Faculty Internship Report on

3D Printing for Biomedical Applications

Submitted by

Sumanta Mukherjee, Asst. Prof. (TEQIP), Prod. Engg. Dept., BIT Sindri

Under the mentorship of

Dr. Falguni Pati, Asst. Prof., Dept. of Biomed. Engg., IIT Hyderabad

Supported by

TEQIP Cell, IIT Hyderabad & TEQIP Cell, BIT Sindri

Duration: 9th July to 27th July, 2019

3D Printing processes rely on layer-by-layer deposition of materials to build net-shaped objects, and the processes allow for extreme flexibility in terms of the type of the materials as well as the geometry of the objects that can be manufactured. Another important aspect of such processes is the possibility of mass customization, which makes them highly suitable for biomedical applications, as manufacturing of products tailored to meet the users' requirements becomes viable. Therefore, the focus of the internship was to explore different materials that can be adopted for development of 3D Printed patient-specific prosthesis.

PLA, ABS, Nylon, TPU, PETG, Polycarbonate (PC) etc. are some of the commonly used materials for Fused Deposition Modeling (FDM) process, and the mechanical and physical properties of these materials needed to be explored for suitability in prosthesis manufacturing. 3D Printing of materials like PLA, ABS, TPU, PCL etc. have already been well-studied by previous researchers, whereas PETG is a relatively newer material. Recently the material has gained traction among the 3D Printing community for the high printability and low cost of PET filaments. PETG offers a moderate Ultimate Strength of 53 MPa as compared to 72 MPa Ultimate Strength of PC and 65 MPa Ultimate Strength of PLA, but it is highly resistant to water and therefore, would not degrade quickly in hot and humid weather such as ours. Based on such observations, PETG was selected as the material for our study.

From ASTM standards, a suitable sample was designed considering 3.6 mm thickness of the samples, as the wall thickness of prostheses are typically close to 4 mm. A large-format FDM Printer (Aha Star, Aha3D) with printing volume of 600 mm x 600 mm x 600 mm was used for manufacturing test samples using the PETG filament. The parts were printed with 100% infill to obtain maximum strength, and multiple trials were carried out to identify the most suitable printing parameters for the selected materials.

From the experiments, the combination of 230 °C extrusion temperature and 50 °C bed temperature was found to be most suitable with minimal over-extrusion, adequate first layer adhesion without any warping or other issues. The following two figures present the designed geometry (Fig. A) and the printed part (Fig. B).

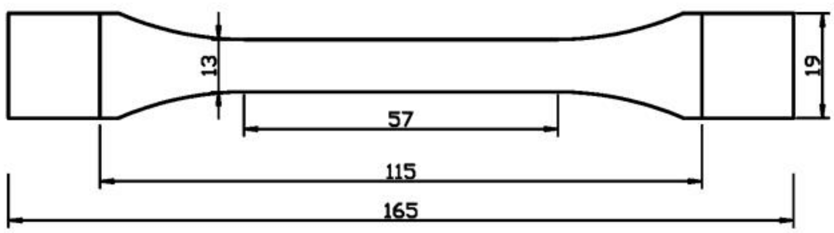

Fig. A: Designed part according to the ASTM standards

Fig. B: 3D Printed PETG part

Future Scope:

Only two printing parameters were considered for 3D Printing PETG parts during the internship, and no mechanical or physical characterizations were performed. Hence, optimization of other process parameters including layer height, orientation etc. can be done to understand the relationship between those parameters and the mechanical as well as the physical properties of printed parts. Once completed, the work can be published as a research paper.