Monitoring of Coal Waste Piles With Fiber Optic Sensing Technology

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***Abstract*—Coal has been for centuries a central energy source to fulfill industrial and domestic needs. Its large scale extraction produced huge amount of debris that were piled in the neighboring of the mines, quite often going into combustion triggered by events like forest fires or lightning. When in this state it can continue for years, releasing substantial emissions of toxic and greenhouse gases with recognized impact in the environment and, more serious in the short term, in the life quality of the populations located nearby. Continuous monitoring of combustion temperature and emission levels of certain gases opens the possibility to plan corrective actions to minimize their negative impact. Optical fiber technology is well-suited to this purpose and here it is described the main attributes of a fiber optic sensing system projected to gather data on distributed temperature and gas emission in these harsh environments.**

Keywords – Remote monitoring of coal waste piles, optical sensing, fiber optics, temperature and gas sensing.

I. INTRODUCTION

The environmental impact caused by the coal waste is associated with water and soil contamination, and becomes particularly serious when these waste piles are in self-combustion. The coal combustion is responsible for the mobilization of large quantities of pollutants caused by the volatilization of elements present in coal and the associated mineral matter [1, 2]. The uncontrolled release of these pollutants, namely greenhouse gases, particulate matter, toxic elements, and especially organic compounds, represents a risk to the environment and to human health. These problems are even more serious when the coal waste piles are located near urban centers, since some of the pollutants can be inhaled or ingested. In this context, the monitoring of combustion temperature and gaseous emissions is essential to identify the associated hazards and probable evolution scenarios, allowing the definition of timely corrective measures to minimize the negative impacts caused by this phenomenon.

Looking for the remote, multi-point and continuous measurement of gas emissions (specifically ammonia, carbon dioxide and methane) and of combustion temperatures in self-burning coal waste piles, a Interreg-Sudoe project entitled *ECOAL – Ecological Management of Coal Waste Piles in Combustion* is under development, with participation of groups from Portugal, Spain and France. A prototype is under installation in a coal waste pile in self-combustion, located in S. Pedro da Cova, (Porto, Portugal), to evaluate its performance under field conditions. It is foreseen the acquired knowledge and experience will allow the system optimization, opening up the possibility of its widespread application in other coal structures of this type. In addition, the results will allow the study of the dynamics and evolution scenarios of the combustion process in these fields, as well as the identification of hazards to the environment and human health.

II. COAL WASTE PILES

The piles of coal waste found over the old mine sites and adjacent areas represent significant environmental concerns due to their potential influence on soils and sediments, as well as on the surface waters and groundwaters of the surroundings. This is indeed a significant environmental problem in Europe, where for century's coal mines were intensively explored. For example, in the north of Portugal, close to Douro River, 28 of these piles were identified. One of these coal waste piles, located in S. Pedro da Cova, near Porto, started burning in 2005 after intense forest fires in the

region, which caused their ignition, adding further environmental concerns. This waste pile is located very close to the oldest center of mining activities in S. Pedro da Cova and near to a population center and social infrastructures. This waste pile has an elongated form, occupying an area of approximately 28 000 m2, with the burning process occurring in the south slope and moving along it (Fig. 1).

Fig. 1. View of the coal waste region (ellipse) and testing site (circle); bottom left: entry to the mine and burning in the pile slope.

III. OPTICAL FIBER SENSING SYSTEM

When evaluating sensing technologies that could be applied under such harsh conditions it became clear fiber optic based was the most adequate. Therefore, the project was built supported in fiber optic technology for temperature and gas sensing.

For distribute temperature sensing, Brillouin techniques will be applied providing a resolution of 0.5 meters over more than 1 km measurement length. For gas detection, the target is the measurement of ammonia, carbon dioxide and methane concentrations. An optoelectronic system has been developed based on *Wavelength Modulation Spectroscopy* (WMS) principle [3]. Two different locals in the coal waste pile were selected for gas concentration measurement.

Fig. 2 illustrates some of the results obtained in laboratory conditions of the sub-system for gas sensing, considering methane and carbon dioxide measurement. A multi-pass cell sensing head with 80 cm of optical path length was used and the DFBs lasers work at wavelengths of 1653.72 nm (for methane detection) and 1572 nm (for carbon dioxide).

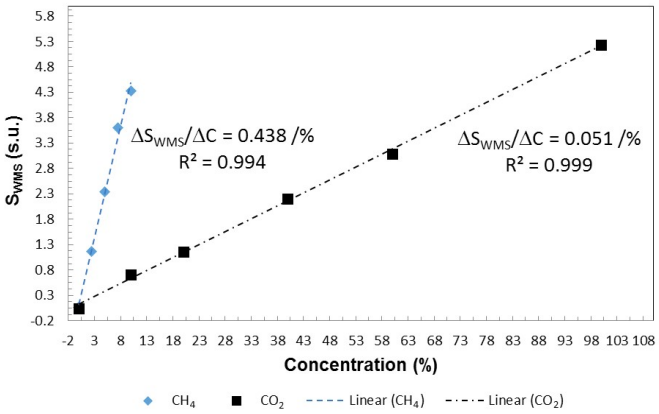

Fig. 2. Data obtained from the WMS interrogation technique versus methane and carbon dioxide concentration.

The optical fiber sensing system is in its final stage of installation and shall be fully operational during February 2015. Results will be delivered in the Conference.

IV. CONCLUSIONS

Here, it was outlined the problematic of self-burning coal waste piles and described a project aiming the development of a fiber optic sensing system for real time monitoring of combustion temperatures and gas emissions, with its performance evaluation derived from a prototype installation in an active coal waste pile. The central goal of this initiative is to contribute to the study of the combustion process dynamics and to set evolution scenarios of such fields, enabling the establishment of measures to minimize the environmental negative impacts originated from these wastes.

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