



CONFERENCE PROGRAMS AND ABSTRACT

**The 3rd FIRST 2019 INTERNATIONAL CONFERENCE
FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY
OCTOBER 09-10, 2019
*Palembang, Province of South Sumatera
Indonesia***

Organized by :



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PREFACE

The 3rd FIRST 2019 (Forum in Research, Science, and Technology) International Conference was initiated and organized by State Polytechnic of Sriwijaya in collaboration with Management and Science, University (MSU), Malaysia and National Chin-Yi University of Technology, Taiwan. The theme of the conference was “Integration of Advanced Technology to Enhance Social Welfare”. The 3rd FIRST 2019 International Conference facilitated the participants from all over the world to meet face to face to open chances in establishing connection and collaboration among them. It was not only for the researchers in academics, but also in industries and governments. This conference became an effective media to link the researchers from many parts of the world conference, for exchanging, sharing, following up and discussing the results of the latest research, industry’s needs, and government regulatory policies. The 3rd FIRST 2019 International Conference became worthwhile platform for researchers to present their finding in the areas on multidisciplinary of Engineering and Science (Track 1), Computer Science and ICT (Track 2), and Social Science (Track 3). It has also provided an opportunity for the professionals and researchers to learn and share about the latest development and research in those 3 tracks.

The 3rd FIRST 2019 International Conference attracted so many authors not only from Indonesia but also from other countries, such as Japan, Taiwan, and Malaysia. There were 180 papers were accepted in the 3rd FIRST 2019 International Conference, including 89 papers for Track 1 (Engineering and Science), 46 papers for Track 2 (Computer Science and ICT), and 45 papers for Track 3 (Social Science). In The 3rd FIRST 2019 International Conference, there were 4 keynote speakers and 2 invited speakers. As the keynote speakers, there were Prof. Yasushi Kiyoki, Ph. D from KEIO University, Japan, Prof. Nurul Taufiqu Rochman, M. Eng, Ph. D, From LIPI, Indonesia, Prof. Tjiptohadi Sawarjuwono, M. Ec., Ph. D., Ak, from Universitas Airlangga, Indonesia, and Prof. Win-Jet Luo, from National Chin-Yi University of Technology, Taiwan. As the invited speakers, there were Dr. R. Wisnu Nurcahyo, DVM from Universitas Gadjah Mada, Indonesia, and Assoc. Prof. Dr. Intan Zaurah binti Mat Darus from Universiti Teknologi, Malaysia. The 3rd FIRST 2019 International Conference committee would like to say thank you very much for all the participants and their respected institutions that have supported for the success of the 3rd FIRST 2019 International Conference, and also for all of the guess and sponsors of the 3rd FIRST 2019 International Conference.

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The Effect of Parameters on the Process of Making Objects with Rapid Prototyping Digital Light Processing Technology on the Bending Stress

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Abstract. The world is currently entering the era of the industrial revolution of 4.0. The era in which the occurrence of disruptive technology. The main purpose of this existence of the industrial revolution to create stability in the distribution of goods and necessities. Broadly speaking, there are some benefits that can be posed by the presence of the industrial revolution 4.0 is encouraging research, customization, and optimization. In addition, there are several challenges to be faced in the industrial revolution was the first IE 4.0 security, the second is the capital, and then a third that is employment, and the fourth is privacy. A method that can respond to these challenges is additive manufacturing using SLA-DLP 3D Printing. The making of objects utilizing CAD data that have been made in advance. This research aims to know the effect of object making process parameters with digital light processing rapid prototyping technology on bending stress. The parameters investigated is the layer thickness and the exposure time. Test specimens made of a material with liquid photopolymer resin refer to ASTM D 790 using SLA-DLP 3D Printer. Measurement results in data analysis using ANOVA design with type 2 factorial design model and level 1 factorial interactions assisted by software Design Expert trial version. The results of the ANOVA is known that factors significantly ($\alpha = 0.001$), to effect of object making process parameters with digital light processing rapid prototyping technology on bending stress., that are the layer thickness=10%, exposure time=2%, interaction layer thickness and exposure time=87%.

