PARAMETER OPTIMIZATION IN 3D PRINTER RECYCLE MACHINE

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DECLARATION

I declare that this project report entitled ―Parameter Optimization in 3d Printer Recycle Machine" is the result of my own work except as cited in the references

Signature : ....

Name : ....

Date : ....

APPROVAL

I hereby declare that I have read this project report 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 : ....

Date :..

DEDICATION

To my beloved mother and father, and those who always support me.

ABSTRACT

3D printing technology has evolves rapidly to becoming one of the most postulate method in manufacturing process. Commonly, standard manufacturing process which is subtractive that produces a lot of waste opposite to 3D printing technology is way friendly to the environment. Application of additive manufacturing method in 3D printing leads to less or no wasted materials. For this promising technology, it still developing especially when there are lots of open source medium for people to access and discover the 3D printing technology. There is always a problem in every human-made creation. As for 3D printing, consumption of plastic materials has significantly increased due to high demand in market. In order to minimize the negative impact of plastic waste to the environment, a machine of recycle 3D printing has been made and a study on parameter optimization on 3D printer recycle machine have been done. By using Minitab software, analysis has been made on the factor of parameter of recycle 3D printing. From that analysis, Taguchi method suggests some of experiment to do and give an optimal value for each parameter that need to optimize in extruding operation. After the optimal value obtained, percentage of error diameter of new filament has been calculated. Analysis of extruded filament was done for every 30cm with minimum of three repetitions. In comparison of the new extruding filament and original filament show that some minor difference of the mechanical properties by using tensile test method. Percentage of error for diameter of filament indicates 1.77mm diameter with 1.14% as the lowest error while diameter of 1.82mm with 4.00% as the highest error. This show that optimization on 3D printer recycle machine has done by get the percentage of error below than 5% and it gives hope for future improvement in this project of recycling waste of ABS polymer.

ABSTRAK

Teknologi percetakan 3D telah berkembang pesat untuk menjadi salah satu kaedah yang paling pasif dalam proses pembuatan. Biasanya, proses pembuatan yang biasa menghasilkan banyak sisa berbeza dengan teknologi percetakan 3D adalah mesra alam sekitar. Penggunaan kaedah pembuatan bahan tambahan dalam percetakan 3D membawa kepada kurangnya atau tiada bahan terbuang. Untuk teknologi yang canggih ini, ia masih berkembang terutamanya apabila terdapat banyak medium sumber terbuka bagi orang untuk mengakses dan menerokai teknologi percetakan 3D. Selalunya akan ada masalah dalam setiap ciptaan buatan manusia. Bagi pencetakan 3D, penggunaan bahan plastik meningkat dengan ketara berikutan permintaan yang tinggi dalam pasaran. Untuk meminimumkan kesan negatif sisa plastik ke alam sekitar, mesin pencetakan kitar semula 3D telah dibuat dan kajian terhadap pengoptimuman parameter pada mesin daur ulang pencetak 3D telah dilakukan. Dengan menggunakan perisian Minitab, analisis telah dibuat berdasarkan faktor parameter pencetakan kitar semula 3D. Dari analisis itu, kaedah Taguchi mencadangkan beberapa percubaan untuk dilakukan dan memberikan nilai optimum untuk setiap parameter yang perlu dioptimalkan dalam operasi penyemperitan. Selepas mendapatkan nilai optimum, peratusan diameter ralat filamen baru akan dikira. Analisis filamen tersemperit dilakukan untuk setiap 30cm dengan minimum tiga ulangan. Sebagai perbandingan filamen tersemperit yang baru dan filamen asli menunjukkan bahawa beberapa perbezaan sifat mekanik dengan menggunakan kaedah ujian tegangan. Peratusan ralat untuk diameter filamen menunjukkan diameter 1.77mm dengan 1.14% sebagai kesilapan terendah manakala diameter 1.82mm dengan 4.00% sebagai ralat tertinggi. Ini menunjukkan bahawa pengoptimuman pada mesin kitar semula pencetak 3D telah dilakukan dengan mendapatkan peratusan kesilapan di bawah 5% dan memberikan harapan untuk peningkatan di masa depan untuk projek kitar semula bahan buangan polimer ABS.

