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Study of Mechanical behavior of 3D printed PLA Material manufactured by Fused Deposition Model Technique

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ABSTRACT

Additive Manufacturing has emerged as a groundbreaking technology. This research investigates the strength-to-weight ratio of PLA material in Fused Deposition Modelling (FDM) 3D printing. Utilizing ASTM standards for specimen preparation, both tensile and compression tests were conducted to determine optimal infill patterns and densities. The study aims to provide insights into maximizing structural integrity while minimizing material usage, offering valuable implications for additive manufacturing applications.

INTRODUCTION:

Additive Manufacturing (AM), has emerged as a groundbreaking technology in recent decades, enabling rapid prototyping and customization with unparalleled flexibility and reliability and easy availability of raw materials and machines in the market [1]. Through the technique of additive manufacturing, also known as 3D printing, objects are made from digital designs in a layer-by-layer deposition of material over a print bed. Compared to traditional manufacturing methods, it offers advantages including design flexibility, rapid prototyping, and decreased waste by enabling the manufacture of complicated forms and customized objects utilizing a variety of materials[2].

Polylactic Acid (PLA) is a biodegradable thermoplastic polymer derived from renewable resources such as corn starch or sugarcane. Because PLA works well with Fused Deposition Modelling (FDM) techn-ology, it has attracted a lot of interest in the additive manufacturing space. It is popular since it is cost-effective, simple to use, and environ-mentally friendly compared to other plastics. It is odourless, requires less print bed heating and also available in a variety of colours and finishes including, transparent, matte and glossy. The standard PLA comes as 1.75mm filament (usually spun around a spool and weighing 1kg). Its printing temperature is around 190ºC - 230ºC.

Additive Manufacturing makes use of a wide range of materials, including metals, polymers, and ceramics. A 3D printed component can be produced by utilising all of these materials in various additive manufacturing processes. The components of this project are being constructed utilising the Fusion Deposition Modelling (FDM) technique[3]. Plastics are typically used in this procedure. Layer by layer, the molten plastic (in the form of a filament) is put over a print bed. The Ender 3 series, Flashforge Adventurer series, Bambu Lab Carbon Series, and other models are among the machines that offer FDM techniques. We will be working on the Ender 3 V2, a popular FDM 3D printer for both hobby and professional use, in this project. We will be dealing with polylactic acid as the material[4]l.

The objective of this study is to explore the impact of infill patterns and densities on the mechanical strength of PLA components (specimens) manufactured through FDM while keeping weight reduction of the component in mind. To ensure reliability and consistency, we adhere to ASTM standards for fabricating standard specimens, enabling direct comparison with established benchmarks[5].

MATERIALS AND METHODS:

The ASTM D638 is a standard test method for tensile properties of plastics. This test method is widely used to determine the tensile strength, tensile modulus, and elongation at break of plastic materials. The test provides valuable information about the mechanical properties of plastics under tension, which is essential for material selection, quality control, and product development in various industries.

SAMPLE PREPARATION:

Specimens are typically prepared as flat, dumbbell-shaped specimens. Here we are choosing the ASTM D638-Type I specimen shape for the tensile test with the specimen thickness of 7.2 ± 0.4 mm. The specimens should be free from defects, such as voids, notches, or surface irregularities, which could affect the test results.

