HYGROTHERMAL CYCLING OF THERMOPLASTIC COMPOSITES IN A STEAM ENVIRONMENT

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ABSTRACT

The effects of repeated steam sterilization were evaluated for four continuous carbon fiber reinforced composite laminates chosen as candidate materials for a surgical instrument product design. The resin systems tested include polyetheretherketone (PEEK), polyphenylene sulfide (PPS), polyether imide (PEI) and epoxy. In this study, composite laminates were subjected to hygrothermal conditioning in a steam environment and the effects were evaluated mechanically and visually. Flexural strength and modulus, as well as changes in coupon weight were evaluated before and after cycling at 0, 200, 400, 600, 800, and 1000 cycle intervals. Photomicrographs were also acquired at these intervals to better understand the mechanism of degradation for each composite laminate.

A significant reduction in flexural strength following 1000 cycles of sterilization was observed for all materials in this study. In terms of flexural strength retention, material performance is ranked as follows: C/Epoxy >> C/PEI > C/PEEK > C/PPS. All materials experienced a slight reduction in flexural modulus; although initial reductions remained steady after about 400 cycles for all materials. The typical exposure effects for all materials were primarily surface oxidation and transverse ply cracking, as shown in the photomicrographs. This study is valuable for material selection and understanding the potential service life of any product exposed to a steam environment.

1. INTRODUCTION

This study evaluated the effect of high cycles of repeated steam autoclave sterilization on the flexural strength of carbon fiber reinforced composite materials. Elevated sterilization temperature and steam exposure is a harsh environment causing complex and synergistic degradation modes, and the effects of this exposure are important to understand not only for material selection but also to identify or even prolong the expected service life of a part. This entails consideration of continuous damage accumulation by many contributing factors such as hygrothermal (combined moisture and temperature) effects, polymer oxidation, matrix cracking, and microstructural changes. It is generally understood that polymeric composite properties are significantly affected by the elements of this study – high temperature exposure, thermal cycling, and moisture absorption. The degree to which composites are affected depends on the matrix, reinforcement, and fiber-matrix interface [1]. Understanding the mechanism of damage accumulation may allow us to compensate by changing manufacturing parameters, or altering the fiber orientation/stacking sequence, or by adding a coating. For example, matrix cracking resulting from residual stresses during laminate processing may be relieved by altering processing parameters such as cooling rate. Matrix surface oxidation may be retarded by

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