Advanced Air-Fuel Ratio Control

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Webinar Overview

- Review of Intro to Air/Fuel Ratio Control
- Maintenance to-dos and not to-dos
- Burner Tuning Examples and Calculations

Combustion Terminology

- **Stoichiometric Ratio** – The perfect amount of oxygen and fuel mixed during combustion such that nothing is left over.
- **Excess air / lean** – When more air (oxygen) is present than necessary to combust the fuel, resulting in left over oxygen.

Optimal Air/Fuel ratio control can...

- Prevent nuisance shut-downs
  - Improper air/fuel ratio can cause the flame safeguard to lose the flame signal
- Improve fuel efficiency
  - Improper air/fuel ratio can waste fuel
- Help obtain tighter control for emissions driven applications
  - Improper air/fuel ratio can increase NOx or CO production
- Help obtain better temperature control
  - Improper air/fuel ratio can make controlling temperature more difficult

Disclaimer

- DO NOT ADJUST YOUR BURNER IF YOU ARE NOT FAMILIAR WITH THE SYSTEM AND THE SAFETY COMPONENTS. PLEASE CONTACT A COMBUSTION SERVICE TECHNICIAN IF YOU ARE NOT COMFORTABLE WITH THESE SYSTEMS.

Maintenance to-dos and not to-dos

- DO: Use the proper testing equipment when adjusting the burner.
  - Manometers
  - Flow Meters/Orifice Plates
  - Combustion Analyzers
- DO: Have the testing equipment calibrated per the manufacturer's specifications.
- DO: Verify flow and pressure data with the burner manufacturer.

Maintenance to-dos and not to-dos

- DO: Record values while adjusting the burner.
- DO: Make sure that there is a load on the system to take the heat away.
- DO: Adjust the burner under normal operating conditions (or as close as possible).
  - Chamber Pressure
  - Temperature

Maintenance to-dos and not to-dos

- DO NOT: Jumper any safeties while adjusting the burner.
- DO NOT: Adjust a burner by eye sight only.
- DO NOT: Change linkage without marking the original position.
- DO NOT: Touch the burner if you are not familiar with the system.

Burner Tuning Example

- MAXON KINEDIZER LE burner
  - Need 14.0 MMBtu/hr
  - 30% Excess Air (for low NOx)
  - As high of turndown as possible

Differential Pressure (dP)

- A burner is essentially a fixed orifice.
  - Combustion Air Mixing Plate/Cone
  - Fuel Nozzle/Ports
- Measure the pressure on each side of the orifice to determine differential pressure.
  - Inlet test ports (separate air and fuel)
  - Combustion Chamber/Duct (common)
- Reference burner manufacturer literature to relate differential pressure to flow

Burner Tuning Example

Typical burner data
Fuel: natural gas at 60°F with 1000 Btu/ft^3 (st) HHV - sg = 0.6 [1]
Combustion air: 60°F - 21% O_2 - 50% humidity - sg = 1.0 [1]
Stated pressures are indicative. Actual pressures are a function of air humidity, altitude, type of fuel and gas quality.

KINEDIZER® LE size		1-1/2"	3"	4"	6"	8"	10"	12"	14"	16"
Max. capacity @ n=1.3 (low NOx) [2]	MBtu/h	0.54	2.4	4.6	9.8	15.8	24.3	34	55	75
Max. capacity @ n=1.1	MBtu/h	0.59	2.6	5.2	11.2	17.7	28.5	39	60	85
Min. capacity	KBtu/h	27	120	230	490	790	1215	1700	2750	3750
Turndown @ n=1.3 [2]		20:1	20:1	20:1	20:1	20:1	20:1	20:1	20:1	20:1
Turndown @ n=1.1		22:1	22:1	22:1	22:1	22:1	22:1	22:1	22:1	22:1
Air flow at max. capacity	scfm	110	500	950	2030	3280	5050	7070	11400	15600
Air flow at min. capacity	scfm	6	26	50	106	171	263	350	596	820
Advised pilot capacity	MBtu/h	0.1	0.2	0.2	0.3	0.5	1.0	1.0	1.0	1.0
Pilot gas pressure [4]	"wc	<0.4	1.0	<0.4	0.6	1.0	4.0	0.5	0.5	0.5
Advised pilot capacity [3]	MBtu/h	0.1	0.45	0.23	0.49	0.79	1.20	1.70	2.75	3.5
Pilot gas pressure [3)	"wc	1	2	6	15	12	15	15	18	20
Advised pilot gas piping diameter [5]		1/2"	3/4"	3/4"	3/4"	1"	1-1/2"	1-1/2"	1-1/2"	1-1/2"
Combustion air pressure @ inlet [6]	"wc	28	32	32	32	32	32	32	32	30
Combustion air pressure differential [7] [9]	"wc	26	28	29	31	27	30	30	28	28
Natural gas inlet pressure differential [8]	"wc	55	52	42	64	40	75	76	120	220
Flame length @ n=1.3 [2]	ft	1	1.5	2	4	6	9	9	10	10
Flame diameter @ n=1.3 [2]	ft	0.5	0.75	1	1.5	3	4	4	4	5
Flame length @ n=1.1	ft	1.5	2.5	4	6	8	10	10	11	11
Flame diameter @ n=1.1	ft	0.5	0.75	1	1.5	3	4	4	4	5

Burner Tuning Example

- 8” KINEDIZER LE Burner data:
  - Max Capacity = 15.8 MMBtu/hr
  - Min Capacity = 790 KBtu/hr
  - Air flow at Max = 3280 SCFM
  - Combustion Air dP = 32” wc
  - Natural Gas dP = 40” wc

Burner Tuning Example

- Determine other flows and pressures with the orifice equation:

$$\frac{P_2}{P_1} = \left(\frac{Q_2}{Q_1}\right)^2$$

- Solving for flow or pressure:

$$P_2 = P_1 \times \left(\frac{Q_2}{Q_1}\right)^2 \qquad Q_2 = Q_1 \times \sqrt{\frac{P_2}{P_1}}$$

Tools to measure differential pressure

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