Material Characterization of Fused Deposition Modeling (FDM) Process

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ABSTRACT

There are many different Rapid Prototyping (RP) technologies available, each with its own unique set of competencies and limitations. While Stratasys’ FDM’s ABS plastic material is much tougher than parts made by other RP processes (such as SLA), we have still experienced brittle fractures at relatively low loads. This experience goes against the claim that Stratasys makes that FDM parts possess 70% of the strength of solid ABS parts. Also, this claim is vague as the yield strength of general ABS can vary from 30 MPa to 130 MPa. In addition, it is very clear that the FDM process deposits material in a direction way; which results in anisotropic parts. With these problems in mind, we set out to characterize the material behavior of FDM parts, as well as the effects of the following process control parameters: a) bid width, b)air gap, c) model build temperature, d) raster orientation, and e) color of FDM material. A series of samples were fabricated by FDM 1650 with various process control parameters and mechanical properties such as stiffness and strength were measured both by tension and by shear tests. Test results showed that air gap and raster were the most significant parameters affecting the mechanical properties. As a modeling method of the anisotropic behavior of FDM parts, Classical Lamination Theory (CLT) of composite material was applied to the FDM parts. Strength of FDM sample was modeled using Tsai-Wu failure criterion and compared with experimental data. Based on the results of the experiment, some build rules of FDM process have been formulated.