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An "Ideal" Mill Inerting System

(Using Conventional Methods)

Objectives

- Attain inert status as rapidly as possible
- Confirm inert status
- Maintain inert status throughout all startup, clearing and trip activities
- Minimum, but adequate use of inerting media
- Avoid raising explosive dust (fines)

Boundaries, Comments

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- Addressing medium speed vertical spindle mills, only
- Not an attempt to override manufacturer's recommendations
- Have not addressed fire suppression
- Not a "cookbook" for detailed engineering such as fogging flow rate determination, inerting media flow rate determination, pipe sizing, nozzle sizing, nozzle location, and site specific control logic

Inerting Media

- Media selection primarily an availability and economic issue
- Steam nearly always most readily available
- Steam nearly always most economical
- Steam used by 66% of PRB Users
- This presented system will address use of steam

Premise

- Almost all inerting systems are open loop
  - How do we know the mill **ever** becomes inert?
  - How do we know **when** the mill is inert?
  - How do we know the mill **remains** inert as long as needed?
- Can we do a **better** job of economizing on the use of mill inerting media?

Testing

- Test Objectives:
  - Establish steam flow vs Time-to-Inert relationship for isolated mill
  - Establish rate of inert decay for isolated mill
  - Establish steam flow required for startup/shutdown (ie PA flow at minimum)
- Test at least one representative mill
- Monitor steam flow rate, mill O_2 & mill press
- Use <u>wet</u> O_2 analyzer for test

