amec
foster
wheeler

Design improvements for older single fired delayed coker heaters

XX mm yyyy

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What you have

Classic single fired coker

What you want

Terrace Wall Double Fired Coker

What you need

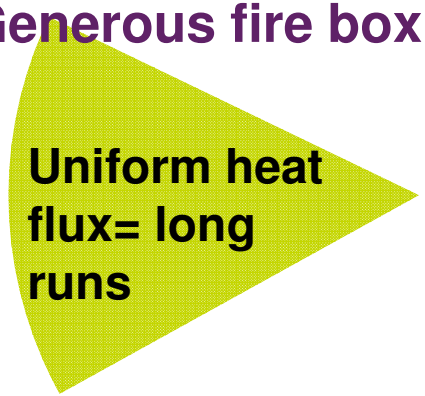
Money!

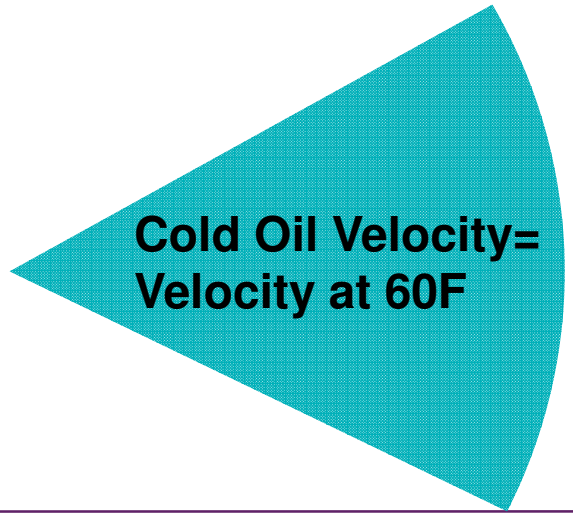
What can we do?

Revamp the coker heater

~~Elliott's~~ Srini's rules for coker heater design

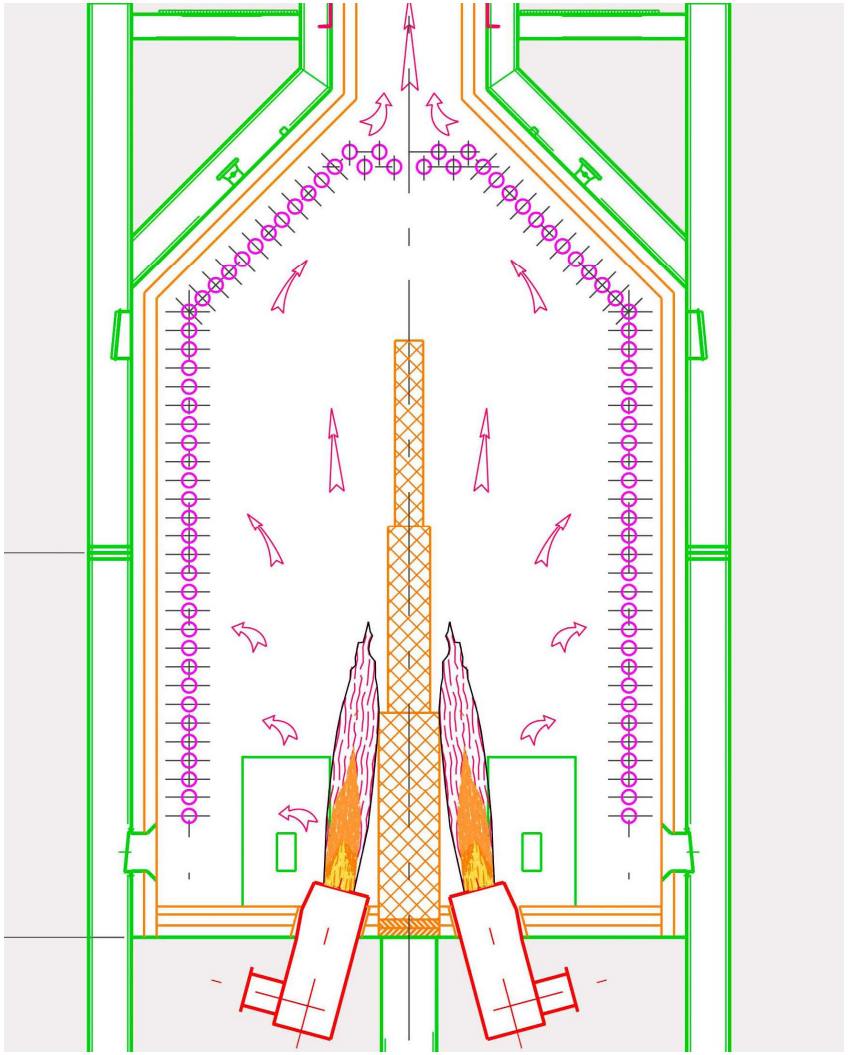
- **Individual pass control and firing required**
- **High cold oil velocities- 6 fps (1.8 m/s) minimum**
- **Minimum residence times above the cracking temperature**
- **Optimum heat flux**
- **No mal-distribution of heat flux (uniform heat flux)**
- **Constantly rising temperature profile (no dead zones)**
- **Symmetrical pass arrangement and connected piping**
- **Proper velocity medium injection rate**
- **Generous fire box dimensions**





