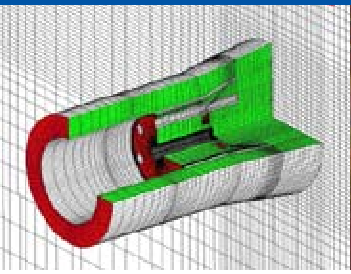
LABORELEC

NEWS

JOURNAL NINTH YEAR
N° 98 / OCTOBER 2008

DOSSIER ON PROCESS AUTOMATION AND COMBUSTION



Complementary expertise in combustion and process automation
To cope with rising fuel prices and high energy demands, power plants require maximum efficiency from their boiler. This means optimal combustion conditions, such as adequate air distribution between the various burners, as well as appropriate automation. Laborelec has experts in both domains and ensures that these experts collaborate closely. This edition of Laborelec News focuses on our recent realizations in both of these areas of expertise.

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Achieving LCP compliance by optimally setting existing burners

Meeting the EU Large Combustion Plants (LCP) directive does not always require implementing expensive technologies. The Amercœur 2 coal-fired power plant in Belgium asked Laborelec to optimize its existing combustion process – with good results.

The plant wanted to know whether a careful fine-tuning of its combustion process would enable the reduction of NO_X emissions to meet LCP standards. Initial air distribution modifications carried out by Laborelec however, were not sufficient.
Laborelec then suggested a series of adaptations combining a burner out of service (BOOS) and flue gas recirculation (FGR). This setup recovers flue gases and distributes them in the top row of burners, instead of coal, by means of a fan. The combination of BOOS and FGR leads to decreased local O_2 content, thus reducing NO_X emissions. To ensure complete combustion throughout the combustion chamber, the setup was supplemented by an existing over fire air (OFA) system. In May 2008, Laborelec optimized the air distribution and air flow rates as a function of the load. The excellent collaboration with local I&C experts enabled an optimal implementation of combustion modifications in the control system.

Reduced emissions for all loads

The solution was designed to address NO_X emissions for intermediate loads. Nevertheless, Laborelec succeeded in reducing NO_X emissions sufficiently for higher loads by further optimizing pressure variations between the secondary airflow and the furnace. The result is a better distribution and mixing of the fuel air, which in turn reduces NO_X emissions.
These combined measures enabled Amercoeur 2 to stay within LCP limits, even at full load.

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CONTENTS

Modelling gas turbine combustion data for early problem detection

Exploiting available data to improve predictive maintenance. That is the aim of the artificial intelligence project on gas turbine combustion dynamics. The project – carried out jointly by Laborelec's Process Automation and Combustion services – strives to model non-linear data in order to identify problems more rapidly.

The deployment of measurement systems and data storage servers in Electrabel power plants has made an increasing volume of operational data available. Laborelec's artificial intelligence project aims to fully exploit this information, which includes numerous input parameters (temperature, pressure, gas flow rate, valve opening, etc.) and output signals (pressure variations, etc.). The project aims to establish multi-variable analyses between these data to enhance problem detection, analysis and process optimization.

How is flame stability impacted?
In the case of combustion dynamics in gas turbines, it is essential to understand which parameters impact flame stability and how. By linking over 100 input and output parameters, the project identifies non-linear models. This will yield a better insight into the dynamic behaviour of the system under varying circumstances.
To establish a behavioural model, the correct functioning of a gas turbine must also be characterized to serve as a reference. Any deviation can then be interpreted as a warning signal. By detecting abnormal signals in advance, costly gas turbine repairs or replacements can be avoided, and the time required to analyze incidents shortened.
The methodology can also be applied to other processes.

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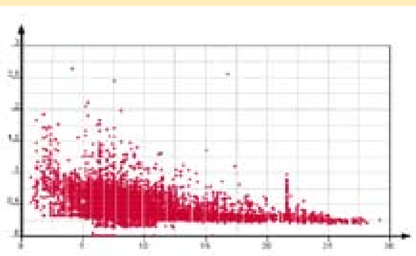


Correlation analysis between process variables.

