INVESTIGATIONS OF LOW NOx CORROSION HAZARD IN BOILER OP650 OF THE RYBNIK POWER PLANT USING A MOBILE MONITORING SYSTEM

PRIYANKA YADAV, BRIJESH KUMAR DUBEY, MOHD. SAIF
STUDENT, ASSISTANT PROFESSOR, STUDENT
BACHELOR OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS
PRANVEER SINGH INSTITUTE OF TECHNOLOGY, KANPUR,INDIA

Abstract: *This manuscript reports the results of an investigation concerning the composition of the boundary layer of the flue gas at the waterwall of boiler K6 (OP650) of the Rybnik power plant. These results were obtained using a boundary layer monitoring system (BLM), which allows the prediction of the low-NOx corrosion hazards in the furnace. The BLM system is first described in detail and is followed by the CO concentration maps for low and high boiler loads. Finally, the results of a single day of operation of the BLM system are translated into predictions of the corrosion rate, and the manuscript concludes with recommendations regarding the proper use of BLM systems.*

Keywords: steam boilers, high-temperature corrosion, NOx emissions

1. INTRODUCTION

Modernisation of pulverised fuel boilers for the reduction of NOx emissions can induce localised areas of reduced flue gas composition, i.e., zero concentration of oxygen (O_2) and an increased level of carbon monoxide (CO), which is a negative in- furnace phenomenon.Such condition lead to accelerated corrosion of the internal surfaces of the boiler wall. Low NOx corrosion significantly shortens the lifetime of the evaporator tubes and is a source of mechanical breakdown and substantial financial losses. An effective method of reducing the risk of corrosion is to implement a furnace protection air system to limit the access of aggressive flue gas components (i.e., CO and H_2S) in the boundary layer near the waterwall tubes.

A practical and patented (PL205438,) solution of an air protection system has been presented previously . In this technology, jet fans, which are driven by waste steam from the boiler, are used to induce airflow. The jet fans generate a hot and high-velocity stream of air for protection of the waterwalls. An additional advantage of jet fans is the simplicity of the design with no moving parts; hence, they are durable and inexpensive.

Despite the application of protection air systems, the areas of corrosion risk, particularly in the form of isolines of gas concentration, should be determined by monitoring the composition of the gas boundary layer of the wall. The Boundary Layer Monitoring method (BLM) allows sampling of the composition of gases inside the boundary layer in the furnace of the boiler either on a continuous basis or on a selected frequency basis. The BLM monitoring system is protected by patents PL202007 and PL208085.

2. BLM METHOD

The BLM method of monitoring implies that the monitoring probes that are used to sample the boundary layer of the flue gas are located at designated points of the furnace. The flue gas from these points is sampled, conditioned and sent for O_2 and CO analysis. The BLM installation to monitor the composition of the boundary layer is presented in Fig.1 The preliminary assumptions for design of a mobile monitoring system are as follows:

- An approach of multiplexing of routes to reduce the costs of multiple O_2 and CO analyses is implemented.
- The gas-line multiplexer is controlled using a PLC controller, which also converts and archives the results of the measurements.
- The gas lines are multiplexed sequentially, and the sample is sent to the respective gas analysers (O_2 and CO). However, the completion of the measurement system with other flue gas components is also possible, depending on the specific user requirements
- Due to the time delays in measurement resulting from the length of the gas routes, the concept of two multiplexers is implemented.

