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Experimental investigation of residence time distribution in twin-screw granulation

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Thomas De Beer

Laboratory of Pharmaceutical Process Analytical Technology,
Ghent University, Belgium.

Outline

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- Background
  - Consigma™-25 system
    - Twin-Screw Granulator
- Experiments
  - Objective – factors and responses
  - Set-up: CI System
    - Results
- Conclusions

Consigma™-25 system

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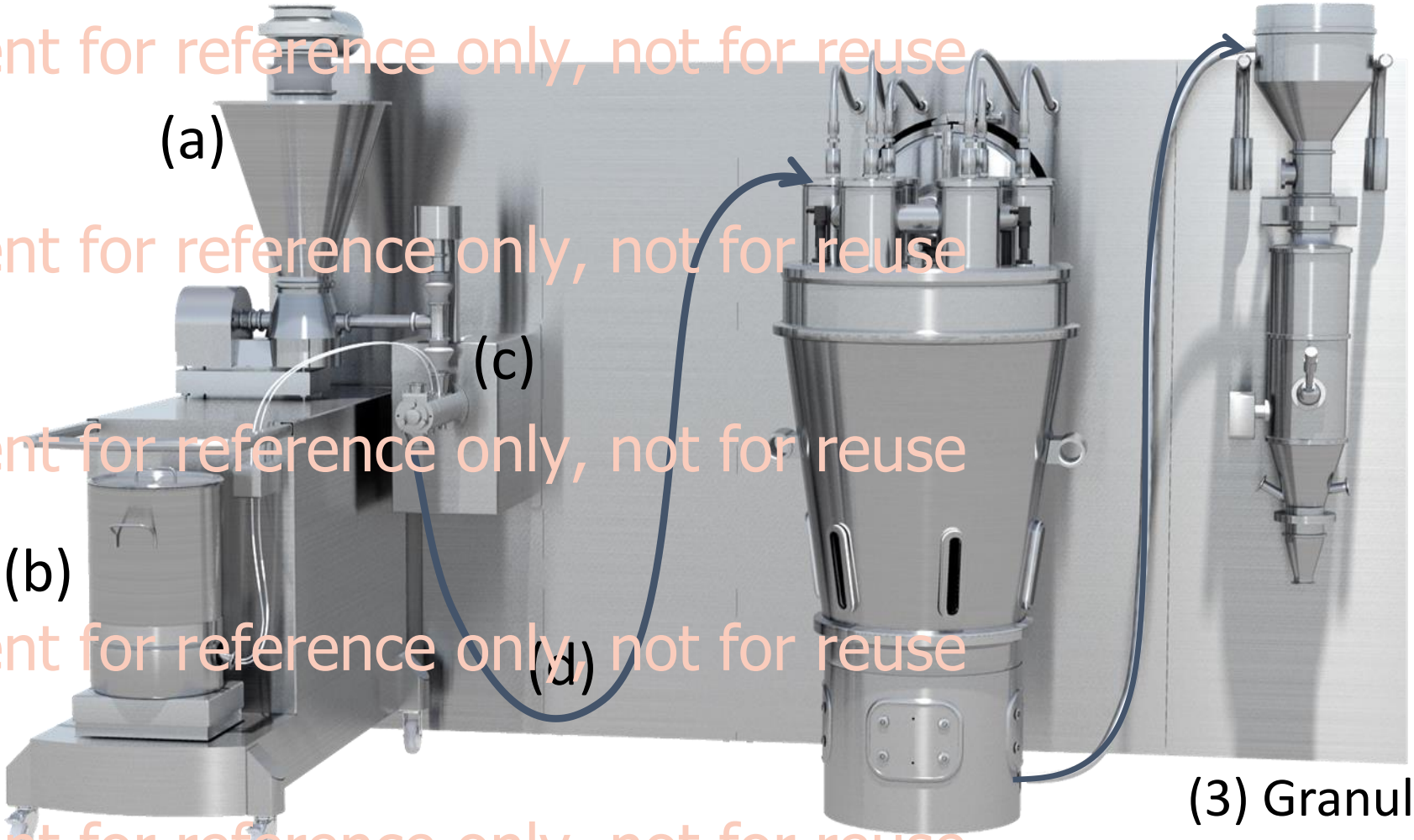

(1) Continuous twin-screw granulator

(2) Segmented Fluid bed dryer

(3) Granule conditioning module

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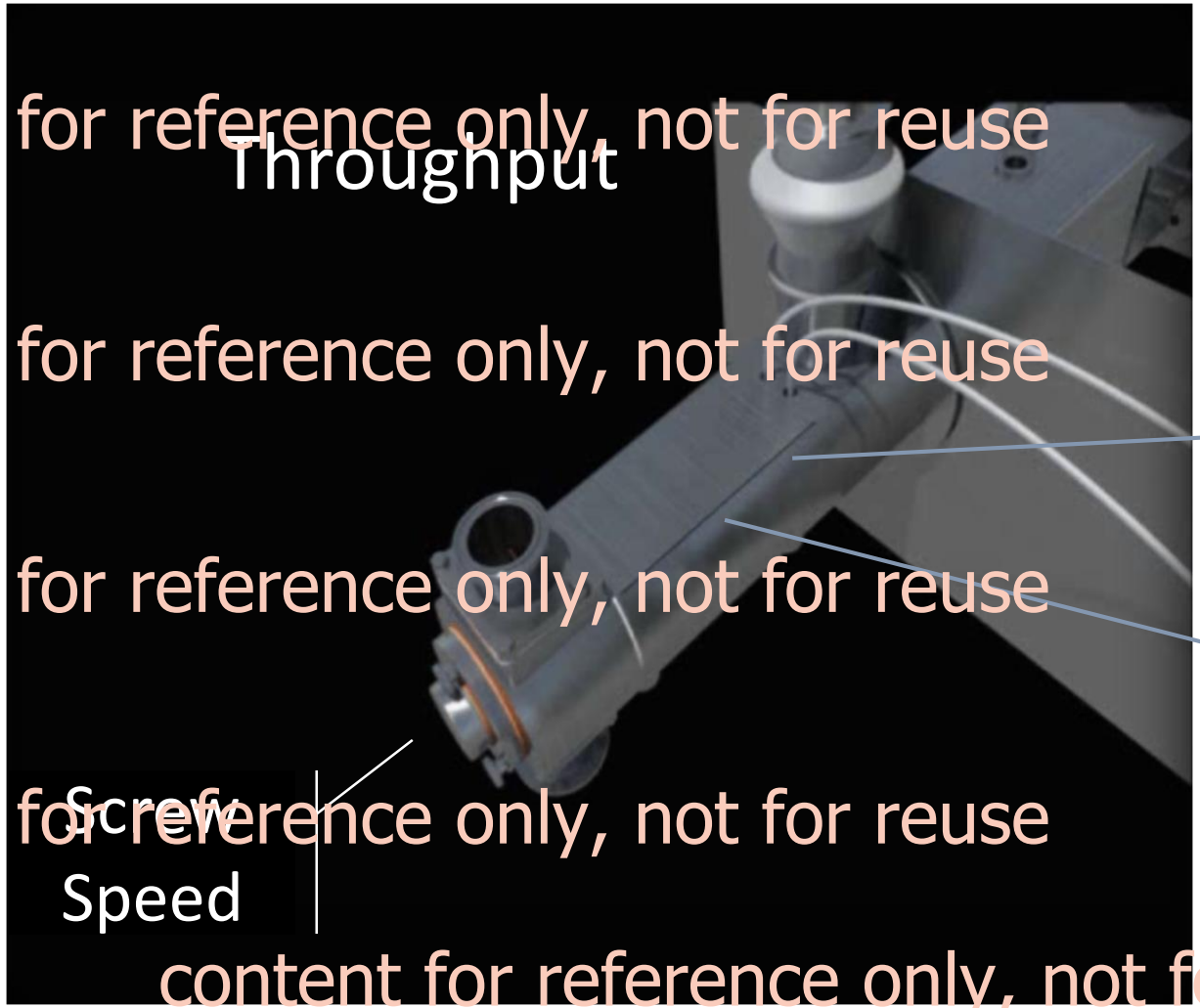
Design of granulator screw, screw speed, material feed rate control granulation



