Faculty of Mechanical and Manufacturing Engineering Technology

OPTIMIZATION OF DIMENSIONAL ACCURACY OF FUSED DEPOSITION MODELING (FDM) PRINTED PART USING TAGUCHI METHOD

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Bachelor of Manufacturing Engineering Technology (Product Design) with Honours

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OPTIMIZATION OF DIMENSIONAL ACCURACY OF FUSED DEPOSITION MODELING (FDM) PRINTED PART USING TAGUCHI METHOD

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Tajuk: **OPTIMIZATION OF DIMENSIONAL ACCURACY OF FUSED DEPOSITION MODELING (FDM) PRINTED PART USING TAGUCHI METHOD**

Sesi Pengajian: **2018/2019 Semester 1**

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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology Manufacturing (Product Design) with Honours. The member of the supervisory is as follow:

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DEDICATION

To my beloved parents

To my kind lecturers

And not forgetting to all friends

For them

Love, Sacrifice, Encouragement, and Best Wishes

ABSTRACT

The part produced by 3D printing has its accuracy varies with the changes in the process parameters of the machine such as quality, temperature, speed, and some others. Taguchi method was applied in order to achieve the optimum accuracy of the printed part. It is a simplified yet powerful method for experimental design using the orthogonal array method. In this project, an orthogonal array of L'9 is used with four parameters which are a print pattern, orientation, support angle, and sidewalk offset. The experiment was set up by involving the process of part design by using SolidWorks. Then nine sample has undergone a process of measuring by Coordinate Measuring Machine (CMM). Thus, the result of a measurement of nine samples has to be compared to CAD data to get the percentage of accuracy. Besides that, the measurement result will have analysed using Taguchi method to determine the default and optimum parameter condition. Then we compare the result from both parameter data. The result shows that optimum parameter condition for this cube pro process is honeycomb for the print pattern, 0 y-axes for orientation, 90 degrees for support angle and 0.4 for sidewalk offset. The print pattern has the most significant effect compared to the orientation, support angle, and sidewalk offset on the dimension accuracy of the part. The shrinkage data value between default and optimum parameter shows that the shrinkages reduce from 0.619 mm to 0.429 mm. An improvement of 0.190 mm with 44.3 % of percentage has achieved by applying the optimized parameter.

ABSTRAK

Percetakan 3D adalah salah satu kaedah dalam Teknologi Alat Perkakasan. Bahagian yang dihasilkan oleh percetakan 3D mempunyai ketepatannya bervariasi dengan perubahan parameter proses mesin seperti kualiti, suhu, kelajuan dan beberapa yang lain. Untuk mencapai ketepatan optimum bahagian yang dihasilkan, kaedah Taguchi akan digunakan. Ini adalah kaedah yang mudah digunakan untuk reka bentuk eksperimen dengan menggunakan kaedah orthogonal array. Dalam projek ini, satu lekapan orthogonal L'9 digunakan dengan 4 parameter iaitu corak cetak, kedudukan, sudut sokongan, dan jarak lapisan kaki lima. Eksperimen ini adalah persediaan dengan melibatkan proses reka bentuk dengan menggunakan SolidWorks. Kemudian 18 sampel ini akan menjalani proses pengukuran dengan mengunakan Measuring Machine Coordinate (CMM). Oleh itu, hasil pengukuran 9 sampel perlu dibandingkan dengan data CAD untuk mendapatkan ketepatannya. Selain itu, keputusan pengukuran dianalisis menggunakan kaedah Taguchi untuk menentukan keadaan parameter yang sebenar dan optimum. Kemudian kami membandingkan hasil dari kedua-dua data parameter. Hasilnya menunjukkan bahawa parameter optimum untuk proses pro kiub ini adalah sarang lebah untuk corak cetakan, 0 paksi y untuk orientasi, 90 darjah untuk sudut sokongan dan 0.4 untuk laluan jarak tepi. Corak cetakan mempunyai kesan yang paling ketara berbanding orientasi, sudut sokongan, dan kaki lima mengimbangi ketepatan dimensi bahagian tersebut. Nilai data pengecutan antara piawai dan parameter optimum menunjukkan bahawa pengecutan berkurang dari 0.619 mm kepada 0.429 mm. Perbezaan 0.190 mm dengan 44.3% daripada peratusan telah dicapai dengan menggunakan parameter yang dioptimumkan.

