Development of regime map for steady-state high shear wet twin-screw granulation
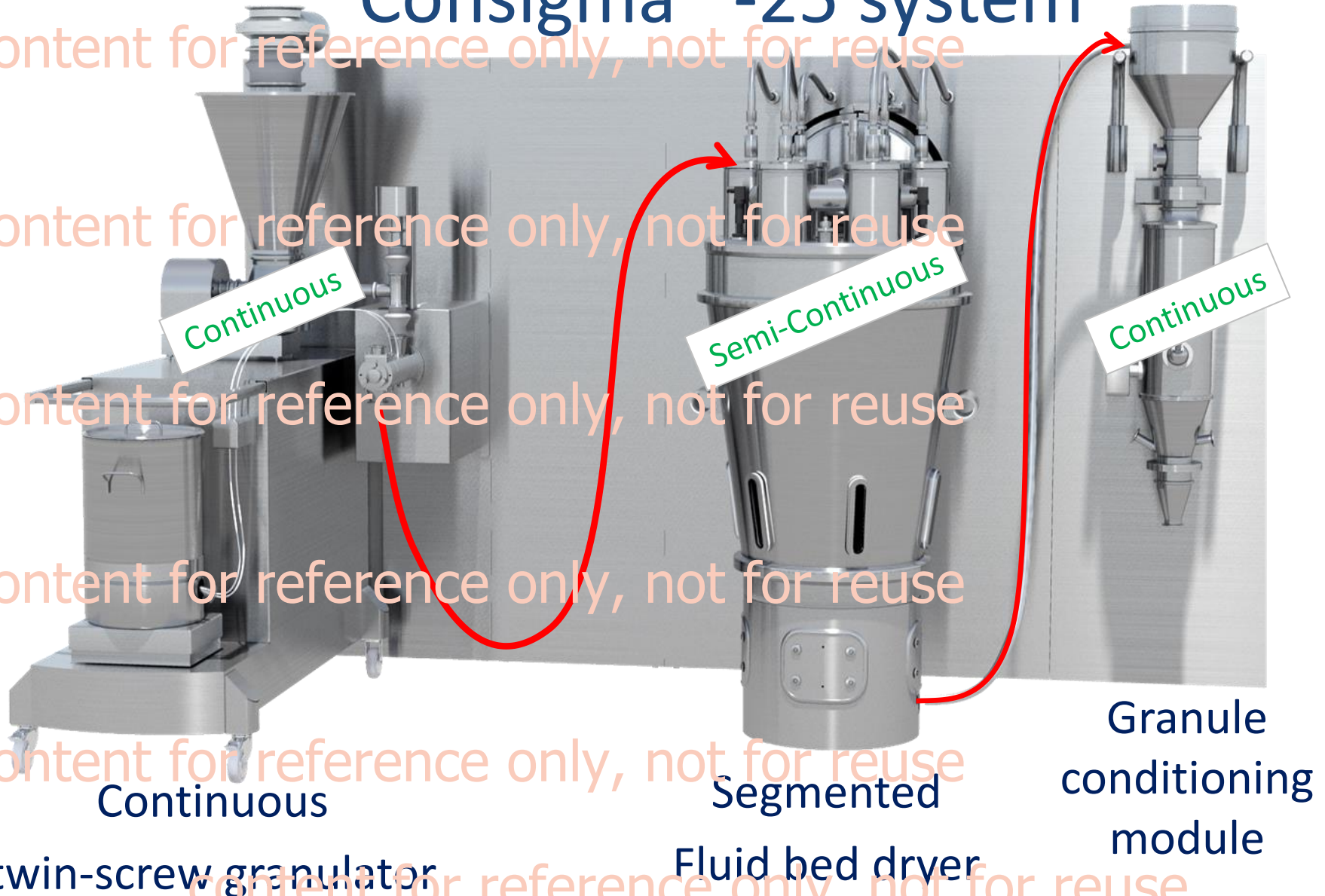
Ashish Kumar

7th International Granulation Workshop
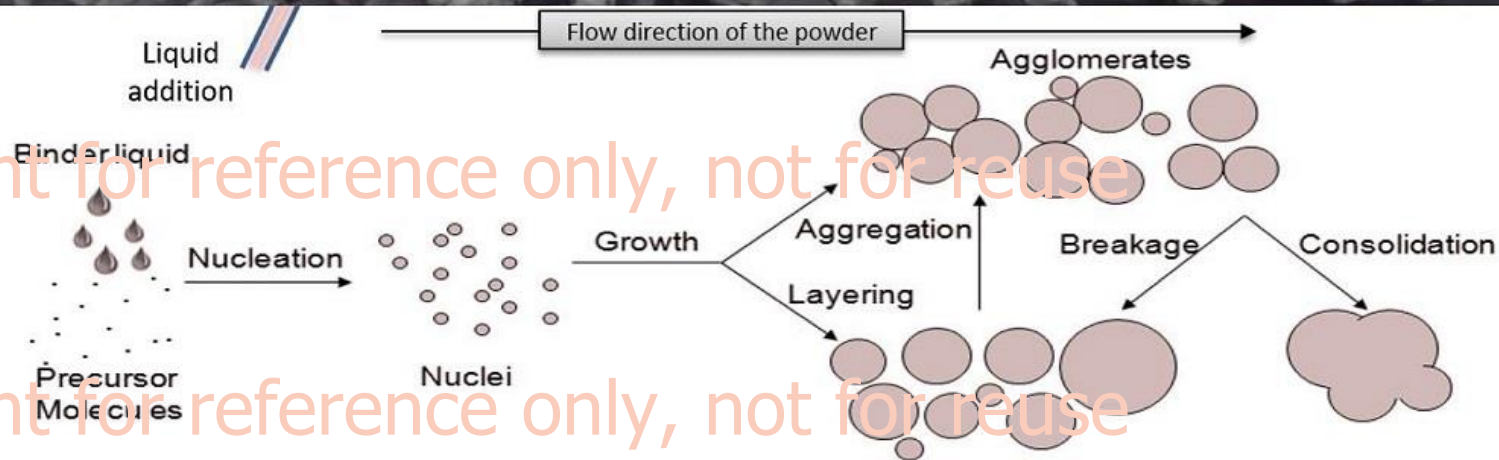
Continuous manufacturing line Consigma™-25 system

