██									
5	Drafting chapter 1					██	██								
6	Finalize and submit chapter 1						██								
7	Drafting chapter 2						██	██							
8	Finalize and submit chapter 2							██							
9	Drafting chapter 3								██	██					
10	Finalize and submit chapter 3									██	██				
11	Compile and submit chapter 1,2, and 3											██	██		
12	FYP 1 final presentation													██	

Remark: ██ Planned process   ██ Actual progress

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A2: GANTT CHART (Continued)

No.	Project Activity	FEB			MAR				APR			MAY			
		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1	Analyse the part of 3D printer	P/A	P/A	P/A											
2	Make 3D printer			P/A	P/A	P/A	A	A	A	A					
3	Data collection and analyzes data				P/A	P/A	P/A								
4	Drafting chapter 4					P/A	P/A	P/A							
5	Finalize and submit chapter 4							P/A	P/A						
6	Drafting chapter 5									P/A					
7	Finalize and submit chapter 5									P/A	P/A				
8	Prepare poster										P/A	P/A			
9	Poster presentation												P/A		
10	Compile chapter 1,2,3,4, and 5										P	P/A	P/A	A	
11	Submit checking													P/A	P
12	Submit hardbound													P	P/A

Remark: ▇ Planned process   ▇ Actual progress

APPENDIX B

B1: ANSYS DATA for hot plate

ANSYS
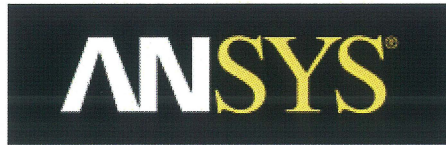
Project

Author	NOR AZIRAH BINTI ARIFIN
Subject	HOT BED
Prepared for	FYP 2
First Saved	Wednesday, May 31, 2017
Last Saved	Wednesday, May 31, 2017
Product Version	15.0 Release
Save Project Before Solution	Yes
Save Project After Solution	Yes

2　Contents

3　Units

TABLE 1

Unit System	Metric (m, kg, N, s, V, A) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

4　Model (A4)

5　Geometry

TABLE 2
Model (A4) > Geometry

Object Name	*Geometry*
State	Fully Defined
Definition	
Source	C:\Users\Acer-NB\Desktop\hot-bed.igs
Type	Igs
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	0.254 m
Length Y	0.235 m
Length Z	3.e-003 m
Properties	
Volume	1.7907e-004 m³
Mass	0.48564 kg
Scale Factor Value	1.
Statistics	
Bodies	1
Active Bodies	1
Nodes	1618
Elements	210
Mesh Metric	None

Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Yes
Parameter Key	DS
Attributes	No
Named Selections	No
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	No
Compare Parts On Update	No
Attach File Via Temp File	Yes
Temporary Directory	C:\Users\Acer-NB\AppData\Local\Temp
Analysis Type	3-D
Mixed Import Resolution	None
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

TABLE 3
Model (A4) > Geometry > Parts

Object Name	*PartBody*
State	Meshed
Graphics Properties	
Visible	Yes
Transparency	1
Definition	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Material	
Assignment	Structural Steel
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	0.254 m
Length Y	0.235 m
Length Z	3.e-003 m
Properties	
Volume	1.7907e-004 m³
Mass	0.48564 kg
Centroid X	0.127 m
Centroid Y	0.1175 m
Centroid Z	1.5e-003 m
Moment of Inertia Ip1	2.2353e-003 kg·m²
Moment of Inertia Ip2	2.6113e-003 kg·m²
Moment of Inertia Ip3	4.8459e-003 kg·m²

Statistics	
Nodes	1618
Elements	210
Mesh Metric	None

6 Coordinate Systems

TABLE 4
Model (A4) > Coordinate Systems > Coordinate System

Object Name	Global Coordinate System
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. m
Origin Y	0. m
Origin Z	0. m
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]

7 Mesh

TABLE 5
Model (A4) > Mesh

Object Name	Mesh
State	Solved
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advanced Size Function	Off
Relevance Center	Coarse
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge Length	3.e-003 m
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Patch Conforming Options	
Triangle Surface Mesher	Program Controlled
Patch Independent Options	

Topology Checking	Yes
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Extra Retries For Assembly	Yes
Rigid Body Behavior	Dimensionally Reduced
Mesh Morphing	Disabled
Defeaturing	
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Automatic Mesh Based Defeaturing	On
Defeaturing Tolerance	Default
Statistics	
Nodes	1618
Elements	210
Mesh Metric	None

8   Modal (A5)

TABLE 6
Model (A4) > Analysis

Object Name	*Modal (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Modal
Solver Target	Mechanical APDL
Options	
Environment Temperature	22. °C
Generate Input Only	No

TABLE 7
Model (A4) > Modal (A5) > Initial Condition

Object Name	*Pre-Stress (None)*
State	Fully Defined
Definition	
Pre-Stress Environment	None

