UNIVERSITEIT GENT

Linking granulation performance with residence time & liquid distributions in twin-screw granulation

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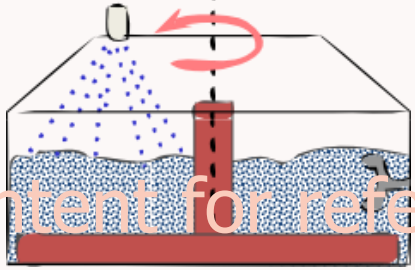
Wednesday, November 11, 2015: 4:25 PM

Ballroom B (Salt Palace Convention Center)

LP PAT BIOMATH

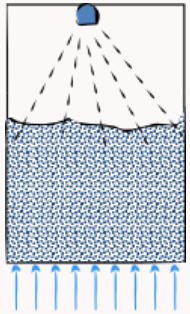
Traditional to new granulation method

High-shear mixer



Drum

Fluidised-bed

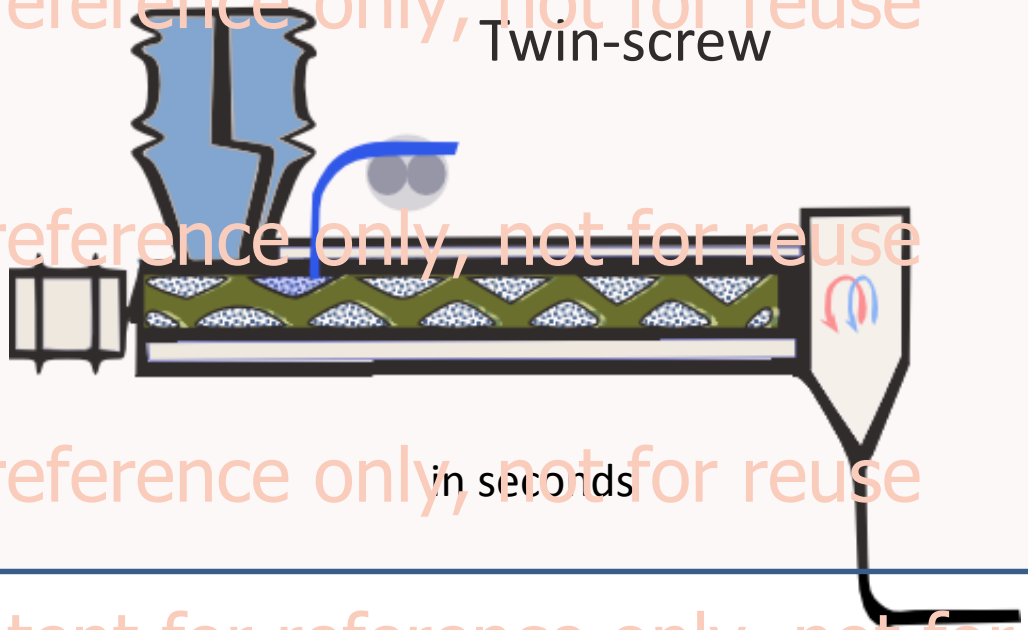


From minutes to hours

Batch

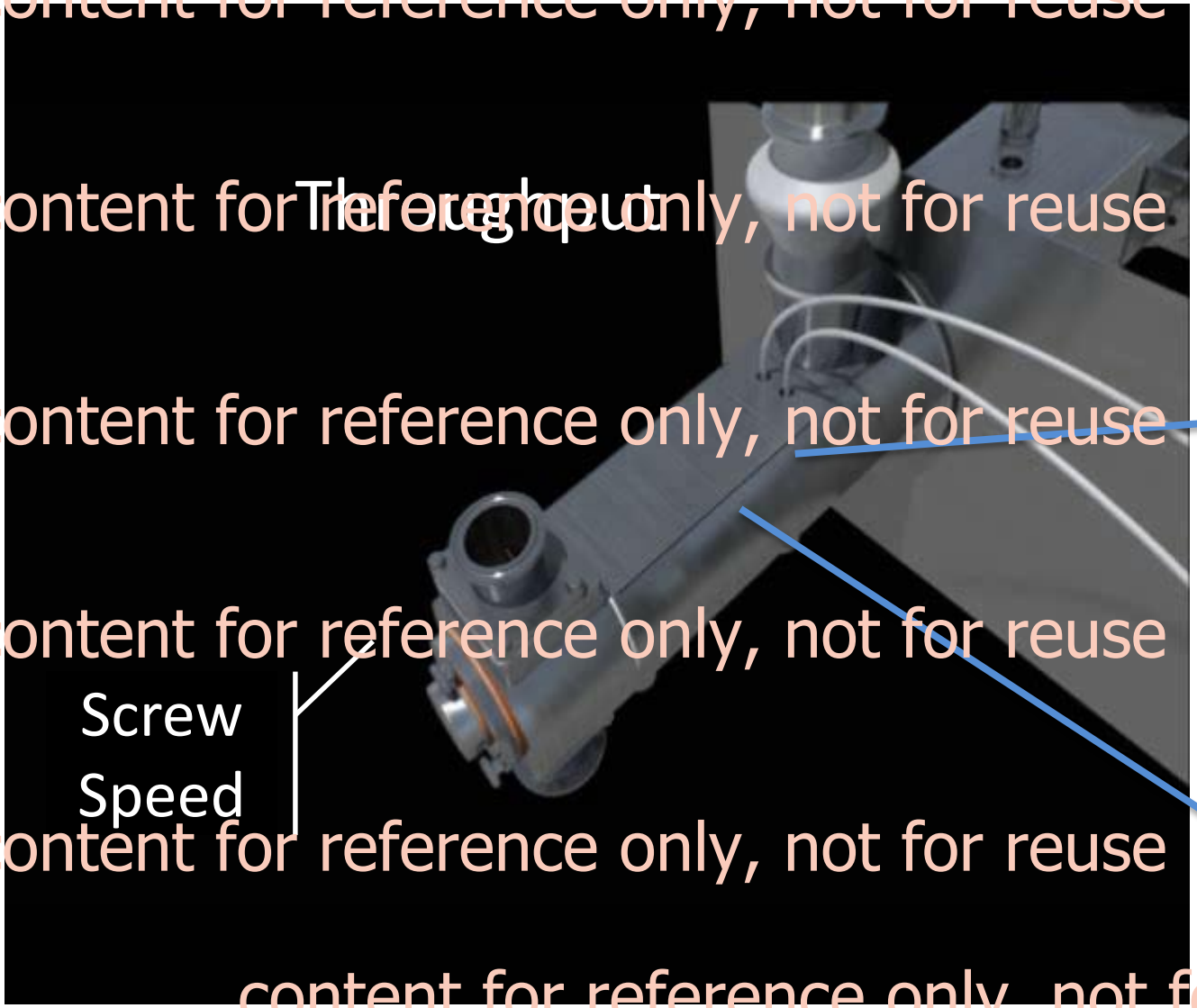
Continuous

Twin-screw

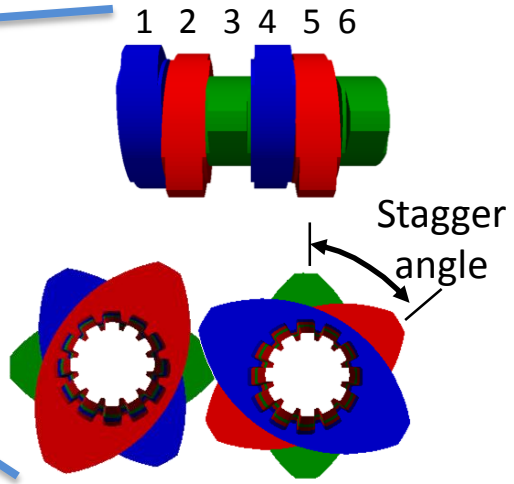


in seconds

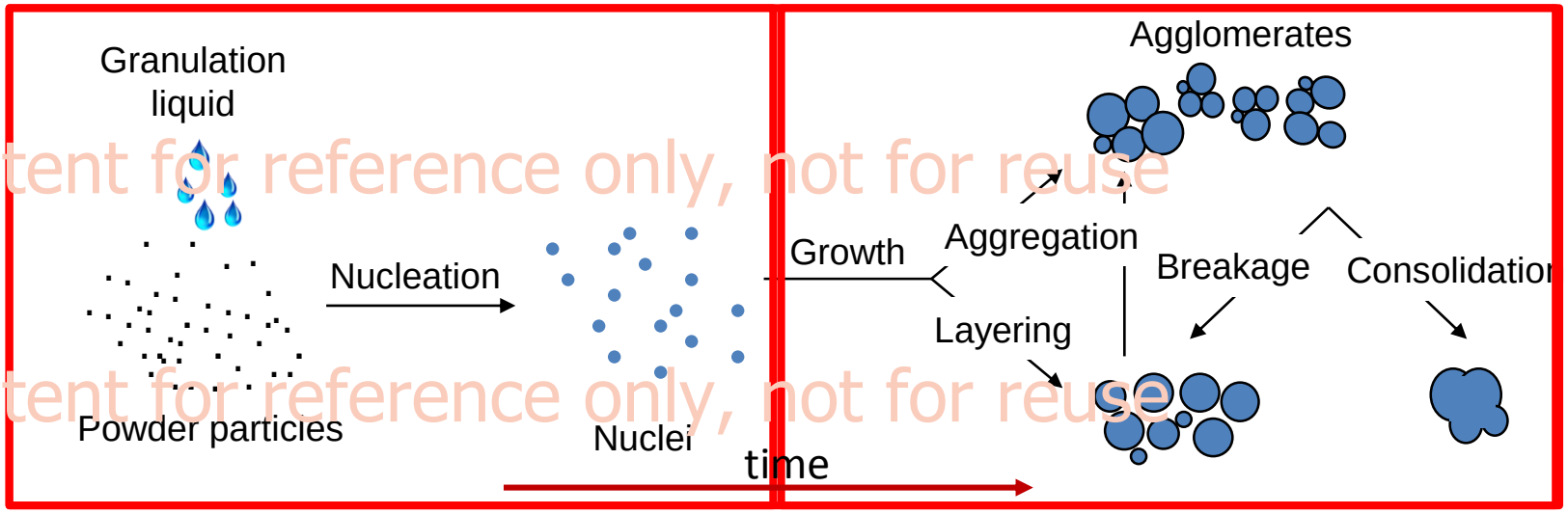
Design of granulator screw, screw speed, material feed rate control granulation

