Biofuels Research Infrastructure for Sharing Knowledge

PARTNER PROFILE

BIOENERGY 2020+ and TU Graz - Austria

BIOENERGY 2020+ (BE2020) is an amalgamation of five scientific locations (Graz, Güssing, Wieselburg, Pinkafeld and Tulln) which, as trans-locational competence centres, drive forward application-oriented research in the field of bioenergy. Collectively, they combine Austrian excellence in research in the fields of:

- Combustion of biomass in small, medium-sized and large plants;
- Thermal gasification of biomass, biogas, biofuels (conventional and innovative);
- Fuel substrate and ash characterisation;
- Fuel logistics;
- The preparation of waste for use in the generation of energy, as well as computational fluid dynamics (CFD) simulation and modelling.

Within the areas of combustion, modelling and simulation, and also within BRISK, BE2020 closely cooperates with the research group 'Energetic Biomass Utilisation' at the Institute for Process and Particle Engineering, Graz University of Technology (IPPT/TUG). This group, which is led by Prof. Dr. Ingwald Obernberger, has been engaged in the research and development (R&D) of the energetic utilisation of solid biomass for more than 13 years.

The key research competences of BE2020 and IPPT/TUG available through BRISK are:

- Characterisation of biomass fuels and ashes;
- Research on the behaviour of ash-forming elements in biomass combustion/gasification processes and their influencing variables, as well as high-temperature equilibrium calculations for ash-forming elements and their compounds;
- Research concerning the possibilities of utilisation of ashes from biomass combustion plants;
- The mechanism of deposit formation and corrosion in biomass combustion plants;
- Technological and ecological optimisation of biomass combustion plants (NO_x reduction by primary measures, improved excess oxygen control, flue gas condensation, fractionated heavy metal separation, technological requirements for the thermal utilisation of new biomass fuels);
- Aerosol formation and characterisation, as well as possibilities for efficient aerosol precipitation in biomass combustion and gasification plants;
- Development of innovative model-based process control systems for biomass combustion plants;
- Simulation of flow and combustion in biomass grate furnaces using CFD and considering kinetic aspects;
- Development of new and innovative measurement devices especially for high temperature *in situ* gas phase measurements and high temperature particle sampling;
- Development of state-of-the art combustion technologies;
- Development of innovative biomass combined heat and power (CHP) technologies.

Figure 1: 180 kW_{th} grate-fired testing plant.

Through BRISK some of the unique laboratory equipment and testing facilities of BE2020 and IPPT/TUG are made available for Transnational Access.

180 kW_{th} grate-fired testing plant

This combustion plant, which has specifically been designed as a testing facility, is based on a horizontally moving grate combustion technology and a hot water boiler (180 kW_{th}).

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Test runs of unusual biomass fuels at this plant are of significant importance to the development of new combustion technologies and combustion behaviour, particularly with respect to fuel characterisation. Within the dedicated test runs involving the respective biomass fuel, which usually last for several days, plant operation data are recorded, gaseous and particulate emissions are measured, and fuel and ash samples are taken and analysed.

In addition, the furnace offers a considerable number of measurement ports for hot gas sampling (deposit probe sampling, high-temperature impactor measurements, etc.) and measurements before boiler inlet. The data gained form an important basis for the characterisation of new biomass fuels and also represent a starting point for the subsequent development, conception and design of real-scale combustion plants including flue gas cleaning systems.

Figure 2: 50 kW grate furnace coupled with a drop-tube furnace.

50 kW grate furnace coupled with an electrically heated drop-tube

The testing facility consists of a continuously fed grate-fired furnace (55 kW_{NCV}), which can be operated with chipped and pelletised biomass fuels. The flue gases are led over a well isolated secondary combustion zone and an upper connection duct to a drop-tube. The drop-tube is made of a 2 metre long silica carbide (SiC) pipe and can be externally electrically heated in order to adjust the temperature and flow conditions at its outlet. Here, measurement ports for gas, particle and deposit sampling and measurements are installed.

Figure 3: Lab-scale combustion reactor.

Within dedicated test runs it is therefore possible to determine the combustion and release behaviour of various biomass fuels in a fixed-bed system, as well as to evaluate particle and deposit formation behaviour under continuous operation conditions. Thereby, the temperature profile of the flue gas can be adjusted to simulate the temperature conditions at the inlet of, for instance, hot water boilers or superheaters of steam boilers.
This testing facility is also an efficient application oriented tool to investigate deposit formation, erosion and corrosion behaviour of fly ash particles and condensable ash forming vapours under fixed-bed operation conditions. The data achieved can be utilised as a valuable basis for advanced fuel characterisation and especially for the development of deposit formation and corrosion models.

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Figure 4: Scheme of the high-temperature impactor (HTI) (left), the HTI directly after taking a measurement (right). *Key*—1: Outer casing; 2: Inner casing; 3: Shell; 4: Orifice plate; 5: Spacer ring; 6: Stagnation plate; 7: Critical Orifice; 8: Spring.

Lab-scale fixed-bed batch reactor

The reactor has been especially developed for the investigation of fuel decomposition under fixed-bed conditions. It consists of a cylindrical retort (height 350mm, inner diameter 120mm) which is heated electrically by two separated PID-controllers. The fuel (100 to 400g depending on the fuel density) is put in a cylindrical holder measuring 100mm in height and 95mm in inner diameter. Both parts are made of fibre-reinforced SiC ceramics. The mounting and vessel for the fuel bed are placed on the plate of a scale which is mechanically separated from the retort by a liquid sealing (synthetic thermal oil). Air, as well as different gas mixtures, can be applied as reaction media.

With this setup it is possible to continuously measure the mass reduction of the sample during the gasification/combustion process. The sample is introduced into the pre-heated reactor and therefore, rapid heating, comparable with the one in real thermal conversion processes, can be achieved. The composition of the gases produced is measured by the extraction of gas samples from the retort and the application of conventional on-line flue gas analyses (FT-IR, CLD, ND-IR). The initial sample, as well as the residues, are analysed, and therefore detailed information about the release of inorganic species from the fuel to the gas phase can also be obtained.

High-temperature, low-pressure impactor

The high-temperature, low-pressure impactor has been developed in order to facilitate *in situ* sampling of submicron particulate matter from high-temperature environments (e.g. from the furnace of a combustion plant). It provides information about the concentration and particle size distribution of particulate matter as well as, by the subsequent analysis of the sampled particles, about their chemical composition. The device can be applied at temperatures up to 1000°C and is therefore a valuable tool for aerosol formation studies.

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