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Research Article

Experimental Study of the Effect of the Build Direction on the Compressive Strength of Components made of Fused Deposition Modeling (FDM) Method and a Three-Dimensional Printer

Alireza Asa[a*] , Saeid Abazary[b] and Abolfazl Masomi[a]

[a]School of Mechanical Engineering, College of Engineering, University of Tehran, Tehran, Iran.
[b]Department of Mechanical Engineering, Science and Research Branch, Islamic Azad University, Kermanshah, Iran.

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Abstract

Rapid prototyping technology capable of building prototypes for various models with different genus provides. This type of modeling component model and delivers a few hours .FDM rapid prototyping system, three-dimensional printers and rapid prototyping of commercial devices. Rapid prototyping methods are now becoming a very convenient and efficient method for small batch production requirements. In most of these methods require no initial investment cost of mold components as well. Strength of components made of fused deposition method and anisotropic three-dimensional printers are highly dependent on the parameter type of the parts are building them. These parameters include the build direction, fiber angle, air gap, width fiber and temperature measurement of model ....Is. Among the multitude of parameters, the most important parameter for the build direction and the fiber angle of the FDM is a three-dimensional printer. Experiments conducted in this study to measure the effects of the build direction on the mechanical properties of materials and components made of fused deposition modeling (FDM) and three-dimensional printer is. Based on tests performed with thawed sediment samples for layering axial compressive strength is equal to 42.37Mpa , which is 12.4% greater than the strength of the sediment sample is FDM with the transverse layering , as well as a three-dimensional printer for samples with a diagonal layering of most of the strength versus strength is 9.41MPa.

Keywords: *Rapid prototyping, fused deposition modeling (FDM), three-dimensional printer, the build direction*

1. Introduction

FDM process made of Stratasys company and three-dimensional printer made of Z company, examples of rapid prototyping technology was used to build the initial model. Among the multitude of parameters, the most important parameter for the build direction and fiber angle of the FDM process and the three-dimensional printer. It depends on the build direction, which means the unit starts operations components, For example, the flat surface of the bottom piece begins and the other components of its position on the surface (the CAD model of the part) is made. Or, for example, construction of one of the side effects and other components of the device are starting to be made. In the first place it stopped pieces from start to kind of reveals the build direction piece. In the first place it stopped pieces from start to kind of reveals layering piece. Angle of the fiber, the fiber orientation of the material is said the build direction (D.T Pham, R.S Gault ,1998; L. Li, Q. Sun, C. Bellehumeur, P. Gu,2002; J. P. Kruth ,1991). In Figure 1, different types of the build direction method is shown in three-dimensional printer. Experiments conducted in this study to measure the effects of the build direction on the mechanical properties of materials and components made of fused deposition method(FDM) and three-dimensional printer is. Based on tests performed with thawed sediment samples for layering axial compressive strength is equal to 42.37Mpa , which is 12.4% greater than the strength of the sediment sample is FDM with the transverse layering , as well as a three-dimensional printer for samples with a diagonal layering of most of the strength versus strength is 9.41MPa.

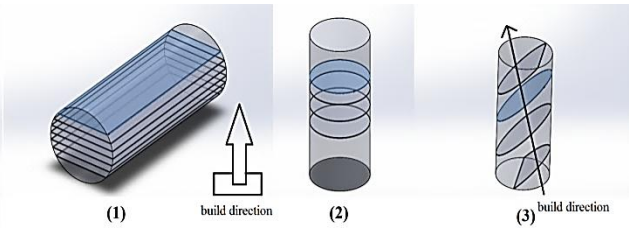

Figure 1. Different types of the build direction in samples made using a three-dimensional printer for axial layering (1), the transverse layering (2), the diagonal layering (3).

* Corresponding author: Alireza Asa

2. Fused deposition modeling (FDM)

Fused deposition modeling technique to speed quickly for a wide range of components are built. It was first produced in 1990 by Fast as a method Stratasys Company were shipped. Fused deposition modeling due to the low cost and high production speeds producers around the world are quickly addressed. In 2008, the company produced 44% of their deposition method has melted and the market has to offer. Currently, fused deposition modeling is becoming a very convenient and efficient method for the production batch and small is. In this piece, there is no need to make the initial investment, the cost of such fees is mold. Spare Parts for NASA enterprises to build their own space travel from a fused deposition modeler uses the International Space Station. Methods fused deposition process so that, in the first three-dimensional model of the fragment in a software CAD, is designed. Then, the model in STL format and then sent to the software Quickslice$_{TM}$. The software used in the fused deposition modeling. The software is able to map data components, fused deposition modeler to control the machine hardware. Physical process, a thin rope belt ABS, through a heating element located on the headstall, and passed it to the semi-molten. Then a thin rope passes through a nozzle on a desired place on the map of the cross is layering piece is made.

