APPLICATION REPORT

Consta-Mix gas augmentation system in Waste Water Treatment Plants

Energy conservation methods are rarely as effective as those used by many waste treatment plants. Besides converting municipal sludge into saleable fertilizer, these plants generate electricity by burning methane gas in internal combustion engines. Surplus power is sold to the local utility, and waste heat generated by the various processes is reclaimed for maintenance purposes. Brown & Caldwell, a consulting engineering firm located in Walnut Creek, California, is a leading designer of such installations. Among the equipment they specify is an Algas-SDI Consta-Mix gas augmentation system used to supplement the normally fluctuating methane supply from the digestors.

Certain types of anaerobic bacteria decompose municipal sludge into non-digestible solids and a sludge gas composed of 60-75% methane and the remainder carbon dioxide. With a lower heating value of 550-700 Btu/scf, the gas can be used as a fuel for internal combustion engines driving electrical generators. Sludge gas is produced at pressures up to 12" w.c. in closed, heated chambers known as digesters. Unfortunately, the methane generating bacteria have unpredictable production rates. Figure 1 shows methane production versus time for a typical operating period at a plant located in the San Francisco Bay area. Engines for this plant could be sized for a 290 kW input, and any excess gas produced by the digester would be burned off by a waste gas flare. Alternately, the engines could be sized for an input of 360 kW. A gas augmentation system would be used to supply an equivalent natural gas/air or propane/air mixture during periods of low sludge gas production. The additional 70kW recovered from the sludge gas by this method provides significant cost savings.

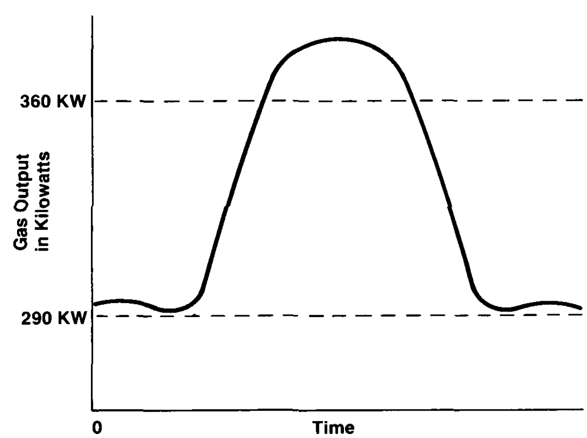
The pay-off period depends largely on the cost of power, the price of natural gas or propane, and the rate of inflation. In a cost analysis of one recent job, the revenue to the user over a twenty year life cycle was estimated to be $80,000 to $400,000 per year, based on projected electrical power costs of $0.075 to $0.125/kW. This study included a 10% general inflation rate, a 12% annual inflation rate for electric power, and a 14% inflation rate for supplemental natural gas. Other expenses are always involved, so the overall pay-off period for this example was calculated to be about four years, an economical figure for many waste water treatment plants.

Digester gas may be used by either turbocharged or naturally aspirated internal combustion engines. Turbocharged engines require a gas pressure in the range of 30-60 psig. Although the engine itself may be more efficient, the complications of compressing wet, dirty digester gas to these pressures significantly increases maintenance and downtime of the entire engine.

Naturally aspirated gas engines, however, require a steady gas inlet pressure of only 4-5" w.c. It may appear that with 12" w.c. pressure at the digester and only 5" w.c. needed at the engine, gas transportation would only require adequately sized pipe. This is generally not the case. Moisture separators, drip traps, flow meters, pressure regulators, manual and automatic control valves, check valves and piping losses all reduce the available pressure, necessitating a boost in the transmission pressure of about 14" w.c. This is easily accomplished with an Eclipse Series HB Hermetic Booster. By keeping the gas supply pressure to the engines under 14" w.c., unreliable low pressure relief valve venting required by paragraph 421 of the NFPA standard 37 can be avoided. A sketch of a gas management system is shown in Figure 2.

In addition to methane and carbon dioxide, sludge gas may contain fine particulate matter, 20% to 100% humidity, greasy oils, and traces of hydrogen sulfide,

FIGURE 1 – TYPICAL GAS PRODUCTION OF ANAEROBIC DIGESTER



hydrogen, and nitrogen. The gas is typically produced at a temperature of 90-100°F (xx-yy°C). To prevent corrosion, all surfaces in contact with the digester gas must be protected. The Eclipse boosters used for these applications have an airtight steel construction with no motor seal, a non-sparking aluminum rotor, and a Class I, Division 1, Group D explosion-proof motor with a 1.15 service factor. All of the surfaces contacting digester gas are coated with epoxy having a minimum dry film thickness of eight mils. Booster sizing must allow for the specific gravity and temperature of the sludge gas, as these affect the ratings of the booster. Performance curves specifically developed for digester gas are available for most of the commonly used Eclipse boosters.

To maintain electrical generation during periods of low methane production, a propane or natural gas standby system is installed. At full capacity, the standby system should be capable of supplying the total input requirements of the engines. The digesters can thus be shut down for maintenance or servicing without disrupting the electrical supply. A very wide standby system turndown range is required, with a minimum of 100:1 commonly specified. Algas-SDI Consta-Mix machines are ideal for these applications. Consta-Mix machines feature precise adjustment of air/gas ratio, constant ratio over the rated turndown range, and reliable operation with a minimum of maintenance.

An example of a methane gas power generating facility is the Waste Water Treatment Plant in Oxnard, California. Oxnard continuously operates two 600 HP engines at a speed of 720 RPM. A third engine is provided for standby. The sludge gas, produced by two digesters, is insufficient to meet all of Oxnard's electrical needs. The plant is therefore connected to the public utility at all times, and no provisions are required for emergency power.

The supplemental gas system consists of two Eclipse Consta-Mix machines. One machine is adjusted to supply a natural gas/air mixture with a heating value of 600 Btu/scf. Gas manifold pressure is maintained at 11" w.c. The second Consta-Mix machine is calibrated for propane gas. Due to the higher cost of propane, this unit is only used as a back-up for the natural gas machine. Operating logs show natural gas to sludge gas ratios ranging between 1:0.6 and 1:2.8 during normal operation. The system is capable of operating with any mixture from 100% natural gas to 100% sludge gas. Waste gas flares installed to burn off excess sludge gas are rarely used at this facility.

Equipment reliability is essential, as Oxnard is operated by a staff of only five people. In two years of operation, little attention beyond routine servicing has been required. Operators follow a preventative maintenance schedule which includes replacing the engine spark plugs every 500 hours, lubricating the Eclipse motorized valves and shut-off valves, inspecting, and if necessary, cleaning the Consta-Mix slide gate, and keeping a log of inlet and outlet gas pressures.

FIGURE 2 — TYPICAL SYSTEM