Pulverized Coal Injection

- Paul Wurth’s Technology for New Installations and Plant Upgrades

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• Basics of pneumatic conveying
  ✓ Dilute vs. dense phase conveying
  ✓ Cost comparison

• Distribution types
  ✓ Static vs dynamic distribution
  ✓ Gritzko flow rate control valve

• Plant upgrades
  ✓ ROI case study for upgrade from static to dynamic distribution

• Upgrade of dilute phase PCI plants
  ✓ General
  ✓ PWIHI R&D program
  ✓ Results

• Recent references
Basics of Pneumatic Conveying

Gas retention

Fluidization
Dilute vs. Dense Phase Conveying

**Dilute phase**
- High speed (pipe wear ⬆)
- More pneumatic power per coal unit mass
- More N\(_2\) required
- Lower combustion eff.
- Low operating pressure

**Dense phase**
+ Low speed (pipe wear ⬇)
+ Less pneumatic power per coal unit mass
+ Less N\(_2\) required
+ Higher combustion eff.
- Higher operating pressure
Cost Comparison

- **Reduced operational cost for dense phase conveying**
  - Less pneumatic power per coal unit mass
  - Less $N_2$ required

- **Lower lifecycle costs despite higher initial capital cost**

![Graph showing total costs over time for dense phase and dilute phase conveying, with a dashed line marking 7 months in recent project at 100% total costs.](image)
Static vs Dynamic Distribution

**Static Distribution**
- Same equivalent pipeline length (same flow resistance) of all injection lines
- Improved distribution accuracy by installing a calibrated nozzle (sub-critical expansion tuyere) in each Injection Line

**Dynamic Distribution**
- Equal distribution onto all the Injection Lines by means of a coal flow rate measurement device, a coal flow rate control valve and a closed loop control installed in each Injection Line
- Best distribution accuracy through individual flow rate control
Static vs Dynamic Distribution

With individual flow rate control

Individual flow rate control switched off

BF 6 – Cockerill Sambre Seraing - Belgium
Dynamic Distribution

- Closed-loop-control with GRITZKO® flow rate control valve and flow rate measurement device installed in main conveying line and in each injection line.

- Excellent accuracy
  - Global flow ± 2 % *
  - Distribution accuracy ± 2.5 % *

- High availability

- Proven and reliable technology

* On 5 minute average
ArcelorMittal Gent, BF B – Belgium:
Equal distribution with average deviation below 1.5% on 5 minutes average
• High resistance to abrasive material
• Used for global flow control on conveying line or individual flow control in injection lines
• Usually linked to a Cabloc device
Plant Upgrades

- Increase of grinding and drying capacities
- Increase of storage capacities
- Intermediate transports
- Increase of conveying flow rates
- Increase of injection rates
- Increase of accuracy of global injection flow rate control
- Upgrade to dynamic distribution: increase of accuracy of the equal distribution of global injection flow onto the injection lines
  - For existing dense phase plants
  - For existing dilute phase plants
ROI of a Plant Upgrade from Static to Dynamic Distribution - Case study:

Nom. BF prod. = 4 500 [t_{HM}/d] - Price Delta between Coke and Coal* = 60 [€/t] - Coal-Coke-Replacement ratio = 0,85

Savings at an injection rate increased by 10 kg/tHM PCI rate
Savings at an injection rate increased by 8 kg/tHM PCI rate
Savings at an injection rate increased by 6 kg/tHM PCI rate
Savings at an injection rate increased by 4 kg/tHM PCI rate
Savings at an injection rate increased by 2 kg/tHM PCI rate

CAPEX range for Upgrade from static to dynamic distribution
Upgrade of Dilute Phase PCI Plant

• **PW has proven track record for new installations & plant upgrades in dense phase**
  - More than 100 references
  - More than 1,000 GRITZKO® valves installed

• **Next step: adopt GRITZKO® valves to existing dilute phase plants**
  - Upgrade of existing dilute flow PCI plants from static distribution to dynamic distribution
  - For reaching significantly better equal distribution accuracy between individual injection lines

• **PWIHI undertook a significant R&D program in this regard**
  - Test campaign conducted by operating a physical test plant with two GRITZKO® valves in dilute phase environment
  - CFD analysis
• Located at IHI R&D centre, Yokohama, Japan

• Main characteristics:
  ✓ Two full size GRITZKO® valves installed
  ✓ Testing in actual operating conditions
  ✓ Flow rate of up to 1.000 kg/h of coal
  ✓ Dilute load level from 10 to 20 kg coal/N₂
Main results from test plant:

- Excellent controllability of GRITZKO® valves in dilute phase
- Clear relationship established between differential pressure and opening position as well as flow rate
Main results from CFD analysis

- Good correlation with physical tests
- Definition of necessary wear protection upstream and downstream of GRITZKO® valves
References for Individual Flow Control

Dense phase dynamic distribution

ArcelorMittal Gent (Belgium)
BF ‘A’ & BF ‘B’

ArcelorMittal Liège (Belgium)
BF ‘B’ & BF ‘6’

ArcelorMittal Fos-sur-Mer (France)
BF ‘1’ & BF ‘2’

ArcelorMittal Gijón (Spain)
BF ‘A’ & BF ‘B’

Trinecke (Czech Republic)
BF ‘4’ & BF ‘6’

DMKD (Ukraine)
BF ‘1M’, BF ‘8’, BF ‘9’ & BF ‘12’

Kardemir (Turkey)
BF ‘5’

NSSMC Kashima (Japan)
BF ‘1’ & BF ‘3’

NSSMC Wakayama (Japan)
BF ‘1’ & BF ‘2’

Dense phase distribution hopper with individual flow control

ThyssenKrupp (Germany)
BF ‘1’, BF ‘2’, BF ‘4’ & BF ‘9’

ROGESA (Germany)
BF ‘3’, BF ‘4’ & BF ‘5’

Salzgitter (Germany)
BF ‘A’ & BF ‘B’

ArcelorMittal Dunkirk (France)
BF ‘2’, BF ‘3’ & BF ‘4’

Hyundai Steel (Korea)
BF ‘1’, BF ‘2’ & BF ‘3’

Dilute phase upgrade from static to dynamic distribution

NSSMC Kashima (Japan)
BF ‘1’ & BF ‘3’

NSSMC Nagoya (Japan)
BF ‘1’ & BF ‘3’ (upcoming)
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