Characterization of an encapsulated Long Period Grating transducer applied as a refractometer

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Abstract - **This work presents the applicability of an encapsulated long period grating for fuel blends and solvents analysis. It was shown that the optical fiber device sensitivity to changes in the external refractive index is not affected by the encapsulation. In addition to the extra protection to external damages provided by the encapsulation, the device reproducibility was considerably improved. For the employed samples this improvement ranges from 40% to 78%. Finally the transducer performance was assessed in the analysis of ethanol concentration in ethanol-water mixture.**

Keywords- Encapsulation, Long Period Grating, Fuel Adulteration, Optical Fiber Sensors.

I. Introduction

The incessant practice of fuel adulteration increases the need for new technologies, techniques and devices capable of monitoring fuel quality. The determination of constituent concentration in blends is generally useful for methods and instruments that assess the fuel conformity.

Adulteration of fuel in Brazil has intensified with the creation of new distribution centers and the liberation of the importation of solvents. Brazilian gasoline is commonly adulterated using hydrocarbons solvents because, in addition to their low costs, these substances are generally present on the gasoline composition, making difficult to identify illegal samples [1]. Gasoline is also tampered with ethanol added in inappropriate proportions. Fuel hydrated ethyl alcohol is mostly adulterated adding water in excessive and illegal proportions.

Using adulterated fuel causes poor performance and both engine and environmental damage. Brazilian economy is also affected due to the drop in tax revenues. Within this context the development of transducers able to assess the fuel conformity and to supply real-time and reliable results assumes a great importance.

The Long Period Grating (LPG), an optical fiber sensor, is a well established tool with technical viability proved in several types of applications, allowing users to measure a lot of physic parameters as, for example, strain, temperature, pressure and the external refractive index [2]. Besides the external refractive index sensitivity, the LPGs are electrically passive, making it an extremely attractive sensor to be used in the fuel industry. Recently a few works showed the applicability of an LPG as an auxiliary parameter on the determination of fuel conformity [3-5].

Though the fiber grating presents very adequate features for its use as a sensor element, its mechanical properties do not attend the robustness required by a sensor. Special care on handling the device must be dedicated when operating optical fiber gratings based equipments. Applied to the fuel analysis, measurement systems that employ LPG as the transducer element will generally be used by operators that rarely have technical knowledge about the related difficulties on working with this type of device. Therefore, an efficient encapsulation system is needed and constitutes a fundamental step into the prototyping process of portable equipments. Developments of devices that enable fiber optic based sensors to be used under realistic conditions are extremely required. Results were already obtained with success in this area [6].

In order to achieve the mechanical robustness required by commercial sensors, this work presents an encapsulation system designed to make LPG more adequate to be used as an integrated part of portable equipments. Device characteristics as sensitivity and reproducibility are presented. Additionally the device applicability to analyze fuels, especially the ethanol concentration in ethanol-water mixture, was studied.

II. Metodology

The LPG used in the experiments was produced using the point-by-point technique based on ultraviolet irradiation [7]. The grating was inscribed into a photosensitive fiber with a Nd:YAG laser, operating at 266nm. The produced grating has periodicity of 400 µm with 65 interaction points, resulting in a total length of 2.60 cm.

Fig. 1 shows the basic components used in the assembly of the encapsulation device. Basically the encapsulation device consists in one shield of galvanized steel, a quartz tube and two drilled screws. The quartz tube, also used on the optical couplers fabrication, has approximately 2 mm of diameter and a 1 mm groove. The screws were drilled (1mm diameter) in order to allocate the quartz tube. In addition to the extra protection, the quartz tube reduces the degrees of freedom of the fiber movements, making the system even more robust.