MEMBRANE COVERS OF BIOGAS STORAGE SYSTEMS

Biogas is one of the renewable energies. An economical solution for storing the gas and reducing odours are covers made of foils or coated fabrics. They are mechanically pretensioned via a middle mast or as cones and sphere segments, stabilized by internal pressure. Mechanically tensioned systems have a smaller storage volume compared to internal pressure supported sphere segments. In single-layer covers, the membranes are both weather protection and gas barrier. The storage volume of gas depends on the elastic, reversible strain of the membranes. Membranes are made of EPDM films, having a rubber-elastic behaviour (Fig. 1).

Two-layer covers have the outer membrane for weather protection. The inner layer, the gas membrane, adapts to the gas quantity. If PE films are used for the gas membrane with the same size of the outer membrane, the gas membrane is attached to the outer membrane when the tank is filled. If the outer and gas membrane consist of PVC/PET fabric, there is still a small volume of air between the outer and gas membrane if the tank is filled. The internal pressure in this supporting air volume is generated by a blower and suctioned outside air. If the tank has no gas, there is a wooden or belt structure inside on which the gas membrane is laid down. In gas production, the gas membrane is in an indefinite state due to the balance of internal pressure of the gas volume and of the supporting air volume as well as the deadweight of the membranes with deposits (Fig. 2).

A typical assumption for the design is the separation into outer and gas membrane. The load-bearing capacity of the outer membrane under external impacts is examined with an assumed, constant internal pressure in the supporting air volume. The special feature is the very high gas tightness for the gas membrane compared to pressure supported membranes used as building envelopes. Simplified Boyle-Mariotte Gas Law applies to gas-tight volumes. The internal pressure depends on the temperature and volume of the enclosed gas.

The internal pressure in the gas chamber is between 250Pa and 300Pa and for the supporting air chamber between 200Pa and 250Pa. This low differential pressure compared to the atmospheric pressure of 850 to 1050hPa leads to an overlapping of external influences and operating conditions in the gas chamber, such as empty, filling, maximum level and emptying. Till now the practical assumption is that these changes have to be compensated by the blower system of the air supported volume, providing a constant pressure.


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Figure 1. Example of a biogas storage system with membrane cover.
Figure 2. Gas membrane layer of the biogas storage cover.
Figure 3:. Test tank for determining the effect of ambient conditions.

Measurements were made on a test tank with volume changes from approx. 100m^2 to 790m^3 in the supporting air volume and approx. 430m^3 to 1130m^3 in the gas volume to determine the effect of ambient conditions on the internal pressure in both volumes. For safety reasons, filling, emptying, empty and full gas volume were simulated only via blowers with air. It is assumed that the measured temperatures with substrate and biogas are higher in a real tank (Fig. 3).

For a summer day preceded by a clear night, temperatures on the outer membrane of over 70°C were measured when the gas chamber was filled. The day was sunny and cloudy with wind speed 3 (Beaufort scale). With controlled and steady volume flow, the internal pressure in the supporting air volume changes briefly by -17%/+5%, in the gas volume the internal pressure of 340Pa fluctuated by -13%/+16% (Fig. 4).

For a clear winter night with a minimum temperature of -11°C and maximum temperature to 37°C midday of the outer membrane, causes the increase of temperature an increase of the internal pressure in the filled gas volume. This decreases with decreasing temperature. The pressure control of the supporting air volume is an open system. Temperature-related changes in the internal pressure are transmitted to the gas space (Fig. 5).

This behaviour can also be seen on windy days. A day with gusts of wind speeds of up to 19m/s is recorded. The mean wind speed was on the Beaufort scale at 5. Higher wind speeds were known from weather forecasts and the internal pressures were significantly increased. A constant internal pressure was set of about 400Pa in the supporting air volume, the average internal pressure in the gas volume was about 520Pa. The gust-related differences were -8% /+8% in both volumes. The pressure differences are considerably greater at lower internal pressure due to the less strength and stiffness of the membranes (Figs 6a and 6b).

The result of the measurements is that, in the structural analysis, the transfer of external influences such as temperature and wind to the gas membrane and the gas chamber is determined.

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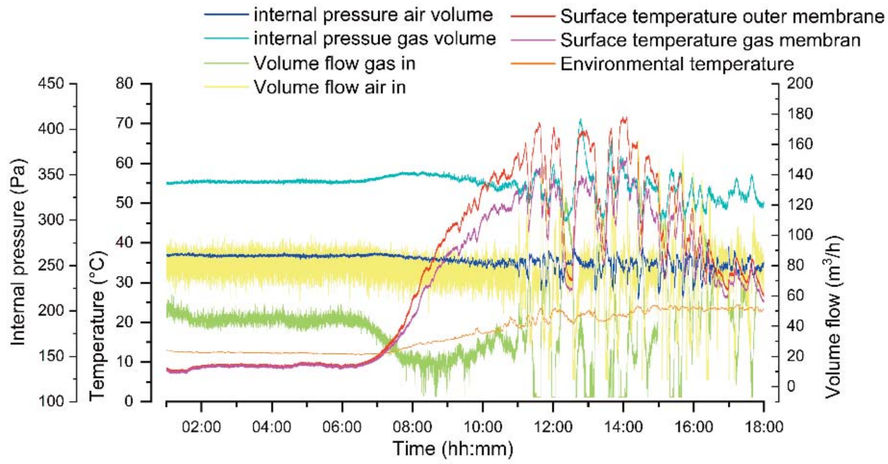

