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Analysis of an Optimal Printing Position of a 3D printed Bolt based on Strength Test

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A B S T R A C T

Fusion Deposit Modeling (FDM) is a 3-D Printing technique which builds layer–via way of means-of-layer of a issue via way of means of the melting and deposition of plastic via the shifting nozzle. Any complicated form which isn't always viable via way of means of conference fabrication strategies are frequently fabricated the use of this system. Moreover, this method permits the innovator to broaden the prototype a whole lot quicker than the traditional technique. Additive production is rising as a favored technique to fabricate complicated third-dimensional additives without difficulty inside a short span of your time. In this study, the bolt and thread of M10 are produced the use of fusion deposition modeling the use of polylactic acid (PLA) cloth. The 3-D CAD version is made with Fusion 360 CAD software. The 3-D CAD fashions are transformed into .STL document that are processed similarly in ‘‘Ultimaker cura” freeware software. This converts the version into collection of skinny layers and creates a G-code document which acts as an enter to computerized 3-D printing system to put layers of loaded thermoplastic cloth successively to construct the version from collection of move sections. Here the 3-D version of bolt and thread of M10 is outlined in horizontal, vertical and willing role to test the power of bolt in numerous positions are cited on this paper.

Keywords: *3D printing; Fusion Deposit Modeling; PLA; Additive Manufacturing; Digital Manufacturing;*

1. Introduction

Fusion Deposit Modeling (FDM) is a 3-D Printing technique which builds layer–via way of means of-layer of a issue via way of means of the melting and deposition of plastic via the shifting nozzle. Any complicated form which isn't always viable via way of means of conference fabrication strategies are frequently fabricated the use of this system. Moreover, this method permits the innovator to broaden the prototype a whole lot quicker than the traditional technique as visible in Fig.1. Additive production is rising as a favored technique to fabricate complicated third-dimensional additives without difficulty inside a short span of your time. In this study, the bolt and thread of M10 are produced the use of fusion deposition modeling the use of polylactic acid (PLA) cloth. The 3-D CAD version is made with Fusion 360 CAD software. The 3-D CAD fashions are transformed into .STL document that are processed similarly in ‘‘Ultimaker cura” freeware software. This converts the version into collection of skinny layers and creates a G-code document which acts as an enter to computerized 3-D printing system to put layers of loaded thermoplastic cloth successively to construct the version from collection of move sections. Here the 3-D version of bolt and thread of M10 is outlined in horizontal, vertical and willing role to test the power of bolt in numerous positions are cited on this paper. Fig. 2 highlights the comparative system go with the drift chart regarding conventional and AM strategies. FDM primarily based totally 3-D printer created via way of means of S. Scott Crump (patented yr 1989) turned into commercialized via way of means of Stratasys Inc. in early 1990 s [9]. Currently, FDM primarily based totally 3-D printing technique is broadly used as it's miles economically inexpensive and smooth to use. It is broadly utilized in product improvement and making prototypes and additionally in production numerous merchandise utilized in aerospace and plane industries, satellite tv for pc applications, clinical appliances, automobile, toys, family appliances, etc. Presently, 3-D printing via way of means of FDM is utilized in domain names like numerical simulation [10], substances [11] and guidance strategies [10].According to ASTM F2792

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12a, FDM refers to a cloth extrusion system this is used to make thermoplastic components via heated extrusion and deposition of substances layer via way of means of layer

