EVEN MORE ON METHANE

Fourth in a series by Al Rutan, the Methane Man

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Temperature is critical to the success of any methane operation if it is to be considered an energy system. If the primary concern is waste management and not energy production, then a net energy loss is not a major consideration. If the intent is to produce energy, a net energy gain from the process is everything.

Body Heat

Methane activity, in one of its natural situations, is found in the digestive tract of warm blooded animals, people included. For people, the normal body temperature is 98.6° F. In a chicken or pig it is 103° F. So right at 100° F is the ideal working temperature for the methane process. To maintain this temperature outside an animal is a problem if the ambient temperature is cool or cold.

Sewage Plants Energy Producers

There were several methane farm operations launched in the upper midwest with much bravado and publicity. All of them are now out of business. On the other hand, sewage plants of medium size still commonly use the process to treat toilet waste and destroy pathogens, but in each instance they consume much more energy during the cold part of the year than they produce. The toilet water flowing into each sewage plant is ordinarily cold. It would be exceedingly difficult for sewage plants to be anything but energy users rather than producers at any time except in the hottest part of the summer.

Universities' verdicts at the end of the methane studies were always the same: "It's possible, but it isn't practical. It takes more energy to run the system than the system can provide." In harnessing methane as an energy system, it is important to conserve heat in the process of producing gas. A few years ago a new sewage plant was built at St. Cloud, Minnesota to the tune of 17 million dollars. I asked the engineer, "Did you insulate the tank?" He said, "Oh yes. The old one used to actually freeze on the north side during the winter." My next question was, "Did you run the insulation into the ground?" His reply, "No. The ground never gets cold." My reply was, "That's right, but it never gets warm either." This sewage plant burned $750,000 a year in fuel oil to keep the digester at 100° F. It costs big bucks to flush the toilet in St. Cloud.

Capturing Warmth

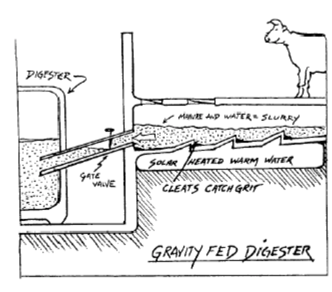
Heat has to be considered as something that is very slippery. Conserving heat requires understanding insulation. We are fortunate that there are many types of insulation available now that simply did not exist a few decades back. On the other hand, there's a general lack of understanding of insulating properties of common building materials such as wood, metal, and concrete. I recommend *Movable Insulation*, published by the Rodale Press in 1980.

Anyone familiar with insulation knows that if it gets wet, it is no longer insulation. Some "closed cell" insulating materials such as urethane, styrofoam, and polyethylene foam are more impervious to moisture than cellulose or fiberglass insulation. Even closed cell materials can break down if moisture under pressure is present.

Styrofoam is used on the outside of the foundations to provide a frost barrier for basements. Soil pressure and moisture can cause the styrofoam to be less than "bone dry" and thereby lose much of its insulating ability.

Situating the Tank

My personal preference is that the methane tank be as effectively insulated as possible. Insulation should be below the flow line of the material entering the tank, but should not be buried in the dirt, regardless of the insulation. The temperature of the ground several feet below the surface stays quite constant at 50° F – 55° F. To the methane tank, the earth is a "heat sink", a cool mass always ready to absorb its heat. The best way to fight this heat sink is to insulate the tank and build it above the ground. Another good reason for a free-standing tank is access to the grit trap at the bottom. A free-standing tank should be covered with six to eight inches of high quality insulation. Various people have asked if a buried tank would work. I can't say that it won't, but I've never seen any that work in a cold climate, and I have seen several that don't.



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Restoring Warmth
When feces leaves the body, the waste is at exactly the right temperature for working within the methane digester. Whatever heat is lost in the interval between leaving the animal and entering the digester has to be restored. If the heat needed is significant, there needs to be a heat source available with an abundance of "free" energy, such as solar or wind.

