BIOGAS Xpose

Maximized biogaspotential from resource innovation in the Biogas Öst region

SUMMARY REPORT

On installation of gas cleaning

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CORTUS ENERGY

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BIOGAS ÖST

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NeoZeo Biogas upgrading

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1. OBJECTIVE

The main objective of the first phase of Action B9 (executed by Cortus AB) in the Biogas Xpose project is to build and test the gas cleaning system for the methanation unit. The system, linking the gasifier with the methantion system, shall reduce the level of impurities to meet the requirement of the methantion system. The secondary objective is to improve/in-depth the knowledge of the trace analysis in the continuous operation of a low size facility, and to gain necessary knowledge and experience in designing and building of the state-of-the-art solution in the gas cleaning technology.

2. BACKGROUND

In general, gasification turns carbonaceous substance in a limited oxidation conditions at elevated temperatures into a gas mixture containing mainly hydrogen (H_2) and carbon monoxide (CO), but also some smaller quantities of carbon dioxide (CO_2), methane (CH_4). Cortus has developed an innovative and cost-effective gasification technology, WoodRoll®. Verification of the theoretical and lab-scale results has been tested in a 500kW test facility in Köping, Sweden. Recently, the facility has been integrated into a continuous plant. One of the outcomes from the WoodRoll® technology delivered during the pilot tests was a high-quality gas, characterized by a high yield of hydrogen (around 60%) and a tar content being under detection limit. Reduction of impurities at source is one of the most important advantages of using WoodRoll® process for second generation biofuels production such methanation.

3. IMPLEMENTATION

In this project biomethane (SNG) is to be produced from the conversion of syngas in a catalytic process. Even though the gas generated in WoodRoll® process has very good characteristics, the catalytic process used in the methantion system requires usually additional treatment to meet a very conservative requirement of the gas. The methantion where H_2 and CO is converted into methane requires a proper ratio, 3:1 respectively for this case as seen in reaction (i)) and delivery of the syngas of high purity as the concentration of, as for instance, sulphur (S) containing substances has to be reduced below the 0,1 ppm level. The amount S-substances in the gas is relevant mainly to the amount of S in the biomass feedstock. However, such low concentration of S required for methanation, cannot be guaranteed by the WoodRoll® process. On the other hand, an additional amount of H_2 is obtained from the water-gas-shift reaction (ii).

In order to push the reaction (i) towards methane production, the system has to be pressurized. However, this in turn, put an extra requirement for the solid particle separation system to avoid damaging the compressor.

$$3H_2+CO <-> CH_4+ H_2O \quad (i)$$

$$CO + H_2O <-> CO_2+ H_2 \quad (ii)$$

The proposed gas cleaning system consists of the following main components: hot gas filter, hot sulphur removal-bed (ZnO), condenser and active carbon bed (C). The layout of the system can be seen in Figure 1.

