SUCCESS STORY:

Developing advanced control strategies

INVESTMENT CASE
Title:
Model- based control strategy for biomass steam boilers
Year (commissioned):
2014/2015
Location:
Wörgl, Tyrol, Austria

Stakeholders:
1. BIOENERGY 2020+ GmbH – research institute
2. Polytechnik Luft- und Feuerungstechnik GmbH – plant manufacturer
3. Berglandmilch eGen, Werk Wörgl – plant owner

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Industrial-scale steam boilers are essential for the generation of electricity as well as the production of process steam used in industrial processes. Currently, the majority of steam boilers are fired by fossil fuels. To decrease CO_2-emissions and ensure access to reliable and sustainable energy, renewable energy sources such as biomass fuels can and should be used in industrial steam boilers.

Modern biomass combustion plants often do not fulfil all dynamic requirements of industrial processes. Specifically, biomass-fired steam boilers producing process steam need to react quickly to changes in the steam demand while maintaining very stable steam parameters. The control strategies applied to the biomass combustion plants play a major role for these requirements as they determine the dynamic behaviour of the biomass combustion plant and have to compensate variations in the fuel quality as well as other internal and external disturbances.

Advanced control strategies

Conventional control strategies currently applied usually consist of a set of standard control loops with PID controllers. These controllers work almost independently and the coupled and nonlinear behaviour of the biomass furnace and the steam boiler are at best considered partially, at worst not at all. External disturbances, e.g. a change in the steam demand, are typically not considered until a deviation of the control variables, i.e. the steam pressure, is measured. This leads to poor dynamic behaviour and operational stability, such as strong fluctuations in the steam pressure.

To fully exploit the potential of modern biomass combustion plants the application of advanced control strategies, considering the couplings and nonlinear correlations between the process variables, are required. These control strategies are based on mathematical models describing the physical characteristics of the plant to be controlled. Thus, external disturbances can be compensated quickly and target-oriented , improving the controlled plant's dynamic capabilities and operational stability.

In the work described, such a model-based control strategy has been developed for biomass- fired steam boilers and implemented at an industrial-scale plant producing process steam for the dairy industry in Wörgl, Tyrol, Austria. This plant is equipped with a fossil-fired steam

Fuel type:
- Wood chips

Feedstock origin:
- Domestic silviculture residuals from thinning, tops, branches etc
- Domestic forestry by-products/ residuals: bark, wet wood chips, etc

Conversion system:
- Boiler combustion, e.g. stand-alone boiler plant including co-firing and combined heat and power

Co-fire:
- Heat generator (i e boiler) is 100 percent biomass-fired.

Heating system heat sources:
- Heat generator is part of a system with fossil fuel fired boilers

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boiler to enable compensation of possible deviations in the steam pressure.

The implementation led to very satisfying results, generally improving the dynamic behaviour and operational stability of the biomass-fired steam boiler. The developed model-based controller was able to compensate fluctuations in the steam pressure while simultaneously increasing fuel-flexibility. As a result, the need for the fossil-fired steam boiler was reduced significantly, decreasing the share of fossil fuels used in the industrial process. Thus, the developed model-based control strategy supports the potential for substituting fossil fuels in industrial-scale steam boilers with biomass.

The investment and its technology

A model-based control strategy for biomass-fired steam boilers has been developed based on mathematical models describing the physical characteristics of the plant. This control strategy has been implemented at an industrial-scale biomass-fired steam boiler producing process steam for the dairy industry.

The new model-based control strategy has been developed and implemented to replace the existing controller of the biomass-fired steam boiler. The goals were to improve the dynamic behaviour and operational stability of the plant, especially reducing the fluctuations of the steam pressure. This should lead to a reduced need

Relation to Sustainable Development Goals:

Ensure access to affordable, reliable, sustainable and modern energy for all

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

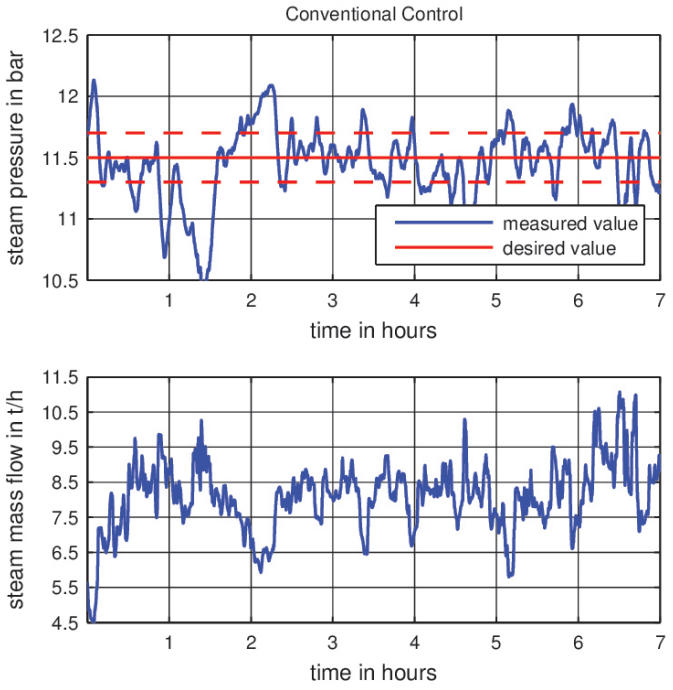
Ensure sustainable consumption and production patterns