TABLE 8
Model (A4) > Modal (A5) > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Options	
Max Modes to Find	6
Limit Search to Range	No
Solver Controls	
Damped	No
Solver Type	Program Controlled
Rotordynamics Controls	
Coriolis Effect	Off
Campbell Diagram	Off

Output Controls	
Stress	No
Strain	No
Nodal Forces	No
Calculate Reactions	No
General Miscellaneous	No
Analysis Data Management	
Solver Files Directory	C:\Users\Acer-NB\AppData\Local\Temp\WB_ACER_Acer-NB_3800_3\unsaved_project_files\dp0\SYS\MECH\
Future Analysis	None
Scratch Solver Files Directory	
Save MAPDL db	No
Delete Unneeded Files	Yes
Solver Units	Active System
Solver Unit System	mks

9 Solution (A6)

TABLE 9
Model (A4) > Modal (A5) > Solution

Object Name	Solution (A6)
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done

The following bar chart indicates the frequency at each calculated mode.

FIGURE 1
Model (A4) > Modal (A5) > Solution (A6)

TABLE 10
Model (A4) > Modal (A5) > Solution (A6)

Mode	Frequency [Hz]
1.	
2.	0.
3.	
4.	3.6581e-003
5.	4.7968e-003
6.	6.1244e-003

51

Total Deformation

Subject: HOT BED

Date   Wednesday, May 31, 2017

Comments:
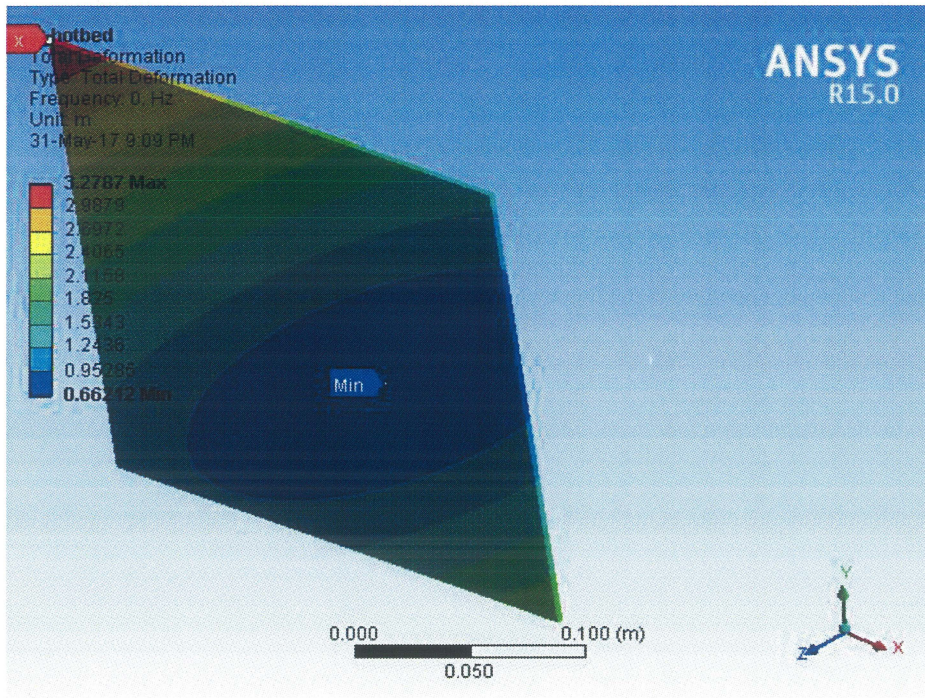
APPENDIX B

B2: ANSYS data of frame.

