Ball Mill Ventilation

GRINDING I – Training Session

General Objectives

- **Gas flow is a thermal exchange support**
  - Heat removal in cement mills
  - Heat support in raw and coal mills to dry coarse material
- **Fine material transport**
- **Ventilation level depends on**
  - Workshop design: open or closed circuit
  - Type of mill: compound, air swept and bi-rotator
  - Nature and characteristics of the material to be ground

Objectives: Removal of fine particles

- **It is essential to remove the sufficiently fine particles, because**
  - They unnecessarily clutter the mill
  - They reduce mill efficiency
  - They may cause over-grinding
  - They produce coating
  - In a closed circuit, they reduce the separation efficiency by re-agglomeration

Objectives: Cement cooling

- **The purpose of cooling is even more important**
  - when the inlet clinker is hot
  - in a closed circuit without ventilated separator
- **Ventilation cooling is always preferable to water spraying in the mill**

Ex: Cement grinding with specific energy of 32 kWh/t
95% energy into heat
Cp ~ 0,75 kJ/kg°K
ΔT of cement ~ 0,95 x 32 x 3600 / (1000 x 0,75) = +146°K

Specific ventilation: 0,6 Nm3/kg of dry air @ 30°C □ 100°C (1,3kg/Nm3)
Cp ~1,0 kJ/kg°K
ΔT of cement ~ - 1,3 x 0,6 x (100 – 30) / 0,75 = -73°K

A good ventilation takes out around the half of the heat of grinding

Why do we control cement temperature?

- **Attention should be paid to the outlet cement temperature**
  - The mill outlet temperature should never exceed 110°C in order to prevent excessive gypsum dehydration (workability problems caused by false set)
  - On the contrary, the temperature must not be lower than 90°C (risk of gypsum dehydration)
  - Preferably the temperature should not exceed 80°C (175° F) in the silos because otherwise, gypsum dehydration may continue

Objectives: Drying raw materials

- Moisture reduces efficiency of grinding as it produces coating and mud
  - Maximum 1,5% H_2O in open circuit
    2,5% H_2O in close circuit
  - Drying chamber 1m3 for 250kg/h H_2O

- Attention should be paid to the mill outlet temperature
  - Mill outlet temperature must be approx. 30°C higher than the dew point (prevent condensation in the bag filter)

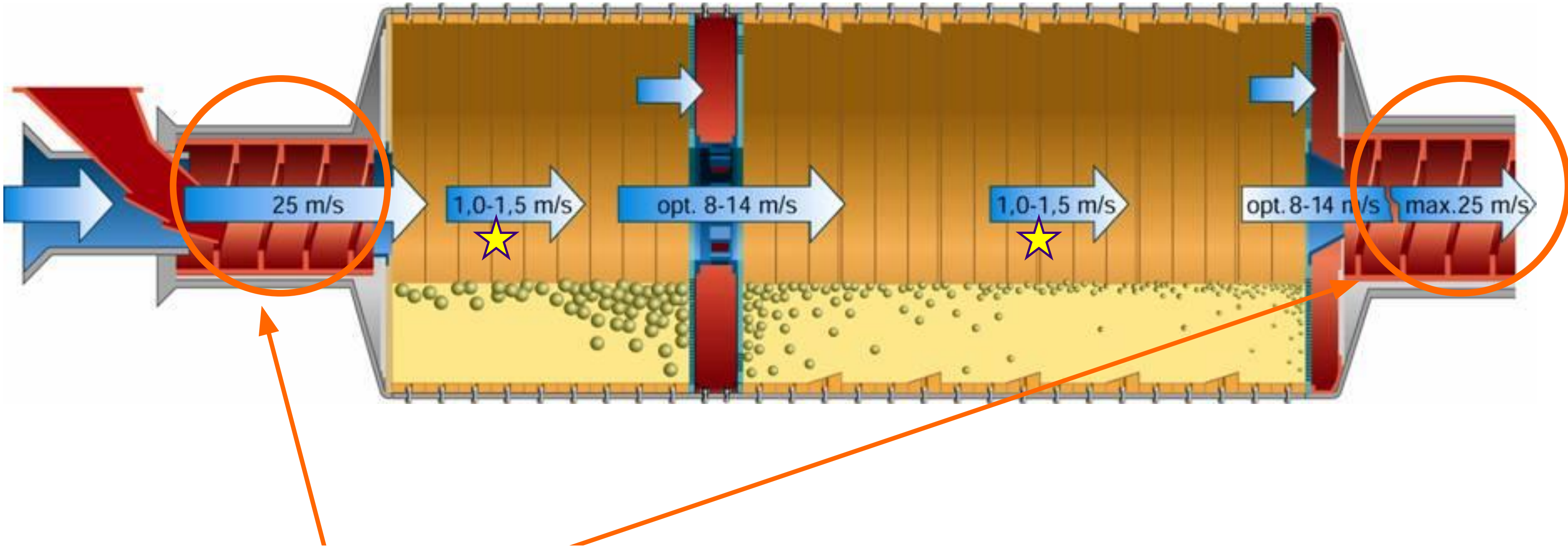
- Reach low moisture content in the final product
  - Avoid clogging in the silos