Review the revamp options

- Convection section
- Radiant section
- Burners
- Draft



Convection section or external preheat

Preheat is always good: True or False?

False - not *always*

Preheat unloads the radiant section and has the benefit of reducing the firing. However, if the preheat is so much that the crossover temperature is approaching or over 750°F, then the longer residence time increases the coking tendencies. Also there is a risk of coking in the convection section.

Convection section operation

Convection section operation has no impact on coking in the radiant section: True or False?

False

The crossover temperature is impacted by convection operation and if fouled, this leads to too little heat pick up in the convection section then requiring the burners to fire harder; increasing the radiant heat flux rate.

Also a fouled convection section may limit draft which impacts burner flame shape and firing ability.

Impact of convection section losses

Convection section fouling

- Higher draft across the convection can cause rate limitations if ID fan or stack limited
- Loss of heat transfer will cause dut load to shift to the radiant section
  - More firing
  - Higher heat flux
  - Higher bridgewall temperature

Crossover temperature increases

- Longer residence times above cracking temperatures
- Possible cracking in shield tube rows

Convection section review topics

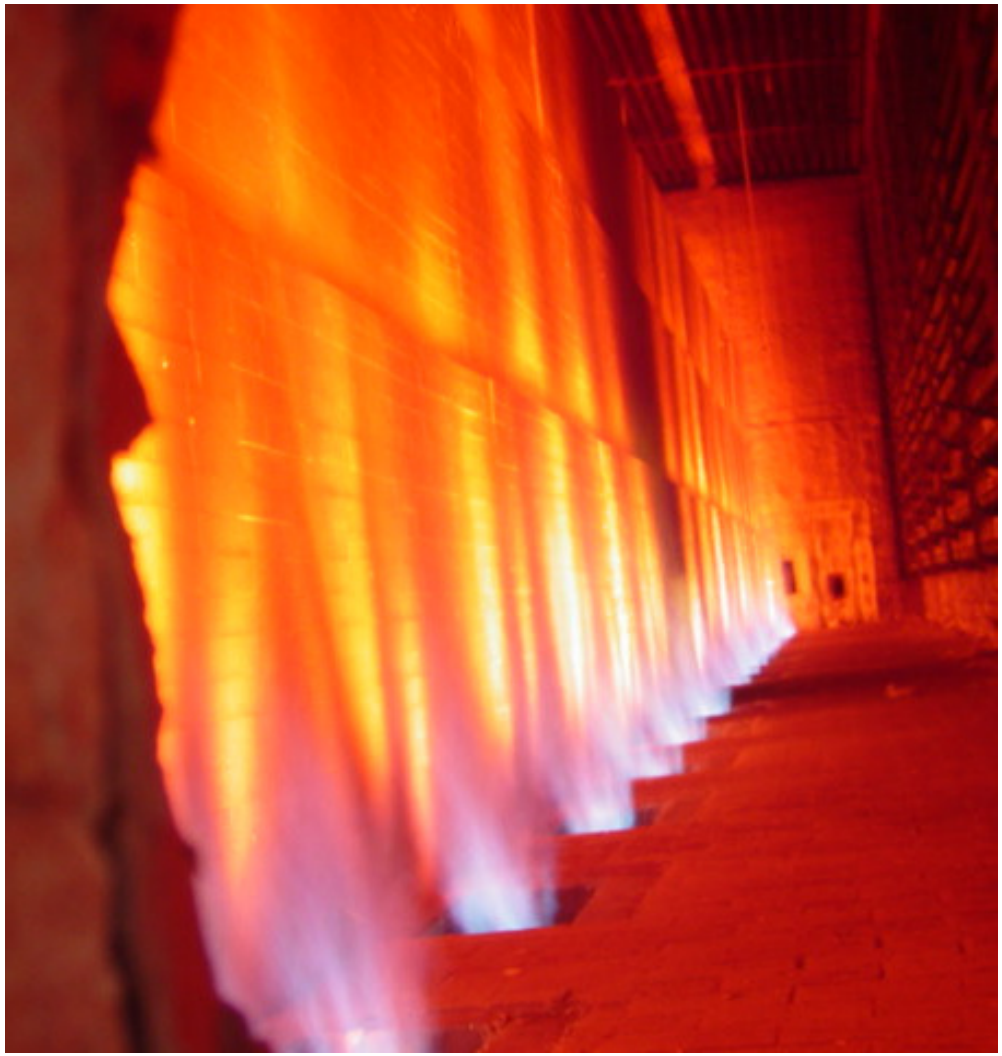
- Crossover temperatures of 700°F are ideal
- 150ºF approach temperature (flue gas out to process in) is a rule of thumb design benchmark
  - More means a fouled convection
  - Steam generation lowers this slightly
- Draft across the convection section should be ~0.3-0.5” WC.
  - Higher if fouling in convection tube’s extended surface
  - Or if increased flue gas flow rate due to high O2/ air leakage
- Check crossover temperatures between passes for fouling or blockage
- Thermally scan convection wall for refractory damage

