



Enabling People of Pakistan with Gripper Prosthesis Model and Various Materials



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BACKGROUND

Typical materials used in 3D printing are a form of biodegradable plastic known as Polylactic Acid (more commonly PLA). This plastic is relatively amenable to being printed flat and thermoformed through applying heat in order to make flat pieces formable into cuff shapes to fit over residual limbs. Typically, these thermoformable parts are proven to have higher strength than parts printed with premade curves. However, the intense heat of the environments in Pakistan call for a different material. In this work, we explore some of the thermal properties of a variety of 3D printing plastics (notably, PLA, PLA+, ABS, PETG and NINJAFLEX) to identify suitable materials for printing prosthetic devices for use in high temperature environments.



Fig. 1: Finished printed Gripper hand models by using the design in collaboration with Grit3D. The hand functions by provided the basic needs of a hand. The mechanism provides a gripping mechanism to be able to grasp round and flat objects.

ANALYSIS

	ABS	PLA	PETG	Flexible
Ultimate Strength	40 Mpa	65 Mpa	53 Mpa	26-42 Mpa
Stiffness	4/10	7.5/10	5/10	1/10
Durability	8/10	4/10	8/10	9/10
Maximum Service Temperature	98°C	52°C	73°C	60-74°C
Density	1.04g/cm ³	1.19-1.23g/cm ³	1.23g/cm ³	1.19-1.23g/cm ³
Price (per Kg)	\$10-\$40	\$10-\$40	\$20-\$60	\$30-\$70
Printability	4/10	9/10	9/10	6/10
Extruder Temperature	220-250°C	190-220°C	230-250°C	225-245°C
Bed temperature	95-110°C	45-60°C	75-90°C	45-60°C
Heated Build Plate	Required	Optional	Required	Optional
Build Plate Surface	Kapton Tape, ABS Slurry	Painter's Tape, Glue Stick, Glass Plate, PEI	Glue Stick, Painter's Tape	PEI, Painter's Tape
Durability	Heated Bed, Enclosure	Part Cooling Fan	Heated Bed, Part Cooling Fan	Part Cooling Fan

Production of Parts for Research

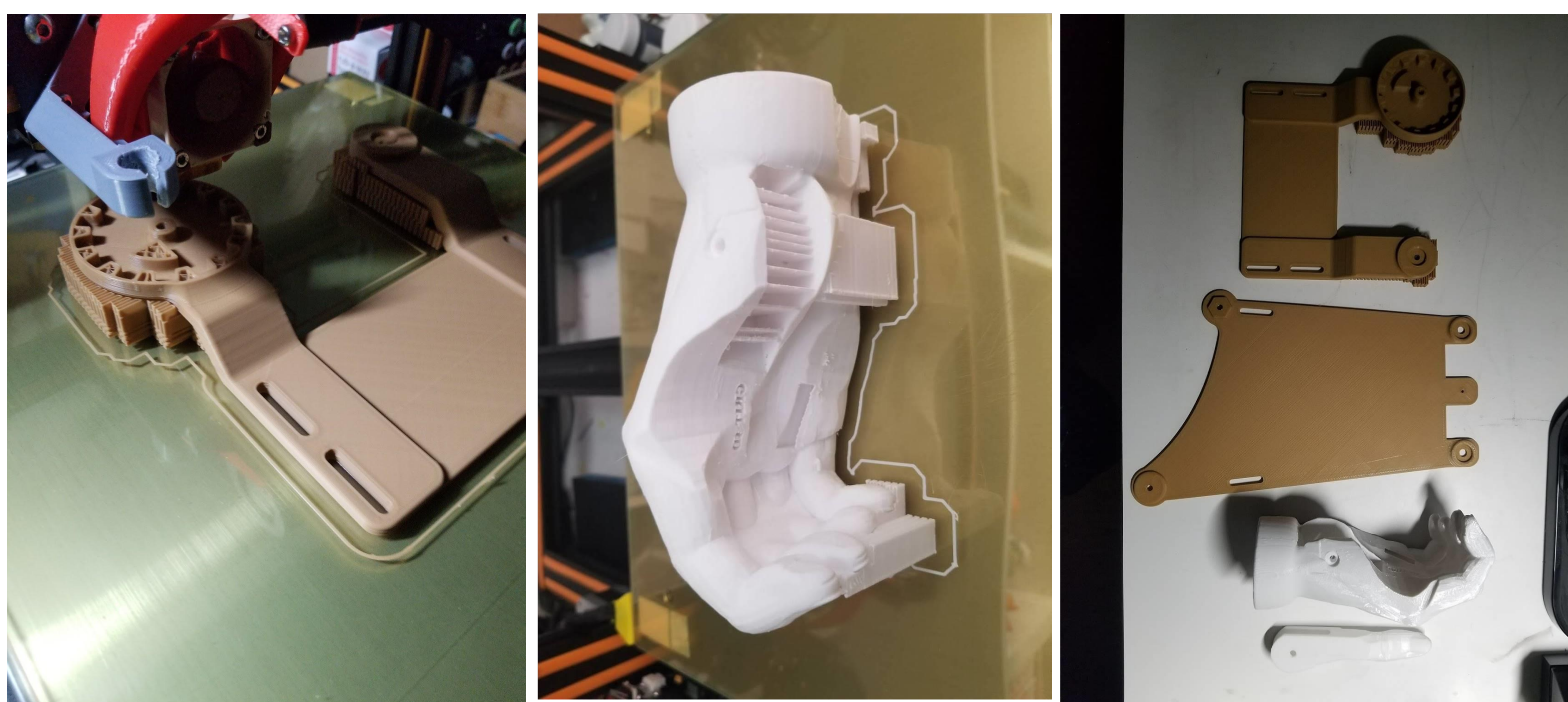


Fig. 2: This is the process of how the 3D printed hands are created. Using the Printer Cr-10 by Creality, it provided a large around build surface to print various objects such as hands and forearms in a larger size. Different materials were printed on this machine. The example demonstrates PLA and PETG as the material of choice for this build. The white represents PETG being used for the main function of the hand. Since the hand is the main function, a stronger material such as PETG is the preferred choice. The brown represents PLA which is used for the forearm. Since PLA has a low melting point, thermoforming is preferred to be used with PLA.

