Minimum emissions and maximum efficiency by primary measures

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New measuring techniques and mathematical models will improve the combustion conditions and thereby reduce the emissions from plants with moving grates fired with biofuels. Advanced measuring techniques can expose the local combustion conditions on the grate. An improved online control will use this information and through direct intervention optimise the combustion conditions and reduce the emissions. New measuring techniques will be tested on full-scale plants, dynamic mathematical models of the combustion processes in the fuel layer and the emissions will be developed, and new control strategies will be formulated.

Objective

The purpose of the project is to develop more environmentally friendly and efficient biomass fired plants - with regard to limitations in formation of undesirable emissions (NO_x, dioxins, etc.) and energy conversion. The goal will be achieved through better control based on dynamic mathematical models of the combustion processes on the grate and furnace combined with advanced online monitoring of the locale conditions on the surface of the grate layer. The improved control system demands the development of advanced mathematical models of the combustion being able to predict the emissions of the most important substance as NO_x and dioxins (Predictive Emission Monitoring Systems, (PEMS).

It is expected that an advanced online monitoring system will provide new knowledge about the chemistry of radicals close to the grate layer and in the furnace. This knowledge and the results of the work with mathematical models can be adapted to all combustion processes with solid biofuels.

Background

The combustion conditions of plants with moving grates fired with biofuels have decisive influence on the emissions. Since the biomass technology is relatively new - and in addition is subject to increasing demands on low emissions - there is a potential and a need for improvements. The enhancements can be achieved through primary means (air distribution, fuel rate, grate movement, etc.)

Straw fired biomass plants are especially brought into focus. Straw has varying density, heating value, water content and chemical composition, giving a generally unstable combustion. This causes formation of dioxin, NO_x and CO. By stabilising the combustion there is a potential for a reduction of the impact on the environment and for an improvement of the energy efficiency of the plant.

Detailed process information about the locale combustion conditions on the surface of the grate layer is difficult to obtain today – and is only used to a very limited extend. Using new types of instruments and advanced dynamic mathematical models calculating immeasurable process variables and predicting emissions will increase the level of information substantially. Experience even show that models in some cases can replace instruments. The improved level of process information can be used for emission reduction through an advanced control concept – i.e. a multi variable model based concept, which is found very efficient in other contexts.

In Denmark works are done to improve biomass-fired plants using existing measuring techniques and traditional manipulated variables (e.g. grate speed, secondary air flow) and to achieve a better theoretical understanding of the combustion processes. Although positive trends are seen, it is a fact that the missing information about e.g. the temperature distribution on the surface of the fuel layer is preventing proper control. One large Danish project is working on detailed descriptions of the mechanisms of combustion of straw, the understanding of the formation of SO_2 and NO_x and mathematical modelling of the combustion chamber. This work is focused on the improvement of design and constructional tools based on the understanding of the chemistry.

A natural extension of these projects is to investigate which new variables it is possible to measure and which has to be calculated by models in order to optimise the combustion in plants with moving grates fired with biofuels. This work will determine how the best measurements, dynamic models and interventions in the process can be combined in order to reduce the emissions from grate-fired biomass plants.

Project partners

dk-TEKNIK ENERGY & ENVIRONMENT is an independent non-profit company providing consultancy, research and development within three main technological fields:

- Sustainable energy efficiency and process improvement
- Air pollution and sources, including fuels, processes and residues
- Integrated environmental and product assessment.

Elsam and Energi E2 (project manager) are leading, Danish production and energy trading companies. Energi E2 owns and operates seven large and ten small power stations and CHP plants in Eastern Denmark, while Elsam owns and operates six large power stations in Western Denmark.

FLS miljø a/s: The FLS miljø Group develops, constructs, manufactures and markets complete boiler islands for power stations, biomass and waste incineration plants.

Babcock & Wilcox Vølund ApS: The business includes waste-to-energy, biomass, gasification and stoker-fired industrial and power plant technology and projects and the engineering and manufacturing facilities as well as R&D facilities.

The Danish Public Service Obligation (PSO), FLS miljø a/s and Babcock & Wilcox Vølund ApS are funding the project, which is of considerable size.