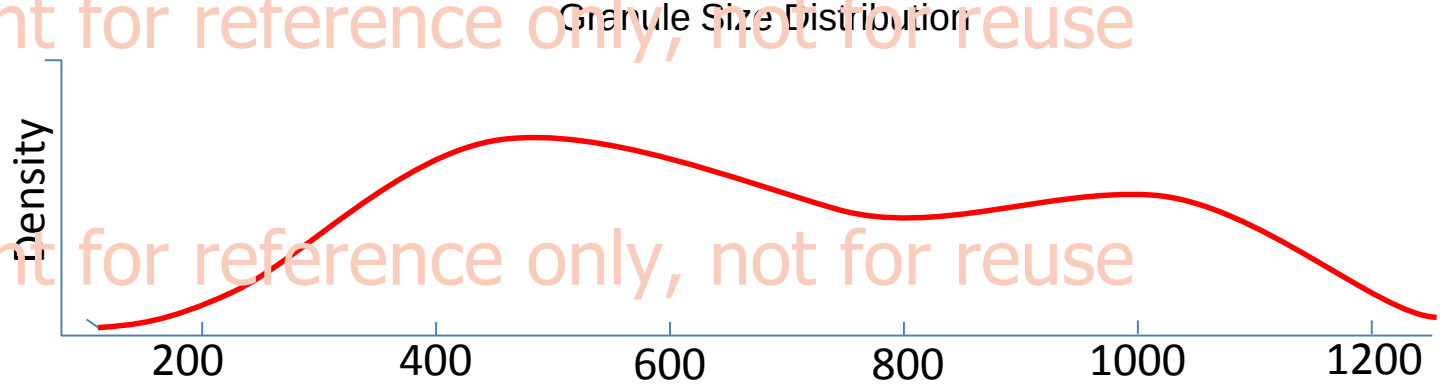


Kneading discs at certain stagger angle

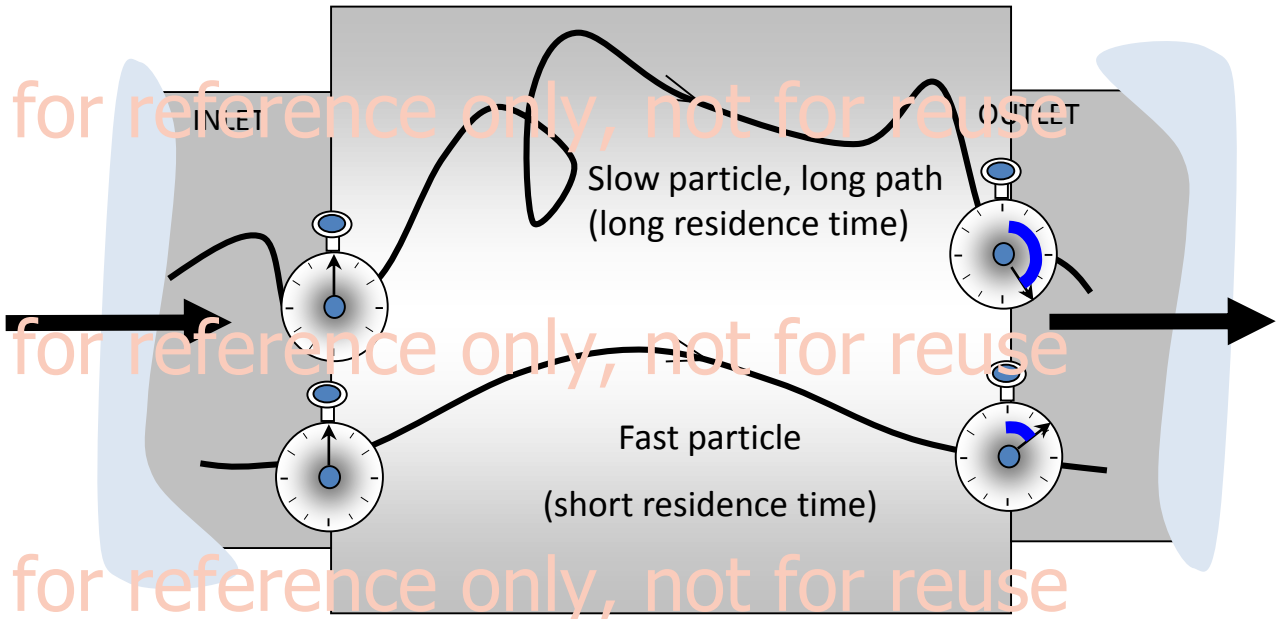


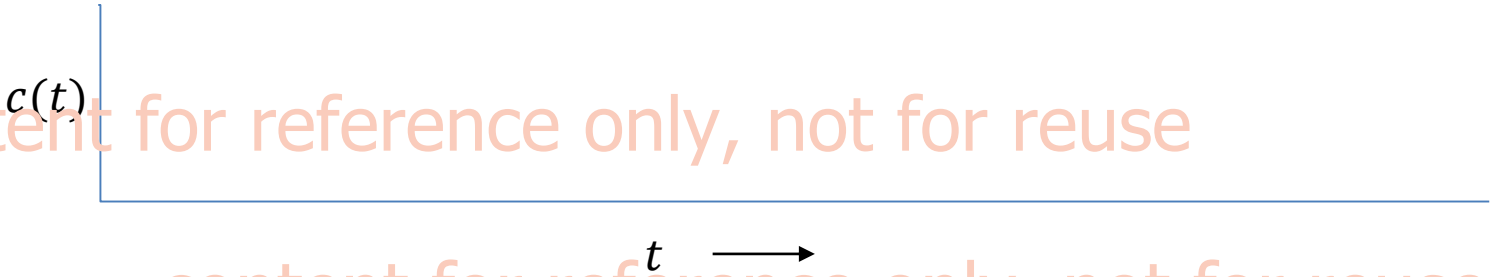
Wet Granulation involves different events which are *queueing*





