DESIGN AND DEVELOPMENT OF LARGE-SCALE SIZE 3D PRINTER

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This report is submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declared that this report entitled “Design and Development of Large-Scale Size 3D Printer” is the result of my own work except as cited in the references.

Signature :.....

Name : YEW SIN WEI

Date : 27/7/2020

APPROVAL

I have declared that I have read this project report entitled “Design and Development of Large-Scale Size 3D Printer” 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.

Signature :.....

Supervisor’s name : Prof. Madya Ir.Ts.Dr. Mohd Rizal Alkahari

Date : 27/7/2020

ABSTRACT

3D printing is an advanced technology for manufacturing complex parts, which cannot be produced by traditional technologies such as subtractive manufacturing processes. One of the common types of 3D printing process is fused deposition modelling. During 3D printing, the printhead module is driven by g-code to move on the x-y-z axis to build objects layer by layer. This concept is almost similar to subtractive manufacturing using Computer Numerical Controlled (CNC), where the cutting tool movement is also controlled by the g-code. However, most of the open source 3D printer is using Arduino and Arduino board is not reliable for heavy-duty industries. One of the popular control systems is called Mach3. Mach3 is not free software but is open to everyone for download on the website. Mach3 can control milling machines, lathes machine, plasma cutters and 3D printers; WAAM is a welding method and or also can be a part of an additive manufacturing process where the metal wire can serve as the same function as the plastic filament in 3D printing to continuous feed onto the building platform. In this project, a large-scale metal 3D printer is developed which is using Mach3 control system.

ABSTRAK

Percetakan 3D adalah teknologi canggih untuk menghasilkan bahagian kompleks, yang tidak dapat dibuat oleh teknologi tradisional seperti proses subtraktif. Jenis pencetakan 3D yang biasa adalah pemodelan pemendapan, di mana modul kepala percetakan didorong oleh g-code untuk bergerak pada paksi x-y-z untuk membina objek secara lapis-lapisan. Konsep ini hampir sama dengan CNC (subtraktif), di mana pergerakan alat pemotong juga dikawal oleh g-code; Walau bagaimanapun, kebanyakan pencetak 3D adalah asas Arduino tetapi papan Arduino kurang dipercayai untuk industri berat; Salah satu sistem kawalan popular dipanggil Mach3, software ini bukan percuma tetapi terbuka kepada semua orang untuk dimuat turun di laman web mereka. Mach3 boleh mengawal pelbagai mesin seperti plasma dan pencetak 3D; WAAM adalah kaedah kimpalan dan atau juga boleh menjadi sebahagian daripada proses pembuatan bahan tambahan di mana wayar logam dapat berfungsi sama seperti filamen plastik dalam percetakan 3D. wayar logam ini dapat dibekal secara berterusan ke atas platform pembinaan bahan. Tujuan penyelidikan ini adalah untuk membangunkan pencetak 3D logam berskala besar dan mengintegrasikannya dengan sistem kawalan Mach3.

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FDM	Fused Deposition Modeling
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CNC	Computer Numerical Control
SLA	Stereolithography
DLP	Digital Light Processing
SLS	Selective Laser Melting
SLM	Selective Laser Melting
LOM	Digital Object Manufacturing
UV	Ultraviolet
PLA	Polylactic Acid
ABS	Acrylonitrile Butadiene Styrene
TPU	Thermoplastic Polyurethane
PETG	Polyethylene Terephthalate Glycol
USB	Universal Serial Bus
STL	Standard Tessellation Language
WAAM	Wire Arc Additive Manufacturing
DED	Direct Energy Deposition
COTS	Commercial-off-the-shelf
SS	Stainless Sreel

LIST OF SYMBOLS

%	=	Percentage
n	=	Quantity
W	=	Weight
F	=	Force
f	=	Friction
l	=	Length
T	=	Torque
r	=	Radius
d	=	Diameter
A	=	Area
V	=	Volume
M	=	Moment
m	=	Mass
σ	=	Stress

CHAPTER 1

INTRODUCTION

1.1 Background

3D printing was initiated in 1986, patented by Charles Hull, who invented the earliest stereolithography process (Lipson et.al., 2013). After a few years later in 1988, FDM was introduced by Scott Crump. FDM then became his foundation company, Stratasys (Gibson et.al., 2010). In the year of 2005, Dr Gordon started the open-source 3D printing project. Open-source 3D printer means the software and hardware of the printer are available to the public typically under license. The information is opened to share, edit, improve, modify, innovate, and to build a 3D printer. The purpose of the open-source 3D printer is to develop the technology at a faster pace. RepRap is the earliest open-source 3D printer. It is an open-source community to develop a 3D printer that is able to produce a pure self-replicating device for it to be accessible for anyone. REPRAP was developed by Dr Adreian Bowyer, a mechanical engineering lecturer at the University of Bath in England (Joshua, 2014).