Relation to Fermentation
The methane process is a type of fermentation. Most folks have baked bread or made homebrew beer or wine at one time or another. For instance, after a yeast dough is kneaded, it is put in a warm place free of draft and allowed to rise. A draft could produce cooling. The yeast organisms feed upon the mixture's sugar. This produces carbon dioxide bubbles, which cause the dough to rise. There is a similar activity within the methane tank. The methane organisms feed upon simple sugars, alcohols, and peptides produced by acid forming bacteria. Methane gas, CH_4 , is the result.

I've been asked if the digestion process within the tank doesn't produce some heat, such as the heat produced in a compost pile. It probably does. Because the metabolic activity is so diluted and spread out within the tank, the heat available is minimal in comparison to the target temperature.

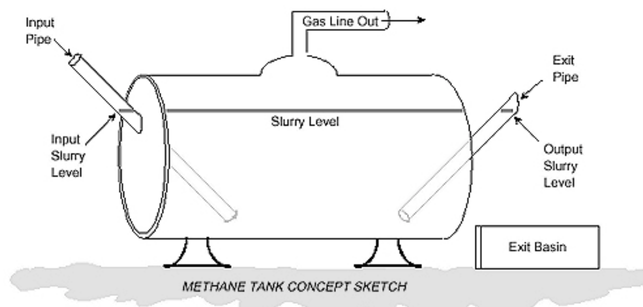
Awareness is Essential
You'll need to know how hot the tank is, day to day, season to season. To eliminate the guesswork, install sensors both inside the tank and outside the tank. Record temperature both inside and outside the tank over a period of time. Then you will know how efficiently the tank is retaining heat, at what rate the temperature drops when no heat is added, and how much energy is needed to raise the temperature. If this is done, then a reliable calculation can be made of how much gas is needed to maintain working temperature if "free" heat is not available.

Producing methane gas is relatively easy. The conservation of heat more than any other factor determines whether a methane system will "fly" or not. Of all the systems I've seen that failed, the principal reason is improper handling of heat.

Care and Feeding of your Methane Digester
Having thought about temperature, we can turn our attention to feedstock. I work with a mixture of manure and vegetation. Sometimes the question is asked: can't one use just vegetation to produce methane? It can be done because Mother Nature does. Swamp gas burning over a marsh is just that. Because the methane bacteria are part of the "flora and fauna" of the digestive tract, every time there is a fresh deposit, there is fresh input of the microbiological organisms needed.

How Much Gas Can I Get?
There's a wide range of mixes of material you feed a methane digester. It's similar to what happens when we eat. Some of the material enters our system to maintain it and some of it passes on as waste. When manure is considered, all of it, minus the water, is designated as "total solids", and the part that is digestible to the bacteria is labeled "volatile solids". The numbers of what is and what isn't available for gas production have been gathered repeatedly over the years. Each account is quick to qualify any statement by saying that there is any number of variables when dealing with animals regarding what they are eating and how they are housed. One of the clearest reference sources is a newsletter printed in 1973 by the New Alchemy Institute in California. Their figures correspond to what I've experienced.

The numbers run like this: a cow drops an average of 52 lbs. of feces a day, of which about 10 pounds are solids, the rest being water. Of the 10 pounds of solids, 80% or 8 lbs. are volatile—can be turned into gas. A horse produces an average of 36 pounds of feces a day, of which 5.5 lbs. are volatile solids. A pig produces 7.5 lbs. per day of which 0.4 pounds are volatile solids. A human produces 0.5 pounds of feces a day of which 0.13 pounds is volatile solid. Chickens produce 0.3 pounds a day which 0.06 pounds is a volatile solid.



All of this is good information, but it still doesn't tell us how much gas we can reasonably expect. If you ask an "expert" in the field, you'll get an answer something like, "It all depends..." All manure contains a degree of nitrogen, but because nitrogen exists in so many chemical forms in nature—ammonia (NH_3), nitrates (NO_3), proteins, etc.—it's difficult to test the total amount of nitrogen in a given material.

