ABSTRACT

The objective of this thesis was to link functional integrity (tensile strength and fatigue life) of polymer parts, made using fused filament fabrication (FFF) additive manufacturing (AM) process, to input parameters, specifically layer height, number of shells, and infill percentage through multi-phased design of experiments. FFF is the most popular AM process. In FFF, a thermoplastic polymer (e.g., ABS, PLA, etc.) is heated past its glass transition temperature, and subsequently selectively deposited, layer-by-layer, via a nozzle that follows a computer-controlled path.

Mechanical testing was carried out for two specimen materials; ABS and carbon fiber reinforced-PLA (CF-PLA). Specimens (ASTM D638-Type V) were tested for fracture strength and fatigue life (number of cycles to failure). The design slicing parameters studied in this work were layer height, number of shells, and infill percentage.

The results revealed a nonlinear concave-up trend in tensile strength vs. layer height. The fatigue behaviour of the specimen were compared to tensile strength trend against the layer height under two different cyclic loading conditions; repetitive unidirectional and fully reversed. The fatigue life vs. layer height for repetitive unidirectional cyclic loading has slightly different trend to tensile strength vs. layer height. Additionally, the trend against the layer height differs even more for the fully reversed cyclic loading from tensile strength behavior i.e., the fatigue life behavior is contingent on the type of stress applied (compressive or tensile stress). Image analyses of the specimens’ fracture surfaces reveal that inter-road voids and their distribution were a function of process slicing parameters. Also, it was found that the void area affects tensile and fatigue strength differently.