UNIVERSITY of GREENWICH
The Wolfson Centre
for Bulk Solids Handling Technology

Plant Operational Instability Induced by Segregation of Food Bulk Solids

Richard Farnish, CEng MIMechE

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Segregation

In the context of this paper, segregation can be thought of as shift in bulk behaviour as a function of the redistribution of particles within the bulk form, where such particles exhibit a range of characteristics in terms of:

Size, shape, density or surface morphology

Segregation

Segregation in processes has production implications almost as varied as the number of industries in which it commonly occurs.

Symptoms of segregation can encompass:

Variable product quality or functional performance
Inconsistent pack or dose weights
Bulk density fluctuations
Unstable discharge/flow from equipment

This list is by no means exhaustive!

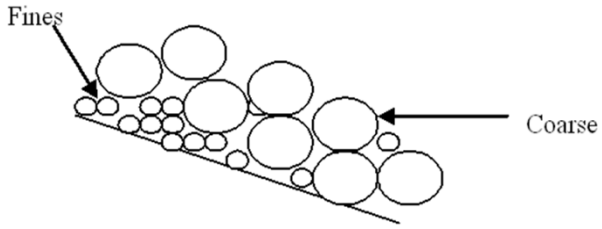
Segregation

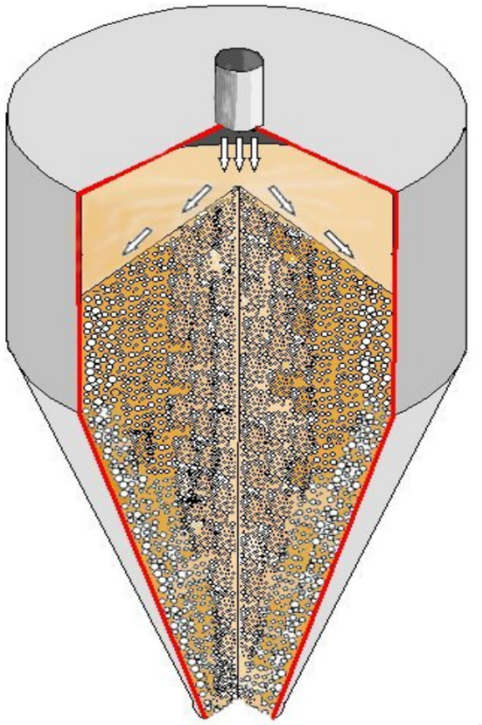
It is important to bear in mind that any homogenous composition of particles (irrespective of the term of reference for differences at particle level) will be susceptible to segregation when handled.

The more handling steps (or severity of inappropriate steps) – the greater the opportunity for intensification of changes in bulk characteristics locally within the system.

Some examples follow:

