THE METHANE PROCESS

Third in a series by Al Rutan,
the Methane Man

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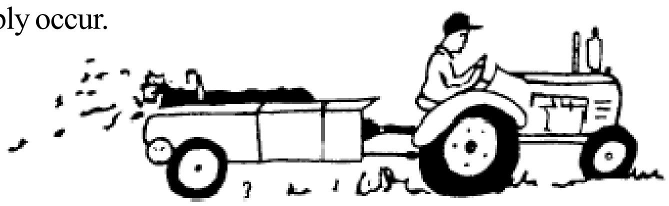
Mold and mildew have been seen by everyone. Most people have observed the process of rotting. We know it is common in nature. Methane gas is just as common, but not as observable. Anyone near a sewer manhole or a plumbing vent pipe can get a whiff of the methane process in action. The reason for saying this is to alleviate the apprehension that the methane process is going to be difficult to harness. It's no more difficult than making a loaf of bread. If the conditions needed are present, the desired result will invariably occur.



What we are considering is a biological process in which we use the waste product of bacteria. We shouldn't even call the little creatures bacteria but more accurately "methogenic micro-organisms."

Primeval Life

In the process of evolution, they antedate the formation of bacteria. They are one of the very earliest forms of life. When scientists explore outer space with telescopes that can separate light spectrums, they look for the presence of methane gas. If the gas is present, there is evidence for the beginning of life. For our purpose, we are going to refer to these methogenic micro-organisms simply as "bacteria." They are curious little critters. Their waste product burns. Not only does it burn, it burns very well. Combustion produces only carbon dioxide and water vapor. There is no ash, no soot, no tar, no dirt of any kind. It's a very efficient fuel.

Characteristics

This fuel is composed of carbon and hydrogen. Its chemical formula is CH_4 . It has an octane rating of 110 and produces around 1,000 BTUs (British Thermal Units) of heat per cubic foot of gas. Because most gas is invisible, it seems mysterious. If we think about our own chemistry for a minute, it won't seem so strange. We know that we breathe in oxygen and exhale carbon dioxide. So we, ourselves, are gas producing organisms.

Gas Makers

If we think about this, then the process of the methane bacteria doesn't seem so strange. The part that is "strange" is that it burns. If mixed with sufficient amounts of air, it burns very rapidly... explosion! In nature, some bacteria operate best in the presence of air because they require oxygen, and some function only when air is excluded. The methane bacteria are of this latter type. When exposed to air, they die. Because they live and function only when air is not present, they are called anaerobic or "without air" bacteria.

Natural Gas and Sewage Gas

What is the difference between natural gas and sewage gas? Virtually none. For all practical purposes the bacteria which make the gas are the same. Natural gas sold by the utilities is 90%, or better, methane. It has been made in the ground over eons of time and in most instances is almost pure methane because the ground has purified or "scrubbed" the gas. The only difference between gas produced in the earth and gas made in. sewage plants is that in the sewage plants the process is speeded up. In speeding up the action there are several gases produced, notably, carbon dioxide. In a sewage plant the mixture is about 70% methane and 30% carbon dioxide, with trace amounts of hydrogen sulfide. The carbon dioxide largely dissipates from "natural gas" over time. The speeded-up process product, including the carbon dioxide, is referred to as "biogas." Actually all natural gas is "biogas" because all of it was produced from something that was at one time living. The only distinction is that so-called "biogas" is produced in a shorter time from things that have been living recently. Making methane for ourselves, we hasten the process.