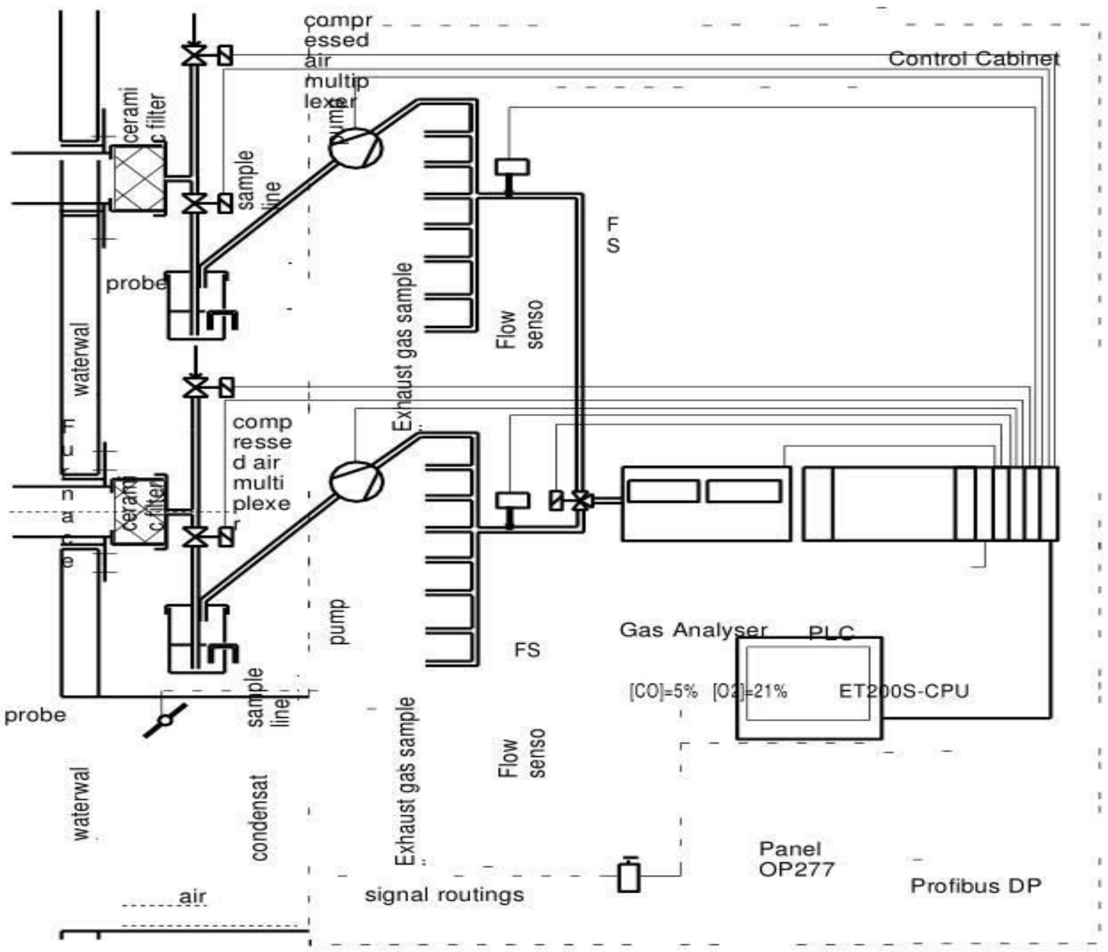


Fig. 1 A schematic of the on-line BLM monitoring system for CO and O_2

- The unused gas lines are purged by compressed air during the preparation process for the next analysis. Purging cools the sampling probes, prevents ash deposition on the sampling probes and cleans the probe filters.
- Each individual multiplexer is made up of two sets of eight valves that shut off the flow of compressed air and attribute the line for analysis. The selection of the currently used multiplexer is realised by a three-way shut off valve.
- The flow sensors (pressure switches) that are incorporated into the measurement system control the permeability of the gas line.
- The operator of the measuring system is able to control the duration of the periodic measurement through an operator panel, which also facilitates the reviewing of the current and archived results.
- The measurement report is available as an Excel sheet stored on a memory card located in the operator's panel.
- The PLC module is part of a distributed system of boiler control and facilitates the visualization of the current distribution of oxygen and carbon monoxide concentrations at specific positions on the boiler walls.
- The measuring system is ultimately intended to control the air protection system

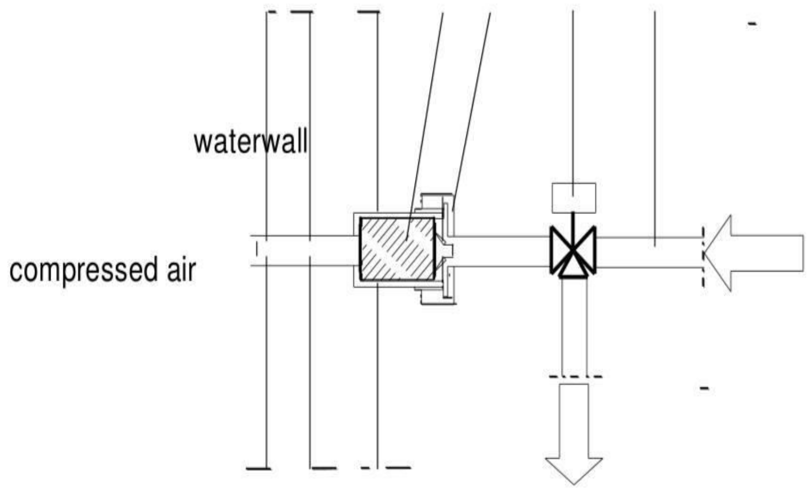


Fig. 2 Sampling probe for online monitoring of CO and O2

using a neural network.As shown in Fig. 2, the BLM system is equipped with sampling probes for online monitoring of C

3. THE PROTECTION AIR SYSTEM INSTALLED IN THE OP650 BOILER OF THE RYBNIK POWER PLANT

The implementation of the low-NOx technology developed by IPW Pol in and Energotechnika Energorozruch and the operation of the boiler with NOx emissions below 300 mg/$m^3{}_n$ (NO_2 at 6% O_2, dry flue gas) has inevitably deepened the reducing atmosphere at the furnace walls, which has led to an increase in the corrosion hazards.

