Name(s)

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Project Number

S0311

Project Title

A Multi-Faceted Material Strength Testing Machine for 3D Printed Plastics

Abstract

Objectives

Today there is a need to understand the strengths of 3D printed products given the recent decreases in 3D printer prices and increase in start-ups 3D printing their products. Professional Universal Test Machines (UTM) can be used to test material strengths; however, they tend to be large and expensive. The objective of this project is to create an affordable, multi-faceted, re-configurable, material strength testing machine that can conduct a variety of different strength tests: Tensile, Flexure, Compressive, Shear, and Layer Adhesion.

Methods

The Testing Machine was designed to conduct 4 Strength Tests in accordance with ASTM standards (D638 - Tensile, D790 - Flexure, D695 - Compressive, and D5379 - Shear) as well as a newly developed test, Layer Adhesion. ASTM does not have a standard for testing Layer Adhesion Strength of 3D Printed Plastics.

The Testing Machine includes an all metal frame, a load cell, 2 stepper motors, an OLED, a MicroSD, 4 Test Fixture Set-Ups, and an Arduino-MEGA with home-generated open-source software using both I2C and SPI protocols. Materials tested were PLA, ABS, and PETG. For each of the materials, 5 Test Specimens were 3D printed and tested for each of the 5 Strength Tests. Specimen geometries were derived from ASTM standards.

To conduct each test, a Test Fixture and a Test Specimen were mounted to the Testing Machine. The test direction (Up/Down) was selected and the Testing Machine powered on. The Stop Button was pressed when the Test Specimen broke or the motors stopped turning. Power was turned off and the data retrieved from MicroSD Card for analysis. For each run, 3 pieces of information was collected - Step Number, Time, and Load Value. The machine was then reset to continue testing for all the materials and test configurations.

Results

Load data was used to determine Yield levels and corresponding Moduli s for each Strength Test was calculated. Data plots for each test were consistent and correlated across materials. For the material Strength Tests, PLA was the strongest, followed by ABS, and PETG. PETG was the most flexible; this was consistent with its lower Modulus of Elasticity values.

Conclusions

This project was declared a success. The Multi-Faceted Material Strength Testing Machine successfully demonstrated 5 different Strength Tests using 3 different materials; used readily available, low cost components; and incorporated electrical, mechanical, and software design aspects. This Material Strength Testing Machine is ready for a small start-up to test their 3D printed products' materials strengths.

Summary Statement

Developing and demonstrating a stand-alone, low cost, open-source, reconfigurable, adaptable, universal test machine (UTM) for strength testing of 3D printed plastics.

Help Received

My father purchased the components and materials that I identified for this project. A local sheet metal shop helped bend the flexure test fixture pieces.