Number of kneading discs and stagger angle

Twin-Screw Granulation - RTD

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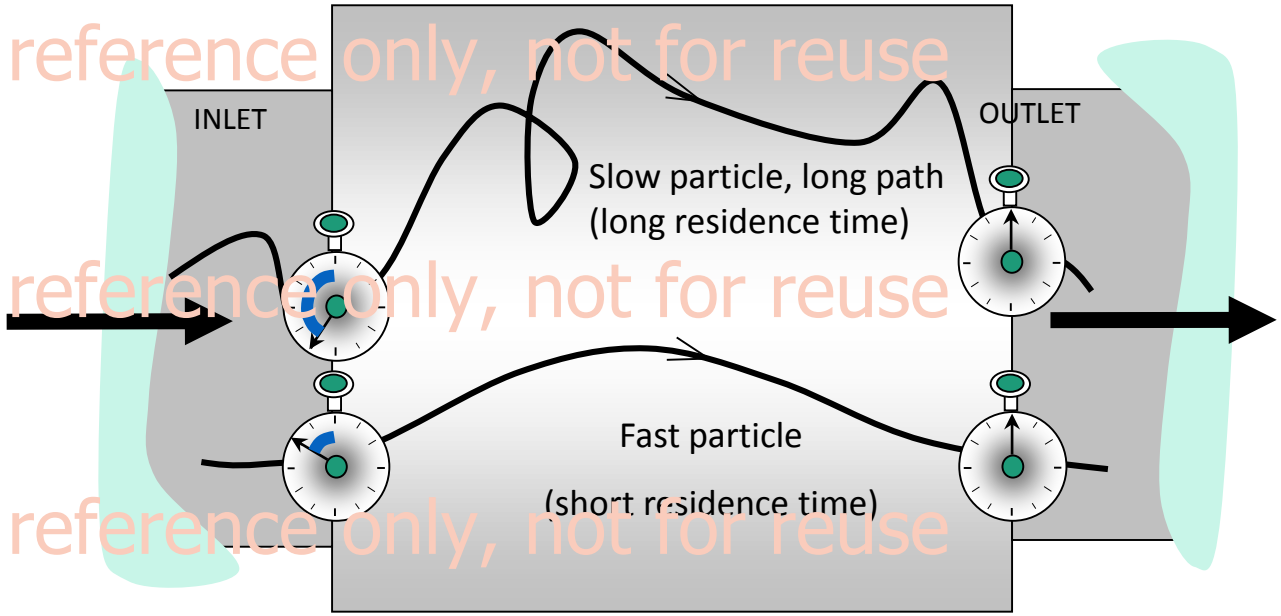
Residence time distribution to know the granulation time and mixing



Objective - factors and responses

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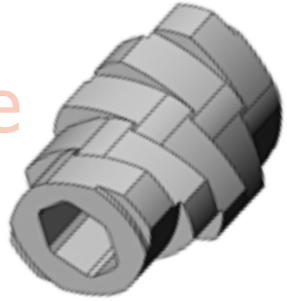
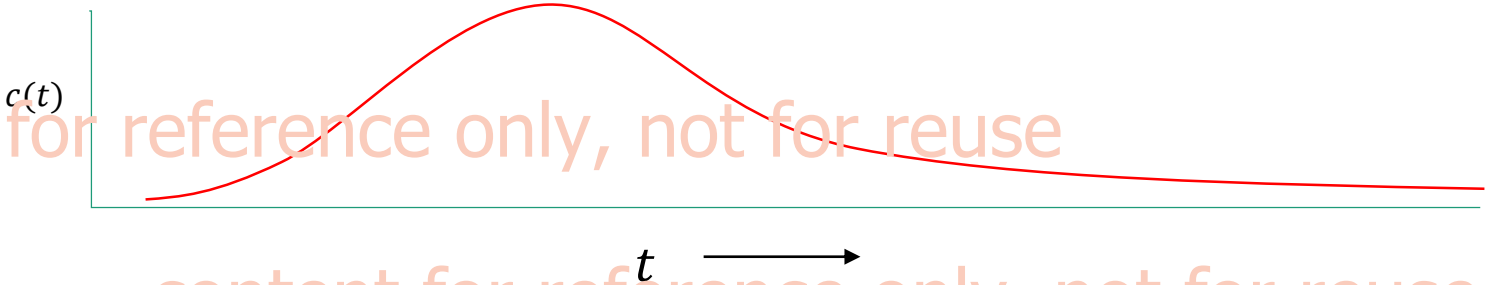
Screw Configuration

- Number of kneading discs
- Stagger angle



Process parameters

- Material throughput
- Screw speed



Set-up: Chemical Imaging System

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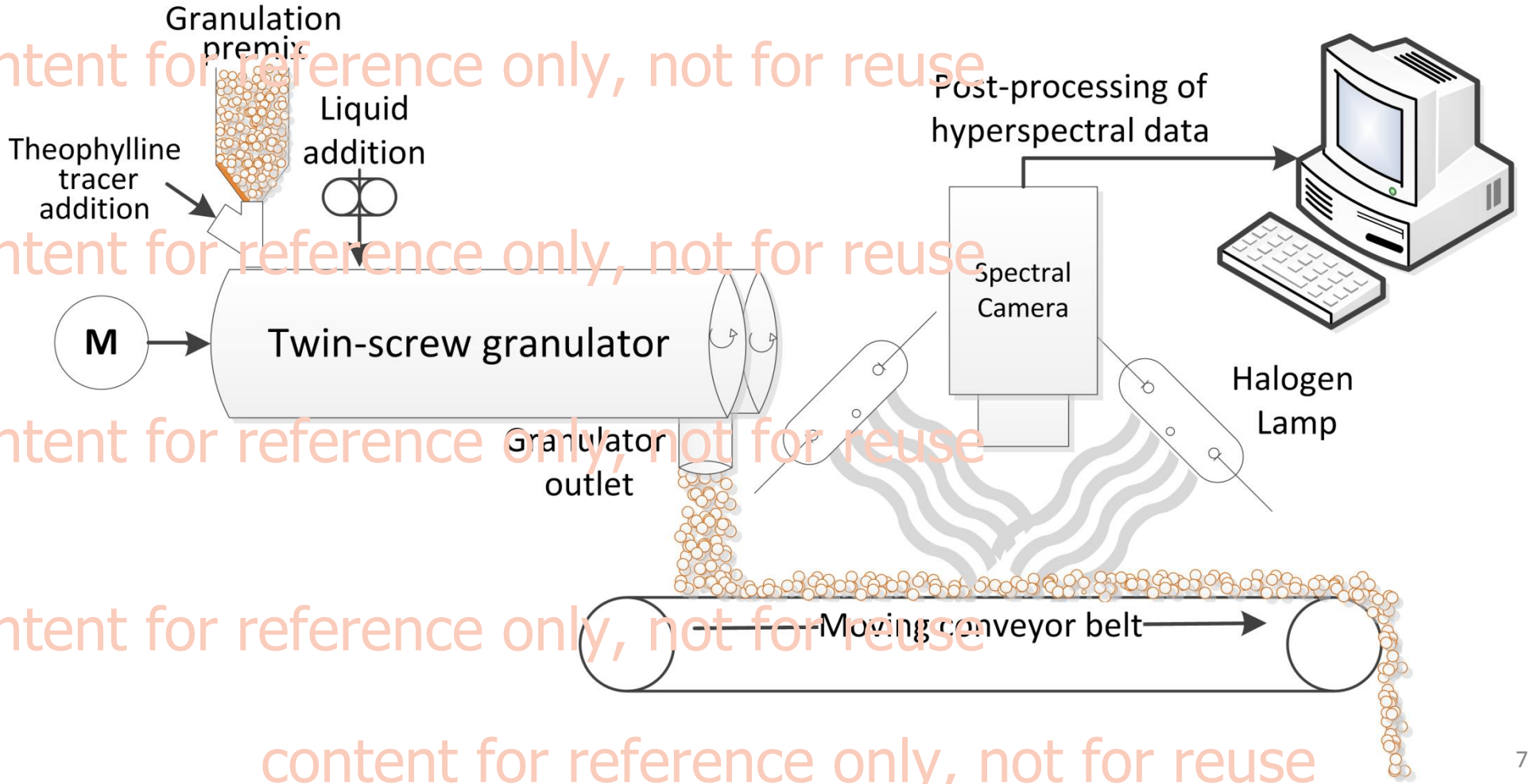
Tracer concentration in granules produced was measured using NIR chemical imaging