Segregation in Processes



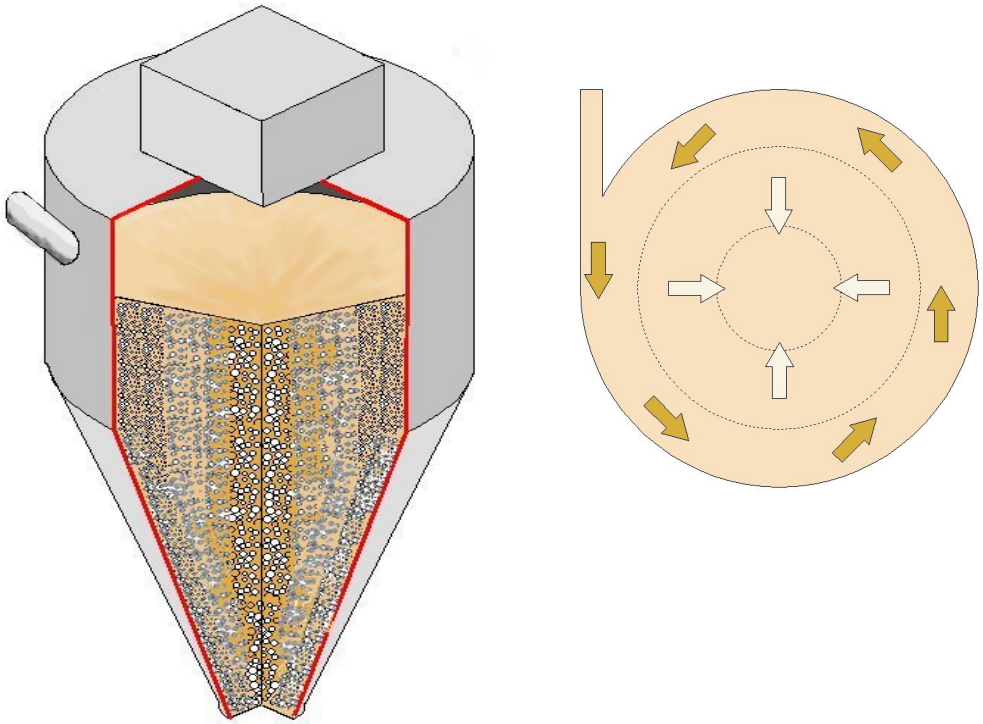


Surface effect / Rolling segregation

Segregation in Processes

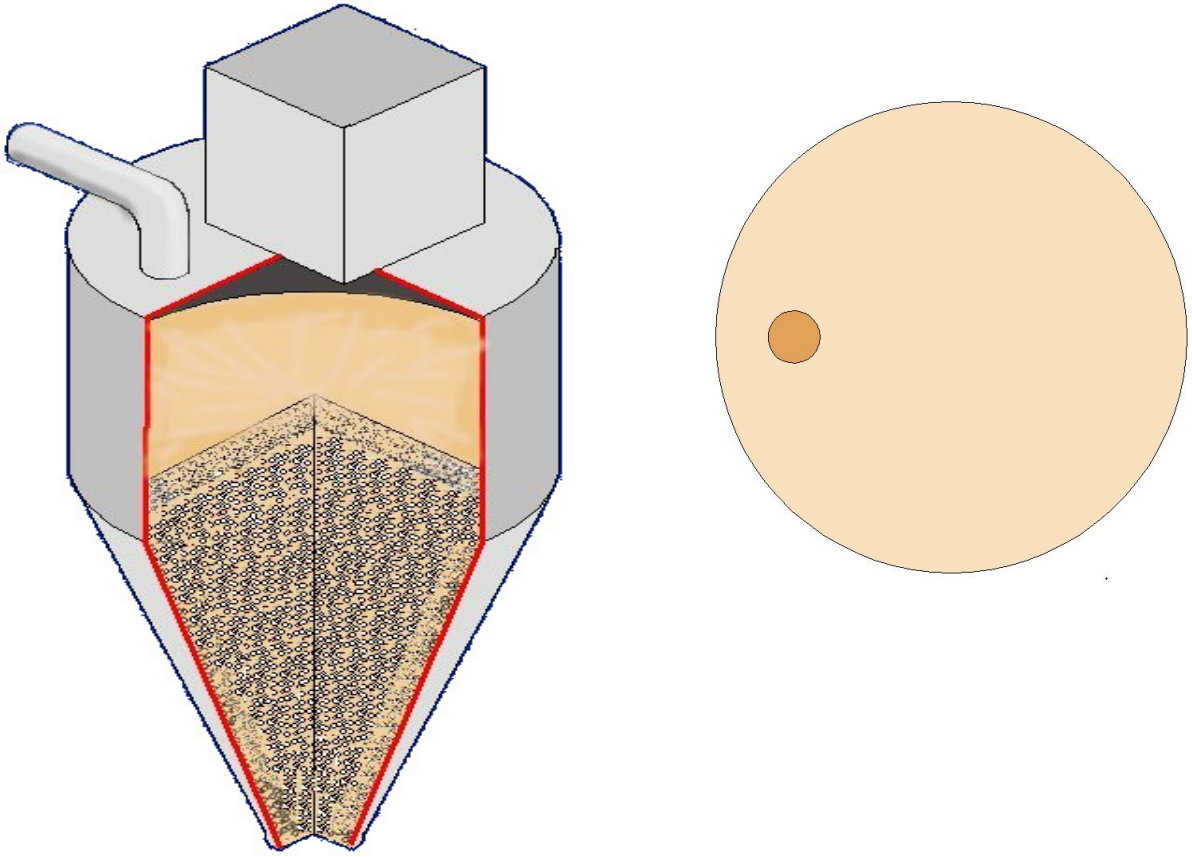
Evidence of rolling segregation in stockpile formation
Image c/o www.geoengineer.org

Segregation in Processes



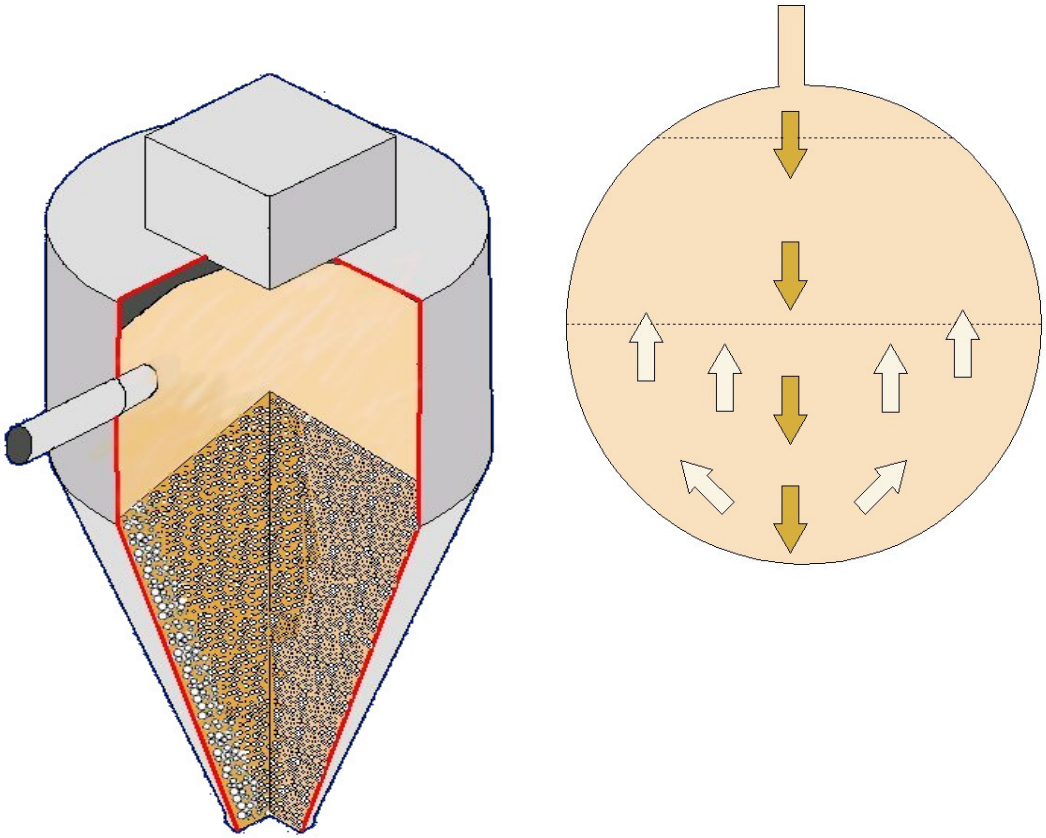
Radial segregation arising from tangential pneumatic filling.

Segregation in Processes



Stratified segregation arising from pneumatic filling through a top plate.

