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PREFACE TO DAVE PAXTON'S BIOGAS SERIES ON
HOMEPOWR ECHO
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Subj : Electric-Powered Roto

JB>Please, please be as specific as you can... seems like information
JB>about Methane Digesters is few and far between. I studied under Rich
JB>Merrill when I was in college and that's how I got turned on to the
JB>idea. This project is really important to the future of small farms as
JB>it is the only way to heat greenhouses cheaply and efficiently in a
JB>rural enviroment. And yes I have access to all the raw materials I'll
JB>need.

OK Jeff, I'll give it the old college try <maybe I should give it a better try than that, I didn't do that well in college, grin>. BTW I am cross posting this message into my local survival board and will cross post replies and pertinent questions in this echo as well.

JB> DP> BTW the "waste" from the digester <spent material, completely
JB> DP> digested> is an excellent fertilizer and is organic.

JB>Ain't it great???   If you get Sustained Ag. you'll know what projects
JB>I'm working on, and any information that you provide will be put to good
JB>use in helping to change our rural communities back to the agrarian
JB>societies they once were.

There will be a few messages I will post on this material. To start it all off I guess I should give a little bit of background on the gas digesters. Prior to and during WW2 there were sporadic attempts at producing and using methane gas in digesters but no organized research. After the war the Chinese and Indian peoples developed the gas to help their energy deficient countries cope with its needs. I have found no written papers on the Chinese developments but I have heard tourists talking about wagons of farm goods being driven around by what appears to be a lawnmower <2 wheels on an axle driven by a small 1 cyl engine, the whole thing having "handlebars" to rotate it in any direction> instead of a horse or water buffalo. These engines are fueled by a big bag of biogas that usually bobbles back and forth on top of the produce. I have no info on the Chinese biogas digesters. However, the Indian government has established the Gobar Gas Research Station at Ajitmal, India. The "guru" of gobar gas is a gentleman by the name of Ram Bux Singh and may possibly even still be doing research at this time. India has 2 sacred cows for every one person. Gobar is their words which if interpreted would come out "cow dung" <to be polite>. So if someone refers to you as a gobar slinger you will know what they mean <grin>. Ram Bux Singh has written many papers on the subject and the Gobar Gas Research Station has released booklets and papers but I have yet to find any of these available here in the U.S. Many people have picked up the ball and tried to run with it. A fellow in Africa by the name of Fry had one of the worlds biggest pig farms and he had some interesting results in digesting the waste in that it cut down disease, flies and smell of his operation and helped his farm produce better crops to feed his pigs.

For the sake of our discussion I would like to use the term "biogas". Since not everyone will be using just cow manure or horse manure or just chicken manure or even just animal manure <vegetable matter is digestible also> "biogas" covers all the areas. A digester using a cow manure should give a gas that is a little less than 2/3 methane, almost a third carbon dioxide and a small amount of nitrogen. There are ways to improve this gas but we will discuss that later and am hopping to get some input from others on "purification" processes.

A basic design of a digester has been developed by the UN and is merely a "trough" <that looks suspiciously like a piece of galvanized pipe used to exhaust gas heater fumes through the roof> that has ends with a hole in the top <of the end pieces>. This is filled with equal amounts of cow dung and water <mixed enough to 'dissolve' the solid into the water> and a truck tire inner tube is cut cross wise and the "trough" is placed in the tube and bands <like hose clamps> secured. The tube is the reservoir for the gas. Supposedly this will produce enough gas for people to cook 1 meal a day for 2 people. It's that simple... but it can also be complicated if you wish to produce larger quantities of gas and improve the quality of the gas and improve the quality of the fertilizer.

