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REDUCTION OF Nox EMISSION IN TANGENTIAL FIRED FURNACE BY CHANGING THE MODE OF OPERATION.

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ABSTRACT

The present work analyses the results of tests on 575 MW units with tangential firing furnace arrangement in sub-stoichiometric combustion. Tangential firing provides good conditions for implementing sub-stoichiometric combustion owing to the delivery scheme of pulverized coal and air. The furnace was tested in several different modes of operation (Over Fire Air, Burners Out Of Service, Excess air, Tilt etc.) to achieve low cost NOx reduction. Actual performance data are presented based on experiments made on IEC's boiler in M.D. 'B' power station..

INTRODUCTION

The modern trends of combustion equipment development are aimed at new low emission burner technology in order to meet increasingly stringent emission standards.

Among the industrial pollutants being restricted and one of the most dangerous is nitrogen oxide. The problem may be solved by combustion tuning or removal from flue gas or both. The first method is much cheaper than the second, although combustion tuning methods are not new and uniqe, they are often overlooked in favor of higher cost technique.

RESULTS OF LOW NOx COMBUSTION TUNING

In the given case the furnace was equipped with a pulverization system using five pulverizers in a hot air direct injection scheme. The pulverized coal from each pulverizer was fed to a separate level of burners, the number of burner levels was therefore equal to the number of pulverizers. The distribution of air along the burner levels could be controlled. A part of the secondary air was fed through the over fire air (OFA) nozzles located above the top level of burners. All the conditions for conducting sub-stoichiometric or staged combustion were therefore available.

Fig. 1 gives the results of testing the operation of the boiler furnace in different modes of combustion process implementation, during all full load tests the boiler was operated with top burner level out of service. In stoichiometric combustion, when all the secondary air was fed through the main burner nozzles, NOx emissions were about 1500 mg/dNm3 (for MD "B" Power Station) and 1140 mg/dNm3 (for Rutenberg Power Station). Feeding a part of the secondary air through the OFA nozzles (OFA 100% open) reduced the NOx content to 1200 mg/dNm3 (for MD "B") and 920 mg/dNm3 (for Rutenberg). When the fifth pulverizer (top burners level) was shut-down, but secondary air was fed through the upper burner level, the rate of NOx emission dropped to 850 mg/dNm3 (for MD"B") and 640 mg/dNm3 (for Rutenberg).

The presented data show that implementing non-stoichiometric combustion reduces considerably NOx emissions, however, it was accompanied by a slight increase in the content of unburned carbon in the ash.

Reduced O_2 is not an original technique for NOx reduction as it is well established, however, in some cases low O_2 levels can be operated in tangential furnace firing pulverized coal. In general reducing O_2 by 1% leads to reduction of 15% in NOx emission, as shown in Fig. 2.

Interesting results were obtained when the boiler furnace was operated with three out of five pulverizers (the lower and upper burner level were shut-down). Turning off the pulverized coal supply to the lower and upper burner levels while feeding a part of the air through the OFA nozzles caused a reduction in NOx emissions (Fig. 3) compared to the boiler operation with closed OFA air.

As shown in Fig. 4, the boiler efficiency was not influenced by any of the techniques used for NOx reduction.

CONCLUSION

Staged combustion should therefore be maintained in the entire range of boiler loading for reducing NOx emission.

In such a manner the results of full - scale investigations of tangential furnace show that technological methods for reduction NOx are available. In parallel with NOx emission decrease, reliable ignition and fuel combustion is provided.