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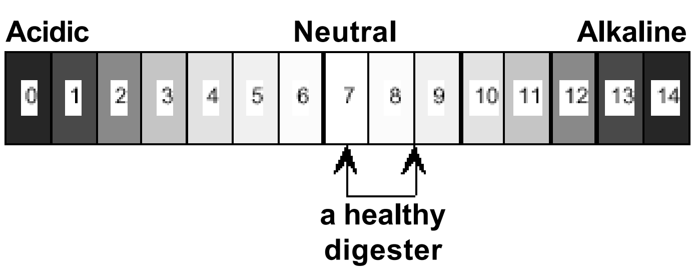
How Does it All Happen?
There are two types of "without air" or anaerobic bacteria that work together to make methane. The first type we'll call "acid forming." Their function is to feed upon raw organic material. They produce no methane, only carbon dioxide and some acids and "food" for the second bacteria type, the methogenic micro-organisms. The "food" consists of simple sugars, simple alcohols and peptides. When the methogenic micro-organisms in turn feed upon this simpler fare they produce methane. Thus when organic material is placed in a container where air is excluded, both carbon dioxide and methane are produced.

Need for Balance
The methanogenic micro-organisms need the food provided by the acid-forming bacteria, but they also need a neutral environment. If the right balance between acid and base (alkaline) is not present, the methane micro-organisms are in trouble and no methane is produced. They have to have a pH of 7 to 8.5 in order to be normally active.

What Does pH Mean?
I think it's important not to assume that everyone is familiar with pH. Websters defines pH as "the negative logarithm of the effective hydrogen ion concentration... used in expressing both acidity and alkalinity on a scale of 0 to 14 with 7 representing neutrality. Numbers less than 7 represent increasing acidity and numbers greater than 7 represent increasing alkalinity." So the term pH means percentage of hydrogen, or more precisely, proportion of hydrogen in relation to the hydroxide ion in a given material. It's the negative logarithm of the hydrogen ion concentration, so a pH of 7 means that the concentration of hydrogen ions is 10 -7 . Aren't you glad you asked? Anyway, it's important information for keeping the digester healthy and happy. The ideal pH for digestion is from 7.5 to 8.5.

The pH Scale



How to Get a Reading
How does one measure pH? This is the easy part. Chemical supply houses and even most drug stores sell rolls of paper (called litmus paper) and/or little plastic strips that turn color when dipped in solution to tell you what the pH is. There is a slightly different color for each of the different pH numbers. You tear off a piece of the litmus paper about 1 1/2 inches long and dip it into a little of the slurry. The paper will start to change color within seconds. When compared to the color scale on the container, you can tell right away what the pH of the slurry is.

Why the Process May Drag
Generally if there's a problem, it's that the slurry is too acidic (pH below 7). If there is a lot of new, raw, green material placed in the digester, the acid forming bacteria have a field day. The methane bacteria are so annoyed by the high acid concentration, they simply can't function. When this occurs, it can take a long, long time for the methane process to get under way naturally. This generally occurs only in the beginning with start up or if too much new material is added at any one time. If a measured amount of new material – no more than 1/40th of the total liquid volume of the tank – is added, then the new material is dilute enough not to upset the balance. At start up, though, there's a lack of micro-organisms, and an inclination towards excessive acidity. Understanding this, we can see why some of the early literature on making methane states that the start-up time can be anywhere from three weeks to three months. This is assuming that one is beginning with totally "new" material without the assist of some already partially digested slurry. A three month start-up would discourage almost anyone from attempting to harness the process..

Starting Up
Partially digested slurry is kind of like sourdough starter. It has large populations of the right kind of micro-organisms to digest raw material and make methane. You can start from scratch, but it's faster if you can get some activity that's already established. When I started a small digester in 1976, I seeded it with some slurry from the St. Cloud, Minnesota, sewage plant. The plant engineer told me at the time that the plant was so overloaded with wastes from a local meat packing house that the digester was just "going through the motions" and really not working properly. I took some of the slurry anyway. What the heck. It was free and I needed something to get the tank producing. After a few days I started to get methane and then I lost it. The tank was still producing a lot of gas, but it was carbon dioxide – it didn't burn. The pig manure I had begun to feed the digester along with the slurry from the St. Cloud plant was just too much raw material for the process. So there was a lot of carbon dioxide and acid. The acid forming bacteria were having a feast. I mentioned the problem to friend with whom I was working at the time. He said, "I make a lot of wine at home. Every once in a while I have the same problem. When I do I add a little baking soda. It straightens out the condition right away. The nice thing is it doesn't leave an after taste. In your case that isn't a problem!"

