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# Design and Fabrication of Portable Tensile Testing Machine for Polymers & Filaments

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## Abstract

This research project presents the design and development of a portable tensile testing apparatus intended for determining the tensile characteristics of polymer-grade tensile specimens. The project also highlights the rationale for using compact tensile testing machines as effective alternatives to conventional large-scale tensile testing systems currently employed in laboratories and industries. Tensile testing is a widely used experimental method for evaluating the mechanical properties of polymers, primarily to determine parameters such as tensile strength and the maximum elongation before fracture. The project is divided into two major phases: design and fabrication of the tensile testing machine. The mechanical design of the system is developed using UG NX software, following which the apparatus is fabricated and experimentally tested. The performance results obtained from the fabricated machine are analyzed to validate its functionality and effectiveness.

***Key Words***: Portable tensile testing, 3D printing filaments, polymers, s-type load cell

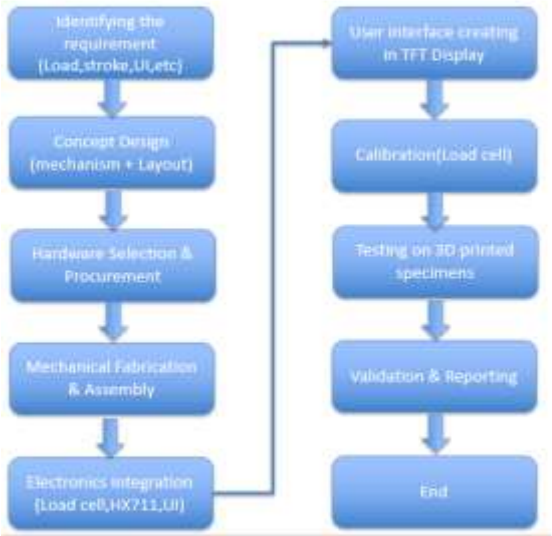
## Introduction

A significant advancement in the field of materials testing is the design and fabrication of a portable tensile testing apparatus for polymers, which enhances accessibility and flexibility in evaluating polymeric materials. The main objective of this project is to design a compact, efficient and cost-effective system capable of accurately determining key mechanical properties of polymer specimens, including yield strength, ultimate tensile strength, Young’s modulus, Poisson’s ratio, and other related characteristics. The proposed portable tensile testing apparatus employs modern electromechanical systems to apply controlled tensile loads to the specimen while continuously measuring its deformation response, thereby generating precise stress–strain data. Unlike conventional large-scale tensile testing machines, which are often unsuitable for field use, educational laboratories, research environments, and quality control applications, the portability of the proposed system enables on-site testing and real-time analysis. This capability significantly improves testing efficiency and practicality. The implementation of this portable tensile testing machine is expected to enhance the speed, accuracy, and reliability of polymer property evaluation, facilitating improved material selection, performance assessment, and failure analysis. Ultimately, the outcomes of this project contribute to the advancement of polymer engineering and its applications across various industries.

## Objectives

The objective of this project is to design and develop a portable, compact, and cost-effective tensile testing machine for evaluating the mechanical properties of polymer materials and 3D printing filaments. The system aims to accurately measure tensile characteristics such as tensile strength, Young’s modulus, yield strength, and percentage elongation under controlled loading conditions. By offering portability and ease of operation, the proposed machine serves as a practical alternative to conventional universal testing machines, enabling on-site testing, research, and educational applications. The project also seeks to generate reliable stress–strain data to support material characterization, performance evaluation, and failure analysis, thereby contributing to improved material selection and advancement in polymer and additive manufacturing technologies.

## Methodology




## Component used for fabrication

1. Aluminum Profile 80x40
2. Electric Linear actuator
3. S-type Load cell
4. Microcontroller-Arduino Mega
5. HX711 (Load cell Driver)
6. 3.5" TFT touch screen Display
7. SMPS (Switch mode power supply)