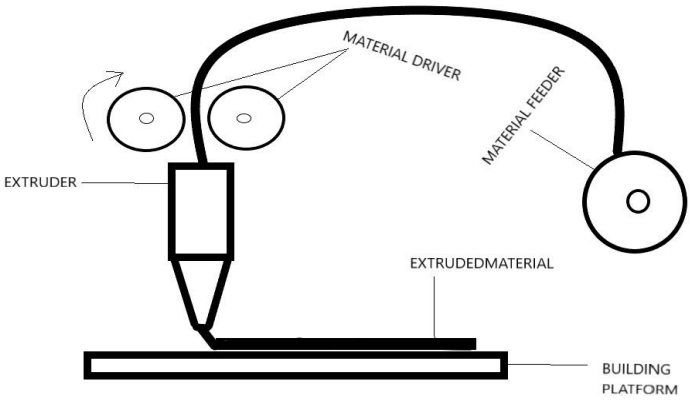

Fig.1 Schematic FDM 3D printer

FDM is a substances deposition subfamily of stable unfastened fabrication technologies. FDM method of AM makes use of a spool fed construct substance (dia 1.75mm) to be had as a bendy monofilament. This is heated to a semi-liquid state. Then, it's miles extruded via a deposition head (that's numerically managed) on a fixtureless desk in a managed environment (temperature). The nozzle motion in x-y aircraft is numerically managed with recognize to the bottom via which complicated geometric fashions may be created preciously. As it finishes deposition the primary layer of filament cloth fabrication at the bed, the constructing platform movements downward (refer Fig.1) for the following layer of thickness deposition. Thereby, a unmarried layer is time and again deposited at a time at the preceding one until the issue is manufactured. In general, relying upon the issue layout and drawing, the aid cloth at the side of construct cloth may be extruded concurrently in a FDM system with twin extrusion holes as proven in Fig. 3. Finally, aid cloth may be discarded both chemically or automatically after FDM fabrication[12].

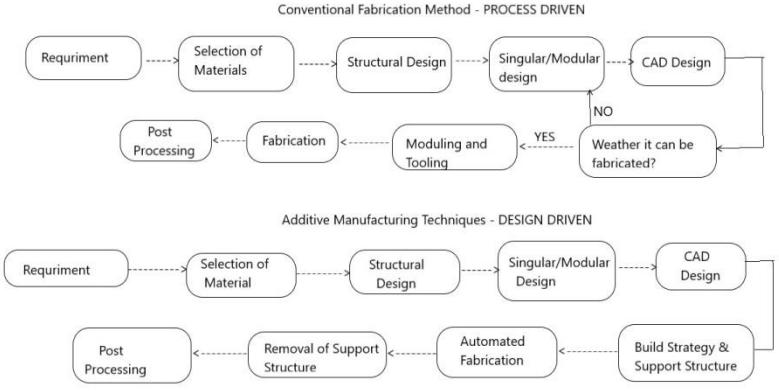

Fig. 2.Comparison of traditional and AM techniques**.**

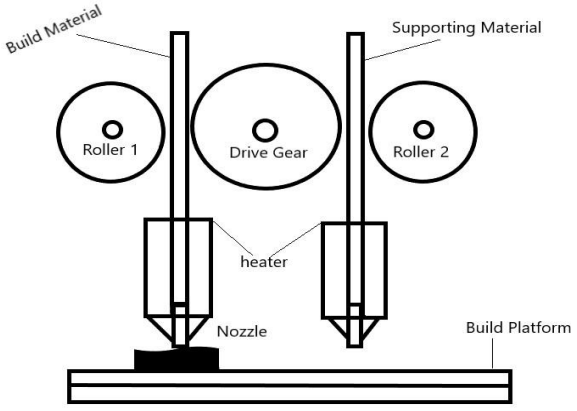

Fig. 3. FDM Mechanism with supporting material

2. Experimental Setup and Analysis

In maximum instances bolts and threads are 3-D revealed in vertical pose due to the fact therein case, they do now no longer want a aid. But I desired to check and examine the numerous positions like horizontal, vertical and willing pose (45°). In this I am going to check 3-D revealed M10 PLA bolt for pulling check, torque and shear strain as visible in Fig. 4. In my experiments I may want to degree best the remaining power or friction point, however now no longer the yield power (elastic limit). Limitation in my check turned into 140 kg. The Material, Methods and different info are given in Table 1. The mechanical homes of the distinct substance of FDM is in comparison and given in Table 2.
Now on this the bolt and thread of M10 (10MM in diameter) is been revealed with the assist of FDM 3-D printer and its specification is given in Table 3.

