PROCESS TRAINING
for operators of
Pfeiffer MPS Vertical Mills

Contents:

1. Heating of mill and grinding plant

In fact there are three processes going on in the MPS mill namely grinding, drying and classifying, and only when all three processes are working well the operation is smooth.
For drying the wet raw material it is necessary that prior to the mill start up the grinding plant is heated for some time. Otherwise the cold grinding plant would take away too much heat from the drying process and the finish product would not be dry - handling problems in the meal transport and silo extraction would follow. Also a caking in the grinding zone could occur, the material sticks on rollers and plate, which results in high vibration and material spillage.
Heating the mill is also necessary to prevent excessive thermal stress in the grinding parts, rollers and bowl. Since the rollers and the bowl have a big mass and thickness, the inside temperature of these parts will for a long time be lower than the outside temperature - heat transfer, heat capacity. This uneven temperature distribution - outside hot, inside cold - creates a thermal stress which can cause these brittle parts to crack. Therefore the temperature at mill inlet should be increased slowly. Due to the minimum heat amount available for the drying process which is normally related to a inlet temperature higher than 120°C it is not possible to heat the mill during operation - first heating with small inlet temperature (95 - 120°C).
During heat up there should be a sufficient air flow through the mill to force the heat transfer to the grinding parts - forced convection. A sufficient air flow will result in a mill differential pressure of > 5mbar.
The duration of heating should be at least until the temperatures after mill and after bag filter reach 85° C. After long shut down periods (>10h) additional 1 hour heating after reaching 85°C after mill should be done.

2. Explanation of some important process parameters, process terms

The operator of the mill has to stabilize the process during start up and to watch the stable running later on by comparing the actual process parameters with the wanted set points. The control loops are therefore in manual mode during start procedure (first 5 - 15 minutes after start) and switched to automatic after stabilization.
For company control matters and for the training of the operators it is helpful to note down the process parameters in a log book every hour. Beside start - stop time and any problems in the grinding plant the following parameters are recommended for being entered the log sheet:
- feed rate to the mill, production rate [t/h]
- differential pressure of mill [mbar]
- air flow through mill [m^3/h]
- vibration velocity at gearbox [mm/sec]
- power consumption or current of mill main drive [kW or A]
- power consumption or current of mill fan [kW or A]
- temperature at mill outlet [°C]
- thickness of grinding bed [mm]
- pressure in tension hydraulics [bar]
- classifier speed [rpm]
- pressure at mill inlet [mbar] (lower than the ambient press. therefore also called „draught“)
- differential pressure of bag filter [mbar]
- position of fan damper [%]
- position of recirculation air damper [%]
- position of fresh air damper [%]
- fineness of product, residue on 90µ sieve [%]
- temperature at mill inlet [°C]

Differential pressure of mill
The differential pressure of the mill is measured at the ring pipes on mill inlet and mill outlet (inlet of classifier).
The differential pressure of the running mill depends on the amount of dust in the mill air and on the air flow through mill. Therefore it can be seen as the sum of the differential pressure resulting from the resistance from the plain air flow and from the resistance from the amount of dust in the mill air. $\Delta p_{MPS\ in\ op} = \Delta p_{MPS\ air\ flow} + \Delta p_{MPS\ dustload}$.
In case the air flow is constant the differential pressure is an indicator for the filling degree of the mill. Therefore and for constant product fineness the air flow is kept constant by a control loop with the fan damper position or fan speed.
The amount of dust in the mill air or in other words the filling degree of the mill is mainly influenced by the production rate (feed rate minus moisture). Therefore the feed rate is in a control loop with the differential pressure as guide value.
The differential pressure of the plain air flow also exists when the mill is not in operation (no dustload in the air) and then depends on the air flow through mill and the open cross section of the nozzle ring only.
The dustload related differential pressure depends not only from the production rate but also on the grindability of the feed material, the moisture of the feed and the efficiency of grinding process.
The grindability or specific power consumption [kWh/t] of the raw material is the amount of energy [kWh] which is consumed by the mill main drive while grinding one ton [t] meal to a

certain fineness. The grindability depends on the raw material and has a natural fluctuation which is homogenized by blending large stocks. The specific power consumption is increasing with the fineness (finer grinding - more energy).
The efficiency of the grinding process is influenced by the pressure in the tension hydraulics, the air flow and the wear condition of the rollers and the table. Also the temperature at mill outlet influences the efficiency of the grinding process, with some raw materials more with others less.
In case the grindability of the raw material is bad and/or the efficiency of the grinding process is poor the internal recirculation of the material in the mill is high. The material is crushed and ground between the rollers and the table then blown either back on the table or in the classifier. The material blown in the classifier is devided into fines (product) and coarse material (grits). The grits are returned in the mill via the grit cone (internal recirculation) to the grinding table where they are ground again.

Material spillage

The amount of rejected material (spillage material) mainly depends on the grain size of the feed material (mass of particles) and the speed of the air in the nozzle ring.
The feed grain size [mm] can be adjusted by the crusher and should be not too big. Therefore the wear parts of the crusher should be replaced in time to prevent big stones.
The speed of the air in the nozzle ring [m/s] depends on the air flow [m^3/h] and the open cross section of the nozzle ring [m^2].
These interrelationship is expressed in the force balance of a particle in the air stream just above the nozzle ring. In a simplified theorie the gravity force pulls down the particle where as the air resistance force is lifting the particle up. Depending on which force is stronger the particle will either fall down or rise up.
In the MPS A case, material spillage is not wanted and only occurs when the air flow is too small and/or the mill is too full.