1. Introduction

In 1981, Hideo Kodama of the Nagoya Municipal Industrial Research Institute discovered two AM (Additive Manufacturing) methods of fabricating three-dimensional plastic models with photo-hardening polymers, where mask patterns or fiber scanning transmitters controlled UV (Ultraviolet) exposure areas up to along with the times made a printer that can print with a three-dimensional perspective. Charles Hull (1984) created the theory of stereolithography, a printing process that allows real 3D objects to be created from digital data. This technology is used to create 3D models from Drawings and allows users to test designs before entering into the manufacturing program.

3D Systems produced the first time an SLA (Stereolithographic Apparatus) machine in 1992. The process of the machine uses a UV (Ultraviolet) laser in compacting photopolymer, a liquid with viscosity and color that makes three-dimensional sections layer by layer. The raw material used for making 3D objects with SLA technology is called a photopolymer liquid resin made from a mixture of chemicals. Although not perfect, this machine proves that very complex parts can be produced overnight. In its



process, SLA itself has parameters that can be classified into several main sections, namely supporting parameters, and recoat parameters. The main parameters are also divided into several parts again, namely layer thickness, exposure time, the hatch spacing, the fill spacing, the hatch overture, the border overture, and the fill cure depth. Parameters are the part that significantly influences the accuracy and strength of each layer during the printing process, so the selection and setting of these parameters are significant.

2. Literature review

Computer-Aided Design is computer software for drawing a product or part of a product. The product you want to draw can be represented by lines or symbols that have a specific meaning. CAD can be in the form of 2-dimensional, 3-dimensional, and solid modeling. Starting from replacing the function of the drawing table CAD software has now evolved and integrated with CAE (Computer-Aided Engineering) and CAM (Computer-Aided Manufacturing) software. Integration is possible because CAD software is currently a product/component design application in the form of stable and surface modeling. Solid models allow us to visualize the components and assemblies that we make realistically. Also, the model has properties such as mass, volume, a center of gravity, surface area, and etc. Some CAD software used in Indonesia is Alias, CATIA, Autodesk Inventor®, Pro / ENGINEER®, Parasolid®, SolidWorks™ and Power Shape, and UGS NX [1]

3D printing is a form of additive manufacturing where a three-dimensional object is formed by adding material layer by layer. The initial step of 3D printing is to make a digital model of the object to be printed. This digital modeling usually uses Computer-Assisted Design (CAD) software or uses online services provided from the 3D printing platform. 3D scanners can also be used automatically to create models from existing objects (such as 2D scanners). Besides 3D scanners that are still relatively expensive (\$ 949), smartphone applications can also be used to create 3D models such as Autodesk 123D Catch [2].

3D printing can use a variety of materials, both liquid, solid, or powder. Some of the processes commonly applied in 3D printing technology are Stereolithography (SLA), Selective Laser Sintering (SLS), Digital Light Processing (DLP), Fused Deposition Modeling (FDM), Selective Laser Melting (SLM), and Electron Beam Melting [3]. At present, materials commonly used for 3D printing are plastic (ABS, PLA, Nylon), metal alloys, ceramics, wood particles, salt, sugar, and even chocolate are also used for printing. 3D printing has enormous advantages and potentials. With 3D printing, various types of goods can be made with free and complex geometry without the constraints of the manufacturing process [4]-[6].

The use of 3D printing covers a variety of fields and is continuously evolving. Current uses of 3D printing include molds, parts, tools, health (teeth and organs), food, art [7], prototypes [8], clothing, furniture, music instruments, toys, and other 3D printers. At the beginning of its emergence, 3D printing was dedicated to the manufacturing process, but the development of this technology was increasingly widespread use. Nowadays, 3D printing is widely used by SMEs (Small and Medium Enterprises) and individuals. The price of 3D printing is getting cheaper so that it can increase reach various circles. The following table 1 explains the development of 3D printing from its initial appearance to the present.

In the late 1960s, many computer-controlled machine tools began to emerge in factories as the latest innovations in efficient manufacturing of mechanical parts [9]. These tools can complete manufacturing tasks with greater accuracy and consistency than can be achieved manually, but they must be programmed every time a new part needs to be built. Correspondingly at the University of Rochester engineering professor Herbert Voelcker developed mathematical theories and initial algorithms that formed the basis for computer programs that design machine parts including how to determine the inner surface in three dimensions [10]. Voelcker is very interested in automating processes that will take data from computer programs to computer programs that are controlled by new machine tools. Much work became Voelcker's operational standard throughout the 1970s in terms of how mechanical parts were designed.