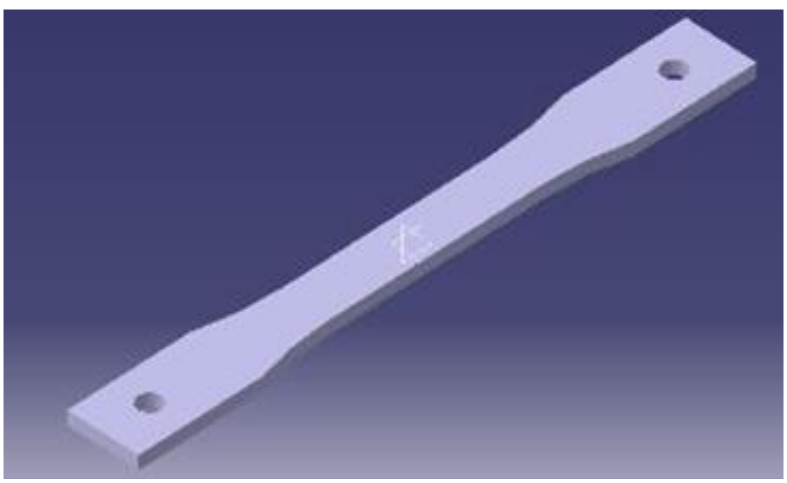

Fig. 1.1 Sample Specimen 7.2 ± 0.4 mm

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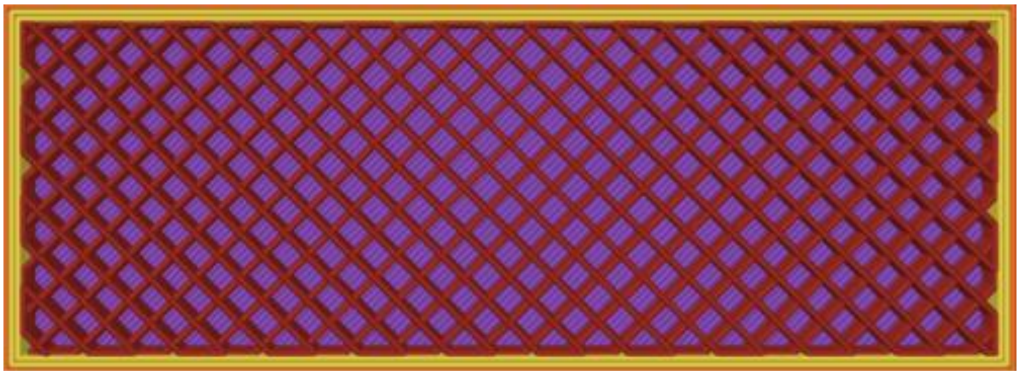
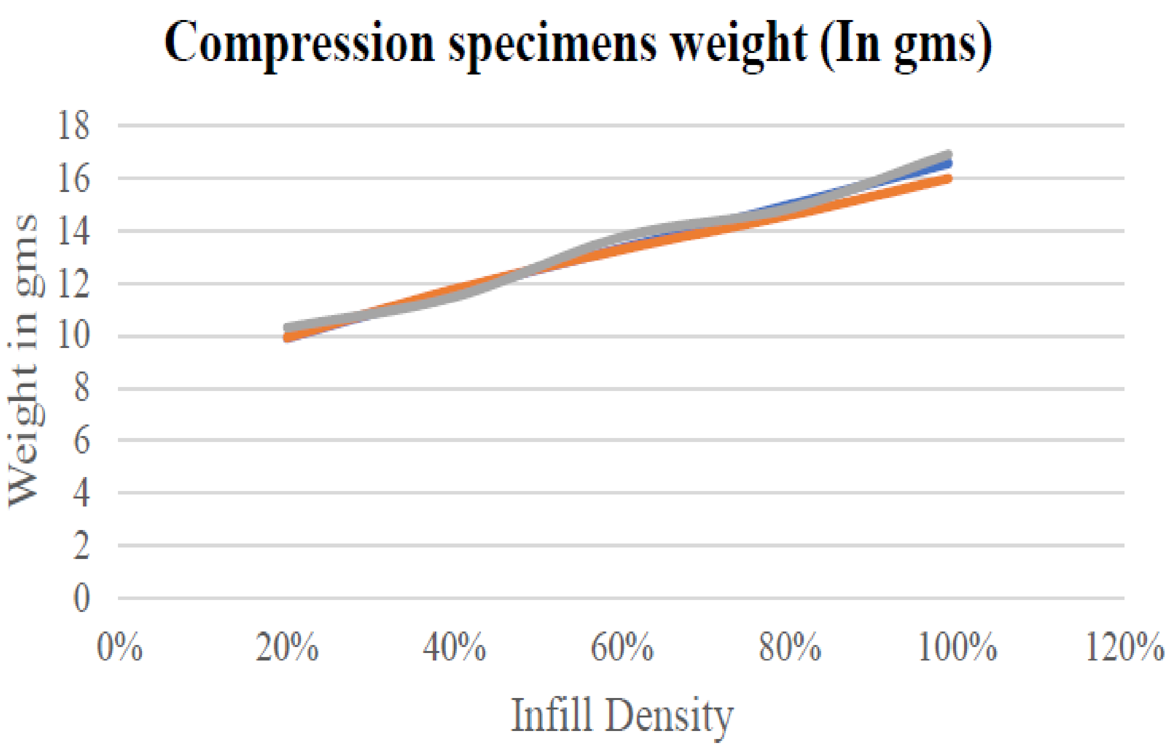
The infills offered by Prusa Slicer are as follows:

1) Rectilinear Pattern



It is a type of infill pattern where rectilinear grid pattern is created by printing one layer in one direction and the next layer is printed by rotating 90º. Infills were printed (taking the infill density of 50% for all the patterns) for tensile test according to the standards and were tested accordingly. Simultaneously compression specimens were printed according to the ASTM standards and tested.

RESULTS:



After testing, infills with average weight 14 gms wit density 60% has good tensile and compressive strength compare to other percentage. From the results we concluded that infills Triangles, Cubic and Gyroid patterns emerged as the strongest. Hence, we will be working on testing the tensile and compressive strengths based on the variation of infill density of these selected infill patterns. They were taken care of that they do not warp due to any environmental temperature changes or irregular temperature of the filament entering the extruder and also enabled a brim layer to avoid any undetected warping.

CONCLUSION:

We can concluded that infills with average weight 14 gms wit density 60% has good tensile and compressive strength compare to other percentage. Infills with Triangles, Cubic and Gyroid patterns emerged as the strongest. By analysing the final outcome and considering the specific requirements of each application, you can make informed decisions regarding the selection of infill patterns and densities to optimize compression strength to weight ratio in 3D-printed parts.

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