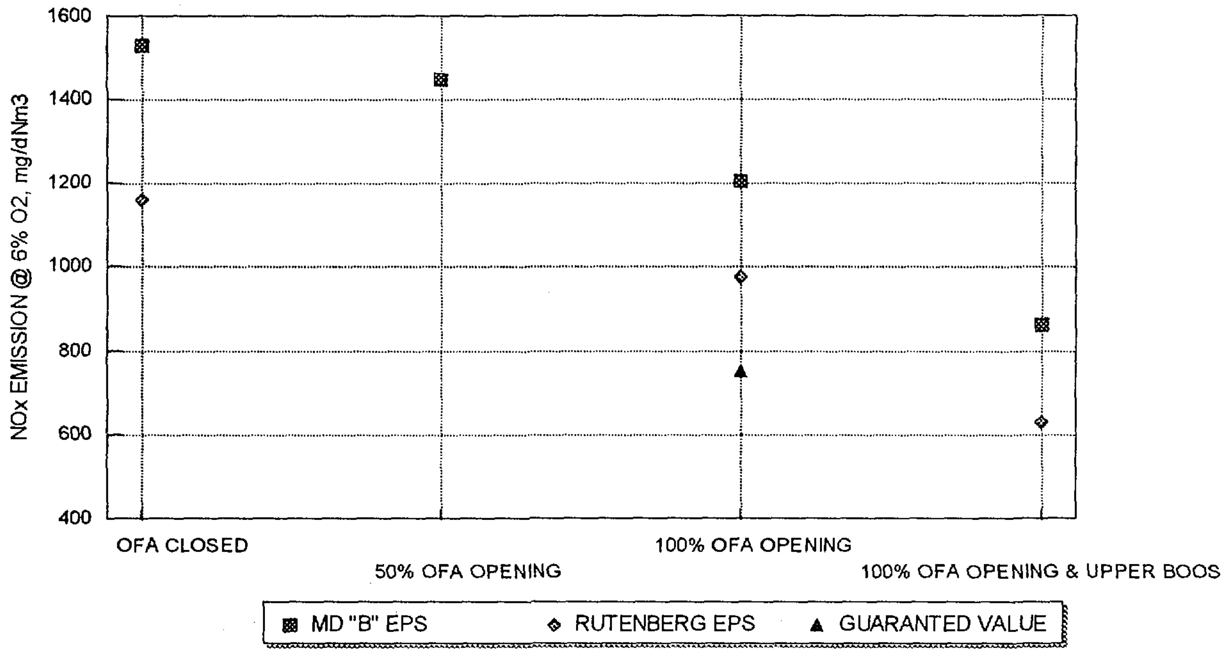

Fig.1. NOx EMISSION vs. BURNER OPERATION CONDITION
NCR LOAD, 4 LOWER MILLS IN OPERATION (OPTIMAL EXCESS AIR)