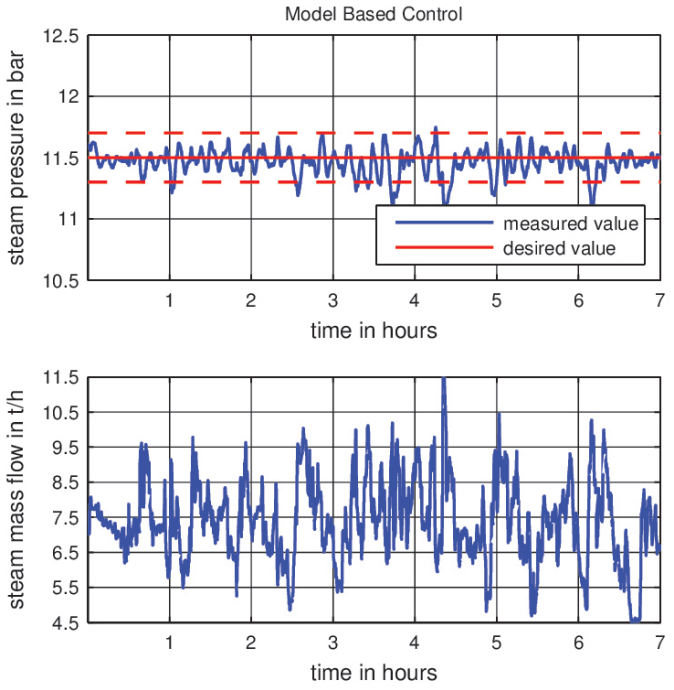
Take urgent action to combat climate change and its impacts

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Comment:

- The model-based control strategy for biomass furnaces with steam boiler makes biomass fuels more relevant for industrial applications. For this reasons it helps ensuring access to affordable, reliable, sustainable and modern energy for all. Furthermore the local biomass fuel supply supports employment, resilience and sustainable forest management.





of an additional fossil-fired steam boiler, and consequently a decrease of the share of fossil fuels used in the industrial process. From a general perspective, the development of the model-based control strategy should contribute to increasing the relevance of biomass fuels for industrial applications.

Factors behind the decision

From the plant manufacturer's point of view: Supplying industrial processes with steam represents a major challenge for biomass combustion plants. Industrial processes typically have high requirements on steam quality while simultaneously exhibiting strong dynamic changes in steam demand. This requires a steam boiler that is able to react to rapid load changes. The control strategy initially applied by the plant manufacturer did not enable biomass-fired steam boilers to meet all dynamic requirements of industrial processes. The main factor behind the decision of the plant manufacturer, to develop and implement a model-based control strategy, was the desire to make biomass-fired steam boilers applicable to a wider range of industrial processes and thus extending the market for such plants.

From the plant owner's point of view:
The industrial process is equipped with a fossil-fired steam boiler, to compensate for the limited dynamic capabilities of the biomass-fired steam boiler, which results in additional costs for operation and maintenance. The main reason behind the decision of the plant owner, to implement the control strategy, was the desire to reduce the dependence on fossil fuels. If a larger portion of the produced steam comes from the combustion of biomass it results in decreased fuel and operating costs as well as lowered CO_2 emissions.

Replicability potential:

- High local replicability
- High regional replicability
- High national replicability
- High international replicability

Scale-up potential:

- High local potential
- High regional potential
- High national potential
- High international potential

Lessons learned

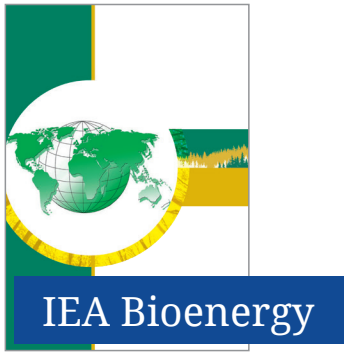
The results achieved were very satisfactory.

Success factors

The developed technology can be applied to any biomass-fired steam boiler. If the costs of biomass fuels decrease, in comparison to fossil fuels, it increases the chances for application of the technology. In addition, stricter standards for the dynamic behavior of biomass combustion plants would make this technology more favorable in already existing plants.

Constraints

Every factor that leads to a drastic price increase of biomass fuels and biomass combustion boilers decreases the chance of application of this technology.



Web sites:
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