Intro to Air-Fuel Ratio Control

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Webinar Overview

- Intro to Air/Fuel Ratio
  - Combustion Terminology and Fundamentals
  - Importance of Air/Fuel Ratio Control
  - Methods of Air/Fuel Ratio Control
  - Pros and Cons of Each Method
- Advanced Air/Fuel Ratio Control – January 2015
  - Maintenance Dos and Don'ts
  - Adjustment Best Practices and Techniques
  - Sample Calculations

Combustion Terminology

- **Combustion** – The rapid oxidation of a fuel, usually via the oxygen present in air, resulting in the release of energy (heat and light).
  - Combustion is the CONTROLLED rapid oxidation of a fuel.
  - Explosion is the UNCONTROLLED rapid oxidation of a fuel.
- **Stoichiometric Ratio** – The perfect amount of oxygen and fuel mixed during combustion such that nothing is left over.
- Example Reaction with Natural Gas (CH_4):
  - $CH_4 + 2O_2 + 8N_2 \rightarrow CO_2 + 2H_2O + 8N_2 + \text{heat}$

Combustion Terminology (cont.)

- **Excess air / lean** – When more air (oxygen) is present than necessary to combust the fuel, resulting in left over oxygen.
- Most industrial combustion applications are run with excess air to ensure that there is no wasted fuel.
- Example: A Natural Gas burner which receives 15 parts air for every part fuel is running with 50% excess air. This burner can be described as "running lean".
- $CH_4 + 3O_2 + 12N_2 \rightarrow CO_2 + 2H_2O + O_2 + 12N_2 + \text{heat}$

Combustion Terminology (cont.)

- **Excess fuel / rich** – When less air is present than necessary to combust the fuel, resulting in unburned fuel.
- Certain applications that require a long, luminous flame or need to control the amount of oxygen within the combustion chamber would have burners set-up to run with excess fuel.
- Sometimes called "sub-stoich" since it's below the stoichiometric air-to-fuel ratio.
- $2CH_4 + 2O_2 + 8N_2 \rightarrow CH_4 + CO_2 + 2H_2O + 8N_2$ + heat

Combustion Fundamentals

- All fuels have a lower and upper flammability limit.
- Combustion can only occur between these limits.
- When changing the firing rate of a burner, both the air and fuel need to travel together to stay between these limits.

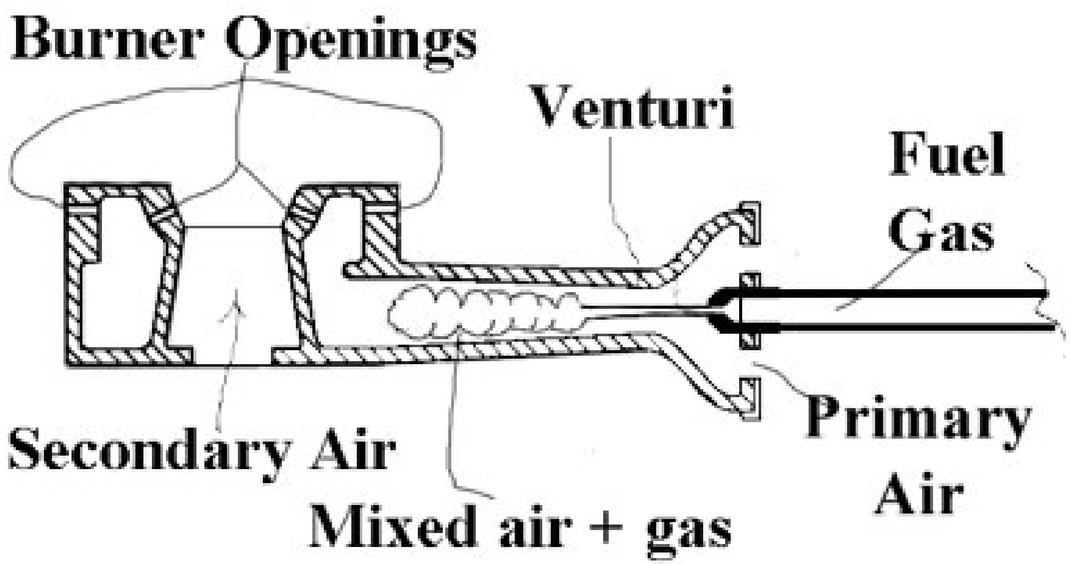
Type of Gas	LFL	UFL	Stoich
Natural Gas (CH_4)	5.0%	15.0%	(10:1) - 9.1%
Propane Gas (C_3H_8)	2.1%	9.5%	(25:1) - 3.8%
Butane Gas (C_4H_{10})	1.8%	8.4%	(32:1) - 3.0%