Continuous

Semi-Continuous

Continuous

Granule conditioning module

Continuous twin-screw granulator

Segmented Fluid bed dryer

High shear wet granulation in TSG involves many different process and equipment variables

Challenges in wet granulation

Understanding the effect of process settings on granulation performance

- Process evolution

- Product quality

Mostly theoretical approaches tracking granule attributes

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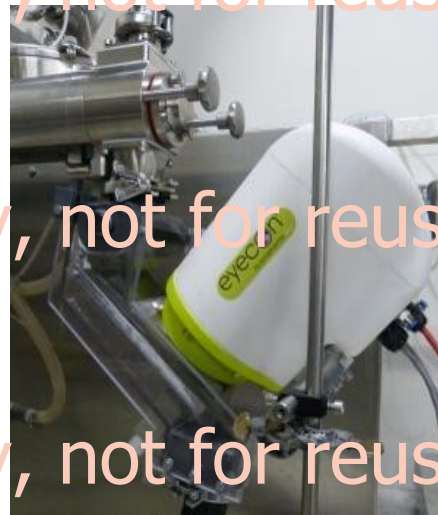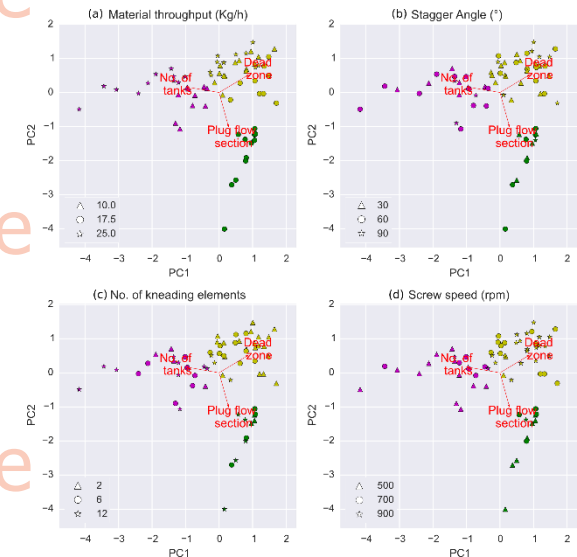
Challenges in wet granulation
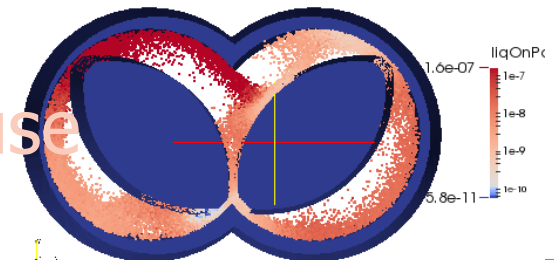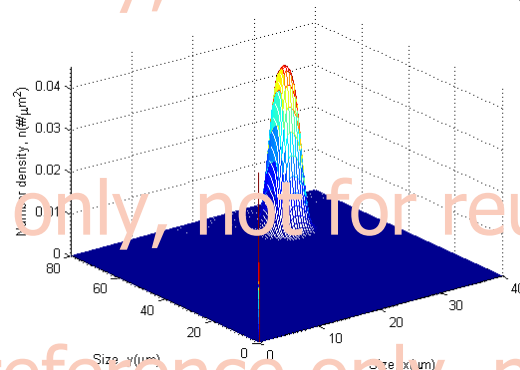
Understanding the effect of process settings on granulation performance