Twin-Screw Granulation – API Map

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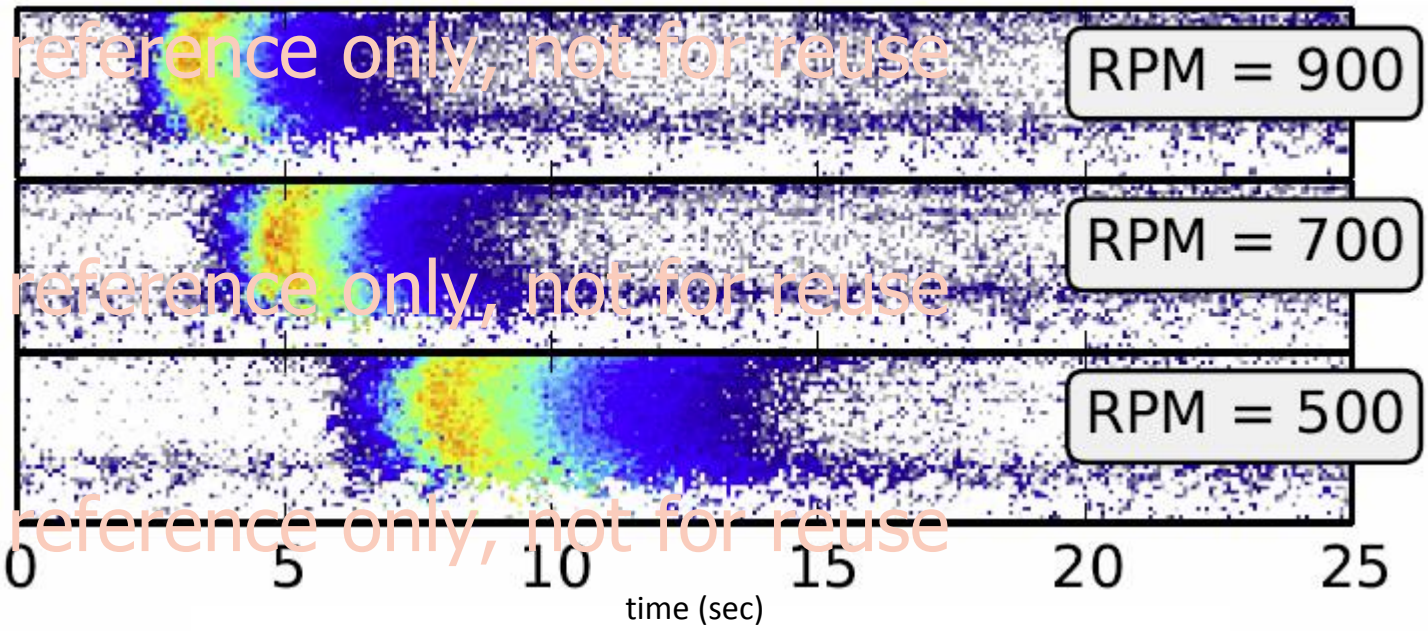