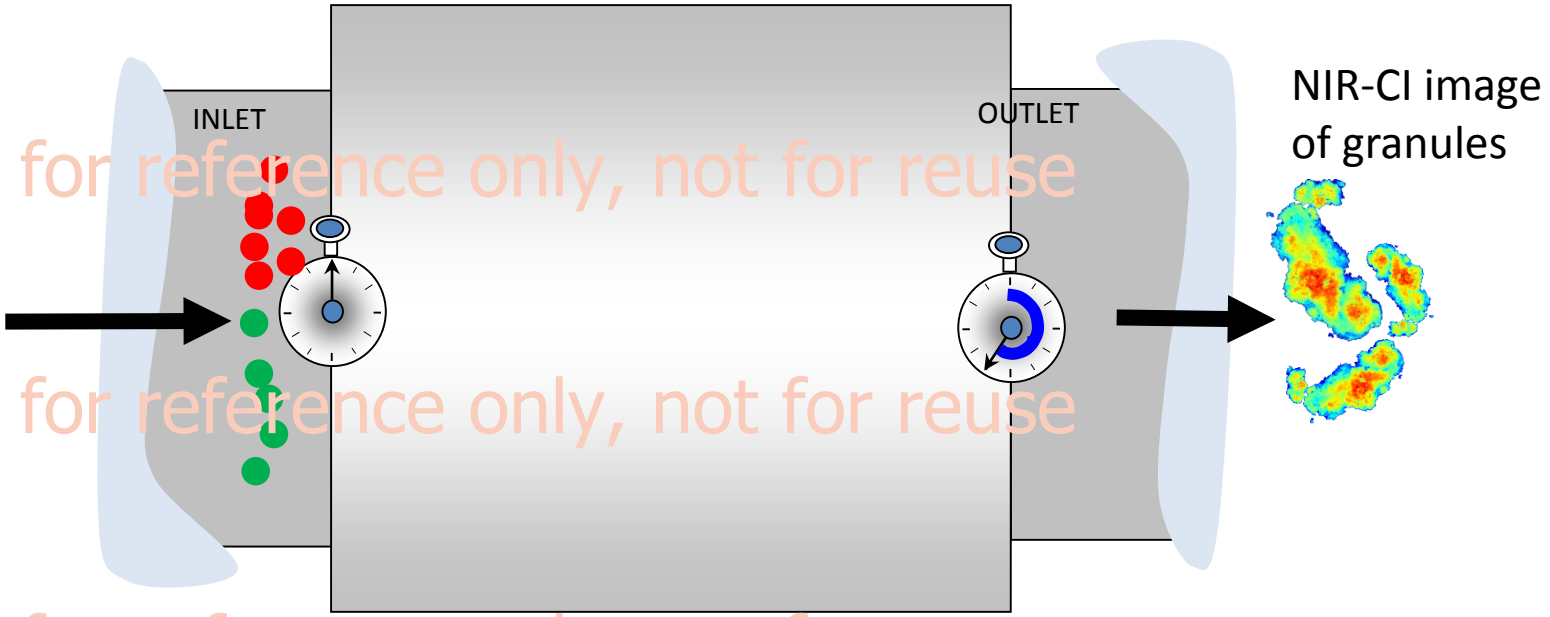
Residence time distribution suggests the granulation time and axial-mixing





