Synthetic Biofuels From Biomass

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ABSTRACT
The importance of biofuels is growing rapidly in Germany and world-wide. This is reflected in steadily increasing research activities in both academia and industry, as well as in an increasing number of joint ventures comprising several institutions. Thus, not only the extent of publications on this highly dynamic topic is strongly increasing but also the public interest due to its obvious socioeconomic relevance. First generation biofuels such as bioethanol and biodiesel are state of the art today. However it is obvious that neither the quantity nor the quality are sufficient to meet the production potential and the standards expected. The second generation currently under development aims at the use of lignocellulosic feedstocks by-produced in agriculture and forestry. Third generation biofuels are issued in diverse research activities ranging from microbial fuels or algal fuels.

1. Introduction

The bioliq® project at the Karlsruhe Institute of Technology (KIT) aims at large scale production of synthetic second generation biofuels from biomass (BTL, biomass to liquids). The bioliq process concept has been designed to overcome scientific challenges and engineering problems, which arise when low grade, residual biomass shall be used to a large extent in a BTL process. Biomass such as straw, hay or residual wood usually exhibit on the one hand low energetic densities, thus limiting collection area and transportation distances. On the other hand, the production of synthetic fuels requires large scale production facilities in accordance with economy of scale considerations. In the bioliq process, biomass is pre-treated in regionally distributed fast pyrolysis plants for energy densification. The products, being pyrolysis char and liquid condensates, are mixed to form stable, transportable and pumpable slurries also referred to as biosyncrude. Biomass is thus energetically concentrated allowing economic transport also over long distances. In industrial plants of reasonable size, the biosyncrude is gasified in an entrained flow gasifier at a pressure slightly above that of the following fuel synthesis. In the bioliq pilot plant synthetic fuels are produced via methanol as an intermediate. The process requires a gasification pressure of up to 80 bar.

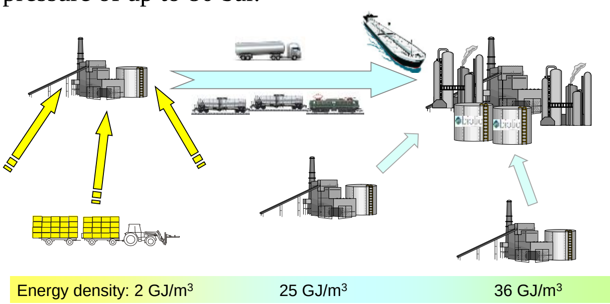

Fig. 1 bioliq concept

On site of KIT, a pilot plant is constructed for process demonstration, to obtain reliable mass and energy balances, for gaining practical experience, and to allow for reasonable cost estimates. The fast pyrolysis plant, already in operation, has a biomass feed capacity of 500 kg/h (2 MW(th)). A twin-screw reactor, equipped with a pneumatic heat carrier loop with sand as the heat carrier medium is the main technical feature of the plant. The biosyncrude is prepared in a specially designed colloidal mixer and stored in stirred container tanks. To prevent from potential sedimentation, the content of the tanks is continuously circulated.

The further process steps have been mechanical completed and commissioned separately in 2013. The high-pressure entrained flow gasifier is designed for 5 MW_{th} (ca. 1 t/h) slurry feed and can be operated at up to 80 bar. The burner is equipped with a twin fluid injection nozzle using oxygen and steam as atomization and gasification media. A 1 MW_{th} burner fed with natural gas is used for process stabilization, e.g. when using low calorific fuels or slurries with a wide and varying specification range. The pumps are designed to feed suspensions with up of 5 Pas viscosity, the burner nozzle is designed for a maximum viscosity of 1 Pas. The gasifier is specifically designed for lower fuel calorific values in the range of 13 - 25 MJ/kg. For adjustment of viscosity the biosyncrude can be heated up to 120 °C in the feed line to the burner nozzle. The gasifier is operated in slagging mode and is equipped with an internal cooling screen, particularly suited for conversion of ash rich feeds and fast start up and shut down procedures. Ethylene glycol slurries with char can be used as model fuel for scientific research. Ash and flux can be added to the fuel feed flow in order to adjust slag melting behavior.

The raw synthesis gas is purified and conditioned by a high pressure hot gas cleaning system, consisting of a hot gas filter with ceramic filter elements, a fixed bed adsorption for HCl and H_2S removal and a catalytic converter for decomposition of nitrogen and sulphur containing trace compounds. Afterwards, CO_2 and water are separated. The purified synthesis gas is then converted to dimethylether in a one-step synthesis process, which is converted in a subsequently following reaction into gasoline. A ZSM-5 zeolite-type of catalyst is used here. In all reactors, a new heat pipe based system is used for heat exchange, providing nearly isothermal conditions in the catalyst bed and improving process control.

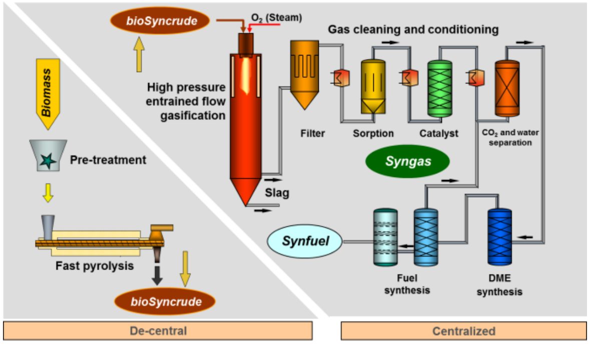

Fig. 1 bioliq process scheme.

Based on mass- and energy balances, an economic analysis of the whole process chain has been performed and will be worked out in more detail when experimental data from the pilot plant become available. Depending on the plant configuration and the selected production scenario and synthesis concept, overall process energy efficiencies from biomass to fuel between 34% and 42% have been estimated.

The process development is embedded into a coherent R&D framework, allowing for scientifically based operation and further development. Process development units for pyrolysis, gasification, gas cleaning and synthesis are utilized to increase the fundamental understanding of the underlying processes, to obtain representative product materials and process data, to develop technical improvements and new process variants, which then can be tested in the pilot plant.

Fig. 2 bioliq pilot plant at KIT.

Acknowledgements

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