Dynamic Operating Regimes of Ball and Tube Mill
With Varying Coal Quality - An Analysis

Presented
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Outlines of The Presentation...

- Ball & Tube Mills: Constructional Overview & Grinding Principle
- Variation of coal quality and its effect on Milling plant operation.
- Practices developed due to variations of Coal quality at Talcher-Kaniha
- Conclusion
Ball & Tube Mills: Constructional Overview & Grinding Principle
Ball and Tube Mill-BBD 4772

- **Broyer** - inventor name,
- **Boulet** - French word for ball and
- **D** - direct firing

- Heavier in construction.
- Exclusive lubrication system for support bearing, Girth Gear and for Main Reducer.
- Separate sealing system,
- Higher aux power consumption, but No Reject handling, this is the biggest advantage.
- Faster response to load variation. So better to work in ABT regime.
It involves nos. of sequences so operating is complex.
Ball and tube mills are working in the principle of:

- Attrition
- Hammering
The particle will remain against the wall as long the forces are balanced i.e. \(mg \cos \alpha + m\omega^2 R = mg \sin \alpha\) as shown in fig.

The particle will separate from the wall at the point where gravitational force is greater than centrifugal force. Gravitational force is more at the top where \(\alpha = 180^0\). The speed must be enough at that point to keep the particle revolving, which is \(m\omega^2 R = mg\), and \(\omega = \sqrt{\frac{g}{R}}\), is called **critical speed of the mill**.

Ball mills are usually operated at 60-80% of the critical speed for better attrition and impact effects.

Change of supply frequency causes change in grinding. We can see a more load pick up as frequency rises and vice versa in ball mill.
Power Drawn in Ball and Tube Mill
As charge volume increases slowly its power drawn will increase, but after a certain volume again power required will reduce as it will act as a solid drum rotating on the bearing with Jacking oil. So KW monitoring is essential in such type of mill.

Stop a feeder or reduce feed rate and increase PA flow to create a balance situation.
Variation of coal quality and its effect on Milling plant operation.
Variation of coal quality- different cases for operation

The coal Quality varies very fast in Talcher-Kaniha: Intra-day, in different times, in different seasons. The GCV changes, the moisture content varies and the VM content varies. The Mills are having different Ball loadings and liner life. The ingress of overburdens can't be ruled out into the mills. Accordingly, the operator has to understand the need for a dynamic operating regime based on the coal quality and physical mill conditions based on the parameters in stead of a pre-defined operating practices.

Following Variations of coal quality faced in Talcher-Kaniha:
- High moisture: “Sticky When Wet”
- Wet and slurry type coal during rainy season
- Blended Coal
- Low GCV Poor Indigenous coal
- Ingress of Foreign materials in particular large stones in Huge quantity
- One end operation due to entry of stones and other overburdens
- Low volume loading and seasonal variation in Mill power
- Role of Mill Shell Liner Life
Variation in Coal Characteristic:

- High inherent moisture content of coal (up to 15-20%)
- Reduced flowability of coal. The coal sticks to the Mill shell if not sufficiently dry.

Effects on Mill Operation:

- Coal lifting is less. Mill capacity drops
- Filling of Mill. Mill dp and Noise misguide
- Coal feed reduces
- Mill Power fluctuates as lumps are formed inside the Mill shell which lift in the form of a huge lump and fall
- Rise in Mill outlet temperature
- Chances of Mill fire during low feed rate
Developed operating Practice:

- Ensure minimum by-pass primary air of 10-15 t/hr for better drying and maintain velocity through the PC pipe.

- Ensure Air inlet temperature as per the characteristic curve: Higher Moisture -> Higher Inlet air temperature.

- Maintaining high classifier temp about 90°C slightly higher than normal.

- Feeders are started only after reaching mill outlet temperature of 60°C for 2 minutes to avoid coal pipe plugging and promotes more stable coal ignition.

- Classifiers and PC pipe temperatures are continuously monitored.
Wet and Slurry Type Coal

Rainy Season conditions

Observable Variation in Coal Characteristic:

- Moisture content rises up to 25-30%
- Slurry type of coal

Effects on Mill Operation:

- Mill Power reduces from 1500 KW to as low as 500 KW as mill is filled with wet coal.
- Mill feed rate reduces as level goes to high value.
- Classifier temperature starts rising due reduction in feed rate.
- Mill power also hunting.
- PA flow will reduce.
Developed operating Practice:

- Mill level control is kept in manual.
- Feeder speed is adjusted to maintain Mill Power and mill outlet temperature.
- If mill is filled with coal, one side feeder is taken out for sometime.
- Bypass air flow is maintained as per given characteristic curve.
- Stockyard coal is used during rainy season.
- Ball sieving and increase in volume loading with higher size (50mm dia.) ball before rainy season.
Blended Coal

Observable Variation in Coal Characteristic:
- Indigenous coal blended with High GCV Import coal. Blending up to 10-15%
- High volatile matters 25-30%

Effects on Mill Operation:
- Less coal demand for same load (300-320t/hr)
- Mill level will reduce
- Sudden rise in Mill outlet temperature
- Mill fire
Developed operating Practice:

- Coal blending is ensured by CHP in 10-15%.
- Blended high GCV Coal feeding is done in lower mills only i.e. in Mill-A, B & C only.
- Classifier temperature is set at 65°C to avoid risks of fire.
- Ensure minimum by-pass primary air flow of 10-15 t/hr.
- Classifier cleaning is done regularly.
- Classifier temperature high alarm is set at 85°C and very high at 90°C to alert operator.
- In case of faster rise, the mill is taken out of service.
Low GCV Indigenous Coal

Observable Variation in Coal Characteristic:
- Low GCV coal containing sand, pyrites, quartz, hard coal and ash.
- GCV below 2500 kcal/kg.

