Preventing Incrustation in the Furnace

KIT Researchers Are Analyzing Residue in Biomass Combustion – With the Goal of More Efficient and Resource-conserving Use of Residual Materials

Many times, when people think about organic waste, what comes to mind is composting or biogas production. But some organic wastes end up in biomass combustion plants, in particular those that are heavily contaminated. There, energy is generated from the heterogeneous material – and along with it, a technical problem: Deposits in the combustion chamber and incrustation on the surfaces of heat exchangers cause wear in the plants and give rise to high maintenance costs. In addition, the slag that is generated must be disposed of.

To address those challenges, several combustion plants, an engineering firm, and KIT are working together in a project funded by the German Federal Ministry for Economic Affairs and Climate Action. Their goal is to be able to regulate the combustion of biomass so that the generation of deposits and incrustations is minimized. They want to be able to recycle the slags – and thereby conserve valuable materials.

A team led by Professor Jochen Kolb at KIT's Institute of Applied Geosciences is contributing to the project from a geoscience perspective. "Our task is to analyze the mineral components in the combustion residues," Kolb says. To that end, the researchers are combusting biomass components in laboratory experiments at realistic temperatures and under defined conditions, and subsequently analyzing the composition of the ash that is generated. The key question concerns the minerals that are created at various temperatures: Are loose, removable crusts being generated – or hard, adherent deposits on the walls of the combustion chamber, and coatings on the metal heat exchangers?

The range of fuels being tested: Biofuel mixes that are being analyzed at KIT with regard to their potential for generating deposits. *(Photo: Kolb / KIT)*

This information is incorporated into so-called phase diagrams. They show which mineral phases are stable at particular temperatures. On this basis, researchers aim to give the operators of biomass combustion plants empirically sound recommendations for optimizing the operation of their plants – depending on the respective biomass that is used.

One finding thus far is that even presumably unproblematic operating conditions can result in deposits and losses of efficiency. "Our studies show that problematic coatings are often created even at temperatures that lie significantly below the ash melting points of the biomass fuels," Kolb says. "The generation of residues that become solid begins already at temperatures around 750 °C to 850 °C – although sintering temperatures in accordance with the German industrial norm (DIN) are mostly assumed to begin at more than 900 °C, and reach up to 1000 °C."

Amid the combustion heat, new mineral structures are created, and they differ in accordance with the temperature and composition of the fuel. In the process, solid, compact slags predominate on the grate; in the combustion chamber, mainly sintered and vitreous deposits; and in the boiler area, to an extent, voluminous coatings ranging from hard to particulate. With the help of sintering experiments at the lab and pilot-plant scales, the researchers are testing to determine which biofuel mixes display high or low caking potential. This kind of differentiation is helpful for systematic influencing of the processes.

When it's too late: Slag and loose deposits from a biomass furnace – disposal required. *(Photo: Kolb / KIT)*

In pursuit of practical applications, researchers are using biomass fuel mixes at four biomass fuel plants for months at a time under realistic conditions. Some of the fuel mixes employed have already been optimized, and others have been left in their original state, to gain a better understanding of coatings as a function of inputs, and to obtain information for subsequent improvements. During planned stoppages, the project partners systematically test the deposits and coatings. In this way, they are generating a dataset that reveals the effects of the mix, the temperature, and of combustion management during operation.

Only the best combinations are ultimately used. "That lowers risk, increases running times, and brings us one step closer to the vision of an intelligent, forward-looking circular economy," says Kolb. Last but not least, the project is making a contribution to the energy transition: Via the optimized use of biofuels, fossil fuels can be conserved and the energy efficiency of decentralized plants can be increased – a goal that is also becoming ever more important for thermal planning in municipalities. "Our project is making biomass heating plants more robust, more economical, and more climate-friendly," says Kolb. "That benefits operators, municipalities, and the environment in equal measure." ■