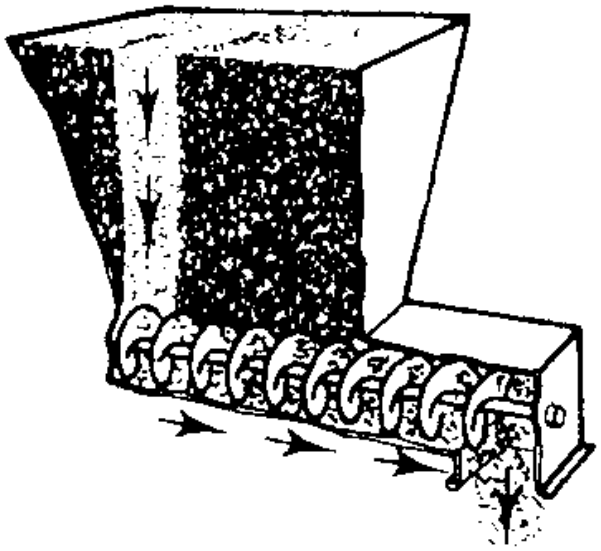
Segregation in Processes

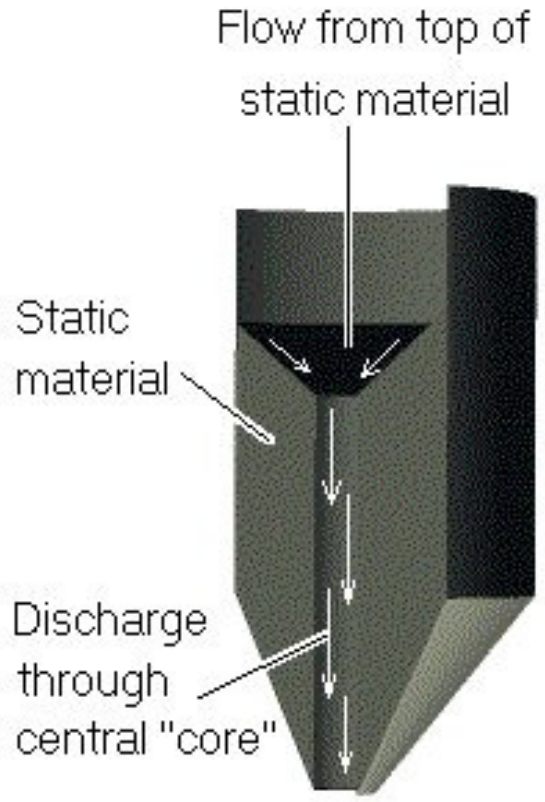


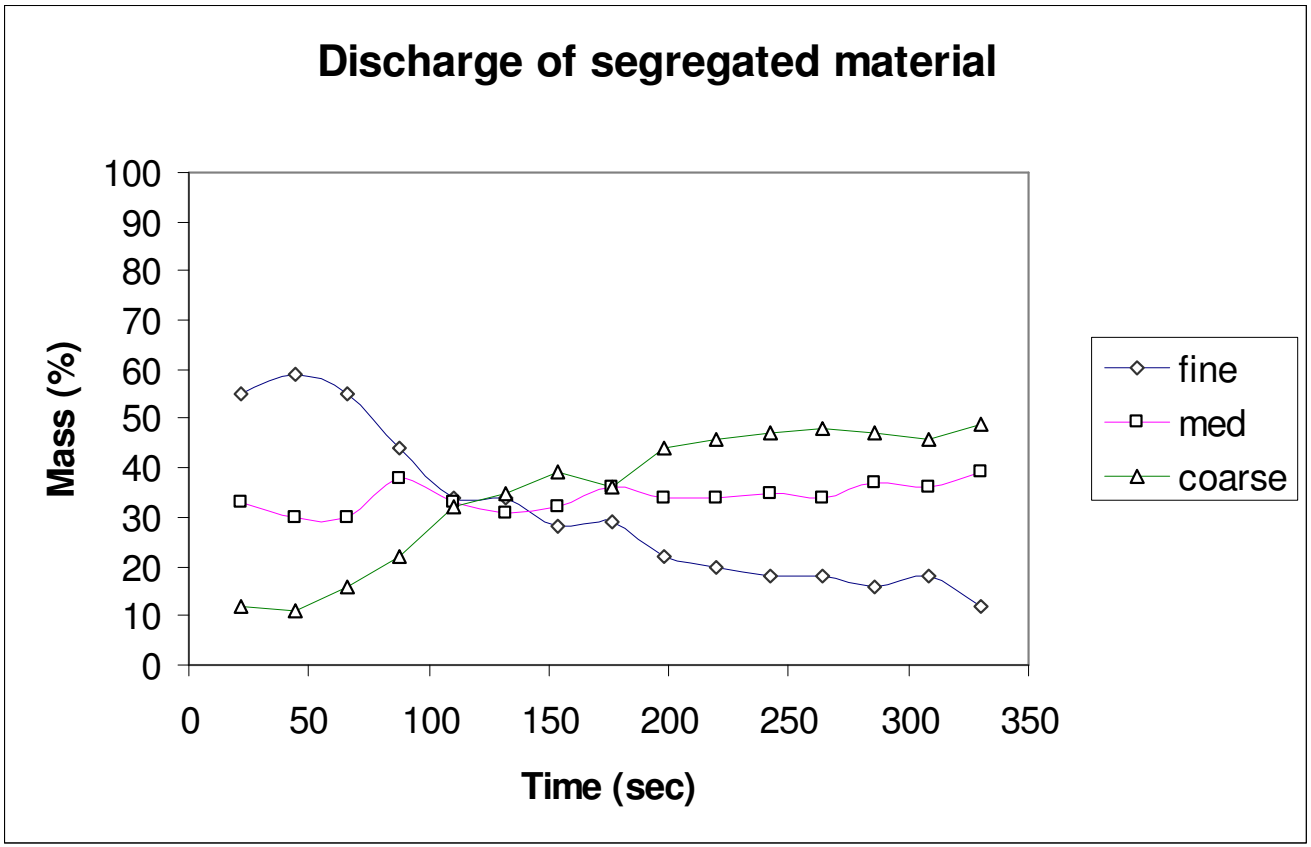
Lateral segregation arising from perpendicular pneumatic filling.

