FlexSNG NEWSLETTER

Flexible Production of Synthetic Natural Gas and Biochar via Gasification of Biomass and Waste

Issue 2 / July 2022

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1. Introduction to FlexSNG

A review on dual-phase oxygen transport membranes: from fundamentals to commercial deployment, written by R. Kiebach et al, and published in Journal of Materials Chemistry A (Nov 2021), is the first paper to be published for the FlexSNG project and can be read here.

This review paper aims to guide new studies that will promote the development and upscaling of dual-phase Oxygen transport membranes (OTMs), basing discussions on recent developments, current opportunities and challenges, and future directions of research. In this review paper, information about the basic working principle, properties, performance and current application in industry of dual-phase OTM membranes can be comprehended.
Next to material properties, preparative methods and manufacturing are in focus, intending to accelerate development and upscaling of new materials and components. Furthermore, existing challenges and research strategies to overcome these are discussed, and focus areas and prospects of future application areas are suggested.

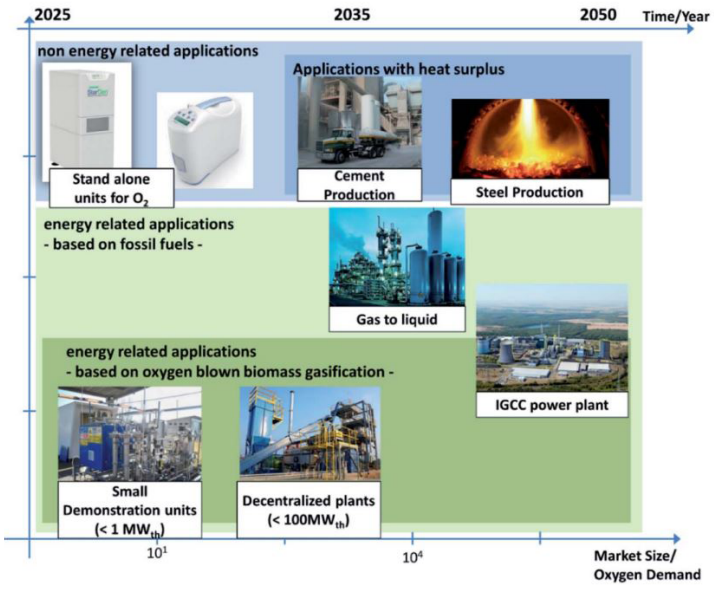

Figure 1. Credit: R. Kiebach et al

2. Two pilot-scale gasification test campaigns conducted at VTT's Pilot Centre Bioruukki

Two pilot-scale gasification test campaigns; process conditions in the gasifier optimized for co-production of biochar and synthesis gas from woody residues. One of the core activities in the FlexSNG project is to develop a new gasification process that can co-produce biochar and good-quality raw synthesis gas and can also switch between two operation modes: (1) co-producing biochar and synthesis gas that is further converted to biomethane, and (2) maximizing the fuel conversion to biomethane. The preliminary gasification experiments conducted in WP4 aim to identify optimal conditions for the gasification and gas clean-up process for both operation modes and various biomass residues and organic waste feedstocks.

So far, VTT has successfully carried out two three-day gasification test campaigns using two different fluidised-bed gasifier designs and crushed bark pellets as feedstock. The work has focused particularly on the co-production mode and optimizing the quality of biochar discharged from the gasification process. A number of operational parameters have been screened, such as gasification temperature, steam-to-fuel feed ratio, steam-to-oxygen feed ratio, fluidising velocity and bed material (sand/dolomite), to investigate their influence on biochar yield, characteristics and partitioning between bottom ash and fly ash.

Based on the preliminary tests, gasification temperatures below 700 °C and low fluidising velocities at the bottom part of the gasifier were best suited for biochar co-production, resulting in high carbon content in the biochar product (>70 %). The biochar produced in the gasification test campaigns have been shipped to EIFER for further characterization to determine its suitability for end use applications, such as soil amendment, construction material, steel making industry etc. The low gasification temperature employed in co-production mode evidently results in increased tar loading in the raw synthesis gas – potentially creating further challenges in hot gas filtration and reforming (e.g. soot formation, clogging by tars). These challenges have been overcome by partially decomposing the tars in the upper section of the gasifier by injecting secondary oxygen (mixed with nitrogen) and elevating the gas temperature to 820-850 °C.