ANSYS®
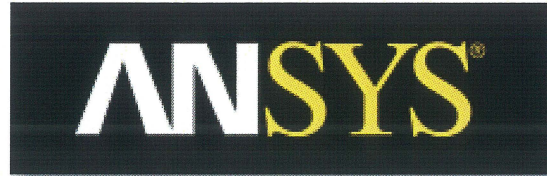
10 Project

Author	NOR AZIRAH BT ARIFIN
Subject	FRAME
Prepared for	FYP 2
First Saved	Wednesday, May 31, 2017
Last Saved	Wednesday, May 31, 2017
Product Version	15.0 Release
Save Project Before Solution	Yes
Save Project After Solution	Yes
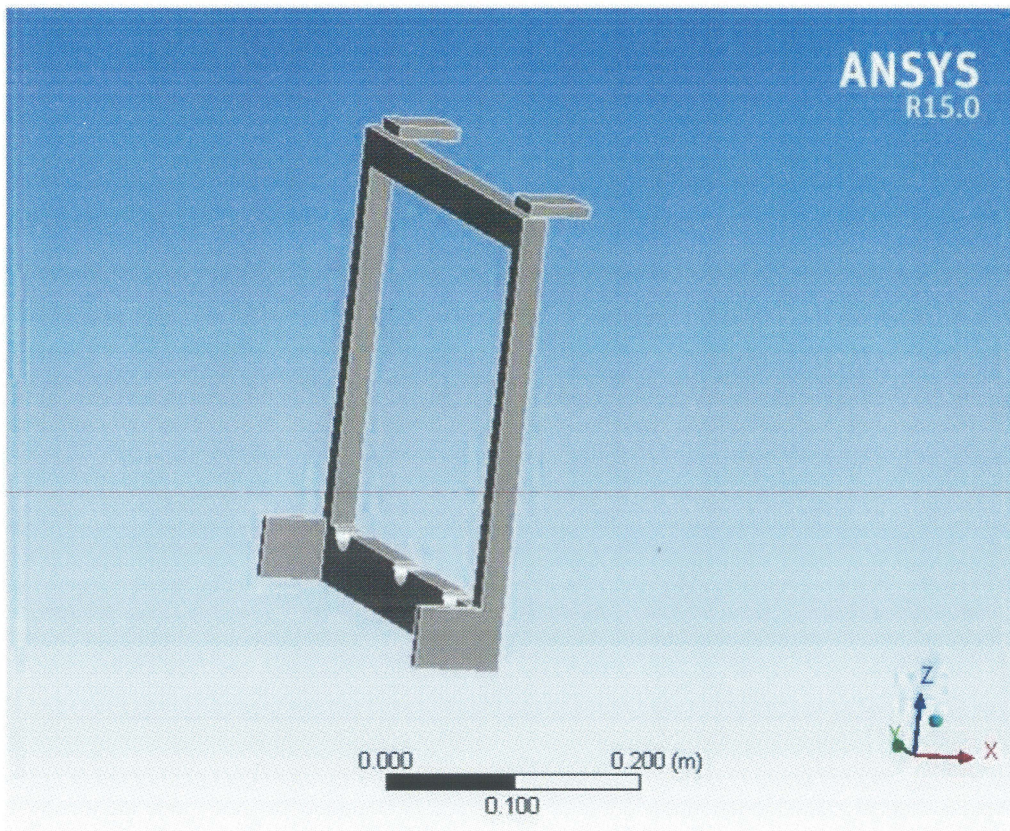
11   Contents

- **Units**

- **Model (A4)**
  - Geometry
    - Part Body
  - Coordinate Systems
  - Mesh
  - **Modal (A5)**
    - Pre-Stress (None)
    - Analysis Settings
    - Solution (A6)
      - Solution Information
      - Results

- **Material Data**
  - Structural Steel

12   Units

TABLE 1

Unit System	Metric (m, kg, N, s, V, A) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

13   Model (A4)

14   Geometry

TABLE 2
Model (A4) > Geometry

Object Name	*Geometry*
State	Fully Defined
Definition	
Source	C:\Users\Acer-NB\Desktop\ANSYS AZIRAH FYP2\frama.igs
Type	Iges
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	0.10947 m
Length Y	0.372 m
Length Z	0.378 m
Properties	
Volume	8.9249e-004 m³
Mass	0.44624 kg
Scale Factor Value	1.
Statistics	
Bodies	1
Active Bodies	1

Nodes	1532
Elements	614
Mesh Metric	None
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Yes
Parameter Key	DS
Attributes	No
Named Selections	No
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	No
Compare Parts On Update	No
Attach File Via Temp File	Yes
Temporary Directory	C:\Users\Acer-NB\AppData\Local\Temp
Analysis Type	3-D
Mixed Import Resolution	None
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

TABLE 3
Model (A4) > Geometry > Parts

Object Name	*PartBody*
State	Meshed
Graphics Properties	
Visible	Yes
Transparency	1
Definition	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Material	
Assignment	Structural Wood
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	0.10947 m
Length Y	0.372 m
Length Z	0.378 m
Properties	
Volume	8.9249e-004 m³
Mass	0.44624 kg
Centroid X	9.1362e-003 m
Centroid Y	0.18578 m
Centroid Z	0.16765 m

Moment of Inertia Ip1	1.7971e-002 kg·m²
Moment of Inertia Ip2	9.747e-003 kg·m²
Moment of Inertia Ip3	8.3432e-003 kg·m²
Statistics	
Nodes	1532
Elements	614
Mesh Metric	None

15 Coordinate Systems

TABLE 4
Model (A4) > Coordinate Systems > Coordinate System

Object Name	*Global Coordinate System*
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. m
Origin Y	0. m
Origin Z	0. m
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]

16 Mesh

TABLE 5
Model (A4) > Mesh

Object Name	*Mesh*
State	Solved
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advanced Size Function	Off
Relevance Center	Coarse
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge Length	3.186e-004 m
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No

