Kiln Process  
October 27-28, 2021

Wednesday, October 27
8:00  WELCOME
8:05  Introduction & Chemistry
10:00 BREAK
10:15 Preheaters and Precalciners
12:15 LUNCH
1:00  Kilns
2:45  BREAK
3:00  Coolers
4:30  EVALUATION

Thursday, October 28
8:00  Burners and Combustion
9:45  BREAK
10:00 Kiln System Emissions
11:45 LUNCH
12:30 Volatile Cycles
2:15  BREAK
2:30  Heat Consumption
4:30  EVALUATION & ADJOURN
Kiln Process

Course Content

1. Raw material design and chemistry
   1.1. Introduction
     1.1.1. Chemical requirements for Portland Cement
     1.1.2. Cement types
     1.1.3. Clinker compounds
   1.2. Typical raw materials used for cement manufacture
     1.2.1. Limestones
     1.2.2. Argillaceous materials
   1.3. Mix design factors and their meaning
     1.3.1. Lime saturation factor
     1.3.2. Silica modulus
     1.3.3. Alumina modulus
   1.4. Chemical impacts on operations
     1.4.1. Strength
     1.4.2. Set-time
     1.4.3. Minor element impacts
   1.5. Summary & conclusions
   1.6. Questions & answers

2. Kiln Systems, preheaters, & precalciners (Ove)
   2.1. Introduction
   2.2. Evolution of kiln, preheater & precalciner design
     2.2.1. Kilns
     2.2.2. Preheaters
     2.2.3. Precalciners
   2.3. Principles of operation of the preheater
     2.3.1. Heat transfer
     2.3.2. Dust collection efficiency
   2.4. Preheater Components
     2.4.1. Cyclone thimble / dip tube
     2.4.2. Material seal / flap valve
     2.4.3. Splash box
   2.5. Precalciner Basics
     2.5.1. Residence time and fuel burn-out
     2.5.2. Mixing effects
     2.5.3. Low NOx designs & operation
     2.5.4. Build-ups & solutions
   2.6. Summary & Conclusions
   2.7. Questions & Answers
3. Kilns

3.1. Introduction
3.2. Chemical reactions taking place in the kiln
   3.2.1. Kiln inlet
   3.2.2. Calcining zone
   3.2.3. Transition zone
   3.2.4. Burning zone
   3.2.5. Cooling zone
3.3. Coating
   3.3.1. Chemistry
   3.3.2. Stability
   3.3.3. Interaction with refractory
3.4. Common kiln operating strategies
   3.4.1. Start-Up
   3.4.2. Shut-Down
   3.4.3. Exceptions
3.5. Common operating problems and solutions
   3.5.1. Examples from attendees
3.6. Summary & Conclusions
3.7. Questions & Answers

4. Coolers

4.1. Introduction
4.2. Cooler evolution
   4.2.1. First generation
   4.2.2. Second generation
   4.2.3. Third generation
   4.2.4. Traditional & new players
4.3. Basics of cooler operation
   4.3.1. Air to material ratio
   4.3.2. Bed depth considerations
   4.3.3. Cooling air velocity
4.4. Typical cooler problems
   4.4.1. Uneven bed depths
   4.4.2. Over and under airing
   4.4.3. Snowmen & red rivers
   4.4.4. Overheating
4.5. Options in clinker crushing
   4.5.1. Hammer crushers
   4.5.2. Roll crushers
4.6. Summary & Conclusions
4.7. Questions & Answers
5. Burners & Combustion

5.1. Introduction
5.1.1. Typical Fuels for cement kilns

5.2. Combustion Reactions
5.2.1. Volatiles
5.2.2. Fixed carbon
5.2.3. Ash

5.3. Factors influencing speed of combustion
5.3.1. Temperature
5.3.2. Air fuel mixing
5.3.3. Volatile content
5.3.4. Char porosity

5.4. Kiln burner design
5.4.1. Direct fired burners & evolution
5.4.2. Indirect fired burners
5.4.2.1. First generation burners
5.4.2.2. Low-Nox burners
5.4.2.3. Third generation burners
5.4.3. Common burner controls

5.5. Calciner burner design
5.5.1. Common calciner burners
5.5.2. Staged combustion
5.5.3. Down draft calciner burners

5.6. Common problems with burners and combustion
5.6.1. Kilns
5.6.2. Precalciners

5.7. Summary & Conclusions
5.8. Questions & Answers

6. Kiln System Emissions

6.1. Introduction
6.2. Overview of regulations

6.2.1. NESHAP
6.2.2. CISWI
6.2.3. HWC
6.2.4. Other (World Bank, general limits)

6.3. Sources of emissions
6.3.1. Combustion
6.3.1.1. NOx
6.3.1.2. SOx
6.3.1.3. CO
6.3.1.4. HCl
6.3.2. Raw Materials
6.3.2.1. SOx
6.3.2.2. CO
6.3.2.3. THC
6.3.2.4. Hg

6.4. Overview of control technologies
6.4.1. NOx
6.4.2. SOx & HCl
6.4.3. CO
6.4.4. THC & VOC
6.4.5. Hg

6.5. Summary & Conclusions
6.6. Questions & Answers
7. Volatile Cycles (Ove)
   7.1. Introduction
      7.1.1. Volatile compounds
      7.1.2. Sources of volatile elements
   7.2. Reactions
      7.2.1. Primary volatilization
      7.2.2. Secondary volatilization
      7.2.3. Volatilization temperatures
   7.3. Sulphur cycle
   7.4. Build-up
      7.4.1. Hot meal testing
      7.4.2. Surface temperature monitoring
      7.4.3. Record keeping
      7.4.4. Strategies to reduce build-up
   7.5. Rings
      7.5.1. Tail Rings
      7.5.2. Spurrite / sulphur rings
      7.5.3. Sinter Rings
      7.5.4. Nose Rings
   7.6. Balls
   7.7. Summary & conclusions
   7.8. Questions & answers

8. Heat Consumption
   8.1. Introduction
   8.2. Heats of Reaction
      8.2.1. Chemical drivers
      8.2.2. Physical drivers
      8.2.3. Tests to perform
   8.3. Heat recuperation in the preheater
      8.3.1. Determining the heat input
      8.3.2. Seeking and correcting inefficiencies
      8.3.3. Minimizing heat losses
   8.4. Heat recuperation in the cooler
      8.4.1. Heat loss in clinker
      8.4.2. Heat loss in cooler vent air
      8.4.3. Radiation losses
      8.4.4. Other losses
      8.4.5. Optimization
   8.5. Radiation losses
      8.5.1. Preheater
      8.5.2. Cooler
      8.5.3. Kiln
   8.6. Raw mix chemical stability
   8.7. Summary & Conclusions
   8.8. Questions & Answers