- Process evolution
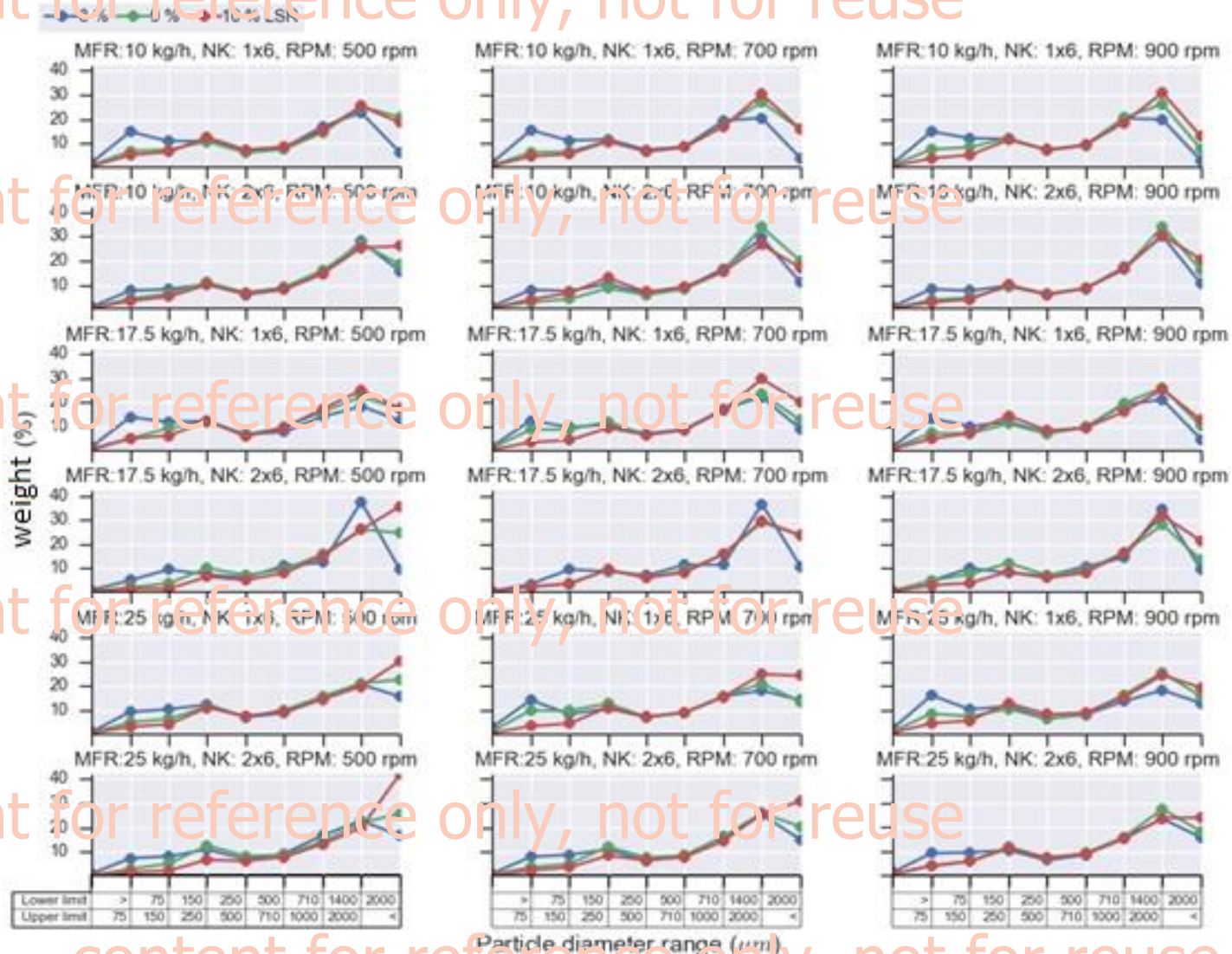
- Product quality

Experiments   multivariate data analysis

Traditional approach involves change in scale dependent process settings on PSD

Increasing number of kneading discs and L/S reduced amount of fines
