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DETERMINATION OF COMBUSTION STABILITY IN PULVERSIED COAL FUELLED STEAM BOILERS

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Abstract

Analysis of firing techniques in pulverized coal-fuelled boilers is a rather complex task. The scheduling of its realization depends on numerous local restricting factors (reliability of instrumentation, applicable loads, momentary quality of coal).

Keywords: combustion stability, pulverised, steam boilers.

1. Summary

Analysis of firing techniques in pulverized coal-fuelled boilers is a rather complex task. The scheduling of its realization depends on numerous local restricting factors (reliability of instrumentation, applicable loads, momentary quality of coal).

The boilers of the power stations under test (and of the Gagarin Thermal Power Station that is to be tested in the future) significantly differ in the realization of auxiliary firing which improves firing stability. Measurements performed and processed till now give a good start for further analysis. Conditions of firing will undoubtedly be deteriorated with the reduction of load and this can quantitatively be evaluated with the demonstrated measuring method, thus, providing valuable data on the system's working life.

Besides load, however, quality of coal (caloric value, compostion), may also cause significant change in stability even when given from the same mine and especially when mixed with coal from other mines and this can only be compensated by increased auxiliary firing with oil or gas. This solution is favourable for safe operation of the boiler but results in significant operating cost increase because of increased fuel consumption.

The following part of the program aims at identifying the individual firing systems based on the evaluation of measurements made so far. Combustion chamber pressure oscillation signal is to be analyzed by computer on the base of signals recorded by measuring tape recorder simulataneously in different points of the combustion chamber with input parameters changed deliberately to an extent tolerable and realizable in operating conditions.

Thus, identification model for the boiler as a firing system can be established. Parallelly, data will be collected that give the range of parameters characterizing coal quality for years. From these and by the constructed model, simulations can be performed that give the possible range for pressure fluctuations in the combustion chamber.

In this way, preliminary determination of the expected mechanical load of the boiler will be possible for the individual types of boilers, and coal qualities and boiler construction can be designed for dynamic load. Furthermore, necessary degree of auxiliary firing and its factor influencing operation can be computed.

2. Introduction

Construction of fuelling systems in pulverized coal fired steam boilers in power plants is based on coal quality as a design value. The experience shows, however, that fuelled coal quality may considerably differ from that designed depending on mining technologies and geological conditions, likely to have an essential influence on the stability of firing with the variation of firing conditions.

Worsening of firing stability can well be monitored by the increase of pressure fluctuation in the combustion chamber. We can determine, however, whether pressure fluctuation in the combustion chamber is due to coal quality variation or to some other disturbance in firing only from the analysis of the fluctuation signal.

Condition of stable burning was first defined by Lewis and von Elbe, namely, that current velocity and flame propagation velocity have to be equal and of opposite direction in at least one point.

This can easily be verified for model burners but for more complicated flames determination of flame stability requires knowledge of flow fields and flame propagation velocity distribution. In power station boilers there is a turbulent flow in the flame with characteristics of mixture formation and of burning fluctuating stochastically in a given range. Thus, loss of stability can be seen from exceeding this range and from growing periodic components of the parameters of burning. This is also called furnace chamber pulsation in everyday practice and its dominant frequency ranges from 0.1 to 5 Hz in pulverized coal fired boilers.

Increase of the periodic component in pressure fluctuation is risky not only for the stability of firing but also because of repeated mechanical stresses on the structural units of the boiler as it can lead to rapid fatigue and failure. The so-called short-cycle fatigue stresses due to poor conditions of combustion and of relatively short duration (of 10 to 15 min.) may cause unexpected breakdown of the boiler leading to serious problems in Hungary's stressed power productions.

Determination of these stresses originating from the worsening of firing permits to prevent a breakdown, to schedule maintenance accordingly, and to systematically redistribute power production about the planned date of repair.

Timely observation and measurement of firing instability are increasingly necessary because redaction of coal's average heating value and variation of its quality with their detrimental impacts on firing techniques can be expected.

Periodic instability of burning arising during firing is detrimental both energetically and for safety. Furthermore, environmental considerations require to reduce flue gas pollutant emission and noise impact.

3. Metrological Analysis of Flame Stability

Pulsation in burning processes in pulverized coal fired equipment points to certain periodicity of burning irregularities to be attributed, irrespective of the equipment geometry, mainly to features of fuelling and flow. Determining pressure oscillations in the combustion chamber caused by burning anomalies yields valuable information on the heat releasing process in the flame.

Effect of input parameters determined for the burning process in boilers is demonstrated by the metrological model in *Fig. 1.* Fluctuation and variation of input parameters affect fluctuation of heat release, thereby pressure oscillations in the furnace chamber and firing efficiency, markedly increasing pollutant emission.

Information from analyzing pressure fluctuation signal in the furnace yields conclusions essential for both the designer and the operator [6].

4. Metrological Approach to the Firing Process

Measurement tasks in combustion technique concern in most cases systems with definite transfer characteristics. Therefore it is important to know how these transfer characteristics arise in the system, i.e. knowledge of its inner construction and interactions is essential. In such cases, mathematical models will be developed and metrological methods applied to obtain the transfer characteristics and information on interactions within the system.