Therefore a protection air system has been built to protect the waterwalls in the most endangered zones of the furnace. The rear and side walls between levels 11.6 m and 25 m (approximately 500 m^2) are covered by the protection air. The protection air system is composed of single distribution units incorporating three sets of air nozzles whereas:

- Two sets of side nozzles distribute the protection air along the waterwall,
- A third set of nozzles distributes the air towards the interior of the furnace to minimise the suction effect of the side nozzles.The single distribution unit is shown in Fig. 3. Five single distribution units are grouped in a column, and three such columns are located at the rear boiler waterwall. Each side wall is protected by a single air distribution column.

In addition, extra nozzles are built in a burner box protecting the side wall

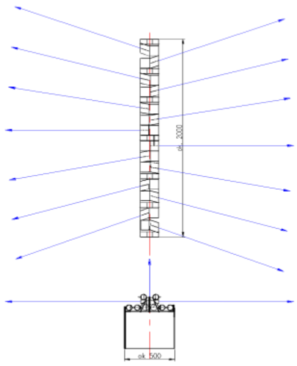


Fig. 3 Single distribution unit of the protective

A schematic of the entire protective air system, including the single distribution units,columns of the distribution units and the supply ducts, is presented in Fig. 4.

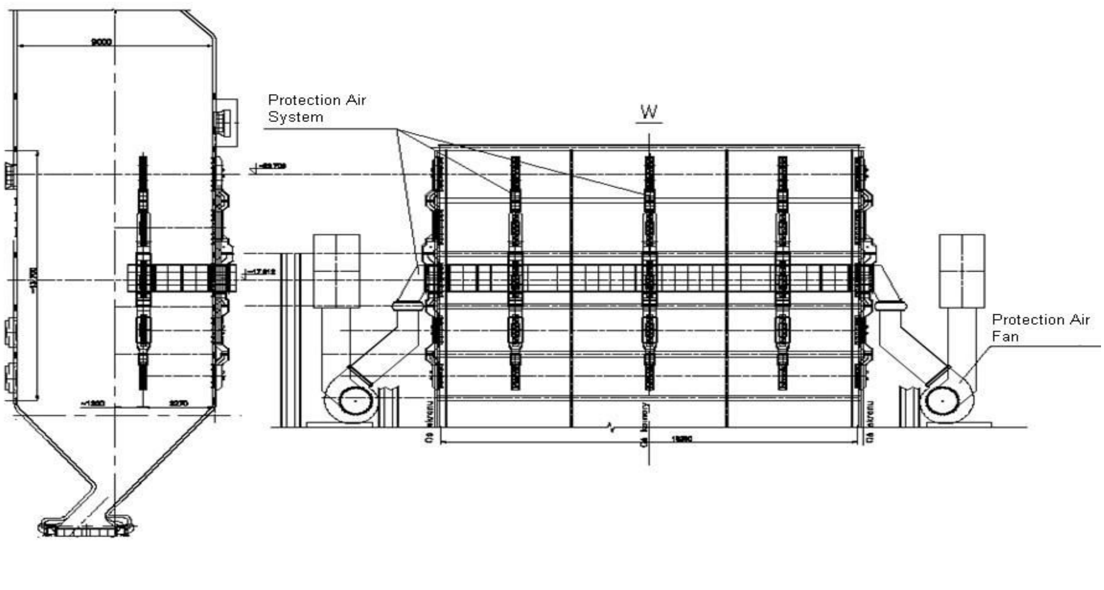


Fig. 4 Protection air system at the K6 (OP650) boiler in the Rybnik power plant

4. INVESTIGATIONS OF LOW-NOx CORROSION HAZARD AT THE OP650 BOILER IN THE RYBNIK POWER PLANT

The BLM monitoring system was used to measure the composition of the boundary layer of the flue gas in the OP650 boiler operated in the Rybnik power plant. A view of a control cabinet and two multiplexers of the mobile online monitoring system are presented in Fig.5

Fig. 5 BLM system installed in Rybnik power plant

The BLM system was used to monitor the rear boiler wall, and investigations were carried out during one week of normal boiler operation. Fig. 6 presents the results obtained for a single sampling point,
Demonstrating the highest values of CO over one day of boiler operation.