Proper ventilation criteria

- **How to express mill ventilation**
  - Ventilation is expressed in terms of gas flow rate (Nm^3/h) and more practically it can be expressed in terms of gas flow velocity in empty tube or above the charge (mill sweep) expressed at 100°C
- **How to measure it: air flow balance**
  - Follow the O_2 concentration across the workshop
  - Air flow measurements
- **The recommendations are as shown below**

	Empty tube speed at 100°C	Above the charge
Compound open circuit	0.6 to 0.8 m/s	0.9 to 1.5 m/s
Compound close circuit	1 to 1.5 m/s	1.4 to 2.2 m/s
Air swept / birotator	2 to 3 m/s	3 to 4 m/s

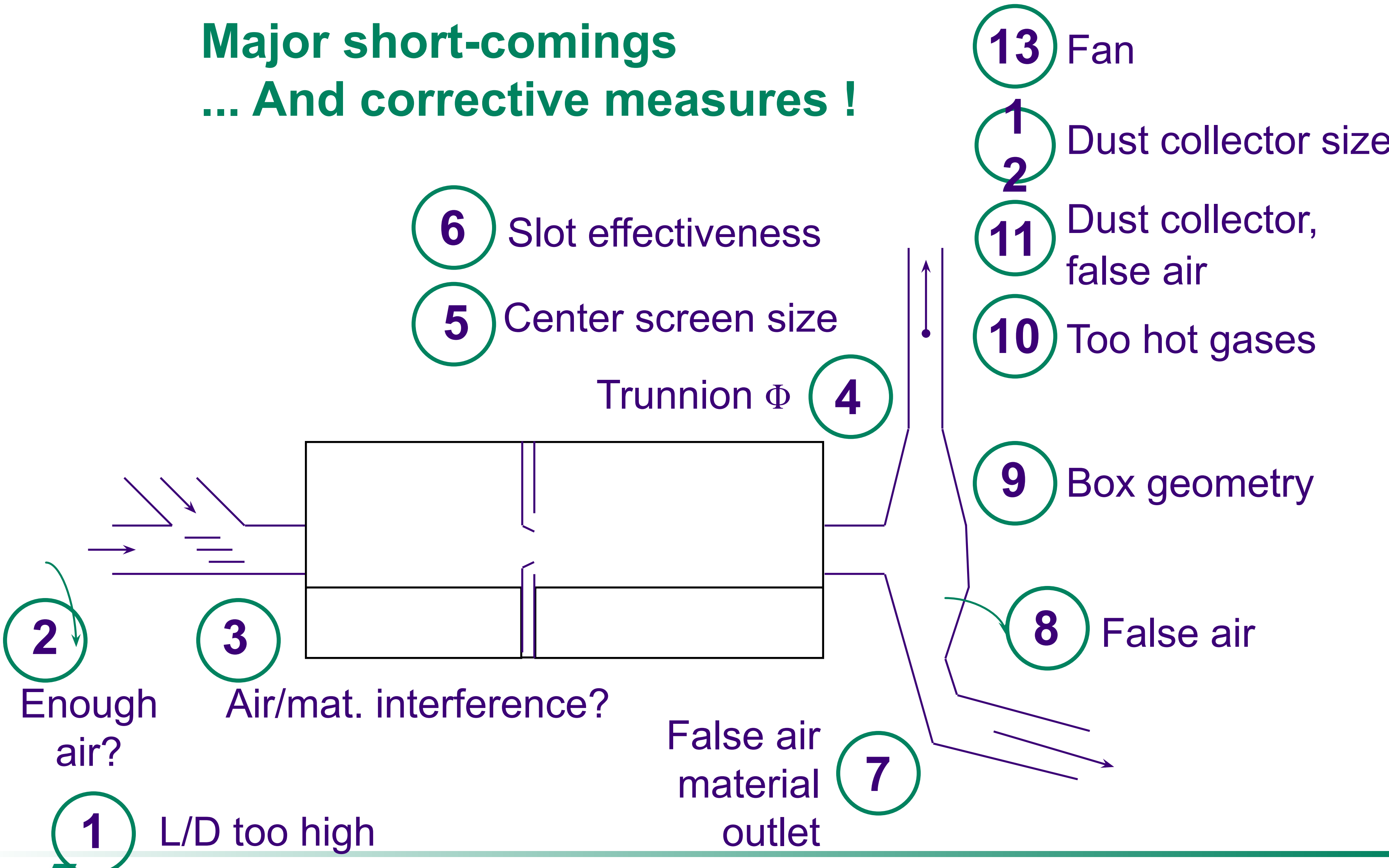
Compound mill ventilation



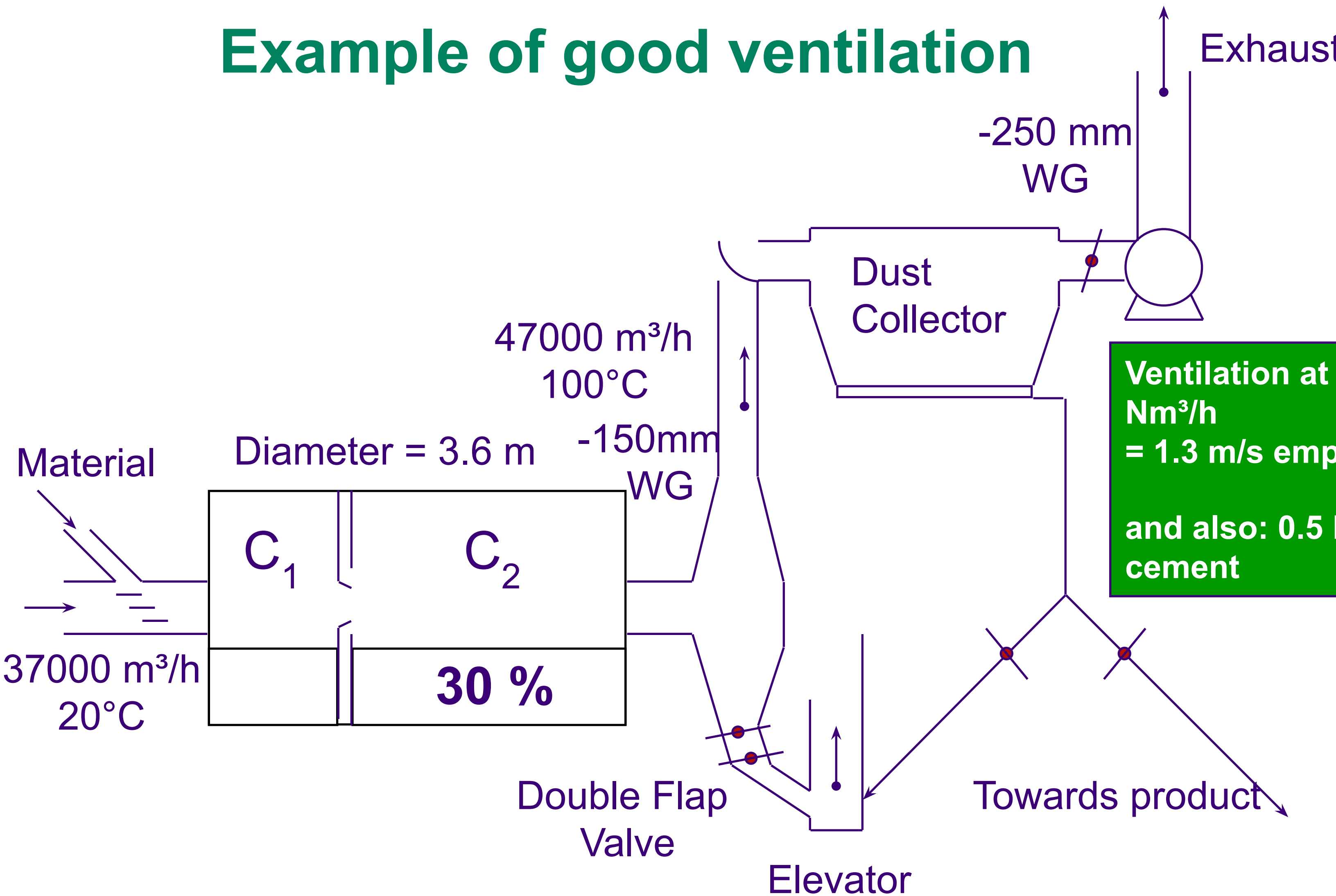
High limit to prevent wear in the trunnion