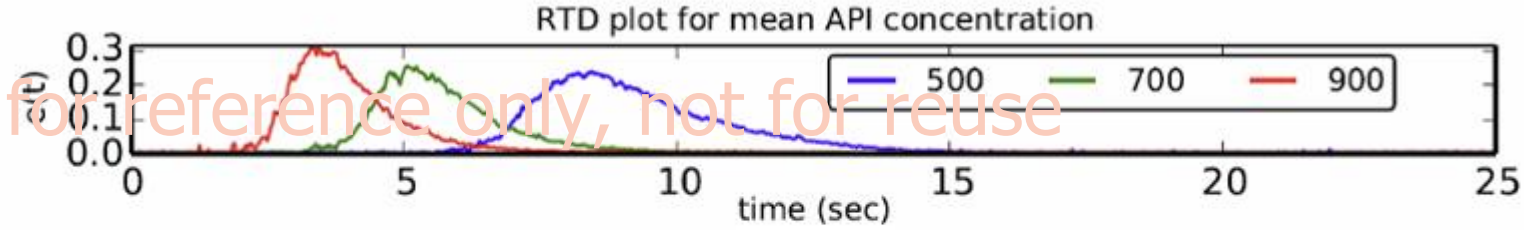

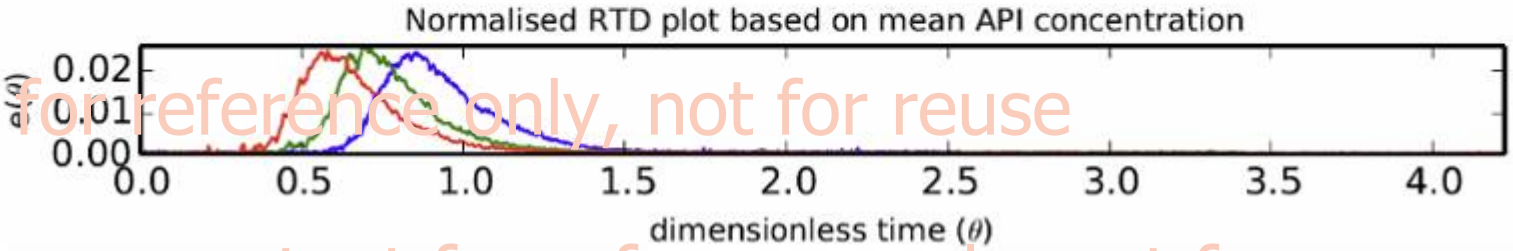

API map- Powder feed rate 10 kg/h

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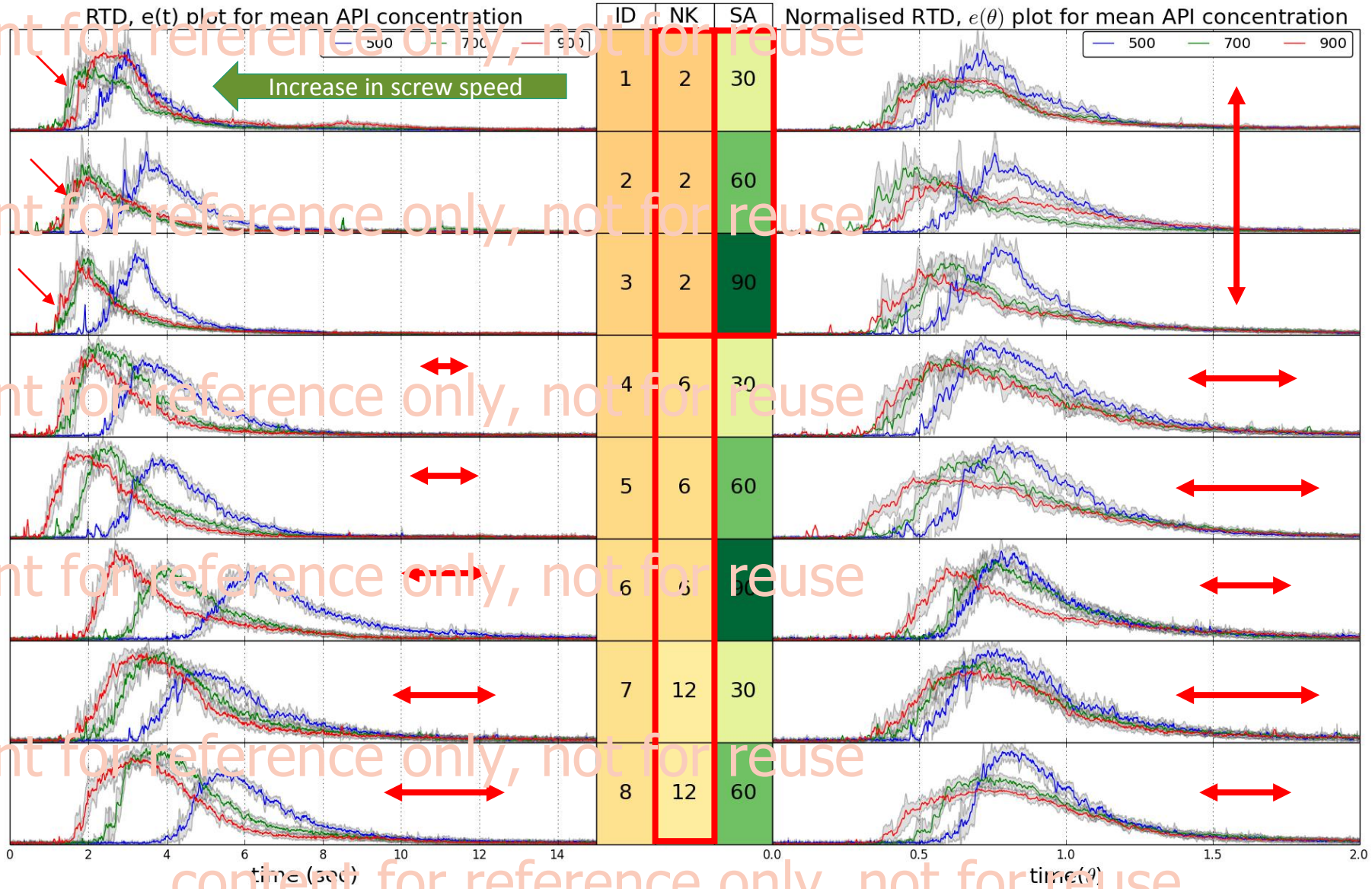

API map- Powder feed rate 25 kg/h

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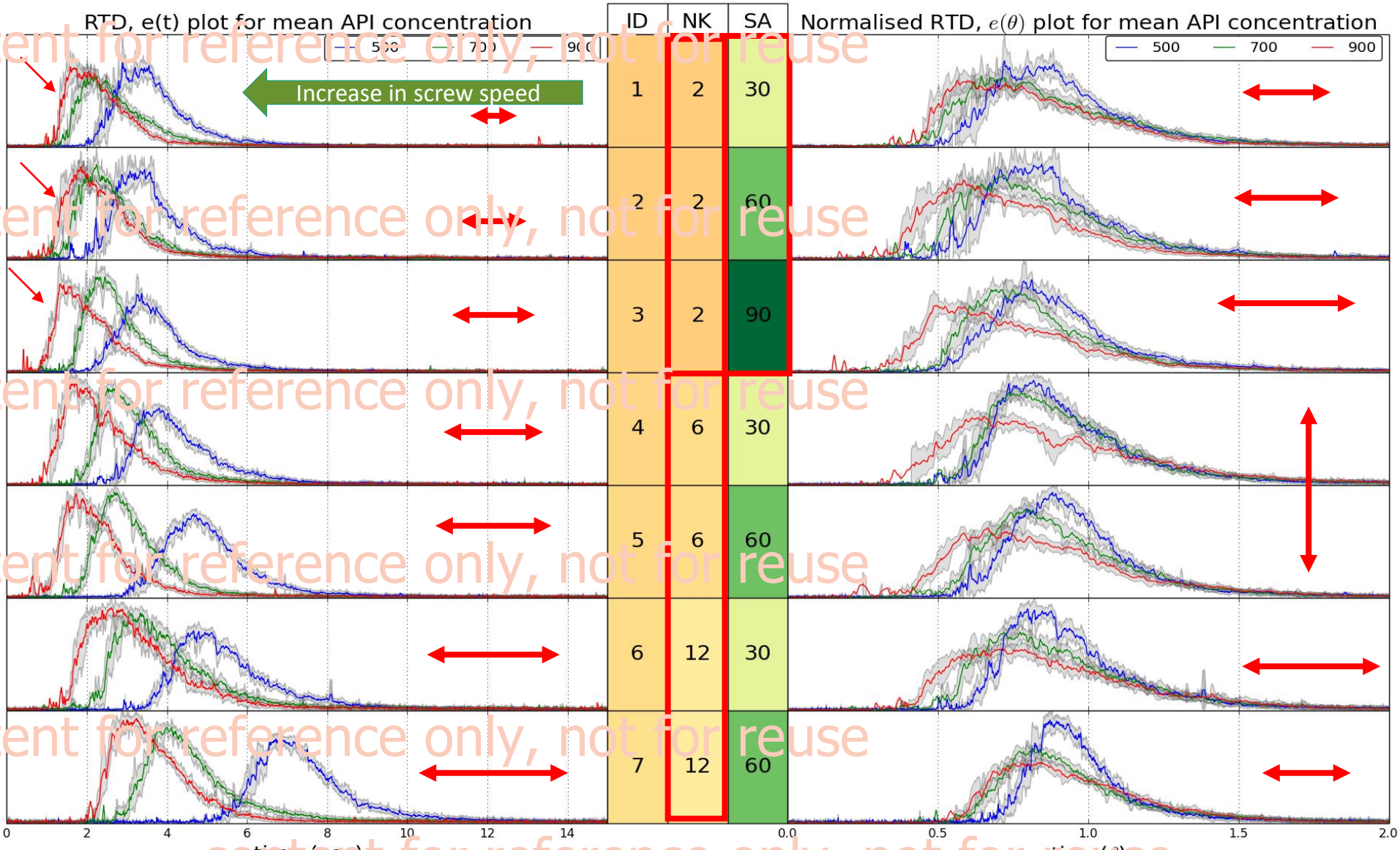