Typical Plant Equipment Operational Characteristics
Core Flow

- arbitrary hopper half angles
- “first in last out” discharge
- preferential discharge channel
- poor interfacing to feeders
- exaggerates segregation effects of particles

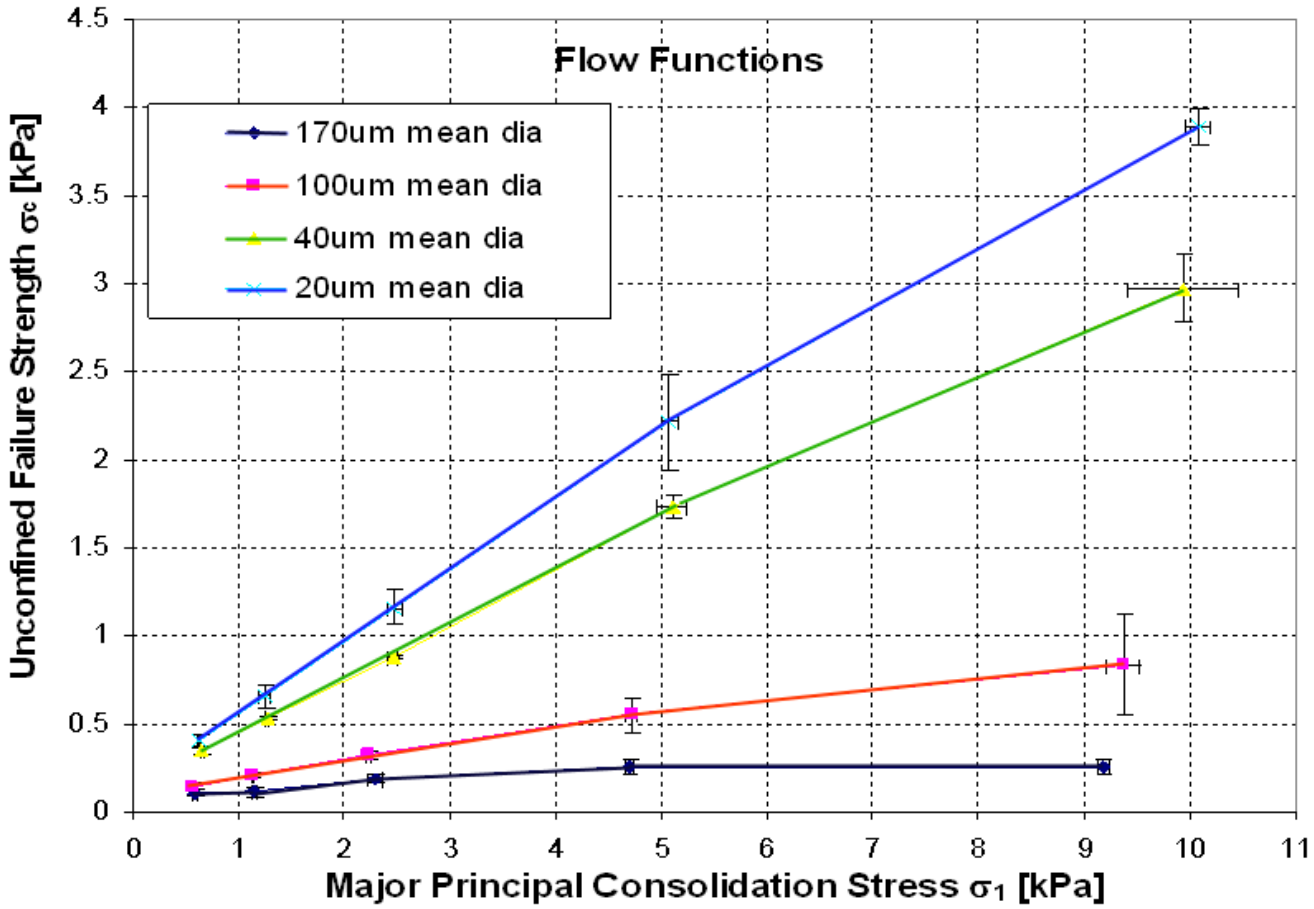