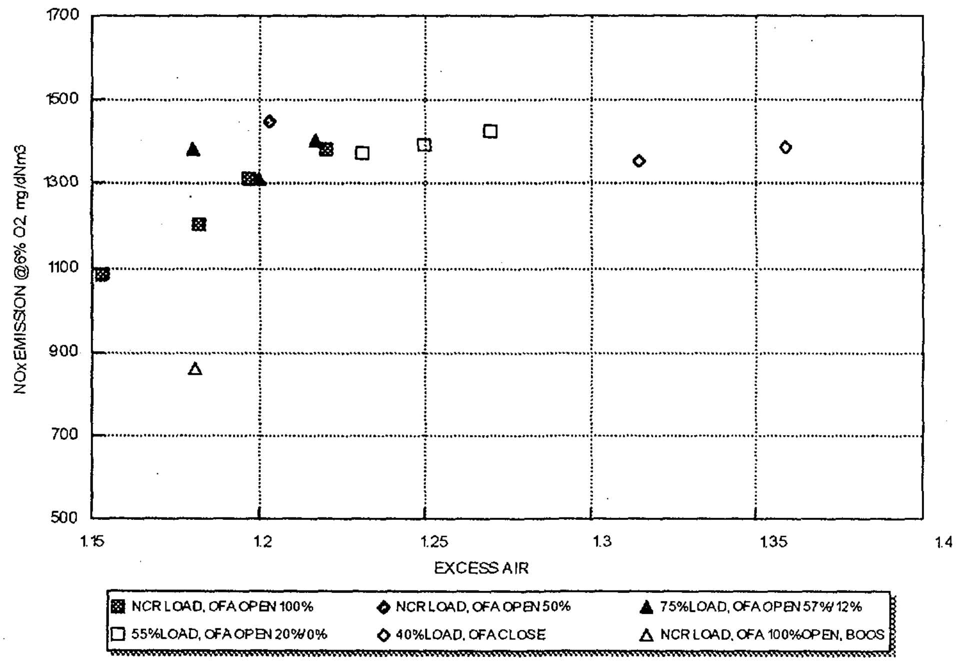

Fig.2. NOx EMISSION vs. EXCESS AIR

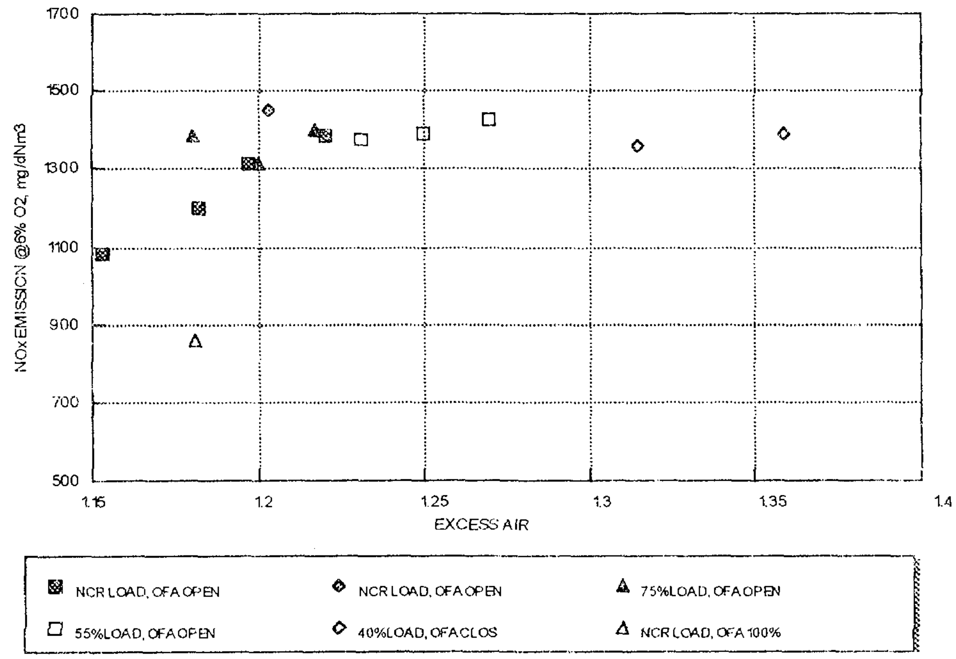

Fig. 3. NO x EMISSION vs BOILER LOAD
(OPTIMAL EXCESS AIR)