API map- quantitative assesment

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Mean residence time , τ

(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

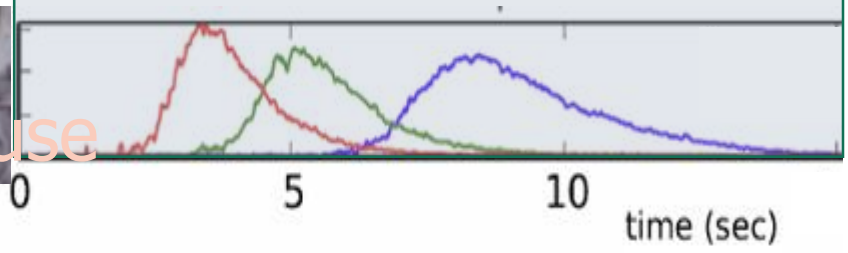
(width of the distribution)

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

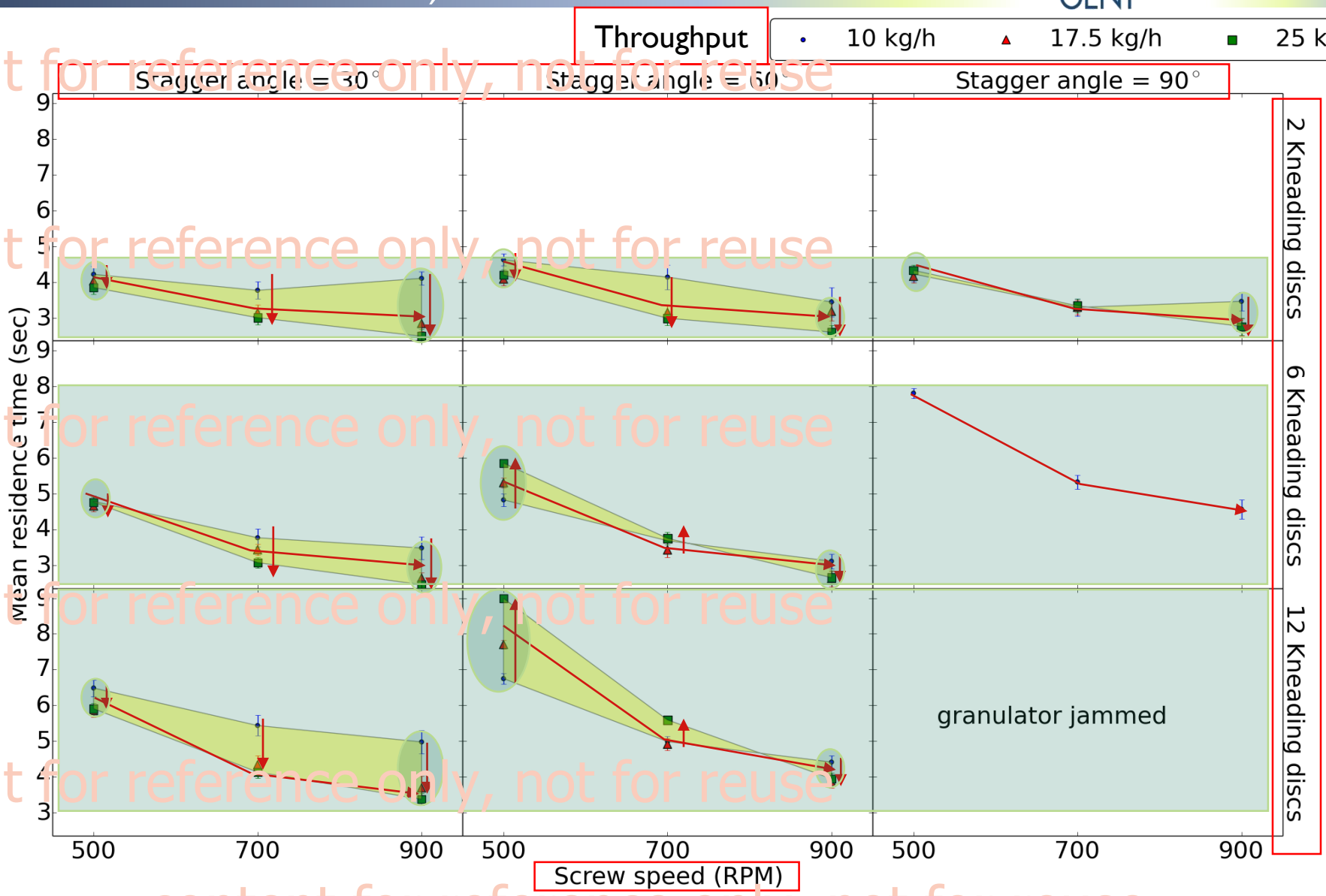
Péclet Number, Pe

$$\left(\frac{\text{Rate of axial transport by convection}}{\text{Rate of axial transport by dispersion}}\right)$$