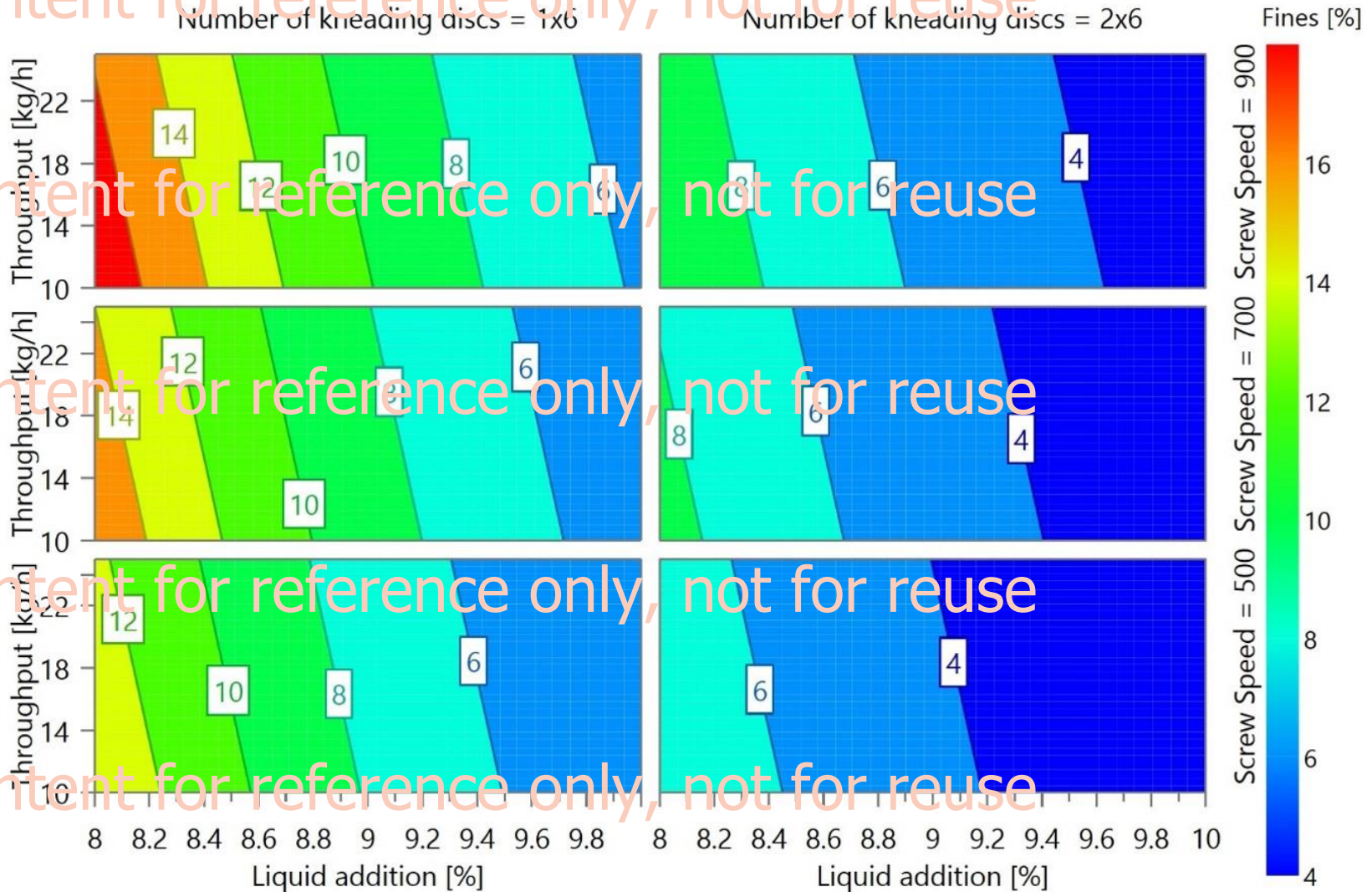
Yield fraction increases at low fill ratio and reduces with increasing L/S
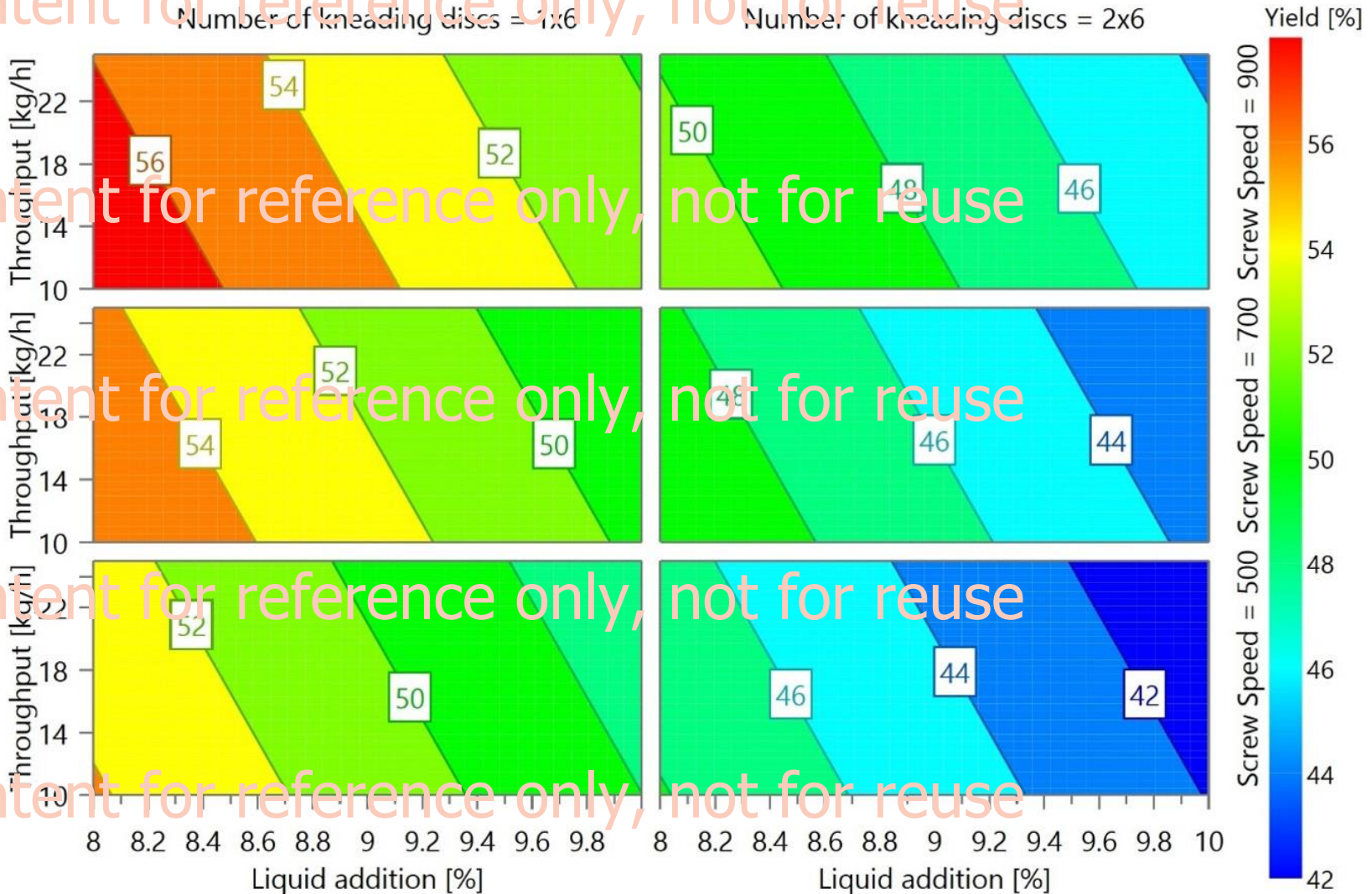
Increasing L/S produced more oversize at high fill ratio

