Fluidized bed gasification of wastes and syngas processing

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Fluidized bed gasification:

VTT has long experience in developing various gasification and syngas technologies for different feedstocks. The development of fluidized bed waste gasification began already in the 1990s and culminated in building a 160 MW_{th} SRF waste gasifier which was integrated into a CHP plant in Lahti, Finland.

High-temperature syngas processing:

After gasification, the gas is filtered at high temperatures. High filtration temperature is preferred for avoiding unnecessary cooling before the subsequent reforming unit in which tars are converted to valuable syngas components H2 and CO. The reforming unit operates at around 900 °C and utilizes nickel and/or noble metal catalysts.

With lower quality waste feedstocks additives are required prior to the filter for capturing excessive chlorine and sulfur from the gas. In addition to additives, filtration temperature is required to be lowered down for allowing proper operation of the hot-gas filter and effective separation of harmful volatile components such as alkali metals that can cause problems in the downstream equipment.

VTT's Bioruukki piloting-facility in Espoo, Finland.

Ultra-cleaning of syngas:

After tar reforming, syngas can be cooled down and fed to an ultra-cleaning process, where trace components such as NH_3, H_2S, COS, HCN, and residual benzene can be removed down to < 0.1 ppm levels.

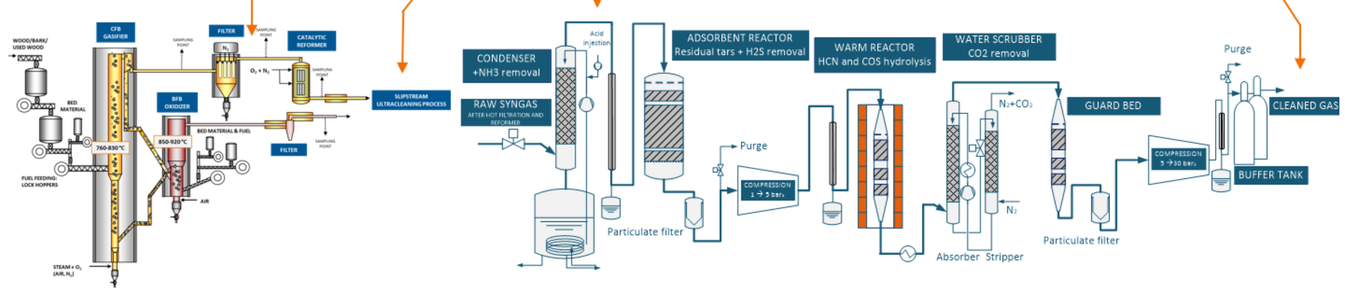
The current adsorption-based ultra-cleaning concept is developed originally for medium-size (150 MW_{th}) synthetic fuel and chemical production considering the limited availability of local feedstocks, logistic costs, and economies of scale of the processing units.

AFTER HOT-GAS FILTER	
Impurity	Concentration [ppm]
NH3	> 3000
H2S	20-400
COS	1-10
HCN	> 10
Benzene	1000-3000

AFTER REFORMER	
Impurity	Concentration [ppm]
NH3	250-500
H2S	20-400
COS	1-10
HCN	1-10
Benzene	10-200

AFTER SCRUBBER	
Impurity	Concentration [ppm]
NH3	50
H2S	20-400
COS	1-10
HCN	1-10
Benzene	10-200

ULTRA-CLEANED SYNGAS	
Impurity	Concentration [ppm]
NH3	<0.1
H2S	<0.1
COS	<0.1
HCN	<0.1
Benzene	<0.1



End-use of syngas:

In addition to CHP applications, the processed and cleaned syngas has multiple different valuable end-uses. VTT has a long history in developing Fischer-Tropsch production from syngas. The existing mobile synthesis unit (MOBSU) is able to convert a 5 m^3/h syngas slipstream into crude quality Fischer-Tropsch.

BioSFerA
Biofuel for biotravels

In the on-going BIOSFERA project, VTT's syngas production pilot will be integrated with BBEPP's mobile gas fermentation unit, where syngas is converted into acetate following microbial oil production. The project explores the benefits of microbes that can tolerate, or even utilize, gaseous impurities such as hydrogen sulfide and ammonia in converting syngas to valuable components.

VTT's role in the project is to enable the conversion of multiple different low-cost waste feedstocks (< 10 €/MWh) in a fluidized bed gasifier to a valuable gas. The produced and processes syngas is provided to the gas fermentation process at required quality levels.

References:

Kurkela. E., Kurkela, M., Tuomi, S. 2022, Development of a Bubbling Circulating Fluidized-Bed Reactor for Biomass and Waste Gasification, CET, Vol. 92.

Kihlman, J.; Simell, P. Carbon Formation in the Reforming of Simulated Biomass Gasification Gas on Nickel and Rhodium Catalysts. Catalysts 2022, 12, 410.

Frilund, F. Hiltunen, I., Simell, P. Activated Carbons for Syngas Desulfurization: Evaluating Approaches for Enhancing Low-Temperature H2S Oxidation Rate. ChemEngineering 2021, 5, 23.

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