



IMPACT OF PARTICLE SIZE DISTRIBUTION OF MATERIAL ON PNEUMATIC CONVEYING OPERATION ON EXAMPLE OF GROUND PHOSPHATE

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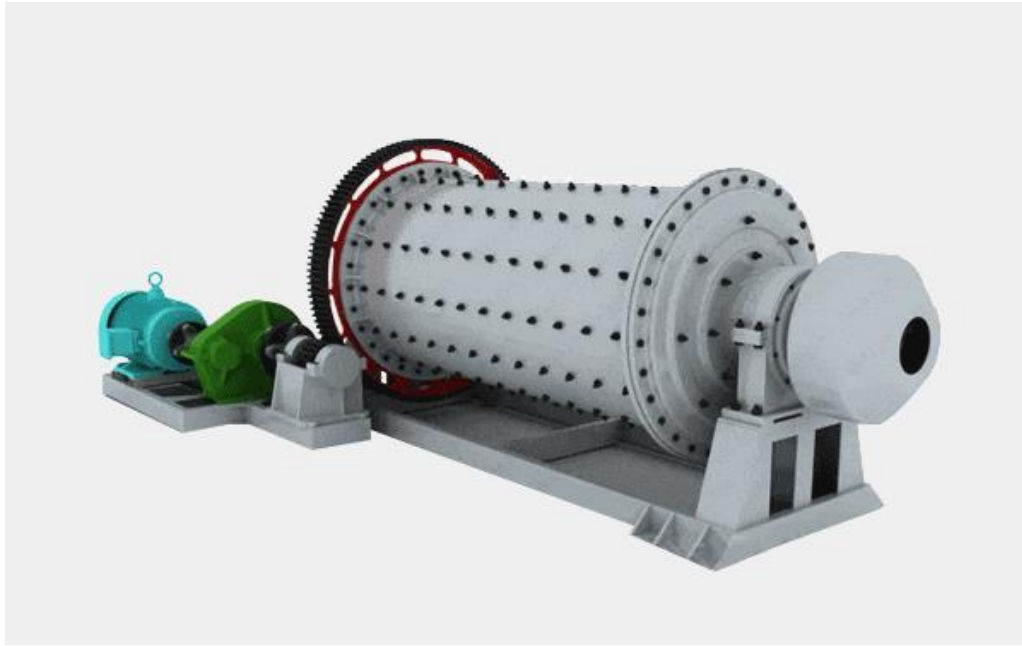
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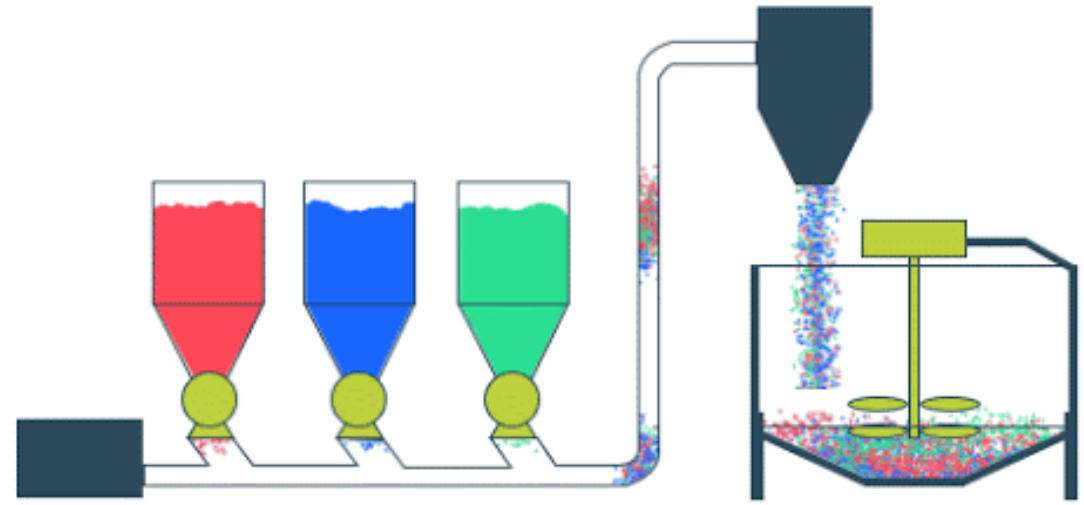