If you are interested in "diving right in" before we have discussed this topic completely I will give you some quick simple instructions on how to get bubbling right away. Find an empty 55 gal drum and another drum just a little smaller <but more than 3" or 4" smaller will make it very inefficient> that will fit inside of it. Cut the end with the bungs off of the larger barrel. NOTE: never use a cutting torch to cut any steal drum, you have no idea what has been in it before and you have no idea what toxic or explosive gasses will be created by "burning" one open. Cut the non bunged end off the smaller one. Remove the smaller bung on the small drum and fit with a water spigot and a garden hose. Fill the big drum about half full of manure. Add water to about 6" below the top. Use a 2X4 to stir. I have a device that is a 1/4 inch steel rod 4' long with 2 enormous flat washers <look like at least inch and a half hole in the washers> welded on each side of the rod at an angle similar to a propeller that when placed in a 1/4 " drill does a fair job at mixing all kinds of things. Then if any straw floats to the top remove it. Leave the "seeds" that have passed through the horse or cow. Open the spigot. Place the smaller barrel inside the larger barrel to serve as a collection "bell" allowing it to sink as far as it can to squeeze out as much air as possible. Slowly though or you will overflow the slurry, allow the air to escape as the barrel is lowered. Be prepared, you will loose some of the juice because of the displacement of the metal in the collector. If the weather is cool it might be advisable to place in the sun before filling, if during the day it gets too hot you can shade the barrel. The "germs" will work form 60 degrees to about 120 but best below 100. Preferably 80 to 90 degrees. Close the valve. Just let it set. In a week or two <if not sooner> the smaller barrel should start to rise. After it has risen about 18" place the hose in a bucket of water <a makeshift safety anti flashback method> and open the valve and bleed all the gas out. Do this twice returning the collector to it's lowest position both times. This has bled the remaining air out of the system. NOTE: as long as there is any air in the system you are literally playing with a stick of dynamite, anything could set it off. Now when the collector starts to rise you have gas to do with as you please. If you don't use it you will see it bubbling out around the edge of the collector after it reaches it's maximum containment. By the way the gas as comes from the digester can be used to run an engine but the average engine uses at least 15 to 20 cu ft per horsepower per hour.

This is the crudest, simplest method of digesting. We will expand from here with a little more technology and efficiency.

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PART1

BC>It would seem that compressing the gas would make it a lot more useful.
Have
BC>you investigated this idea? Can it be compressed to a liquid state like LP
BC>gas?

The pure methane can be compressed till it turns liquid. However, there is some question as to whether this would be a good idea. It is a lot like natural gas. It would take an AWFUL LOT of energy to compress it to the point of liquefaction. I would rather think that a small scale <single plant on a private farm> producer would have to be happy with compression to 4 or 5 hundred pounds.

BC> How many horses, cows, sheep or goats do you need to make this effort worth
BC>while?

Well, that is an interesting question. If you boarded horses for instance any gas you get from the "waste" product that has to be cleaned up anyway is worth it. PLUS you get some excellent fertilizer for your garden or lawn. The average small farm of 10 acres or so with a couple of cattle, couple of pigs, waste from crops grown can get a moderate amount of gas. If you are in a commercial situation <say pig farming> you have more than enough to make it worth while. If you have a small farm <5 acres or less> and have a neighbor that would be very happy to have someone haul off his manure pile then you have all that you need, space, rural setting, and a source of materials.

All I can say is if you have a cow or other animal or even crop waste <what you gonna do with all those plants after you pick anyway?> and have an old heating oil tank laying around why not give it a shot, nothing to lose and lots to gain. Fill the tank up <after washing it out with a good detergent> with a slurry of whatever waste you have available and run a hose from the top of the tank to a pile of old tractor inner tubes <if you can pry them away from the kids that is> as a collector and see what develops. Once you start getting gas run some propane type lanterns on them to light the yard at night or cook your lunch on a modified gas stove in the barn or whatever, once you get going you can make up your own mind. If it's not worth while dump the tank on the grass or garden or whatever and forget it. You didn't loose anything but a little spare time. I think once you get the free gas flowing though you will be bitten by the methane bug.

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PART2

Well, now that we have the basics of temperature <60-95 degrees>, slurry consistency <with FRESH horse and cow (and I would suppose pig) a mix of half manure and half water>, and evacuation of all air from system we should get to some improvements on the 55 gal drum in the first post. First of all we need to determine whether a "batch" feed system <like the 55 gal drum> or a continuous feed system is what you need. If you are digesting just vegetable matter batch usually works best because pumps and pipes tend to clog with the fibrous material. As a rule vegetable matter seems to give more gas over longer time of production. Manure usually takes a week or two to start and the gas production is rather high for a week then it drops off a little for the next week but the third week it starts tapering off and then the next 5 or 6 weeks you will get about as much as you did the first 2 weeks. It should be completely done in 2 months time. I have no experience with pure vegetable matter digester. I have heard that they are active longer and that they produce between 5 and 10 times the volume of gas. I do know that a combination of manure and vegetable matter in a batch digester <a 55 gal drum as a matter of fact> lasts longer than manure alone and the gas production is sustained for a longer period of time. If using vegetable matter the ratio of solids to liquid should be close to 1:10 but don't forget to figure the liquids in the vegetable matter. For instance a 55 gal drum full of over ripe tomatoes has a rather high % of water already and a barrel of GROUND UP leaves and twigs would have a much lower % of water. Manure lends itself very nicely to continuous feed systems. If you are designing your system from scratch you should first figure out how much manure your livestock produce per day. If you have, say, 2 55 gal drums of manure a day then you can figure out the ideal size for a continuous feed system. Figuring 8 weeks complete digesting time and the input of <roughly> 200 gals of effluent <2 55 gal drums manure and two of water> a day times 56 days you need 11,200 gallon capacity. Now 11,200 gal times 231 cu in per gal. and you have a digester of 2,587,200 cu in. now divide by 1,728 cu in per cu ft and we arrive at a rounded off figure of roughly 1500 cu ft. <please do the math over yourself, this was all done on a scratch pad with pencil while on the computer, it is susceptible to error> or 15X10X10<for example only, we will discuss shape and design later>. So, you can "feed" your digester 200 gals a day, and remove 200 gals a day of excellent liquid fertilizer and have a steady flow of gas. Batch feeders will need a number of digesters each being loaded on a rotating schedule to maintain a steady flow of gas. I have heard of 3 batch digesters working well but 4 pretty much guarantees a good gas flow almost continuously. With manure you would empty and refill one every 2 weeks on a rotation basis. So batch fed digesters would be 200 gal a day times 14 days or 2800 gal tanks. Multiply by 231 cu in or 646,800 cu in. Now divide by 1728 or just under 350 cu ft each.