Patch Conforming Options	
Triangle Surface Mesher	Program Controlled
Patch Independent Options	
Topology Checking	Yes
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Extra Retries For Assembly	Yes
Rigid Body Behavior	Dimensionally Reduced
Mesh Morphing	Disabled
Defeaturing	
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Automatic Mesh Based Defeaturing	On
Defeaturing Tolerance	Default
Statistics	
Nodes	1532
Elements	614
Mesh Metric	None

17   Modal (A5)

TABLE 6
Model (A4) > Analysis

Object Name	*Modal (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Modal
Solver Target	Mechanical APDL
Options	
Environment Temperature	22. °C
Generate Input Only	No

TABLE 7
Model (A4) > Modal (A5) > Initial Condition

Object Name	*Pre-Stress (None)*
State	Fully Defined
Definition	
Pre-Stress Environment	None

TABLE 8
Model (A4) > Modal (A5) > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Options	
Max Modes to Find	6
Limit Search to Range	No
Solver Controls	
Damped	No
Solver Type	Program Controlled

Rotordynamics Controls	
Coriolis Effect	Off
Campbell Diagram	Off
Output Controls	
Stress	No
Strain	No
Nodal Forces	No
Calculate Reactions	No
General Miscellaneous	No
Analysis Data Management	
Solver Files Directory	C:\Users\Acer-NB\AppData\Local\Temp\WB_ACER_Acer-NB_3856_2\unsaved_project_files\dp0\SYS\MECH\
Future Analysis	None
Scratch Solver Files Directory	
Save MAPDL db	No
Delete Unneeded Files	Yes
Solver Units	Active System
Solver Unit System	mks

18 Solution (A6)

TABLE 9
Model (A4) > Modal (A5) > Solution

Object Name	*Solution (A6)*
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done

The following bar chart indicates the frequency at each calculated mode.

FIGURE 1
Model (A4) > Modal (A5) > Solution (A6)

TABLE 10
Model (A4) > Modal (A5) > Solution (A6)

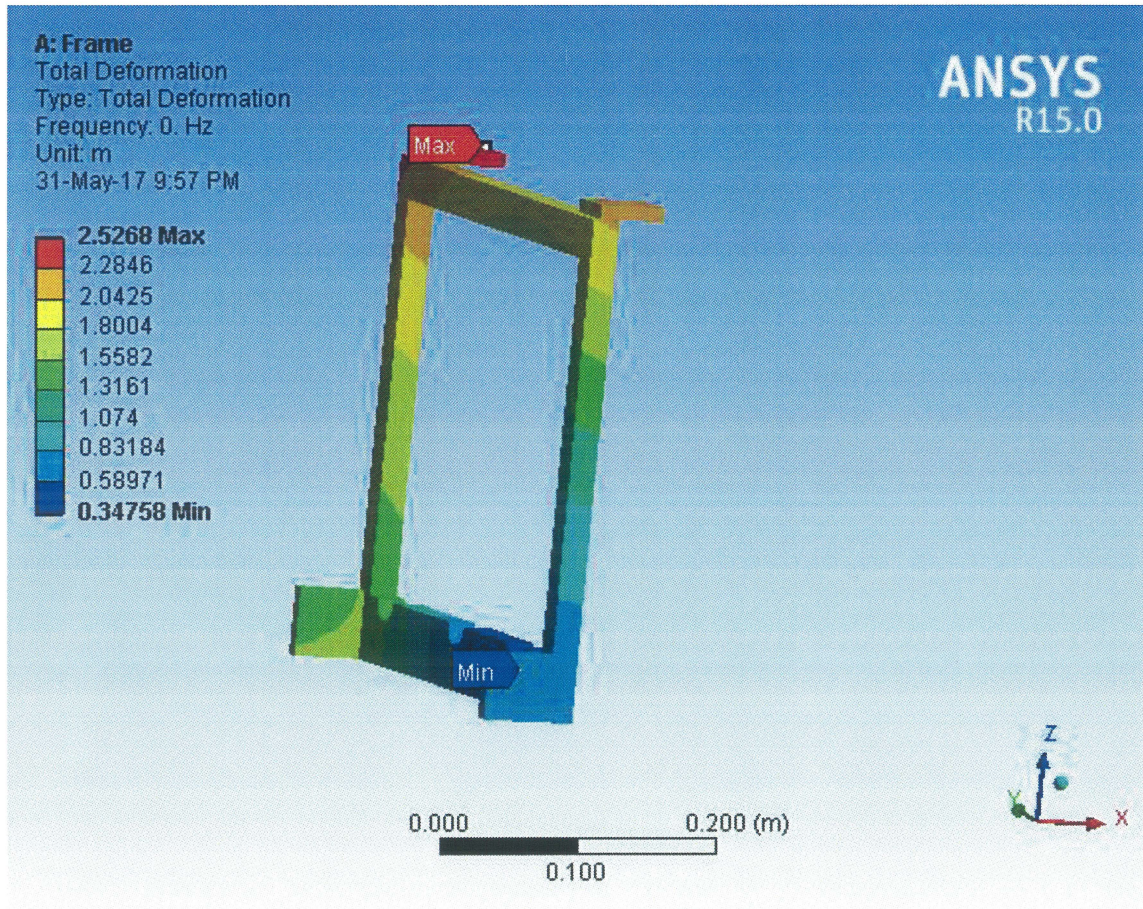| Mode	Frequency [Hz]
1.	
2.	
3.	0.
4.	
5.	3.6578e-003
6.	6.248e-003