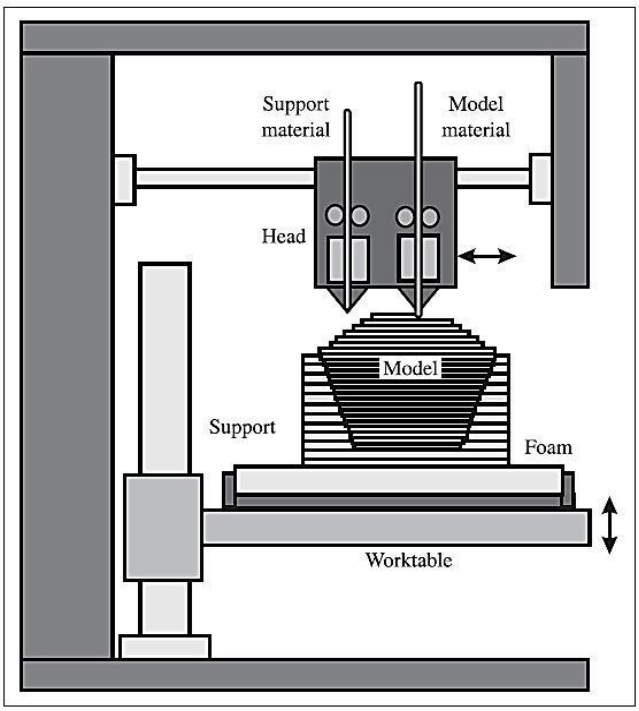

Figure 2. schematic diagram of FDM process(L. Li, Q. Sun, C. Bellehumeur, P. Gu,2002) .

After the semi-molten material was extruded from the nozzle out new material before the material is extruded and welded the flapper. Headstall is capable devices at page X_Y to move materials into and out of the geometry of the fragment is layering. Table holding device is capable of moving in the vertical direction Z at page. Thus, a new layer is injected into the previously poured layer and, thus, and thus form part of the piece is shaped protuberances. In fact, the plan is to set down the X_Y, moving platform builds on the first layers. Then built a platform next layers down to layer thickness, This continues until the part is complete. After a period of time, usually a few hours, the device is capable of complete physical embodiment, which is exactly similar to the fragment to produce a CAD model. I should note that this device has two functions, one of them revealed that the manufacturing base and the jobs are sent to other major components.Fused deposition modeling machine hardware mechanism is shown in Figure 2 (D.T Pham, R.S Gault ,1998; L. Li, Q. Sun, C. Bellehumeur, P. Gu,2002; Fused Deposition Modeling ,1998; Mukesh K. Agarwala, Vikram R. Jamalabad, Noshir A. Langrana, Ahmad Safari, Philip J. Whalen, Stephen C. Danforth, 1996).

3.Three -dimensional printer

The process of three-dimensional printer for the first time at the University of Massachusetts, America was invented. Figure 3 shows a schematic of this process. HP creates three dimensional pieces to form a layer. The first layer is a powder that is sprinkled on the table. Nutritional powder is made from a cylinder with a piston rising. The powder is compacted by a roller, flat piece of jet injectors with the adhesive forms. These jets to control the selected points on the CAD, two-dimensional layer of glue do action shots.

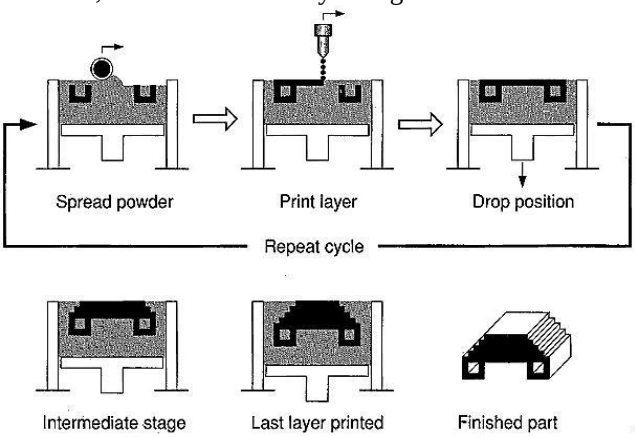

Figure3. Schematic diagram of Three - dimensional printer Process (H.J Jee, E Sachs ,2000).

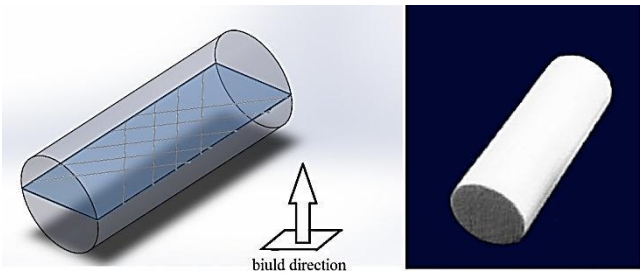

Figure 4 (a). To define axial layering made of FDM method in this experiment, the actual built right into axial layering method is FDM.