This work eventually led to the development of a Computer-Aided Design (CAD) software program as it is known today. The first rapid prototyping method was discovered in 1986 in California, USA, namely the Stereolithography method [11]. Rapid prototyping can be defined as methods used to create a scale model (prototype) of parts of a product or product assembly quickly by using three-dimensional Computer-Aided Design (CAD) data. Rapid prototyping allows the visualization of a three-dimensional image into an original three-dimensional object that has a volume.

Table 1. The development of 3D printing in the world

Year	Development
1980	The first patent for Rapid Prototyping by Dr. Kodama
1986	The first patent for SLA (stereolithography) by Charles Hull
1987	The appearance of the SLA-1 Machine
1988	SLS technology patent by the University of Texas, Carl Deckard
1990	The emergence of the EOS Stereos system (SLS technology for plastics and metals)
1992	FDM (<i>Fused Deposition Modelling</i>) patent
1993	Solids cape discovery
1999	The use of 3D printing in the health field
2000	Making kidney print 3D
2005	Launch of Spectrum Z510, the first 3D printing on the market with high definition color
2006	The open-source project starts
2008	The first 3D artificial prosthesis
2009	FDM patent in the public domain
2010	The first 3D prototype car show (Urbee)
2011	<i>Cornell University began making 3D food printers</i>
2012	The first prosthetic jaw is printed and implanted
2013	Chinese researchers began to print ears, liver, kidneys with living cells, and are developing so they can print functioning organs in the next 10-20 years.
2016	Daniel Kelly's Lab can print 3D bones

Uses ultraviolet light to freeze the surface of the photopolymer with STL format instructions. The process continues layer after layer until the parts are formed. In the SLA technique, a prototype is made by firing a laser beam at the surface of a container (vat) that contains a liquid photopolymer (resin). This liquid will immediately harden when the laser hits the surface. After one layer is finished, a platform is moved down a few millimeters, a recoated blade cleans remnants of resin on the surface, and the next layer is worked on top of the completed layer.

DLP (Digital Light Processing) technology uses a digital micromirror device that reflects and focuses UV (ultraviolet) light on the surface of photoreactive materials that polymerize layer by layer. [12]

Design of Experiments can be interpreted as an experimental design carried out through planned changes to the input variables of a process or system so that causes and factors can be traced to bring about changes in output in response to experiments that have been conducted [10]. In general, experiments are used to study the performance of processes or systems that are usually visualized, such as a combination of machines, methods, people, and other resources. Because it is necessary to use a statistical approach that is applied to the experimental process, the experimental design aims to obtain or collect as much information/data as needed and is useful in conducting research on the issues to be discussed. Research should also be carried out as efficiently as possible, given the time, cost, energy, and materials that must be used.

3. Methodology

The method used in this study includes literature, design, and experimental studies of SLA-DLP 3D printing objects. This research was conducted at the CNC Laboratory of the Department of Mechanical Engineering of the State Polytechnic of Sriwijaya. *Fabrication of tensile specimen*

In this research, 3D printing with DLP (Digital Light Processing) technology is used. Where the object is produced from photopolymer (resin) material, the reason for using that material is to get better 3D printing object detail. Test specimens were made using ASTM D 790 standardization, as shown in Figure 1.

The purpose of this test is to obtain the effect of the parameters of the process of making objects with rapid prototyping digital light processing technology on bending stress, so that the resulting product is by design, especially in terms of material bending strength. Also, the resulting data were analyzed to determine the factors that influence the bending stress on the parameters (layer thickness and exposure time) of the process of making objects with rapid prototyping digital light processing technology.

To make SLA-DLP 3D printing object test specimens, it is carried out in 3 stages :

- Design 3D models using CAD software
- Slice and export 3D models using Creation Workshop software
- Perform 3D object specimen model testing using the SLA-DLP 3D Printer tool. In making test specimens fixed factors (parameters) are fixed, and parameters are controlled, the fixed parameters are shown as in Table 2, and the controlled factors are as in Table 3.