59

Total Deformation

Subject: FRAME

Date   Wednesday, May 31, 2017

Comments:

Low Cost of 3D Printer

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Kampus Pekan, 26600 Pekan, Pahang Darul Makmur.
noraziraharifin@gmail.com

Abstract — Nowadays 3D printer has become a big challenge in technology of prototyping using the printer. This technology is not only used in industries of manufacturing but used for prototyping for an important constraint. This project is to development of low cost 3D printer but not only about the cost budget effective as output but the working process of the 3D printer.

After this project gets final touch it will benefit for the common people with the effectiveness cost. 3D printing technologies are available to build a 3D object printing but this project aims to use the 3D manufacturing process that gives the effectiveness solution at low wastage of printing materials.

Index Terms—CATIA, 3D PRINTER, Thinker-cad. *(key words)*

INTRODUCTION

The toy industry is among the biggest beneficiaries of the technology in world. Toys has a different type and design such as the toy action figures is characters of every toys and kids will love the way that Action Figures can bring their favourites characters to life. Toys already as tend to be small, different design and made out of plastic, making it easy to 3D print them.

Everything around us such as toy, medical tools and buildings are designed and created by 3D printing, making them a necessity in today's society. Toys companies are often referred to as new technology and the industry is commonly to fulfil the children and all of the age to ensure the products is suitable for different age. This technology such as modify, download, and share three-dimensional designs using software and convert using computer driven machines as making 3D drawing to adjust and embodiments of the designs.

3D printing most common use in industries of manufacturing to produces the product in small part. This printer will make simple process to ensure the shape that we need it can process. Using 3D printer will help to make the complete produce and only need to produces using CATIA and using 3D printer to print the small product base on the drawing.
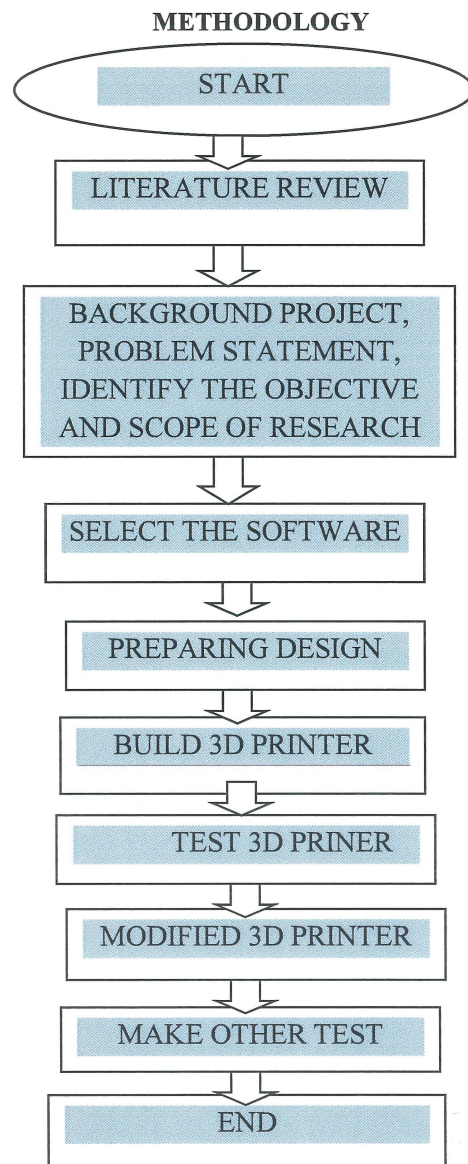
METHODOLOGY

