Optimization of SNCR systems and combustion processes at district heating plants in Sweden.

Summary

A process optimization system was implemented by applying the MultiSimplex software in the SNCR-system and combustion process at the Söderenergi district heating plant in Södertälje, Sweden. To date, the optimization project has yielded two important results: 1. Automation of the SNCR-system and combustion process. 2. Substantial emission reductions, 25 % lowers NOx emissions and 60 % lower CO-emissions, when the SNCR-system and combustion process is controlled by MultiSimplex in automation mode. Another economical and environmental benefit is that the NH3 consumption for the SNCR-system has been lowered by 40 %.

A similar MultiSimplex control system was installed for the SNCR-system at the Fortum district heating plant at Högdalen, Sweden. The result has been a cost reduction for ammonia consumption and NOx-taxes by 15%.

BACKGROUND

Introduction

Nitrogen oxides acidify lands and lakes, carbon oxides impact on global warming. An optimization of a flue gas cleaning system and combustion process will decrease the emission of nitrogen oxides and carbon oxides and will also save hundreds of thousands of Euros in pollution taxes every year. In a world of ever increasing environmental demands and international competition there is a constant pressure on energy suppliers and manufacturers to become more efficient. It has been especially important for industries with harmful emissions to improve their operations since they face both competitors and tougher environmental demands. In Sweden, the pollution taxes on NOx are 4 500 Euro per yearly tonne emitted and throughout the EU, there is a new limitation on emissions that will take affect starting 2005. Plants, which are non-compliant, run the risk of having their plants closed down or facing lawsuits. The combustion process is of particular interest for quick practical implementation of continuous improvement methods for mainly two reasons: It will see much tougher emission requirements in a few years. It also uses raw material that requires continuous changes of the control parameter set points in order to always strive towards optimal operating conditions.

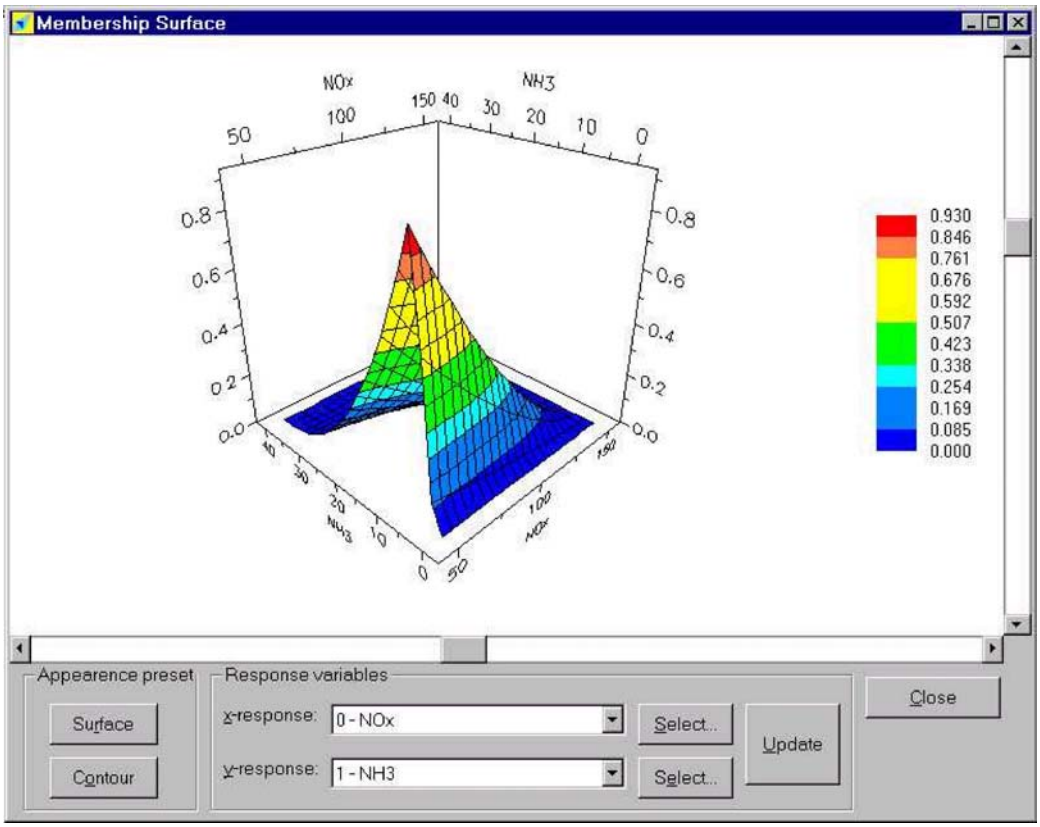
The main objectives with the projects were to decrease the CO and NOx emission as well as the NH3 consumption in the combustion- and flue gas cleaning process. I.e. in an economically beneficial way reduce the emissions.