Regime map: consolidating knowledge

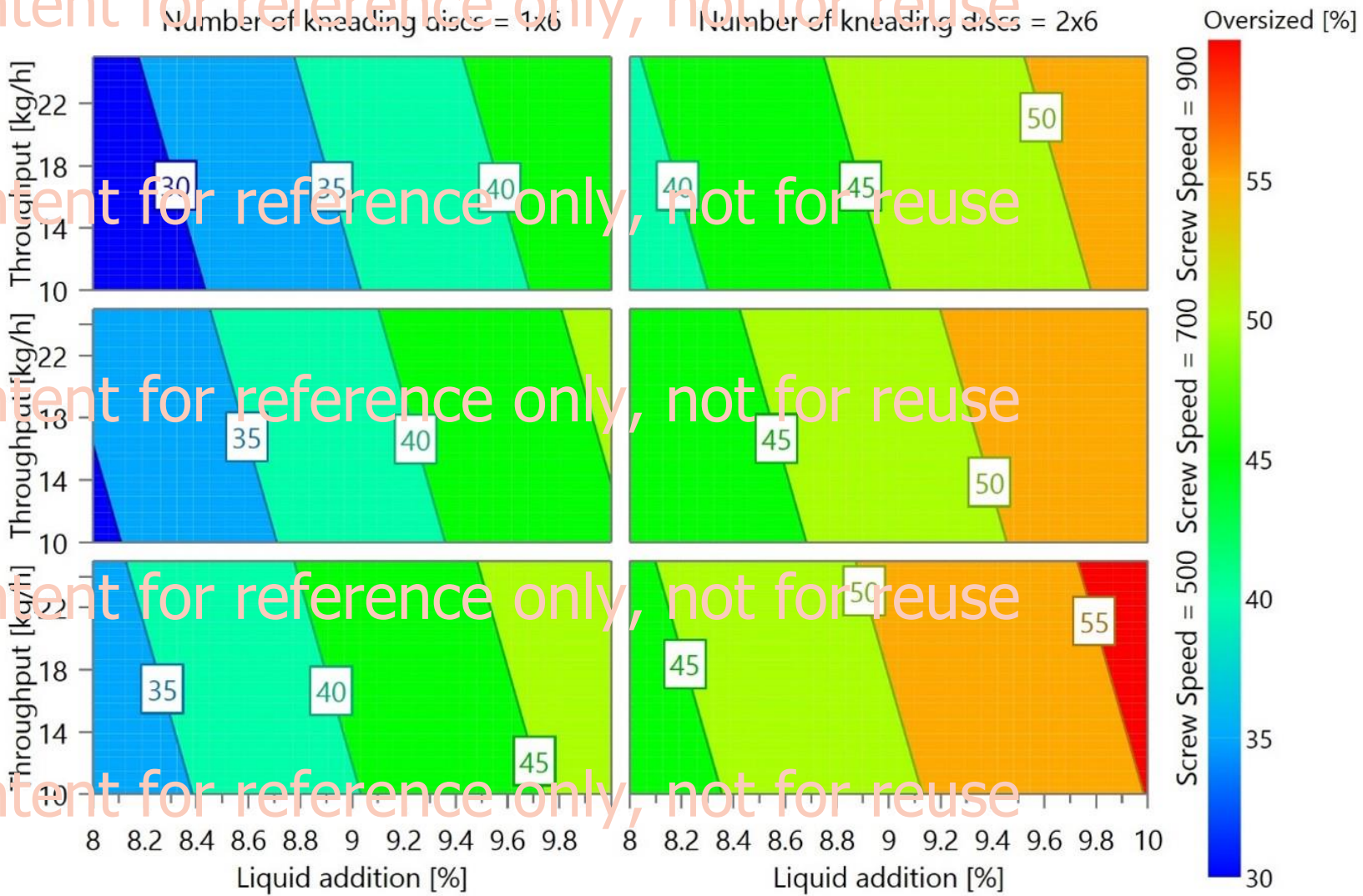