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Improve RTO performance with MLM

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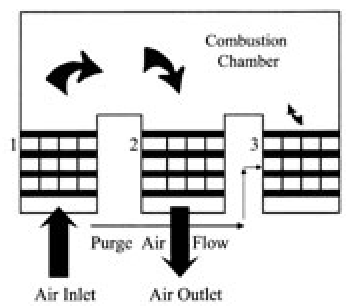

Figure 1. Process Diagram of three can RTO showing one heating/cooling cycle. Relative airflows are shown as arrows. The function of the three cans in this example are (1) preheating the air entering the combustion chamber (or taking heat from the ceramic media) (2) cooling the air exiting combustion (or heating the ceramic media) and (3) capturing and heating the small amount of air left untreated by the previous valve change in the purge canister. At the next valve change, canister 1 will become the purge canister, candister 2 will switch to preheating and canister 3 will become the cooling canister. With yet another valve switch the canisters change function in similar fashion so that each canister is seen to act as heating, cooling and purge once in a repeating, three-fashion manner.

The city of Fitchburg, Mass. operates a multiple hearth incinerator that burns municipal sludge to minimize waste volumes. Although not universally utilized by municipalities in the United States, incineration is a widely accepted and used method of sludge disposal. The major benefit of incineration is a reduced need for landfill space. An 85 to 95 percent volume reduction of material normally sent to a landfill is a typical result of incineration [1].

Incineration is used extensively in countries with limited open space. Japan incinerates approximately 75 percent of its municipal solid waste [2]. In Europe, on the other hand, Finland reported 90 percent of such waste is sent to a landfill and in tiny Denmark, 75 percent of such waste is incinerated [3]. Ultimate disposal of solid waste remains a challenge to municipalities worldwide. In Texas alone, 6.5 pounds of solid waste was generated per person per day in 1998 [4].

The city of Fitchburg municipal incinerator

Burning solid waste will generate harmful gases that must be treated before exiting the stack into the atmosphere [5]. Fitchburg, Mass. burns solid sewerage sludge produced by the various wastewater treatment plants owned and operated by the city. Additionally, the city accepts sludge from other New England municipalities. Fitchburg is paid, on average, $250 per dry ton to treat this sludge.

Figure 2. Modern three-canister RTO unit.

Exhaust gas produced by the incinerator is treated before being allowed to exit the stack and disperse into the environment. Following the incinerator is a tray tower, a venturi scrubber and a wet electrostatic precipitator. These air pollution control steps remove particulates and heavy metals from gases exiting the multiple hearth incinerator.

The final step in air pollution control is a Regenerative Thermal Oxidizer (RTO). Such process units are also called "afterburners" as an RTO is often the last step in an air pollution control application. Afterburning is used to destroy volatile organic compounds (VOCs) and malodorous gases that otherwise would exit the stack. VOCs are known to support "smog" air pollution [6]. The most common VOC present in the off gas from the Fitchburg incinerator is acetone [(CH3)2CO]. Tempeartures measuring 1500 F (816 C) are maintained in the RTO chamber to assure complete oxidation of such compounds to CO2 and H2O.

Typical of Fitchburg RTO designs, the gas being treated is both preheated and cooled as it passes to and from the combustion chamber. A series of valves open or close every 90 seconds to change the airflow direction. As the air flow changes, the gas entering the combustion chamber is preheated while the gas exiting the combustion chamber is cooled before final release. The purpose of this process flow is to capture and reuse heat in the RTO. Natural gas burning, required to maintain the high combustion temperature, is minimized and fuel cost is controlled.

This capture and release of heat is accomplished by the presence of heat recovery media in canisters (or "cans") that adjoin the combustion chamber of the RTO. A simple process diagram is presented in Figure 1 and a photograph of a typical three can RTO in Figure 2.