The next step in the gasification process development is to study the gasification performance of the more challenging raw materials: high alkali agrobiomass (e.g. straw) and waste-derived feedstocks (e.g. Solid Recovered Fuel, SRF). One of the key aspects will be to investigate how their gasification behavior can be improved (e.g. ash sintering prevented) by using biochar as co-feed in the gasifier.

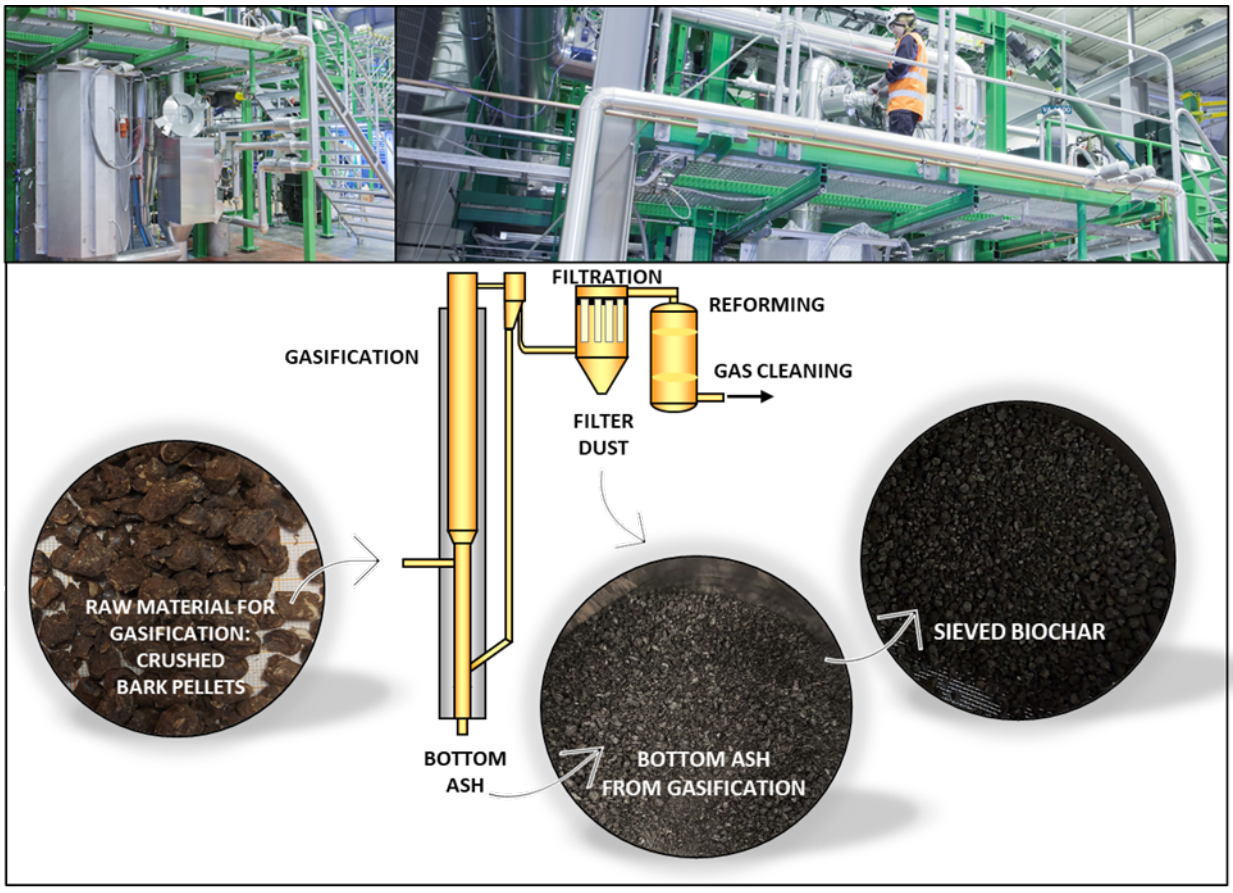

Figure 2. Credit: VTT

3. Oxygen transport membranes getting closer to real world applications at DTU

Test of performance in gasifier-fed conditions and advances in the design of the prototype module to couple to VTT gasifier

