**Process Heating Virtual In-Plant Training - Homework # 2**

1. The oven has three zones, each with a burner with input fuel usage of 10,600 ft3 of natural gas per hour. On an average the prime oven operates at 60% of its rated capacity. The oven operates for 7,488 hours per year. Estimate the stack heat loss on this oven under the following conditions: HHV of natural gas = 1100 Btu/ft3, Fuel cost = $5.20 per MMBtu, Stack temperature: 330°F, Flue gas oxygen: 8.0% when operating at high fire. Negligible combustibles were found in stack gas analysis. Ambient air temperature: 68°F.
   1. If the oxygen in the stack gas was reduced to 3%, assuming no change in the stack temperature, what would be the annual energy and cost savings?

(hint: use efficiency improvement calculator)

* 1. Using a heat exchanger effectiveness of 45%, increase the combustion air temperature using the heat from the stack gases and improve the condition and controls on the burner to reduce stack temperature to 248 degrees F. Determine the annual energy and cost savings.
  2. Examine the use of oxygen enriched fuel for the original conditions of the oven, prior to energy efficiency efforts for (a) and (b). Determine energy savings before (a) and (b) and then after (a) and (b).

(hint: use efficiency improvement calculator and oxygen enrichment calculator)

1. The fuel used is natural gas. It is flowing through an orifice with diameter of 1.7 inch with the inside pipe diameter of 4 inch with a square edge section. The coefficient of discharge is 0.45 and the temperature of the gas is 75-degree F with a pressure of 16.7 psia. The pressure drop across the orifice is 8.3 inch of water column. Determine the flow rate of natural gas in SCFH and the energy content for a flow of 12 hours. (hint: flow and energy used calculator)
2. For a furnace with 1600°F flue gas temperature and 3.5% oxygen in the flue gases using approximately 60°F combustion air, the available heat (in terms of percentage of the fuel heating value) is (select only one):

* 50%
* 13%
* Depends on the burner firing rate
* Depends on the type of burner used

1. Calculate burner **heat input required to offset wall losses** for a furnace with the following operating conditions. (Hint – Use PH Basics section and wall loss calculator).
   * + Annual operating hours = 8760 hours
     + Fuel cost = $5/MMBtu
     + Flue gas temperature = 1800°F
     + Combustion air temperature = 600°F
     + Oxygen in flue gases = 4%
     + Wind velocity = 0 mph
     + Surface shape/orientation = Horizontal cylinder
     + Wall surface area = 2500 ft2
     + Surface emissivity = 0.9
     + Average wall surface temperature = 250°F
     + Ambient temperature = 75°F
     + Fuel Temperature = 70°F
2. Calculate the heat input (Btu/hr) required to allow for radiation heat loss from TWO round openings of 12 inches in diameter in a furnace wall with 9 inch wall thickness, 1.5 ft2 effective opening in a furnace with 2200°F temperature. Assume the emissivity is 0.9 and the user-defined view factor is 0.58. The furnace flue gas temperature is 1800°F, the combustion air temperature is 600°F, the flue gases contain 4% oxygen, fuel temperature 70°F, and the ambient temperature is 80°F. Use annual operating hours = 8760 hours and fuel cost $5/MMBtu. (Hint – Use opening loss calculator).
3. Using the flue gas calculator in MEASUR tool and the data given below, estimate the savings ($/year) through the reduced fuel costs for the following cases. The furnace uses typical natural gas as a fuel:
   1. Excess O2 reduction:

* Oxygen in flue gases
  + Current conditions = 6%
  + New conditions = 2%
* Flue gas temperature = 1800°F
* Combustion air temperature = 80°F
* Fuel = natural gas at $5 per million Btu
* Operating hours per year = 8,000 hours/year
* Current heat input used = 10 million Btu/hour
  1. Flue gas temperature reduction:

Assuming the flue gas temperature is reduced to 1000°F and all other parameters / conditions remain the same, estimate the savings ($/year) through the reduction in fuel cost. Use O2 in the flue gas as 6% (**not 2%**).

1. Develop a baseline model for the **pusher type reheat furnace** using the data sheet provided and the MEASUR tools Process heating assessment module. Copy and paste the Sankey diagram below.