With the current demand on efficiency, an optimization of the process is required. MultiSimplex® is an efficient tool for optimization of processes.

Objectives

The main objective was to improve the environmental standards and to lower the cost of the flue gas cleaning and combustion processes at the above-mentioned district heating plants. This objective was to be carried out by establishing a combined output parameter (called a joint response) and then optimize the joint response. The joint response was

composed by NOx-emission, NH3-residual in the flue gases and NH3-consumption. The second response was composed CO-emission and oxygen content. The objective was also to automate the operation of the combustion- and flue gas cleaning process.
These objectives were to be carried out without limiting or disturbing the Heat and power generation.



3-D graph, describing the joint NOx/NH3 response

Technologies and/or methodologies used

The MultiSimplex® technology can be referred to as an evolutionary operation (EVOP).

EVOP was introduced in the 1950s. The basic idea is to replace the static operation of a process by a continuous and systematic scheme of perturbations in the control variables. The result is evaluated and the process is shifted in the direction of improvement. The simplex method was originally developed for evolutionary operation, and is very suitable for this purpose. The simplex method is especially appropriate when:

·Process performance is changing over time.

·More than three control variables are to be perturbed.

·The process requires a fresh optimization with each new lot of material.

In most practical optimization situations more than one response variable must be considered simultaneously. MultiSimplex® uses the approach of fuzzy set theory to

form a realistic description of the optimization objectives. Different response variables, with separate optimization objectives, can then be combined into a joint response.

In an ideal world, the optimum levels for a process would be easy to find. But in all reality, the world is complex, nonlinear and multivariate. MultiSimplex® is a multivariate nonlinear optimization tool. It seeks the optimum step-by-step. Ordinary statistical methods require the fulfillment of many assumptions concerning distribution, linearity, etc. The MultiSimplex® methods do not have to be adjusted to such assumptions, and are consequently easier to apply to most real world problems.

The MultiSimplex optimization tool interacts with the control system and continuously changes process parameter set points in order to always strive towards the continuously changing optimal operating conditions, yielding the wanted process output.
The tool can be integrated with any modern control system.
New control parameters can also be added to the system when further process optimization is wanted, or, as the plant is being upgraded or modified.

In this project the emission of CO, NOx and NH3 consumption were to be minimized by the optimization tool. The combustion processes, with changing raw material and tougher environmental restrictions makes a good case for practical implementation of continuous process optimization. In this very application the input parameters NH3 injection flows and flue gas reflux have been connected to MultiSimplex in order to continuously find the best set points for these parameters, which minimizes the emission of NOx and consumption of NH3.
The very use of the MultiSimplex tool also drives plant operators to consider issues such as improvement of measurements; other control system applications and also connections between process systems, helping to improve the overall plant operation.

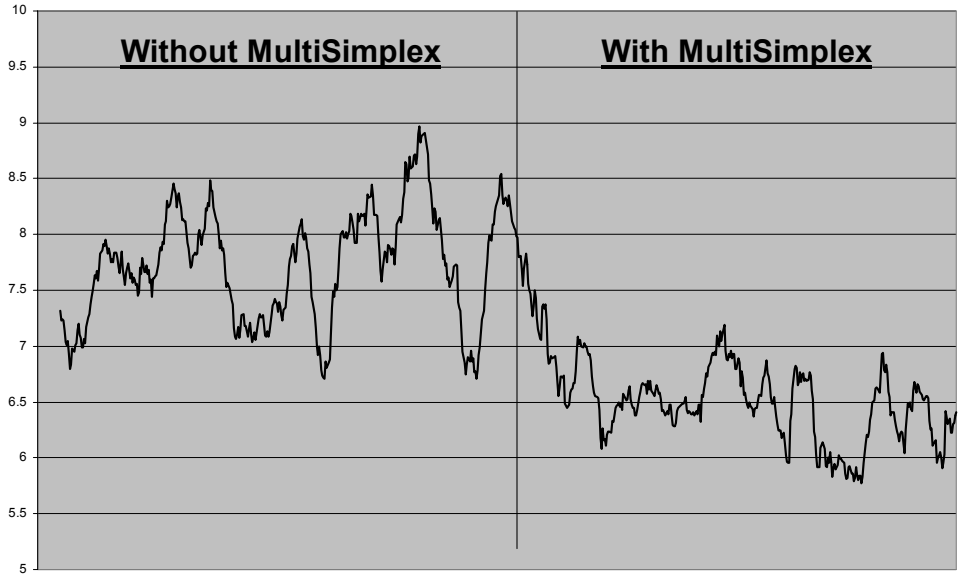
Total costs and contribution from external sources of funding.
The project cost was approximately 50,000 Euro, each, and was fully funded by the plant owners.