Retubing or replacing can help coking tendencies

Radiant section design

Most Radiant coker heaters issues relate to these items

- Burner flames
- Tube diameters
- Tube metallurgy
- Radiant coil layout
- Fittings (plug headers and return bends)



Where are the current operational issues?

- Require longer runs?
- Need to lower heat flux?
- Want more capacity?
- Need to lower pressure drop?
- Just be more efficient?

Radiant section Client 1

Issues

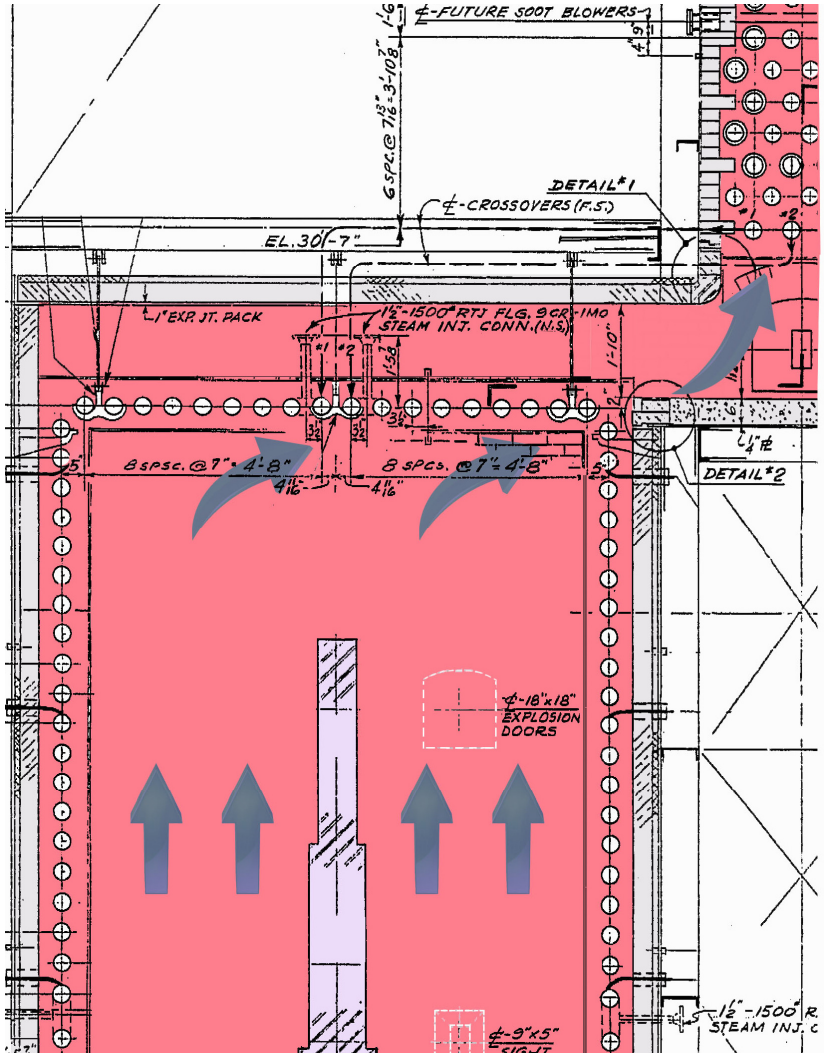
- Coking issues on roof tubes
- Long burner flames
- Return bend erosion