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

Inspirators

- High pressure fuel is delivered to the inlet of the inspirator
- Venturi tube design pulls combustion air into the inspirator
- Ratio control dictated by the size of the fuel nozzle and an air adjustment damper

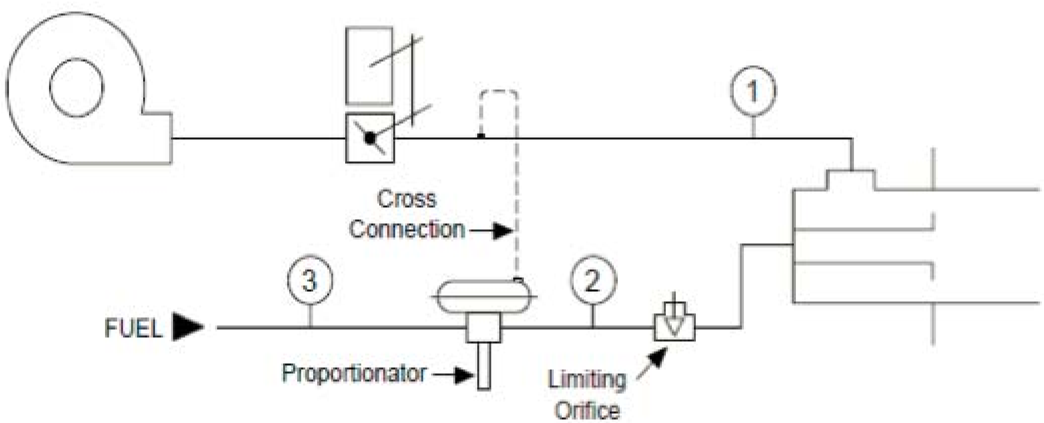


Inspirators (cont.)

- ~4:1 Turndown
- Pros: Low Cost, Simple Design, Available in many sizes
- Cons: Low turndown, Minimal characterization
- Critical Component: Gas Nozzle/Spud

Cross-Connected Ratio Regulators

- Composed of the following components:
  - Air Control Device (Control Valve or VFD)
  - Proportionator/Ratio Regulator
  - Limiting Orifice
- Control signal sent to the air control device, and an impulse line from air manifold feeds the fuel's ratio regulator to adjust the fuel flow.



Cross-Connected Ratio Regs (cont.)

