Retrofit projects at wastewater treatment plants are fertile ground for two special types of heat exchanger.

Heat Exchangers in Municipal Wastewater Treatment Plants

BY JAMES R. LINES

The majority of today's wastewater treatment plants utilize anaerobic digestion techniques for biological stabilization of municipal sewage sludge. These plants which today are an integral part of any community are tremendous consumers of energy With energy costs constantly on the rise and consumption closely monitored, existing plants, some of them retrofitted, and new plants alike are installing plate and spiral heat exchangers in an effort to reduce energy consumption, and so improve operating efficiencies.

Each type, however, is considered for very different reasons. Plate heat exchangers may be selected for their high thermal efficiency and minimum capital investment. Spiral heat exchangers, on the other hand, are turned to for their ability to effectively handle fluids containing solids and fibers, similar to those encountered in wastewater treatment plants.

First time users will want to become familiar with the basic construction features, advantages, limitations and applications of these heat exchangers.

Readers familiar with the heat exchangers may find some fresh information regarding their installation or operation.

Spiral heat exchangers in their normal orientation are true counter current flow heat exchangers, with hot and cold fluids flowing in opposite directions relative to each other. Basically, each exchanger is an assembly of two long strips of metallic plate wrapped around a mandrel to form a pair of concentric passages. Normally, alternate edges of the passages are welded closed so fluids flow through continuous, isolated channels. Fluid cross contamination is not possible under normal conditions.

The passage spacing is maintained primarily by sealing bars mounted at the passage edge and spacing studs. Depending on the fluid handled, the spacing may range from 1/4" to 1 1/4". Certain designs do not contain spacing studs, such as units applied to handle sewage sludge. The lack of spacing studs reduces the likelihood of plugging. Depending on thermal and pressure drop requirements, passage width may range from 9" to 96". Covers with full face gaskets are fitted to each side of the unit. Complete units are available from 5 ft 2 to 3000 ft 2.

Material of fabrication may be carbon steel, 304SS,316SS, L grade stainless, Alloy 20, Alloy 400, Alloy 200, as well as many other weldable and cold workable material. For wastewater treatment plants, however, carbon steel and stainless steel have normally been sufficient. General guideline for pressure and temperature limitations are 150 PSIG and 800 F.

Spiral heat exchanger advantages:

- passage spacing can be as large as 1 1/4", allowing sewage sludge to be handled
- each fluid flows through a single uniform passage, eliminating maldistribution and localized low velocity areas
- fluid flow is fully counter current for optimal thermal efficiency
- covers may be removed, exposing the heat transfer surface for inspection and/or cleaning
- compact design requires less space than a conventional heat exchanger
- spiral passage promotes turbulence and induces a scrubbing action which lowers the fouling tendency.

PLATE HEAT EXCHANGERS

Plate heat exchangers consist of a series of thin corrugated plates suspended from a carrying bar and clamped between a fixed and a movable head plate. The corrugated plates, or heat transfer plates, are normally 304SS or 316SS; however, other materials can be used. Each heat transfer plate is fitted with an elastomeric gasket, partly to seal and partly to distribute process fluids. Connections in the fixed or movable head plate permit entry of process fluids into the plate pack.

The heat transfer plates have spaces between them which form channels for fluid flow The hot and cold fluids are distributed through alternate channels in a counter current arrangement. This counter current geometry allows temperature crosses to be effectively managed for maximum thermal efficiency. The channel formed by two adjacent plates is three dimensional in nature and

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is the key to the plate heat exchanger's high efficiency. The three dimensional flow pattern induces turbulence at very low Reynolds numbers, and when coupled with a relatively small hydraulic diameter, results in very high heat transfer rates. Since the plate length is relatively short, optimizing allowable pressure drop is easily achieved.

Heat transfer plates can be arranged in a variety of configurations, with the standard being a single pass arrangement. When it is necessary to improve thermal efficiency, plates may be arranged in two, three or more passes.

General guidelines for pressure and temperature limitations are 250 PSIG and 350 deg. F.

Plate heat exchanger advantages:

- design produces high thermal efficiency, allowing maximum heat recovery
- compact design requires a fraction of the space taken up by conventional heat exchangers
- unit may be expanded to accommodate future increased duties
- cross contamination not possible under normal operation; possible leaks are vented external to the unit
- access to heat transfer surface for maintenance is simple
- design exhibits low fouling tendency
- unit is economical to operate

DIGESTER SLUDGE HEATING APPLICATION

The primary application for spiral heat exchangers is digester sludge heating. Digester temperature must be maintained within tight tolerances for proper sludge stabilization, approximately 95 deg. F for mesophilic digestion. Hot water heats the digester sludge as it is circulated through a spiral heat exchanger before returning to the digester.

The spiral design must take into consideration

A. heat losses through the digester walls, roof and floor

B. the heat required to bring incoming raw sludge to operating temperature

C. an allowance for heat input from the digestion process, which is exothermic.

Spiral heat exchangers are ideally suited for this service. Digester sludge contains approximately 4wt percent solids and fibers, which tend to plug conventional heat exchangers.

RAW SLUDGE PREHEATING APPLICATION

Raw sludge preheating with spiral heat exchangers is accomplished by recovering waste heat from digested sludge and using it to preheat the raw sludge before it enters the digester. During colder periods of the year, the raw sludge feed to the digester may be 45 to 50 F. Using the heat available in the digested sludge, which leaves the digester at approximately 95 degrees, to preheat the raw sludge greatly reduces the size and operating cost of the digester sludge heater.

The counter current spiral arrangement allows efficient and economic heat recovery; 60 percent recovery is nominal. Additionally, the spiral is capable of handling these solid and fiber laden fluids.

LIQUID RING VACUUM PUMP SEAL COOLER

Methane gas generated during the digestion process can be compressed with a liquid ring vacuum pump and sent back to the digester. The compressed gas bubbles up through the sludge and aids in agitation and mixing. To remove the heat of compression and dissipate heat generated by the pump, recirculated seal water must be cooled. A plate heat exchanger, using city water or tower water, may be applied as the seal cooling system Plate heat exchangers are compact are economical, and require little service water for cooling.

JACKET WATER COOLERS

Various pieces of equipment such as diesel and gas engines require jacket water cooling. Closed loop water can be used to reject the heat from these engines and plate heat exchangers fed with cooling tower or city water may be installed to cool the closed loop jacket water. Optimized heat recovery systems have been used to recover this jacket water heat. In turn this hot water has been fed to operate digester sludge heaters.

Plate heat exchangers are an economical option for this service, providing low initial investment, good performance characteristics, low service water consumption, and ease of maintenance.

GENERAL COOLING AND HEATING APPLICATIONS

Plate heat exchangers also work effectively for general liquid-to-liquid heating or cooling. Additional applications may be lubrication oil cooling, clarifier effluent cooling/heating recovery, and building climate control.

In conclusion, spiral heat exchangers have been shown to be economical and reliable for handling municipal wastewater treatment plant sludge heating duties. These exchangers are able to operate reliably when fed with solid and fiber laden fluids, such as sewage sludge. Plate heat exchangers provide an economical option for basic liquid-to-liquid service. Compactness, efficiency, reliability, ease of maintenance, and low initial investment make this exchanger design the choice for many wastewater treatment applications.■