How to monitor the performance of a vertical mill

Introduction

- The aim of this procedure is to define a way to monitor the performance of a vertical mill
- Which are the key indicators that should be tracked that can confirm that the Vertical Raw Mill (VRM) is operating well or not?
- How can we interpret any drift of these indicators?
- How can we diagnose the reason for the poor operation

Safety aspects

- It is imperative a risk assessment is made and all the necessary safety procedures and appropriate personal protective equipment are used.

Prerequisites

- Be able to monitor indicators with historical data (ex. IP21 or control system).
- To perform a good diagnosis on your mill, it is essential to have the signals below on-line:
  - ***Mill Feed rate*** (t/h)
  - ***Vibrations of Mill*** (mm/s). For process evaluation mill body (eg Loesche) or mill gear box (eg. FLS). The Lafarge recommended location on the gear box input shaft.
  - ***Mill DP*** (mbar)
  - ***Mill motor power*** (kW)
  - ***Specific power consumption of the mill*** (kWh/t). Obtained by division of mill power (kW) by mill feed rate (t/h)
  - ***Mill Fan power*** (kW):
  - ***Specific consumption of the fan*** (kWh/t): Indicate the need of ventilation per ton. Obtained by dividing fan power (kW) by mill feed rate (t/h)
  - ***Bed depth*** (mm). Don't use internal cylinder sensor (magnetic). There are uncontrollable and not reliable. The IR technology is no more efficient. Prefer external sensors like "roller with string" or those using ultrasonic technology. (e.g. Dunbar or Port La Nouvelle Plants). Cheap and easy to control.

    For more information, see procedure "How to do an on-stop inspection of a VRM"
  - ***Water injection flow rate*** (m3/h) and ***preferred valve opening position & pump power*** (rpm/min or % of maximum speed). As the quality of water injection has a major impact on mill performance, if you want to be more accurate, you can implement also a flow indicator on each water spray.
  - ***Gas flow*** (m3/s), or cyclone dp and fan power or / and ***fan speed*** (rd/min or % of maximum speed)
  - ***Hydraulic pressure*** of the grinding system (bar)
  - ***Flow rate of the rejects*** (t/h) based on the power consumption of the elevator
  - ***Mill feed grain size***. Two sensors can give a good approximation of the grain size of the material:
  - The kg/m given by the weigh feeders
  - A noise sensor located on the triple flap valve
  - ***Mill Outlet Temperature Outlet mill temperature*** (°C)
  - ***Mill fan inlet pressure (mbar) ID fan pressure*** (mb)

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Action Steps

1. Follow on-line the performance and the efficiency of the VRM

The key performance indicators for a VRM are:

- Vibrations of the mill at a low level
- Low & stable mill DP Mill DP at a low level
- Low & Stable Specific power consumption of the mill: VRM kWh/t at a low level
- Stable fan power Need of ventilation per ton: Fan kWh/t at a low level
- Raw fineness on target and consistent

Based on your own experience on the mill, establish reference performance levels for each indicator.

EXAMPLE

For example, a good performance for the PLN VRM is:

- ***3.2 mm/s vibration***
- ***48 mb for mill DP***
- ***8 kWh/t for mill***
- ***7,5 kWh/t for the fan.***

Examples of reasoning:

- ***If vibration and mill DP are low, the VRM is operating very well and has some margin.***
- ***If vibration and mill DP are high, the mill is on limit and has some malfunction.***
- ***If the vibrations are high and the DP low, the bed depth for instance, is probably too low.***
- ***If the specific consumption of the mill is too high, the mill efficiency is abnormal***
  - ***Too high dam ring?***
  - ***Size of the feed material?***
  - ***Wear of roller and table?***
  - ***New profile of roller & table along with the new material spec.?***
  - ***Abrasive material?***
  - ***…***
- ***If the need of ventilation is too high, the mill efficiency is abnormal***
  - ***False air?***
  - ***Drift in gas flow sensor?***
  - ***…***
- ***If the variation of raw fineness is too high***
  - ***Problem in separator?***
  - ***Drift in gas flow sensor?***
  - ***…***

Action Steps

2. Follow on-line all the parameters that have an impact on the key performance indicators

Have in mind that nothing is more tricky than a sensor! Don't hesitate to call into question the accuracy of your sensors, especially those that are involved in the control loops.

Check the sensors

There are several ways of checking sensors:

- Cross check by other sensors on line. Example: a T° with another T°, a flow rate by a power consumption etc… Then, use the graphic facility of the software to make coherence between signals. Change scale to superpose the curves. You will see immediately any drift if the two signals diverge.
- Cross check on-line with portable equipment: Pitot, T°…
- Check-up on a stop: unblock pressure holes, clean airflow devices, check bed depth sensor…

Check the parameters

The following are the parameters that can influence the key point performance indicators of the VRM and the way they are checked.

- ***Check bed depth***
  - Impact: there is a direct influence between bed depth and vibration level. A low bed depth always increases vibrations.
  - Sensor check: don't forget that the accuracy of the measurement has to be checked regularly on a stop.

    See procedure "How to do an on-stop inspection of a VRM".

- ***Water injection***
  - Impact: the quality of water injection has a major impact on all the performances of the VRM. A blocked spray will have an influence on DP, vibration kwh/t…
  - Sensor check: check on-line the coherence between the flow rate and the pump speed/ control valve opening Make the two curves superposed by adjustment of the scale in the software. Graphically, if the flow rate curve is under the pump speed, this indicates that one or several sprays are blocked. On the contrary, if there is more flow rate than speed, one spray has probably broken off, reducing the circuit pressure drop.