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RP	-	Rapid prototyping
PLA	-	Polylactic acid
ABS	-	Acrylonitrile butadiene styrene
€	-	Modulus young's
^{o}C	-	Temperature
%	-	Percentage
S/N	-	Single to noise
Ŋ	-	Single to noise ratio
Y	-	Variance
mm	-	Millimeter
w	-	Power
m/s	-	Velocity

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CHAPTER 1

INTRODUCTION

1.1 Background

In today's era, technology evolves rapidly from day to day. Rapid prototyping (RP) or mostly known as 3D printing is a good example of growth manufacturing technology which just not increase production rate but also saves time consumption and overall cost including cutting down labor cost. There are a lot of advantages in 3D printing such as low material using. That is because Rapid prototyping technologies are able to produce complex physical model in a layer by layer. Before we can successfully manufacture a batch of zero defect product, there is always some reject of final products due to human error or technical error. Due to this, there will be a bunch of 3D printed material waste.

Plastic filament is available in a variety of types of material, colours, diameters and lengths. Two types of materials commonly used as filament for 3D printing which are known as Polylactic Acid (PLA) and Acrylonitrile-Butadiene-Styrene (ABS). Both of the materials are plastic based and easy to melt once it is exposed to heat. 3D filament is the basic consumable resource that most types of 3D printers use for printing. As a traditional printer needs ink cartridges in order to print, 3D printers need plastic filament. Most of the filament produced today is from virgin, unused petroleum based plastic which generates not only increasing amounts of global waste but contributes to carbon emissions, resulting in significant environmental damage. That is why it is necessary to recycle the rejected products to prevent waste and to achieve cost effective production in 3D printing technology.

In market there are many type of 3d printer recycle machine even we can make it our own. There some important parameters in 3d printer recycle machine such as material, pressure and temperature. Usually, the aim for this project is mainly to optimize the parameter of 3D printer recycle machine which could significantly make a new filament. Those can be achieved by recycling failed prints of 3D project by shredding and extruding process into new filament.

1.2 Problem Statement

In this project, existing low cost 3D printing machine which is called Mendel 3D printer is used as reference model. This machine is built by using open source technology. The filament is quietly expensive because the materials are mixture of petroleum-based and plant-based source and this are not biodegradable material. That is why technology on recycle device for filament is elevating. So there goes production of several 3D printer recycle machines by different companies. But, none of them are integrated recycle machine which can be attached to the 3D printer. Due to that, a project for integrated 3D printer recycle machine had been developed as shown in Figure 1.1.

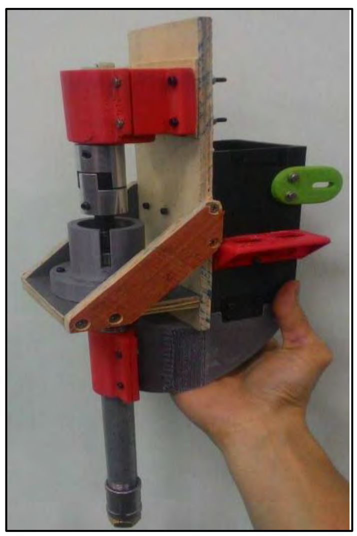

Figure 1.1 : Integrated 3D printer recycle machine

However, the current machine was too small and the size of filament been extruded does not achieve the standard and consistent filament size. The other limitation is the machine is too heavy to be attached to the 3D printer. Therefore, this latest project is about to design a new and improved 3D printer recycle machine to overcome those problems. Make a parameter optimization based on 3D printer recycle machine.

1.3 Objective

The objectives of this project are as follows:

1. To optimize the parameter in 3D printer recycle machine by measuring a new recycle filament.
2. To analyze the parameter in 3D printer recycle machine by using Taguchi method application in Minitab software.
3. To make a comparison of mechanical properties with two different filament by using tensile test method.

1.4 Scope of Project

The scopes of this project are:

1. Minitab software will be used in analyze parameter in 3D printer recycle by using Taguchi method.
2. The new recycle machine will implement the similar working principle of the previous one.
3. Optimization based on previous one 3D printer recycle machine.