☆ **Empty mill @ 100°C**

Major short-comings
... And corrective measures !



Example of good ventilation



Ventilation at ~ 34400 Nm³/h
= 1.3 m/s empty mill

and also: 0.5 Nm³/kg of cement

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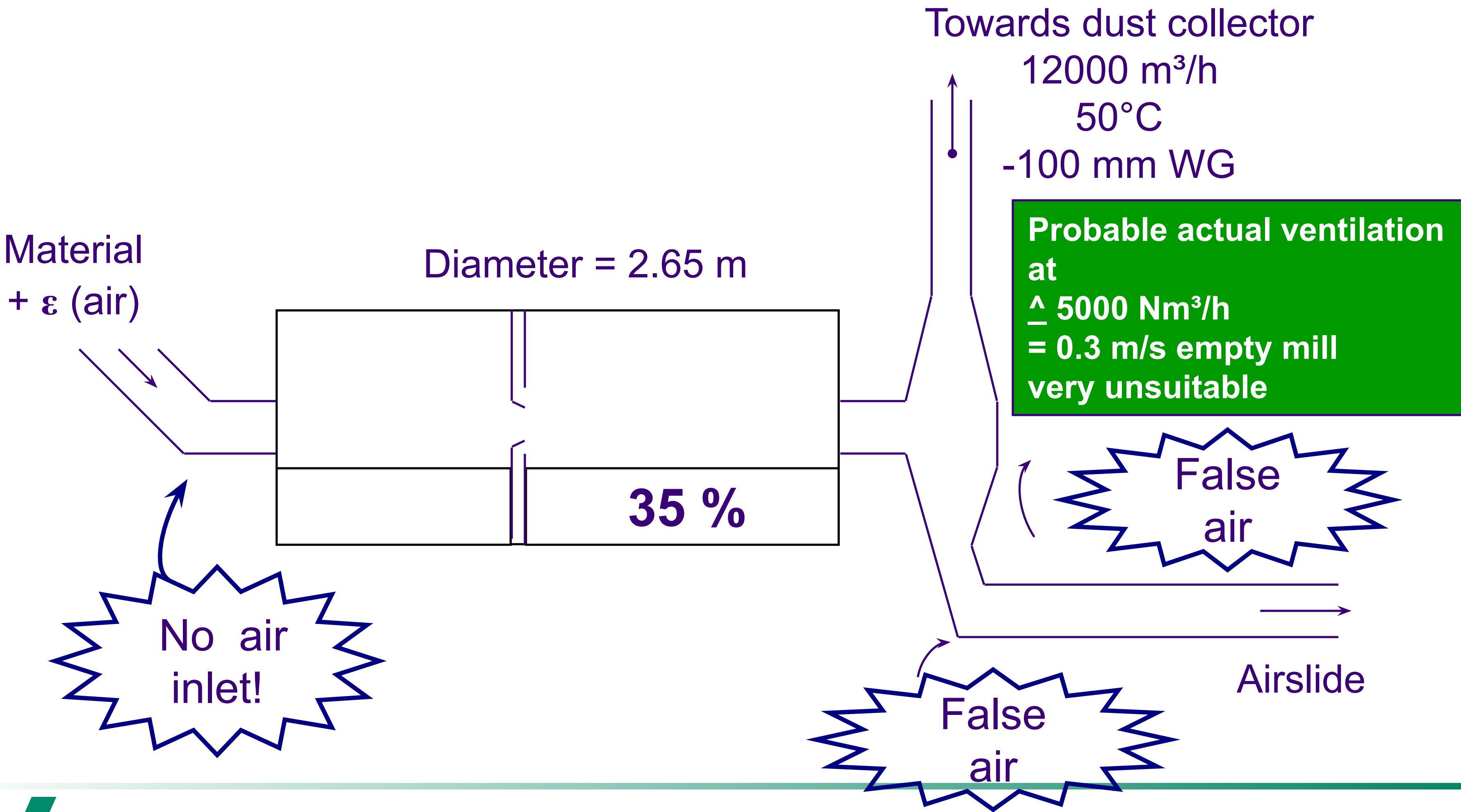
Example of poor ventilation



Current control on an existing workshop

PROCESS CHECKS

- **overload at mill inlet**
- **slot plugging by ball or nibs**
- **centre screen plugging**
- **slot openings**
- **False air at outlet rotating seal**
- **False air at mill discharge (good work of the flap)**
- **False air in the filter**

Ways to improve mill ventilation

- Replace the mill inlet chute (step instead of ramp)

- Replace ventilation ring of partition

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A consequence of under-ventilation

- **Under-ventilated mill**
  - air flow over the load: 0,8 m/s, hot clinker

- **Consequences**
  - mill outlet temperature 124 °C
  - plaster false set due to excessive gypsum dehydration 3,35% of semi-hydrate instead of 1%!