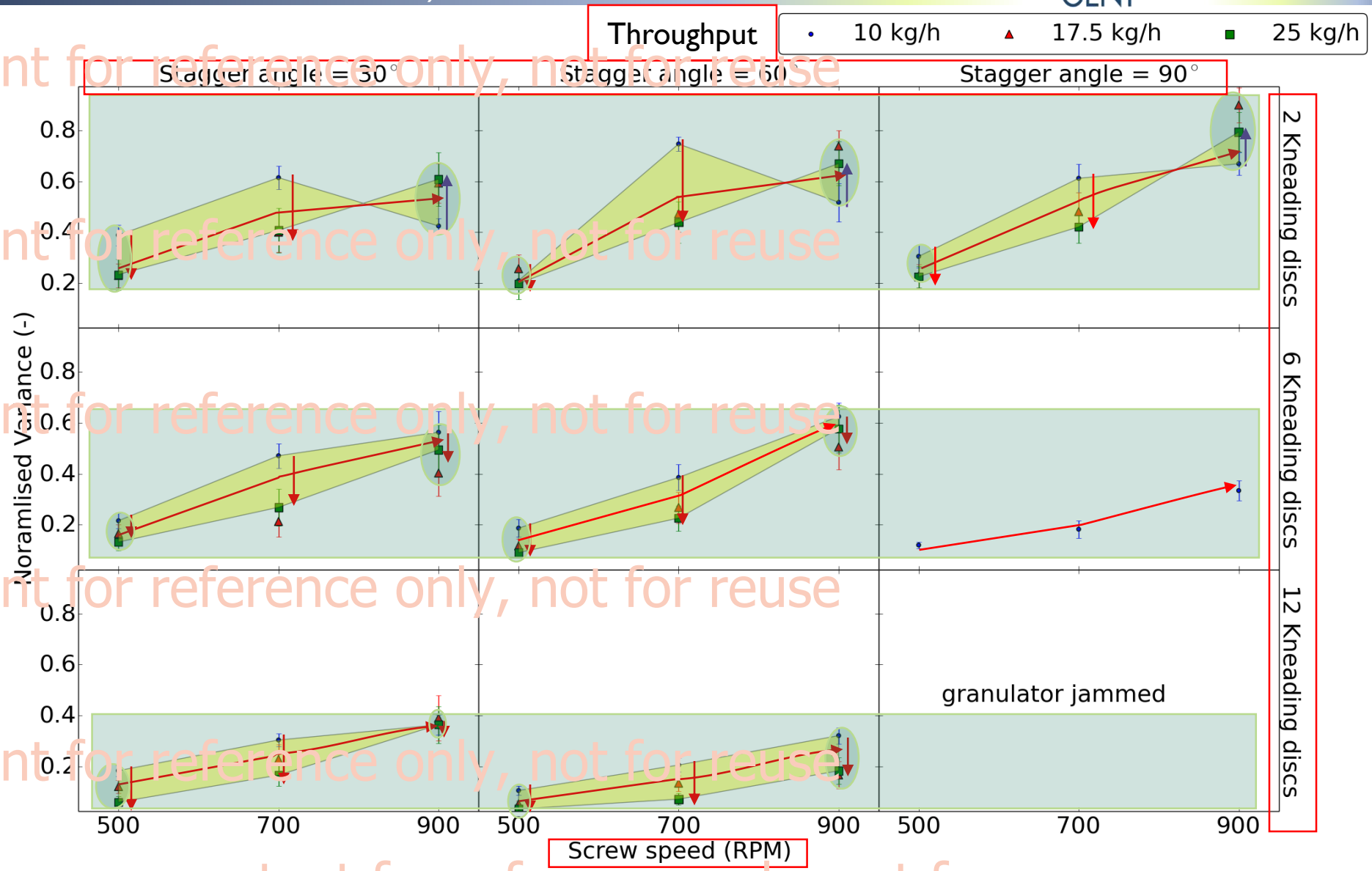
$$\text{Pe} = \frac{UL}{D}$$



Mean Residence Time
(the mean of the distribution)



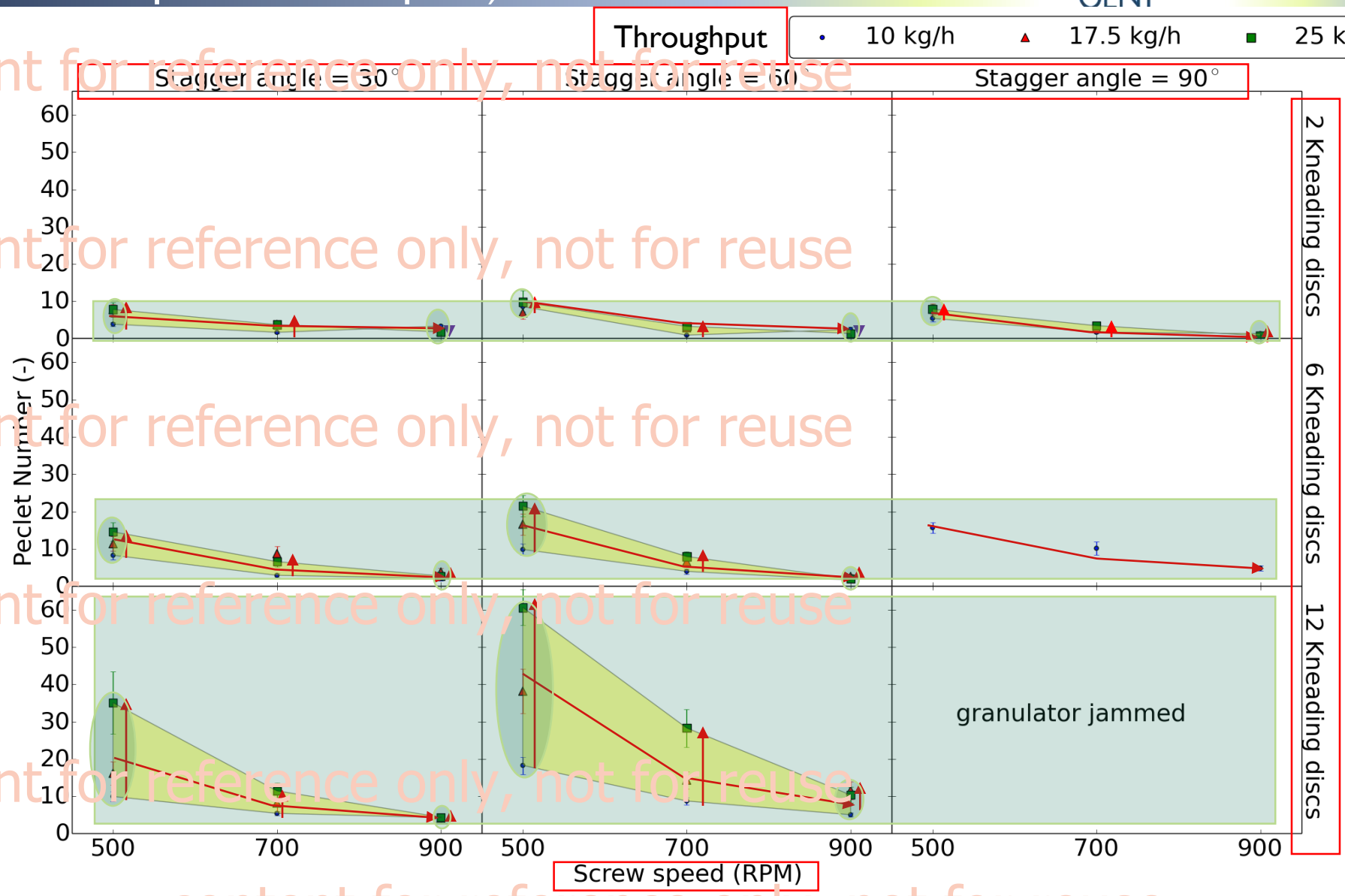
Normalised Variance
(the width of the distribution)



