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Mathematical Modelling of Biogas Dehumidification by Using of Counterflow Heat Exchanger

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Abstract : Dehumidification of biogas at the biomass plants is very important to provide the energy efficient burning of biomethane at the outlet. A few methods are widely used to reduce the water content in biogas, e.g. chiller/heat exchanger based cooling, usage of different adsorbents like PSA, or the combination of such approaches. A quite different method of biogas dehumidification is offered and analyzed in this paper. The main idea is to direct the flow of biogas from the plant around it downwards; thus, creating additional insulation layer. As the temperature in gas shell layer around the plant will decrease from ~ 38°C to 20°C in the summer or even to 0°C in the winter, condensation of water vapor occurs. The water from the bottom of the gas shell can be collected and drain away. In addition, another upward shell layer is created after the condensate drainage place on the outer side to further reducing heat losses. Thus, counterflow biogas heat exchanger is created around the biogas plant. This research work deals with the numerical modelling of biogas flow, taking into account heat exchange and condensation on cold surfaces. Different kinds of boundary conditions (air and ground temperatures in summer/winter) and various physical properties of constructions (insulation between layers, wall thickness) are included in the model to make it more general and useful for different biogas flow conditions. The complexity of this problem is fact, that the temperatures in both channels are conjugated in case of low thermal resistance between layers. MATLAB programming language is used for multiphysical model development, numerical calculations and result visualization. Experimental installation of a biogas plant's vertical wall with an additional 2 layers of polycarbonate sheets with the controlled gas flow was set up to verify the modelling results. Gas flow at inlet/outlet, temperatures between the layers and humidity were controlled and measured during a number of experiments. Good correlation with modelling results for vertical wall section allows using of developed numerical model for an estimation of parameters for the whole biogas dehumidification system. Numerical modelling of biogas counterflow heat exchanger system placed on the plant's wall for various cases allows optimizing of thickness for gas layers and insulation layer to ensure necessary dehumidification of the gas under different climatic conditions. Modelling of system's defined configuration with known conditions helps to predict the temperature and humidity content of the biogas at the outlet.

Keywords : biogas dehumidification, numerical modelling, condensation, biogas plant experimental model
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