Material Strength Test



Fig 3: A force meter is used to determine how much force is needed to completely break the test object of various materials. ABS, PLA, PETG, and TPU were the subjects tests

Conclusions

- 3D Printing has provided a more comfortable and friendly approach towards prosthetics.
- Partnership with Grit3D and e-NABLE resulted in addressing the high cost of medical prosthetics.
- Continue the search for the ideal combination of different 3D printed materials for the best possible

MATERIAL ANALYSIS

PLA is the easiest polymer to print while at the same time providing great visual quality. The material is rigid but can is very brittle. ABS is significantly better than PLA with higher temperature resistance and toughness. PETG is a softer polymer with additive properties to combine the pros of PLA and ABS. Flexible (TPU) is a material used for flexible applications with high impact resistance and elongation.

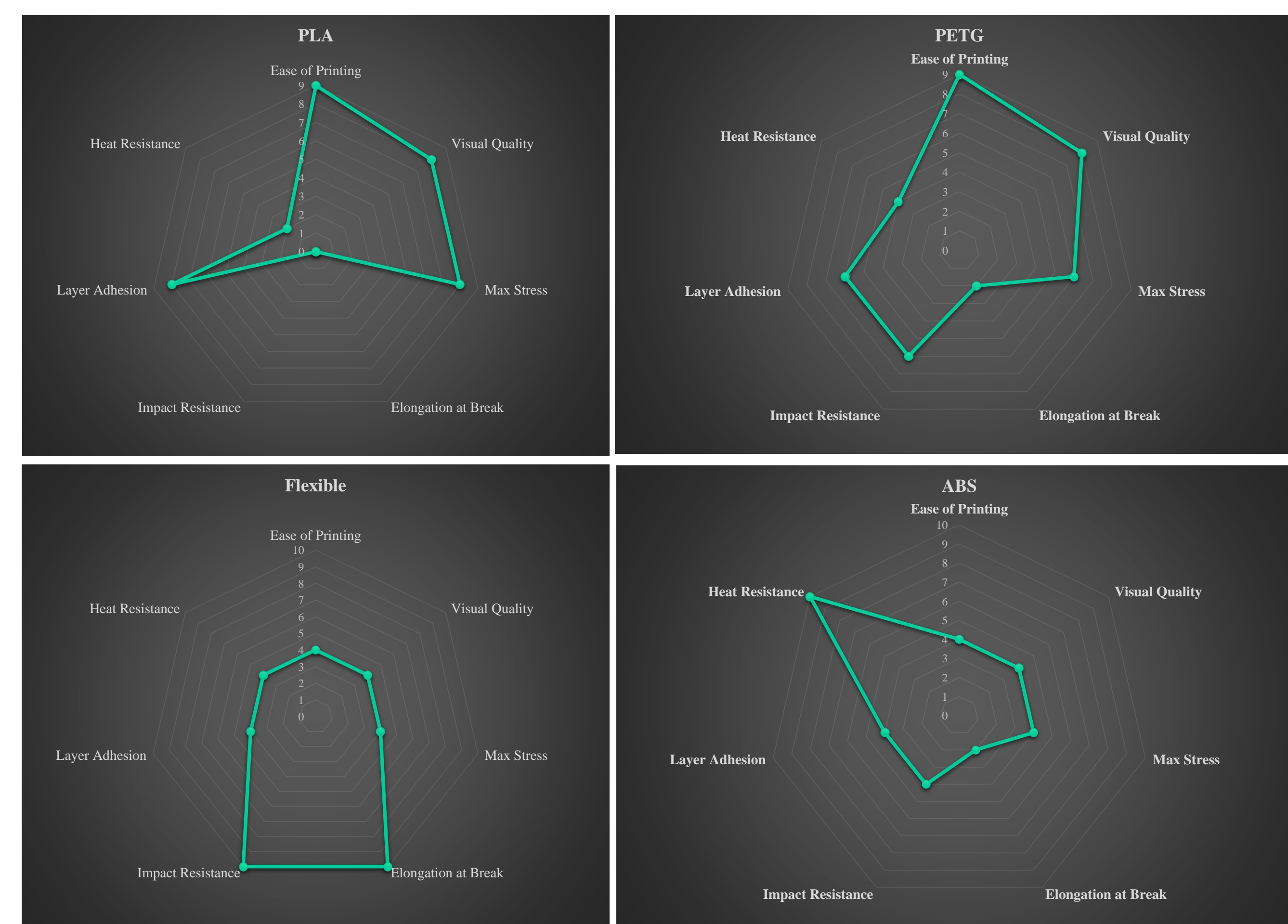


Fig. 4: Radar graph showing all the properties of each material (PLA, ABS, TPU, PETG). The properties being tested ranges from a scale of 1-10 (Ease of Printing, Heat Resistance, Layer Adhesion, Impact Resistance, Elongation at Break, Mass Stress, Visual Quality,)