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LIST OF ABBREVIATIONS, SYMBOLS, AND NOMENCLATURES

FDM	-	Fused Deposition Modelling
SLA	-	Stereolithography
DOE	-	Design of Experiment
ABS	-	Acrylonitrile Butadiene Styrene
PP	-	Polypropylene
PE	-	Polyethylene
OA	-	Orthogonal Array
S/N Ratio	-	Signal-to-Noise Ratio
ANOVA	-	Analysis of Variance
3D-CAD	-	3-Dimensional Computer-aided Design
STL	-	Standard Triangle Language
RP	-	Rapid Prototyping
CMM	-	Coordinate Measuring Machine

CHAPTER 1

INTRODUCTION

1.0 Introduction

In this chapter, the purpose of the project will be described generally. Start with a brief explanation of the background of the project. Then, the problem statement that leads to the idea for this project and objective that aimed to achieve are established in order to overcome the problem statement. This chapter also explains the scope that will be discussed in the project and the project significantly.

1.1 Project Background

3-D printing is additive, which suggests that it creates the favored type with a constructed-up manner. This means, that the frame is built up as a skinny layer without a preform. The applied substances area unit ordinarily some kind of plastics. There is a unit many ways of the 3D printing technology relying on the layer introduction manner. The FDM (Fused Deposition Modelling) 3D printing era works on associate "additive" precept by suggests that of giving birth down material in layers; a plastic filament is uncoiled from a coil to supply a component. The time become evolved by mistreatment Scott Crump within the overdue Eighties. The FDM technology desires code program that approaches associate STL file (stereolithography report layout). After that, we tend to need to slice the model with the other application for the construct method. If needed, support structures are often generated. The version is made by suggests that of extruding thermoplastic textile to form layers because the material hardens once extrusion from the nozzle. A plastic filament is

uncoiled from a coil associated an extrusion nozzle flip the flow on and rancid. There is a malicious program-power that pushes the filament into the nozzle at a managed charge. The nozzle is heated to soften the fabric. It's going to be enraptured in each horizontal and vertical pointer with the help of a numerically managed mechanism. The nozzle managed by suggests that of a computer-aided producing (CAM) code program bundle and also the element is made from very cheap up, one layer at a time. The stepper cars area unit utilized to makeover the extrusion head. The mechanism uses associate X-Y-Z linear movement. The FDM printing technology is very flexible, and it is can handle with the small overhangs on the lower layers. The FDM generally has some restrictions and cannot produce undercuts without support material. Many materials are available, such as ABS and PLA among many others, with different trade-offs between strength and temperature properties. We picked the most advantageous technology from the 3D printing methods while considering the printing quality and the level of difficulty of the building process. This technology is the FDM, i.e. the 3D extrusion. Thereafter, the next main concern was the structure of the 3D printer, more specifically what structure we want to conform to.

By employing a style of experiment method, principally the whole the probabilities ought to be done before the best performance will be completed. The number of tests will increase quickly Sood et al. (2016) mentioned the result of many factors on the geometrical accuracy exploitation style of Experiment (DoE) ways and located vital factors and best parameter settings to reduce geometrical deviations. Mohamed et al. (2016) discerned an outline of current investigations geared toward geometrical accuracy. For additive producing, the specified realistic geometrical tolerance values are presently not well-known. The abovementioned literature demonstrates an outsized variation in discovered geometrical deviations for FDM. These variations will most likely be explained by the used producing boundary conditions. This emphasizes that reliable and comprehensive data concerning

geometrical tolerances is hardly well-known - neither in literature nor in standards. Thus, inside this investigation, a technique to look at dimensional deviations and to derive realistic tolerance values for additive producing was developed.

Despite their area unit much-published works on optimizing the method parameters for AM, solely a number of discussing the overall impact of the method parameters, notably the influence of the extrusion temperature on the mechanical properties. To boot, the body of knowledge lacks the understanding of fashion improvement for FDM parts for prime repeatability and dimensional accuracy. Thus, a scientific means that of labor the influence of the method parameters is needed. This work focuses on work the impact of each parameter on a private basis at heaps of levels than previous work can urge a clearer understanding of those effects. Therefore to evaluate the impact of method parameters over the dimensional accuracy and repeatability all the written specimens were measured and compared to the designed CAD model. In total, the study boxed in 9 measurements for each specimen that incorporated the overall length (OL) of the specimen, the whole breadth (OW), the thickness (T) and breadth (W) of the part.

The analysis was done by Taguchi approach that is assisted by Minitab Software. The parameter selection or the factors for this studied are support angle, layer resolution, print pattern, fill spacing, print strength, and sidewalk layer to improve a good dimensional accuracy of the design. The material used is Acrylonitrile butadiene styrene (ABS).