Phosphates – fertilizers - essential in the agricultural sector

~ 95% of the world phosphate rock production - fertilizer industry



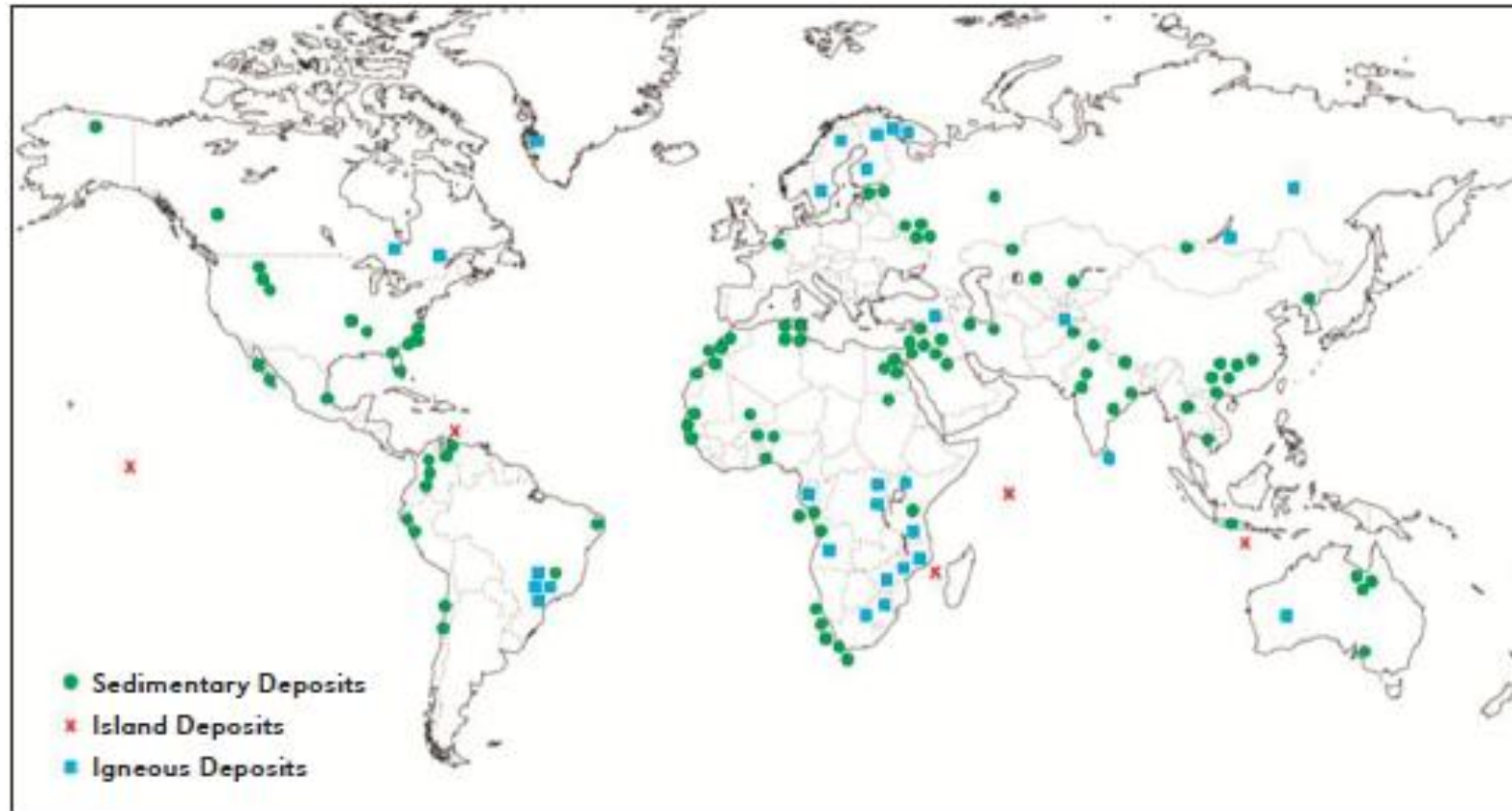
Grinding



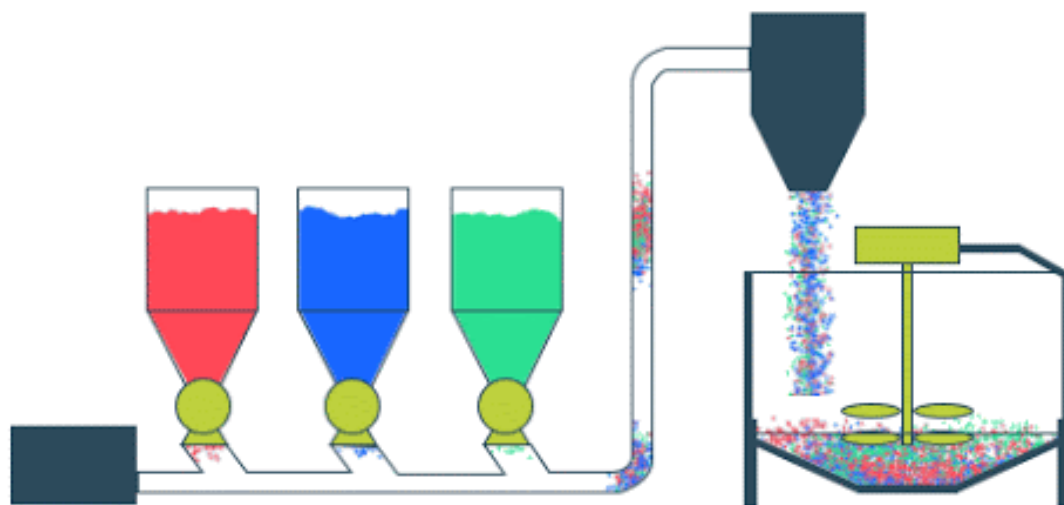
Pneumatic conveying system



Mechanical conveyor



Different types of phosphate rocks widely differ in their characteristics



Physical properties of bulk material must be taken into the consideration in pneumatic conveying system design and operation

30 t/h 240 m ground phosphate pneumatic conveying

Pneumatic conveying was working with no problems

Clogging

Line chocking

Build-ups in pipes

Sudden pipe blockage

All kinds of pneumatic system inspections were conducted, and possible causes that were leading to stoppage of the flow could not be found.