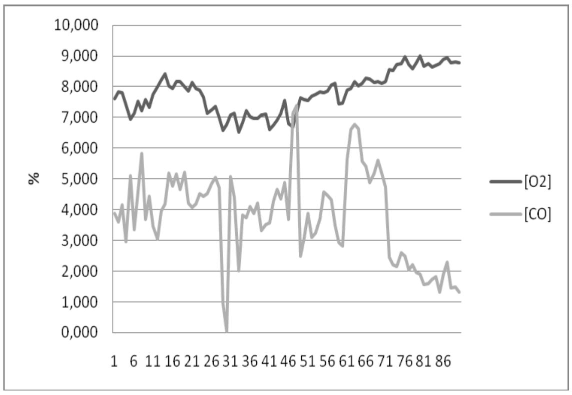
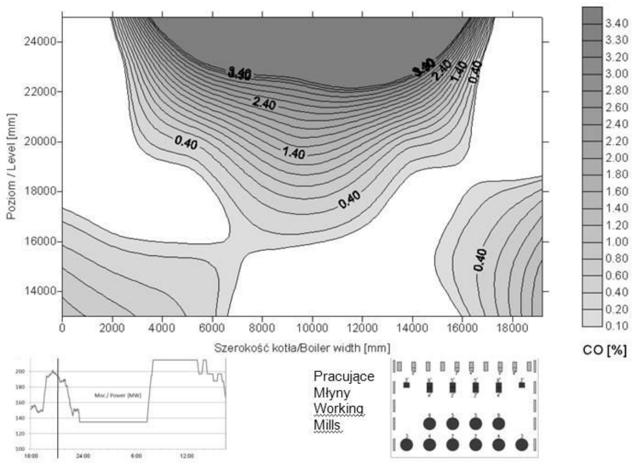


Fig .6

Fig. 6 CO and O_2 concentration trends over one day of boiler operation (sampled every 15 minutes) at a single sampling point, demonstrating the highest averaged CO concentration at the rear wall of the OP650 boiler.

Fig. 7 and 8 show exemplary data concerning the CO values for high and low boiler loads, respectively. Such concentration maps clearly identify the waterwall zones that are highly affected by corrosion and may provide valuable online information for the control of protective air systems. The clear dependence of concentration on the boiler load and the CO concentration is visible.



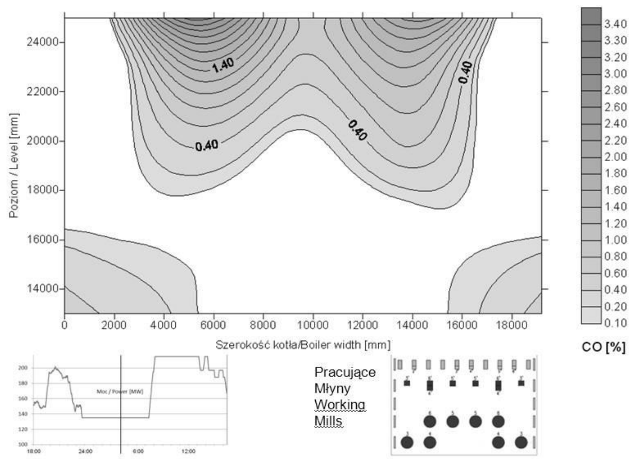


Fig. 7 The distribution of CO concentration over the surface of the rear wall of the OP650 boiler during high boiler load with 5 coal mills in operation.

Fig. 8 The distribution of CO concentration over the surface of the rear wall of the OP650 boiler during low boiler load with 4 coal mills in operation.

As mentioned earlier, the CO results were averaged over one day at each sampling point at the rear boiler wall. Such manipulation allowed for the calculation of the corrosion rate □g/□□ [nm/h] using the formulas given in. The results of such corrosion rate predictions are shown in Fig. 9.