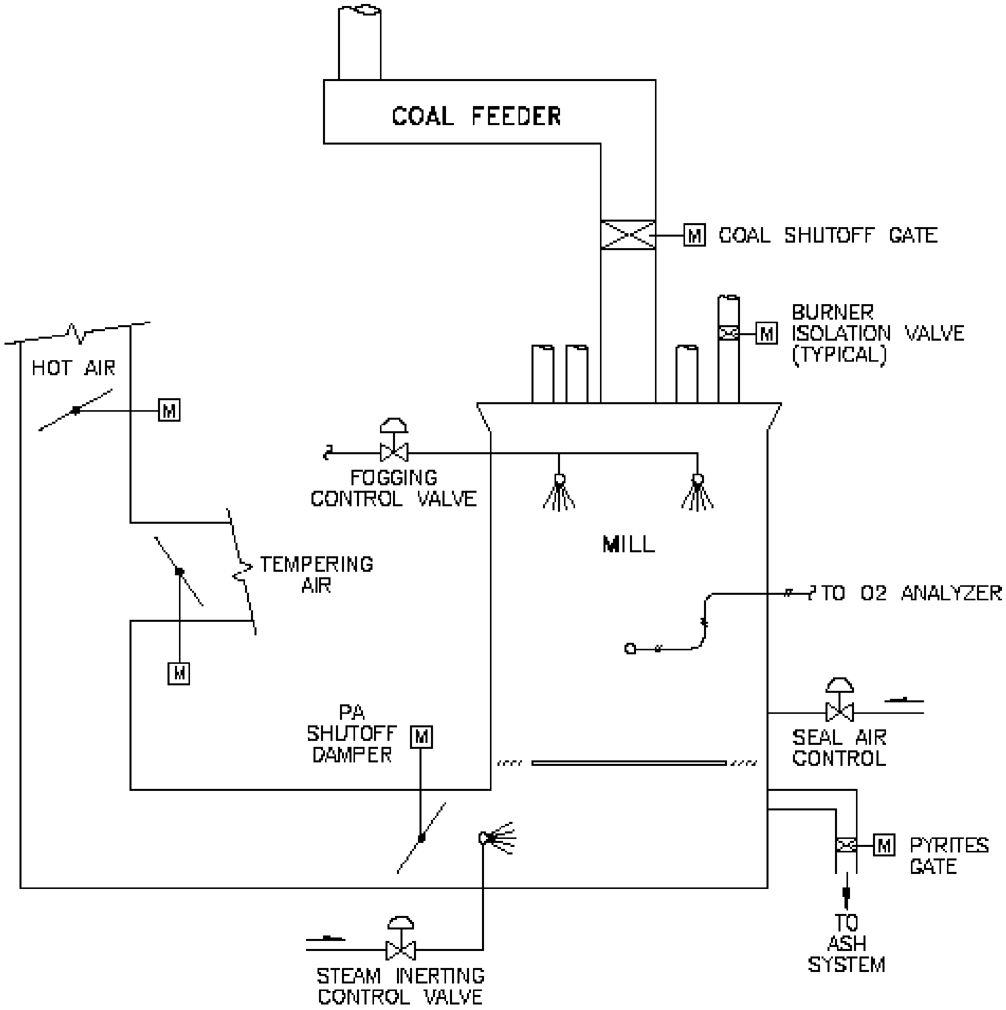
Inerting Modes

- Normal startup
  - Mill is clean when started
- Normal shutdown
- Post trip recovery
  - Mill is dirty when tripped
  - May proceed to shutdown, OR
  - May proceed to restart

Normal Startup

- <u>Isolate Mill via power actuators</u>
  - PA TSO damper closed
  - PA control dampers closed
  - Feeder discharge gate closed, (OR If no power operated discharge gate, then auto-close feeder inlet gate AND feeder seal air)
  - Mill burner isolation valves (swing valves) closed
  - Mill seal air valves closed
  - Pyrites box gate closed

Instrumentation & Control Devices



Normal Startup
(Continued)

- Start Mill Inerting System (MIS) sequence
  - Commence fogging
  - Cease fogging after **3 to 5 minutes**
  - Begin inerting steam flow at "Normal Inerting Flow" rate (sufficient flow to bring mill environment down to 14% O_2 within **2 minutes**)
  - Once "Inert Status" is attained, automatically reduce inerting steam flow to "Inerting Maintenance Low Flow" rate

Normal Startup
(Continued)

- <u>Start Mill</u>
  - Mill is still isolated
  - MIS is still in automatic at "Inerting Maintenance Low Flow" rate, modulating as required to overcome leakage and condensation to maintain "Inert Status"

Normal Startup
(Continued)

- Start coal feeder
- Open burner isolation valves (swing valves)
  - Mill PA control damper and temperature control dampers in control mode as recommended by mill manufacturer
  - PA flow commences through the mill, thus diluting inerting media
  - MIS is still in automatic. Feed forward increases inerting media flow rate to “Inerting Maintenance High Flow” rate required to maintain inert status with PA flow through the mill
- Stop MIS after mill is in successful operation as recommended by mill manufacturer

Normal Shutdown

- Reduce mill load to minimum feeder speed
- Start MIS at high flow rate required to maintain inert status with PA flow through the mill

Normal Shutdown
(Continued)

- Stop feeder
  - MIS is still in automatic at high flow rate
- Strip mill
  - MIS is still in automatic at high flow rate
- Close swing valves
  - MIS flow rate reduces to normal as required to overcome leakage and condensation to maintain inert status

Normal Shutdown
(Continued)

- Follow manufacturer’s mill cleaning procedure (swirl, etc)
- Stop mill
- Stop MIS

