Maintaining Power

A Brazilian power generation company expects to decrease maintenance downtime by identifying the cause of wall erosion in a coal boiler.

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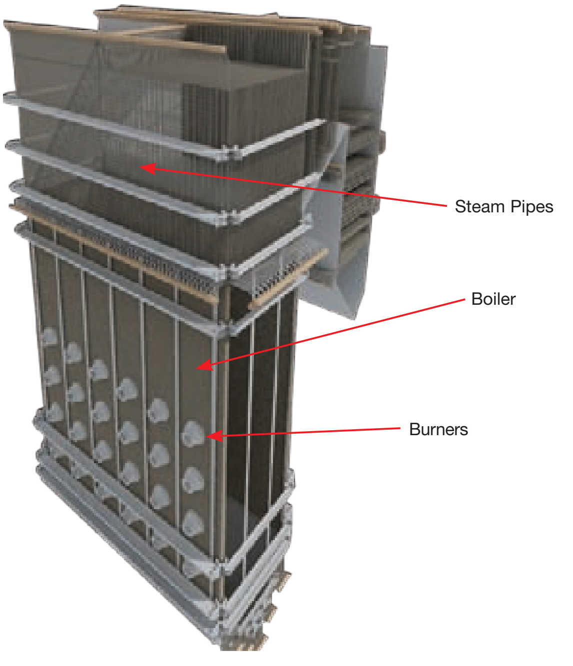
Fear of a reduced energy supply in coming years has made energy generation a hot topic in engineering. In Brazil, power is generated by both hydroelectric means and the use of fossil fuels. The Jorge Lacerda Power Plant, owned by Tractebel Energia, is one of the largest in Latin America and is responsible for a significant portion of the energy distribution in southern Brazil. The complex has three plants for generating electricity. The largest plant, UTLC, has a generating capacity of nearly 1,260 gigawatt-hours.

The large boiler (10 meters by 20 meters by 60 meters) at UTLC contains four horizontal rows of six burners, fueled by pulverized coal. The burners heat water in high-pressure steel tubes — called steam pipes or boiler tubes — within the walls of the boiler to create steam. The steam is used to spin a turbine, which, in turn, generates electricity.

A common problem in coal-fired boilers is erosion of the boiler walls. Wall erosion puts operation of the boiler at risk because material failure in these areas exposes the steam pipes to fuel within the boiler. Addressing this problem is quite costly because of the materials involved; in addition, the boiler must be shut down while repairs are made. The associated costs can be reduced if erosion of the boiler tubes can be minimized.

To find ways to minimize erosion, the mechanism of erosion must first be identified. Three possible causes of boiler wall erosion are chemical attack caused by buildup of sulphur, excessive exposure to heat, and burner misalignment. In the last case, erosion is further aggravated because particles of coal are not completely consumed and can physically abrade the boiler walls. Through physical analysis of the tubes, Tractebel engineers were able to determine that the cause of the erosion in the UTLC boiler was probably related to burner misalignment. Misaligned burners or burner components can lead to incomplete combustion of the pulverized coal, resulting in wall erosion.

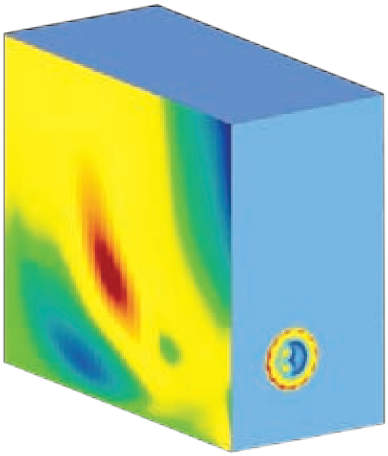
Tractebel Energia together with ESSS, an ANSYS channel partner in South America, turned to an ANSYS CFX engineering simulation to confirm the cause of the erosion. The analysis was set up to simulate the multiphase flow (pulverized coal and air) within the boiler. The team analyzed the operation of a single burner and its impact on the nearby boiler walls to gain a better understanding of the overall erosion process.