A consequence of false air
Example of Le Havre plant

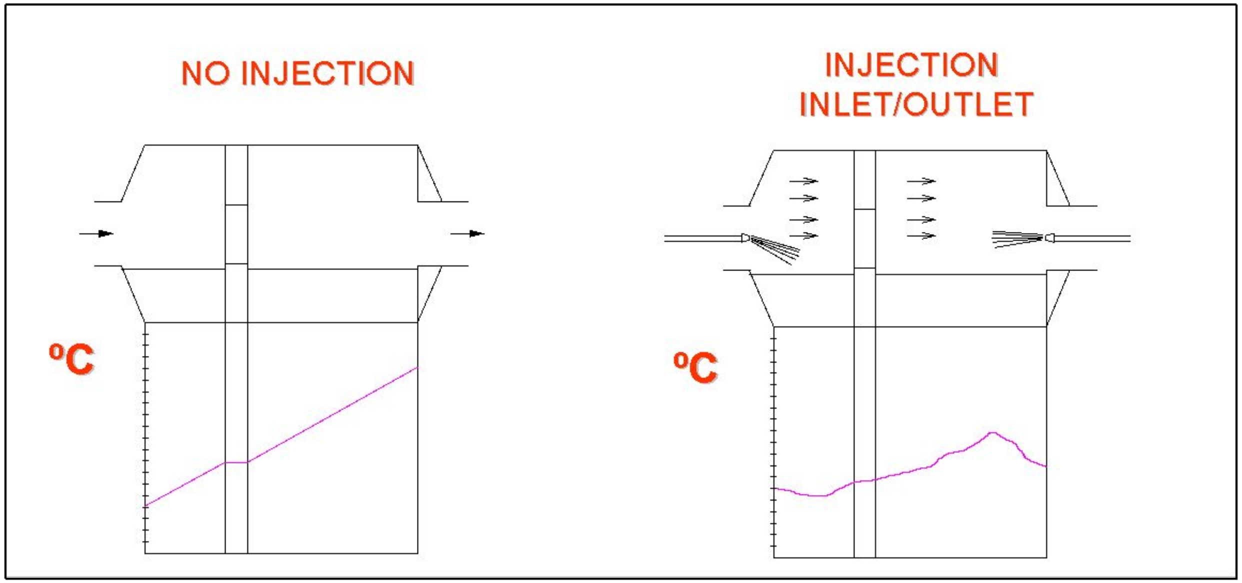
- **False air in an Aerofall drying mill will lead to increased costs for**
  - Thermal energy (drying at 400°C)
  - Power consumption for ventilation

- **By improving the sealing of the mill circuit, false air was reduced by 55000 m³/h, and the gains were 40k €/year**

Water Injection

- **The mill ventilation system should be optimised before considering water injection**
- **The water requirement to the mill should be established by conducting a heat balance across the mill**

Water Injection



- Dehydration of gypsum
- Coating
- Low mill efficiency

- Slot blockage
- Inefficiency in dedusting equipment
- Temperature oscillations affect ventilation

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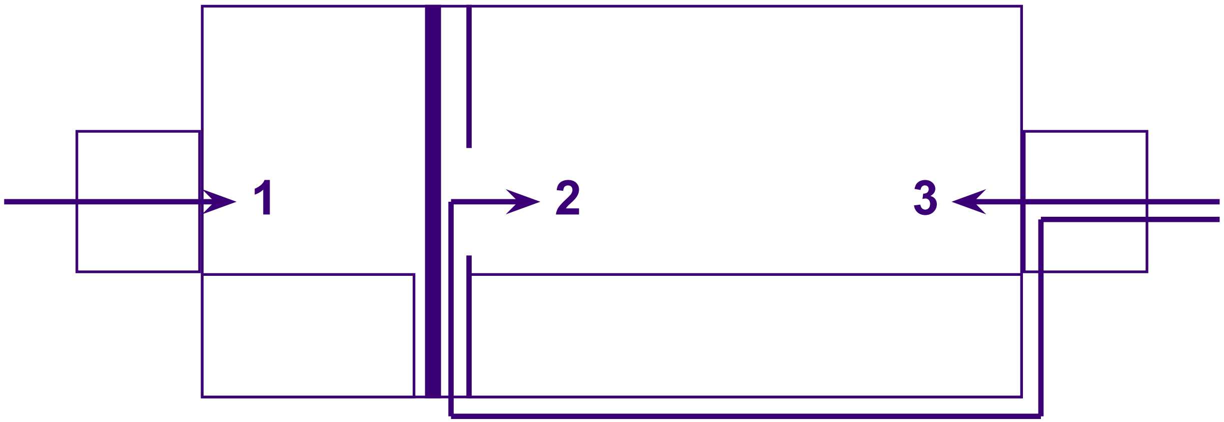
Spray Locations



- **1 - Feed end**
  - Mechanically simple, process problems
- **2 - Partition**
  - Can be mechanically problematic, best for process
- **3 - Discharge end**
  - Good if mill is weakly vented and/or short compartment or only small amounts are needed