Next time we will discuss design of digesters. think about which type would best fit your needs.

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PART3

OK, now we have a brief history, an understanding of the temps required, the proper consistency of the slurry, the construction of a "simple" digester, and an idea of the general size and type of digester we want to build. Now we need to get into the construction and the refinements of the different digesters. One of the first modifications we need to make to the simple tank is we need an agitator. This is a requirement in all digesters but especially in continuous feed digesters. The reason we need an agitator is because of the tendency of the slurry to form a hard <some say it can get as hard as concrete> cap on the surface of the liquid. A simple set of paddles that are rotated for a half an hour while you are preparing the daily feeding for the digester is sufficient. The paddles must break the surface and return below the surface. Paddles that stir like an egg beater are not always effective in that the blades may hold the cap in place and merely rotate the cap instead of break it up. There are people experimenting with using the compressed methane blown into the bottom of the digester through "jets" like a Jacuzzi to agitate but I have no written info or hands on experience with this method. This is all that is needed in the batch digester. A tank, the slurry, and agitator, and a collection system. I have seen digesters that are nothing more than large water or fuel tanks filled with slurry with an agitator inside to break up any cap that might form and a bung in the top connected to a pipe that then goes to a storage system. It's really that simple for a batch system. If you have access to large tanks somewhere and enough "raw material" to fill them your in business <as long as you have developed an agitation system>. One problem is that the gas can be very corrosive to both steel and concrete <the 2 most popular building materials> so an adequate coating that won't deter the digestion is needed. Fiberglass may be a possible building material but I have no idea how it will hold up in contact with the slurry or the gas. I do know they are building fiberglass septic tanks these days which would indicate that it is an acceptable material. However, no mater what material you use it is very important to support it properly. The weight of a tank full of liquid is extremely high and it needs to be supported and constructed well to hold together. This is a reason many digesters are underground or partially underground so that the earth around the tank will help hold it up. However, it should be well insulated because in most place the ground temperature is lower than the point at which the proper microorganism can live. In some areas it is necessary to heat the tank to maintain the temperatures necessary for the microbes to do their thing. We will discuss heaters next post and go on from there.

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PART 4

Well, we have discussed the batch digesters pretty well and roughly discussed the continuous feed digesters but we need to talk about temperature. We should maintain a temperature of 85 to 105 degrees to produce the most gas within the 8 week digestion period <for manure>. Now, just how are we going to do this? To monitor the temperature is not exactly an easy task. You can't open anything or air will be introduced and you will experience a stop in gas production to say nothing of the possibility of explosion. The best method <in my humble opinion> is to install a sensing device somewhere in the middle of the slurry that is attached to wires that are then securely connected to leads outside the tank for an electronic thermometer. I have seen simple setups that were not expensive that were merely a thermister connected to a volt ohm meter and the person using it knew that the reading on the volt meter had to be within a certain range to be between the 85 to 105 temperature range. Now, lets say you are in a climate that can go down to freezing or less for 3 months a year. Needless to say you have to do something to heat the slurry. FIRST of all the tank should be WELL insulated. I have see applications where people have tried to insulate with fiberglass. As a rule this doesn't work too well. Fiberglass is almost useless when it gets wet. The best set up I have seen was a tank that was sprayed with a polyurethane foam <4 inches thick> and then the foam was covered with a rubberized roof paint. Now, we have an insulated tank. How do we heat it? Solar heaters are a possibility only if you have very good insulation. The temp goes up during the day but on cloudy days or overnight the temperature can drop if it is not properly insulated. If you are considering building a large enough digester you will probably be running an auxiliary motor to use the gas to generate electricity or to compress the gas for use at another time. If this small motor is water cooled you have a terrific source of heated water that would normally go to waste. A series of valves that could be adjusted to change direction of the cooling water from the engine to maintain the temperature in the tank. You technical types could probably come up with