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The Benefits of Baking Soda

So I tried the baking soda. It worked like a charm. Within three days I had methane on the way. At a seminar I was presenting a few weeks later, I mentioned this to the group. Baking soda was my "discovery" for straightening out the pH in the digester. One of the people at the seminar sent me a clipping from Business Week magazine a couple weeks later. It was dated June 14, 1976. The headline for the article read "Dosing Sewage With Baking Soda." It went on to say this was a whole new idea for treating sewage plants; they used to use large amounts of ammonia. The article further proclaimed that soda not only assisted in the more efficient digestion of sludge but increased the volume of burnable methane gas. The most surprising statement of all: bicarbonate of soda "acts as a sort of vitamin for bacteria." This is the secret for keeping your digester sweet and happy. Just add a little at a time until the pH is just right. Keep adding it periodically if the pH keeps dropping until the acid forming bacteria are no longer producing an override of acid. Don't be fooled if a lot of gas starts coming. The baking soda itself will produce some carbon dioxide.

The Nature Of Heat

Heat is essential for abundant methane production. In warm climates the process works with little help when the other conditions needed occur. For many of us who live in a cold climate, making methane work is a challenge. One needs to keep in mind that heat stratifies, whether in air or water. Heated fluids are less dense and tend to rise. This natural thermal stratification in liquid is, of course, the very reason why the thermal syphon principle in water heaters works so well. It was this very fact which suggested a digester design with a false floor containing only water. The bottom, the lowest point of the "working" tank, could be heated by a thermosyphon action from some heat source such as solar, or even a little of the gas itself. The heat from the lowest part of this "double boiler" type design would rise through the slurry so that the very bottom of the "working" tank could more easily be kept at the desired temperature in the entire digesting area. Such a tank would most easily be constructed of fiberglass. It could be virtually any size. Next time we'll think about the barriers to the transfer of heat – insulation – a critical key to any successful operation. This brings us to the question of whether the operation is a net energy producer or an energy consumer.

Al Rutan

Al with the prototype of his Methane Digester

... and the finished Metal Tank Methane Digester on its trailer
(See ESSN July 2005 for internal design)

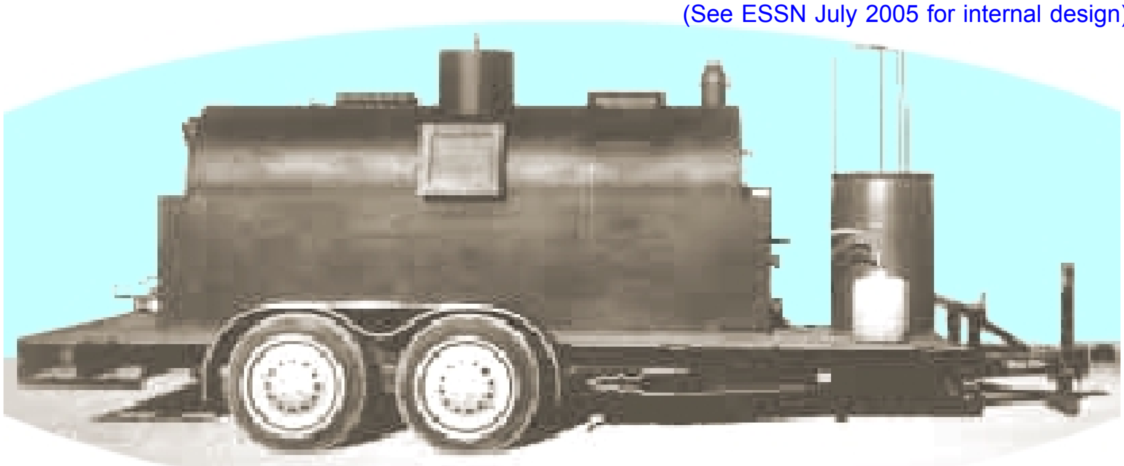

Photo by Al Rutan