Design Features

- Suspended arch
- 347H SS tubes

Desired operation

- Reduce coking
- Longer runs
- Current design capacity



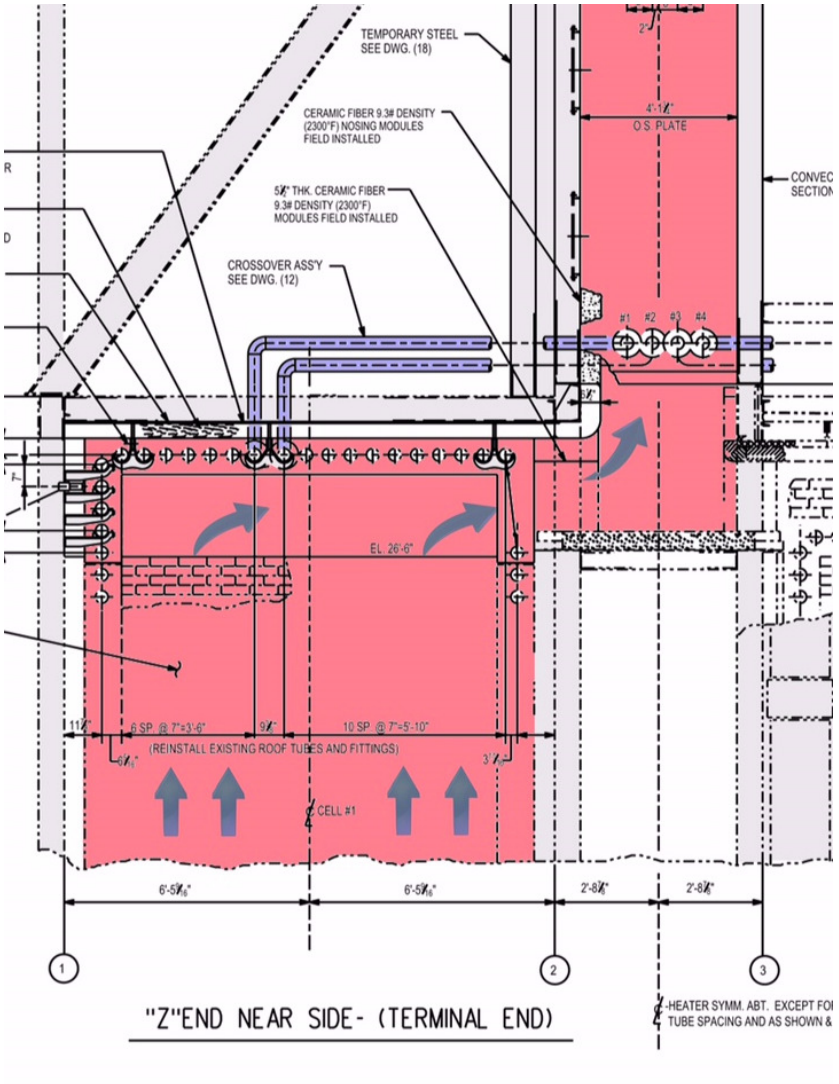
Radiant section Client 1

Solutions

- Added tubes to the side wall to increase surface area
- Tubes raise to roof to increase burner to tube clearance
- Improved cast return bends with constant thickness back wall
- 347H SS for increased TMT