electronic valves that are controlled by a circuit <computer?> that would activate to keep the temperature within the limits. If neither of these is a possibility there is a third option. I have seen digesters that use some of the generated gas to maintain the heat with burners directly heating the tank itself. This was in a plant that was designed to process "waste" material and produce fertilizer, gas was just an accidental sub product. This tank was maintained at 130 degrees. There is a strain of the anaerobic that flourishes in the 120 to 140 degree range. However, using gas this way does cut into the gas production. At least with the engine you are producing either electric or compressed gas and the heat is a waste product that can be put to use. Gas is consumed at a rate of about 15 to 20 cu ft per hour per horsepower. If you can find a small enough water cooled engine and the digester is large enough the engine can run constantly to keep up with the production of gas. If not you will need a "temporary" storage area for the gas. This is what the collector "bell" is on the first digester we discussed. Basically you need an area that will expand with gas production and contract when the gas is used or compressed by the compressor. This is an area that is up for grabs. I have seen something as simple as a pile of tractor inner tubes all connected at the valve stems with a rubber hose. When the gas production has inflated the tires to a given size it is then used or compressed into a storage tank until the tubes are flat again. It's time to use your imagination and find your own interim device. Just remember, it is VERY important that you fill and bleed all systems a couple of times to remove all air. Not doing this could be fatal.
Next time we will talk about continuous feed digester.

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PART 5

OK, now we get to the refinements of the design. Other than the heating method and placement batch systems have been pretty well covered up to now. The heat <coming from whatever source you have chosen> can be introduced by heating coils in the bottom of the tank or if you are using a steel tank the coil can wrap around the outside of the tank with good contact to steel. I remember one system that had a steel tank that copper pipe <or tubing?> was wrapped around the lower 2/3 of the tank and was soldered to the metal tank to assure proper heat transfer before the insulation was applied.

The continuous feed digester is what I have designed for my first digester project. Being an experiment and also because will have to trailer in my manure it will be a small experimental plant for the first project. However, if you are talking about the 1500 ft plant <I know of many local small farms or horse boarding facilities that easily have 2 55 gal drums of manure a day just cleaning out their barns and stalls to say noting about what they don't bother with in the paddocks or pastures> the same general design will work, only on a bigger scale. I will present the dimensions for a 1500 cu ft digester. Use the math I presented in a previous post to figure out exactly what size digester you need. We will discuss general design, feeding methods, removal of the spent material and then we will try to get into treatment of the gas and use of the gas.

First of all I would probably go with a concrete "vault" type of digester. Just a plane tank with input on one end and output on the other will work but doesn't quite do the job right. Some of the new material would mix with the old material and the output would be not all completely digested material. There is a way to help prevent this. If we build a vault type tank that is 10 feet wide by fifteen feet long by 12 feet high <wait a minute, 10 by 12 by 15 isn't 1500 cu ft! True but the extra 2 feet is for the gas to collect in and for the agitator to break the surface of the slurry> with the input on one end and the output on the opposite end the one thing that will help prevent new material from mixing with the outfall is a baffle about 5 feet from the input end of the tank. If we build the baffle out of 8" cement blocks then we should

extend the tank by 8" to make up for the displaced slurry. The distance of 5 feet was established by a little known fact that as the microbe attaches itself to the suspended solid and starts processing the material it becomes lighter and floats in the solution closer to the surface.
Since the digestion starts fairly soon in a constant feed system the most production of gas comes within a week or so of introduction and continues for about 2 weeks which is about 1/4 of the time it is in the digester. Placing the baffle about 1/3 of the distance keeps you from "pushing" material over the wall before it is ready. The material is introduced into the bottom of the tank, as it starts the process it floats toward the surface and the natural flow of the liquid will carry it over the baffle when the next batch is fed. The outflow pipe is in the far end of the tank about 6" below the top of the slurryand a soil pipe "trap" is used to keep air from getting into the digester, and most depleted material is removed. Since the surface of the slurry is about 2 feet below the top
of the tank the height of the wall should be about 8 feet tall. Now that we have the baffle in we need to consider agitation. If you want to try the "gas jet" mixing system now is the time to install the pipes and jets. If you are going to use the paddle wheel style you need to figure out where and how they are going to be installed. Since the major purpose of the agitators is to break up the cap and a large wheel would not break the surface but over a limited amount of the arch it would probably be best to use smaller paddle wheels with more than one axle. Two axles with 4 foot <diameter of the swing of the paddles> paddles would work quite well. The shafts should be geared instead of sprocket and chain so the top paddles are going in the opposite directions and they can be staggered and intermeshed like the blades of an eggbeater. The shafts can be very expensive solid steel shafts or plain old water pipe and they can be slip fitted into the next size water pipe or fitted with fancy pillar block bearings. The arms of the paddles can be welded to the shaft or bolted to the shaft and the paddles themselves could be just 2 by 6's bolted on the end of the arm and one half way down the arm. One shaft should extend through the end of the tank to