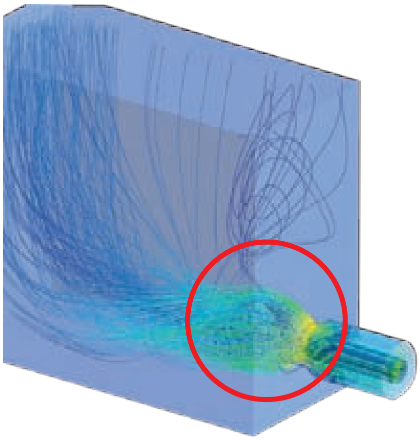
Tractebel's UTLC complete coal boiler

The initial flow simulation considered the complex burner geometry in detail. Burners are constructed from various plates that form the swirler as well as a deflector. Both help to mix the airflow with the pulverized coal to ensure the stability of the flame inside the boiler. Flame stability and proper mixing assist in more efficient combustion. The simulation focused on resolving the details of the burner flow to obtain an accurate outlet flow profile for the burner that could be used in a larger simulation of the boiler interior. The software provides the capability to easily extract desired results from the first (burner) simulation as boundary conditions for the second (boiler) simulation.

In a second flow simulation, a large portion of the boiler was simulated with the burner inlet located on the right side of the boiler. The objective was to capture the effect of a single burner on nearby boiler walls to determine if the wall shear pattern arising from the burner flow matched the erosion pattern observed on the boiler tubes.



Air velocity profile on symmetry wall; red indicates areas of highest velocity

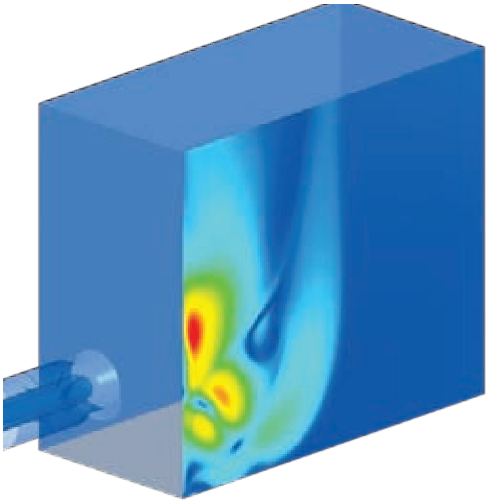


Swirling effect on particles from the coal burner

The results showed that flow detaches from the burner to make contact with the boiler wall at a distance of approximately 3 meters from the burner. The multiphase simulation confirmed that particles of coal following this flow path would reach the boiler wall at high speed. By calculating the rate of erosion on the boiler wall, the engineering team was able to map wall locations that suffer more wear. The map obtained from the shear data was very close to the wear data originally obtained for the boiler.

The fluid flow results enabled Tractebel engineers to identify modifications that might be made to minimize wall erosion in the boiler. Future projects will involve altering the geometry of the model and boundary conditions to determine whether anticipated design changes would reduce wall erosion. It is estimated that the altered design will reduce boiler downtime from once every three years to once every five years.

Without the insight provided by ANSYS CFX software, Tractebel would have been limited to trial-and-error testing to identify and mitigate the cause of the undesirably high erosion. Tractebel was able to determine the erosion pattern and make informed and cost-effective decisions regarding the operation of the burner and, consequently, the plant. ■



Wall shear stress pattern on boiler walls; red indicates areas of highest wall shear (erosion)

Advanced Simulation for Fossil Fuels

ANSYS solutions are used around the world every day to study established coal, oil and gas combustion systems, as well as cutting-edge power generation and process equipment such as oxy-fuel combustors, chemical looping reactors, gasifiers and biomass furnaces.

The study of combustion and related flow phenomena in fossil fuel reactors provides critical insights for retrofitting existing equipment or designing new processes. Engineering simulation solutions from ANSYS provide all necessary capabilities to increase performance and energy efficiency, to understand the source, and to develop strategies that reduce the carbon footprint as well as control and reduce pollutant emissions from a large range of fossil fuel and biomass reactor types.

Typically, the simulation of combustion equipment includes fluid flows such as reaction, radiation and thermal phenomena. Coal and other fuels are represented as a secondary phase and are fully coupled with flow, enabling simulation of a large range of particulate concentrations from dilute flows to packed beds. Such analyses provide local velocities, particulate concentrations and traces, composition of combustion gases, fuel conversion rates, and temperatures. These quantities enable the user to investigate operational issues such as local temperature peaks, combustion efficiency or mixing problems.

Additional engineering details can be simulated through a number of specially developed features. For example, pollutant formation, emissions and mercury can be predicted using detailed chemistry and pollutant formation submodels. Similarly, appropriate particle models are available to allow for prediction of erosion and/or slag build-up in furnaces.

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