Comparison of Energy Indicators for the Extraction of Carbon Dioxide from Landfill Gas in Absorption Processes Modeling

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1. Introduction

According to Government data, there are 21 landfill gas facilities in Ukraine and this number rising. On the other hand, there is demand to reduce natural gas import. Therefore, from a technical and economic point of view, the expediency is obvious of processing landfill gas into biomethane with carbon dioxide extraction, which is also marketable product.

The most widely used in the EU countries for processing biogas and landfill gas to biomethane are water and amine absorption technologies. In [1] was shown the amine process has up to 30% of the energy costs more than water one. However, amine absorption gives a calculated yield of biomethane up to 10% more than water and the use of this difference largely can compensate for the cost of regenerating a saturated absorbent.

2. Water and amines processes modelling

Water process

The process of gas purification occurs in three stages using fresh water that does not contain impurities, which circulates in the circuit. Figure 1 shows the technological scheme of landfill gas (250 Nm^3/h) purification from CO_2 using two variants A and B.

Simulation of water absorption process was carried out using own GasCondOil software.

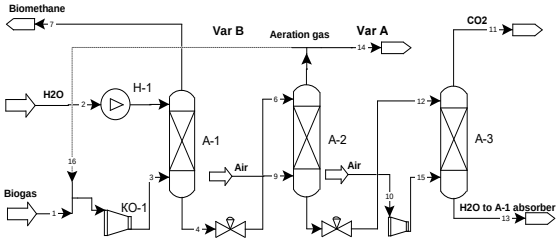

Figure 1. Technological scheme of absorption water purification

According to Var A, degassing gas (aeration gas) is used as a fuel gas. When using Var B, the resulting fuel gas is mixed with the initial landfill gas to increase the yield of methane in the purified gas.

The purified landfill gas enters the A-1 absorber at a pressure 0.26 MPa. Fresh water is supplied countercurrently to gas in the absorber. Water saturated with acidic components enters the evaporation column A-2, where it is blown with aerating air under pressure 0.12 MPa, while the methane is almost completely removed from the aqueous solution. In column A-3, at atmospheric pressure, the aqueous solution is purged with aerating air, while CO_2 is completely removed from the aqueous solution, which then enters the absorber A-1.

Amines process

Figure 2 presents a schematic flow diagram for the purification of landfill gas with aqueous solutions of amines. The processes were modelled using Aspen HYSYS 3.2 software.

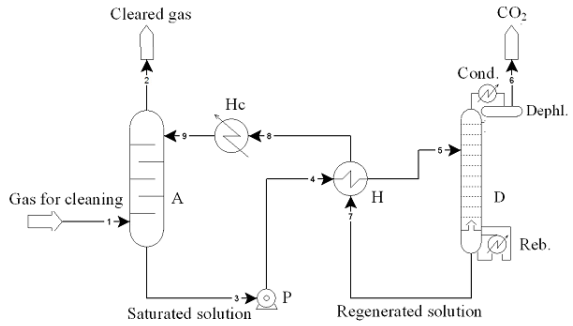

Figure 2. Technological scheme of absorption water purification

Gas at pressure 0.26 MPa and temperature 40°C enters the absorber A and is irrigated with an aqueous solution of a chemisorbent. In the absorber column, the concentration of carbon dioxide is reduced to ~2% (vol.). Purified gas is sent to the consumer. The saturated solution enters the upper part of D desorber, where the carbon dioxide is stripped. The regeneration process is carried out at a boiling point of chemisorbent.

3. Calculation results

Table 1 shows the comparative indicators of landfill gas (% vol.: CH_4-63, CO_2-34, N_2-1, H_2O -2) purification. The specific energy consumption of water, amine and water-amine [2] absorption was, respectively, 0.31, 0.66 and 0.46 kWh/Nm^3 of biomethane product. Methane in water process is lost in amount of 7.2%, whereas in the amine and water-amine absorption losses are practically absent.

Table 1. Gas composition.

Process indicators	**Absorption processes for the extraction of CO2 from landfill gas**		
	Water	Amine	Water-Amine
Total energy consumption, *kWh*	**47.7**	**111.8**	**78.7**
Specific energy consumption, *kWh/Nm3_biomethane*	**0.31**	**0.66**	**0.46**
Total losses of CH_4,*%*	**7.2**	**-**	**0.25**

Figure 3 illustrates the decrease in CO_2 concentration in landfill gas results in a sharp decrease in specific energy consumption in the amine process, while water and water-amine absorption has almost constant energy consumption.

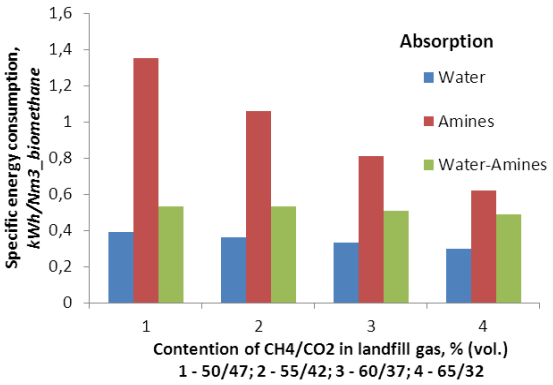

Figure 3. Specific energy consumption in biomethane production from landfill gas

4. Conclusions

Using computer simulations, the technological schemes of the most common amine and water processes for extracting carbon dioxide from landfill gas and producing of biomethane are analyzed.

Energy consumption for the amine absorption is 2 times higher compared to water absorption, but the yield of biomethane is 7–8% higher.

The results of the above calculations and studies can be used to optimize the extraction of carbon dioxide and produce biomethane.

5. References

[1] Yu.Ivanov, O.Pyatnichko, H.Zhuk, L.Onopa, M.Soltanibereshne. Extraction of carbon dioxide from gas mixtures with amines absorbing process // Energy Procedia 128 (2017) p. 240–247.

[2] Patent Russian Federation № 2508157 http://www.freepatent.ru/patents/2508157.