provide a means of powering the shafts/paddles assembly. As they will be below the top of the liquid there will have to be a seal installed to prevent leakage of the slurry around the shaft. This shaft could be powered by a hand crank , an electric motor, or a hydraulic motor powered by the auxiliary motor that also compresses the gas, runs a generator, and heats the slurry.

We will talk more about refinements next time.

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PART 6

Now we have a tank 10'x12'x15'8" inside detentions. Probably a poured concrete slab floor and cbs walls and a baffle 5' from the input end of the digester. The agitators have been discussed and in the case of mechanical paddles a shaft that would extend through one of the end walls to be powered. We now have to consider other things that will have to pass through the walls or ends of the digester. The input line and the outfall line are the first things that come to mind. The outflow should be a 4" <minimum> PVC line that is placed through the end wall of the end on the 10' side of the slurry tank.We will also need a "clean out"drain. If we have poured the floor with a pitch from all walls to the clean out plug and pipe and placed the pipe in the floor before pouring the cement then it will be coming out through the floor and no penetration of the wall is necessary.
The input line should come into the 5' side of the slurry tank. It should come in low on the wall near the slab floor. If you are going to use gravity feed <we will discuss this later> the input and outflow pipes should be as large as possible to ease this gravity flow. If you are going to use pumps then the pipes need to be sized according to the size of the pump. Also there is the need for heater lines. If you are using the heat of the auxiliary engine the pipes should be the same as the hoses that go to the radiator. You need one in and one out line through

the wall. It is best to use copper pipe because of the heat transfer ability but this can be expensive. Galvanized water pipe is the next best thing. A grid laid out on the floor with T's and elbows works adequately. It is also advisable to put the pipe through the baffle and heat the input side also. Now that we have all the access pipes and shafts in and out of the tank we need to coat the tank. There is a black tar type paint on the market that will protect the cement but there is some question as to whether or not it will inhibit the digestion. I would probably go with fiberglass resin coating. I don't think there is any need for the cloth to be used or to have a "chopper" spray the tank with resin/fiber combination but it wouldn't cause any problems if you did. A good solid, soaking coat of resin/hardener over the floor, walls, and top of the walls. We haven't talked about the "lid" yet. The lid would be <in the ideal system that I would build> would be a 6" or so thick poured concrete "traffic lid" <in the language of septic tank companies> with steel reinforcement. You will need some sophisticated machinery to place it on top when we are done <it is quite heavy>. It would be possible to make it in sections that would be more manageable with ordinary farm equipment. These sections would have to be caulked to each other besides to the walls when put in place. This lid <or lids> would have to be coated also on the surface exposed to the gas. OK, we have the heaters in place, the tank resined, the input and out fall lines in, the agitator in place, now we are ready to spray the exterior of the tank with foam insulation. when the foam is hardened and the coating <rubberized paint> is dry we can backfill around the tank if it is underground.

We will discuss the gravity feeding system next time.

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PART 7

Feeding Systems... basically there are 2 types. Pump feed and Gravity feed. In either case the input pipe should have a good gate valve so that in case of need work can be done on the feeding system without interfering with the slurry's action. If the tank is above ground pump feed systems work well since the prepared slurry is going to have to go up hill to some degree. If you have positioned your digester properly though an underground tank can be easily gravity fed. If the mixing tank can be placed above the slurry then it's all down hill from there <literally>. The feeding system is nothing more than a tank in which the daily feeding can be prepared and some way of delivering the prepared slurry into the digester. Our 1500 ft digester is fed 200 gals a day. A basin or open tank should be <short cutting the math from before> roughly 26 2/3 cu ft <7.5 gals per cubic ft> so I would make my mixing basin probably 3 ft square and about 4 ft deep to allow for slopping and mixing. Basically all that is needed here is a place to mix the water with the manure. This can be accomplished by dumping the manure into the basin and mixing in water with a hoe till the liquid reaches a line or "high water mark" on the side of the basin to indicate enough water has been added. However, there are some that feel better results can be obtained by "grinding" the manure first. This is usually accomplished by installing a "hopper" like device over the basin with a good strong garbage disposal mounted in the bottom and feeding the ground material into the tank. The manure can be shoved into the garbage disposal with a hoe and "rinsed down" with water. You must be careful not to add too much water though so that the "line" is not passed. If you are not using the grinder but just mixing the ingredients it is best to let it sit for 10 or 15 minutes or so after mixing and then removing all the hay that floats to the surface. Again, leave everything that has passed through the cow or horse. The hay will help form a cap on the slurry so it is best to remove it. On a gravity feed all we need to do now is open the valve and let the slurry run into the tank. If we are using a pump system the slurry should be pumped from the basin up into the digester. The outflow system should be very simple. The pipe is brought up to the level of the surface of the slurry inside the tank.