Ceramic saddles have been the historic choice of heat recovery media in RTO units. Saddles operate with a high-pressure loss, so even though fuel gas cost is controlled, saddles are the main reason that RTO units have traditionally been major consumers of electric power. As power costs increased in recent years, so have operating cost for RTO saddles units. The Fitchburg RTO unit operating conditions with saddles are summarized below:

Air Flow: 14,000 cfm
Pressure Drop Across two Beds of Saddles: 25 inches WC
At this pressure drop, with a power cost of $0.10/kWh, the brake horsepower required to move the air volume can be estimated as:

BHP = (cfm X pressure drop) / 5390 = (14,000 X 25) / 5390 ~ 65

At the given power cost, one BHP costs $816 per year. Therefore the electric power cost (816 x 65) of the Fitchburg RTO was $53,000 per year [7].

Saddles also tend to "nest" or "mesh" together over time as the bed of saddles settles. This not only increases pressure drop (and hence raises power costs) but also aggravates plugging and fouling problems inherent with beds of saddles. Indeed, plugging of a saddle bed may raise the pressure drop across the bed long before the bed has the opportunity to fully settle. The problem at Fitchburg was so severe that the saddles had in large part ground themselves down to a fine sand. Note the condition of saddles that were removed from the RTO in Figure 3. In addition to the sizable volume of sand, close inspection revealed that very few saddles where physically whole.

As the saddle bed compressed, distinct marks were left in the insulation at different stages of settle. Eventually, the compression of the saddle bed was severe enough to force the saddles into

the insulation lining inside of the canisters. Note these effects in Figure 4.

In addition to high power costs, saddle RTO units also have high maintenance expenses as the beds must be frequently backwashed to clear deposits. The operating history of the Fitchburg RTO notes that wash outs were required every other month. The need for frequent wash outs of saddle beds in RTOs has been noted in field installations previously. In addition to the need for frequent maintenance shutdowns, the pressure drop tended to never return to the pre-maintenance value [8]. This "creep" of pressure drop eventually necessitates replacing the bed with new saddles.

Multi–Layer Media

First introduced as an alternative heat recovery media for use in RTO units in 1996, Multi–Layer Media (MLM) offered the city a possible major reduction in electric power usage with no loss of thermal efficiency (so no increased fuel cost) compared to saddles. The free-floating plate design of MLM resulted in a much lower pressure drop. MLM also has more surface area and more mass than saddles, so the heat recovery property of MLM in an RTO is superior to saddles.

Figure 3. Saddles that were removed from the Fitchburg RTO prior to MLM installation.

Additionally, the parallel plate design of MLM has proven extremely resistant to fouling in field applications where saddles had a very short useful life [8].

MLM uses a thin layer of inorganic glue to bind the units for installation purposes. At operating temperatures this glue quickly dissipates so as not to upset the self-supporting function of the media. This self-supporting structure is accomplished by rotating each succeeding layer of media by 90 degrees.

The city of Fitchburg decided to replace the saddles in their RTO unit with MLM-180 in June 2002. Technicians observed a dramatic reducion in pressure drop immediately upon startup of the unit. As opposed to the 25 inches WC pressure drop with saddles, the pressure drop across two beds of MLM was only 4.5 inches WC.

In addition to the dramatic reduction in observed pressure drop, the variable speed drive on the fan feeding Fitchburg's RTO now operates at 50 percent of capacity. The load on the drive was 85 percent previously. Of even greater importance, the city reports that new daily records for amount of sludge burned are routinely being set.

$40,000+ per year power savings

Repeating the earlier calculation of brake horse power requirements:

BHP = (14,000 X 4.5)/5390 ~ 12

One BHP costs the city $816 per year, so the yearly power cost to Fitchburg is now estimated to be:
816 X 12 ~ $9,800 per year with MLM installed vs. $53,000 with saddles.

So now the city has a projected power savings in excess of $40,000 per year! The installation of MLM media also allowed the city to increase capacity of the existing RTO unit and still realize power savings compared to what it had been paying the power company using saddles. At a projected airflow of 24, 000 cfm, the RTO will be operating at:

Figure 4. Distinct settlement lines and impressions into insulation along inside of the canister walls caused by collapse of the saddle

Air Flow: 24,000 cfm
Pressure Drop Across two Beds of MLM: 7 inches WC

bed in the Fitchburg RTO.