Laboratory for Process and Environmental Engineering (Faculty of Mechanical Engineering, University of Belgrade)

Simple characterization of problematic material

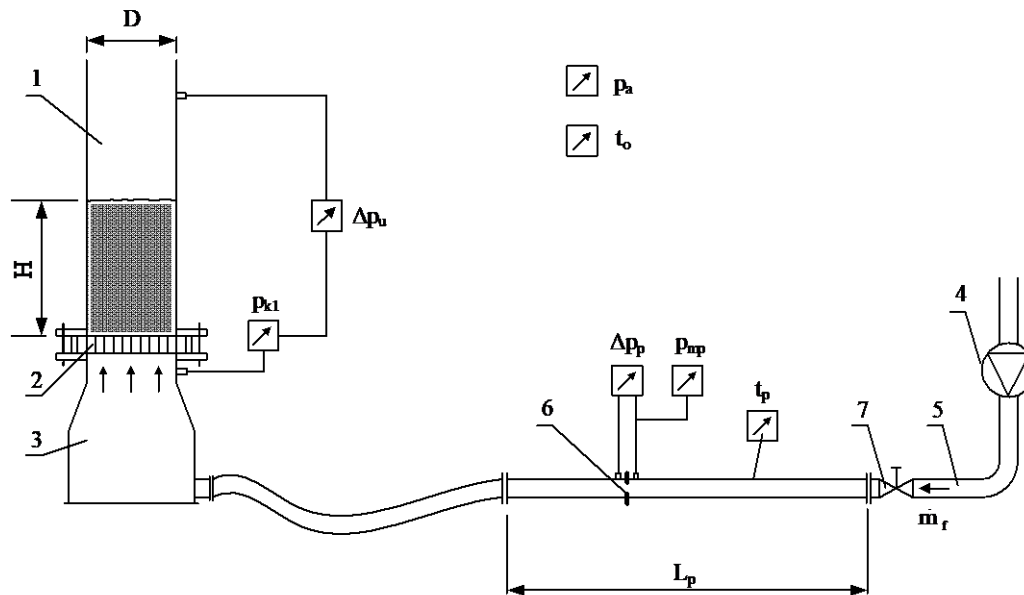
One sample, about 20 kg of ground phosphate was delivered from the plant

Input data on material characteristics used for pneumatic conveying system design

Ground phosphate										
Sieve analysis									Bulk density (kg/m ³)	
Sieve (mm)	1	0.63	0.5	0.4	0.25	0.125	0.063	< 0.063	Non-tapped	Tapped
coarsely ground (%)	0.60	1.90	2.20	3.20	33.80	26.70	14.60	17.00	1343	1702
finely ground (%)	0.40	1.30	1.90	2.70	10.60	20.00	41.50	21.60	1207	1582

Laboratory tests:

- Sieve analysis - SRPS ISO 2591-1:1992 and SRPS ISO 3310-1:2018
- Bulk density, Tapped bulk density - SRPS EN ISO 787-11:2010 and ASTM D7481-18
- Physical density - SRPS B.C8.023
- Permeability (factor) - ASTM D7743-12



1. plexiglas fluidizing column, 2. porous membrane, 3. air flow equalization chamber, 4. air mover,
5. pipeline for air supply, 6. orifice plate,
7. regulating valve

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Sieve (mm)	Average particle diameter (mm)									
coarsely ground	0.227									
finely ground	0.155									

Input data

Sieve (mm)	0.8	0.63	0.4	0.315	0.2	0.125	0.08	0.063	0.056	<0.056
Sample 1.1	0.59	1.85	9.19	10.29	21.33	34.06	18.38	1.60	0.51	2.19
Sampe 1.2	0.74	1.57	9.48	10.80	52.68	17.64	4.70	1.73	0.16	0.49

Ground phosphate

Sieve (mm)	Average particle diameter (mm)						Bulk density (kg/m ³)	Bulk tapped density (kg/m ³)	Physical density (kg/m ³)
Sample 1.1	0.233						1320.4	1692.8	2663.3
Sampe 1.2	0.275								

Sieve (mm)	0.2	0.16	0.125	0.09	0.08	0.071	0.063	0.063	0.056	<0.056
Sample < 0.25 mm	4.20	19.80	34.95	26.28	3.92	5.02	4.93	0.27	0.09	0.55

Sieve (mm)	Average particle diameter (mm)				Bulk density (kg/m ³)	Bulk tapped density (kg/m ³)	Physical density (kg/m ³)
Sample < 0.25 mm	0.135				1141.4	1331.2	2500

Ground phosphate < 0.2 mm

Minimum fluidization velocity 16-17 cm/s

Permeability factor in range $(7.41-24.09) \cdot 10^{-6} \text{ m}^2/(\text{Pa}\cdot\text{s})$