Post Trip Recovery

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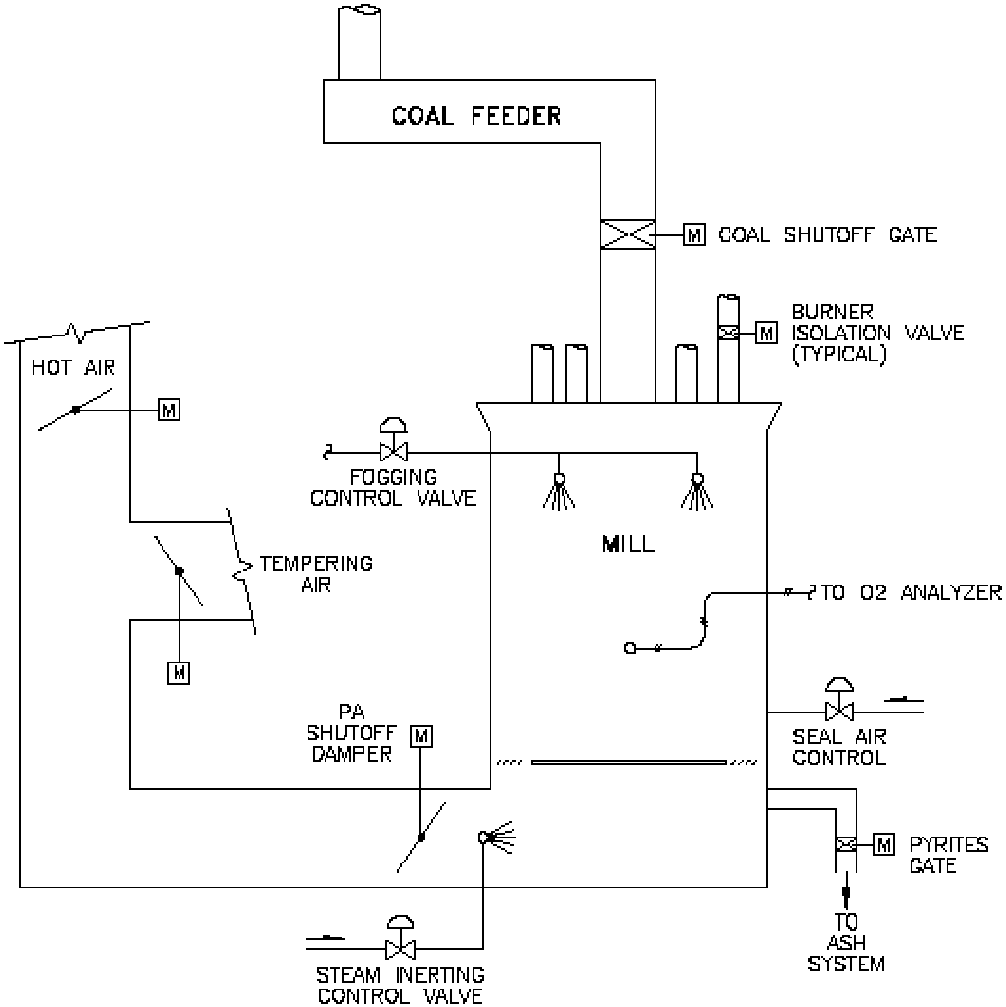
- Automatically start MIS upon trip
  - Simultaneously fog for **3 to 5 minutes** and admit inerting steam at high flow rate to bring mill environment down to 14% O_2 within **2 minutes**
- Restart mill (if recommended by manufacturer)
- Empty mill OR
- Set PA flow to minimum and open swing valves
- Slowly back out MIS