Having many time-scales is challenging

Mixing time scale



Bed of granules produced continuously

t ⟶

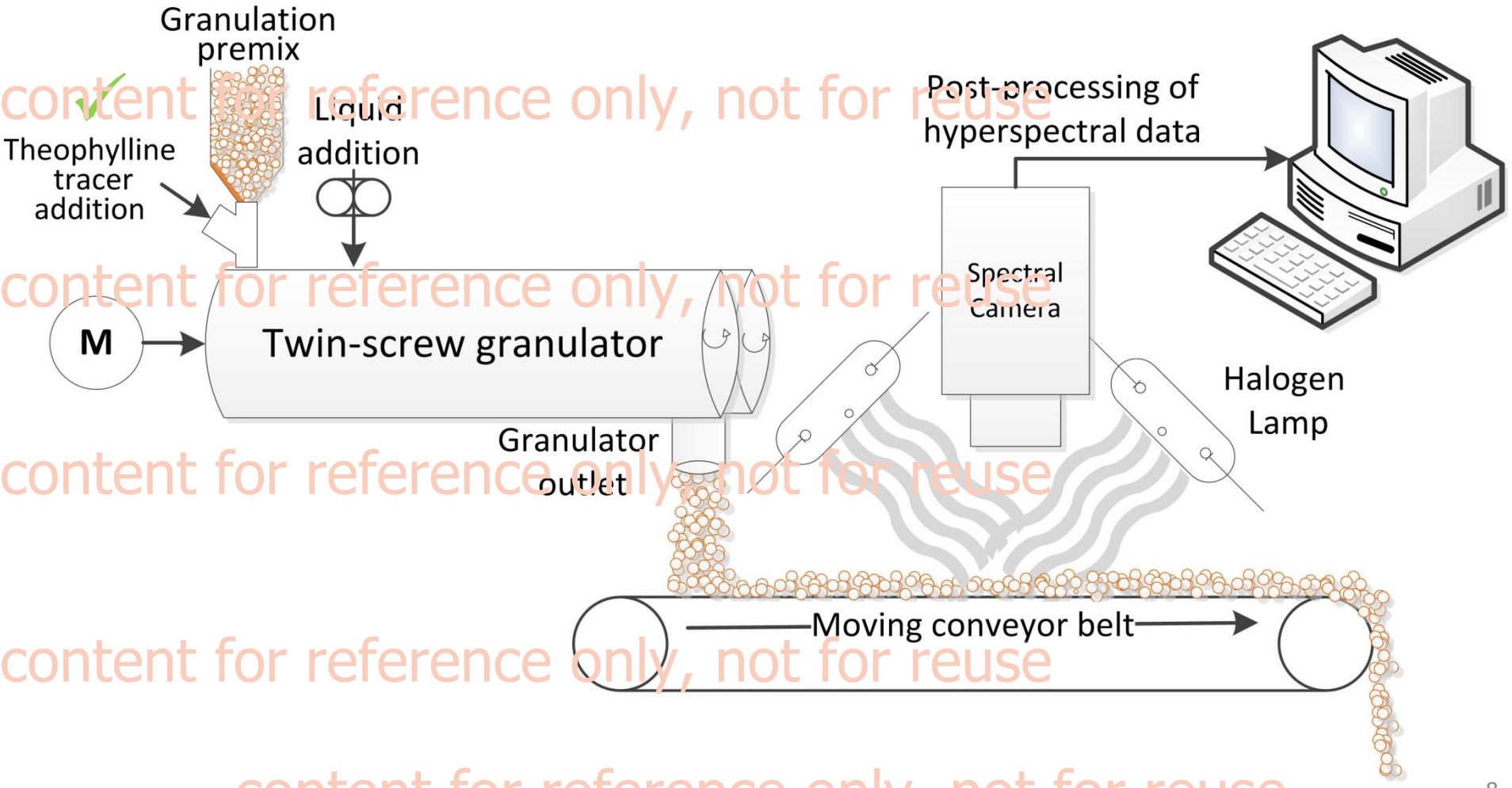
Analysis of distributions in twin-screw granulation