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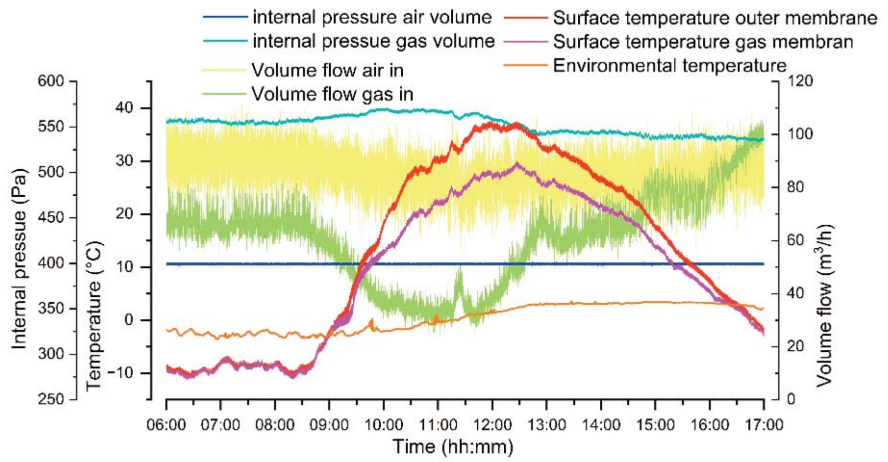

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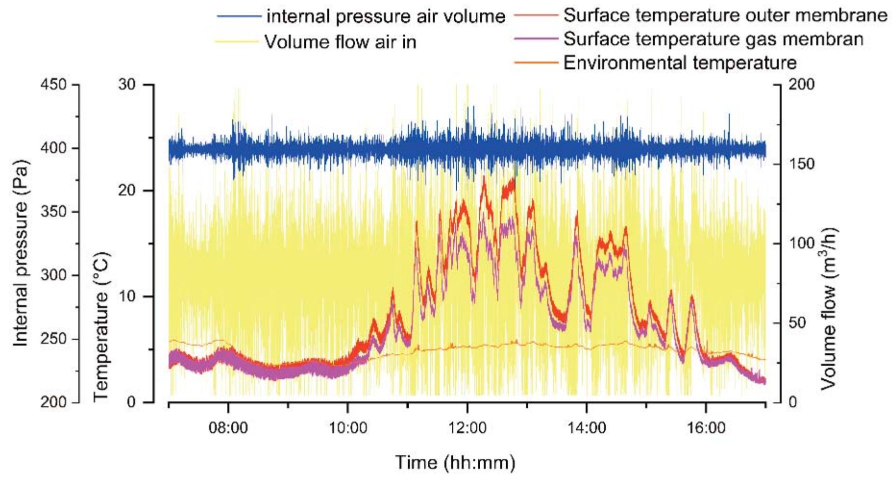

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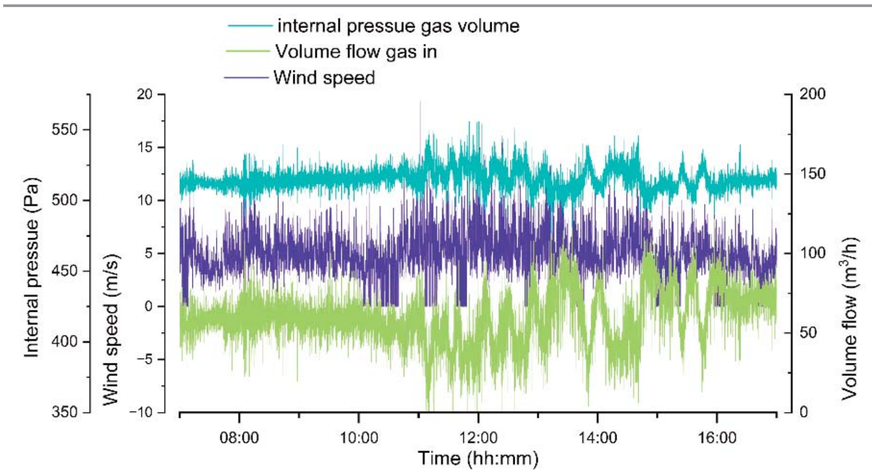

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Figure 4. Diagram showing results of 24 hours measuring during summer day.
Figure 5. Diagram showing results of 24 hours measuring during winter.
Figure 6a/b. Diagrams showing results of 24 hours measuring during a windy day. Diagram A has a constant internal pressure.