Relocated the crossovers for same tubes per pass

Convection section replaced for optimum design



Client 1 Results- Design Conditions

Old	New
132 tubes	140 tubes
8350 ft2	8906 ft2
TMT- 1075ºF	TMT- 1200/1400ºF (1)
A200 T9 (2)	347 H SS
Plug headers	Cast return bends (3)
ΔP= 320 psi	ΔP= 330 psi (4)
10,500 Btu/hr-ft2	8400 Btu/hr-ft2 (5)

- (1) 1200ºF Design but 1400ºF for spalling operations
- (2) client upgraded the 132 tube design to 347H SS, added tubes were 347H SS
- (3) previous return bends had graduated thickness from tube wall to back wall, new return bends had full thickness walls
- (4) Pressure drop is with ~10% more flow and reduction is from return bends rather than plug headers
- (5) client added APH and new burners

Radiant section Client 2

Issues

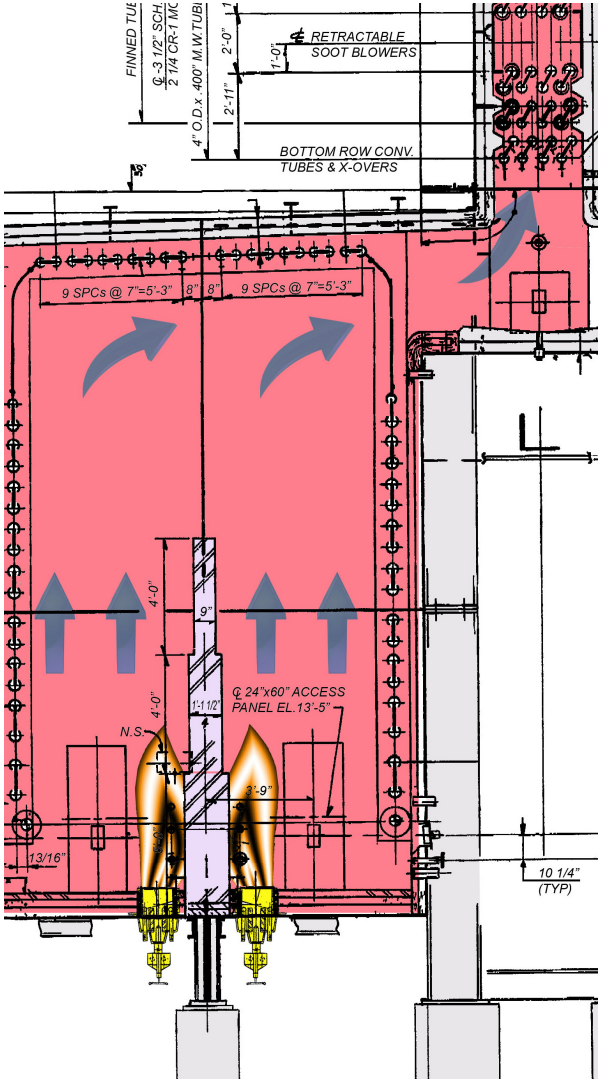
- High pressure drop
- Capacity limited

Design Features

- Plug headers
- Different tube diameters in radiant section
  - Roof tubes 4.0” OD
  - Wall Tubes 4.5” OD