For well-mixed system, NV = , For poorly-mixed, NV = 0

Dispersion Model-Peclet Number

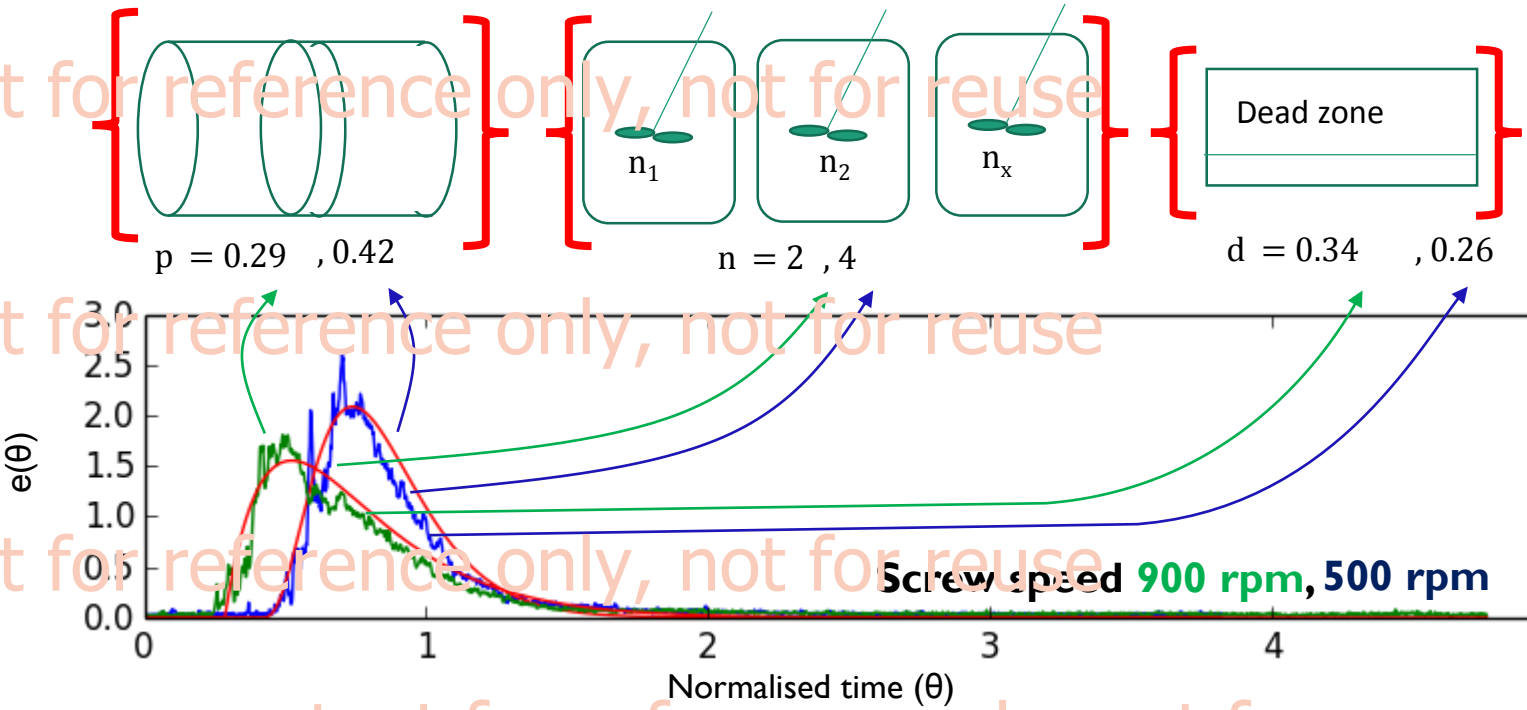
(convective/dispersive transport)



Modified Tank-In-Series model

$$e(\theta) = \frac{b[b(\theta - p)]^{n-1}}{(n-1)!} e^{[-b(\theta-p)]}$$

where, $b = \frac{n}{(1-p)(1-d)}$



Conclusions

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- It is not (always) true that, *"the extent of axial mixing in the mixing zones of the granulator does not change for different configurations and process conditions (Lee et al. 2012)"*. In fact they have a direct influence on both RTD and the axial mixing in TSG.
- Together with a PSD study it can be confirmed which mixing regime is most desirable for granulation purposes.
- In further study we will investigate material properties influence on the RTD and mixing.
- The results obtained will be used in our future work on mechanistic modeling of the granulation process in TSG.

Aknowledgements

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Q&A

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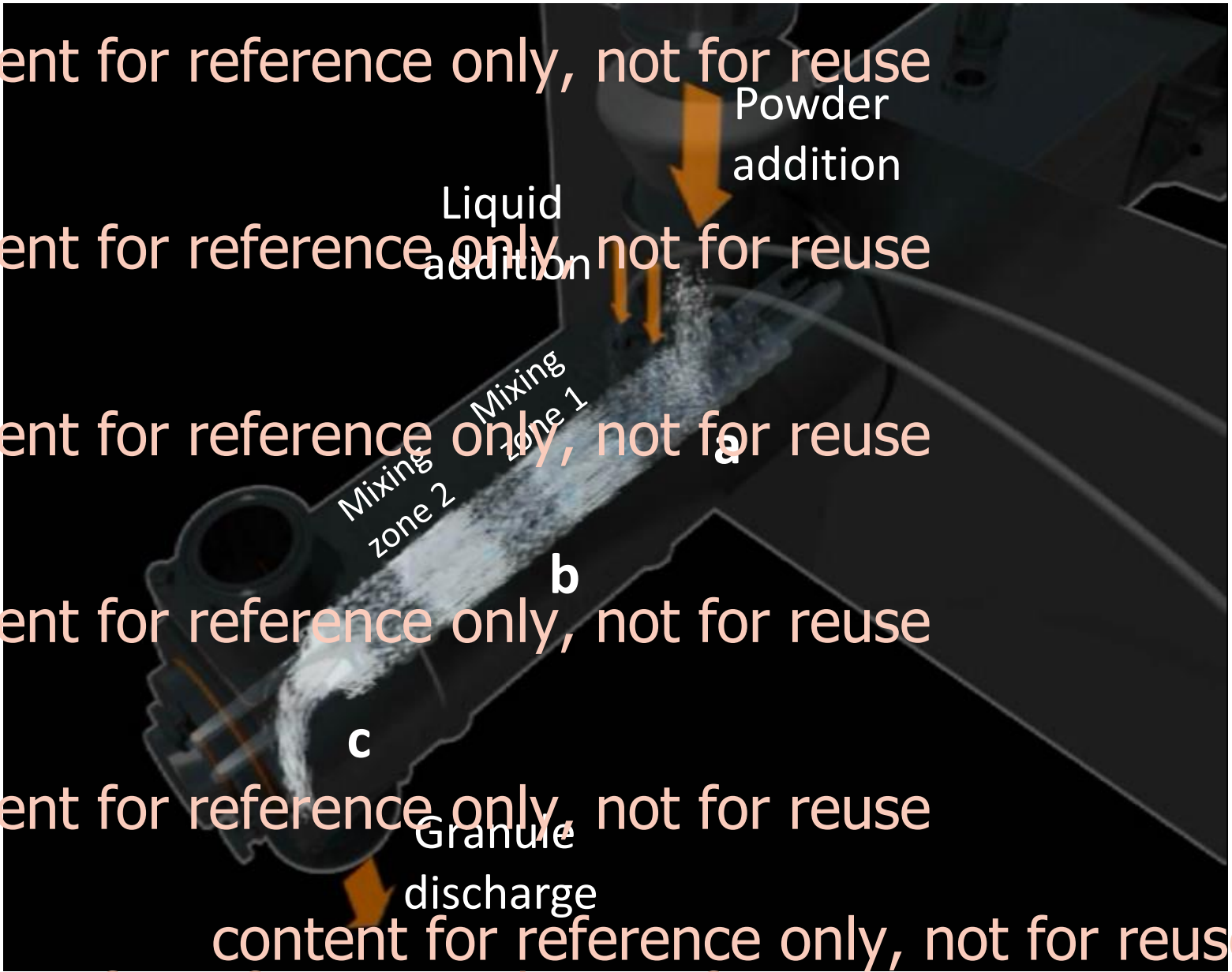