CHAPTER 2

LITERATURE REVIEW

2.1 3D Printing

3D printing is a common method being used in rapid prototyping technology. It is basically used to manufacture plastic parts used for concept visualization or even final parts. (Bak, 2003) state that during future dramatic increase within the application of 3-d printing generation. In addition, manufacturers in various industries already implement the use of 3D printing due to its efficiency and faster rate of production. These mean that 3D printing is on rising demand for production line.

To ensure faster progress on the improvement of 3D printing technology, open source platform such as RepRap is the one with low cost of investment needed compared to others. RepRap are the most commonly used 3-D printers (Moilanen & Vadén, 2012). There are various model of open source for low cost 3D printer such as Prusa i3 and delta. To considerably abbreviate the ideal opportunity for creating patterns, molds, and models, some manufacturing ventures have begun to utilize fast prototyping strategies for complex patterns making and factor prototyping (Yan & Gu, 1996).

As the benefits of 3D printing have lured many developers and manufacturers to use it, this situation results the high volume of filament usage for printing. That is why this state has leads inventor to develop waste recycle system for low cost 3D printing so that the waste can be put into used without having to spend so much money to buy new set of filaments.

2.2 Recycle System Integration

As the demand on the low cost 3D printing seems to reach the extravagant level due to its ability to just not only work efficiently but also cheap and reliable, has cause the high request on the building materials. Devices which can recycle material and help slow the depletion of natural resources and make engineering and manufacturing a more ecological-friendly practice are very beneficial in the industry (Rensberger & Hinora, 2016). That is why a recycle system for plastic waste is required.

In addition to the system, extrusion principal is needed to extrude the filament produced by the recycle system. They made use of the similar principle to injection moulding that used screw, which in their cases was to force the material into the barrel with heating element and then plastic was melted before being compressed and driven through a die (Rensberger & Hinora, 2016). To be clear, those initial projects are not integrated with low cost 3D printing. They made the recycle machine that extrude new filament separately. Besides, the plastic shredder and filament extruder are disassociated from one another for the recycle system. This will cause more time being consumed due to the need to handle separate machines one after another. Thus, this method does not comply with the requirement for integrated recycle machine with low cost 3D printing.

To meet the objective of having an integrated recycle machine on a low cost 3D printing, (Ramli *et al.* 2015) came out with a concept system. The concept was about low cost 3D printers that are integrated with a plastic waste recycle machine which can produce filament with only one cycle of process. In addition, the cost of feedstock for 3D printing were reduced along with the energy used because of the proposed system did not use filament, but fed directly from the shredded plastic waste as the source of the recycle machine.

2.3 Parameter Optimization

In order to optimize manufacturing process, there are several important criteria need to be an attention. Different strategies have been utilized to improve this procedure, for example, genetic algorithm, geometric programming, geometric plus linear programming, disperse seek strategy, and reaction surface system. For 3d printer recycle machine, the important parameter need to optimize is their pressure, temperature and the material using. (Udroiu & Nedelcu, 2011) say that some extruding parameters must be optimized, such as pressure, temperature control and material consumption.

2.3.1 Taguchi Method

Genichi Taguchi, Japanese engineer proposed the Taguchi method is an advancement approach that contains exploratory outline and factual examination to enhance the item quality by coordinating quality control at the planning stages (Shrestha & Manogharan, 2017). This strategy accomplishes by making the item or process execution coldhearted to varieties in components, for example, materials, manufacturing hardware, workmanship and working conditions. The fundamental objective is to present the impact or advantage of the procedure as a component of certain plan factors with a general target to amplify or limit the estimation of the capacity inside the manufacturing procedure. Figure 2.1 show example table of Taguchi method included the parameters.