This should be the position of the outflow container or basin. As the level is raised by the input of new slurry the surface suddenly becoming higher than the opening of the outflow pipe will force the spent material through the pipe and out into the catch basin until the levels are equal. Then you have a basin full of the most wonderful liquid fertilizers you can find.

Again, once you start making gas the system should be bled <remember the water in a bucket to make a simple backflash protector?> a couple of times to get all air out. Any storage system <and compressors> also have to be bled. Your In Business...

Next we will discuss slurry particulars and gas <now you got it, what you gonna do with it> Hope you have been finding these posts interesting.

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PART 8

The proper care and feeding of a slurry???? Gees, I dunno. This is a book to be written yet. Here are my recommendations.

Temperature: well, the little buggers <grin> can live as low as 32 degrees to a little over 150 degrees. They best produce gas in two ranges 85 to 105 degrees or around 120 to 140 degrees. I recommend the 85 to 105 range though because of ease of maintaining this range. The higher range is used by those most interested in producing fertilizer than gas. I think they feel the higher temperature helps to sterilize the fertilizer.

pH: the best pH range for the digester is around 7 and 8. Too much fresh manure in the feeding could cause too high of acidity <too low of

a pH reading> and the slurry can "stick" and stop gas production. If left alone the slurry will correct itself and continue digestion in time. External means of controlling the pH can be used. However, sampling the slurry to see which way you need to go is difficult. If gas production suddenly dies off after a feeding though it is usually a sign the acidity is too high.

Consistency of slurry: The "suspended solids" in liquid should be below 10%. If less than 5% it is terribly inefficient. round 8% works well. However, you must consider the liquid already in the material to be digested. Fresh cow and horse manure is normally mixed half and half with water to reach optimum consistency.

Basically just stand back and let the little suckers do their work.

The Gas, how to process it and what to do with it. This too is still being written. However, there are certain known facts that can be dealt with when handling the gas. First of all gobar <cow manure> gas is less than 2/3 methane and almost 1/3 carbon dioxide with small traces of nitrogen and hydrogen and others. If we can remove the carbon dioxide we can increase the value of the gas. I am still looking for good ways to do this. I have heard that drawing the gas through lime water will help. I guess you would have to run the gas through "bubble stones" like those in some aquariums or some sort of membrane that would reduce the gas to very, very tiny bubbles and let it bubble up through the lime water to the surface to be collected for use. If any of you readers out there have any ideas, speak up. Also, you can draw the gas through iron fillings to remove the corrosives that might attack the engine if you plan on using the gas in this manor. There are also dryers that can be used to remove vapor that is also present.

However, there are those that feel none of this is necessary. I have yet to get to this point to form an opinion. There was a fellow by the name of Fry that <if memory serves me correctly> took an old 1 cyl diesel that ran methane through a hose into the intake of the engine, installed a magneto to fire a spark plug that he screwed into the hole that the injector was supposed to be in an fired it up. It supposedly ran for years this way without any processing of the gas. With the abundance of small water cooled diesels these days i hope to try something along these lines when the time comes. If it causes damage inside the engine I will attempt to remove some of the corrosives in the gas. Removing the carbon dioxide "purifies" the gas and makes it burn hotter if used for lighting or furnaces, boilers, heaters, etc. If I were planning on having large amounts of gas compressed for these purposes or for use in ordinary gasoline engines that are converted for this use I would definitely be concerned with cleaning the carbon dioxide <and the corrosives for the sake of my storage tanks> if for no other reason than reducing the volume of the gas to be compressed. The gas straight from the digester can be used as fuel in a gasoline engine. Close to 20 cu ft per horsepower per hour is consumed. However, If cleaned of the impurities, the cu ftage would drop because the mixture could be leaned out in the carburetor.

OK, I have covered most of it. If I have left something out or you have a question that I did not cover or something is unclear let me know. I will make any information I have available.

