

## **SUPERVISOR DECLARATION**

“I hereby declare that I have read this thesis and in my opinion this thesis 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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DESIGN AND DEVELOPMENT KOSSEL MINI 3D PRINTER

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The thesis submitted in partial fulfilment of the requirements for the degree of  
Bachelor of Mechanical Engineering (Design and Innovation)

Faculty of Mechanical Engineering

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JUNE 2015

## DECLARATION

“I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledged.”

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## ABSTRAK

Pencetakan 3D adalah antara salah satu teknologi yang paling pesat berkembang yang boleh dikaitkan dengan konsep prototaip pantas yang boleh mengeluarkan apa-apa jenis bentuk daripada model CAD dengan ketepatan yang tinggi untuk produk akhir. Objektif projek ini adalah untuk mengkaji proses operasi model pencetak Kössel Mini 3D, untuk menyiasat bahan pelekat untuk pencetak 3D dan untuk mengoptimumkan parameter yang mengurangkan ketinggian sudut penjuru. Untuk mencapai matlamat ini, siasatan keatas beberapa jenis bahan pelekat telah dijalankan untuk menyokong mendapatkan percetakan Kössel 3D yang optimum. Proses pengoptimuman melibatkan teknik *Design of Experiment* dimana *Response Surface Method* telah digunakan. Hasil kajian menunjukkan bahawa gam UHU sangat berkesan dan murah untuk digunakan di atas permukaan pencetak. Tambahan pula, parameter optimum untuk kualiti percetakan diperolehi di 192 ° C suhu lapisan, 13% daripada pengisian kepadatan dan 0.33mm ketinggian lapisan. Beberapa cadangan juga telah dicadangkan untuk kegunaan penyelidikan pada masa hadapan.

## ABSTRACT

3D printer is one of the fastest growing technologies which can be related to the rapid prototyping concept that may produce any kind of shape from CAD model with high accuracy to the final product. The objectives of this thesis are to study the Kossel Mini 3D printer model's operation process, to investigate the adhesive material for 3D printer and to optimize parameters that minimize the corner lift height. In order to achieve these goals, investigations on several types of adhesive materials has been performed to support the finding of the optimum Kossel 3D printing setting. The optimization processes involved the Design of Experiment technique where Response Surface Method is applied. The result shows that UHU glue is very effective and cheap to be use on the printer bed. Furthermore, the optimum parameters for printing quality is obtained at 192°C of layer temperature, 13% of infill density and 0.33mm of layer height. Some recommendations were also proposed for the future research purposed.

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## LIST OF ABBREVIATIONS

2D	=	TwoDimensional
3D	=	ThreeDimensional
CAD	=	Computer Aided Design
CAE	=	Computer Aided Engineering
DOE	=	Design of Experiment
DWG	=	Drawing
FDM	=	Fused Decomposition Modeling
FEA	=	Finite Element Analysis
RSM	=	Response Surface Method

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

##### 1.1.1 What Is 3d Printing

Printer commonly referred as a technology of copy and paste which a device that accept text and graphic as output on paper which is in concept of 2 dimensional axis x and y from a computer. Printer is an external device that communicates with another digital device to print what is shown on screen. In enhancement of technology, printer came out with variety model from a black cartridge to variety color and be a part of human needs especially who in part of telegram.

Nowadays, the technology area have been raise another level which 3 dimensional (3D) printing methods or well known as addictive manufacturing. Furthermore, 3D printing is covers of processes and technologies that offer capability of production of parts with different material. It is wide to believe that 3D printing or additive manufacturing has a good potential in these enhancement of technology. 3D printer also covers various aspects which lets a printer painted with various forms in dimension z. 3D printer includes three different dimensions that is, x, y and z, where previously only on the position x and y dimensions. This is allows the printer to print a form of this kind as a whole. Nevertheless, there is also a limitation that cannot be avoided the easy way.

Advantages of this 3D printing are almost the entire form can be printed and it allows the manufacturing cost and process surely less in the range of 50 percent to 90 percent of it. If imaginable in which a product is produced through the variety of order to enable it to produce a variety of shapes. This will likely take a very long time. In accordance with the basic knowledge, a form of manufacturing process will take 2 or 3 hours. By using this reserve, it enables a product produced only in a short time. Furthermore, the 3D printer is capable of producing a form without using any additional tools.

### **1.1.2 Type of 3d Printer**

3D printer comes out in variety of type such as Stereo Lithography (SLA), Fused Decomposition Modeling (FDM), Selective Laser Sintering (SLS), Laminated Object Manufacturing (LOM) and Direct Metal Laser Sintering (DMLS). It is divided because of the type of information and how it operates in terms of form and also used the basic needs such material. SLA can produce in high accuracy with the help of laser and detailed parts which is the minimum thickness of the layer 0.02 millimeters and produce a smooth surface finishing.