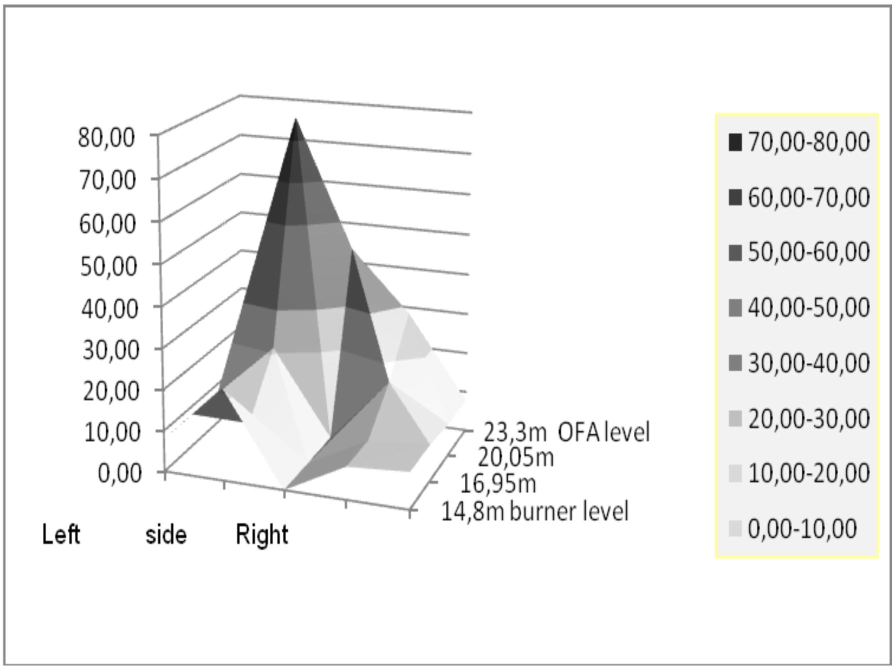


Fig. 9 Surface view of the corrosion hazard expressed in terms of the corrosion rate [g/ nm/h] from the one-day- averaged CO concentration measured at the rear waterwall of boiler K6 in the Rybnik power plant.

5. CONCLUSIONS

The analysis of the results obtained in this study leads to the following conclusions:

- The simultaneous occurence of CO and O_2 at a given waterwall point indicates a proper operation of the protection air system (Fig. 6).
- The composition of the boundary layer of the flue gas is variable. Therefore, the existing incidental measurements of the instantaneous gas composition are not representative of the actual distribution of the concentrations of O_2 and CO at the furnace wall of the boiler, and therefore, they do not reflect the actual corrosion risk of the tubes over a long period of time. Further work will determine the influence of external factors, such as the boiler load, fuel composition and staging and excess air number.
- Continuous measurements using the BLM system facilitate the identification of the most vulnerable areas of the furnace walls and are a valuable tool for designers of air protection systems and anti-corrosion coatings.
- The continuous corrosion rates obtained through BLM measurements serving as a diagnostics tool facilitate the forecasting of waterwall durability over long periods, and therefore, the rates are important for overhaul planning[7,8].

REFERENCES

- Pronobis M.: Modernizacja kotłów energetycznych (Modernisation of steam generators in Polish), WNT Warszawa 2002.
- Patent PL 205438 Sposób i układ urządzeń do ochrony przed korozją ekranu energetycznego kotła (Method and system for protecting boiler waterwalls against corrosion), 30.04.2010 WUP04/10.
- Ostrowski P.: Steam jest ventilators for creating protection air at boundary layer of water- wall of power boilers. Ostrava, Czech Republic, September 2009.
- Patent PL 202007 Sposób i urządzenie do quasi-ciągłego monitorowania chemicznego składu spalin w przyściennej warstwie ekranu energetycznego kotła (Method and system for quasi-continuous monitoring of flue gas composition in the boiler waterwall boundary layer), 29.05.2009 WUP 05/09.
- Patent PL 208085 Sonda do quasi ciągłego poboru spalin na ścianie wewnętrznej ekranu zwłaszcza w kotłach z pyłowymi palnikami o niskiej emisji NOx (Probe for quasi-continuous sampling of flue gas in low-NOx pulverized fuel boilers), 31.03.2011 WUP 03/11
- Pronobis M., Hernik B., Wejkowski R.: Kinetics of low NOx corrosion of waterwalls in utility boilers. Rynek Energii Nr 6 (91) – 2010.
- Rusin A.,Wojaczek A.: Wspomaganie decyzji remontowych maszyn i urządzeń energetycznych za pomocą analizy niezawodności (The use of reliability analysis for the support of decisions on maintenance of power machines and devices). Rynek Energii Nr 6 (79) – 2008.
- Rusin A.,Wojaczek A.: Wpływ zmienności obciążeń cieplnych kotła na prawdopodobieństwo uszkodzeń korozyjnych rur ekranowych w warunkach niskoemisyjnego spalania (Influence of thermal loads variation on the probability of waterwall tubes corrosion failure in low-emission combustion). Rynek Energii Nr 6 (85) – 2009.