ROBOTIC 3D PRINTING OF CONTINUOUS CARBON FIBER PEEK

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Fused Filament Fabrication (FFF) also called Material Extrusion (MEX) is a 3D printing technique that can manufacture parts from continuous fiber reinforced polymers. In this work, a custom-built 3D printing head with a circular nozzle is installed on an ABB IRB1200 robotic arm. A Programmable Logic Controller (PLC) box monitors and controls the nozzle temperature through a thermocouple and two heating elements. The build platform is a ¼ inch thick polyetherimide (PEI) bed bolted down to a flat Aluminum plate. A ThermoPlastic UniDirectional (TPUD) tape which combines continuous high strength carbon fiber and poly ether ether ketone (PEEK) is provided by Teijin Carbon America (Tenax®-E TPUD PEEK-HTS45). The tape is slitted to a 1/16-inch width for 3D printing, and has a nominal thickness of 0.14 mm. Different nozzle temperature, step size, and 3D printing speed were investigated, and optimum values of 410 °C, 1.65 mm, and 10 mm/s, respectively, were selected for manufacturing tensile specimens per ASTM D3039-17. Thermal testing using Differential Scanning Calorimetry (DSC) is performed to determine glass transition temperature (T_g) and degree of crystallinity for the 3D printed specimens. Furthermore, microscopic imaging of the cross section of a tensile specimen is explored to evaluate fiber distribution and voids. Tensile modulus, strength, and failure strain of 108 GPa, 1159 MPa, and 1.76% are obtained, respectively, which show improvement in mechanical properties of 3D printed composite parts compared to the literature. A T_g of 142.7 °C is found, which is in line with the materials datasheet, and degree of crystallinity is 38%. Microscopic imaging and failure cross-sections show a twist in the fiber bundles and some issues with the consolidations of the layers. These issues can be resolved by using a slotted nozzle, and will be explored in future.

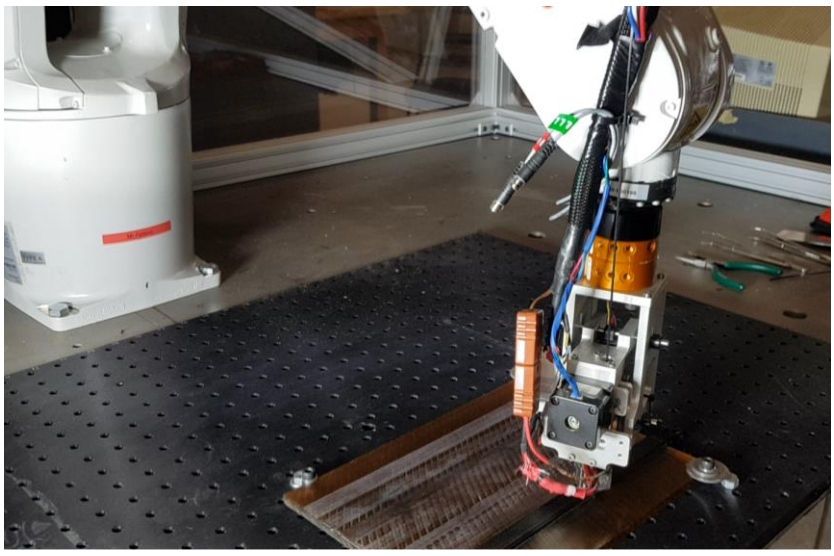

Figure 1: Robotic 3D printing of a tensile specimen from PEEK-carbon fiber on a PEI build platform.