Table. 1 Parameters of 3-D Printer

Method used	Fused Deposition Modelling
Material	PLA,220degree c
Nozzle	0.4 mm
Perimeters	5
Infill	100%
Layer Height	0.14 mm
Bolt size	M10 x 20

Table. 2 Properties of PLA

Properties		**Annealed**		
		PLA	**PLLA**	**PDLLA**
Tensile Strength	MPa	59	66	44
Elongation at break	%	7	4	5.4
Modulus of Elasticity	MPa	3750	4150	3900
Yield Strength	MPa	70	70	53
Flexural Strength	MPa	106	119	88
Rockwell Hardness		88	88	76
Unnotched izod impact	j/m	195	350	150
Notched izod impact	j/m	26	66	18
Heat Deflection Temp	^C	55	61	50
Vicat Penetration	^C	59	165	52

Fig. 4 .3-D printed bolt

Table. 3 Specification of M10 Bolt (All readings are in mm)

NOMINAL SIZE(M10)	MAXIMUM	MINIMUM
Body diameter	10.00	9.78
Head thickness	6.63	6.17
Across the flats	17.00	15.73
Across the corners	18.48	17.77
pitch	1.50	1.00
drill	9.00	8.50

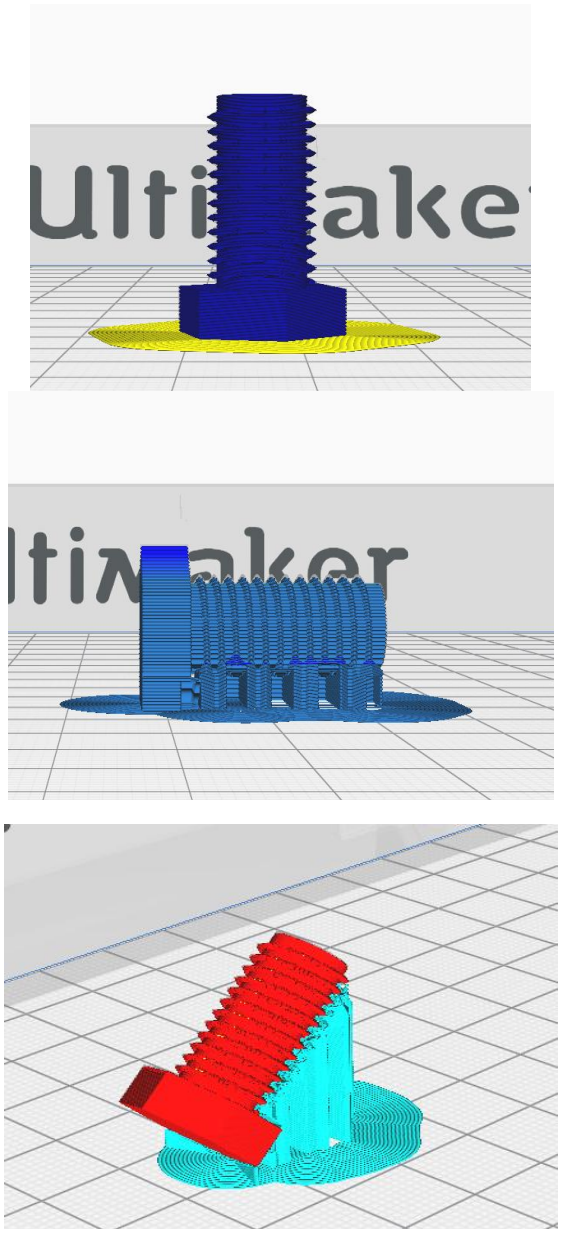

Fig.5. 3-D model of M10 bolt (a) Vertical position; (b) Horizontal position; (c) Inclined position, 45°

All the CAD fashions are advanced the use of SOLIDWORKS and it's far transformed into .STL (a stereolithography CAD format, additionally referred to as Standard Triangle record) record. These documents are processed the use of freeware software ‘‘Ultimaker Cura”, in which it converts the fashions into a chain of skinny layers and creates ‘G-code’ documents, as visible in Fig.5. This G-code consists of commands that act as an enter to an automatic 3-D printing gadget. The G-codes makes the 3-D printer to put layers of loaded thermoplastic cloth successively to construct the issue from a chain of cross-sections. The layer corresponds to the digital cross-phase of the CAD version and is permitted to get fused to create the very last shape. The high benefit of this approach is to fabricate state-of-the-art functions or shapes easily[13].

