Getting the MOST out of your combustion system

Brian Kelly
General Manager, Industrial Sales
Hauck Manufacturing Company
Getting the **MOST**

- **MOST** Production
- **MOST** Quality
- **MOST** for your fuel $/**MOST** energy efficiency

- When you consider these issues, your combustion system in combination with your kiln/furnace is the key in achieving these objectives.

**FIRST**, take a good hard look at your present system/situation.
**MAINTAIN YOUR EQUIPMENT**

- Burner tuning
- Combustion air filtering
- Kiln maintenance
- Controller tuning
- Training/Record keeping
BURNER TUNING

Air/Fuel Ratio

• Over time burner settings (air/fuel ratio) will drift, because of component wear, temperature, etc…, this can ultimately affect:
  • Efficiency/Fuel Usage
  • Product Quality
Example: A burner’s air/fuel ratio drifts to 30% excess air from its initial setting of 10%. Readjustment back to 10% will result in a 15% energy savings.
Combustion Air Filtering

• Unfiltered Systems
  - Overtime dust/particulate will build up in pipes/burners
    - Increased system pressure drop (ie. smaller pipe)
    - Less air to burner = Less air to system = Less input
      = Less production = Wasted energy

• Filtered Systems
  - Regular maintenance schedule based on operating conditions.
Kiln Maintenance

The objective: Contain heat in the kiln to heat product/minimize heat losses.

• Openings
  ▪ Radiation losses = wasted energy
  ▪ Air infiltration = wasted energy

• Refractory
  ▪ Poor refractory maintenance=wall losses=wasted energy

• Pressure Control
  ▪ Poor/No pressure control = wasted energy/poor uniformity
Controller Tuning

Tuning of controllers

• Tighter control = less fuel usage/tighter uniformity
  ▪ Best controller can’t overcome a poorly tuned/designer combustion system
Training/Record Keeping

Training

• Basic combustion training/knowledge

Record Keeping

• Baseline reference for optimum operation.
• Easy to check/adjust to baseline.
• Analysis can be done.
EQUIPMENT AND CONTROL

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Equipment and Hardware

Equipment/hardware on the kiln/furnace

• Is the equipment right for the job?

• Equipment age: Many combustion systems are 15 years or older.

• Burner and Component advancements/improvements:
  ▪ Improved mixing
  ▪ Improved emissions
  ▪ Improved turndown
  ▪ Improved heat transfer
  ▪ Tighter air/fuel ratio control
System Control

Control Systems/Methods

• Best burner + poor/inadequate control scheme = poor performance.

• Advancements in control technologies can assist in system control: Precision and reaction.

• Control of the combustion system has to address the application/product requirements. The design of the system will dictate:
  ▪ Temperature Uniformity = Product Quality
  ▪ Efficiency = Lower Fuel Costs
  ▪ Maximum Heat Transfer = Optimum Production
Fuel-Only/Excess Air Control

Air Valve

Controller

Gas Valve & Actuator

Air Trim Valve

To Other Burners in Zone

Limiting Orifice
**Fuel-Only/Excess Air Control**

**Advantages**
- Simple
- Less expensive
- Maintains high exit velocity/temperature uniformity

**Disadvantages**
- Versatility
- Thermally inefficient
- Burner must be excess air capable
Ratio/Cross-Connected/Pressure Balanced

Diagram:
- Air
- Gas
- Air Valve & Actuator
- Controller
- Air Impulse
- Air Trim Valve
- Limiting Orifice
- Ratio Regulator
- To Other Burners
Ratio/Cross-Connected

**Advantages**
- Simple/relatively easy set-up
- Generally inexpensive
- Fuel efficient

**Disadvantages**
- Temperature uniformity will suffer with reduction in burner exit velocity with turndown
Pulse Fire Control
Pulse Fire Control

- Specialized type of cross-connected control
- Frequency modulation instead of amplitude modulation
- Special air solenoids and ratio regulators for each burner.
- Burners fire high-low or high-off
- Can be used with any burner capable of cycling
**Pulse Fire Control**

- Burners operate at either high fire or low fire.
  - High and low flows are fixed and repeatable (for reliable and almost unlimited turndown).
- Heat input is controlled by varying the amount of time the burners are pulsed off.
  - Individual burner “high fire” times are sequenced so all burners “take their turn” at high fire.
Pulse Fire Control

25 % Demand

Time

Burner

0 6 12 18 24 30 36 42 48 54
Pulse Fire Control

50% Demand

Burner

1 2 3 4

Time

0 6 12 18 24 30 36 42 48 54
Pulse Fire Control

Advantages

• Reduces fuel usage
  - Reduces excess air required for uniformity & turndown.
  - Increases heat transfer
• Reduces emissions
  - Less fuel input required = A lower emissions potential.
  - Better “natural” flue gas re-circulation.
• Increases/promotes temperature uniformity without excess air
• Uniform piping and equipment to every burner
• All burners are set identically (high/low fire)
• Electronic zoning makes changes easy
• Pulse logic can be tailored for application needs = Flexibility
Pulse Fire Control

Disadvantages

• Hardware costs
  ▪ Each burner has air and gas controls valves so upfront capital costs are higher than traditional control systems
  ▪ Control system can be more expensive
Efficiency

How can fuel usage be reduced further beyond the methods discussed?

**Air Preheat**

- How does heat recovery save fuel?
  - Preheating the air reduces the heat required to attain exit gas temperature.
  - Flame temperature is increased.
  - More heat is now available to heat the load instead of the air.
PREHEATED AIR

### Energy Saving

**Current Units**
- US-Units
- SI-Units

**Select Fuel**
- Average Natural Gas
- Blast Furnace Gas
- Butane

#### Enter Combustion Condition data for both cases

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Case I</th>
<th>Case II</th>
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<td>Combustion Air Temperature</td>
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<tr>
<td>Exhaust Temperature</td>
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<td>Excess Air (%)</td>
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<td>Oxygen in Combustion Air (%)</td>
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<td>Flue Gas Recirculation (%)</td>
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<tr>
<td>Flue Gas Recirculation Temperature (%)</td>
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<tr>
<td>Fuel Preheat Temperature</td>
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**Energy Savings Calculations**

<table>
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<tr>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>Available Heat Case I (%)</td>
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<tr>
<td>Available Heat Case II (%)</td>
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<tr>
<td>Energy Saving in Case II (%)</td>
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</tbody>
</table>

**Buttons**
- Calculate Energy Savings
- Energy Cost
- Print Preview
- End
How do you preheat the air?

**Recuperation**
- Centralized Recuperator/Heat Exchanger
- Self-recuperative burners

**Regeneration**
- Paired Regenerative burners

Air preheat will be seen more often as fuel prices continue to rise and CO₂ (carbon) emissions become increasingly regulated.
There is no one burner, one control method, or one system that will act as a magic wand for increased productivity, improved product quality and reduced fuel costs. There are advantages and limitations with all system types.

In the end, the question remains: What change, upgrade, or improvement will be the best choice to achieve your goals in your application?
Thank you

Questions??