Fiber Bragg Grating Embedded in Latex Paint to Monitor Drying Process During First and Second Coat

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Abstract: This work shows results of application of a fiber Bragg strain sensor to monitor the latex paint drying process. Fiber Bragg strain sensor was embedded into a commercial vinyl-acrylic latex paint to detect strain during first and second coat. The second coat was applied 240 minutes after first coat application, as recommended by manufacturer. For both coats, the latex paint film changed from liquid state to solid, and the mechanical deformation was monitored by the packaged fiber Bragg strain sensor during all drying process. The influence of water addition in the drying process also was investigated. For the first coat, the latex paint was diluted with one part paint and one part water, and was observed that the increase of the water into the paint decreases the mechanical deformation magnitude.

Keywords: Fiber Bragg grating, optical fiber strain sensor, paint drying process

1. Introduction

Paints are made of numerous components, and these components can be classified as volatile or nonvolatile. Volatile paint components include organic solvents, water, and coalescing agents. Nonvolatile components include binders, resins, plasticizers, paint additives, dyes, and pigments [1]. Most conventional paints are often formulated with organic solvents to improve performance and durability. However, due to the current strictest global environmental legislation and regulatory norms of human health, paint manufacturers are committed to design and developing paints and coatings that have low- or no-VOC (Volatile Organic Compounds). As a consequence, water-based paints have been considered a promising alternative for future, and have attracted considerable attention. The need of improve performance is essential to determine whether these new product formulations are equal or better in quality and durability than solvent-based paints. The drying time, for example, is important information that should be respected after application of a paint film to a substrate, not only for its physical appearance but also for its better protective properties. Most surfaces need two coats of paint to be optimally durable. Therefore, to apply a second coat is vital to let the previous coat of paint dry completely. The recommended drying time is always specified on the label of the paint.

Most water-based paints are latex paints and its drying process is usually divided into three steps. The first step corresponds to the evaporation of water from the latex surface resulting in more concentrated latex; the second step starts when the particles first come to irreversible contact; and, finally, the third step starts with the formation a continuous film [2-3]. In latex coatings, the polymer chains are confined in particles which must coalesce during solvent evaporation and subsequent ageing to form a protective and mechanically rigid film.

In Brazil, the paint industry uses the Brazilian Technical Standard (NBR 9558) for determination of the drying time of its formulations. The technical standard describes the methodology for characterization of the paint drying time, and the drying process is sub-divided in four stages: dry-to-touch, tack-free, dry-to-handle and dry-through. Each regular time interval the operator touch the paint film with his finger/fingernail and these four stages are classified [4]. On the other hand, in most of applications a non-contact method is required, as the operator can damages the painted surface, and personal impressions can produce erroneous results in the determination of the paint drying time.

For strain monitoring of composite or concrete structures, fiber Bragg grating (FBG) sensors have several advantages, including ideal size for embedding into composites without introducing any significant perturbation to the characteristics of the structure. These sensors have emerged as a reliable, in situ, non-destructive tool for monitoring and diagnostics control [5]. Fiber Bragg grating can be fabricated in photosensitive optical fibers by an appropriate sideways exposure to ultraviolet light periodically distributed along a segment of optical fiber [6-7]. This results in a grating consisting of a periodic perturbation in the refractive index of the fiber core whose periodicity is in the range of micrometers. When light with a broadband is coupled into the optical fiber, the Bragg grating will reflect a narrow-band spectrum with a central peak wavelength called the Bragg wavelength that fulfills the Bragg condition [8]. External parameters as strain and temperature variations along the grating are detected as a shift in the Bragg wavelength. This dependency allows the FBG to be applied as a sensor of such parameters [9-10].

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