Fibre Bragg grating applied to monitor the stress evolution on drying time of latex paint

Ivo de Lourenço Jr., Gustavo R. C. Possetti, Marcia Muller and José Luís Fabris
Programa de Pós-Graduação em Engenharia Elétrica e Informática Industrial - CPGEI
Universidade Tecnológica Federal do Paraná - UTFPR
Curitiba, Brazil
lourenco@utfpr.edu.br

Abstract—**This work shows results from the application of an optical sensor based on fibre Bragg grating to monitor the drying of paints. The drying time of the latex paint film was monitored along 370 minutes by an encapsulated fibre Bragg grating employed as transducer device for the mechanical forces inherent to the process. Along the drying, the paint film changed from a sticky liquid state to a solid state. Changes in the film during the drying are analyzed by the FBG strain sensitivity. Temperature changes were also monitored with another Bragg grating in the same optical link.**

Keywords-fibre Bragg grating; paint; optical fibre; drying process.

I. Introduction

Nowadays, paint represents one of the most important applications of polymers. In the early phases of paint industries, the raw materials, oils, resins and pigments used in the paint formulations were exclusively natural in origin. In modern paint formulations, materials of natural origin are still employed, although in lower amounts [1]. The paint industry, trying to satisfy the current strictest global environmental legislation and regulatory norms of human health, developed an alternative methodology of paint production to obtain products with low Volatile Organic Compounds (VOC) emission. Therefore, to solve these problems, water-based formulations and powder paint are alternatives proposed by the paint industry.

Most water-based paints are latex paints and its drying process has been attracted some of attention from the researchers [2] – [4]. There are some tests that paint industry performs to guarantee the desired properties in its formulations. Particularly, tests on wet paint films consist on the measurement of drying time by the Dust Method, Touch Dry and Through Dry [5]. During the polymer film formation from latex, a stable colloidal dispersion transforms to a continuous, transparent and mechanically stable film [6]. The process of film formation, from wet latex to polymeric film is usually described into three stages [7]. The first stage corresponds to the water evaporation from the latex surface resulting in more concentrated latex; the second starts when the particles first come to irreversible contact, and iridescence action may be observed on the latex surface; the third starts with the formation of a continuous film. Paint films are subjected to a great variety of mechanical forces and deformations, the evolution of such stress during film formation being little experimentally probed.

In Brazil, the paint industry employs direct contact methods that are influenced by the operator sense to check the drying time of its formulations. The determination of the drying stages described by the Brazilian Technical Standards (NBR 9558) are made by the contact of the fingers and fingernails with the paint film and often leads to a lack of reproducibility and repeatability [8]. In this determination method, the drying process is sub-divided in four stages: dry-to-touch, tack-free, dry-to-handle and dry-through. However, in most of applications a non-contact method is required as the operator can damages the painted surface, and personal impressions can introduce errors in the determination of the paint drying time. Clearly, there is a lack of drying monitoring techniques that could be applied in the paint industry.

Petersen et al proposed a cantilever method to follow the macroscopic stress evolution of a polymer film. The films are dried on a flexible substrate, and the substrate curvature caused by the film stress evolution was detected with a laser beam reflected from a small mirror fixed to the cantilever [9]. It was observed a stress evolution that reflects the influence of a great variety of micromechanical processes. Two other non-contact methods for monitoring the drying paint process were proposed, both of them based in the detection of light reflection from the film. One method is based on the detection of the speckle pattern obtained when the film surface is illuminated by a laser beam [10] and the other on the reflectivity of an electromagnetic pulse of terahertz (THz) [11]. On other hand, along the last years, temperature and strain have been successfully measured with a special class of optical sensors based on fibre gratings [12] – [15].

In this work a fibre Bragg grating device (FBG) was used to follow the macroscopic stress evolution on the drying time of a commercial latex paint based on poly vinyl acetate. Changes in the film during the drying process are analyzed by the FBG strain sensitivity.

II. Theory

A fiber Bragg gratings is a periodic modulation of the fiber core refractive index whose periodicity is in the range of micrometers. This periodic modulation couples light from core co-propagating mode to the contra-propagating mode at a

This work is supported by CAPES, CNPq, FINEP, Fundação Araucária and ANP (PRH10-UTFPR).