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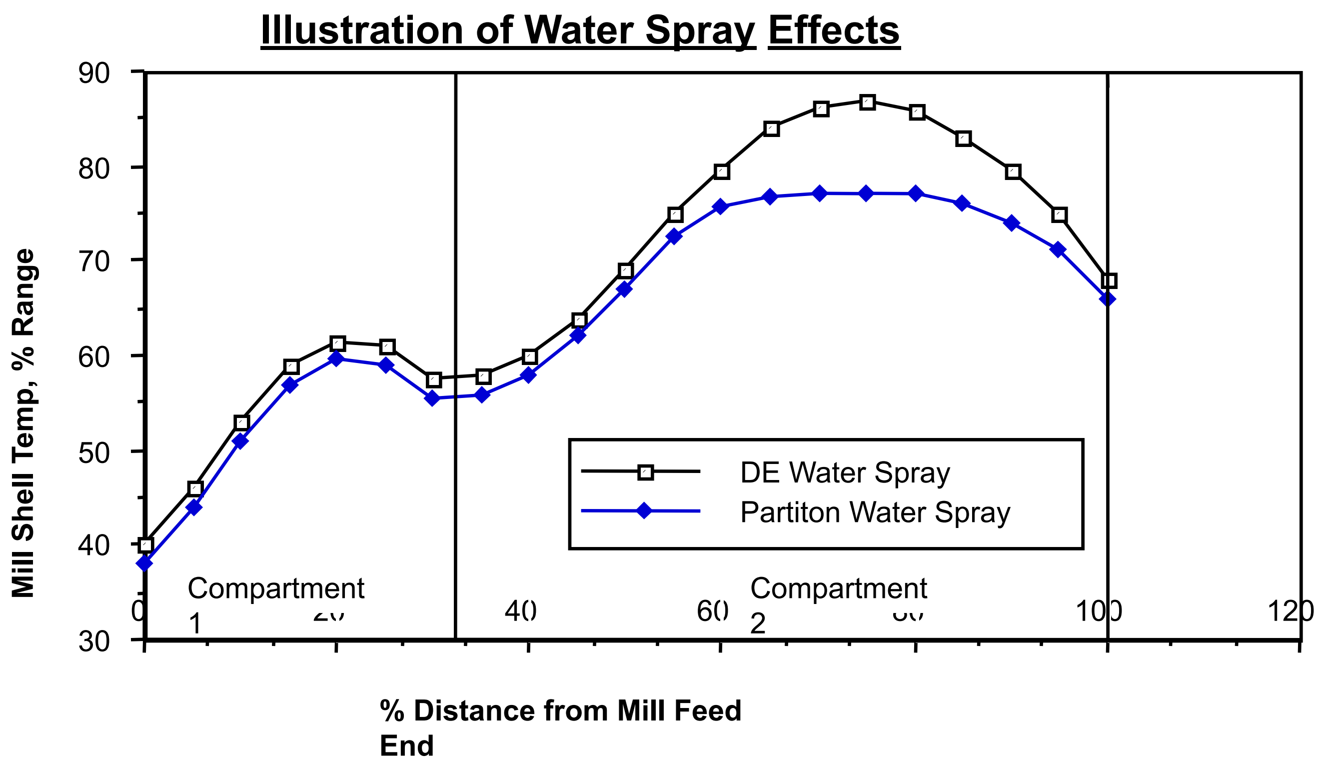
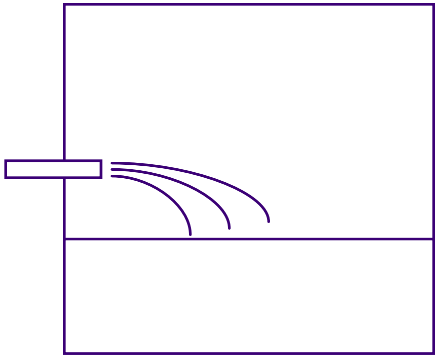
Thermal Profile