RESULTS

Saving energy was not the objective of the project and only automation and emission reduction issues were considered. However, an energy/fuel saving parameter could be added to the joint response and thus be optimized with the same optimization system, MultiSimplex®.
The plant emission cost is based on EURO/ton NOx emitted and liters of NH3 consumed. The installation of the MultiSimplex® system has at Fortum resulted in a 15% lowering of the combined cost for NOx emissions and NH3 consumption. At Söderenergi, The CO emissions have been lowered by 60%, the NOx emissions have been lowered by 25% and the NH3 consumption has been cut down by 40%. Hence, the economical benefits were considerable for both projects and the payback time was less than one year. If the savings from the automation of the process had been considered, the total savings probably would have turned out to be even greater.
The environmental benefits were substantial with a significant reduction of the CO and NOx emissions as well as the NH3 consumption and NH3 residuals in the flue gases and condensate.

The total work required for implementation of this particular application of the software tool can be translated into 4 "man-months" /application.
The implementation and utilization of the tool changes the plant operation in several ways. It drives a systemized handling of all available control and output signals. This simplifies the process of adding new control signals to be included in the optimization routine. It also simplifies the maintenance of the signals and the sources of those signals (motors, sensors, etc). The utilization of the tool also highlights important relationships and enhances understanding of the plant itself. The automation of the plant results in freed resources for "higher level" work, for example, experimentation and considerations regarding possible introduction of new measurement. Another field that was explored was possible connections between process systems.
The energy savings were not evaluated. However, a lower emission is a good indication of more efficient fuel usage.
The Energy in theses particular plants is produced from incinerating domestic waste "fuel" and wood chips.

Production cost (NO_x-fee + NH_3) SEK/ton steam



"The use of the MultiSimplex system for operation of the SNCR system at the waste incinerator P2 at Fortums Högdalen plant, has resulted in an approximate 15% reduction of production costs. This is mainly a result from reduced NO_x emissions."
Christer Andersson,
Fortum Technology & Environment AB

" Using the MultiSimplex system for optimizing our SNCR system and our combustion process have resulted in significant reductions in both CO (60%) and NOx (25%) emissions as well as NH3 consumption (40%)."
Per Oxelmark,
Söderenergi AB

LESSONS LEARNED

Positive aspects of project implementation

We learnt that using fuzzy logic by having the "joint response" concept is a powerful method of simultaneous optimization of several outputs at the same time and that the very construction of a joint response alone, for an application like this, results in new insights about what you really want to optimize.
We learnt that it is economically, environmentally and organizationally beneficial, to automate the operation of a combustion process. The reasons for this are lowered emissions and pollution taxes as well as the creation of more intellectually challenging work tasks for the personnel involved.

REPEATABILITY

The project has been "replicated" on two more waste incinerators at the Fortum district heating plant in Högdalen as well as at the biomass fuel heating plant at Stora Enso Fine Paper, Nymölla mill (Sweden). At the latter, the objective was to reduce both NOx- and CO-emissions by using only secondary- and tertiary- airflows. These airflows were connected to MultiSimplex in order to continuously find the best set points for these parameters, which would minimize the emission of NOx- and CO- emissions. The result at Stora Enso was a 10% reduction of both NOx and CO- emissions, only by optimizing the air flow balance in the system.

This indicates that the project could be repeated in any combustion process using waste or biomass as fuel, anywhere in Europe.

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