Measurement of distributions

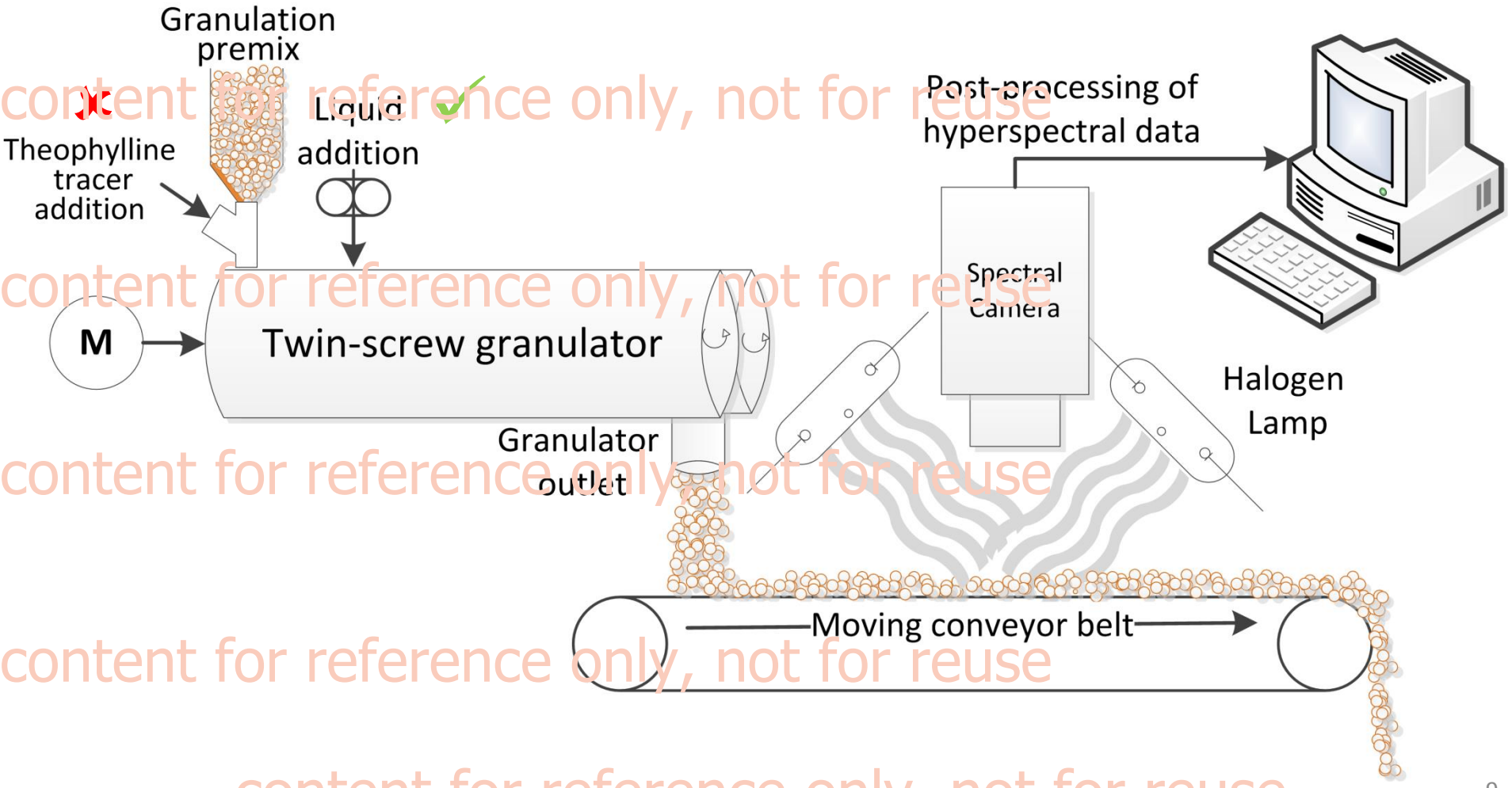
Results

Summary

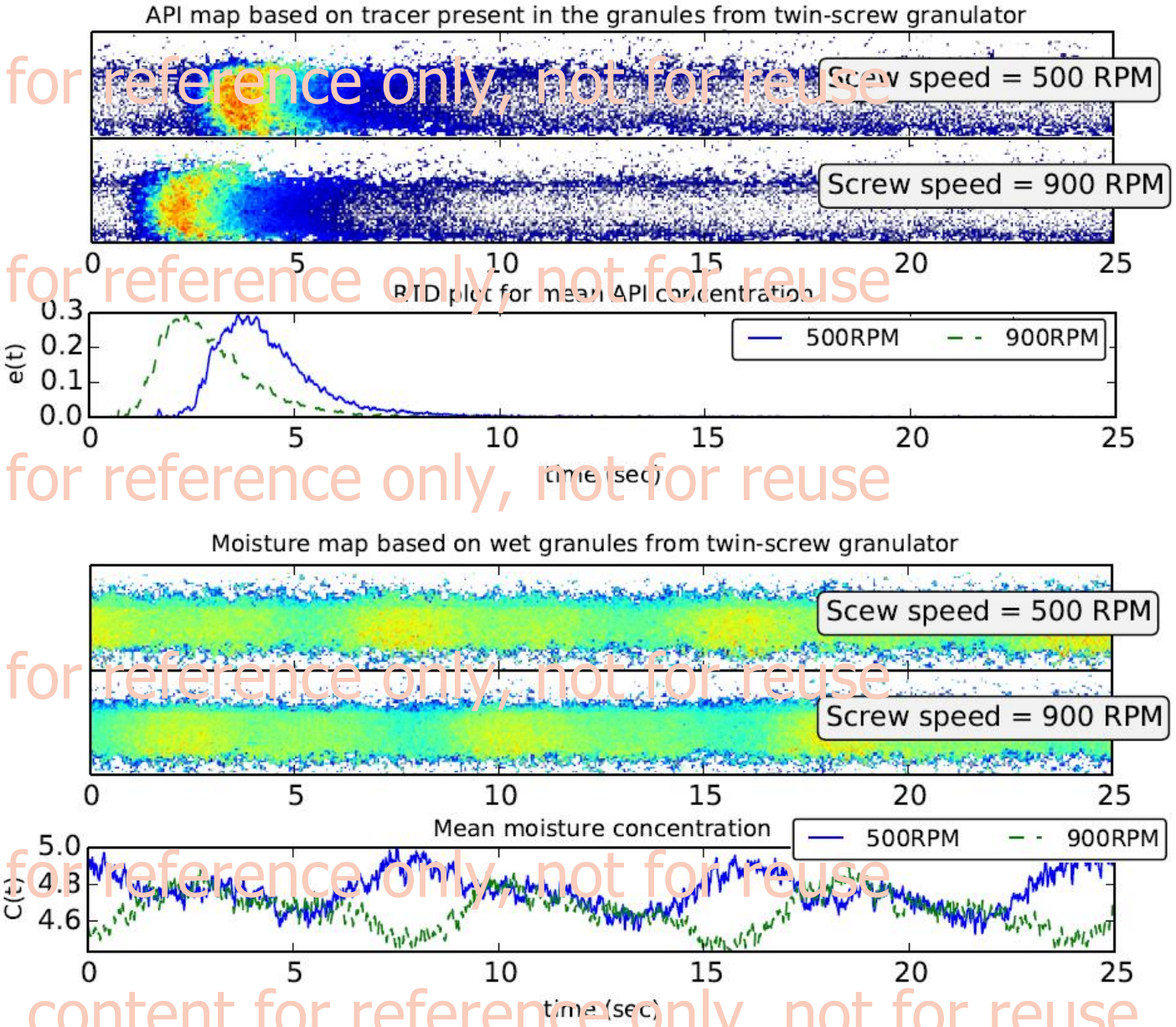
Tracer concentration in granules measured by NIR chemical imaging



