Analysis and Optimization of Void Spaces in Single Ply Raw Material using Finite Element Method and Fused Deposition Modelling

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ABSTRACT
Fused Deposition modelling (FDM) technology is based on decomposition of 3-D computer models into thin cross sectional layers, followed by physically forming the layer and stacking them up layer by layer. FDM provide freedom to add material in the desired area and we are also able to create hollow region in certain portion of layer. In this way low weight with good strength single ply raw material with hollow cross section is produced. Void spaces were created in single ply raw material. FEM analysis was applied to select the material. Results of FEM analysis shows that ABS material is better compressive as comparison to Nylon101, Nylon6/10. So ABS material is selected for manufacturing of specimens. ABS specimens were manufactured with the help of FDM. Compressive test of specimens at 8000N shows that two small square structures give optimum results for ABS material.

Keywords
STL - Standard Triangulation Language, FEM - Finite Element method
ABS -Acrylonitrile Butadiene Styrene, FDM - Fused Deposition modelling

1. INTRODUCTION
In modern time low weight high strength materials is in high demand with the development of automobile and aerospace sector. The term rapid prototyping refers to a class of technologies that can automatically construct physical models from computer aided design data and allow designers to quickly create tangible prototypes of their design rather than just two dimensional pictures. Fused deposition modelling is based on decomposition of 3-D computer models into thin cross sectional layers, followed by physically forming the layer and stacking them up layer by layer. RP provide freedom to add material in the desired area and we are also able to hollow certain portion of layer. In this way low weight with good strength single ply raw material with hollow cross section is produce.

2. PROBLEM STATEMENT
The main requirement is to create Void spaces in single ply raw material to decrease weight of single ply raw material. FEM analysis is applied to compare the Nylon101, Nylon6/10 and ABS material. CAD drawing of void spaces are created and then it is converted into STL files to give input to FDM machine. ABS specimens were manufactured with the help of FDM. Compressive test were done on the specimen to find the compressive strength.

3. METHODOLOGY

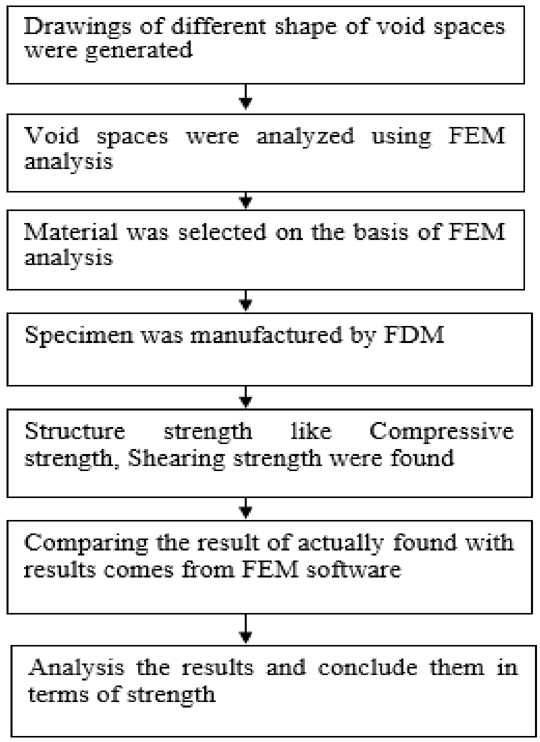
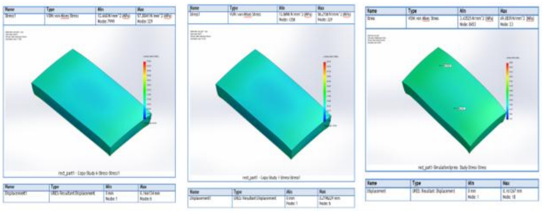


Figure 1: Flow chart of methodology

4. MATERIAL SELECTIONS BY FEM ANALYSIS
Three dimensional drawing of single ply raw material with void space are created by CAD software are analysed with FEM software. Displacement is the criteria for deciding the strength. Strength is inversely proportional to the displacement therefore the compressive strength is considered for selection of the material and shape of void space. Load applied on the specimen was 8000N during the FEM analysis. Fixture is applied at the bottom surface and load is applied at the top surface.

4.1 Compressive strength of various materials (without void space)



NYLON101 NYLON6/10 ABS

Table 1: Result For Without Void Structure

S No	MATERIALS	DISPLACEMENT in *mm* (COMPRESSIVE TEST)
1	NYLON 101	0.166134
2	NYLON 6/10	0.2196229
3	ABS	0.161

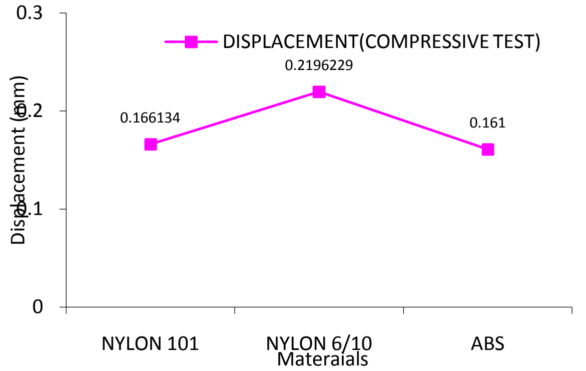
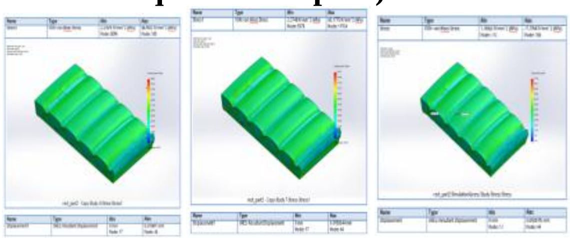