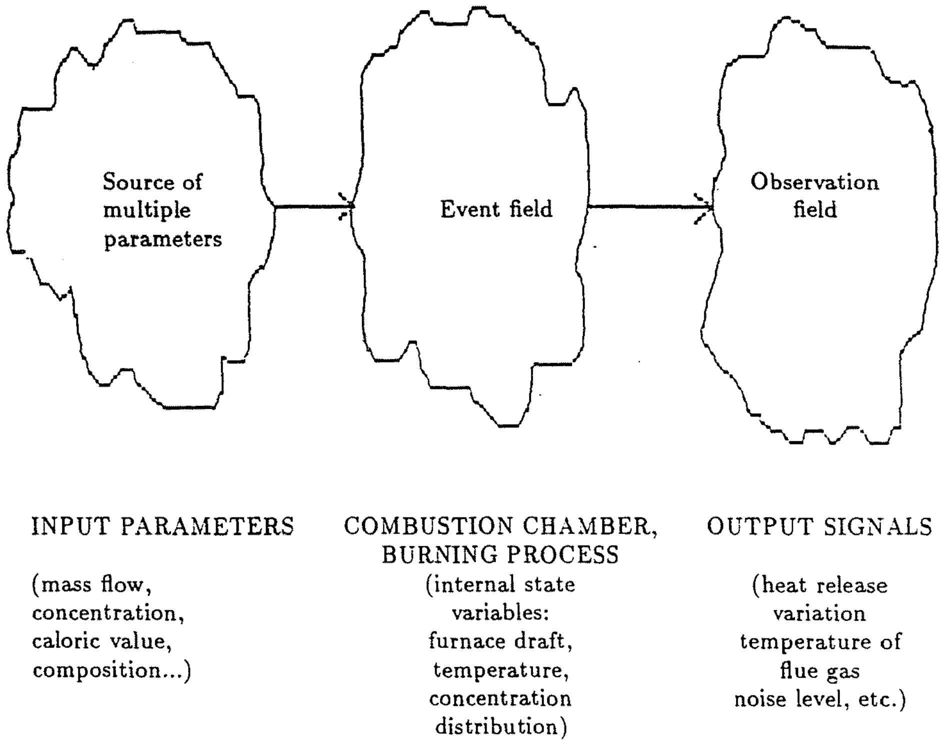

Fig. 1. Metrological model

As to behaviour, firing equipment may be considered as dynamic systems. In knowledge of time function of all the variables in a dynamic system, a complete description will be possible by using internal states. These variables, often called state variables, provide information on the interior of the system.

To have the system metrologically definite, the effect of input signal on state variables and methods for measuring the variables have to be known, and a method should be selected for analyzing output signals [8].

In firing pratice, for a given combustion chamber geometry, internal state variables are:

- combustion chamber draft,
- distribution of concentration,
- temperature, etc.

Input signals of the system:
- mass flow,
- concentration,
- caloric value,
- composition, etc.

Output signals:
- fluctuation of heat release,
- flue gas temperature,
- flue gas composition,
- noise level, etc. (*Fig. 1*).

In high-capacity, pulverized coal fired power station steam boilers, pressure oscillations measured at a defined point of the firing equipment produce mainly stochastic signals form which information is obtained by methods of mathematical statistics. Probabilistic elements help to determine deterministic components of the stochastic signal and their magnitude pointing out causalities for internal state changes in the boiler [6,7].

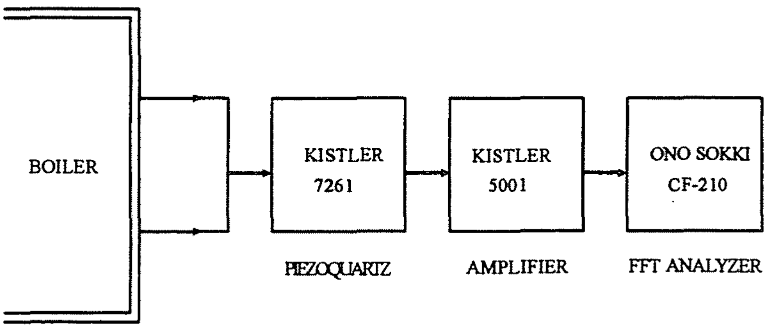

Fig. 2. Measurement arrangement

5. Measurement Method

Magnitude of pressure oscillation in the combustion chamber as a characteristic measure for burning pulsation has been measured with KISTLER 7261 type piezoquartz pressure gauge. Measurements have been performed on steam boilers of the Thermal Power Stations in Pécs, Tisza and Ajka. The measured signals have been recorded and processed by CF 250 type FFT analyzer manufactured by ONO SOKKI.

For evaluating the information content of the measured signal, amplitude-frequency spectrum, probability density and probability distribution

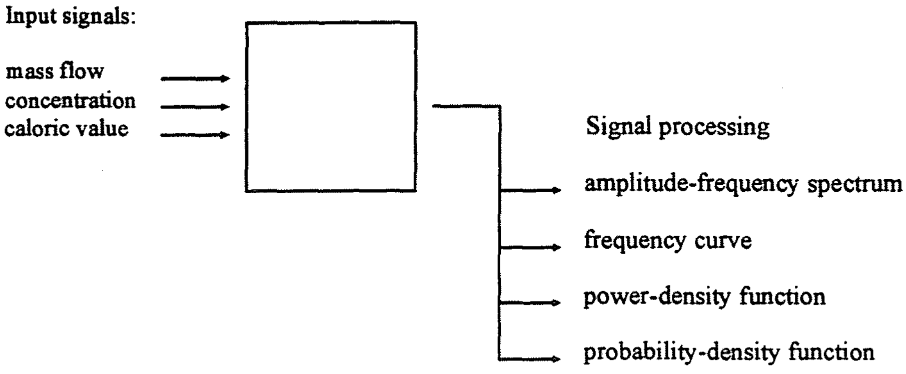

Fig. 3. Model of evaluation

function have been determined from the recorded time functions as probabilistic means. Before their determination, measurement evaluation will briefly be summarized.

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