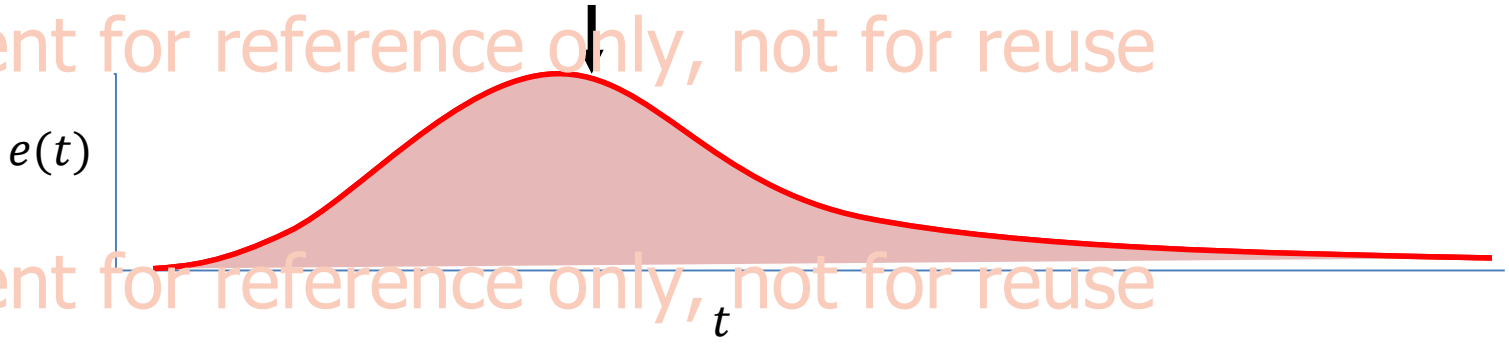
Moisture distribution in granules also measured by NIR chemical imaging



Tracer maps used to measure distributions



Quantitative assessment of RTD profiles



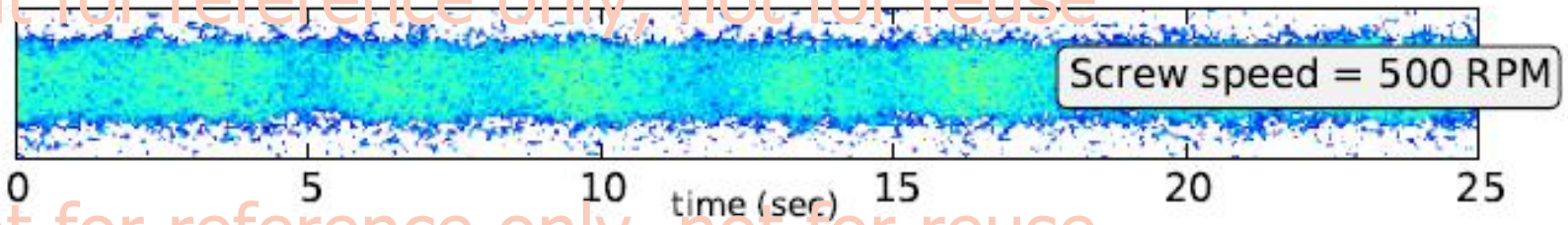
Mean residence time, $\bar{t}$
(a measure of the mean of the distribution)

$$\tau = \frac{\int_0^\infty t \cdot e(t)dt}{\int_0^\infty e(t)dt}$$

Variance, σ^2
(width of the distribution, i.e. axial mixing)

$$\sigma^2 = \frac{\int_0^\infty (t-\tau)^2 \cdot e(t)dt}{\int_0^\infty e(t)dt}$$

Qualitative assessment of the moisture maps



Shannon Entropy based **Mixing Index**

$$H(X) = \sum_{j=1}^{n} P(X_j) \log_{256}(1/P(X_j))$$

$$\mathrm{MI} = -\frac{1}{\log_{256}(n)} \sum_{j=1}^{n} P(X_j) \log_{256} P(X_j)$$

Mixing Index

Residence time and moisture distributions effect on the granulation performance

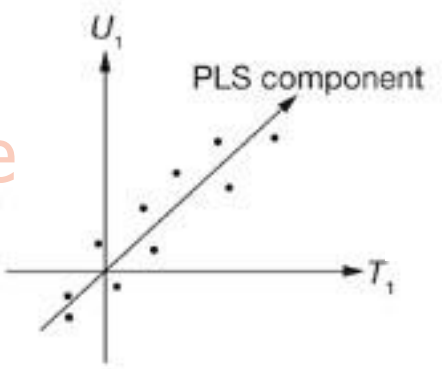
spike

Fines	Yield fraction	Oversized
< 150 µm	> 150 to <1400 µm	> 1400 µm

$t \longrightarrow$

Screw Configuration

- Number of kneading discs (4, 6, 2x6)
- Stagger angle (30°, 60°)



PLS regression model using MODDE 10.1

Process parameters

- Material throughput (10-25 kg/h)
- Screw speed (500-900 rpm)
- Liquid-to-solid ratio (6-8%)