## Fabricated Model

**Fig 1:** Fabricated Model

## Wiring Diagram

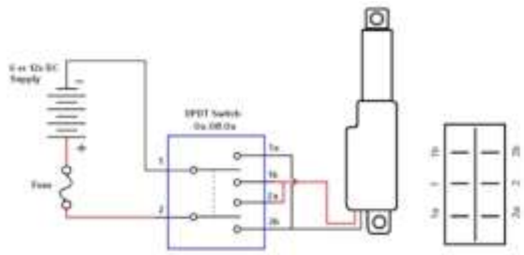


**Fig 2**: Wiring diagram Actuator to SMPS and DPDT switch

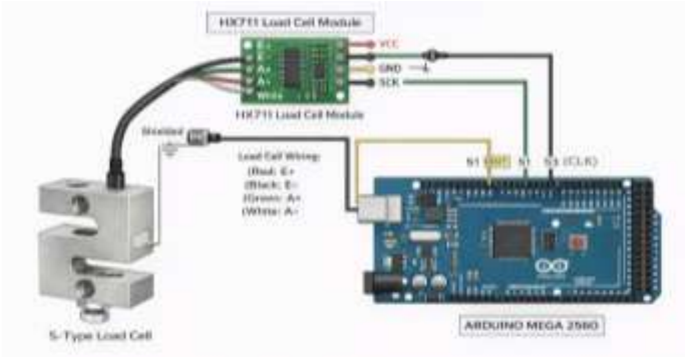


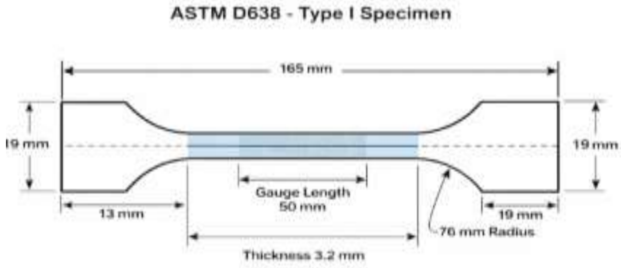

**Fig 3:** Arduino to HX711 and Load cell

## Working principle.

- The portable tensile testing machine works on the principle of applying a controlled uniaxial tensile load to a polymer specimen and measuring its mechanical response.
- The test specimen is clamped between two grips, where one grip is fixed and the other is connected to a linear electric actuator.
- The electric linear actuator provides uniform linear motion, gradually applying tensile force to the specimen during the test.
- An S-type load cell is mounted in series with the specimen to measure the applied tensile force.
- As the specimen is stretched, the load cell deforms, causing a change in resistance of the strain gauges inside it.
- The load cell generates a low-magnitude analog voltage signal proportional to the applied force.
- The HX711 load cell amplifier amplifies this weak signal and converts it into a high-resolution digital output.
- The Arduino Mega microcontroller receives the digital load data from the HX711 module.
- The Arduino processes the data using calibration factors to determine the actual applied load.
- Based on load and elongation values, stress and strain are calculated using standard equations.
- The Arduino continuously records data to generate a stress–strain curve.
- The test continues until the specimen fractures or reaches the preset load/displacement limit.
- The measured data is displayed on a TFT/LCD screen or stored for further analysis.

**Specimen used for testing**

Specimen taken as ASTM D638 type 1 cross-sectional area of 41.66 $mm^2$




**Result**

*Average Tensile load for PLA is 60 Mpa for

Load = 2496 N

Equivalent load ≈ 255 kg

Table 1 :Actual load obtained on at break point

| Material Type | Infill Percentage | Load at break point |
|---|---|---|
| PLA | 20 | 166 |
| PLA | 25 | 175 |
| PLA | 30 | 190 |

# Conclusion

•A portable tensile testing machine suitable for testing 3D printed polymers and filaments was successfully designed and developed.

•The system effectively measured the tensile load and strength of PLA specimens.

•The calculated tensile load values confirm that the developed setup can handle typical polymer testing requirements.

•The results demonstrate that the portable system provides reliable and repeatable measurements comparable to conventional tensile testing machines.

•This portable tensile testing solution offers a cost-effective, compact, and user-friendly alternative for material testing in educational, research, and small-scale industrial applications.

# References

1] M. Kadari, Design and Fabrication of Portable Tensile Testing Machine for Polymers, International Journal for Multidisciplinary Research (IJFMR), vol. 6, no. 3, May-June 2024. IJFMR

[2] M. Rizal, U. Aulia, and R. Yudiansyah, “Development of a portable universal testing machine for investigating the mechanical properties of medium-strength materials,” Aceh International Journal of Science and Technology, vol. 12, no. 1, pp. 25-32, Apr. 2023. Jurnal Usk

[3] Development of a portable Universal Testing Machine (UTM) compatible with 3D laser-confocal microscope for thin materials, Advances in Industrial and Manufacturing Engineering, vol. 4, May 2022. ScienceDirect

[4] S. V. Gunter et al., “Portable universal tensile testing machine for studying mechanical properties of super elastic biomaterials,” Engineering Research Express, vol. 3, no. 4, 2021. ResearchGate

[5] K. Nandy et al., “Open-source micro-tensile testers via additive manufacturing for the mechanical characterization of thin films and papers,” Plos One, vol. 13, no. 5, 2018. PLOS

[6] A. Salih, “A low-cost open-source uniaxial tensile system for soft tissue tensile testing,” Machines, vol. 2, no. 4, 2024. MDPI

[7] J. H. Arrizabalaga and M. K. McCrink, “Fabrication of an economical Arduino-based uniaxial tensile test apparatus,” J. Chem. Educ., 2017. American Chemical Society Publications

[8] F. Akkoyun, “An inexpensive tensile test machine for educational and research use,” DergiPark, 2023. DergiPark