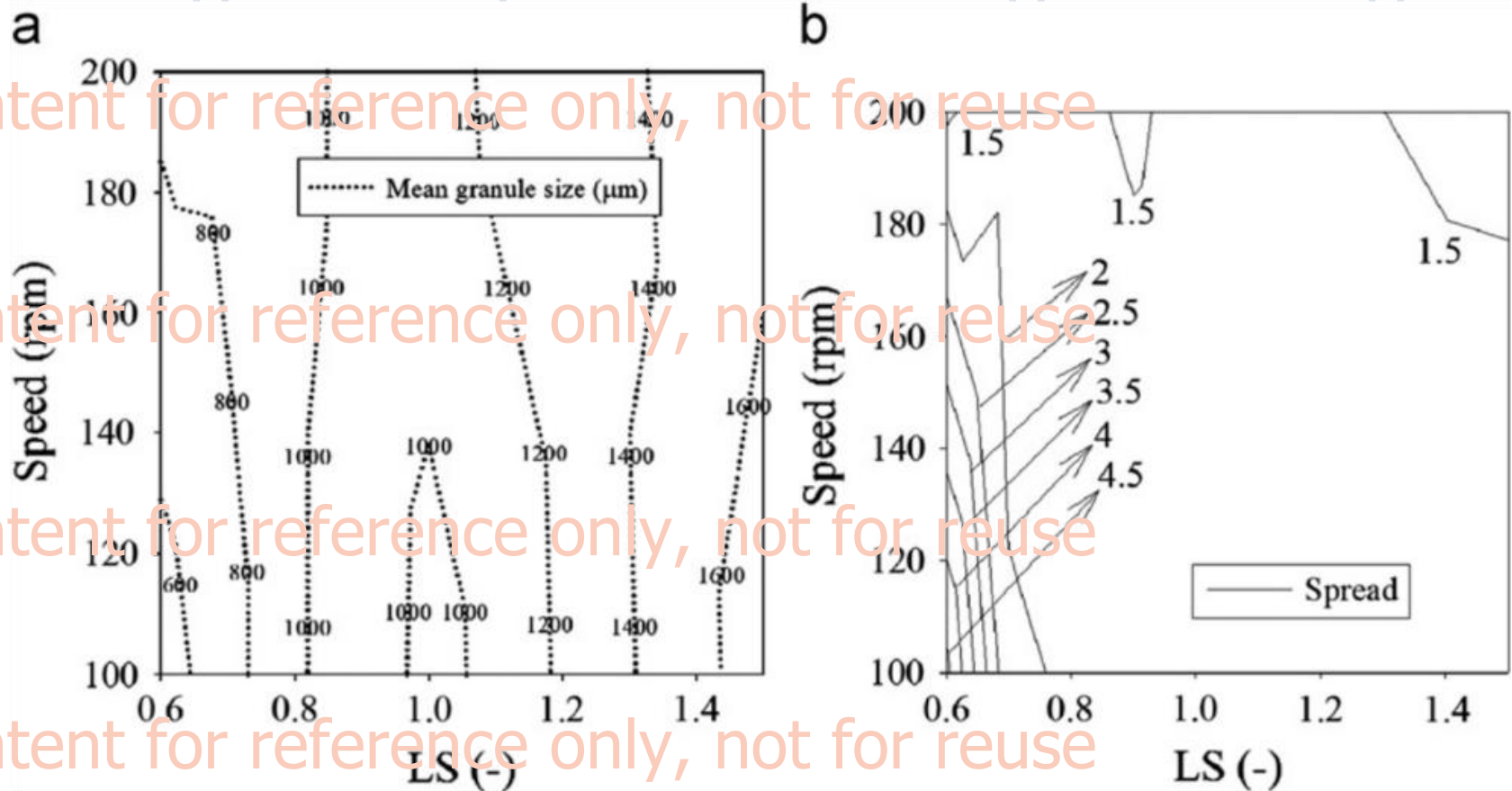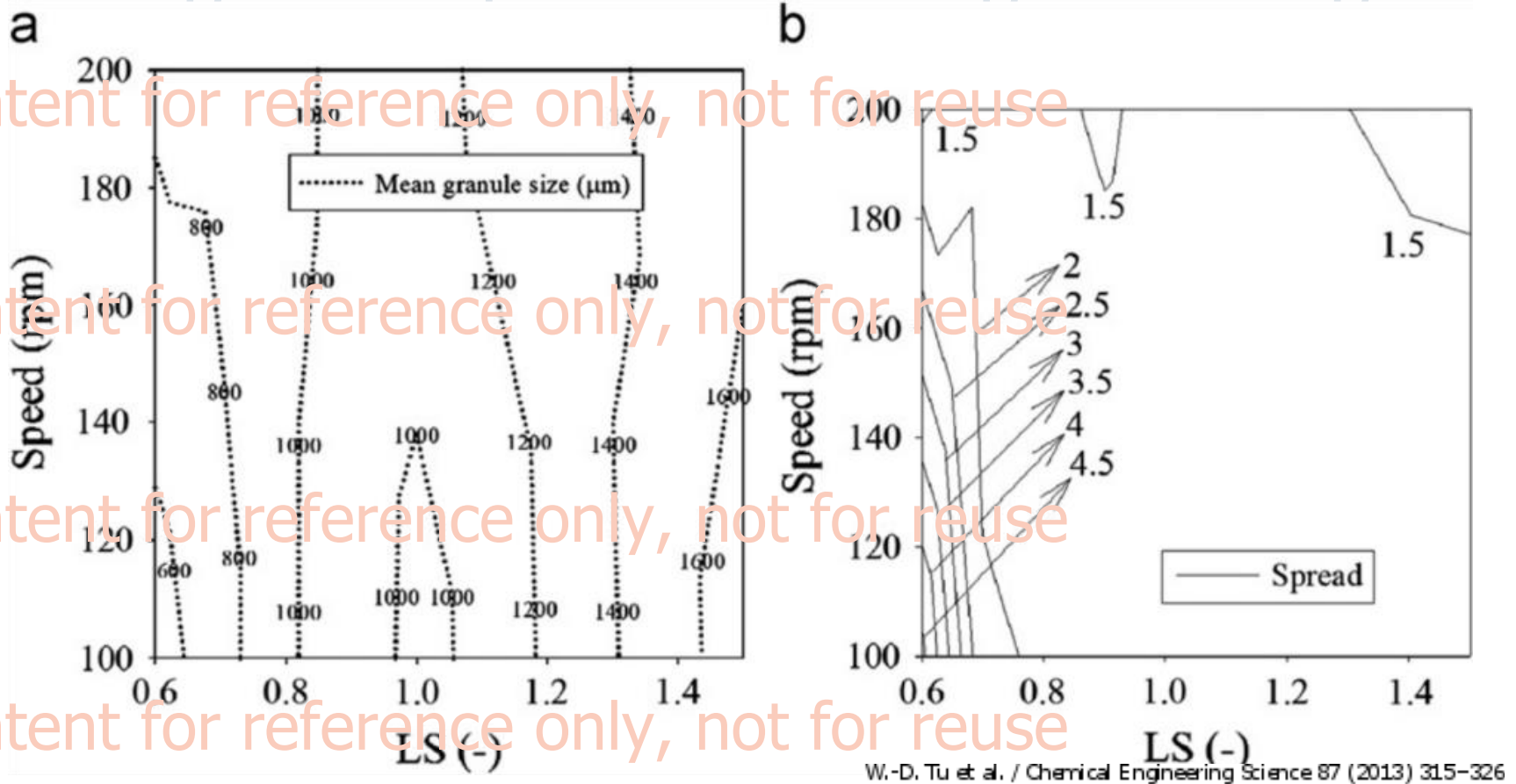