    See example in Annex 1.
  - To go further and be even more efficient, you can also fit the water circuit with a flow indicator at each spray and follow the difference between them. Effectively, we can have the same global level of water injection but one spray can give less flow than the others. This unbalance can have an impact on the DP and vibration.

    See also the example in Annex 1.

- ***Gas flow and fan speed***
  - Impact: the gas flow has an impact on the fineness, mill DP, vibrations.
  - Sensor check: it is important to see any drift of this sensor.

  Three solutions:
  - Create another signal based on the efficiency of the fan and make them superposed. You will see on line graphically any drift.
  - Check sometimes the gas flow by Pitot
  - Clean regularly the airflow indicator

- ***Mill feed grain size***
  - Impact: the impact is on kWh/t, vibration, DP.
  - Sensor check: two sensors can give a good approximation of the grain size of the material
  - The kg/m given by the weigh feeders
  - A noise sensor located on the mill feeding device (triple flap or rotary feeder)

- ***Feed rate of the mill***
  - feed rate of the reject elevator
  - Sensor check: check the kW without material on a stop and adjust the zero.

- ***The other parameters*** having an influence on the key performance indicators can not be checked during operation, such as:
  - Dam ring
  - Worn out of table and rollers
  - Mechanical condition of the mill like condition of lourve rings / air in-leaks / separator sealing / worn out parts, mill feed chute

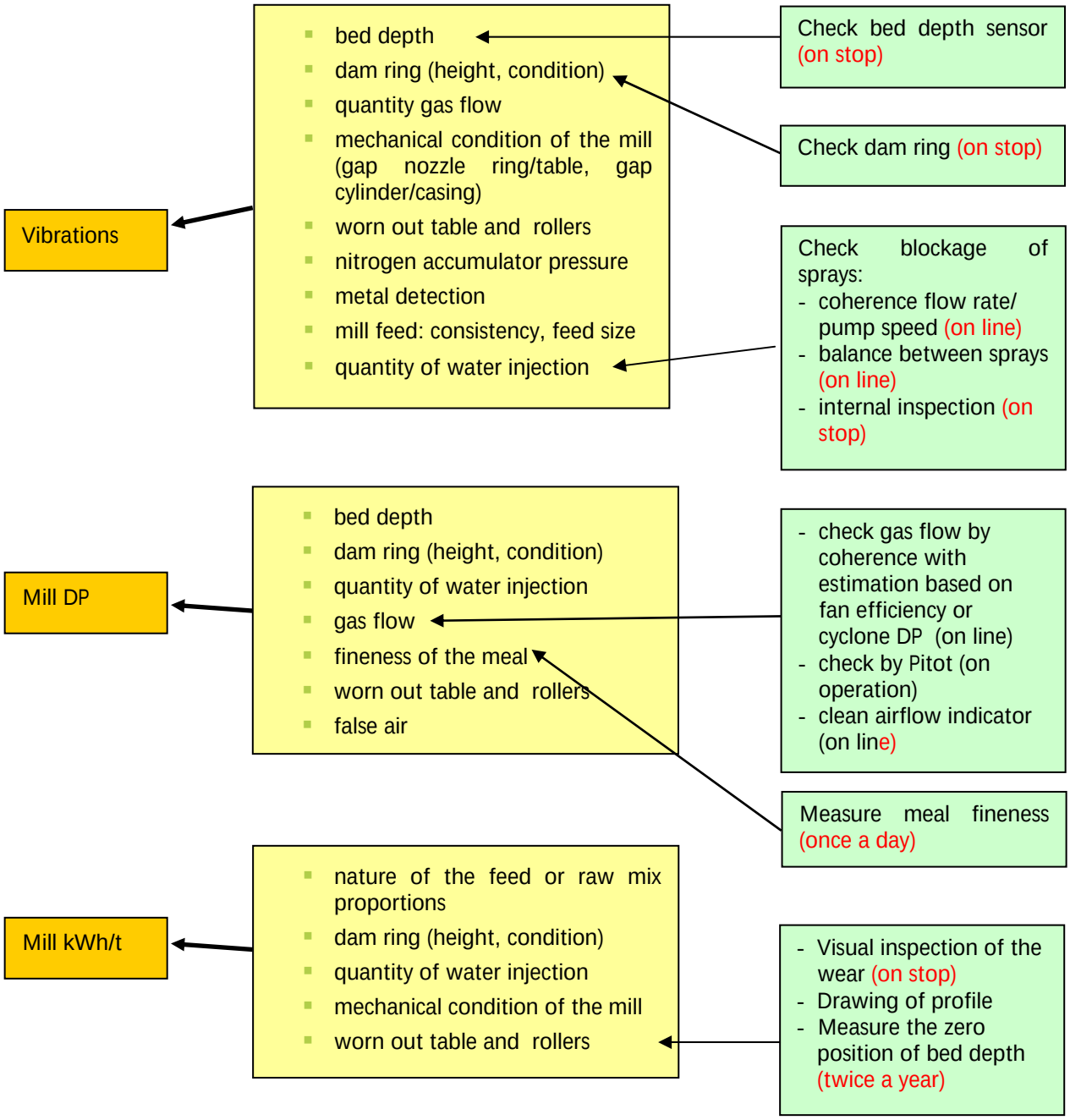
    For that see the procedure "How to do an on-stop inspection of the VRM"

3. Observe the mill during operation

- Check:
  - feed size
  - leaks
  - cylinder movements
  - abnormal sounds
  - foundation block movement / vibration

4. Diagnose the cause of poor performance

Here are classical trouble-shootings, possible causes and sensors check up:



Appendix

1. On-line detection of a water injection problem