Oxygen transport membranes, or OTMs, is a technology that enables separation of oxygen from air with no expense, very little electric energy, and it's easily scaled up or down to the size of the plant requiring an oxygen supply. The technology is particularly attractive in small scale applications for distributed power generation and micro grids, where the application of classic cryogenic separation systems would prove too expensive.

The activities carried out at DTU for WP3 aim to i) assess the performance of the OTMs in gas compositions present in VTT gasifier in WP4 and ii) design an OTM prototype module that will be physically coupled to VTT gasifier to demonstrate the feasibility of the concept.

A test campaign was carried out on single tubes in DTU laboratories and provided very promising results. The tubes were characterized by testing them in a range of temperatures and compositions up to 1000C, including the composition of the producer gas obtained by VTT's gasifier, and it was possible to confirm the capability of the tubes to achieve the target of oxygen permeation flux of 3 ml/min*cm2 set for the project.

The design of the OTM module was completed and the construction is proceeding. The module will be hosted in a compact, autonomous test stand, installed with all the necessary equipment for testing the prototype and the safety devices to ensure smooth and safe operation.

The next steps on DTU side will be the assessment of long term stability of the single tubes in simulated producer gas atmosphere (250h operation) in parallel with the construction of the module and the preliminary troubleshoot and testing of the prototype in the designed operative conditions.

