# PhD Dissertation Defense Announcement
# Mechanical and Aerospace Engineering Department
# University of Texas at Arlington

## In-situ Observation of Extrusion Processes in Thermoplastic Material Extrusion Based Additive Manufacturing

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### Abstract

In thermoplastic material extrusion based additive manufacturing, solid polymer filaments are fed into extruders to generate extrudates that are needed to build 3D plastic products. There is a finite gap between the inner surface of an extruder and the edge of a filament. This gap facilitates the insertion and translation of the filament inside the extruder. However, it is still not clear how the gap is filled during the extrusion. Lack of this information makes it difficult to model the temperature distribution and flow profile during the extrusion. In this work, we built experimental apparatus to directly observe the gap-filling processes of Acrylonitrile Butadiene Styrene (ABS) and Polylactic Acid (PLA) filaments, for different combinations of extrusion temperatures and feed rates. Although ABS and PLA are, respectively, amorphous and semi-crystalline polymers, for both materials, we found: i) the gap inside an extruder was filled through three different steps during the initial stage of extrusion; ii) the gap-filling level depended on extrusion temperature and feed rate; and iii) there was no noticeable difference in the gap-filling level when the extrusion started with an empty tube or resumed after the printing had been paused. The steady extrusion processes of ABS were simulated with computational fluid dynamic software. Two sets of simulation were conducted: one with glass tube and the other with aluminum tube. The numerical results for the case of glass tube were validated by comparing them with experimental results. The simulation results indicated: 1) when polymer flow was sufficiently heated, the flow characteristics were similar in the cases of glass and aluminum tubes; 2) if the feed rates were high, due to shorting heating time and low thermal diffusivity of the polymeric material, the polymer were insufficiently heated and clogging might occur; and 3) as heat transferred faster through the aluminum tube to the polymer, the feed rate that caused clogging in the case of aluminum tube was higher than its counterpart in the case of glass tube.