The 3-D printing approach used on this observe is FDM. PLA, an industrial-energy plastic polymer, is applied as a thermoplastic substance. This substance is fed to a 3-D printer withinside the shape of filament (dia 1.75mm) furnished with the aid of using spools wherein it's far melted withinside the extrusion head and feeding mechanism at round 260°C, as visible in Fig. 3. Based on the sooner organized code, the printer head lays the substances layer with the aid of using layer. Thus, all of the bolt is produced primarily based totally on additive production concepts. The bolts with specific positions produced with the aid of using the FDM approach calls for completing touch. The printing floor is smoothened, and irregularities may be eliminated with the aid of using chemical remedy with acetone vapor, record completing, or sandpaper. The specification of the additive production gadget primarily based totally at the FDM approach to be had is indexed in Table 1.

Here the Table. four indicates that how a lot period and weight of the filament is wanted to get the 3-D revealed bolt in 3 specific positions. And additionally, how a lot time taken with the aid of using the printer to cause them to is given below. In the case of supports, the vertical pose does now no longer have any assist, while horizontal pose having the assist and willing pose additionally has assist, that is greater whilst as compared to horizontal.

Table. 4 Detail and different position of Filament

	M10 Vertical	**M10 Horizontal**	**M10 incl (45°)**
Filament used(m)incl.supports	1.24m	1.37m	1.45m
Filament used(g)incl.supports	3.67g	4.01g	4.36g
Printing time	40min	46min	62min
Supports	No	Yes	Yes, big+custom

3. Results and Discussion

The experimental study is carried out in the laboratory using mechanical loading conditions for weight limitation of 140kg.

Table. 5 Test Result for different position of M10 Bolt

	M10 Vertical	**M10 Horizontal**	**M10 incl (45°)**
Pull Test	105kg	Over 140kg	109kg
Shear Test	123kg	Over 140kg	Over 140kg
Torque Test	2.6 Nm	5.2Nm	2.7Nm

In this firstly, all the positions were carried out with pull tests and the vertical and inclined position bolts were damaged at 105kg and 109kg, while horizontal pose stood unbroken at 140kg also. This is observed through a shear and torque check also.The above Table.5 indicates a clean desk approximately the check outcomes. The red colour indication indicates that the bolt breaks at that weight and colour blue indication indicates that the ambitious did now no longer damage at that specific weight.By the outcomes, we are able to see that bolt published withinside the horizontal role is higher than the alternative positions which we're taken. Since the vertically placed published bolt would not want any assist due to the layer-through-layer published layers, it has vulnerable bonding among them. Therefore, we are able to say that the horizontal role is greater strong than the alternative positions, however the horizontal pose desires assist to build.

4. Conclusion

In this study, an additive production approach primarily based totally on fused deposition modeling is used to fabricate a bolt of 10M. An industrial-electricity plastic polymer, PLA is applied right here considering the fact that it's far a thermoplastic aliphatic polyester derived from renewable resources, including corn starch, tapioca roots, chips or starch or sugarcane.The 3-D published bolt of 10M has been published and examined with diverse positions. Generally, all will print it as a vertical pose because it would not want any assist, however we are able to see that the horizontal pose is more potent than the alternative positions, however the horizontal pose desires assist. Therefore, bolts may be published as withinside the horizontal pose for great

outcomes if the bolts ought to convey huge loads, you need to cross for steel bolts. Since it's far a plastic bolt of 3-D published, we're going for the great as a horizontal pose.

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