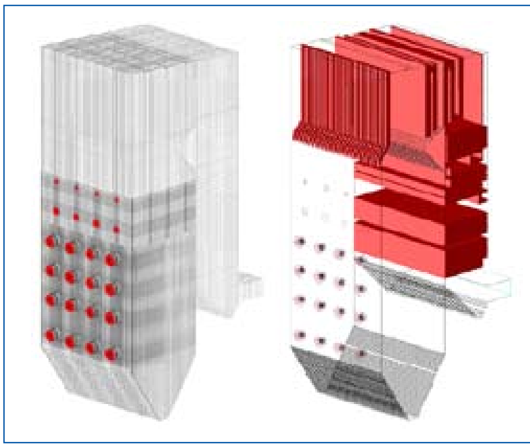
Computational fluid dynamics

Simulating the combustion process to improve boiler performance

In the past, existing boilers have been designed for the combustion of fossil fuels. Today however, more and more power plants use biomass to fuel their electricity production. Does the combustion of biomass affect boiler performance? Laborelec uses computational fluid dynamics (CFD) to determine the effect of changes in design and fuel composition on a boiler's behaviour.

From reference model to improved design
In the first phase, the existing boiler configuration is translated into a reference model. This enables our experts to simulate the actual combustion process. The model is based on operational data such as the fuel composition and the flow rate, as well as construction parameters such as the type of burner and its dimensions.
This reference model can then be used in the process of improving the boiler's performance, for instance after a switch in fuel composition. The CFD model makes it possible to simulate changes such as the effect on a boiler's heat flux when switching to a 100% blast furnace gas. Our experts can often suggest certain adaptations to optimize performance based upon their vast experience. These changes may include modifying the flow rate or changing the burner configuration. The CFD system's calculations confirm which alterations generate the best result.

Proven track record
CFD modelling of boilers has already proven its benefits. For instance, the CFD model of a Polish power plant boiler revealed hidden flaws. At first glance, the low NO_X burners were performing optimally, realizing excellent low NO_X values. However, CFD simulation revealed a high degree of CO production, accelerating corrosion of the boiler walls. Based on this result, our experts advised operators to optimize the boiler's wall air system.



The computational grid of this boiler contains 9.2 million cells.

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Close collaboration with CFD experts at Recom

Laborelec is active in two stages of a CFD modelling project. Our experts gather the necessary input data and they analyze the model's results. For the actual calculation process, they collaborate with Recom, a spin-off from Stuttgart University. Recom developed the AIOLOS software, which uses a calculation grid containing more than ten million cells. The spin-off has access to a supercomputer to perform the enormous number of calculations required.
In addition to simulating boiler performance, Laborelec also uses CFD for thermodynamic modelling of power plant steam cycles.

Fine-tuning low NO_X burners at Kallo

Laborelec is taking part in a project to replace existing burners at the Kallo 1 and 2 gas-fired power plants in Belgium with low NO_X burners. The project involves optimizing the overall fuel/air ratio and redefining the process control setup. It is a complex issue that the plant has entrusted to Laborelec's Process Automation and Combustion teams.

The main challenge with low NO_X burners is to achieve an optimal fuel/air distribution inside the furnace. Maintaining an optimal fuel/air ratio with appropriate oxygen levels for each burner requires careful fine-tuning.
On top of that, achieving a low NO_X combustion also requires the local excess air coefficients to be adjusted accordingly for every burner. A global excess air coefficient must first be defined for the complete installation, and this figure must then be optimally distributed across the individual burners in order to obtain low NO_X emissions. This excess air coefficient is a function of the oxygen percentage that must be present in the flue gases at the end of the process to avoid CO emissions.

Defining an ideal process control setup

The Kallo project involves a large number of burners, 16 in total. The number of active burners, as well as the air and gas flow rates, are a function of the load. Furthermore, a specific excess air per burner has been foreseen to favour NO_X optimization. The challenge is to ensure that the combustion dynamics keep their low NO_X characteristics without making complex adjustments. Laborelec's expertise in both combustion and automation enables it to integrate both aspects.
The newly defined process control setup is rather innovative in its structure. It features an integrator that ensures that the target global excess air coefficient is met by adapting its distribution across the burners according to process variations.

Fine-tuning on site

In the first stage, the process control setup will be put into service to check if the combustion dynamics are in accordance with the implemented control logic. Combustion specialists from Laborelec will then fine-tune all parameters on site to ensure a low NO_X combustion.
The new installation is scheduled to enter service at the end of October.