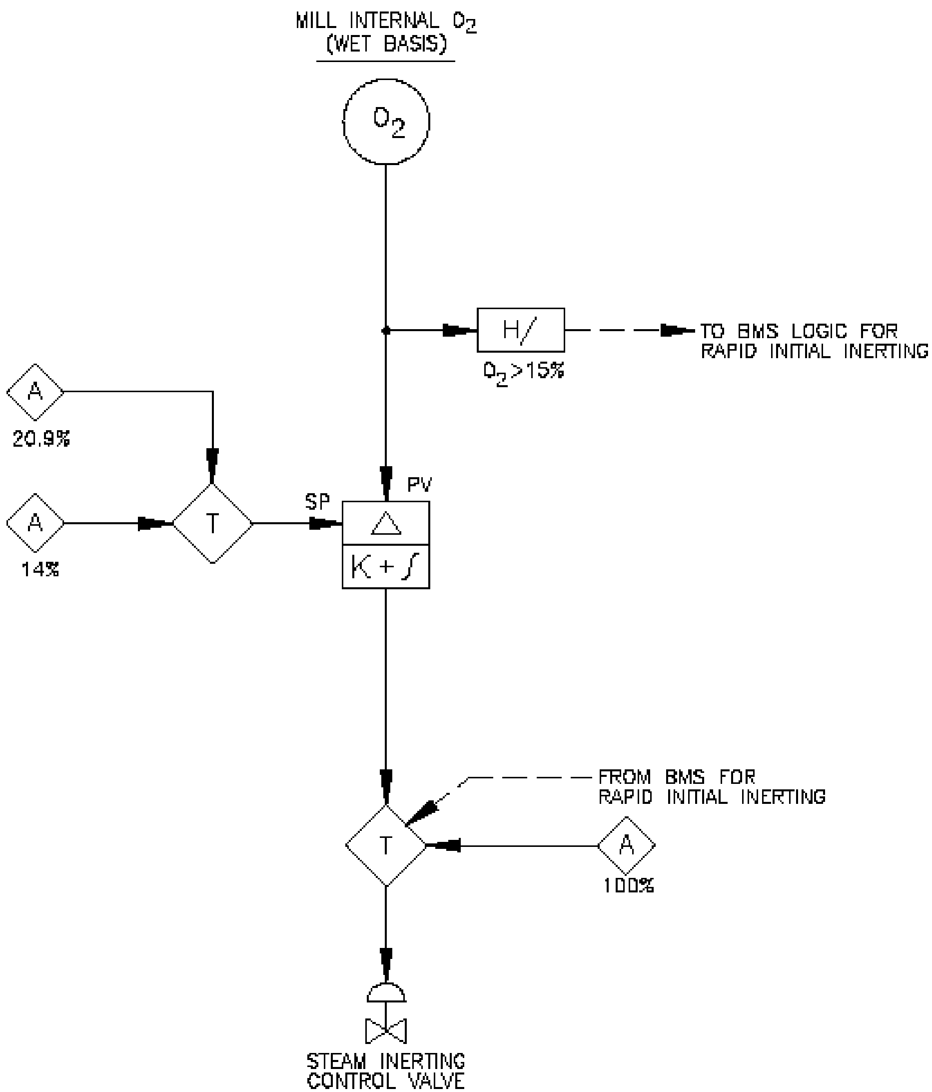
Instrumentation & Control Devices



Control Features

- Precede system design by testing
- Add mill O_2 analyzer to close the intelligence loop
- Purge O_2 analyzer sample port when not in use
- Change steam inerting FCV to be modulating
- Include actuators for all isolation devices
- Include position limit switches for all isolation devices

Control Logic



Design Issues- Elapsed Time to Inert

- Should inert as quickly as possible
- Time-to-Inert impacted by:
  - Mill size (Volume)
  - Completeness of isolation
  - Isolation integrity
  - Seal leakage
- Steam flow limitations:
  - Steam flow availability
  - Practical steam pipe size & line velocity
  - Quantity & size of inerting nozzles

Design Issues-
Inerting Steam Pipe & Valve Size

- Steam flow requirements:
  - "High" steam flow to inert isolated mill as quickly as possible
  - "Medium" steam flow to inert mill at min PA flow
  - "Low" steam flow to maintain isolated mill inert status
- Design parameters:
  - Steam press & temp
  - Pipe max line velocity per plant PDTs
  - Modulating control valve, max C_V for "High" flow rate
  - Control valve must control at "Low" flow rate

Design Issues-
Inerting Steam Nozzles

- Nozzle locations:
  - Follow manufacturer's recommendations
  - Consider locating in PA inlet duct
    - Steam will rise through isolated mill (much lighter than air)
    - Steam will flow through all of mill at startup/shutdown
- Nozzle Size:
  - Follow manufacturer's recommendation while minimizing velocity

Design Issues-
Fogging System

- Flow rate as high as practical pipe size allows
- Nozzles:
  - Several locations
    - 1. As high as possible
    - 2. Above each horizontal surface
    - 3. Below throat ring
  - Nozzles aimed away from mill swirl
  - Nozzles aimed away from horizontal surfaces
  - Nozzles aimed away from hot metal surfaces
  - Nozzle velocity low (avoid raising fines)

Instrument & Device List

- Mill O_2 analyzer, 0 – 20.9% wet basis
- Inerting Steam PCV, with power operator
- Inerting Steam FCV, with power operator, ZSC and ZSO
- Inerting Steam Nozzles, quantity as required
- Inerting Steam FM, local or remote reading for test & monitoring

Instrument & Device List
(Continued)

- Fogging Water PCV (~70 psig at nozzles)
- Fogging Water FCV, with power operator, ZSC and ZSO
- Fogging nozzles, quantity as required
- Fogging Water FM, local or remote reading for test & monitoring

Instrument & Device List (Continued)

- Primary Air Tight Shutoff Damper (PASO Damper) with actuator, position feedback and ZSC
- Hot Air Control Damper (HA Damper) with actuator and ZSC
- Tempering Air Control Damper (TA Damper) with actuator and ZSC
- Coal Feeder Shutoff Gate with actuator, ZSC and ZSO
- Mill Seal Air Shutoff Valve with actuator, ZSC and ZSO
- Burner Isolation Valves, with actuator, ZSC and ZSO
- Pyrites Box Gate, with actuator, ZSC and ZSO

“Ideal” Mill Inerting– Last Slide

Prepared by:

Exothermic Engineering Co., LLC
Liberty, MO
www.ExoEng.com
billsmith@ExoEng.com