Desired operation

- Lower pressure drop
- Increased capacity



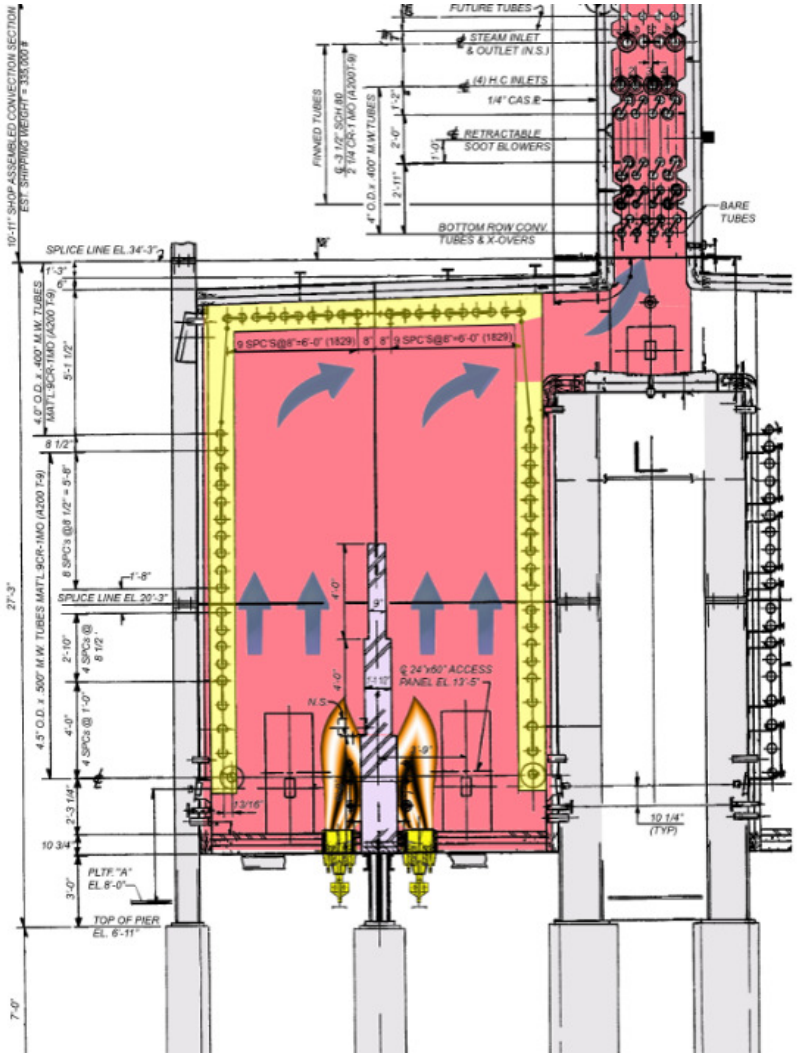
Radiant section client 2

Solution

- Plug headers changed to contoured plug headers –saved 15% of ΔP
- One tube diameter in radiant section additional ΔP impact

Could have added tubes in the pressure relief door area for heat flux reduction

Capacity increased



Client 2- Results 'Old' Design Operation

Old	New
116 tubes	116 tubes (1)
10,713 ft2	11,184 ft2 (1)
TMT- 1230ºF	TMT- 1230ºF (2)
A200 T9	A213 T-9 (3)
Plug headers	Cast return bends
ΔP= 400 psi	ΔP= 340 psi (4)
9000 Btu/hr-ft2	8645 Btu/hr-ft2

- (1) 11 tubes per pass increased from 4" OD to 4.5" OD
- (2) Same design basis for new tubes as old tubes
- (3) API 530 has lower stresses on A 200 T9
- (4) results of contour plug headers for old plug headers

Retubing a coker heater can…

1. Lower pressure?
2. Increase capacity?
3. Reduce heat flux?
4. Increase TMT range?
5. All of the above?
6. Some of the above?

Trick question!

- Each item can be addressed but not all at one time. For example, reducing heat flux and increasing capacity, usually are not possible in most circumstances

Double row roof tubes

Do I lose much going from a double row roof tube design to a single row?

- Not much, especially if there is a suspended arch design that can add tubes. The shielding effect of the double row design means the first row is about ~70% effective for radiant heat transfer and the second row about ~30%. The heat flux increase is not as significant an impact as expected as the TMT is marginally increased

Metallurgy

Should I go to 347H SS instead of 9Cr-1Mo on the next retube?

- Not necessarily. 9Cr-1Mo can run to 130°F which works well for spalling operations as we recommend a 125°F maximum TMT temperature for optimum spalling operations
- Older designs may only have TMT set at 115°-120°F while new 9Cr-1Mo tubes can be designed for 130°F
- 347H SS or other high alloy materials may be considered for quicker spalling operations, non-organic fouling situations or with experience higher operating temperatures

Spalling

Can On line spalling be used on every heater?

- Most heaters. It is ideal for 4 pass twin cell box heaters with a common convection section where the convection section is preheat for the radiant section. Other combinations have issues with the steam or condensate heat pick up in the convection section and resulting temperature ineffective for the temperature fluctuation needed to spall the coke off the tubes. It is a tube flexing operation of expanding and shrinking the tube and not simply a steam sparging operation

Other revamp options

- Tubes in convection section future tubes section
- Tubes in sootblower lanes
- Buy tubes – not pipe, i.e. 4”; 4.25” 4.5” 4.75” OD
  - With cast return bends used, tube spacing does not need to change
  - As tubes the wall thickness can be specified
- Add APH system
  - Lower firing and raises efficiency
  - Increases flux rate
- Check burners for flames shape and stability
- Replace burners and shape flames as needed
- Check draft for plugged convection section
- Replace stack dampers if locked closed

Of course if you have a lot of…

Money!