Effects on Mill Operation:
- Coal flow increases to meet same load demand.
- Rise in Mill Power with hunting.
- Poor fineness
- Damage of Mill Internals requiring mill outage for repair.
- As the Grindability Index reduces, the mill throughput comes down.
Low GCV Indigenous Coal

Developed operating Practice:

- Additional Mill is taken into service.
- Additional Ball charging is done to improve grinding and lifting of coal.
- Feeder speed is adjusted to maintain Mill dp, mill out let temp and mill power.
Ingress of Foreign materials like stones in large quantity

Observable Variation in Coal Characteristic:

- Large size stones during reclaiming.
- Ingress of stones due to breakdown in crusher and VGF.
- No significant observable variation in Coal loading.
- Only the abrupt rise in Mill Power leads to conclusion regarding change in Coal Quality

Effects on Mill Operation:

- Sudden rise in Mill Power up to 250-300 KW without addition of Grinding Balls for a longer time may be nearly 48 hours
- Mill level is high
- Increase in Mill noise level
- Reduced Mill output despite higher mill Power and higher air flow
Ingress of Foreign materials like stones in large quantity

Developed operating Practice:

- Maintain mill dp or noise level.

- Reduce Feeder speed.

- Taking one feeder out of service if required.

- Increase ball loading by compromising high power consumption. This facilitates better pulverization of the stones and faster evacuation of stones in the form of sand.
One End Operation Due to Entry of Stones and Other Overburdens

- The entry of any large size stone / pebble in the drag link chain type coal feeder leads to jamming of the feeder and then tripping.

- Then increase the running feeder speed to maximum and maintain the mill level (3.0rpm).

- Reduce the main PA flow so that mill will not empty 20-25t/hr for both sides.

- Reduce mill outlet temperature set point by 5-10C so that mill temp will not rise.

- Close the bypass damper of non running side to 0% immediately.

- Observe mill kw, noise & dp level, and mill outlet temperature.

- But for blending fed mill, if one feeder tripped mill is being stopped to avoid fire incident.
Low Volume Loading and Seasonal Variation in Mill Power

- The erosion rate of forged ball is very fast and nearly 12-15 MT per mill per month.

- In India, the sources of Forged steel Balls are a few only and consistent supply is not being done due to many reasons.

- Mill capacity reduces as mill ball loading reduces.

- Extra mill is to be run to get the desired load.
With Poor coal quality Mills with shell liner life beyond 40000 operating hours are not able to lift the rated 91t/hr.

With a shell liner life of 60000 hours or, above and when the ball loading is up to 1800 KW, the mill is loaded up to 80 TPH in worst coal conditions.

But, with new mill shell liners, even at 1450 KW, the mill is able to take a load of 95-97 TPH despite a poor quality coal being fed.

As the mill shell liner life increases, the coal lift reduces and the mill output reduces for the same Mill Power.

To get the desired output, the volume loading needs to be increased for compensating the wearing out of mill shell liner.
Proper communication level developed between Operation and CHP personnel regarding the coal being fed into any bunker.

Extra vigilant and added alarms about the mill parameters.

Monsoon preparation at CHP end to maintain the chutes, feeders and conveyors.

Maintaining Mill Power up to 1700 KW by ball charging.

Forged Steel Balls replaced with Hichrome Balls for consistency in Mill Power. *(This has been done in seven Mills and another three Mills shall be converted in 2013-14).*

Whenever any Raw Coal Feeder of a Mill with blended coal feeding trips, the mill is taken out of service to minimize the risk of fire and explosion.
In case of any reduction in Main PA flow of any Mill, classifier is inspected and cleaned.

In case of sudden rise of Power, the mill is emptied by reducing the Feeder speed and increasing the air-coal ratio.

During taking any Mill into service, the temperature rise of PC Pipes and classifier is monitored.

Mill outlet temperature High alarm and Very high alarm has been provided at 85°C and 90°C to alert the operator.

Fast rise in mill outlet temperature may be due to fire, so operator has been advised to stop the Mill and carry out steam inerting before again taking the Mill into service.
The coal quality in India is deteriorating and getting a consistent coal is difficult.

For smooth mill operation, it is required to have a well established communication between the Coal Handling and main plant operation engineers.

The Mill operator should be vigilant and follow established operating practices.

Efforts should be made to carry out a perfect blending of imported coal.

Monsoon preparation and use of less water in Coal Handling Plant will reduce operational problems of the Mills.

For improved performance of Tube Mills, the Volume loading of Balls need to be maintained and efforts should be made to ensure Mill Power above 1500 KW in any case.

One end operation of Tube Mills may be avoided as far as Possible. Minimum bypass flow of 10-15t/hrs must be maintained.

The Mill Liners if replaced within 30000 to 40000 hours reduces the problem of coal quality variation as coal lifting from Mill shell is assisted by liners with higher lift.
Thank You...