Figure 2.1: Example of Taguchi method table (Shrestha & Manogharan, 2017)

Table I. Printing parameters with their ranges and values at three levels

Parameter design	Printing parameters	Range	Level 1	Level 2
A	Saturation	35–100%	35	70
B	Layer Thickness	80–120 μm	80	100
C	Roll Speed	6–14 mm/s	6	10
D	Feed-to-Powder Ratio	1–3	1	2

2.4 Injection Moulding

Injection moulding is a manufacturing technique for making parts from thermoplastic and thermosetting materials. Injection moulding can be referred as a process to solidify molten material inside a mould. This process is basically using screw mechanism that pushes the material through the cylinder with heating element into the mould. Various materials can be used with injection moulding depending on the required product to produce and this manufacturing method is suitable and reliable. Various issues identifying with cost, exactness, and quality of 3-D items should be overcome before this innovation can accomplish across the board appropriation. (Sherman, 2009) stated that in terms of cost, materials suitable for 3-D printing can run 10 to 100 times more than typical injection molding thermoplastics.

2.4.1 Process Elements

The fundamental process for injection moulding is part formation in the mould cavity from injected molten polymer that is compressed and forced into a die after being compressed inside the heated barrel (Berman, 2012).

There are four significant units involve in the injection moulding process which are hopper, injection unit, control unit and the clamp unit. Hopper is mainly to shred material into little pieces or bits before being melted in the injection unit. In the injection unit, there are heating and melting elements followed by pumping and material injection into the mould cavity. Then the control unit has the task to monitor and control the injection unit. Finally the clamp unit that has ejecting plate is used for clamping the mould and ejecting solidifies material inside it. Another source states that 3-D printing is competitive with plastic injection molding of runs around 1,000 items (‗Print Me,'' 2011).

Figure 2.1 illustrates the units involved including the important units for single stage screw machine in injection moulding process.

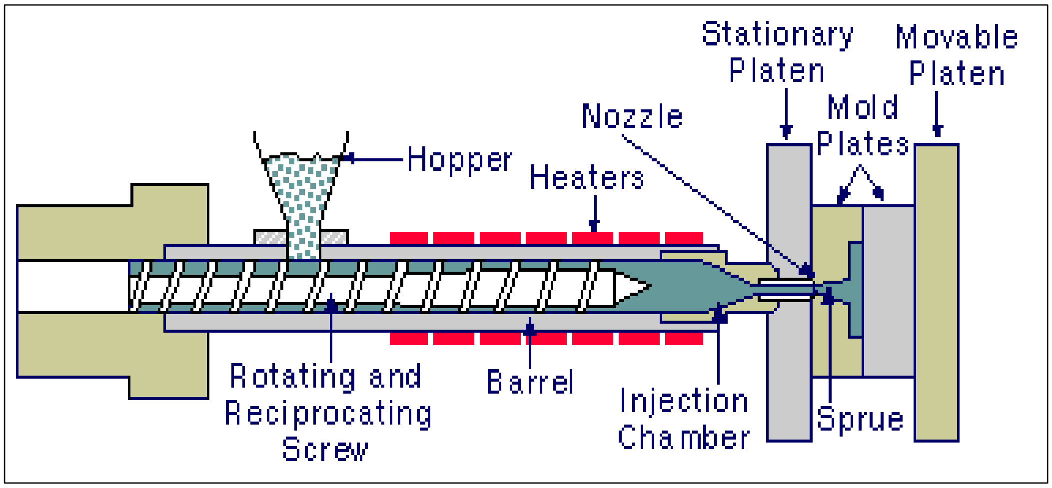

Figure 2.2: Single Stage Screw Machine (*dc.engr.scu*)

2.5 Filament

As we know 3D printing is additive manufacturing that build a product layer by layer by using plastic as their raw material that call filament. There are two types of filament that are commonly being used in 3D printing which are Polylatic Acid (PLA) and Acrylonitrile butadiene styrene (ABS). There are lots of materials that had been explored for 3D printing because of its characteristic which is thermoplastic. Two recent open-source equipment innovative improvements, 3-D printers and RecycleBots, offer another way to deal with polymer reusing enveloping the potential for disseminated handling to high-value included items. (Kreiger *et al.,* 2014) stated that this can reverses the historical trend towards centralized recycling facilities. Commercial 3-D printers, which allow for accurate fabrication of merchandise or scale fashions, are a beneficial production and design tool.

Manufacture of feedstock with RecycleBots from post-purchaser plastic likewise can possibly reduce the natural effect of 3-D printing, and may give a motivating force to conveyed, in-house reusing of plastic (Pearce *et al.* 2010).