Hope I haven't bored you all to tears. I just tried to relate some of my accumulated knowledge on the topic to answer Jeff's question and inform anyone else that might have been interested. Is this enough info Jeff???

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ADDITIONAL INFO FROM SUBSEQUENT POSTS

Subj: Re: CO2 FILTRATION

Henry Shaw messaged Todd Henson re: Re: CO2 FILTRATION

. James Hill's message to you on this subject was right on target. As
. he pointed out, lime is simply CaO, which when added to water, reacts
. with the water to form dissolved Ca2+ and (OH)- ions (CaO + H2O ->
. Ca2+ + 2OH-). If you add sufficient lime to the water, you will reach
. a point at which the solution becomes "saturated" with the dissolved
. species and no more will dissolve. At this point, you will begin
. forming solid Ca(OH)2. Not much Ca(OH)2 can dissolve in water, so it
. doesn't take much to saturate the solution. (If you start with
. "slacked lime" which is CaO that has already been reacted with water
. to form Ca(OH)2, then somewhat more will dissolve.)
. When you introduce CO2 to the system, some of the CO2 dissolves in the
. water. The dissolved CO2 also reacts with water to form several other
. dissolved species ((CO3)2-, HCO3-, H2CO3). At some point, the
. carbon-bearing species will reach a sufficient concentration such that
. the solution will reach saturation with respect to CaCO3, which is the
. predominant mineral in limestone, and the compound that makes up most
. seashells. That "saturation" concentration places a limit on the
. amount of CO2 that can be in solution (in any form). Although there
. are numerous intermediate reactions involved, the overall net reaction
. for the precipitation of CaCO3 from a solution saturated with Ca(OH)2
. can be written as:
.
. CO2(gas) + Ca(OH)2(solid) <--> CaCO3(solid) + H2O(liquid)
.
. By using thermodynamics, one can calculate exactly how much CO2 can
be
. present in a gas that is in equilibrium with both Ca(OH)2 and CaCO3.
. To do this, one calculates the free energy change of the above
. reaction. Using the data in my wife's freshman chem book (I'm at home
. and don't have access to the better compilations of thermodynamic data
. I have at work), I find that the free energy change at 25deg C and 1
. bar pressure is -74.8kJ for one mole of Ca(OH)2 reacted.

. The free energy change, delta-G, of a reaction and the equilibrium
. constant, K, for any reaction are related by:
.
. delta-G = -R*T*ln(K)
.
. where R is a constant of nature known as the gas constant and T is the
. temperature measured in Kelvins. For this reaction, K =
. [CaCO3][H2O]/P(CO2)[Ca(OH)2], where the brackets mean "the
. concentration of", and P(CO2) is the partial pressure of CO2 in the
. gas. (More properly, the equilibrium constant is defined in terms of
. "activities" and "fugacities", which are thermodynamic niceities that
. we can ignore for this calculation). The concentration of a pure solid
. is by definition always = 1, and since the solution in this case is
. very dilute, we can assume that the concentration of water is also
. nearly 1 (i.e., it's almost pure water). in this case, we find that:
. 74,800 = 8.31 * 298.15 * ln(1/P(CO2))
.
. -30.2 = ln(P(CO2)
.
. P(CO2) = 7.74x10^-14
.
. The partial pressure of a gas in a mixture is simply the portion of
. the total pressure that is due to that gas. At 1 bar total pressure,
. then, the amount of CO2 in a gas in equilibrium with both Ca(OH)2 and
. CaCO3 is only one part in 1/(7.74x10^-14) = 1 part in ~1.3x10^13.....
. a very tiny quantity.
.
. You probably won't be able to achieve such low levels of CO2, however.
. Because none of the chamical reactions involved happen
. instantaneously. What you want to do to maximize the surface areas of
. all the reactants involved and to maximize the amount of time that the
. reactants are in contact with one another. James' idea of using a
. "bubbler" of some sort to break up your gas stream into a lot of small
. bubbles in the limewater solution is a good one; this will greatly

. increase the surface area of the gas in contact with the water. In
. addition, you want the lime to be finely divided, because for each
. atom of Ca that is removed from solution as CaCO3, another atom of Ca
. must be provided to the solution by dissolving a bit of Ca(OH)2.
. Increasing the surface area of the solid will increase the rate at
. which the Ca(OH)2 can dissolve (the rate is proportional to the
. surface area).
.
. Another thing to consider is the geometry of your tank. You should
. introduce your gas stream at the bottom of the tank, and for the same
. volume tank, it would be much better to use a tall, thin tank than a
. wide shallow one. It will take longer for the gas bubbles to rise
. through the tall tank than the shallow one, thus increasing the time
. available for the CO2 in the bubbles to equilibrate with the solution.