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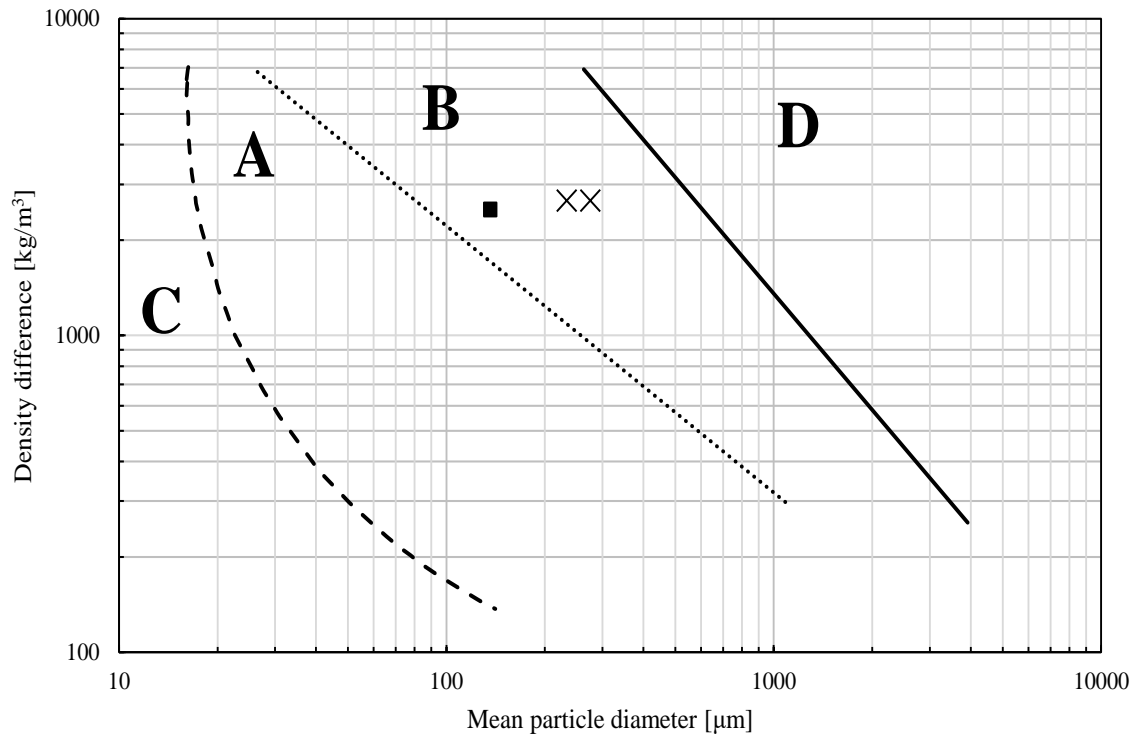
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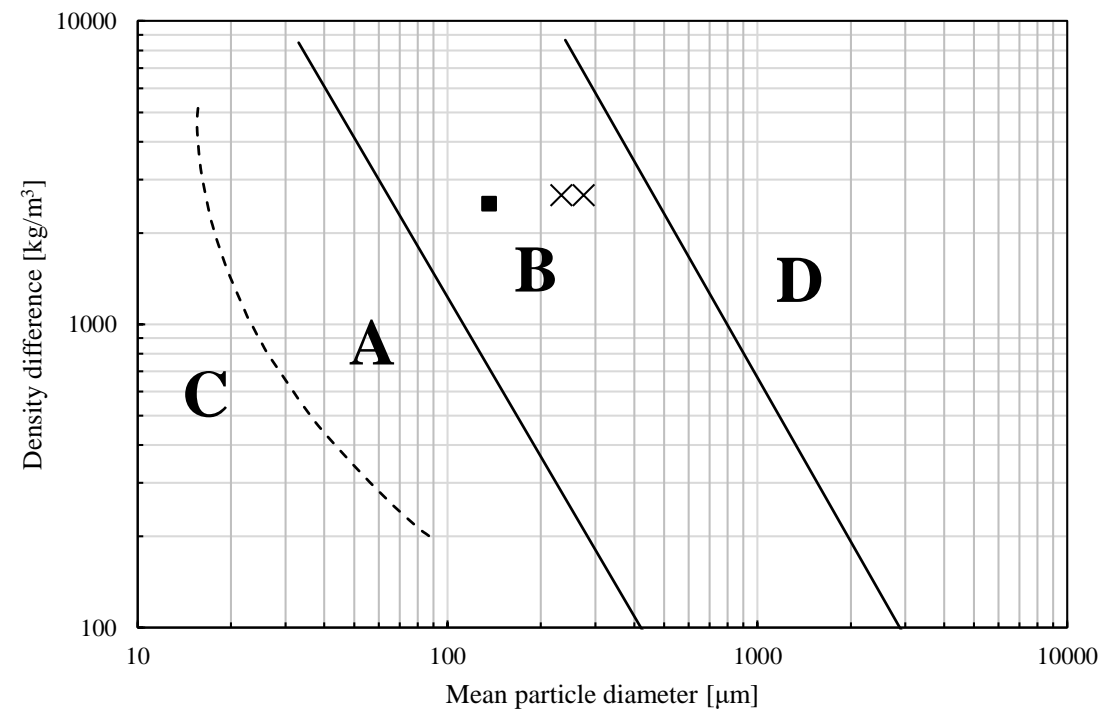
Minimum fluidization velocity 16-17 cm/s and 10 cm/s

Permeability factor in range $(7.41-24.09) \cdot 10^{-6} \text{ m}^2/(\text{Pa}\cdot\text{s})$ and $(3,01 - 7,03) \cdot 10^{-6} \text{ m}^2/(\text{Pa}\cdot\text{s})$