In places where the powder is poured glue stick adhesive and the first layer is formed by a piston, the bottom layer is a slice thickness. At this point, again, is sprinkled powder on the piece and the second layer is made as the first step, the process continues to produce the final piece (J. P. Kruth ,1991; J.-P. Kruth, M.C. Leu, T. Nakagawa ,1998; H.J Jee, E Sachs ,2000).

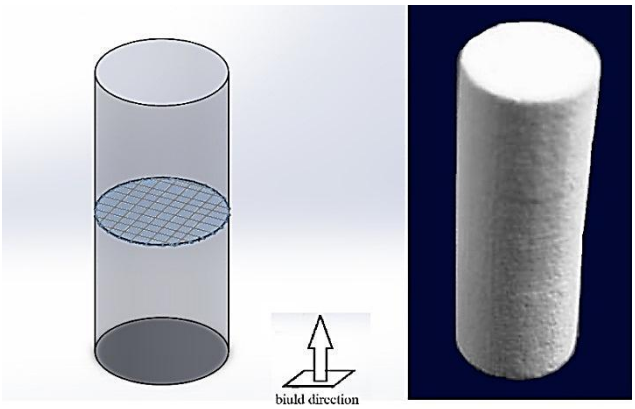

Figure 4 (a). To define transverse layering made of FDM method in this experiment, the actual built right into transverse layering method is FDM.

Details of the experiment

Pressure testing of ABS material as a raw material melt deposition process, the ZP102 powder as raw material Three-dimensional printers are used. With dimensions of 12.7mm diameter and 25.4mm in length of test samples and according to ASTM D695 standard test is performed. The compression tests were conducted with the universal testing machine Zwick (Typ 1474). Tests were conducted at room temperature (25°C and 60% relative humidity), with a velocity of 1mm/min and a 50kN load cell was used. The specimens were loaded until they broke.

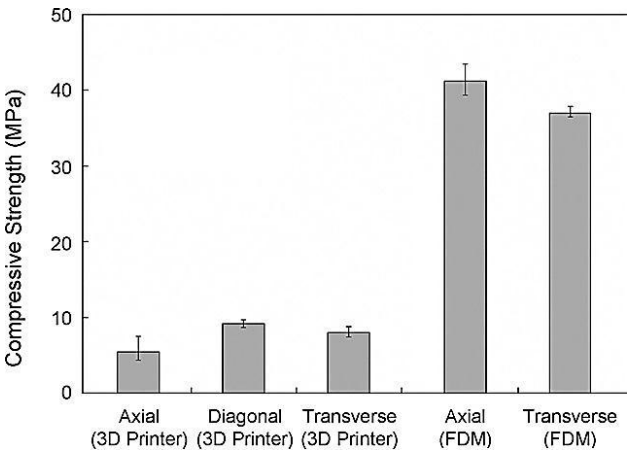

Figure 5. The compressive strength of each specimen.

In order to test the effect of pressure on the strength layering piece, the only parameter is examined. To define the axial and transverse layering samples made of fused deposition technique is shown in Figure 4 (a) and 4 (b). The fiber angle (45 ◦ / -45 ◦) is considered. Fiber angle (45 ◦ / -45 ◦) by default in "the Quick slice program" is available. For a three-dimensional printer, a piece for layering in the axial, transverse , and diagonal is made (Figure 1). Angle of about 45 degrees the diagonal of the build direction of sediment are planned.

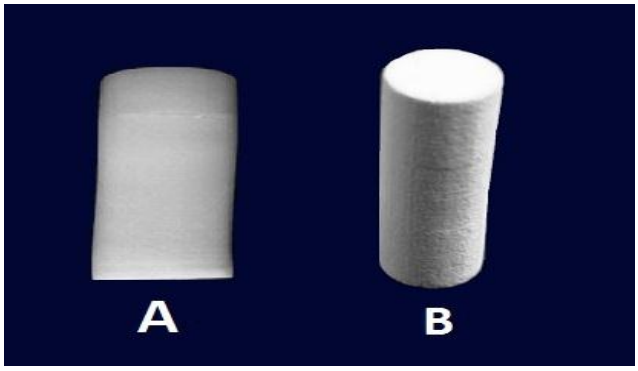

Figure 6 (a). Damaged modes of FDM samples for transverse –layering in form A and form B modes samples of healthy subjects before testing.

