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Building of Complex Structures through Fused Deposition Modelling

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Abstract:
This deals with study of 3-D printing and building a complex structure through fused deposition modelling using Stratasys 400mc. The study aimed to provide a general overview of 3-D printing such as its types, advantages, limitations and comparison with general manufacturing process. It is also referred as the technology of additive manufacturing and propagated equally as the industry of cellular telephone. An object can be printed from a template of digital content to a physical object in three dimensional is referred as 3D printing. It is implemented layer by layer by employing numerous material that including metal, plastic and nylon etc. There has been wide range of fields or sectors where 3D printing can be more effective in usage with quite faster and cost-effective solvent in various fields. The current applications of 3D printing enhancing and disclosing that the enthusiasm to have a look out on it. Hence, this article addresses the functioning of 3D printing, its current and future applications in different fields. The construction of a complex structure is done through fused deposition modelling. Here the "complex structure" refers to a general structure which is relatively complex to build using general machining processes / subtractive process. Additive Manufacturing replaces the limitations with a different set of restrictions used in conventional process. This experiment also addresses the challenges in building a nano complex structure through fused deposition modelling.

Keywords*: Additive Manufacturing,3D printing, Stratasys 400mc, Fused Deposition Modelling, Complex Structures.*

1. INTRODUCTION

A method of manufacturing also known as additive manufacturing (AM), due to the fact that instead of removing the material to create a part, the process adds material layer upon layer to create the desired shape. The term AM encompasses many technologies including subsets like 3D Printing, Rapid Prototyping (RP), Direct Digital Manufacturing (DDM), layered manufacturing and additive fabrication. In this paper we use AM to refer 3-D printing as they both are same.

While the adding of layer – upon – layer approach is simple, there are many applications of AM technology with degrees of sophistication to meet diverse needs including, Prototyping and Manufacturing [1],specialized and complex parts [2], engineering and construction [3] aerospace [4], military, biomedical engineering [5-7],footwear and fashion industry [8], a means to create highly customized products for consumers and professionals alike. To produce small lots of production parts. Hobbies and home use. Future applications [9] like in buildings, automobiles [10-12], AM in education [13] one day body parts.

In this experiment a structure which is relatively complex to build with general machining is built through fused deposition modelling based 3D printer and analyzed. A step by step approach is followed with detailed pictures. Due to the nature of FDM process [14], many advantages arise, such as the design freedom to produce complex shapes [15] without the need to invest in dies and molds, the ability to produce internal features, which is impossible using traditional manufacturing techniques. FDM enables the reduction of the number of assemblies by producing consolidated complex parts. More advantage of FDM can be reaped through the supply chain by reducing the lead time and the need for storage and transportation, especially in applications where high customization is necessary. On the other hand, FDM technology has challenges such as producing parts with anisotropic mechanical properties, staircase effect at curves, coarse surface finish, the need for supports for overhanging regions and more.

2. BUILDING OF COMPLEX STRUCTURES ON FUSED DEPOSITION MODELLING BASED 3D PRINTER – A CASE STUDY

Step-1:- Conceptualization and CAD

The first step is to conceptualize and design a complex structure. Here in this case a missile like structure is placed inside the grooved circular structure or ball and this circular ball is placed inside the skeletal square structure, where the ball is free to rotate inside the skeletal structure. This type of construction takes multiple process and assemblies in general machining which is cumbersome. The size of the component build in this case study is in scale of 60% of the each dimension shown in the figure.