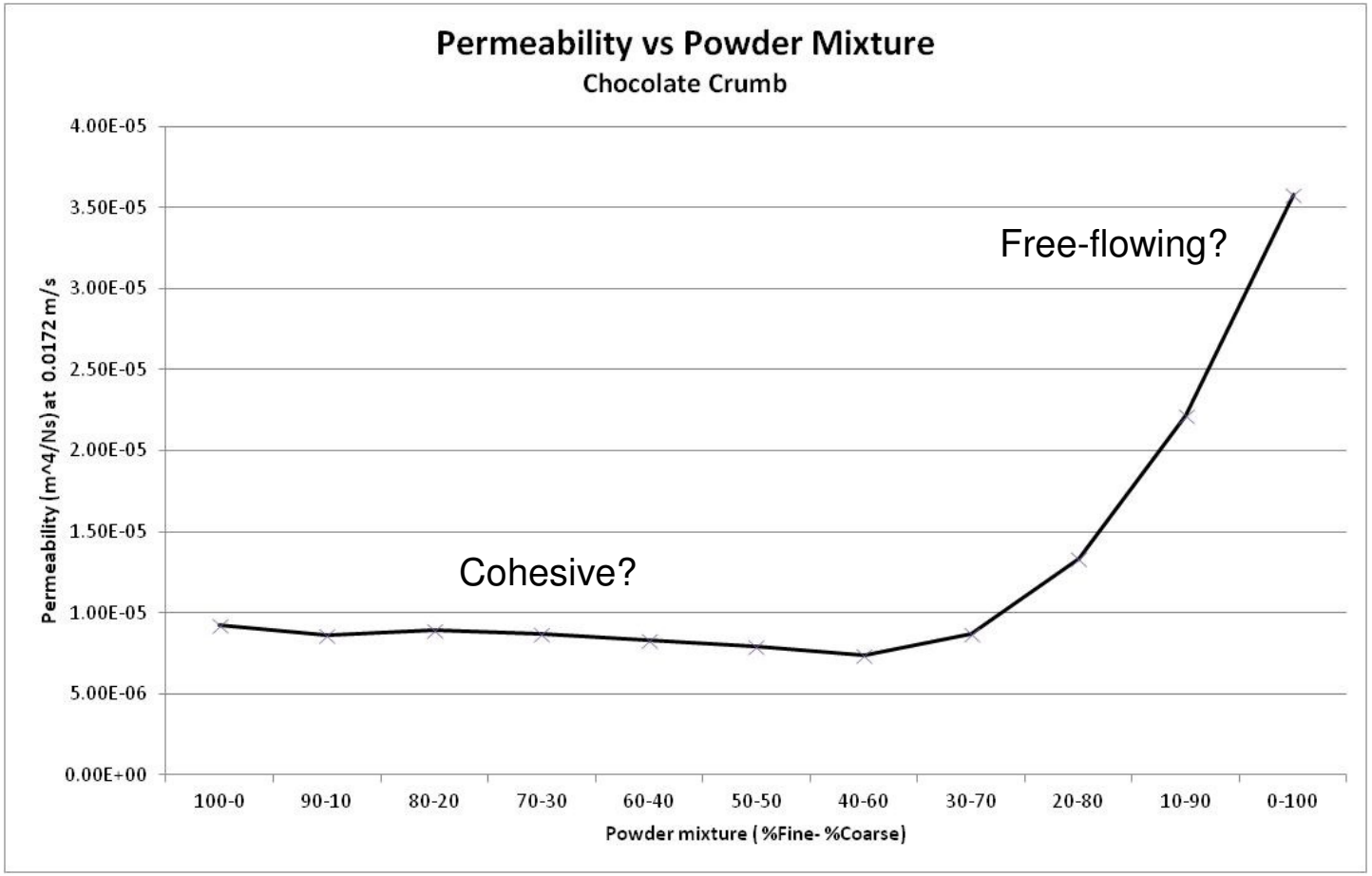


Variation of particle size with discharge time, for a product flowing from a core flow vessel

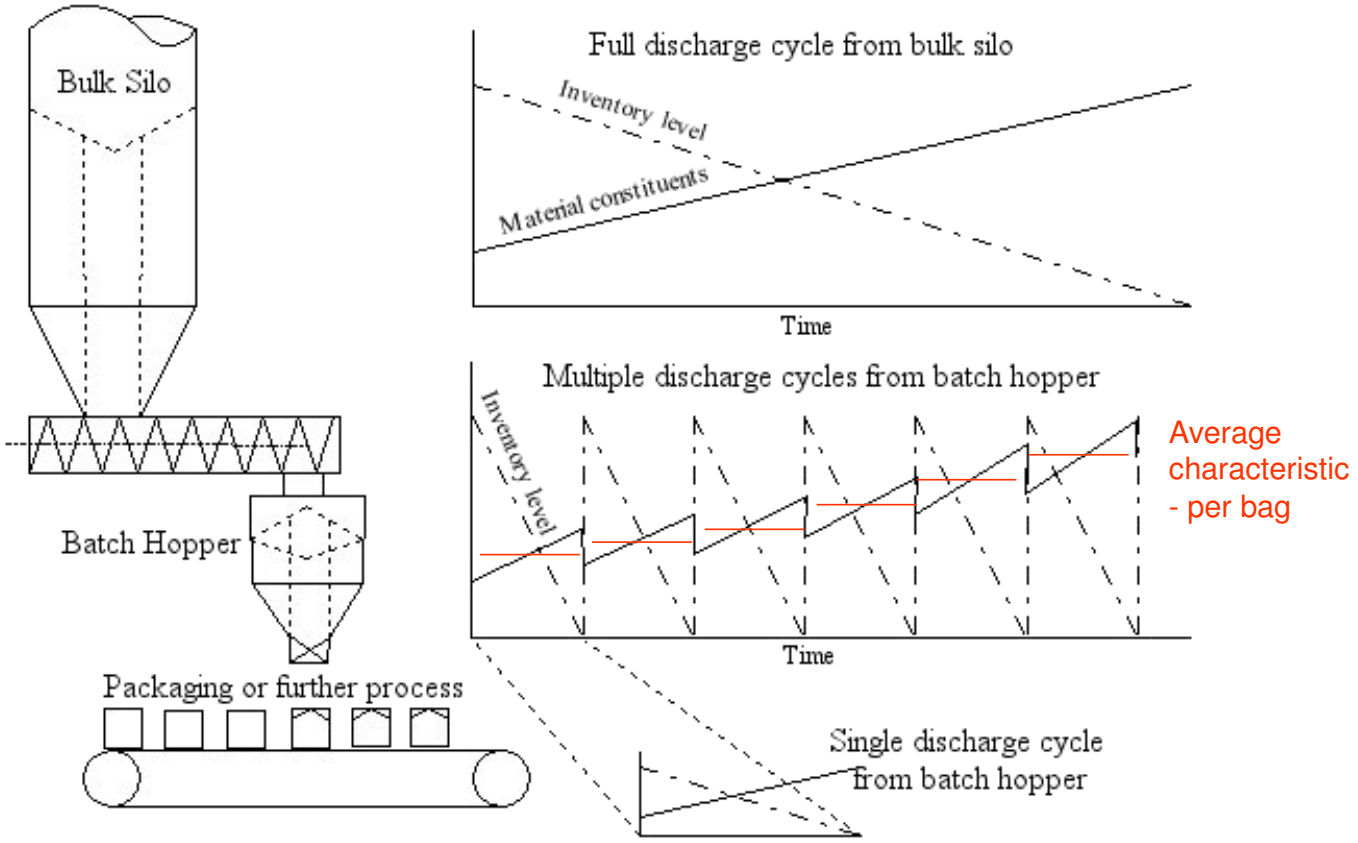
Change in flow behaviour as a function of particle size