α-Lactose monohydrate was granulated with distilled water

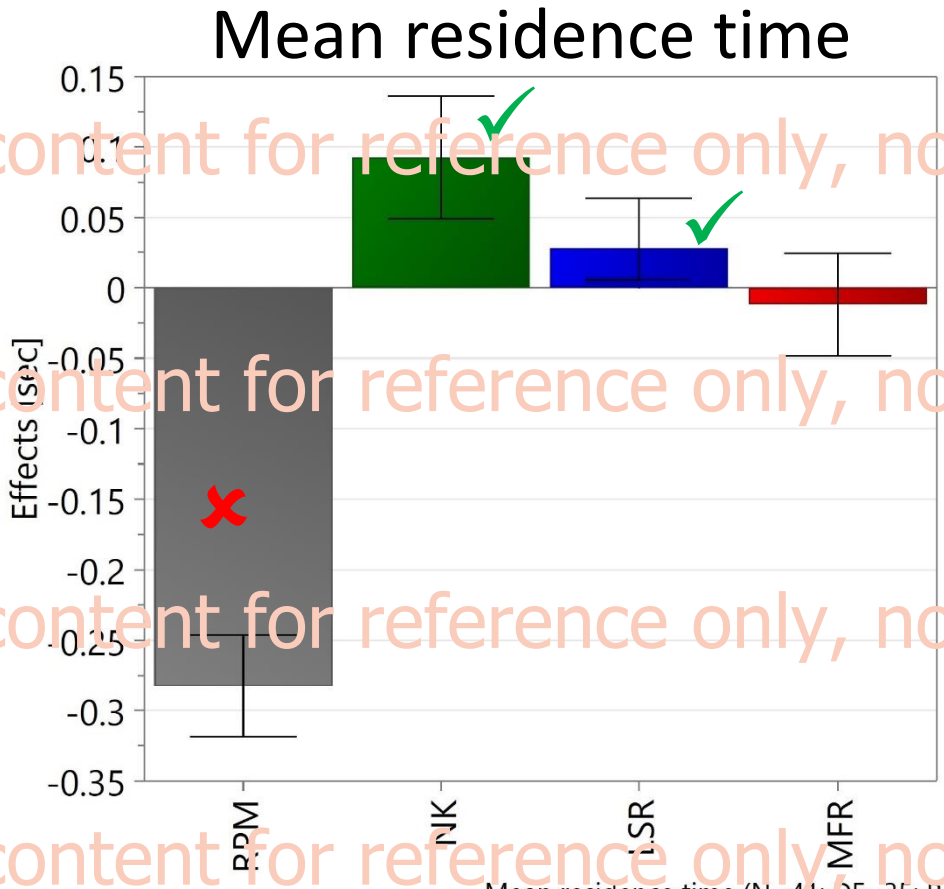
Analysis of distributions in twin-screw granulation

RTD Measurement by Chemical Imaging

Results

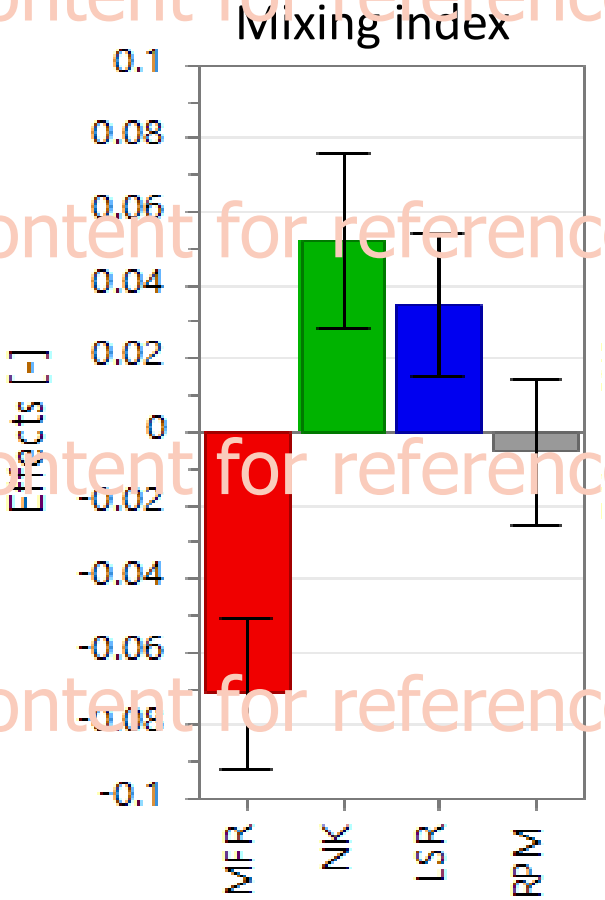
Summary

Increase in L/S lubricates moving parts but flow is sluggish



Mean residence time (N=41; DF=35; R2=0.88), Normalised variance (N=46; DF=40; R2=0.84) Conf. lev.=0.95

Increase in no. of kneading discs and L/S improved liquid distribution, but not enough



Mixing index (N=43; DF=34; R2=0.80), Fine (N=49; DF=39; R2=0.93),
Oversized (N=47; DF=38; R2=0.92) Conf. lev.=0.95

MFR: material throughput; NK: number of kneading discs; LSR: liquid-to-solid ratio; RPM: screw speed

Analysis of distributions in twin-screw granulation

RTD Measurement by Chemical Imaging

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The results showed that..

...number of kneading discs increases residence time but also restricts axial mixing.

..material throughput and number of kneading discs dictate solid-liquid mixing, but solid-liquid mixing is not sufficient.

.. non-conventional screw elements with modified geometries should be explored for improvement in solid-liquid mixing.

.. Theoretical methods like DEM simulations can useful to investigate the feasibility of new mixing element designs.

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