Nowadays, there are many open-source 3D printers in the market. For example, Anet A8, Printrbot Play, Creality CR-10, Prusa i3, Deezmaker Bukito, Rostock Max, Ultimaker 2 Go, Lulzbot Mini, BCN3D Sigmax. (Mika Yeap, n.d.).

1.2 Problem Statement

The conventional manufacturing types of machinery such as a laser cutting machine, lathe machine, and milling machine are limited to produce certain product since the machine is only carried out a specific subtractive cutting action. Traditional manufacturing process can't produce a complex shape and hollow product (Meron, 2012). Furthermore, the traditional manufacturing process cause more material waste. The processed materials generate wastes in the form of fragments or silk. The waste materials are needed to further process to be used again. In contrast, 3D printing can save materials because it is additive manufacturing to realize digital 3D files into a real 3D object. The model is done by building up the object layer by layer (Mpofu, 2012; Berman, 2012). 3D printing is flexible, it can produce just about anything with cost-saving, design of products also can be customized. Most of the 3D printer are control by Arduino system. Arduino also has its advantages, which are small, safe, easy-to-use and reliable, but the Mach3 system can improve this system for better results. The usage of Arduino on 3D printer brings more disadvantages other than advantages to the user and printing process. One of the disadvantages of the Arduino system is vulnerable to heavy industry. In contrast, Mach3 works on Windows PCs to control the motion of motors (stepper & servo) by processing G-Code. Mach3 is a feature rich program which is also easy to use. It provides macro programming capabilities, but programming needs to be done.

1.3 Objectives

The objectives of this project are as follows:

i. To design and develop a new large-scale size 3D printer.

ii. To fabricate a new 3D printer with printing size of (500x500x1000) mm^3.

iii. To analyse the developed 3D printer and the print part.

1.4 Scope of Project

The scopes of this project are:

i. Development of a new large-scale size metal 3D printer by using Mach3 control system.

ii. Development of a new large-scale size 3D printer by using the concept of Wire Arc Additive Manufacturing.

iii. The heating source is from micro-plasma.

1.5 General Methodology

The flow chart of this project is shown in Figure 3.1. This project starts by literature review about the non-commercialize software called Mach3 and understanding conventional and construction process of a 3D printer. Then, market analysis is carried out to determine the electronic hardware requirement to integrate Mach3 on a 3D printer. After that, the functions, advantages and disadvantages of competing products are compared and figured out. Next, the budget of the project based on the products on the market is determined. Next, a House of Quality was created to determine the interrelationship between customer requirements and engineering characteristic of the product. Meanwhile, the design specification of the machine is listed for the product and the performance requirement. Then, several concept designs are created and analyse the best solution from multiple options as the reference for product development. The design and simulation were done in CAD software to illustrate the product. Then, the items listed in the bills of material is gathered. Next, the technical drawing of the design is generated by using CAD software. After the hardware is presented and assembled, Mach3 is integrated to the chassis. A report is written and submitted. Finally, present information about the large-scale size 3D printer to the panels.

CHAPTER 2

LITERATURE REVIEW

2.1 What is 3D printing?

3D printing is a kind of additive manufacturing to realize a digital 3D files into a real 3D object. The model is done by building up the object layer by layer (Mpofu, 2012; Berman, 2012). 3D printing, also known as rapid-prototyping is also a part of the manufacturing process. Normally, industries use a 3D printer to print out the designed product for testing in the alpha phase (before the product launch in the market). That's why 3D printing has a name of rapid prototyping. However, there is still some section of industries use a 3D printer to manufacture the finalized product such as a toy, key chain, pictures, 3D text, prosthetic arm, mechanical parts of the machine, and even medicine. 3D printing is a small production manufacturing process, it can't be a mass production since the manufacturing process takes times to complete a unit (King, 2012).