Blast Furnace Non-Destructive Testing (NDT) for Defect Detection and Refractory Thickness Measurements

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ABSTRACT

Modern Blast Furnace operation, which combines high productivity with high fuel injection rates, will have a significant effect on hearth lining wear. This will ultimately shorten the hearth life. In the iron and steel industry, traditionally, empirical techniques based on thermal flux measurements in combination with numerical modeling has been used in order to estimate the refractory thickness and quality in operating Blast Furnaces. Recently, a more accurate and reliable technique based on stress wave propagation principals has been developed for measuring refractory lining thickness in operating Blast Furnaces. Acousto Ultrasonic-Echo (AU-E) is a Non-Destructive Testing (NDT) technique that uses the resulting time and frequency spectra of the compressive waves to map and evaluate the condition of the lining in Blast Furnaces. In addition, the technique uses known material properties to account for thermal and dimensional effects for the refractory evaluation.
This paper presents the main principles of AU-E technique and discusses a few examples related to NDT measurements in various Blast Furnaces.

INTRODUCTION

During the past two decades significant improvements to the design of the blast furnace have taken place. These improvements include increased furnace volume and operating pressure; new furnace structure and cooling design; improved burden screening and distribution; advances in sensors, instrumentation and control; and the introduction of techniques to lower energy requirements and to save labor. All of these developments have had the objectives of lowering iron costs; increasing campaign life; and improving working conditions for personnel operating and maintaining the furnaces. Typical campaign life is 15 to 20 years, depending on the cooling and refractory design as a whole and the hearth area in particular. Hearth repairs are certainly one of the most costly items. It is therefore profitable to extend the existing hearth life as much as possible.

The hearth lining deteriorates slowly during their operational lifetime. In addition to the expected wearing of the lining, incidents such as gas leakage, water attacks, premature furnace shut downs, and thermal fluctuations could cause severe damage to local areas and eventually the whole structure and causing a reduction in productivity and raise safety concerns. The reliable assessment of refractory lining quality and thickness is important for maintaining a healthy and productive campaign. Any methodology should be reproducible and continuous.

Presently, there are two distinct methods used for estimating the refractory lining thickness in a blast furnace: 1) core-drilling, and 2) thermal couples. In the core-drilling method, a core is drilled up to a pre-determined temperature depth. Hereafter, the core is analyzed in the laboratory to determine if the refractory is deteriorated, i.e. cracks, CO disintegration, etc. Thermal couples are a more passive and permanent monitoring system. The thermal coupling probes are recording the temperatures at various positions around the furnace and based on the thermal properties of the refractory, the remaining thickness is estimated. Discontinuities and fingers could result in false thermal assessments resulting in inaccurate thickness measurements. In addition, core-drilling is not an option that can be repeated as often as desired.

In recent years, the Non-destructive testing (NDT) techniques had limited success in measuring the wear profile in blast furnaces. Radioisotopes, particularly Co-60 sources, were introduced to the blast furnace to determine the refractory lining thickness by a radioactive counter system outside the shell (1). The common issues associated with radioisotopes are the contamination of the steel,