W.-D. Tu et al. / Chemical Engineering Science 87 (2013) 315–326

Boundaries were drawn to separate the growth behavior in terms of the L/S ratio and screw speed.

Regime map: consolidating knowledge

W.-D. Tu et al. / Chemical Engineering Science 87 (2013) 315–326

Dimensional measurements limits its applicability.

Growth regime map for wet granulation

"Dry" Free-Flowing Powder

"Crumb"

Slurry/ Over-Wet Mass

Steady Growth

Rapid Growth

Increasing Deformation Number, $De = \rho_g U_c^2 / Y_g$

Increasing Growth Rate

Nucleation Only

Induction

Decreasing Induction Time

0

100%

Maximum Pore Saturation,

$$s_{max} = w\rho_s(1-\varepsilon_{min})/\rho\varepsilon_{min}$$
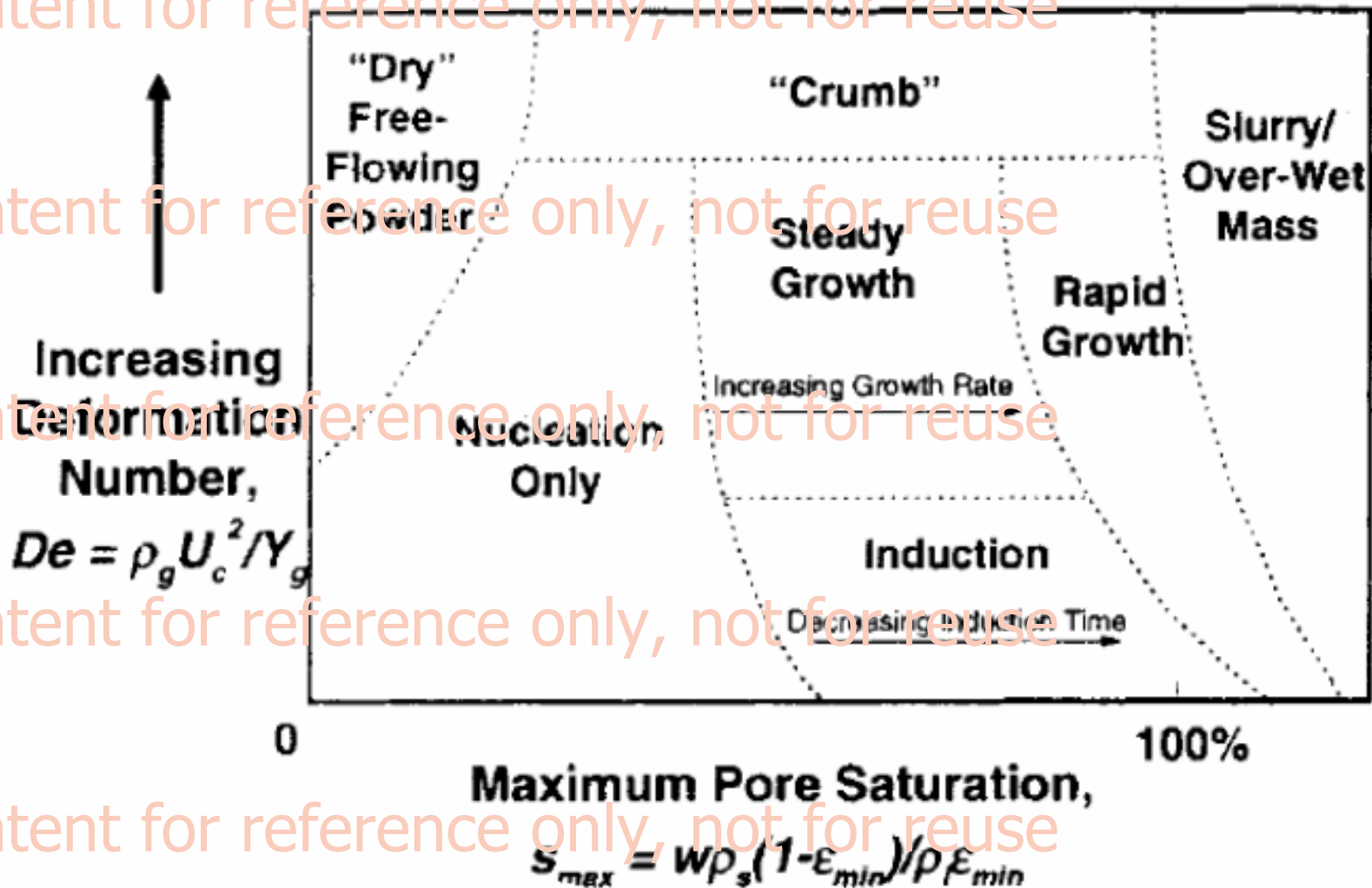
source: Iveson *et al.* (1998). AIChE J., 44,1510 - 1518

13

Regime map: consolidating knowledge

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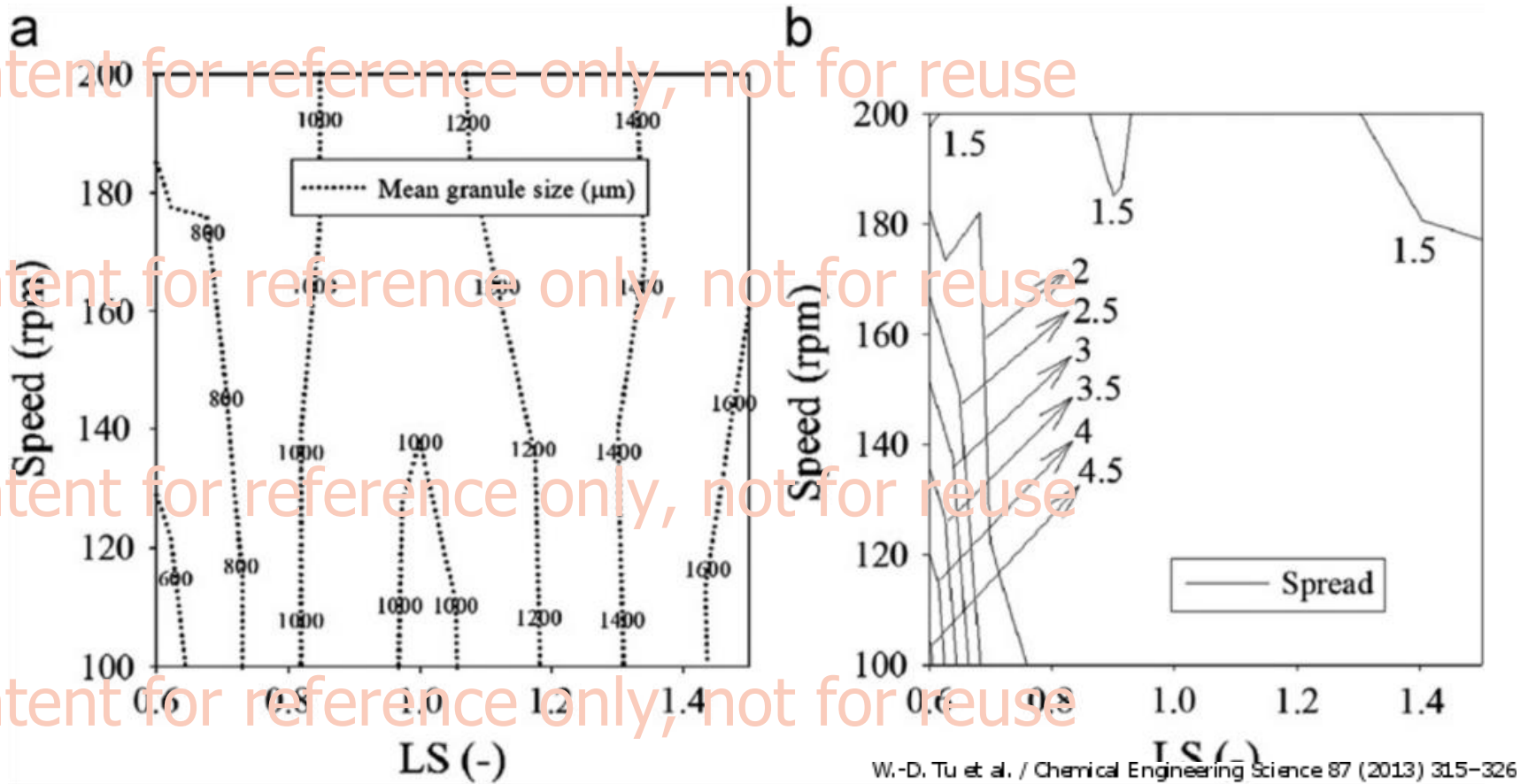
Mean of granule size distribution is not representative.