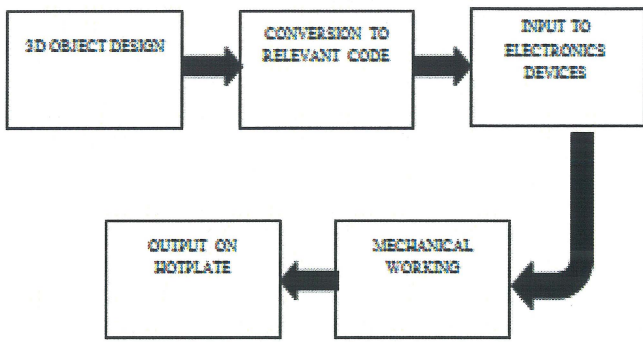Figure 1.0 Flowchart of process

61

Figure 2.0 Simplified block diagram process of 3D printer

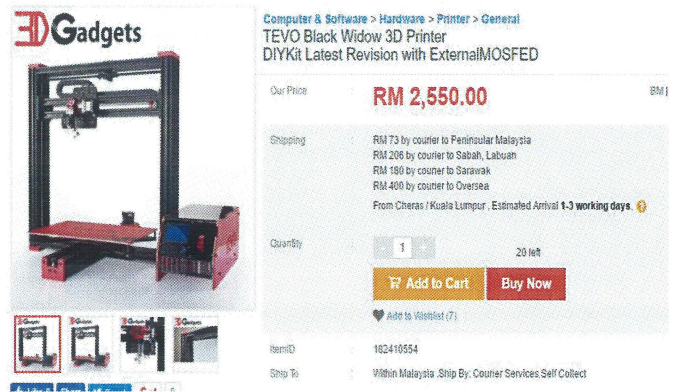

Figure 4.0 Market price

RESULTS AND DISCUSSION

The result of the study and presented the results of the 3D printer build.

COMPARISON BETWEEN 3D PRINTER MARKETS

The total price of 3D printer less than RM1310, price to make a 3D printer is cheaper than the market price market price and table 4.1 for total cost of components. The frame used from wood to ensure the cost is less than the Perspex and metal. The advantage of wood is easily to shape, machining and assemble. The other components in 3D printer is used because the components were function such as motor to move the extruded and hot bed, power supply current, hot bed hold the product and fan for cool the extruded. To minimum the cost of 3D printer need ensure cost lowest than market price. Change the frame to wood will ensure the 3D printer strength and low cost.
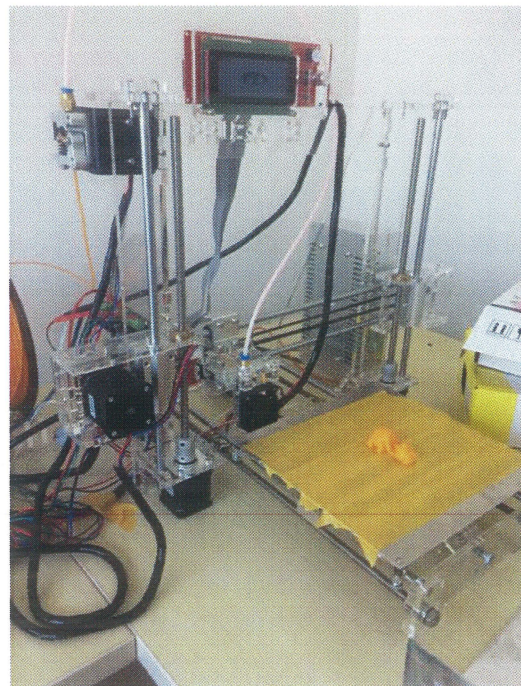
COMPARISON OF 3D PRINTER ORIGINAL AND MODIFIED

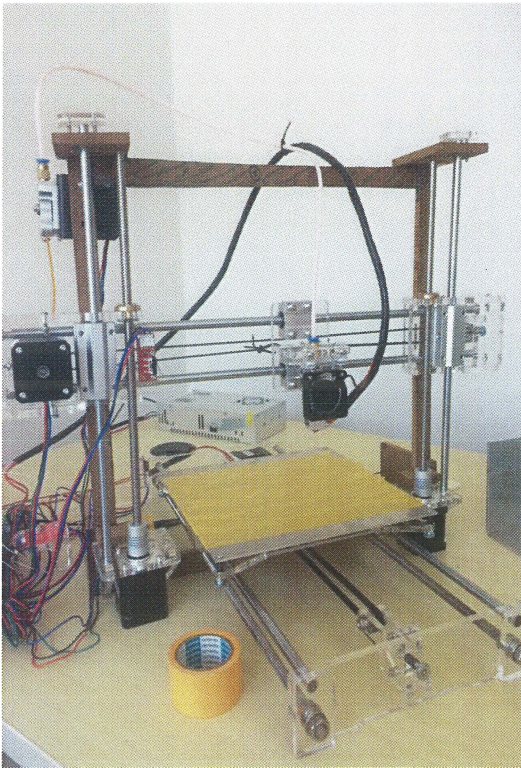Figure 5.0 original pursa i3

Figure 3.0 Market price

Figure 6.0: Modified pursa i3

The original 3D printer used as refer actual position of the part components in 3D printer.