And you want…

Terrace Wall Double Fired Coker

Come see us!

Amec Foster Wheeler Fired Heater Division

Questions?

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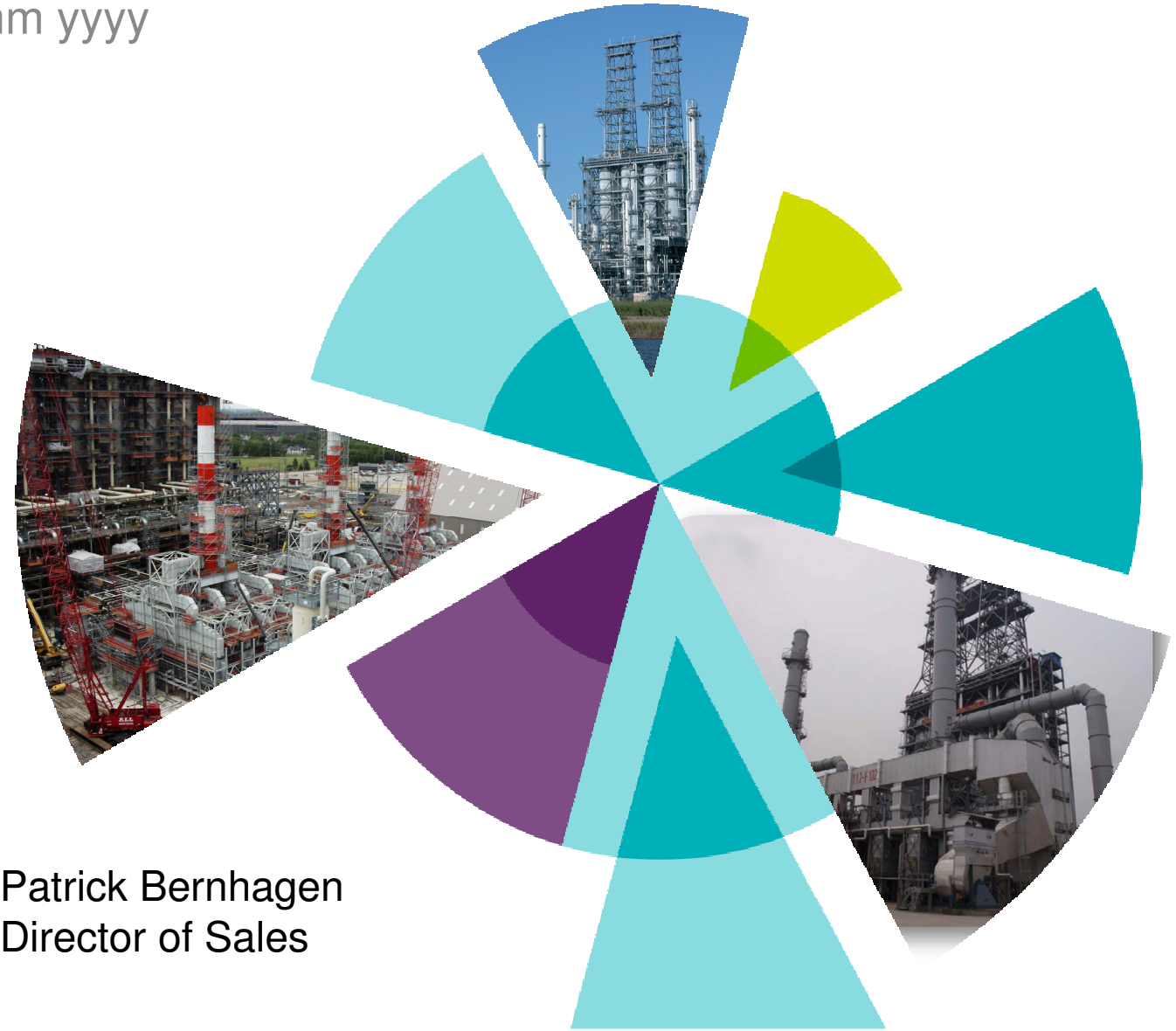

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