Apart from that, FDM is used an extruder to extrude a filament or wax material that traces the part across the layer by layer with 0.15 millimeters minimum layer thickness. Selective Laser Sintering or SLS is well known as a laser printer that used powder to be the layer of product. This type of printer may print out a product with minimum layer thickness to 0.10 millimeter and the surface finishing is average. Figure 1.1 shows the example of Fused Decomposition Modeling 3D printer Kossel Model which brought Blomker Industries.

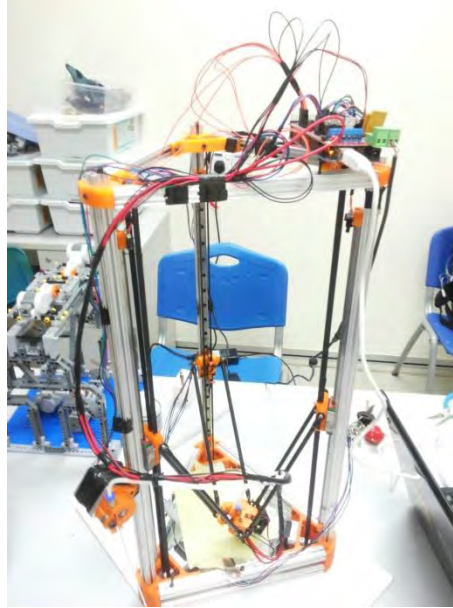


Figure 1.1: Kossel Mini 3 Dimensional Printers from Blomker Industries.

### 1.1.3 Advantages of 3D Printing

In fact, 3D printing technology has been made its way in year 1986 but it did not gain its tractions until early year 2000. Since that, there is several improvements that been introduced by engineering peoples where it comes to a technology that can brings a lot of benefits to world. It was comes hottest technology and popular inside the world of engineering, architecture and especially manufacturing fields. Some of interesting advancements in 3D printing technologies are possible to create part or product in jus few hours and able to create most of any shapes.

Most of commands from user and developer said 3D printing brought cheapest price and costing in process of producing a product. It might help companies save up to 60 percent of manufacturing cost. This was related to cheaper raw material and lesser workforce needed. Traditional method likes milling and lathe machine needs more cost where the raw materials such steel block a quite expensive. Moreover, worker and their soft skill were needed in manufacturing a precise product with good quality and quantity.

3D printing also listed as a quick production as compared to practical method where it is more sustain and eco-friendly machine. Similar to other devices or machines, they also lead on same direction and goal but in different speed and time travel also differs significantly. Nowadays, 3D printer machine and its technology are able to create an object with several of shape in few hours. This leads supplier to be on-demand manufacturing for modeling and may be reconsider about costing before the real line manufacturing.

Basically, 3d printing technologies creating the object start from zero to hero or in other hand from flat screen without anything to exact physical parts just in few hours. Tools and waste are very rare to use and happen. In part of performing, the technology will print all type of shape without using any tools. For example, CNC machine generally used its bits to cut and for sure it will form the waste of steel. Compared to 3D printing technology, it made a part without forming the waste and without using any tools while performing.

## **1.2 Problem Statement**

Existing research stated that few problems while printing on a glass especially on Kossel Mini 3D printer that brought without heat bed. One of it is corner lifted during printing. This thesis is a proposal to find out which low cost adhesive material that suitable and to optimize several independent variables that available in the software so that can improve the printing quality even using a low cost 3D printer

### **1.3 Objective**

1. To assemble and study Kossel Mini 3D printer model's operation process.
2. To investigate which low cost adhesive that suitable to use between 1<sup>st</sup> layer and glass bed.
3. To optimize the parameter that available in order to increase the quality of product.

### **1.4 Scope of work**

This thesis is focus on:

1. The structure of Kossel Mini 3D printer and its mechanisms.
2. Several low cost adhesive material that suit to obtain the best result of printing
3. Optimization method on several variables where DOE technique on Response Surface Methodology also involved.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Rapid Prototyping Technology

Fabrication for manufacturing technique technology is classified as subtractive, formative and additive. All of the fabrication either falls into one of these categories or a hybrid process. Referred to rapid prototyping technique, it is a group of technologies that capable of performing on the process. Almost of it completely under computer control with less intervention of human once the operation has begun. In 1993, Burns said that RP is an Automated Fabrication and creates five of criteria which referable and classified as what he said. The five criteria are:

- i. The process should take in raw material in some shapeless form that blocks, sheets or a fluid to produce a product with definite shape.
- ii. The process is without significant amount of human interaction.
- iii. The process must consist of shape with some degree of three dimensional geometrical complexities.
- iv. The process must not involve with the manufacture of new tools for each different shape to be generated.
- v. Each of item produced must be a single object not an assembly of the component parts thus eliminating joining operations such as gluing, welding and riveting.

These criterions concludes that each of product must be produce without any modern tools and it should be form in piece shape that no need any joint like glues, welds and rivets and all the part was assembled with less human attention. By employing these criteria, it established the fabrication techniques as automated and Figure 2.1 shown the example of it.