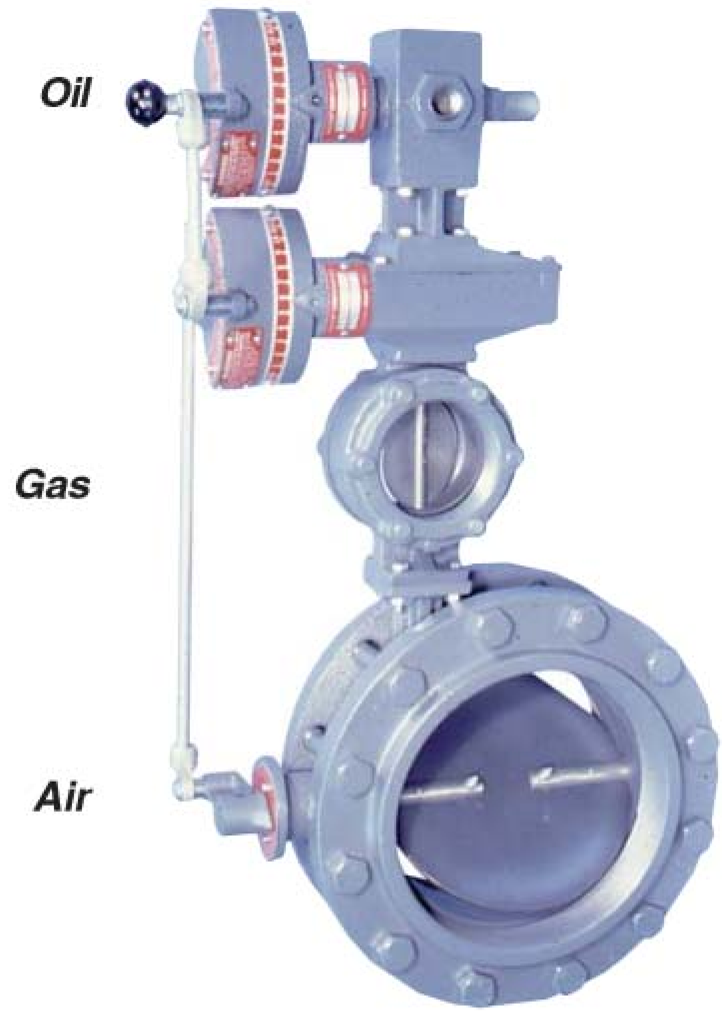
- ~20:1 Turndown
- Pros: Flexible Installation, Low Cost
- Cons: Minimal characterization
- Critical component: Impulse Line

Mechanically-Linked Control Valves

- Air Valve and Fuel Valve connected via mechanical linkage.
- Commonly found in boiler applications (jack-shaft)
- Characterizable fuel valves offer adjustment capabilities for the entire range of operation.
- Good for multi-fuel and oil-fired applications.

Mechanically-Linked Valves (cont.)

- ~40:1 Turndown
- Pros: Higher Turndown, More Characterization
- Cons: Higher Torque Requirements for Control Motors, Less Flexible Installation
- Critical Component: Linkage arm between air and fuel valves