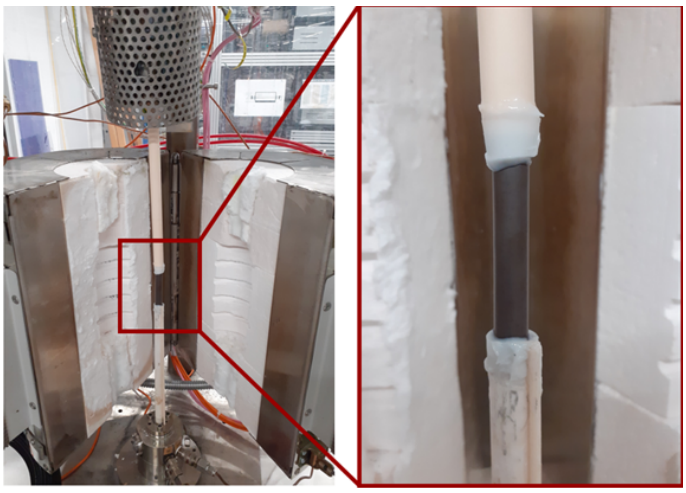

Figure 3. Credit: DTU

4. Biochar characteristics open a wide variety of possible end-use applications

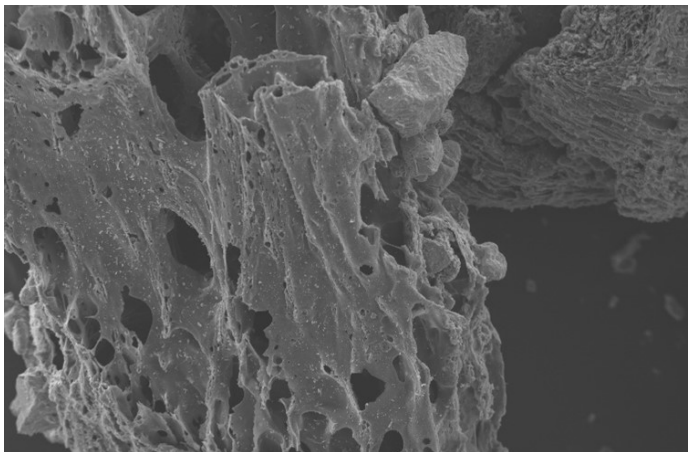

Figure 4. Credit: EIFER

The key idea of the FlexSNG concept is to switch between maximized syngas production and co-production of biochar. Biochar is a storable and valuable gasification by-product with some different end-use application options. One is its use as high-quality fuel, as intended in the FlexSNG concept to improve low-quality feedstock by mixing with biochar. Biochar has many uses, including soil amendment, as stand-alone mixed fertilizer, for co-composting with green wastes, as construction material, as fodder additive, for wastewater treatment or remediation of contaminated soils. Not least, biochar is considered as a permanent natural carbon sequestration sink and so as one important Carbon Dioxide Removal solution in the future.

The end-use for biochar depends on its properties, which vary from the feedstock and the severity of the biochar preparation process (temperature and time). Therefore, the physicochemical and surface characteristics of the biochar from the first two gasification campaigns at VTT are determined by EIFER.

Biochar from FlexSNG gasification is a dry, porous black powder containing around 75-85% carbon and only minor amounts of oxygen and hydrogen. Its fuel properties are promising due to the low volatile content <15% and the high HHV > 30 MJ/kg. The amount of ash is considerably increased compared to the feedstock bark, the ash composition reflects a slight contamination with the bed materials used. All concentrations of heavy metals as well as polyaromatic hydrocarbons are below the thresholds of the European fertilizing regulation. The surface structures of the biochar confirm a high sorption capacity due to the increased surface area and a high porosity. All results confirm the good quality of the biochar so far; no restrictions for the common end-use application for biochar are found.

In the next steps, biochar will be evaluated regarding its material use and its long-term stability for carbon sequestration in soils. Pellets from biochar will be manufactured and shipped backed to VTT for further gasification tests.

5. Recent events

Since January 2022 FlexSNG has been presented across Europe at the following events:

- IConBM2022, International Conference on BIOMASS (21 April 2022), Denver, US - The role of catalytic reforming in the production of synthesis gas from biomass and waste.
- EUBCE 2022 (9-12 May 2022), online - Advances in Gasification for Synthesis Gas Production.
- The International Conference on Thermochemical Conversion Science: Biomass & Municipal Solid Waste to RNG, Biofuels & Chemicals (6 June 2022), Naples, Italy - Development of a bubbling circulating fluidized-bed reactor for biomass and waste gasification.

At this years IConBM International Conference on Biomass, Naples, Italy, June 5-8 2022, Esa Kurkela gave a presentation to introduce the FlexSNG project and to present the latest project publication "Development of a bubbling circulating fluidized-bed reactor for biomass and waste gasification", that will be available soon in "Chemical Engineering Transactions Journal" (CET). The full presentation is available here.

Figure 5. Esa Kurkela, VTT at IConBM

6. Meet the research students

Meet Francis Lebreux Désilets in the first of a series of interviews to get to know the research students involved in the FlexSNG project.

In 2021, Francis Lebreux Desilets completed his bachelor's degree in chemical engineering at Polytechnique Montreal in Canada. Where he specialised in process systems engineering and environmental process design. Through Polytechnique Montreal Bachelor-PhD fast track program, Francis joined

Figure 6. Francis Lebreux Désilets, PhD candidate

FlexSNG Canadian Team as a PhD student under the supervision of Pr. Paul Stuart.

His research focuses on systems engineering for the strategic planning of net-zero eco-park in an industrial symbiosis context.
The developed methodology and techniques will be applied through comprehensive case studies on the new FlexSNG process in Canada and Northern Europe.

Check out Francis' interview here.

7. FlexSNG Consortium meeting, VTT, Espoo, Finland

Due to the global pandemic the FlexSNG were unable to meet in person until this summer, 17-18 June 2022, when at least one representative from each work package joined the meeting in Espoo, Finland, hosted by the project coordinators VTT.
The meeting was fruitful, allowing partners to share results and discuss future plans, in particular the different case study scenarios.
The consortium was also taken on a tour of the VTT Bioruukki pilot centre where different technologies were presented and explained.

Figure 7. FlexSNG Consortium at Biotuukki pilot centre

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