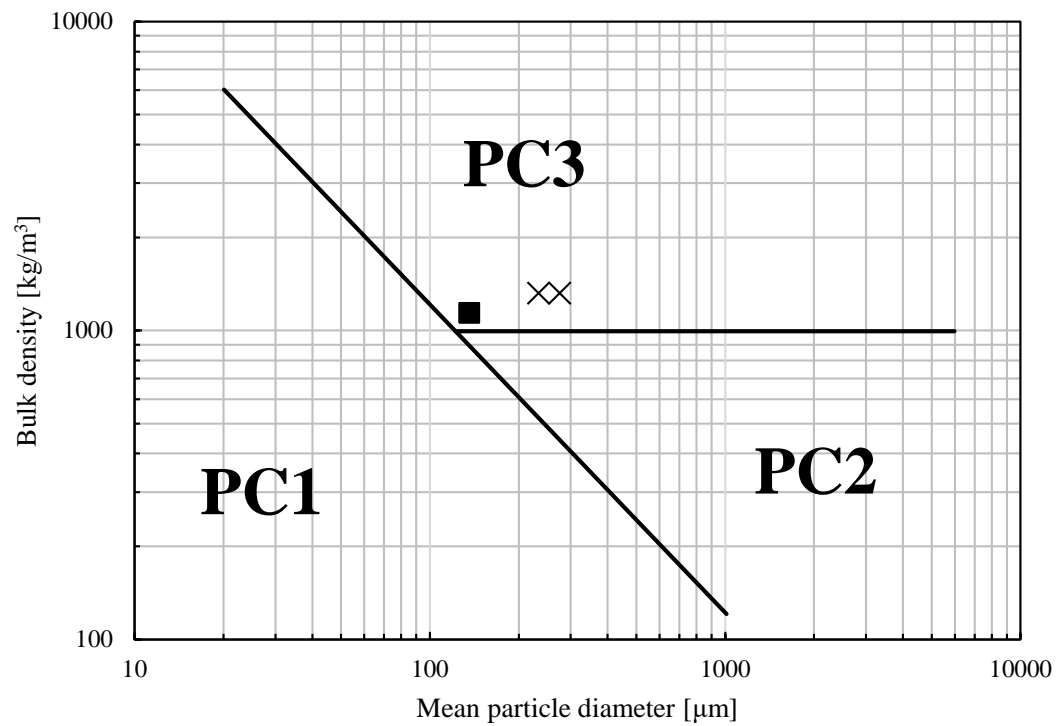
x Ground phosphate ■ Ground phosphate < 200 μm

Geldart's classification



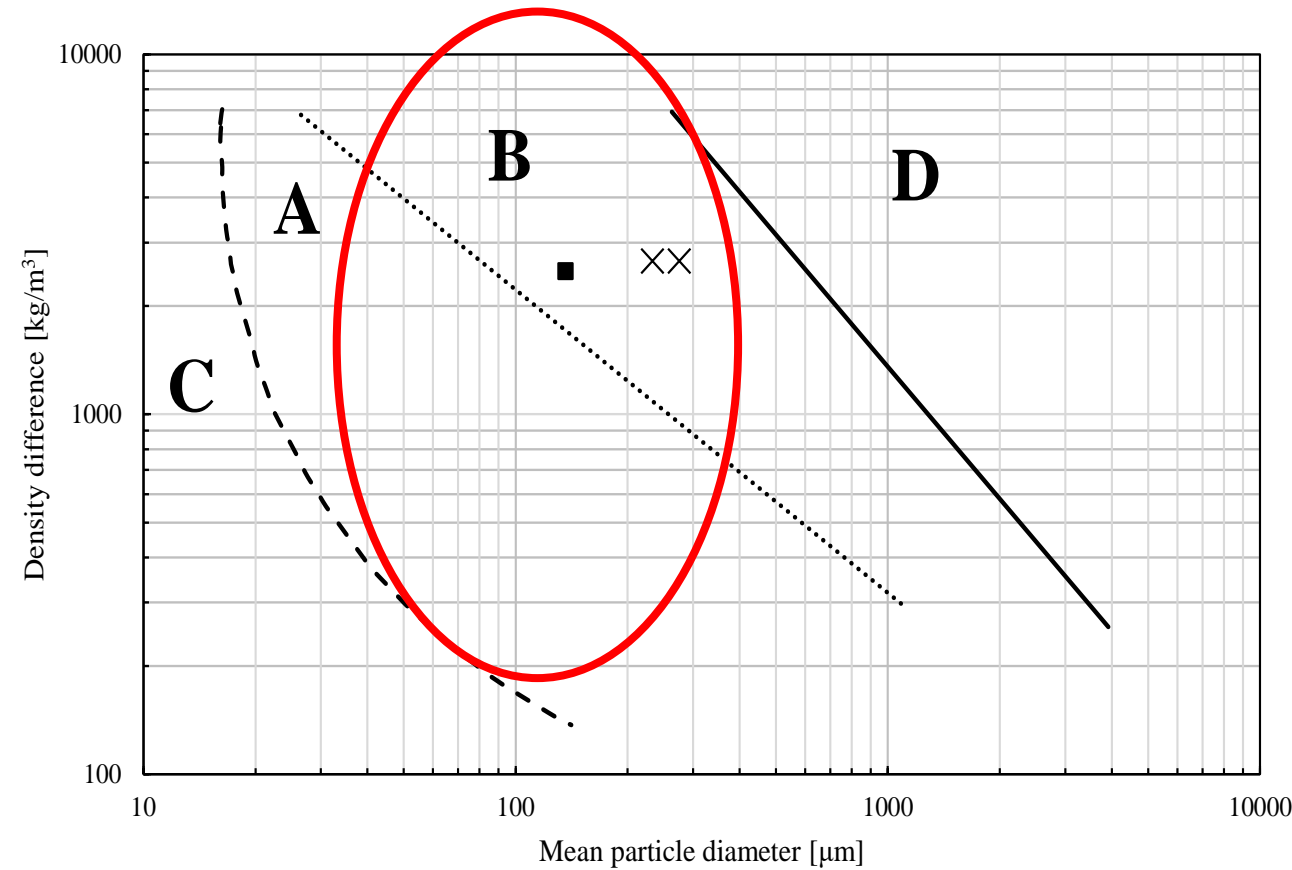
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Dixon's slugging diagram