Why Consider Nitrogen?
The process wants one part nitrogen to every 30 parts of carbon. Manure is nitrogen rich, averaging about 15 parts carbon for each part nitrogen, so all the studies show that gas production is substantially increased by including some carbon material along with the manure. The nitrogen proportion may be even higher in animal waste if urine is included with the feces because urination is the principle way an animal rids itself of excess nitrogen.

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To illustrate, straight chicken manure will produce only five cubic feet of gas for each pound of manure, but chicken manure mixed with paper pulp will produce eight cubic feet of gas for each pound of manure used. My experience was an outstanding ten cubic feet of gas for each pound of chicken manure when the manure contained some ground feed that had been spilled.

Cow manure will produce only 1.5 cubic feet of gas per pound, but cow manure mixed with grass clippings will produce 4.5 cubic feet of gas per pound of manure.

The Nature of Biogas

Assume that we have a gas producing system and it's making gas nicely and filling the gas holder. What do we actually have? It's important to understand that it isn't all methane. A proportion of it is carbon dioxide, produced by the acid forming bacteria, which doesn't burn. This fact isn't immediately evident because if one ignites the end of a hose coming from the gas holder, there is a blue flame.

The fact that is important to know is: if we had pure methane we would have a hotter flame—about 1000 BTU (British Thermal Unit) for each cubic foot of gas. With the dilution of carbon dioxide, we have roughly 600 BTU for each cubic foot of gas.

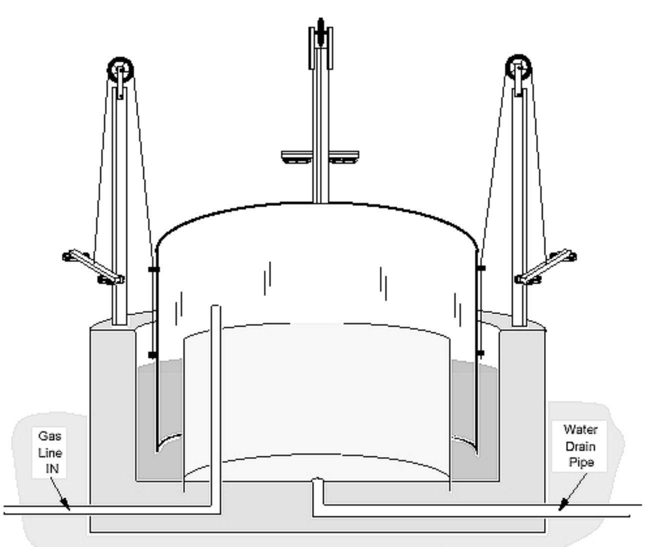
The composition of the gas in our gas holder will be:
CH_4 methane: 54 – 70%
CO_2 carbon dioxide: 27 – 45%
N_2 nitrogen: 0.5 – 3%
H_2 hydrogen: 1 – 10%
CO carbon monoxide: 0.1%
O_2 oxygen: 0.1%
H_2S hydrogen sulfide: trace

Wouldn't it be nice if we could separate out the methane and dump the carbon dioxide. Interestingly enough, Mother Nature has made it very easy to do just that because these gases all have different specific gravity weights.

How to Get Pure Methane

The specific gravity of methane is about 0.55 in relation to the weight of air, so it rises, as does hydrogen. Carbon dioxide on the other hand is twice the weight of air. Within a vertical gas container, if the gases are allowed to settle, they will naturally separate themselves, the flammable gases rise to the top. This fact suggests that a good design should have a petcock at the bottom of a vertical gas holder. Use it to bleed off the accumulated carbon dioxide. In the right setting, this isn't environmentally harmful, because the trees and growing things around the yard will welcome a fresh sniff of carbon dioxide.

Al Rutan



Elysium