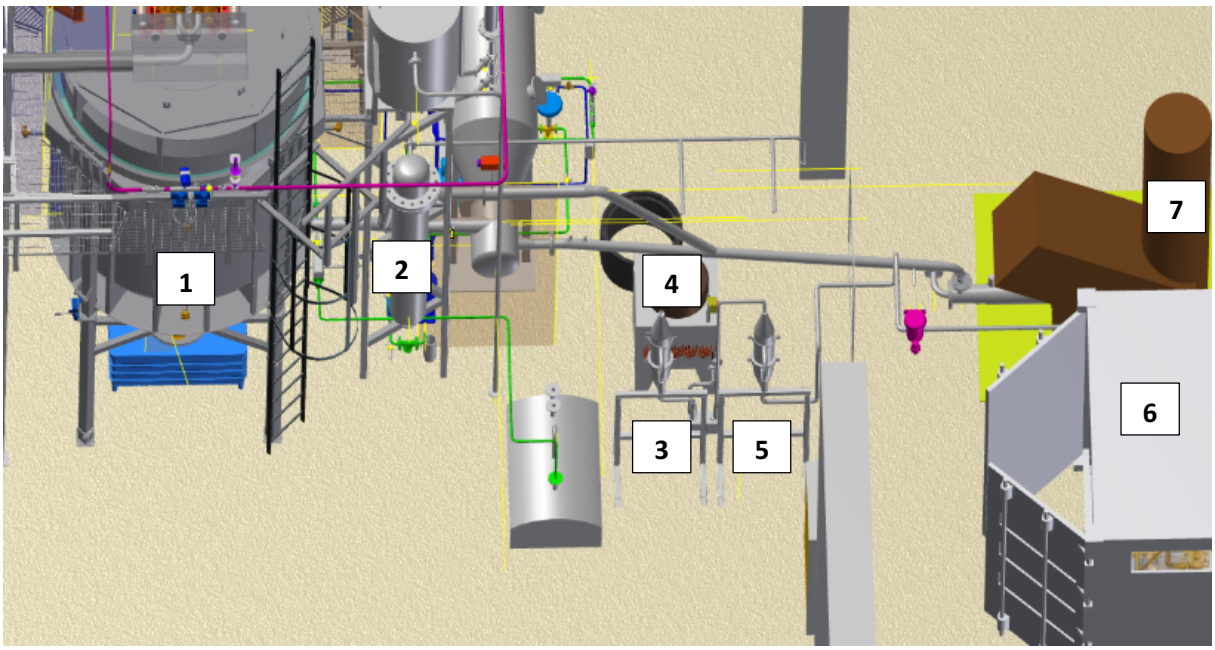

Figure 1: Elements of gas cleaning system: 1. Gasifier, 2. Gas filter, 3. S-removal column, 4. Condenser, 5. Active carbon column, 6. Methanation unit, 7. Flare

Removing sulphur components is one of the most important roles of the gas cleaning system due to protection of reformation the catalyst. The column is filled with ZnO granulates forming bed of approximately 500 mm in height. The optimal temperature of adsorption of sulphur is around 400 °C thus the gas needs to be kept warm with the heat-tracing system. At the entrance the gas is around

400-350 °C and a pressure of 300-400 Pa. The whole system including hot metal filter is held warm, and due to pressure drops in the filter over the filled-columns the gas has to be sucked with help of either suction fan or ejector to the destination. After the S-removing column the gas is cooled and the water with minerals and ammonia is condensed in the condenser, and the cooled gas below 20 °C degrees is sent to the Active Carbon columns. The active carbon columns capture the remaining contaminations, and the treated gas will further be sent through a fine particle filter and finally to the compressor. The compressed gas is first sent to a water gas shift reactor and then to a reforming reactor. Before and after every module in the gas cleaning system, there is a separate evacuation system for by-passing a foreseen stream of gas into the flare. This allows optimization of, different and often-varying, conditions associated with the operation in the gas cleaning system, as well as in the up- and downstream systems.

4. RESULTS

In the beginning of 2015, the installation work for the gas cleaning system was started. The first pilot test of the new gas cleaning was carried out during April of 2015. The gas passed through the cleaning line and was bypassed before reaching the methanation system. The results from first pre-tests with syngas though the gas cleaning system are present in table 1. The pressure indicators show the pressures at the inlet of (104.PT), after the filter (103.PT) at the outlet 110.PT (after the active carbon column) while 107.TT measures the temperature of the gas leaving the filter, and 109.TT measures temperature of the cooled gas after the condenser. The aim of the test was to enable to keep a constant and controlled gas flow through the system.

Table 1: 104.PT (pressure transmitter at the inlet), 104.PT (pressure transmitter after the filter), 110.PT (pressure transmitter after the active carbon bed), 109.TT (temperature transmitter measuring the cooled gas after the condenser), 107.TT (temperature transmitter measuring the gas after the filter)

Time	104.PT	103.PT	110.PT	107.TT	109.TT	BYPASS	M FLOW
min	Pa	Pa	Pa	°C	°C	%	kg/h
0	66	-179	-316	168,4	-	70	2,4
10	40	-283	-450	169,7	32,0	50	
20	7	-552	-747	171,4	43,8	45	3,6
25	-12	-685	-900	-	-	45	3,5
30	0	-631	-800	174,0	52,3	45	3,7
35	4	-700	-870	175,2	52,5	45	3,5
40	0	-750	-980	176,8	56,7	45	3,4
45	10	-700	-900	177,7	59,8	45	3,4
47	-31	-950	-1190	178,3	62,9	40	3,9
50	-20	-956	-1190	178,4	65,0	40	3,9
55	-50	-1163	-1382	178,7	67,2	40	3,9
60	-38	-1346	-1555	-	70,5	40	3,9
65	32	-1280	-1467	-	75,8	42	2,9
70	20	-1386	-1588	-	79,8	42	2,9

5. DISCUSSION

The initial trials proved the tightness of the system to avoid air leakage (the system is built in a slight under-pressure to allow a certain flow of the syngas through the cleaning vessels) but the fine particles could penetrate the filtering system and were captured on a “homemade” cotton membrane inserted just before the compressor. The suction is made by a suction fan. Based on the first runs a need of some modification of the gas cleaning system with a more efficient particle separation system is foreseen. More powerful heating systems for the particle filter, and an additional separation system for the downstream piping will be also revised to reduce the risk of clogging and condensation of the steam in the “hot filter zone”. Optimization of a flashing system for the filter and turn-over rate of ZnO bed are one of the highest priorities during next campaign.

6. CONCLUSION

Due to unsatisfactory gas purity after the treatment in current gas cleaning system, there is a need of a system upgradation. A root-and-cause analysis has been conducted in order to identify deficient modules in the gas cleaning system. Hence, the next phase of Action 9 is to add some additional components to the system.