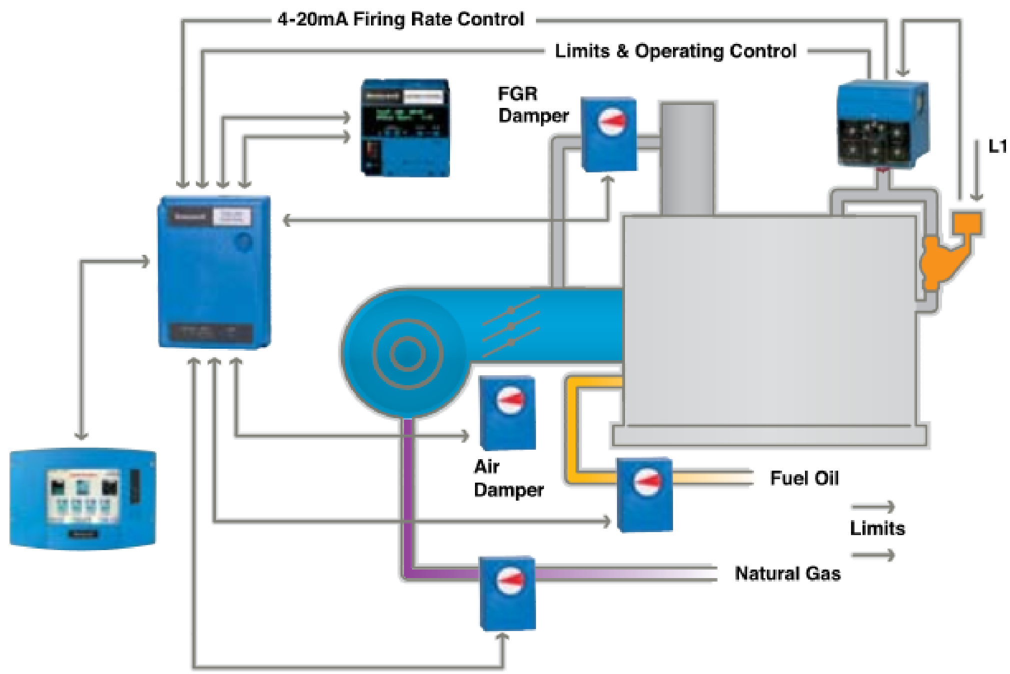


Electronically-Linked Control Valves

- Sometimes referred to as "Parallel Positioning"
- System's control interface receives single control signal, and controls multiple actuators (can control up to 4).
- Built-in safeties ensure that actuators travel together to maintain ratio.
- Actuators are characterizable, allowing for individually defined flow curves.
- Commonly used in emissions driven applications due to repeatability of control and level of characterization.
- Flexible to install since air and fuel valves do not need to be located near each other.

Electronically-Linked Valves (cont.)

- ~40:1 Turndown
- Pros: Flexible Installation, Great Control Resolution
- Cons: Increased Complexity and Cost with Additional Components
- Critical Component: Control Interface

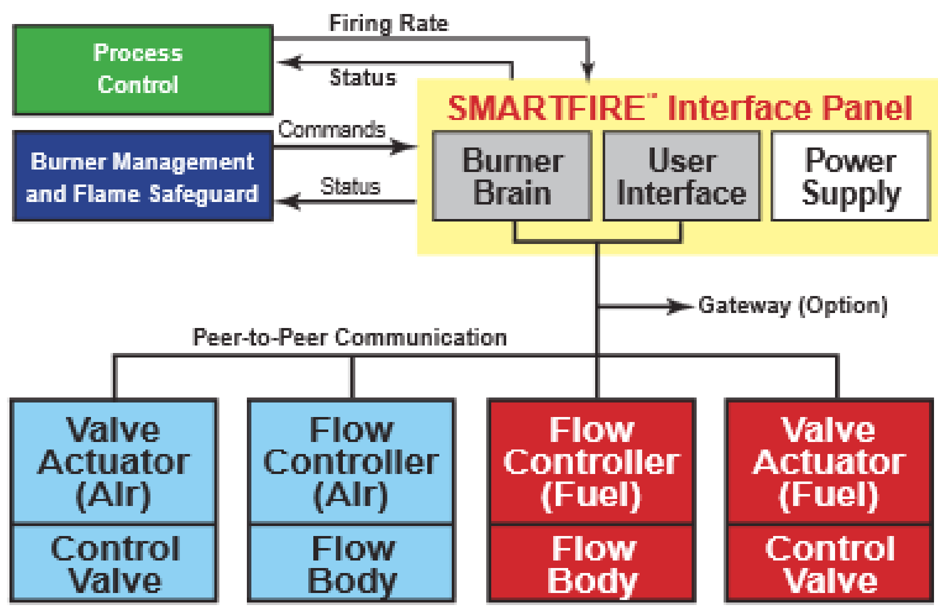


Fully Metered Mass Flow Control

- Air and Fuel flow meters used in conjunction with electronically-linked control valves.
- Valve positions determined by central control interface based on heat requirement and flow feedback.
- Commonly used in emissions driven applications due to repeatability of control and level of characterization.
- Flexible to install since air and fuel valves do not need to be located near each other.

Fully Metered Mass Flow Control (cont.)

- ~20:1 Turndown
- Pros: Best Available Control Technology, Self-tuning/correcting with flow feedback
- Cons: More expensive, Can be slower to respond to aggressive control signals.
- Critical Component: Interface Panel



Any Questions?

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