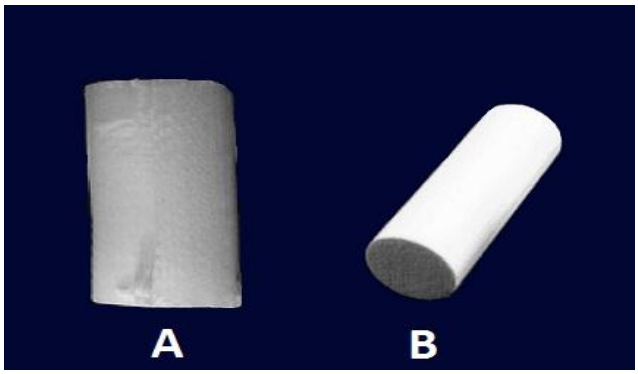

Figure 6 (b). Damaged modes of FDM samples for axial – layering in form A and form B modes samples of healthy subjects before testing.

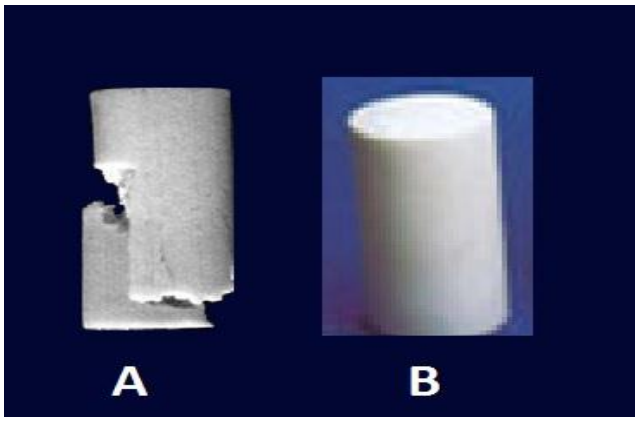

Figure 6 (c). Damaged modes of 3D Printer samples for diagonal –layering in form A and form B modes samples of healthy subjects before testing.

Table 1: Compare of Average Values from Compression Test

Build direction			Material
diagonal	transverse	axial	
-	37.69(Mpa)	42.37(Mpa)	FDM
9.41(Mpa)	7.36(Mpa)	5.67(MPa)	3D Printer

4. Results

The compressive strength of each specimen in Figure 5 and table 1 shows the build direction of structures.

- Compressive strength of fused deposition modeling axial build direction is equal 42.37Mpa. 12.4% greater than the strength of the fused deposition modeling for the Transverse build direction.
- The three-dimensional printer, for example, the diagonal of build direction between the three types of fibers, which have the greatest strength against strength is 9.41MPa. Sample layering axial direction, the three-dimensional printer which has the lowest strength equal to the strength of 5.67MPa.
- The results of experiments show that the build direction behavior of anisotropic (heterogeneous) parts made by rapid prototyping shows. Thus, the behavior of these components are heterogeneous, their strength will vary.
- The mode of destruction on the pressure testing of the components in Figure 6 a, 6b and 6c are shown.
- Along with the destruction of many of the models built using FDM parallel to the layering order they occurred. But in the case of three-dimensional models built to assist printers in order to destroy these models cannot be considered conclusive.

References

D.T Pham, R.S Gault (1998), A comparison of rapid prototyping technologies, *International Journal of Machine Tools and Manufacture*, Volume 38, Issues 10–11, October 1998, Pages 1257-1287

L. Li, Q. Sun, C. Bellehumeur, P. Gu(2002), Composite Modeling and Analysis for Fabrication of FDM Prototypes with Locally Controlled Properties, *Journal of Manufacturing Processes*, Volume 4, Issue 2, 2002, Pages 129-141.

J. P. Kruth (1991), Material Incress Manufacturing by Rapid Prototyping Techniques, *CIRP Annals - Manufacturing Technology*, Volume 40, Issue 2, 1991, Pages 603-614.

Fused Deposition Modeling (1998) , FDM®, System Documentation, Stratasys. Inc1998.

J.-P. Kruth, M.C. Leu, T. Nakagawa (1998), Progress in Additive Manufacturing and Rapid Prototyping, CIRP Annals -Manufacturing Technology, Volume 47, Issue 2, 1998, Pages 525-540

Mukesh K. Agarwala, Vikram R. Jamalabad, Noshir A. Langrana, Ahmad Safari, Philip J. Whalen, Stephen C. Danforth, (1996),Structural quality of parts processed by fused deposition, *Rapid Prototyping Journal*, Vol. 2 Iss: 4 pp. 4 – 19

H.J Jee, E Sachs (2000), A visual simulation technique for 3D printing, *Advances in Engineering Software*, Volume 31, Issue 2, February 2000, Pages 97-106