Figure 2: Result for without void structure

4.2 Compressive strength of various materials (Two small square void space)



NYLON101 NYLON6/10 ABS

Table 2: Result for two small square void structure

S No	MATERIAL NAME	DISPLACEMENT (COMPRESSIVE TEST) mm
1	NYLON 101	0.216401
2	NYLON 6/10	0.0958644
3	ABS	0.0928

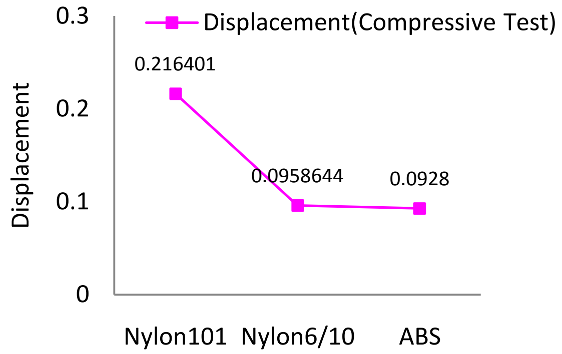


Figure 3: Result for two small square void structure

Result of FEM analysis show that ABS material has 0.161mm displacement in without void structure and 0.0928mm displacement in two small square void structure which is less displacement as comparison to Nylon101 and Nylon6/10. ABS material has better compressive strength. So ABS material is selected for manufacturing of specimens by Fused deposition modelling.

5. MANUFACTURING OF SPECIMEN BY FUSED DEPOSITION MOULDING

Fused deposition moulding is used to manufacture the specimens of ABS material of different void shape structure. Size of the specimen is 25mm x 5mm x25mm. Solid works drawing in STL format is given as input to FDM machine. The chamber temperature is maintained in the range of 75^0c to 79^0c and nozzle temperature is maintained in the range of 310^0c to 320^0c. Nozzle of the machine spread a minute layer of base material on the table. SR30XL soluble material is used asbase material. Temperature of the base material is maintained in the range of 295^0c to 300^0c. Processor of the machine supply the model material in those places which were shown solid in the drawing through nozzle and base material supply to those portions which were shown void for support of the structure. P430XL ABS model (IVR) material is used as model material. Temperature of the model material is maintained 305^0c to 310^0c. Process of model and base material is continuing until product is not completed with the layer resolution of 0.2540mm.

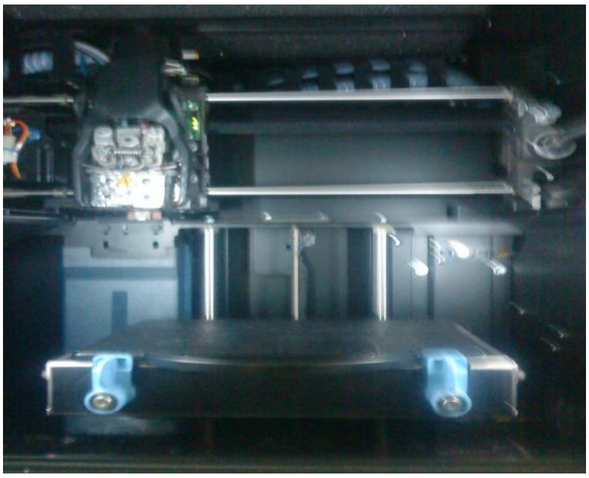


Figure 4 : Fused Deposition Modelling Machine

For removing base material from the void space solution of following chemicals in water is maintained at 50^0c in vibrating mode:

A. Tetra sodium N_1-bis carboxyl to methyl)-I-glutamate and citric acid

B. Sodium Per carbonate

Temperature of solution is maintained at 50^0c with the help of electrical heating element and the turbulence is created in the solution by vibration. Solution is alkaline in nature and the specimen is dipped in the solution for 20 to 24 hours to remove the base material. After removing the base material, specimens were dried out in atmosphere.

Figure 5: Solid Specimen

Figure 6 : Two small square void specimen

6. COMPRESSION TEST

Compressive test is done with the test speed of 2mm/min. Load applied on the specimen is 8000N.

Table 3 : Result of Compressive Test

Sr No.	Part Name	Result of compressive test(displacement in mm)
1	Solid	0.204
2	Two small square void shape	0.083

7. RESULT

Two small square void structure shows 0.083mm displacement in compressive test. So it is better alternative in compressive load.

8. REFERENCES

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