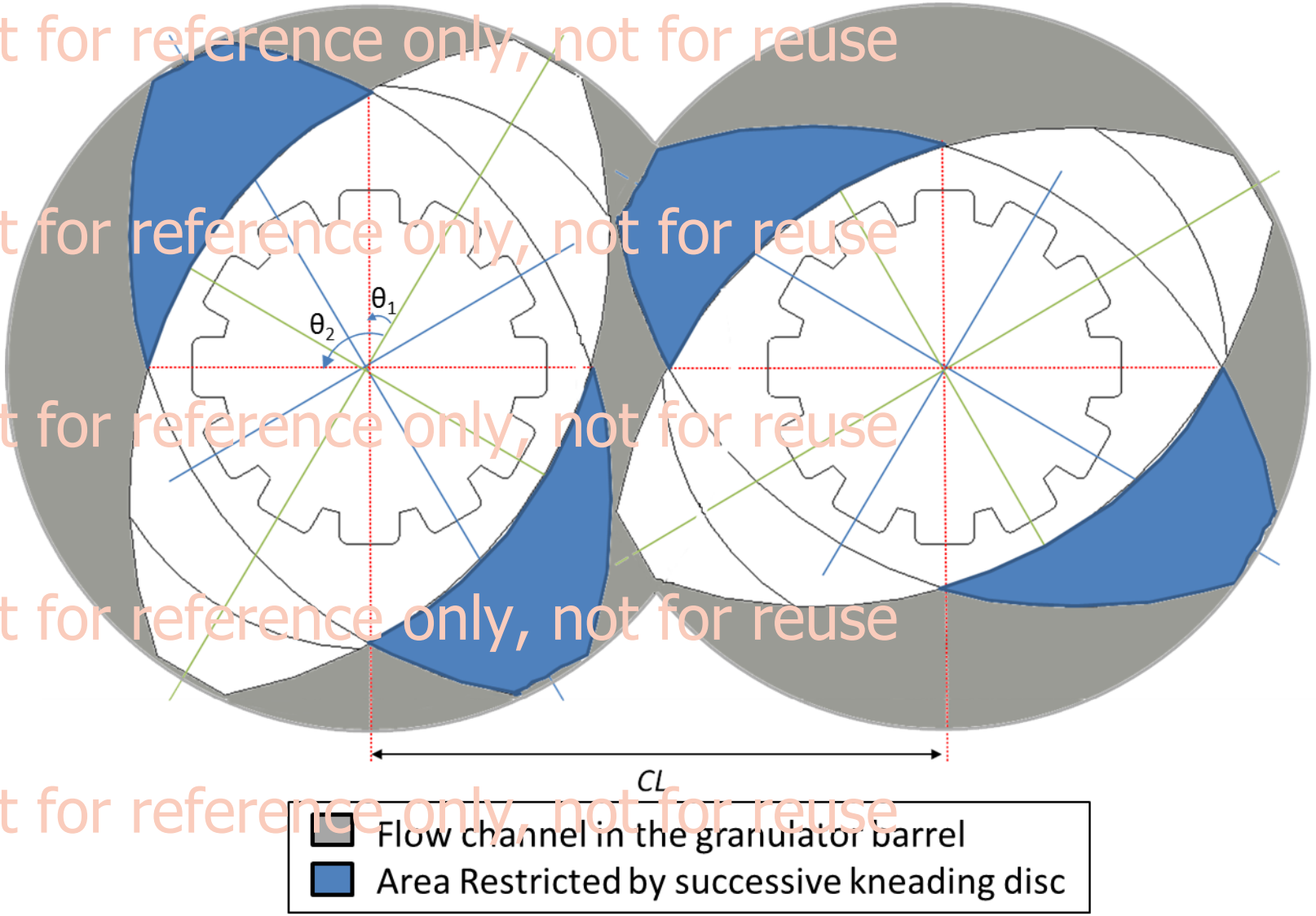

API map- qualitative assesment

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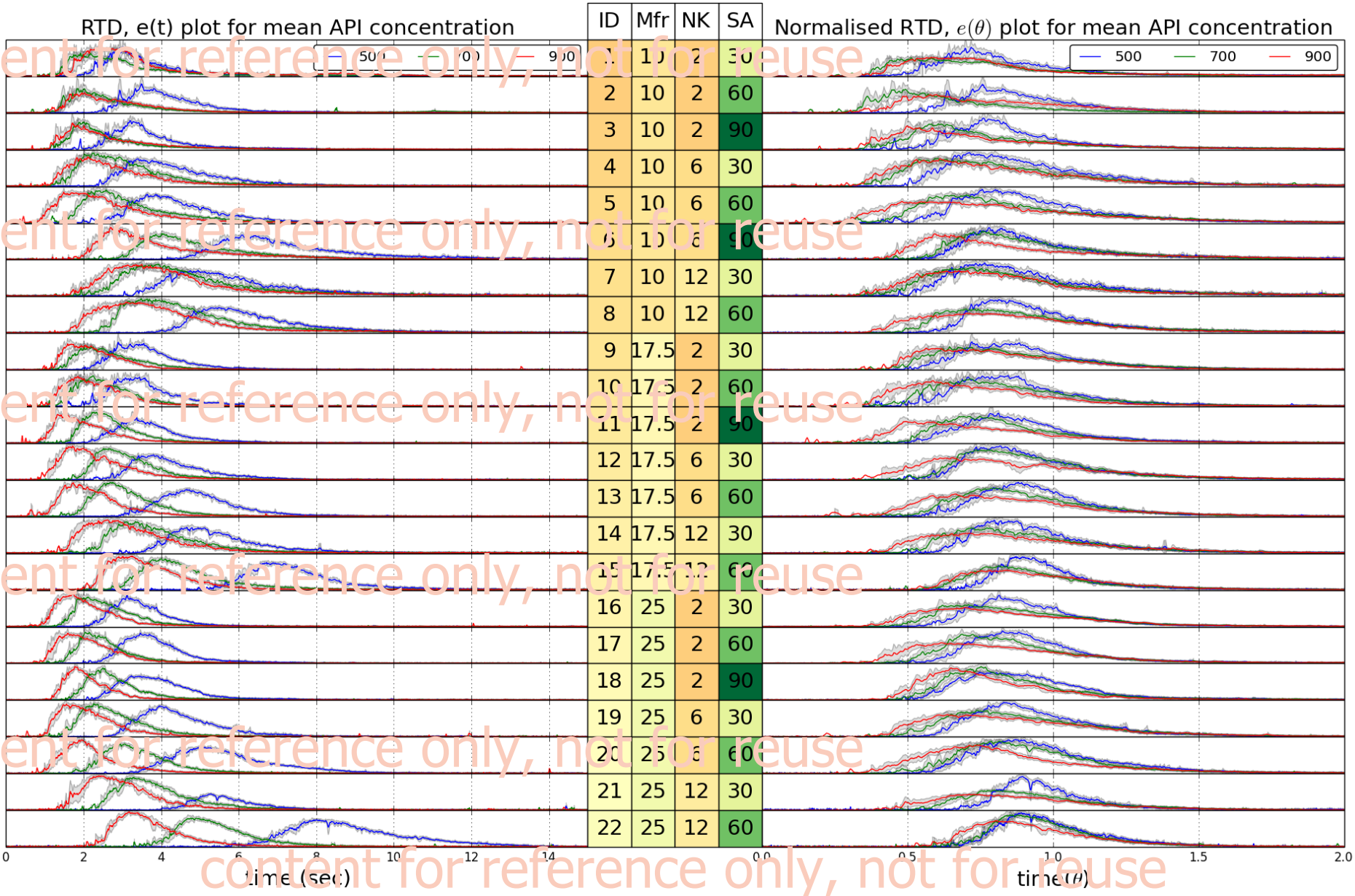

ID	Mfr	NK	SA
1	10	2	30
2	10	2	60
3	10	2	90
4	10	6	30
5	10	6	60
6	10	6	90
7	10	12	30
8	10	12	60
9	17.5	2	30
10	17.5	2	60
11	17.5	2	90
12	17.5	6	30
13	17.5	6	60
14	17.5	12	30
15	17.5	12	60
16	25	2	30
17	25	2	60
18	25	2	90
19	25	6	30
20	25	6	60
21	25	12	30
22	25	12	60

API map- Powder feed rate 17.5 kg/h

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