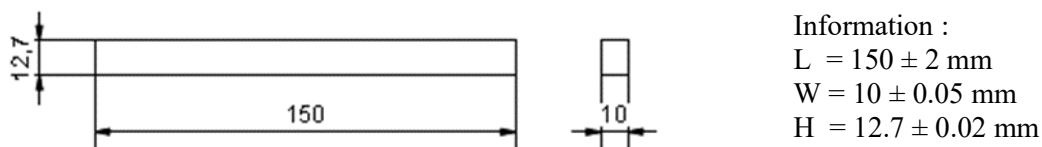


Figure 1. Standard test specimens

Table 2. Fixed factors in making test specimens

No	Parameter	Value	Unit
1	Off Time	1	s
2	Bottom Exposure	50	s
3	Bottom Layers	8	
4	Z Lift Distance	4	Mm
5	Z Lift Speed	3	mm/s
6	Z Retract Speed	3	mm/s

Table 3. Controlled factors in making test specimens

Parameter			
Layer Thickness	Exposure Time		Unit
0.05	10	12	mm
0.07	10	12	s

Analysis of test data using the analysis of variance (Two-Way ANOVA) with 2 level factorial design experimental methods, using 2 (two factors) and 1 (one response) supported by Design-Expert® Trial Version software. Data obtained from further testing are analyzed with ANOVA, which aims to test the hypothesis (H_0) that the average of two or more populations is the same. The concept of variance analysis is based on the concept of the F distribution and can be applied to analyze the relationships between the various observed variables. In statistical calculations, analysis of variance is strongly

influenced by the assumptions used such as normal distribution, identical (homogeneity of variance), independent (freedom from error), and linearity of the model. The normality assumption of distribution explains the data characteristics of each group [10].

Two-Way ANOVA (analysis of variance) in this study is used to determine whether there is an effect of the difference between several independent variables (factors) with the dependent variable (response) and each variable has two levels (level). To determine the effect of variables on the response, then the ANOVA needs to be calculated the sums of squares. In this study, as for the tools and materials used, namely:

- a) Autodesk® Inventor® Professional 2019 software, 64 Bits Educational Version
- b) Creation Workshop software version 13 Beta, 64 Bits for SLA-DLP 3D Printing Slicing and Control
- c) Design-Expert® Trial Version software
- d) 3D printing with Rapid Prototyping Digital Light Processing technology
- e) Laptops
- f) Bending test equipment, Hung Ta Type HT 9502
- g) Liquid Photopolymer Resin

4. Results and Discussion

After testing the test specimen, obtained test data to be analyzed, so that known factors that influence bending stress, can then be determined an optimization of parameter combinations to get the value corresponding to the results of production using a 3D Printer with rapid prototyping digital light processing technology.

To determine the effect of factors on the response value of the test specimens, data analysis of bending test results was carried out using analysis of variance (Two-Way ANOVA) with 2 level factorial design methods, using 2 (two factors) and one response. Specimen testing is done randomly according to the measurement design matrix in Tables 4 and 6, with three replications so that 12 test specimens are produced. After testing the test specimen as shown in Figure 2, the test results obtained the minimum, maximum, average, standard deviation and the ratio of each response and factor on the test, shown in Table 5.

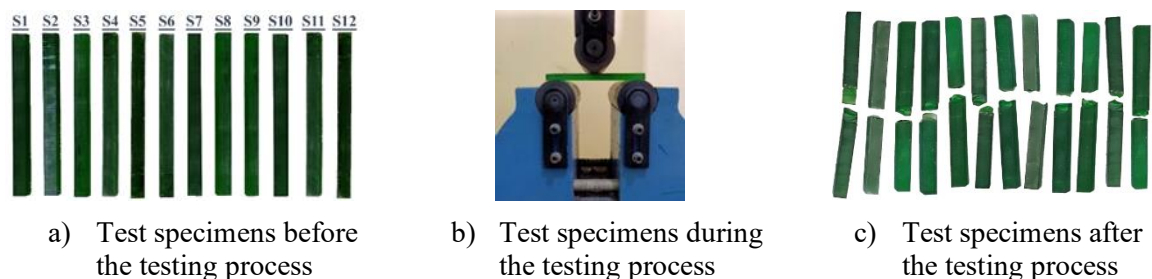


Figure 2. Test specimen process

Table 4. Bending test results with 3 replications

Factor 1		Factor 2		Response 1
Std	Run	A: Layer Thickness (mm)	B: Exposure Time (s)	Bending Test (Kg/mm ²)
2	1	0,05	10	4,83
7	2	0,05	12	6,36
8	3	0,05	12	6,4
4	4	0,07	10	5,98
12	5	0,07	12	3,77
3	6	0,05	10	4,78
1	7	0,05	10	4,66
11	8	0,07	12	3,79
6	9	0,07	10	6,01
10	10	0,07	12	3,75
9	11	0,05	12	6,38
5	12	0,07	10	6,05