DRAWING OF 3D PART CATIA

Computer aided three-dimension interactive application or CATIA, software that suitable for design the drawing 3D product and develop the design to print in 3D printer after save STL file. This software provides the advanced technologies to design the complex drawing to print. CATIA enables the creation of 3D parts from the 3D sketches to develop the 3D drawing. In this project, simple toys assembly is provided. Assemble part show the design used CATIA software.
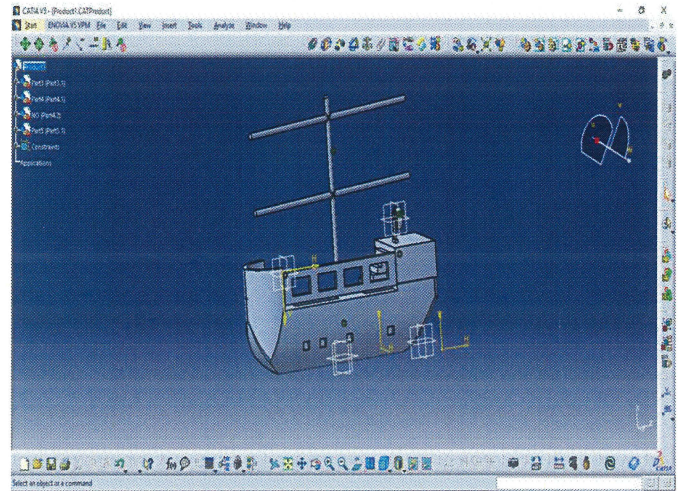

Figure 7.0: CATIA drawing

DRAWING PRODUCT "THINKER CAD"

Thinker cad browser-based 3D design and modelling tool, easy make perfect design with simple design in minutes and the imagine anything. 3D designs that thinker cad product such as toys, prototypes, home decor figures, case phone and other. Thinker cad was founded by Kai Backman and Mikko Mononen in 2011 that can bring the first Brower-based 3D design in the platform.
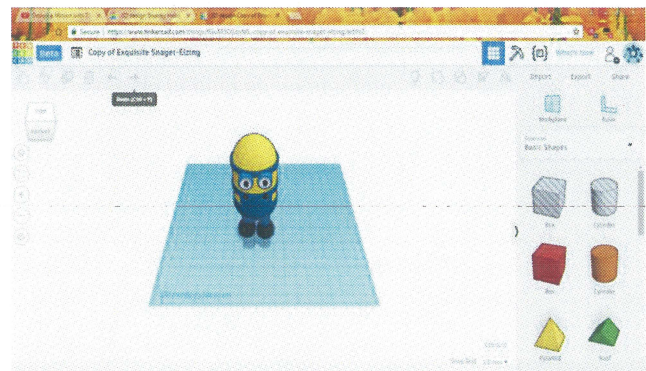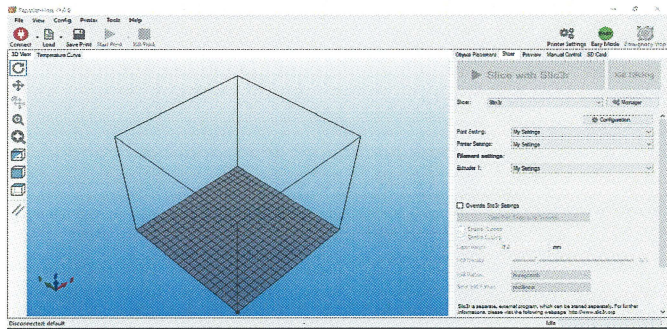

Figure 8.0: Thinkercad drawing

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PROCEDURE TO PRINT PRODUCT (REPETIER HOST)

Repetier-Host works with almost all 3D FDM printers. Repetier-Host is easy to use for beginner to control the printer, slider and printing process. This software is easy multi-part printing in one time, can load duplicate of many models and print them simultaneously.

Figure 9.0 Repetier host software
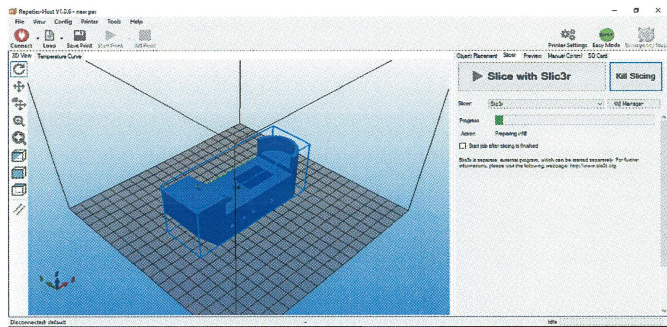
Figure 10.0 inside Part in Repetier host
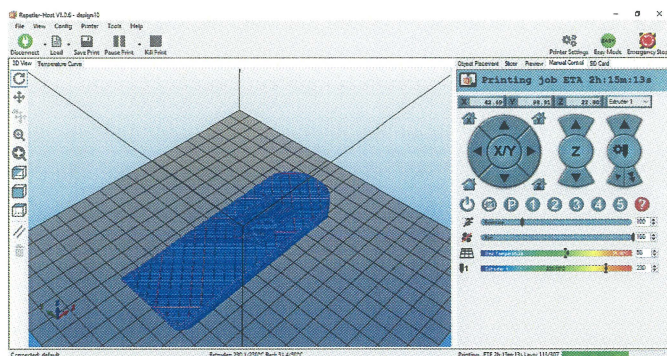
Figure 11.0 Controller of Repetier host

PRODUCT OF 3D PRINTING

3D printer allows faster innovations design and the manufacturing timing to produces product are shorter. 3D printer changes the face of products with easy to use online apps and software that people can create the unique product. In designing the toy need to put some ideas into the virtual files.