****

TH>After reading your Biogas article(s), I decided to ask around re: your
>statement that you needed to find some way to scrub the CO2 out of the
>gas coming from the digester. Here are most of the responses that I
>received. Some are useful... some aren't.

TH>All responses are from the Fido SCIENCE conference area. I told
>several people that I'd let them know if you made any headway in
>removing the C02. Any info you send, I'll post over in SCIENCE.

****

I read the responses with great anticipation but so many chemical solu- tions !
Here is a biological solution. You will need to work out the engineering
problems.

The green plants constitute the second largest consumer/controller of the CO2

levels in our world. They dont cost a thing to maintain and if properly
selected

could yield profitable returns.

Pass the gas over a green plant and it will take up all the CO2. but needs light

on the whole to do the job.

Two groups of plants that would be suitable are members of the family
Crassulaceae (they absorb CO2 even in dark) or some sort of algae such as
EUGLENA, a unicelluar mobile creature.

Maitenance would be a minor harvesting of excess growth and use it as feed
or
fertilizer.

****

Howdy, everybody! I'm new on this echo, coming to you from McScott's
BBS
in Abilene, Texas. I've been looking for something like this for a long
time, and I'm very gratified to have finally found a forum to discuss these
subjects with like-minded people. My thanks to the moderator for providing
us with this forum.

Another local user sent me a text file of some of the messages from the
past month or so, so I do have an idea of what subjects are under discussion,
and I even have a couple of ideas to contribute...

Someone had been wondering about the efficiency of methane digestion in
colder climates, relative to keeping the tank warm enough to work properly.
Instead of using power to heat it, why not opt for a more passive approach?
There are two that come immediately to mind, one low-tech, the other no-
tech-
first, it would certainly be possible to rig up a solar heater, just like

you would use to heat you water- use a heat exchanger in the tank so that
the water in the heater would not need to be replaced, and the insides of the
pipes would stay nice and clean.
  Secondly, why not just build a nice, huge compost pile around you digester?
(that is, assuming that you are using an above ground tank...). A compost
pile can easily reach internal temps up to 140 degrees F, and the bigger it
is, the longer it stays at those temps. If you are using an in-ground digester
tank, this method would also work well with a heat exchanger setup. Another
benefit of this is that it is possible to draw methane off from the compost
itself. (I don't know how that's done, but it has been done).

  Also, I noticed that one of the subjects the moderator is interested in
having discussed here is smelting and casting of metals. Well, that just
happens to be a subject that I am extrememly interested in- I have several
of Dave Gingery's books, and intend to make some small machine tools of
my own.
I am a machinist by trade, and I love working with metal, so I can't wait
until I am in a position where I can set up and start casting!

****

SK> Howdy, everybody! I'm new on this echo, coming to you from
McScott's BBS
SK>in Abilene, Texas. I've been looking for something like this for a long
SK>time, and I'm very gratified to have finally found a forum to discuss
these
SK>subjects with like-minded people. My thanks to the moderator for
providing
SK>us with this forum.

Well, Howdy back, Steve.

SK> Secondly, why not just build a nice, huge compost pile around you
digester

SK>(that is, assuming that you are using an above ground tank...). A
compost
SK>pile can easily reach internal temps up to 140 degrees F, and the bigger it
SK>is, the longer it stays at those temps. If you are using an in-ground
SK>digester
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Another
SK>benefit of this is that it is possible to draw methane off from the compost
SK>itself. (I don't know how that's done, but it has been done).

I have seen a compost pile/heater set up. A large enough pile will heat water in a storage tank to over 100 degrees <more than enough for a digester> and a heat exchanger would probably keep the temp about right with circulateing water <or other fluid> thru the exchanger. However, I am concerned with the polution of the air with the methane that naturally oozes from these piles. Part of the idea of the digester is to put to use a gas that will be "lost" to the atmosphere if left to nature and that has been found to be one of the depleaters of the ozone layer. And, since internal combustion of the gas may result in other polutants I usually ask people that are interested in methane to experiment with external combustion power sources once they get their digesters up and running. It is so much easier to use the internal combustion engines that I normally don't make the suggestion till after they have become well seated in the methane use and it would be easier since they already have everything working to do the necessary experimenting to come up with an adequate power plant. The polutants from the internals run on methane is much less than those run on gasoline though, so it is an improvement.

SK> That's it for now... more later! Steve Kreitler

Hope to hear from you in the future. Are you into windmills, PV<photovoltic> cells, DC storage devices, electric vehicles, steam vehicles, recovering "lost" heat or energy, or solar heat and storage?

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