Changes in Permeability as a Function of Particle size

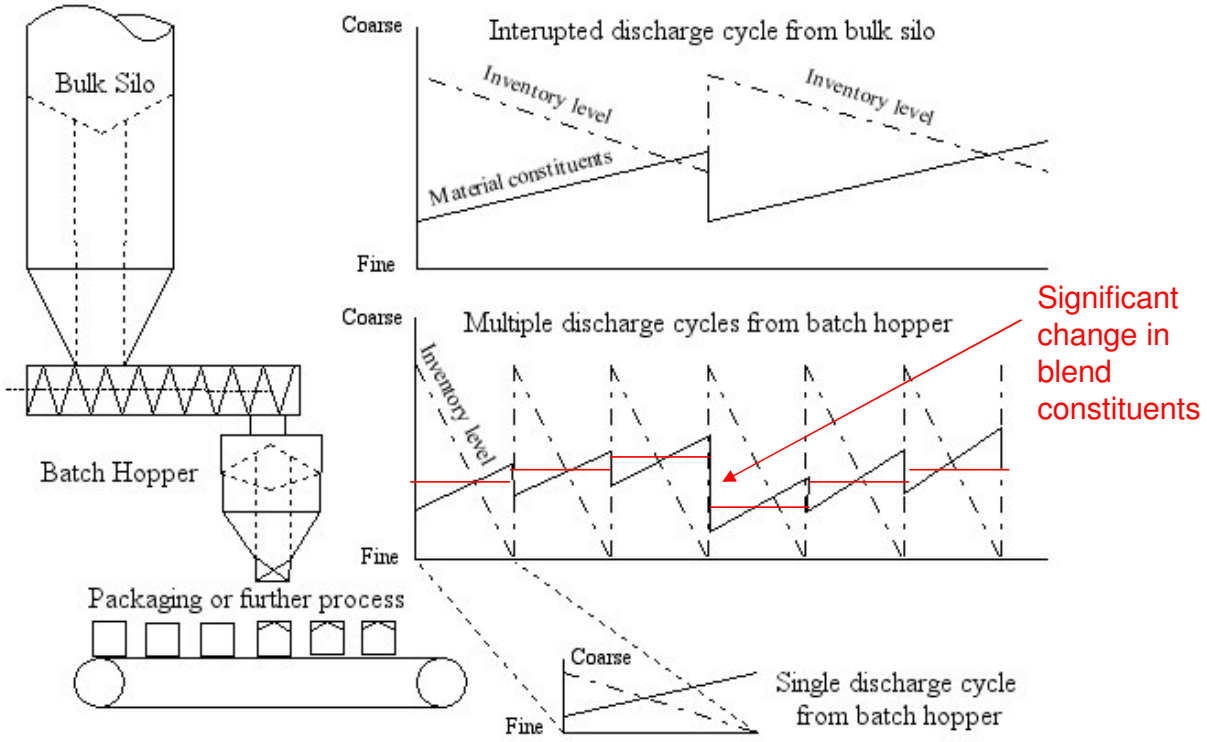


Segregation in an Idealised Process



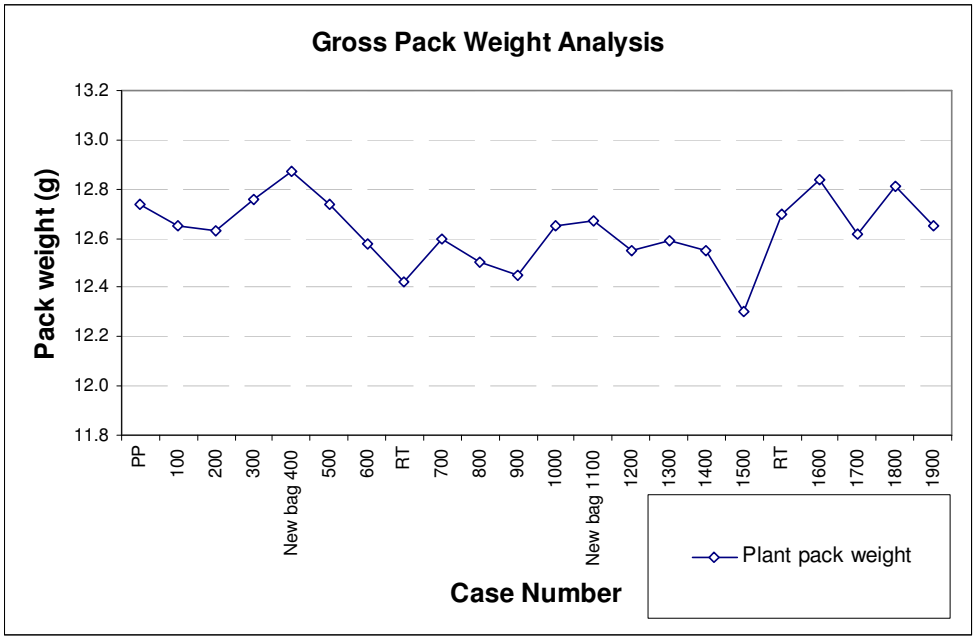
Cumulative segregation effects on a process

