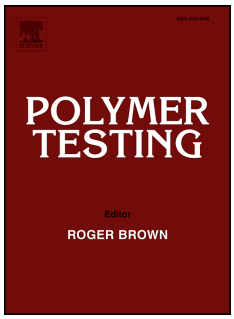

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Fracture mechanical characterization and lifetime estimation of near-homogeneous components produced by fused filament fabrication

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Abstract

It has been widely believed that components produced by fused filament fabrication (FFF) experience weak mechanical properties due to weld lines. However, recent studies disproved this finding by reaching strength values almost identical to those of compression-molded plates by optimizing the printing parameters. Hence, the present work investigates different fracture mechanical properties on specimens produced by FFF under optimized conditions dependent on the strand orientation. For monotonic loading conditions, tests on compact tension (CT) and single edge notched bending (SENB) specimens resulted in rather similar results for specimens produced in 0°, 0°/90° and 90° strand orientation. Surprisingly, the 90° orientation, in which the strand interface is directly loaded, even outperformed the 0° orientation in certain cases. Fatigue tests on CT-specimens proved a similar independency of the strand orientation for both crack initiation and crack propagation laws, which can be used for lifetime estimation of components produced by FFF.

Keywords

Fused filament fabrication; additive manufacturing; polylactic acid, homogeneous properties, fracture mechanics, lifetime-model

1. Introduction

Fused filament fabrication (FFF), also known as material extrusion [1], fused deposition modeling (FDM™) or 3D-printing is an extrusion-based additive manufacturing technique that allows the automated fabrication of complex parts [1]. The process is based on the extrusion of a thermoplastic filament that is transported by two counter-rotating driving wheels into a hot die, in which the material