1.2 Problem Statement

3D printing is a method similar to “standard” printing with multiple layers of “ink” printed on top of one another to produce a solid object. In practice, conventional inks are too thin, so most printers use plastic material. Brown, E. (2014) says that the most common type

of 3D printer uses plastic that is heated and forced through a small nozzle. Thus, it is important to determine the right parameters of the 3D Printing machine in order to produce a part which can fulfill the desired specifications. There are basically few parameters which are important and will influence the specifications of the produced part, and these parameters are the print pattern, orientation, support angle, and sidewalk layer. The combinations of the different setting of the parameters will definitely produce parts with different specifications, thus the study of the suitable combination of parameters is necessary for optimum output produced.

1.3 Objective

The objectives of this project are:

i. To determine the optimal process parameter of FDM by using Taguchi approach.

ii. To evaluate the shrinkage value of printed parts on dimensional accuracy for Acrylonitrile butadiene styrene (ABS)

1.4 Project Scope

The scope of this project is specifically to design the part by using SolidWorks and make a pattern out of it using the Cube Pro 3D printer. For the material required to produce the part model is ABS. The result data will be tabulated and analyzed using Minitab software.

1.5 The significance of the Project

Acrylonitrile Butadiene Styrene (ABS) is a useful alternative of thermoplastic resin commonly used to produce patterns for a 3D printer. The finding of this study will have benefits to the reduction in production lead-time and cost for Acrylonitrile Butadiene Styrene material.

1.6 Project Planning

The Gantt charts are used as a tool for planning and scheduling operations involving experimental research. On the other hand, charts are easy to construct and understand. The Gantt chart for this project is shown in Table 1.1.

Table 1.1: Gantt chart for Project Planning

PROJECT GANT CHART																																							
Project Activity	**2018**																			**2018/2019**																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1.Title Registration	**BP Briefing**							**Mid Term Break**							**Study Week**	**Final Semester Examination**		**Semester Break**											**Mid Term Break**					**Study Week**	**Final Semester Examination**		
2.Research on project																																							
3. Literature Review																																							
4.Abstract																																							
5.Introduction																																							
6.Methodology																																							
7.Design the Part																																							
8.Print the part																																							
9. Measure the part and collect data																																							
10. Analyze the result																																							
11.Documentation update																																							
12.Report writing																																							

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

A literature review is a significant process of evaluating and research information on the studies. The sources of the literature review are obtained from the journals, books, and electronic resources. All of the information is based on historical data, manufacturing method and past studies that related to this study. The purpose of this chapter is to explain the history of the additive manufacturing system, 3D printer fused deposition modeling, the process of the 3D printer. In this chapter also, will explain all the theory and implementation of the components regarding the project to achieve the project objective in detail. All the journal article, book, and valid internet that has been taken are about the rapid prototyping, the 3D printer processing, about the Taguchi Method system, the parameter of Fused Deposition Modelling of the previous research.

2.1 Background History

2.1.1 Rapid Prototyping

According to the Sood et al. (2009), the term speedy prototyping relates to a speedily growing vary of machine-controlled machines or approaches like stereolithography (SL), coalesced Deposition Modelling (FDM), selective optical

maser sintering (SLS), laminated object producing (LOM), and so on. The fabricate three dimensional (3-D) solid object from CAD info robotically while not victimization tooling and bottom human intervention.

Vishwas et al. (2017) confirm that fast prototyping may be a technology for the creation of parts the usage of CAD details. In preference to ancient techniques that trust reductive methods, RP strategies rely on as well as materials that are appropriate methods for the component creation. Thanks to some favorable circumstances, RP has forced the massive plan of collection additives to cater to the desires of consumer's associate degreed speedy changes in less time and have an aggressive half over others.

Mohd Nazri Ahmad et al. (2018) the rapid growth of interest in the Taguchi method has led to numerous applications of the method in a world-wide range of industries and nations.

Carneiro et al. (2015) think that fast prototyping represents a brand new area of the prototyping method evolution. With the final advances, it's far now possible to build bodily fashions quicker and with more complex geometries, pushing this type of techniques from printing mock-ups and prototypes models towards printing very last merchandise in restrained series.

Lieneke et al. (2016) say that addictive manufacturing emerged for the first time in the Nineteen Eighties and has mostly been used for speedy Prototyping considering that then. similarly, traits grew to become the processes into a generation capable of producing. In current years, the additive production of cease-use elements accelerated appreciably this is known as rapid manufacturing.