Figure 12.0 example of product 3D printer

PATTERN INSIDE THE PRODUCT

The printer uses that some patterns, that can be controlled Repetier-Host software to choose such as rectilinear, line, concentric, honeycomb, Hilbert curve (slow), Archimedean chords (slow), and actogram spiral (slow).
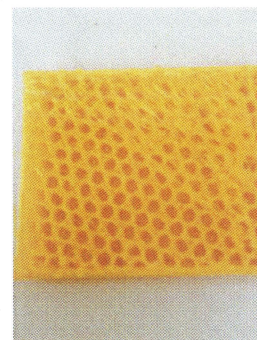
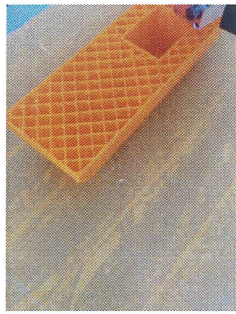

Figure 13.0 Honeycomb pattern

64

Figure 14.0 Rectangular pattern

ANSYS

ANSYS hot bed plate- ANSYS load used to know the deformation for surface of hot bed plate and the min deformation occurs in middle and the max deformation ends of plate.
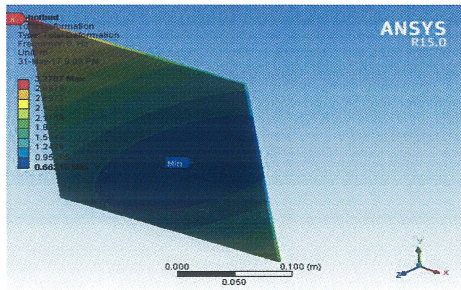

Figure 15.0 Deformation of hot plate

ANSY Frame- holds all the components together. The frame made out of fiber wood. The minimum load for the frame occurs on bottom because support part and the maximum load above.
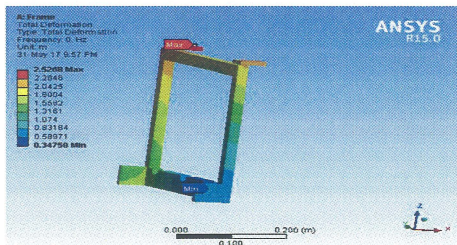

Figure 16.0 Deformation of frame

CONCLUSION

The 3D printer process has been studied in this project. 3D printer process used Fused Deposition Modelling (FDM) technique by melting layer-by-layer of plastics filament at nozzle used temperature 200°C for Poly-lactic acid (PLA) filament. The type of filament used in FDM technique such as Poly-lactic acid and Acrylonitrile Butadiene Styrene heat difference temperature to melting the filament.

Low cost of 3D printer has successfully been development. The process make 3D printer require patient because the components for 3D printer have lot of part and detail procedure to produce the capable machine work. The low cost of 3D printer successful by change the material of frame. The frame make from the fibre wood is cheaper than aluminium or Perspex.

3D parts have produced using low cost of 3D printing. The parts have design using the CATIA and Thinker Cad were printing using the low cost of 3D printer and the parts successfully finish. The toys and assemble toys are produce using the printing.

The finite element analysis (FEA) is the numerical method for solving problem of manufacturing product. The typical solving methods for this project include load for support the machine, structural analysis and the deposition force for 3D printer.

RECOMMENDATION

Problem solving recommended in order overcoming the 3D printer work properly such as adjustable manual of nozzle extruded by touch the hot bed before make the printer because if the nozzle not touch the hot bed it not function and the printing are damaged. Before printer make sure the filament in the nozzle and 3D part can printing. The low cost of 3D printer is ensure the entire component to assemble are ready and the Board with Minitronics assemble correctly with wire ensure the current not explode.

ACKNOWLEDGMENT

Firstly, I would like to express my gratitude to Faculty of Manufacturing Engineering for their kindness to give opportunities to me do my final year project and get award of the degree of Bachelor of Manufacturing Engineering.

The special thanks to supervisor from University Malaysia Pahang (UMP), Dr. Kushendarsyah Saptaji. The supervision

and support the truly help in the progression and smoothness of the final year project 1 and 2. The cooperation is appreciated for his willingness to give his time generously.

Last but not the least, I would like to thank for my beloved family for supporting me spiritually throughout writing this thesis.

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L. M. Galantucci, I. Bodi, J. Kacani, and F. Lavecchia, "Analysis of Dimensional Performance for a 3D Open-source Printer Based on Fused Deposition Modeling Technique," Procedia CIRP, vol. 28, pp. 82–87, 2015.

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