Table 5. Mean, standard deviation, and the ratio of specimen test results

Factor	Name	Units	Type	Subtype	Min	Max	Coded	Values	Mean	Std. Dev.
A	Layer Thickness	mm	Numeric	Continuous	0,05	0,07	-1,000=0,05	1,000=0,07	0,06	0,0104447
B	Exposure Time	s	Numeric	Continuous	10	12	-1,000=10	1,000=12	11	1,04447

Response	Name	Units	Obs	Analysis	Min	Max	Mean	Std. Dev	Ratio	Trans	Model
R1	Uji Bending	Kg/mm ²	12	Factorial	3,75	6,4	5,23	1,0827	1,70667	None	2FI

Obtained graph data from Table 4 during random testing, as in Figure 3 as follows :

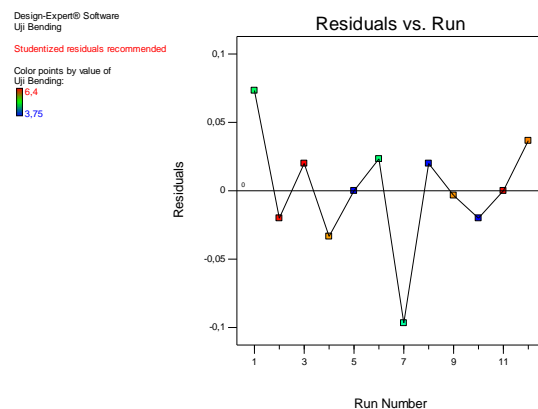


Figure 3. Residual graph independent of bending stress values

From the test data in Table 4 and Table 5, it can be analyzed the influence of the factors on the bending stresses of test specimens made using rapid prototyping digital light processing technology with analysis of variance (ANOVA), which is assisted with the Design-Expert® Trial Version software. The results of the ANOVA are shown in Table 6, as follows:

Table 6. ANOVA results from the bending stress test specimens

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	12,88	3	4,29	1775,90	< 0.0001	significant
<i>A-Layer Thickness</i>	1,37	1	1,37	568,40	< 0.0001	
<i>B-Exposure Time</i>	0,29	1	0,29	119,30	< 0.0001	
<i>AB</i>	11,21	1	11,21	4640,00	< 0.0001	
Pure Error	0,019	8	2,417E-003			
Cor Total	12,89	11				

The Model F-value of 1775,90 implies the model is significant. There is only a 0,01% chance that an F-value this large could occur due to noise.

Values of "Prob > F" less than 0,0500 indicate model terms are significant. In this case, A, B, AB are significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model.

From the ANOVA calculation results that are assisted by Design-Expert® Trial Version software as shown in Table 6, it can be seen that the biggest F_{value} is the thickness layer and the main factor that most influences the bending stress of the test specimen is the layer thickness. From Table 6, it can be concluded that there is a significant factor influencing the bending stress of the test specimen so that H_0 is rejected. By using equation, it can be calculated the percentage contribution value of each factor that affects the bending stress of the test specimen, i.e.

$$\text{Layer Thickness Factor} = \frac{(1,37-0,019)}{12,89} = 10 \%$$

$$\text{Exposure Time Factor} = \frac{(0,29-0,019)}{12,89} = 2 \%$$

$$\text{Interaction of layer thickness factor with exposure time} = \frac{(11,21-0,019)}{12,89} = 87 \%$$

In this study, it can be concluded that:

- It is known the effect of the parameters of the process of making objects with rapid prototyping digital light processing technology on the bending stresses of test specimens printed using additive manufacturing methods with the basis of liquid photopolymer resin.
- Known factors that significantly influence the value of bending stress, namely layer thickness = 10%, exposure time = 2%, the interaction of layer thickness and exposure time = 87%

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Acknowledgments

The authors acknowledge funding support from the Directorate of Research and Community Service of the Ministry of Research, Technology and Higher Education of the Republic of Indonesia through a Research grant (Institution: State Polytechnic of Sriwijaya) by contract number: 5512/PL6.2.1/LT/2019. The authors also regard thanks to all civitas academic State Polytechnic of Sriwijaya for motivation and help.



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