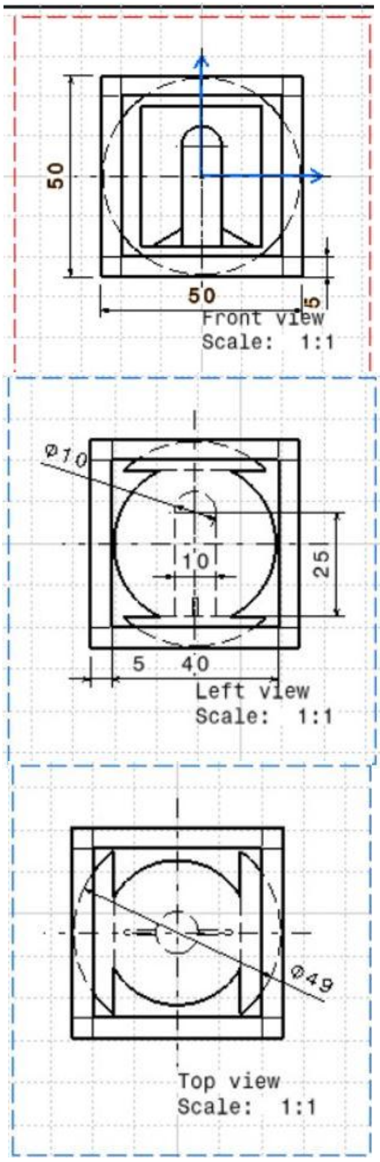

Fig: 1 Drafting of the Complex Structure

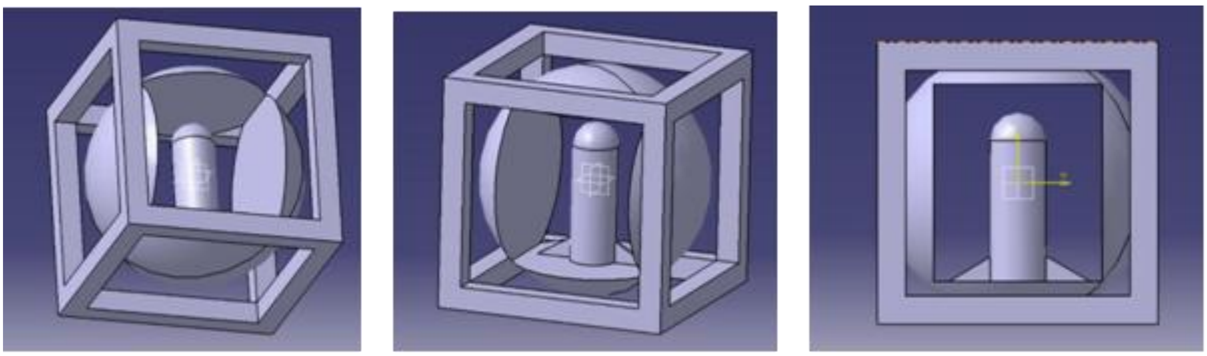

Fig: 2 Complex CAD Structure

Step-2:- Converting to STL Format

Model should be converted into STL file format such that it is used as input to slicing software.

Step-3:- Selecting Build Parameters

1.Open the STL file format in Insight Software given by Stratasys. Now certain parameters need to be selected such as, Slice height - 0.2540mm, Model tip - T-16 tip, Model material - ABS-M30,Support tip - T-12 tip, Support model - SR-30 support, Part interior style – Solid, Support style – Smart, Estimated build time – 2hr 3 min. 2.Generating slice models and support structures. 3.Generating tool path. 4.And finally estimating build time.

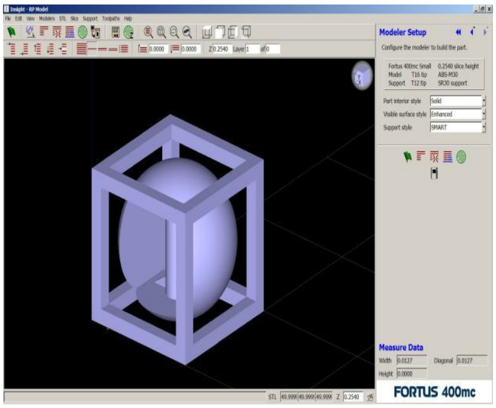

Fig: 3 Opening the STL file format in INSIGHT

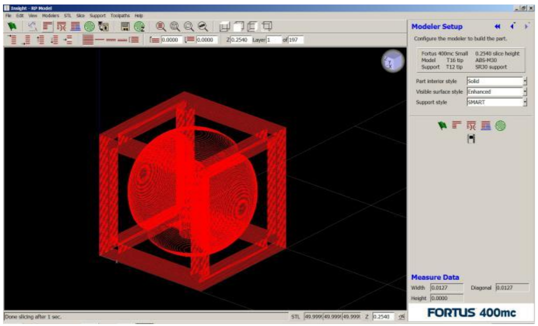

Fig: 4 Generating slice modelssoftware

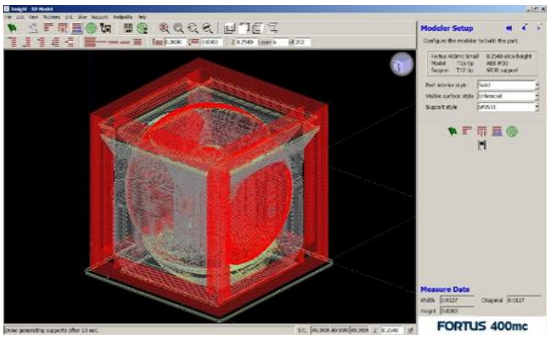

Fig: 5 Generating support structures

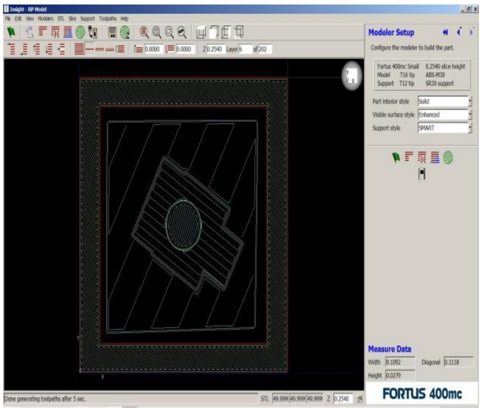

Fig: 6 Generating Toolpath

Step-4:- Machine Setup

Setting up the oven area, Positioning the object to be build in the envelope sheet. Inserting model material and support material canisters. Establishing required nozzle tips and calibrating the envelope area. The surrounding temperature should be cool enough to operate the machine without errors.