Segregation in Many Processes



Segregation effects within a batch process as a result of “topping up”

Segregation in a process – Case Study 1



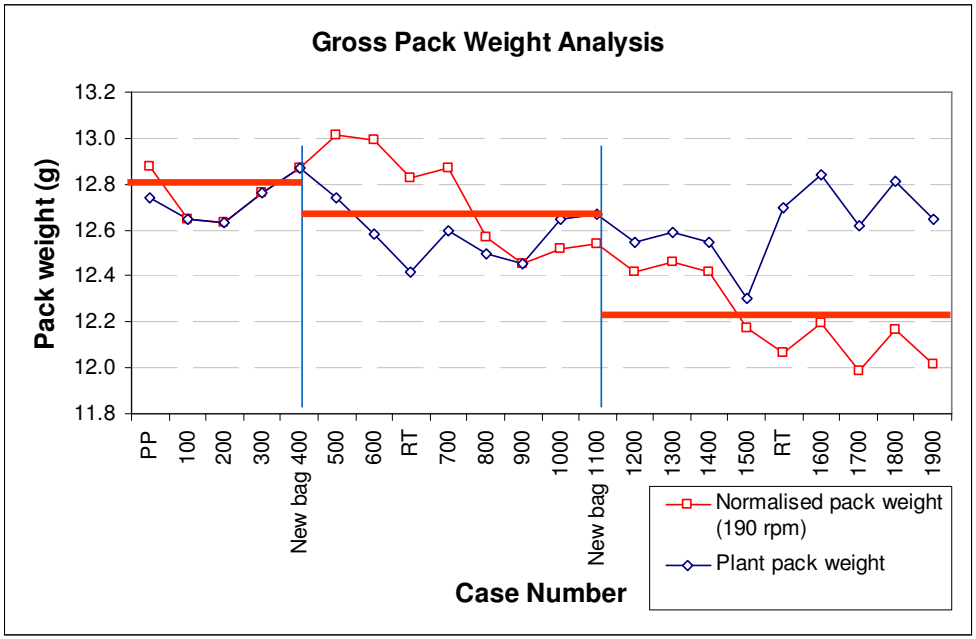
Segregation effects on a manually adjusted volumetric system – industry data

Segregation in a Process – Case Study 1

	Auger Speed (RPM)	Pack Weight (Av. of 5) g	Av.Weight divided by RPM	Pack weight normalised to 190 RPM
PP	188	12.74	0.068	12.88
100	190	12.65	0.067	12.65
200	190	12.63	0.066	12.63
300	190	12.76	0.067	12.76
New bag 400	190	12.87	0.068	12.87
500	186	12.74	0.068	13.01
600	184	12.58	0.068	12.99
RT	184	12.42	0.068	12.83
700	186	12.6	0.068	12.87
800	189	12.5	0.066	12.57
900	190	12.45	0.066	12.45
1000	192	12.65	0.066	12.52
New bag 1100	192	12.67	0.066	12.54
1200	192	12.55	0.065	12.42
1300	192	12.59	0.066	12.46
1400	192	12.55	0.065	12.42
1500	192	12.3	0.064	12.17
RT	200	12.7	0.064	12.07
1600	200	12.84	0.064	12.20
1700	200	12.62	0.063	11.99
1800	200	12.81	0.064	12.17
1900	200	12.65	0.06	12.02