Air flow through mill

The air flow through mill is necessary for several reasons. First of all the air transports the material inside of the mill and the product out of the mill to the bag filter. But the air also transports the heat for the drying process.Furthermore the air fluidizes and stabilizes the grinding bed.
The air flow is measured by the differential pressure of an orifice.This measured value is used as a guide value in a control loop with the fan damper postion.

Vibration velocity at gear box

The vibration at gearbox indicates the smoothness of the process and protects the mill from mechanical damage.
If the vibration is too high there is an alarm and a stop limit which prevents damage to the gearbox, the wear parts of rollers and bowl as well as to the bearings of the rollers.
Excessive vibration occurs when the mill is too empty (thin grinding bed), too full (very thick grinding bed) or when big metal pieces are in the mill. Also too low an outlet temperature can create a increased vibration level.

Power consumption of mill main drive

Like the differential pressure of the mill the power consumption of the mill main drive is an indicator for the filling degree of the mill.

Power consumption of mill fan

Like the differential pressure value shown at the orifice the power consumption of the mill fan is an indicator for the amount of air flow.

Classifier speed

Together with the air flow the classifier speed determines the fineness of the product. Higher classifier speed - finer product, lower air flow - finer product.

Other parameters like the pressure in the tension hydraulics or the differential pressure throughout the mill have only negligible influence on the fineness - results of these parameters will only be found in the particle size distribution of the meal.

Differential pressure of bag filter

The differential pressure of the bag filter indicats the resitance for the air flow created by the bags. Like the differential pressure of the mill it depends also on the amount of air flow and the dustload. Excessive differential pressures can reduce the air flow and will occur when there is a problem with the cleaning cycle of the bags or condensed water creats a coating on the bags. Low differential pressures at the bag filter will occur when there are holes in the bags or other leakages. Leakages create pollution and production loss.

3. Loading, precharging the mill

To ensure a successfull start the process conditions of the mill have to be good.
Too small an amount of material in the mill will create excessive vibration during start up - as there is no material between rollers and bowl.
Also, a missing material layer on the weighfeeder creates a lack of material in the mill during start up (delay of feed) and therefore leads to high vibration.
For the first start and after cleaning for maintenance purposes the mill and the weighfeeder have to be loaded with limestone. This is done by starting the machines of the feeding group in local mode or in a special loading mode in which the interlocking between mill and feed group is canceled. The mill will not run at this time. The feed group is stopped when there is sufficient material in the mill. The material is then distributed in the mill manually with a shovel.
When the mill is too full the mill main drive can be overloaded and it will be necessary to remove some material from the mill.

4. Preparations for mill start up

The grinding plant is started in a special sequence which is fixed in the interlocking - see interlocking diagram.
Before the mill group is started the material removal group, the gas route group and the gear oil supply group have to be started.
For safety reasons and for the success of the start several checks are necessary before the mill is started:

- check whether all works in the grinding plant are completed, all doors in the system closed and nobody is in danger. For the safety of the site staff it is also helpful to give an oral start up warning by telephone or walky talky some time before start.

- check whether the mill is heated up properly or still hot from the last operation. Is sufficient steam available? Heating time and temperature after mill have to be considered.
$T_{outlet\ MPS} > 90°C$

- check the mill's filling condition - too empty, normal, too full - and arrange action if necessary. The mill's filling degree depends on the last stop condition - feed rate before stop, emergency stop or stop procedure.

- check whether there is a material layer on the weighfeeder.

- check whether all necessary equipment is available and no fault is indicated.
  # all machines of the feeding group ready
  # enough limestone in the feed bin
  # enough place in the meal silo
  # gearbox oil temperature not too cold or too hot
  # compressed air for the bag filter cleaning
  # automatic mode for the groups

- check whether the control loops are in manual mode.

- check whether all process parameters are reasonable adjusted, check set points.
  # feed rate
  # classifier speed
  # air flow, fan damper position
  # pressure in tension hydraulics

5. Mill start up

With all start up preparations carefully completed the mill can be started by giving the start command to the mill group. While the mill main drive accelerates the operator has to watch the development of the power consumption of the mill main drive and of the differential pressure of the mill. When the usual values are reached the start command to the feed group is given.

During the first 5 to 15 minutes of operation the mill has to be stabilized. The operator has to watch the process parameters carefully and take the right steps.

Indicators for the stability of the process are:

- # vibration velocity at the gearbox
- # differential pressure of mill
- # power consumption of mill main drive
- # air flow through mill
- # power consumption of mill fan
- # temperature at mill outlet
- # grinding bed thickness and its fluctuation

The operator influences the process by adjusting the following parameters:

- # fan damper and other damper positions
- # heat supply, temperature and amount of steam
- # feed rate
- # classifier speed
- # pressure in tension hydraulics

When the process is stable for some minutes the control loops can be switched to automatic mode.The control loops are necessary because the process parameters vary with the grindability of the raw material, the moisture of the feed and the heat supply. Because of this variation it is also not possible to give standard values of the process parameters. Furthermore it is necessary that the operators of the mill have an understanding of the process.