Step-5:- Printing and Removal of Prints

Printing the object and checking weather the machine is running smoothly. Removing theprinted object from the oven bay carefully with precautions.

Step-6:- Post Processing

In post processing stage, if the object contains any support material it should be dissolved in a water-ammonia solution to separate support material from model And if necessary surface finishing can be done.

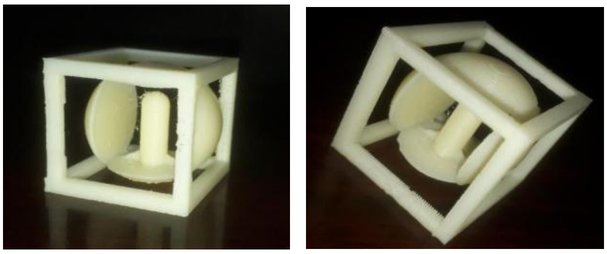

Fig: 7 3D Printed Complex Structure

3.RESULTS AND DISCUSSION

This work presents the design considerations and limitations in FDM in printing of complex structures aspect. It discus the limitations of FDM in aspects of unfused structures such as very small details. This work provides dimensional accuracies and surface roughness. In addition we can see stair case effects in the 3D printed Object of dimensions less than 0.5mm. The stiffners produced in this object are in complete as the dimensions of stiffners are less than 0.2mm which is less than tip diameter. The surfaces of the object where support material is removed is rough and patchy compared to the surfaces with no support material.

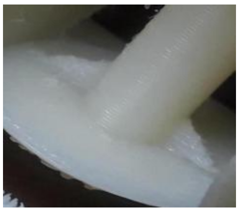
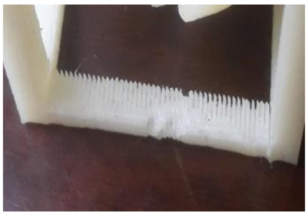

Fig: 8 Improper building of stiffners
Fig: 9 Staircase effects

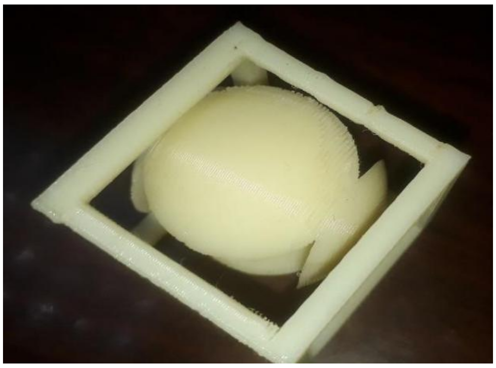

Fig: 10 smooth surface finish

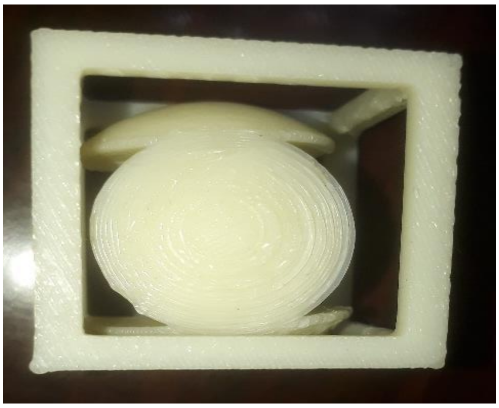

Fig: 11 Rough surface finish (support material (no support material on this surface) removed surface)

4. CONCLUSION

Currently FDM is still an immature manufacturing technology for nano structures and fine internal surface finishing. The support removal processes should also be improved and new easily removable materials should be used. Developments in additive manufacturing offers significant possibility of creating new products. A summary of main research issues includes [16]:

1.Studying the influence of process parameters on surface features, mechanical properties, and material characteristics of the parts by modeling studies and/or experimental work.
2.Developing new materials based on the capabilities of the additive processes.
3.Establishing rules and protocols to design for additive manufacturing.
4.Creating a real time process control for the additive manufacturing systems.
5.Exploring the hybrid manufacturing and multi-materials additive manufacturing.
6.Improving the productivity of the additive manufacturing systems.

Process repeatability, complex thermal stresses, and material microstructural implications of the process are the largest challenges to industrial applications of additive manufacturing, especially in the aerospace industry. These factors affect the density of additive parts and consequently all the mechanical properties and material characteristics. There are currently two options to overcome these challenges. The first, and most common solution is to refine the quality of the additive parts through carefully controlled post processing techniques. The second, and less established solution is to optimize and control the process parameters to produce high quality parts.

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