

- **Abstract**

This This project explores the use of 3D printing with special materials, focusing on thermoplastic polyurethane (TPU) mixed with a foaming agent. These materials are known for being flexible and lightweight, and their properties can be adjusted by changing the printing temperature, flow, and speed. Our goal was to understand how to get the best possible print quality and mechanical performance from them.

To improve the printing process, we added a closed chamber around the 3D printer to control the surrounding temperature. We built a heating system using a heater, fan, thermistor, and Arduino-controlled PID system, which helped keep the temperature stable during printing.

We also experimented with different settings — like nozzle temperature, flow, speed and layer height, to see how they affect the final part's quality. A series of test samples were printed using design of experiment method, and we evaluated how the internal structure and porosity were affected.

To measure the strength of the printed parts, we assembled a universal testing machine to perform compression tests and better understand how the materials respond under pressure. We also partnered with SESAME (a scientific research center in Jordan) to scan samples using micro-CT imaging, giving us a clear picture of the internal foam structure.

Overall, this project shows how environmental control, parameter tuning, and custom testing can lead to better, lighter, and more reliable 3D printed parts — especially for industries that need flexible or energy-absorbing components like automotive, medical, or wearable devices.