The estimated power cost per year after the capacity increase is:

BHP = (24,000 x 7)/5390 ~ 31
816 X 31 ~ $25,500 after capacity increase

So after a capacity increase of 42 percent, the city will have a power cost that is over 50 percent less than its power cost when using saddles!

$1.1 Million Yearly Revenue Increase

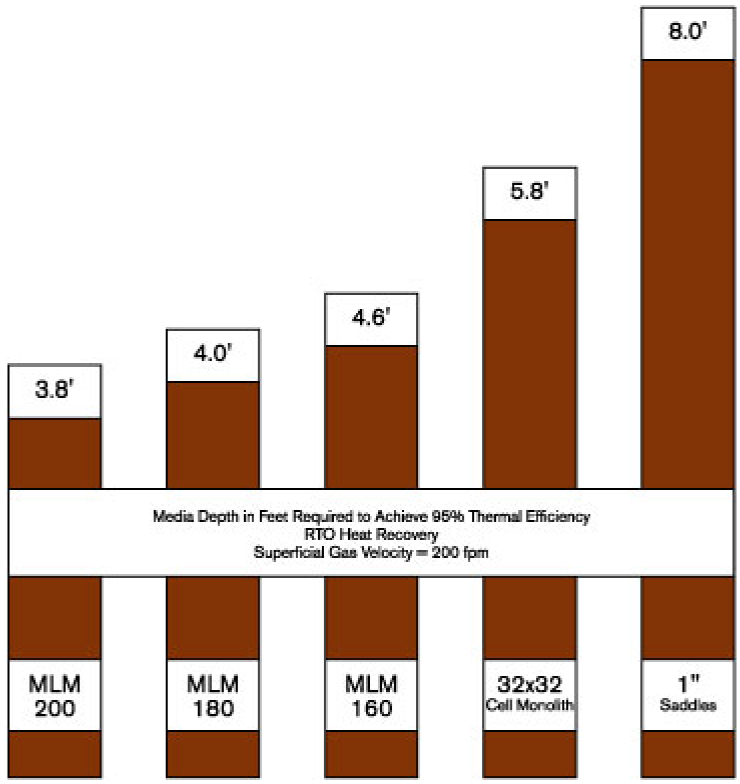

Figure 5. Depth of heat recovery media needed to achieve 95 percent thermal efficiency.

A major, unplanned benefit of the retrofit project was quickly realized by the city. After startup of the RTO with MLM in place, the sludge volume burned increased by an average of 30 percent per day. As previously noted, the city receives compensation of $250 on average for each dry ton that is accepted from a number of surrounding communities.

Operating personnel report that most of the 30 percent capacity increase has reflected increased tonnage that is now being accepted from other municipalities. The incinerator, on average, is now burning 1.9 dry tons per hour. (The incinerator is rated for 2.0 dry tons per hour.) Using 30 percent of this figure and assuming an 8000-hour operating year, Fitchburg has increased revenue generated by their municipal incineration operation by $1,140,000.

Environmental Benefits

Besides saving money, reducing power consumption also reduces greenhouse gas emissions. It is estimated that one horsepower is equivalent to 0.746 kWh [9]. The generation of a kWh is estimated to cause the release into the atmosphere of 1.341 pounds of CO_2 gas [10].

Figure 6. Multi-Layer Media, MLM, supplied by Lantec Products.

Therefore, elimination of 53 hp, as explained above, can be equated to the elimination of 336,073 kWh per year (assuming a 340 day operating year). If this equivalent of electric power is not generated then the potential reduction as a result of this project is over 450,000 pounds of CO_2 gas emission per year. ***PE***

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ADDITIONAL INFORMATION

For more information, contact Paul Guerra or James Eldridge of Lantec Products at (781) 769-1901 or visit www.lantecp.com.