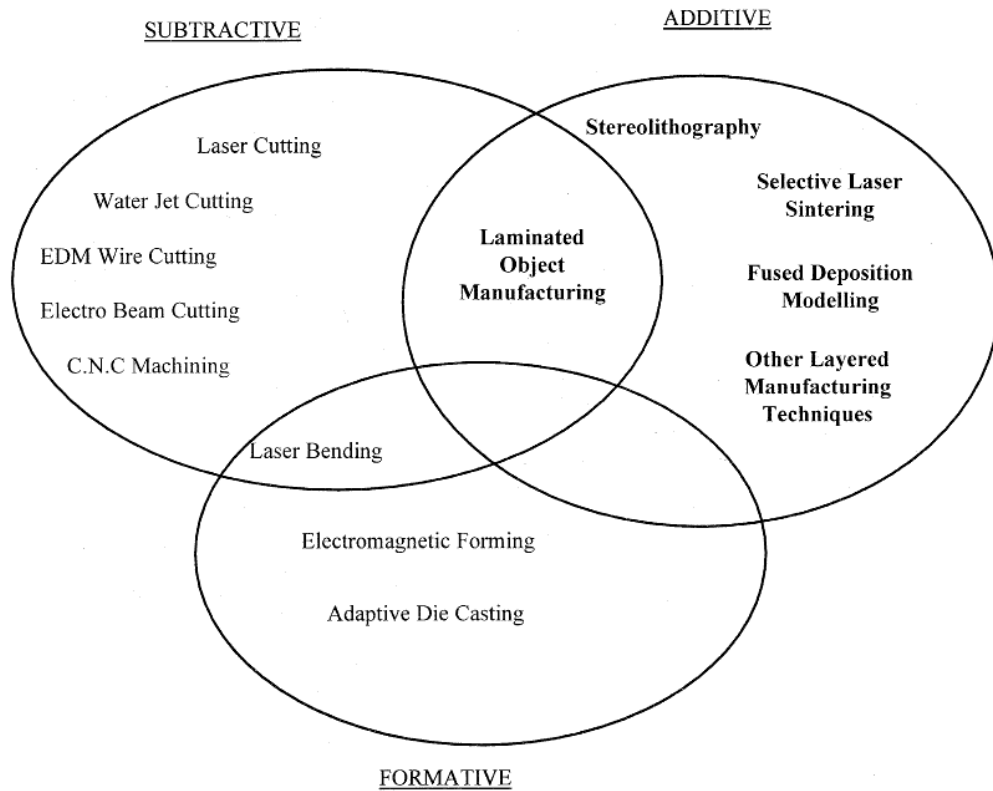


Figure 2.1: Rapid Prototyping Technique  
(Source: Onuh, S. O., & Yusuf, Y. Y. (1999))

The Computer Numerical Control machine that consisted of techniques such as milling, drilling, and grinding is not classified as a rapid prototype and strictly does not comply with the five criteria. This is because of the machine required some human interaction to remounting the work pieces in manufacturing complex geometries. Otherwise, the device has the capabilities to be versatile with multi-axis and could provide an automatic fabrication facility.

One example for a hybrid process is laser bending. This process was combined an automated subtractive technique and an automated formative technique. In 1995, referred to Thompson, laser bending involved the generation of bending stresses in a sheet material using a laser heat source to induce differential cooling rates in selected areas.

## 2.2 3D Printing Technology

The rapid development in technology nowadays, directly improve the method of printing and equipment used in printing. With the advance of technology especially in mechatronics, the printer can be more helpless for human beside photo copy in 2D. 2D printer commonly referred to ink jet and laser jet. These two type of 2D printer are used the same application. An ink jet printer is used to sprays the ink whether black or color to paper. Otherwise, the laser printer used different method which applying an electrical charge to drum so that it will picks up the laser printer's ink, called toner. This toner then will applies to paper for another procedure of printing.

Technically, paper does not have third dimension which z-axis or height to measure because of paper is normally thin enough to use in 2D. Refer to Figure 2.2 below show the limitation of printing which lack of printable area of a paper.

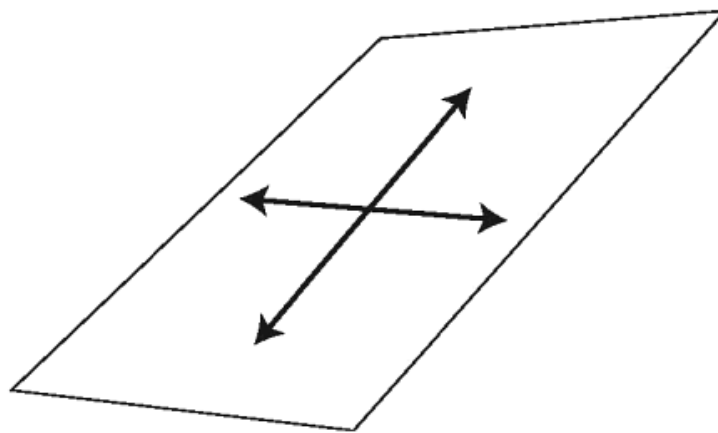


Figure 2.2: Printable Area Only in Two-Dimensional (Source: Kelly, J. F., & Hood-Daniel, P. (2011))