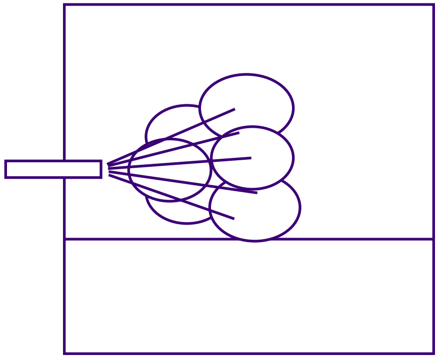
- Note how much cooler the 1st compartment is
- Discharge end sprays tend to have a mid-compartment hot spot

Finish Mill Water Sprays

poor atomization
= spray lands on load



excess atomization
= spray goes into air stream



- **Poor atomization**
  - Loss on Ignition increases
  - Exit air temp high
- **Excess atomization**
  - Discharge material temp high
- **Spray controlled by nozzle design and air / water ratio**

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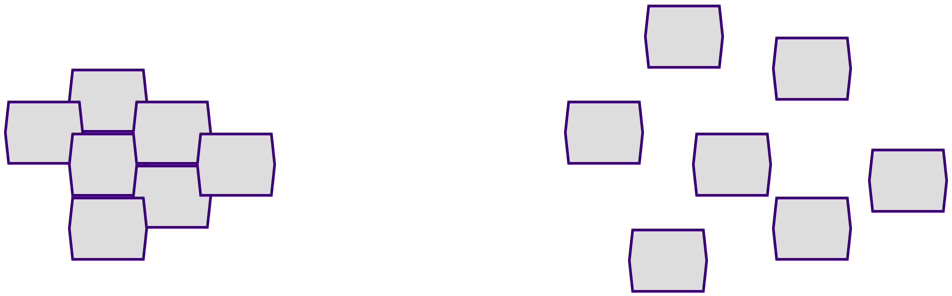
Water injection - Reminders

- **Objective**
  - Decrease the temperature peak to avoid gypsum dehydration when all action has been done on ventilation
- **Current controls**
  - Cleaning the injection cane (good level of atomization)
  - Stable flow injected

Coating and agglomeration

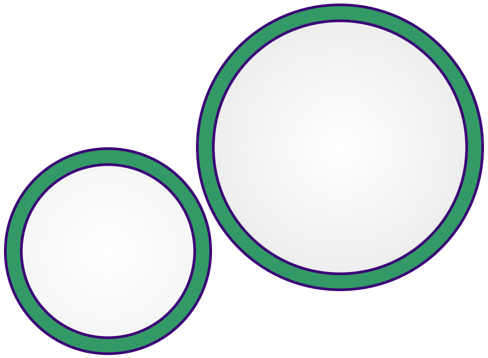
- Impact on separator efficiency
- Impact on ball charge efficiency

Agglomeration



- **All fine particles tend to aggregate or agglomerate**
  - friction causes electrostatic forces
- **Limestone and gypsum have a greater tendency**
- **Gets worse in a hot mill**
- **Separators will reject agglomerated particles as a coarse piece**

Ball Coating



- **Originally for pack set problems**
- **Ball coating softens impact: therefore, grinding efficiency is lost**
- **Can reduce lifting effect of liners**

Ball Coating

- **Ball coating can be a result of the following conditions**
  - Too Much Moisture Input
  - Poor Mill Ventilation
  - Mill Overheating
  - Mill Overloading
  - Inadequate Grinding Aid

Adequate ventilation will help alleviate persistent problems

Grinding Aids

- **Grinding aid reduces electrostatic forces**
- **Most common grinding aids**
  - TEA (Triethanolamin)
  - DEG (Diethylenglycol)
  - Common Brands are Chryso and Grace

- **Cost (0,6-1,2) Euro/kg**
- **Usage (150 - 400) g/t cement**

- **Before introducing new grinding aid, it needs to be tested in the mill**

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