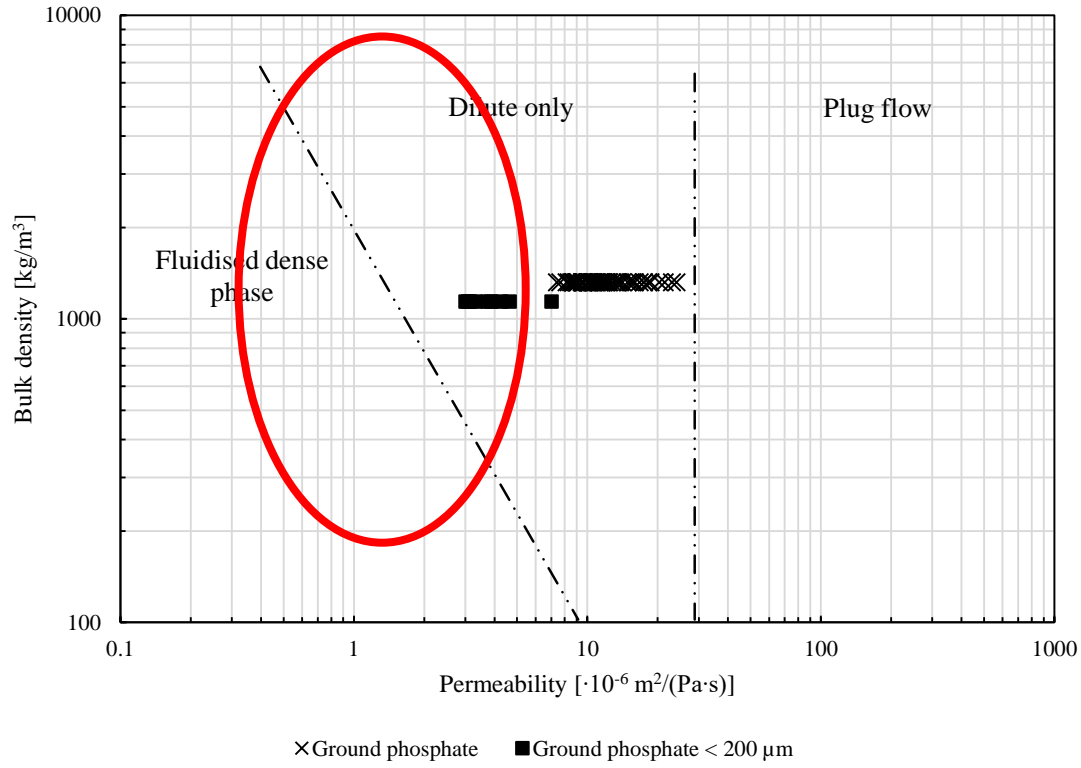


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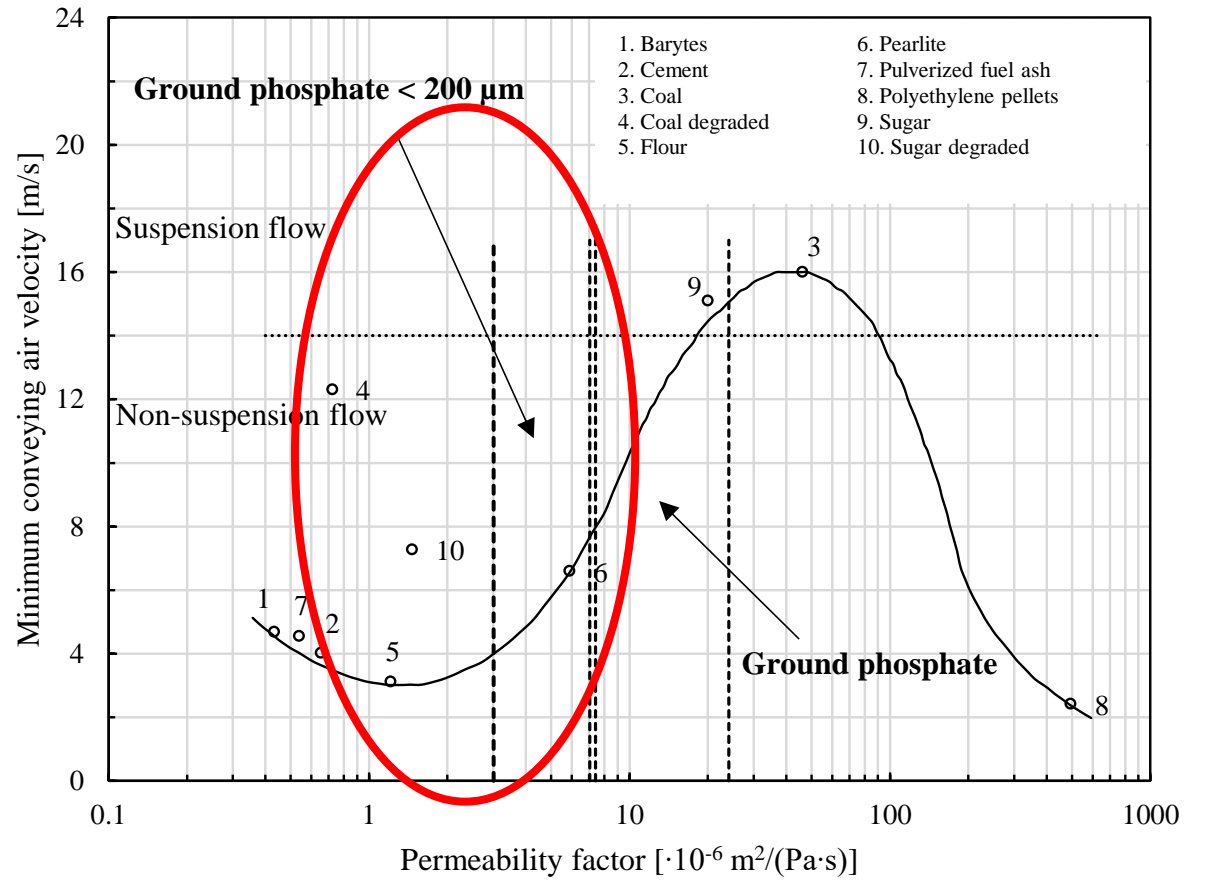
Pan's diagram