Plant data

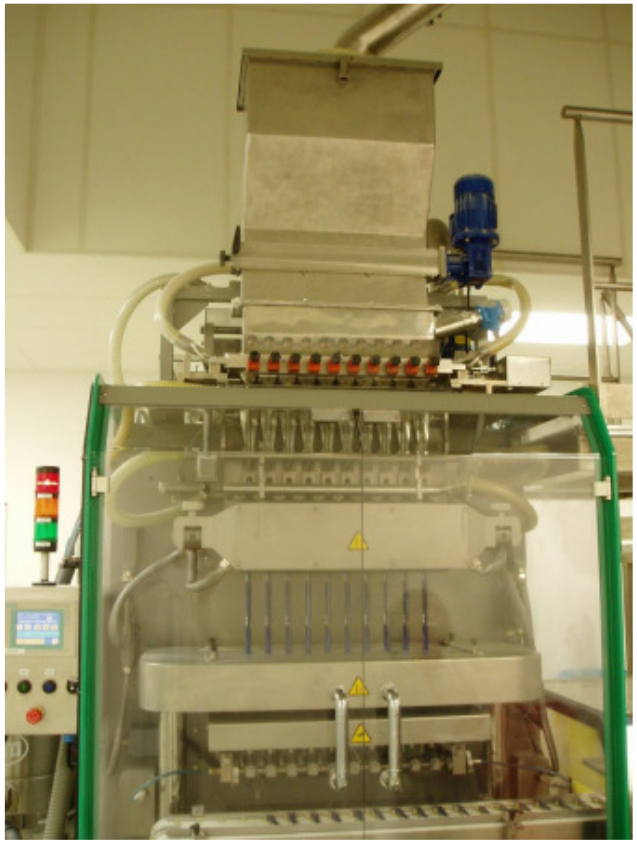
Segregation in a Process – Case Study 1



Decreasing bulk density

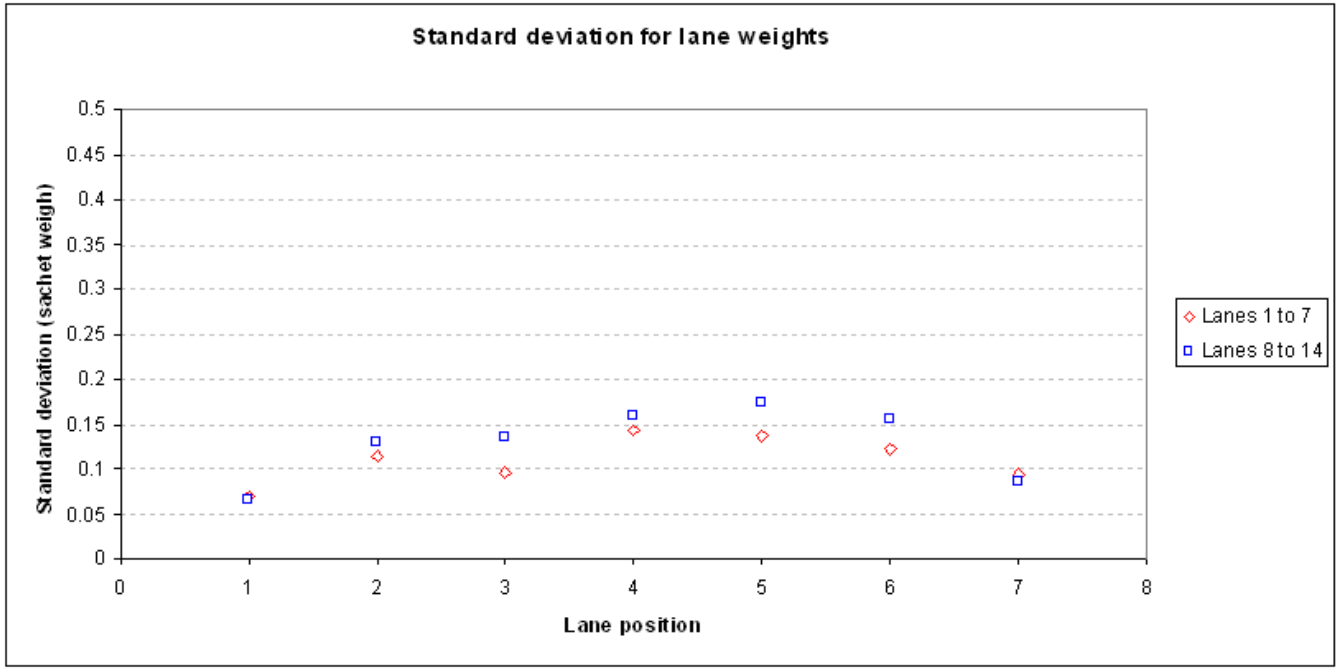
Segregation effects on a manually adjusted volumetric system – industry data (8% drift in bulk density)

Segregation in a Process – Case Study 2



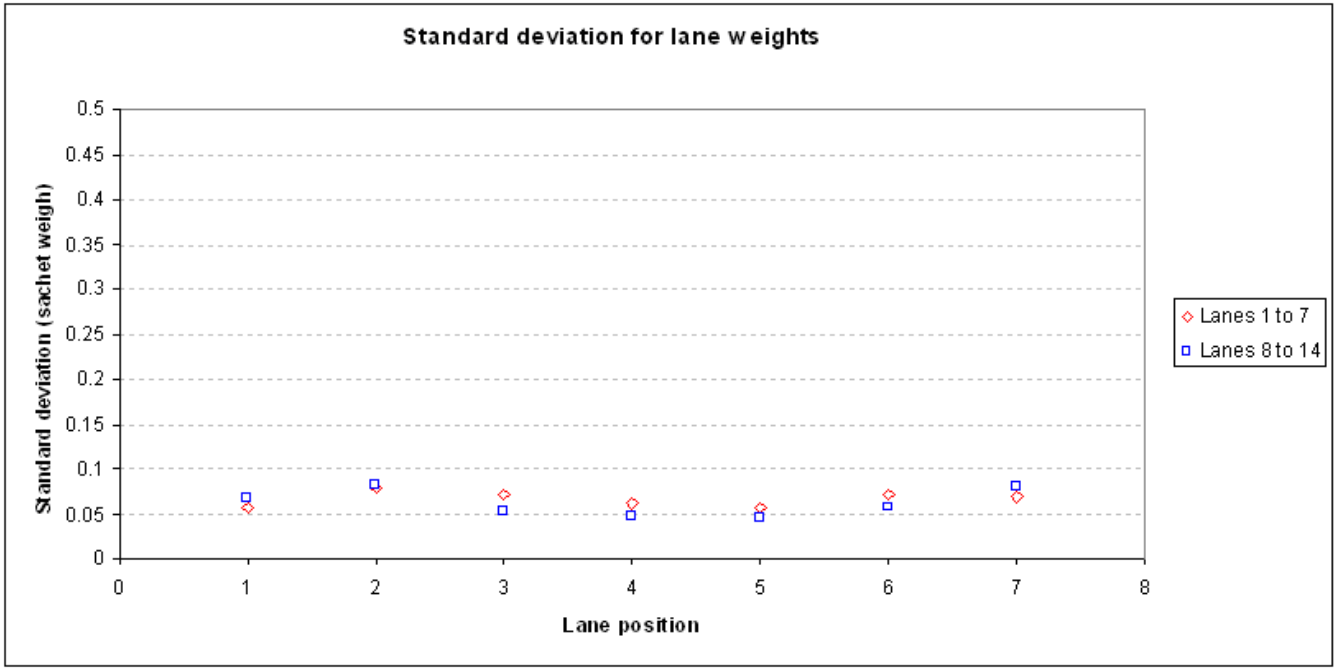
Sachet filling line

Segregation in a Process – Case Study 2



Segregable material

Segregation in a Process – Case Study 2



Non-segregable material

Conclusions

Segregation is an ongoing challenge for many industries across most sectors.

Characterisation techniques exist to evaluate the sensitivity of a bulk material to shifts in its bulk composition.

It is essential to note that reliance on particle size distribution to benchmark segregation may not be ideal. Segregation can occur on the basis of particle size, shape or density.

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Richard Farnish, CEng MIMechE

R.J.Farnish@gre.ac.uk

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