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May 2017

Comparing fuel costs

RTO (Ceramic Bed) vs an HTT RCO (A-A Exchanger catalytic)

The emission control industry appears to have created a stream of misinformation and untruths concerning the fuel cost comparison between RTO and RCO systems. Simply put, they do not tell customers that natural gas at 1600ºF has half the heat value than it does at 70ºF. Customers pay for FT3 of natural gas, not BTUs. So when suppliers calculate a 1,000,000 BTU operating cost it is really a 2,000,000 BTU operating cost.

Let’s take a look as some background information beginning with how the systems operate.

Theory of Operation:

RTOs use a high-density media, such as a ceramic-packed bed still hot from a previous cycle to preheat an incoming VOC-laden waste gas stream. These preheated, partially oxidized gasses then enter a combustion chamber where they are heated by auxiliary fuel (natural gas) combustion to a final oxidation temperature typically between 760ºC to 820ºC (1500ºF to 1600ºF) and maintained at this temperature to achieve maximum VOC destruction. Temperatures of up to 1100ºC (2000ºF) may be achieved, if required, for very high control efficiencies of certain toxic VOCs. The purified, hot gases exit this chamber and are directed to one or more different ceramic-packed beds cooled during an earlier cycle. Heat from the purified gases is absorbed by these beds before the gases are vented to the atmosphere. The reheated, packed bed then begins a new cycle by heating another incoming waste gas stream.

When the exhaust stream contains condensible vapors, these will condense on the packing and then will be vaporized again when the flows are reversed, once again releasing the condensibles back into the exhaust stream.

An HTT RCO uses an Air to Air preheat exchanger and a precious metal catalyst bed, allowing oxidation to occur at approximately 550-600ºF. This lower temperature requirement reduces the amount of natural gas needed to fuel the VOC abatement system and the overall size of the incinerator. Catalysts typically used for VOC incineration include platinum and palladium (Gay, 1997; Biedell and Nester, 1995).

If design conditions are satisfied, typically no pretreatment is required, however, in some cases, PM removal may be necessary before the waste gas enters the incinerator. This is critical for both RCOs and RTOs and both will require periodic cleaning. The periodic maintenance required for cleaning Catalyst is usually acomplished with a high pressure shop vac. An RTO will require a complete disassembly of the packing media for cleaning. Catalytic systems may utilize internal filters that process the air stream before it reaches the catalyst material. A sacrificial bed also can be employed to prevent PM from reaching the catalyst. Some manufacturers fluidize the catalyst beds to help pass the PM through the system (Biedell and Nester, 1995).

Advantages and Disadvantages of Regenerative Incinerators:

Advantages of RTOs:

- High temperature capability up to 1100ºC (2000ºF)
    - Recuperative incinerators are generally limited to 820ºC (1500ºF) due to heat exchanger limitations
    - Catalytic incinerators are generally limited to 600ºC (1100ºF) due to catalyst imitations
- Less susceptible to problems with chlorinated compounds

Advantages of RCOs:

- Lower fuel requirements than RTOs because of lower temperatures
- Startup can be 20-30 minutes. Can be shut down when not operating.
- Catalyst also destroys CO in waste stream
- Lower NO_x emissions than RTOs

Disadvantages include the following (Gay, 1997; Stone, 1997):

Disadvantages of RTOs:

- Higher initial cost
- Difficult and expensive installation
- Large size and weight
- Startup can be many hours, units are left on when not running
- High maintenance demand due to number of moving parts

Disadvantages of RCOs:

- Possible catalyst poisoning from silicone, heavy metals
- Catalyst operating life is usually 30-40K hours; for a 1 shift operation, replacement is typically 15-20 years
- Used catalyst must be regenerated or replaced

Other Considerations:

- Regenerative incinerators offer many advantages for the appropriate application. Depending upon the waste stream composition, high flow, low concentration waste streams consistent over long time periods can be treated economically with either RTO or RCO systems,.
- Pretreatment to remove PM may be necessary with either system to prevent the packed bed from clogging and or the catalyst from poisoning. In RCO units, precious metal-based catalysts usually have a longer service life and are much more resistant to poisoning and fouling than less expensive base metal catalysts (Gay, 1997).

Now let's take a look at what costs are associated with each system type.

Cost Information:

The following represent cost ranges (*expressed in 2002 dollars*) for regenerative incinerators of conventional design. The design costs are both with and without a catalyst, under typical operating conditions, developed using EPA cost-estimating spreadsheets (EPA, 1996). They are referenced to the volumetric flow rate of the treated waste stream flow. RTOs and RCOs are field-erected and not available as pre-packaged units. The cost ranges do not include the cost for a post-oxidation acid gas treatment system. The upper levels of the cost ranges apply when the control device is used for very low-VOC concentration streams of less than around 100 ppmv at very low flow rates (around 2.4 scm/s or 5,000 scfm). As a rule, smaller units controlling a low concentration waste stream will be much more expensive per unit volumetric flow rate than a large unit cleaning a high pollutant load flow (EPA, 1996).

Cutting through all the industry misinformation and untruths, what is the most effective way to estimate fuel and electrical costs for the total systems?

Here is a formula for easily calculating the natural gas cost under normal operating conditions:

[(SCFM x 60) X *E(T2 - T1)] / **53 CFM per 1^{o}F = X BTU/HR

**E = 100 – HE% Eff*
***1 BTU will heat up 53 CFM by 1^{o}F*

Use the value of heat content of the natural gas at the operating temp to calculate the CFH of natural gas needed per hour. As the operating temp increases the heat value of the gas decreases. The heat content of natural gas at 500^{o}F is different at 1600^{o}F, so the BTUs can be calculated using the above formula.

Most customers are especially interested in how many CFH of natural gas they will be purchasing for operation, therefore the BTU to CFH conversion must be made to obtain an accurate cost estimate.

Heat content of Natural Gas at Temperature (Per North American Comb Handbook):

70^{o}F	1080 BTU/FT3
550^{o}F	870 BTU/FT3
1000^{o}F	700 BTU/FT3
1600^{o}F	500 BTU/FT3

Calculate (T2 - T1) on HTT Systems

Sample Calculation:

Flow Rate	1K SCFM
Inlet Temperature	100ºF
Operating Temperature	550ºF
Preheat Exchanger Efficiency =	70%

E(T2 - T1) = 450ºF x 30% Efficiency = 135ºF

[(SCFM x 60) X E(T2 - T1)] / 53 = X BTU/HR

[60,000 SCFH X 135F] / 53 = 152,830 BTU/HR

Convert calculated BTU to CFH of natural gas at elevated temperatures:

1K SCFM 152,830 BTU/HR / 870 BTU/FT3 = 175 CFH (NATURAL GAS @ 550ºF)

5K SCFM 764150 BTU/HR / 870 BTU/FT3 = 878 CFH (NATURAL GAS @ 550ºF)

10K SCFM 1,528,300 BTU/HR / 870 BTU/FT3 = 1,750 CFH (NATURAL GAS @ 550ºF)