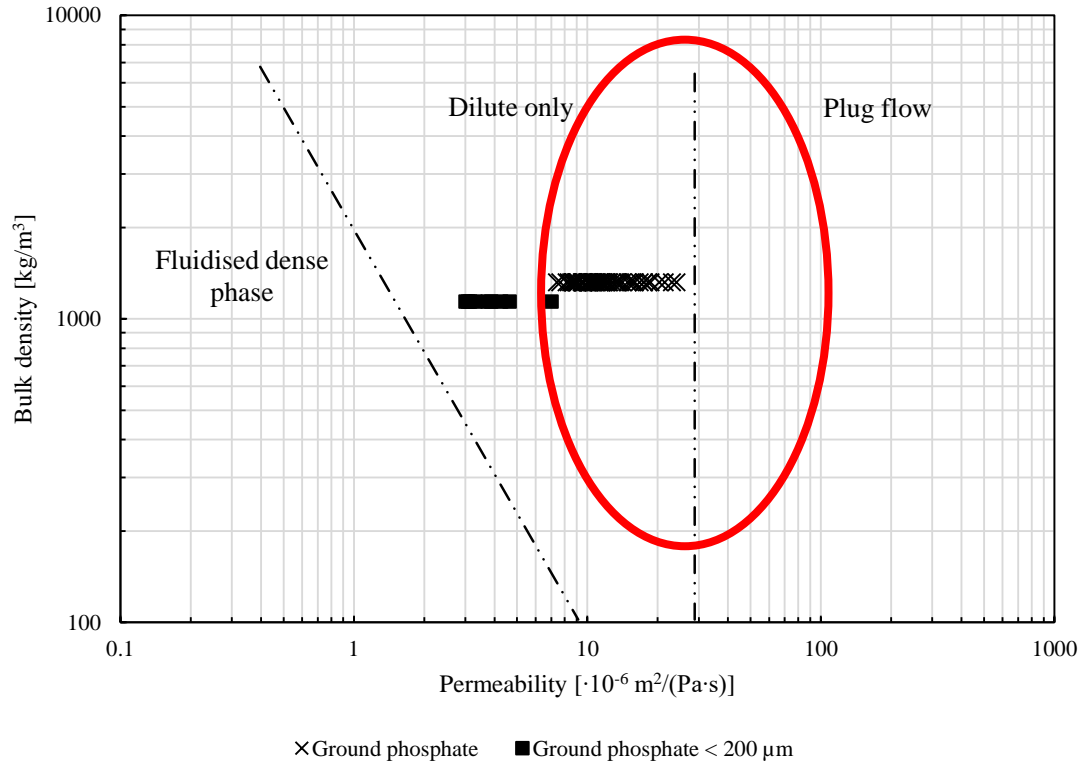
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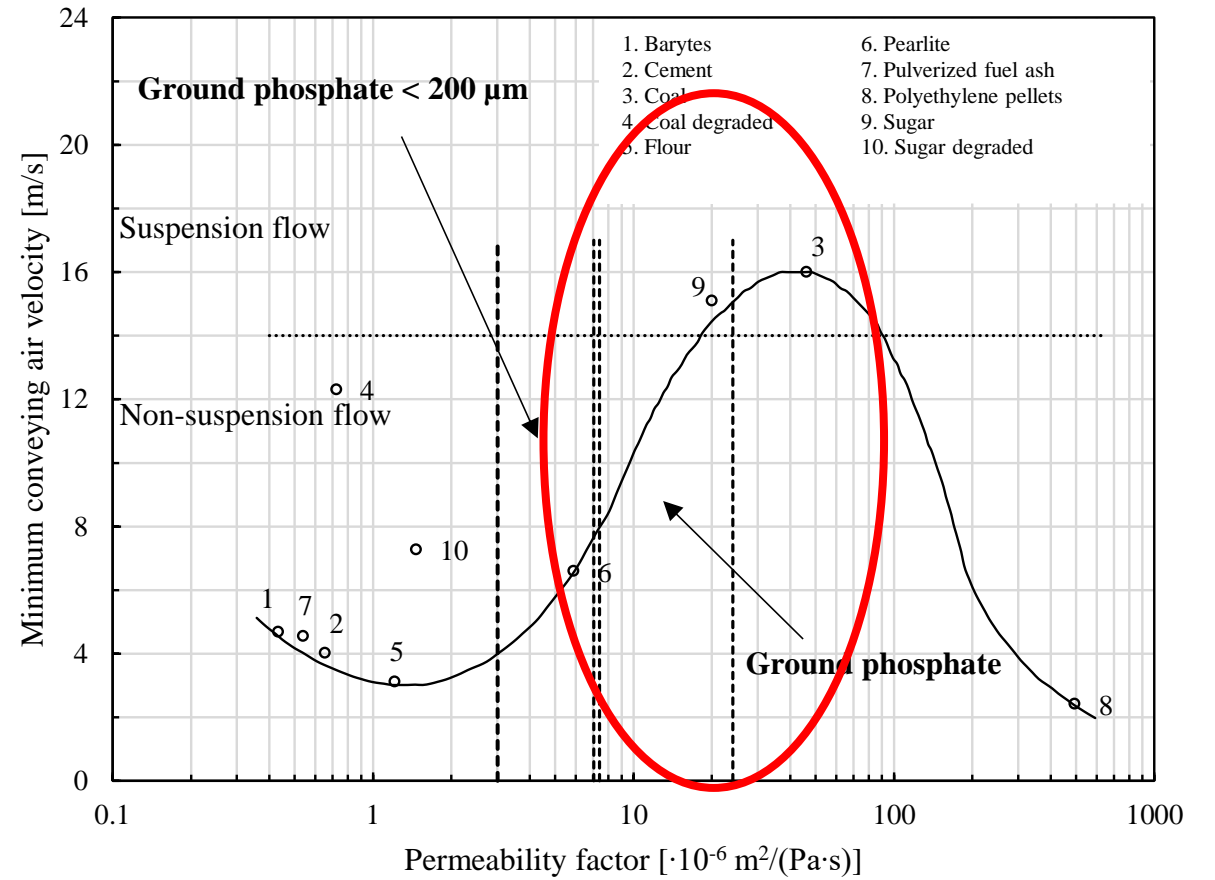
Jones' diagram