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CDM&T tool awarded the 2008 SUEZ Innovation Trophy

Laborelec and Electrabel Netherlands have been awarded the 2008 SUEZ Innovation Trophy for their combustion dynamics monitoring and tuning tool (CDM&T). The tool assists power plants in determining the optimum level of combustion stability with minimum emissions for their gas turbines.

The tool was originally developed for the Eems power plant, which operates five General Electric 9FA 350 MW gas turbine units equipped with a DLN2.0 combustion system. Thanks to premixed combustion, the plant realizes low CO_2 and NO_X emissions. However, premixed combustion can cause combustion oscillations that risk damaging the gas turbine. The CDM&T tool makes it possible to maintain more consistent combustion stability.
Electrabel Netherlands and Laborelec developed hardware able to withstand high temperatures. They also developed the software, including data processing tools and an automatic alarm system.
CDM&T offers major advantages for gas-fired power plants. It assists in:

- Finding an optimal balance between combustion stability and environmental performance
- Reducing unplanned breakdowns by automatically notifying operators in the event of combustion oscillations, thus enabling them to take appropriate action
- Root cause analyses; for instance, it helped reveal the true root cause of burner damage at the Eems plant

These benefits earned it the 2008 SUEZ Innovation Trophy.

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Performance monitoring tool ready for industrialization

Laborelec has developed a new tool for monitoring the efficiency of power plants and their main components. It is now ready for application and implementation in power plants in Belgium and Luxemburg.

The tool is based on the DIN 1942 norm for calculating the performance of an entire plant and its main components such as the condenser, the turbines and the boiler.
In the initial phase, Laborelec defined the ten to fifteen most important types of measurement data needed to make a reliable determination of a plant's performance. Since these measurements have a major impact on the accuracy of the calculations, power plants need to ensure that they are collected with great precision.
Laborelec then built a software tool to extract the required measurement data from the plant information management system (PIMS) and to execute the calculations. The tool was developed in VBA and has been integrated into an Excel programme. It – among other things – calculates turbine performance based on the inlet and outlet pressure and temperature readings.
The tool has already been field tested by power plants in Belgium and Luxemburg. Based on their feedback, it has been fine-tuned and is now ready for industrialization.
The next steps are the complete rollout in Belgium and Luxembourg, before moving on to the rest of Europe. In collaboration with Electrabel Métier Generation, Laborelec will also develop key performance indicators (KPIs) for each power plant, against which they can benchmark their performance.

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Lowering NO_X emissions to make power plants LCP compliant

The EU Large Combustion Plants (LCP) directive puts new constraints on burner management in gas and coal/biomass-fired power plants. Reducing NO_X emissions while ensuring plant productivity is a challenge. Laborelec assists plant managers in achieving this.

Obtaining a low NO_X combustion in a gas or coal/biomass-fired power plant requires a number of conditions to be met. The appropriate fuel flow rate in the burner must first be identified, as well as the optimal volume of air. This volume depends on various factors such as the type of fuel and the dimension of the combustion chamber. Once these ideal parameters have been identified, it is essential to ensure an appropriate distribution of air inside the furnace.

Precision measurement is crucial

Setting the ideal fuel and combustion air ratio when configuring low NO_X burners requires extremely precise measurements of combustion parameters and emissions.
In the case of new power plants, this configuration begins at the design stage. For existing plants, Laborelec optimizes combustion on site, for instance by modifying the air distribution inside the furnace and by implementing an over fire air (OFA) system. This custom work demands appropriate knowledge and tools. Laborelec uses software such as computational fluid dynamics (CFD) (see also p.2) to simulate how the combustion is propagating inside the furnace. Based on these studies, Laborelec determines the optimal settings by trial tests on site. The new settings are also integrated into the plant automation systems.

Optimizing existing combustion processes

In the case of existing burners, an optimum has to be identified with parameters that affect the emissions.

Laborelec helped the Awirs 5 gas-fired power plant with the purchase and commissioning of new low NO_X burners.

Here, obtaining lower NO_X emissions requires a series of trial and error tests based on Laborelec's experience to determine the optimal combustion. This was recently the case at the Amercoeur 2 power plant (see also p.1).
One of the methods to achieve lower NO_X emissions is by spreading the combustion over various upward stages inside the furnace. Another field of action consists in staging the flame with a decreased temperature inside the furnace, resulting in lower NO_X emissions. This technique was recently applied at several power plants.

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