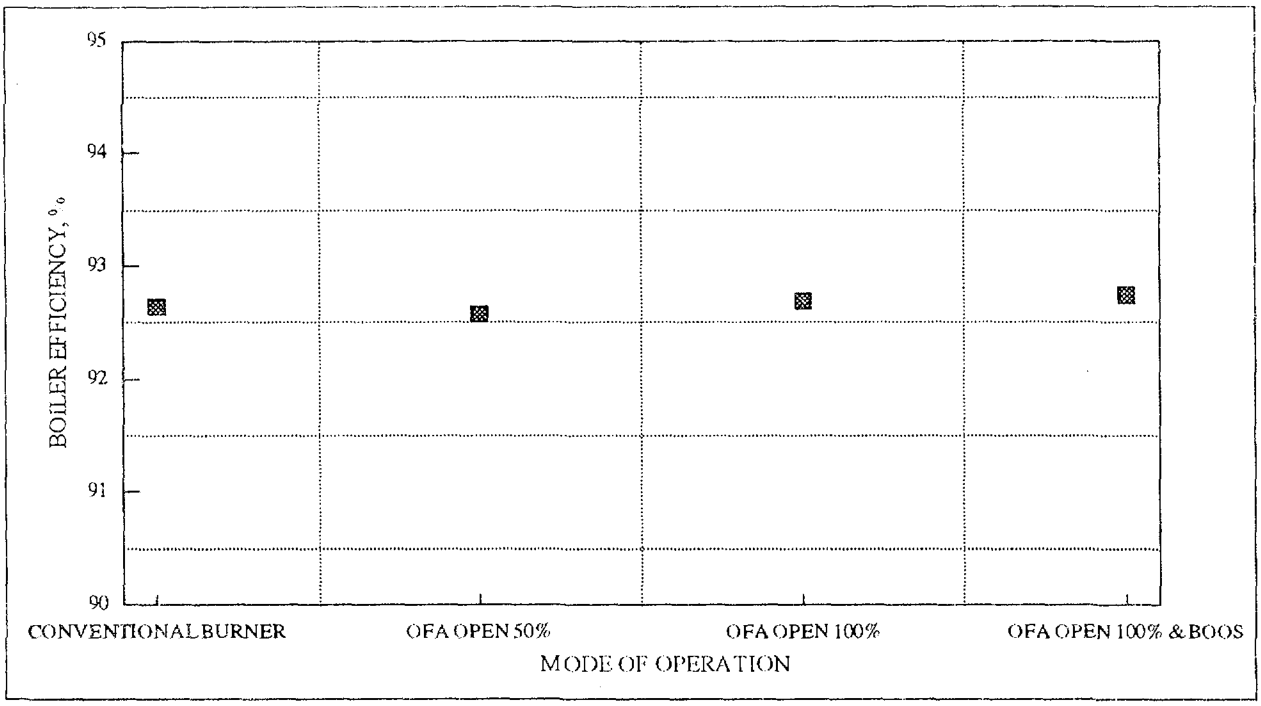

Fig.4. EFFICIENCY vs. MODE OF OPERATION
NCR LOAD. OPTIMAL EXCESS AIR

VIBRATION ANALYSIS OF AN INTERNAL COMBUSTION ENGINE

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ABSTRACT

This work presents the application of a vibration signature analysis method for early fault detection and diagnosis in internal combustion engines. The successful implementation of this method in various maintenance programs motivates the application of this method to the class of SI engines. The goals in applying this method are to provide alerts for abnormal operation, to enable detection of the source of the abnormality, and to provide the means to estimate the severity of the problem.

Experiments were performed with a four-stroke, four-cylinder in-line, carbureted SI engine. The vibrations were measured with a uniaxial acceleration transducer mounted on the engine-block. To obtain the vibration signature the signal from the transducer was transformed to the frequency domain by application of a Fast Fourier Transform (FFT) procedure. Our measurements demonstrate that various malfunctions can be detected with this method. For example, malfunctions in a single spark plug changed the pattern of the vibration signature. Inaccurate timings of the ignition sparks or timing belt also affected the contour of the vibration signature. Disturbances in the vibrations signature were also observed when an engine supporter was loosen.

INTRODUCTION

Vibration analysis methods are particularly common as a fault detection and diagnostic tools for rotating machines such as centrifugal pumps, compressors, electric motors, gas and steam turbines [1]. The concept originating the vibration signature analysis method is that mechanical systems with moving parts, such as an engine with a rotating crankshaft, comprise an elastic system that oscillates in response to excitations like in-cylinder pressure variations and inertia forces. During regular operation conditions several characteristic modes of vibrations can be distinguished. Each of the modes is characterized by its frequency and a pattern of relative amplitudes reflecting the stiffness of the system, its mass, fitting tolerances, friction levels, and other parameters that are typical to the system. Apparently, irregular operation conditions that result from variations of the excitations or changes in the system characteristics, affect the vibration signature of the system and can be detected with an appropriate vibration monitoring and analysis method.

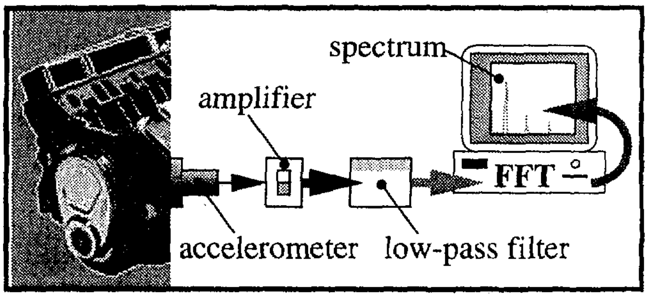

Fig. 1. Experimental set-up

The purpose of the vibration analysis is three fold. First, to provide an early alert for abnormal operating conditions, second, to enable the detection of the source of the upcoming malfunction, and third to provide the means to estimate the severity of the problem and the anticipated time to a possible catastrophic failure. To accomplish these tasks the vibrations of the system are measured during a finite time interval and, with the aid of an FFT analyzer, are broken down into the sum of the harmonic components of the motion. Frequently, the amplitudes and the frequencies of these harmonic components, which make up the spectrum in the frequency domain, can be related to possible malfunctions of specific components of the system (see [2], [3] for examples in the field of industrial equipment).

Despite the wide usage of vibration analysis methods for rotating and other equipment, these methods have not been practiced widely as a diagnostic tool for reciprocating machines. The reason is the complex nature of the reciprocating machines that incorporate a large number of moving parts. Methods for determining the rotational vibrations of crankshafts can be found in the literature [4], however, these studies address the design issue rather than the application of the vibration response of the crankshaft as a maintenance tool. Nurhadi *et al.* [5] have studied the correlation between the vibrations measured by accelerometers mounted on an engine with engine components as the sources for the excitations. In their experiments the engine was motored by an electric motor through a V-belt, while compression and combustion were alleviated by removing the spark plug. deBotton *et al.* [6] applied the vibration signature analysis method to determine the condition status of an internal combustion engine and the present work constitutes a continuation of their work.