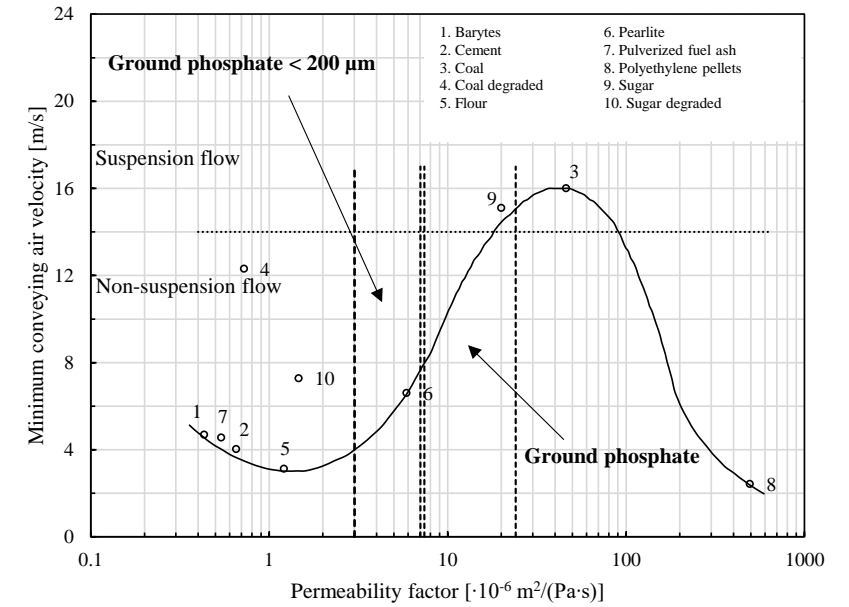
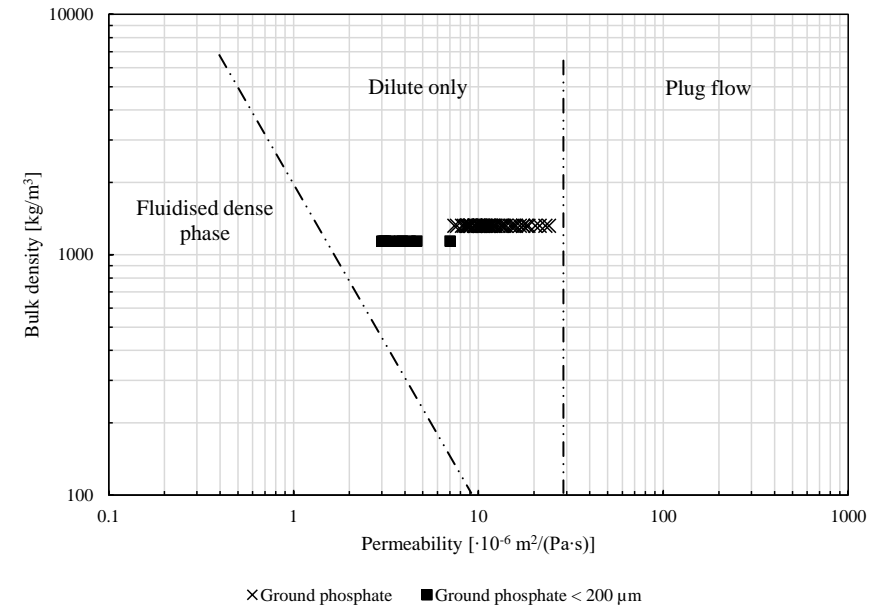
Mills' diagram



Jones' diagram



Mills' diagram



- A few simple laboratory tests of material to be conveyed might be sufficient to indicate possible roots of problems with pneumatic conveying system operation
- Even minimal deviation of initial particle size distribution of material is very important issue
- If the plant operates with previous crushing or milling facility, constant and uniform grinding quality must be ensured