OPERATIONAL CRITERIA AND BURNER MODIFICATIONS FOR ACHIEVING LOW LOAD UNSUPPORTED COAL FIRING ON TANGENTIAL AND WALL-FIRED UNITS

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RMEL SESSION ABSTRACT:

With all the renewables on line, coal plant owners commonly need additional flexibility to be on reduced load standby for extended periods. However, they also don’t want to co-fire expensive oil or gas to support coal at low loads. The goal is to fire coal unsupported at the lowest loads possible.

This session presents the common operational and system issues as well as the criteria behind achieving low load flame stability on both tangential and wall-fired units, and the possible equipment upgrades / modification that can be applied.
Coal fired units were not designed for low load operation flexibility

- Below control load operation, everything really starts to be affected.
  - Boiler steam, water and tube metal temp control
  - Low steam turbines inlet temperatures
  - Coal pulverizers, burners, flame scanners & flame stability
  - Loss of air flow controllability
  - Thermal and mechanical transients
  - Control of emissions/control systems
    - ESP’s
    - Wet FGD’s
    - SCR’s

Courtesy: ICT, Inc
Add in the daily challenges that affect operations

- Weather / wet coal
- Need to be on standby even when market price is below production price
- Pressure for quicker startups with short notice
- Rapid ramp rates/ constant equip. cycling
- Slow controls or equipment response
- Managing operation for daily emission limits
- Typical equipment problems & delays
- Less experienced operators managing risks
Key design & operational factors influencing unsupported coal flame stability and turndown:

<table>
<thead>
<tr>
<th>Boiler</th>
<th>Burners</th>
<th>Coal</th>
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</thead>
<tbody>
<tr>
<td>• Unit load</td>
<td>• Burner Design</td>
<td>• Reactivity</td>
</tr>
<tr>
<td>• Zonal heat release rates</td>
<td>• Flame retention features</td>
<td>• FC/VM ratio</td>
</tr>
<tr>
<td>• Excess air</td>
<td>• Mixture velocity</td>
<td>• Coal rank / HHV</td>
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<tr>
<td>• WB air press. &amp; distrib.</td>
<td>• A/C ratio</td>
<td>• Moisture content</td>
</tr>
<tr>
<td>• Furnace cleanliness</td>
<td>• Burners / mills in service</td>
<td>• Sulfur / Iron Oxide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ash content</td>
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<td></td>
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<td>• Oxygen content</td>
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Burner Systems: Typical pulverizer outlet flow conditions produce very lean A/C ratios at lower feed rates that are not conducive for flame stability.
At higher A/C ratios and cooler low load firing conditions, the use of special High Turn Down (HTD) tilting tangential nozzles is available for unsupported coal firing.

**Case Assumptions:**
- Two adjacent elev. I/S
- Burner elevation separation: 60 inches
- Normal dirty air velocity
- Applicable: Lignite sub & bit. coals
Comparison Views of Standard vs Special High Turn Down (HTD) Coal Nozzles
-Tangential Firing Systems-

Conventional Coal Nozzle Assembly

High Turndown Coal Nozzle Assembly

Courtesy R-V
HTD coal nozzle assemblies produce the required conditions for unsupported stable coal flames at lower unit loads.

Special corrugated V-shaped diffuser with shear bars produces local turbulence & recirculation.

Coal nozzle and inlet elbow design concentrates coal, reducing A/C ratio and adjusts for discharge velocity.
Managing A/C ratio’s entering fuel nozzles

- When it's difficult to balance A/C ratios between burners within range for flame stability, adjustable riffles/kits have been used successfully.

- On-line adjustable riffles can tightly balance either coal and/or primary air all within a single device.
HTD tangential fired industry experience evolved from back in the days of the oil crisis.

- ~35 Field erected industrial units
- ~20 Utility units

**Typical Turndown Results**

<table>
<thead>
<tr>
<th>Before w/std nozzles- % MCR</th>
<th>W/HTD Nozzles- % MCR</th>
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</thead>
<tbody>
<tr>
<td>50%</td>
<td>25%</td>
</tr>
<tr>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>30%</td>
<td>18%</td>
</tr>
<tr>
<td>20%</td>
<td>15%</td>
</tr>
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</table>
Common Wall-fired Burners Supplied by Various OEM’s
Stable unsupported wall-fired coal burner flames are a function of burner design, coal quality, and burner zone heat concentration.

40% to 45% MCR is a common TD range for most wall-fired coal boilers.
Wall-fired burner designs and upgrades are available that with some optimization can improve unsupported coal flame stability from ~45% down to under 30% MCR.

**Case Assumptions:**
1. High quality burners (Swirl #: 0.8 to 1.2)
2. Opposed or adjacent wall-fired burners I/S
3. Proper A/C ratio
4. Quality flame scanners
Wall-fired burner upgrades that can improve low load unsupported flame stability

**Air Registers**
- Stronger air register swirl generation & stronger recirculation zone and **better air flow** control at lower load

**Stability Nozzles**
- Mechanical **flame stability** coal nozzle. Courtesy: Doosan
- Aerodynamic **flame stability** coal nozzle. Courtesy: R-V

**Fuel Concentration Nozzles**
- **Fuel Concentrating** coal nozzle assemblies.
30% MCR firing eastern bituminous high sulfur coal in dual zone axial swirl low NOx registers fitted with aerodynamic flame stabilizing tips
IN SUMMARY

- Most coal fired units and their subsystems were not initially designed for flexible operation and minimum load operation.

- High Turndown (HTD) coal nozzle assemblies installed on tangential fired units can produce unsupported coal firing as low as 15% unit load.

- Burner upgrades with some re-optimization on most wall-fired units can increase unsupported turndown below 30% MCR.

- Turndown potential is unit specific based on equipment assets.