Hungarian University of Agriculture and Life Science
Szent István Campus
Mechanical Engineering Course

THESIS TITLE

Mechanical properties for composite material used 3D printing

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Summary

In 1980s, new industrial manufacturing was existed, known as Additive manufacturing or also known as 3D printing. 3D printing is a manufacturing process where objects are created by adding layers of material on top of each other, instead of removing material from a block, as it was in the subtractive manufacturing.

In 3D printing, three-dimensional solid objects of the desired shape are created using 3D modeling software and a printer that lays down successive layers of materials of different shapes to obtain the final shape that corresponds to the digital model. This manufacturing method has been successful in producing intricate and complex engineered parts, and these products are made from metal, ceramic, polymer, and composite materials. These products have found their way into many industrial applications such as in aerospace, automotive, medical and even in the food industry.

One of the most commonly 3D printing used technology is Fused Deposition Modeling (FDM), The process involves a heated extrusion nozzle that melts and extrudes the polymer filament layer by layer into a three-dimensional object. The mechanical properties and characteristics of the objects in this printer depend on many factors, mainly the properties and quality of the polymer filament used to print the object.

Polylactic acid (PLA) is a biodegradable thermoplastic polymer, its filaments used widely to print in FDM technology due to its ease of printing, and environmental friendliness, which made it interesting to study the mechanical properties of its filaments, as well as its objects.

The aim of this study was to investigate the behavior and properties of PLA filaments before printing, as well as printed samples, in relation to tensile testing.

Tensile tests were performed on four different types of commercially produced PLA filaments (HD PLA, rPLA, PLA White, PLA Carbon) to determine the Ultimate Tensile Strength (UTS) of each filament (before printing). Bollard style tensile grips used to hold the filament, in place during a tensile test. It is a type of grip used in materials testing, particularly for tensile testing. Bollard style tensile grips are designed They typically feature two cylindrical grips that are mounted on a testing machine, with one grip being fixed and the other being movable. The movable grip is connected to the testing machine's load cell, which measures the amount of force being applied to the specimen. Zwick Roell Z100 testing machine with ISO 527-1 standard was utilized to conduct tensile strength experiments on the PLA filaments and printed samples, and the results were 52.1 MPa for HD PLA and (50.3, 29.7, 47.1) MPa for (rPLA, PLA White, PLA Carbon) respectively.

Additionally, samples were printed used ISO 527 - 2 -5A from each type to determine their UTS under the same conditions and printing parameters. Fused Deposition Modeling (FDM) was used to create tensile samples of the four types of PLA filaments and the average UTS for each sample (HD PLA, rPLA, PLA White, PLA Carbon) was (52.8, 50.4, 36.2, 47.0)MPa, respectively.

And also, these types of filaments were re-manufactured in the laboratory used single screw extruder machine to determine their UTS after recycling, and the average UTS for each sample (HD PLA, rPLA, PLA White, PLA Carbon) was (56.3, 58.6, 30.6, 45.2)MPa, respectively.

Additionally, the filaments were re-manufactured and reinforced with hemp fibers, which are natural fibers, to investigate whether any improvement in UTS occurred for the types (HD PLA, rPLA, PLA White) and the average UTS for each type was (37.5, 53.5, 38.5)MPa.