Using scale-independent parameter and a broad look on distribution

Specific mechanical energy (kJ/kg)

$$SME = motor\ rating \times \%\ torque \times \frac{RPM_{oper.}}{RPM_{max.}} \times \frac{gearbox\ efficiency(0.97)}{material\ throughput}$$

Liquid to solid ratio (%)

Quartiles of distribution D25, D50, D75

Quartile ratio D75/ D25

A higher L/S ratio led to formation of oversized granules instead of increasing yield
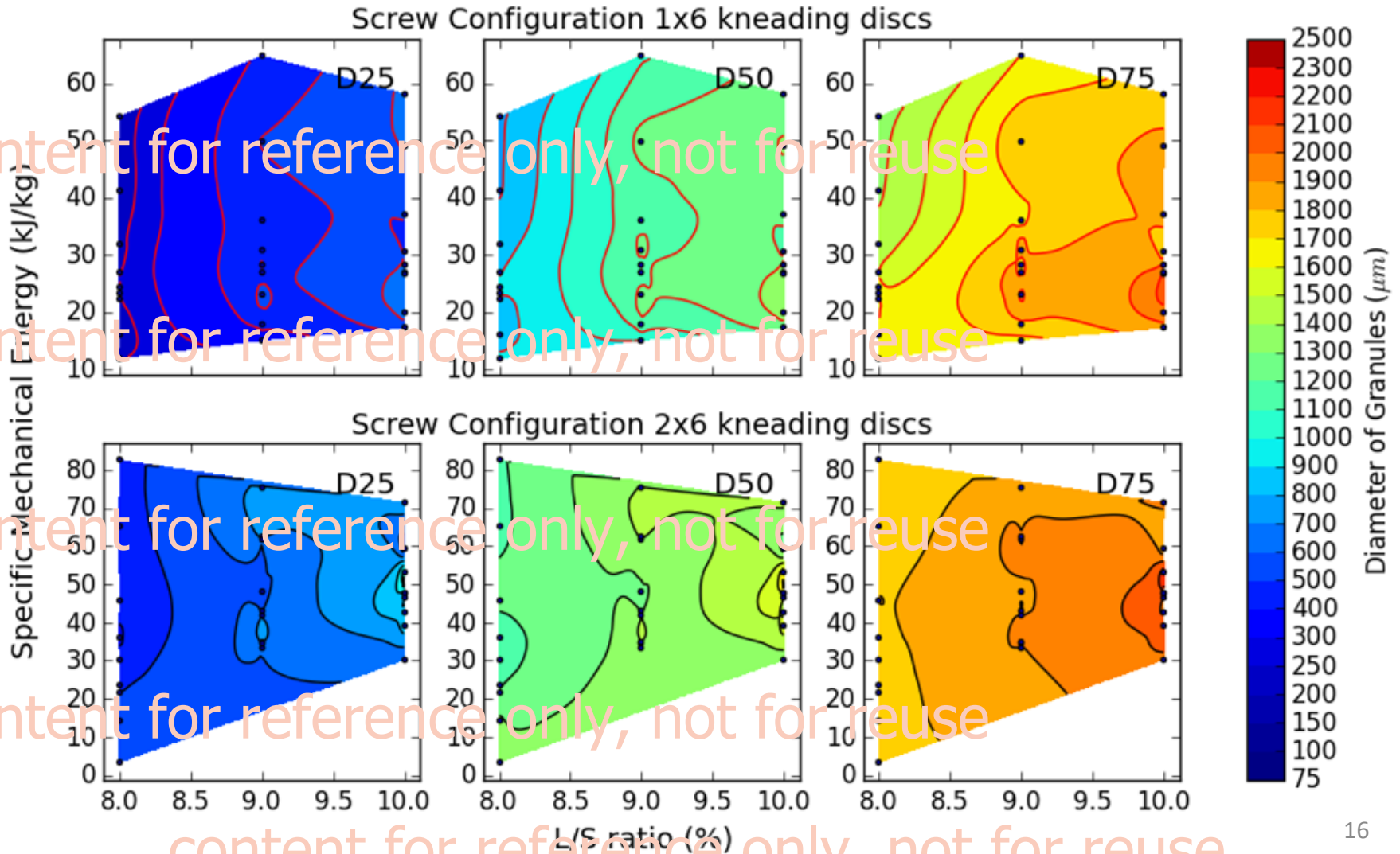
Width of the distribution reduced at higher L/S ratio and SME level
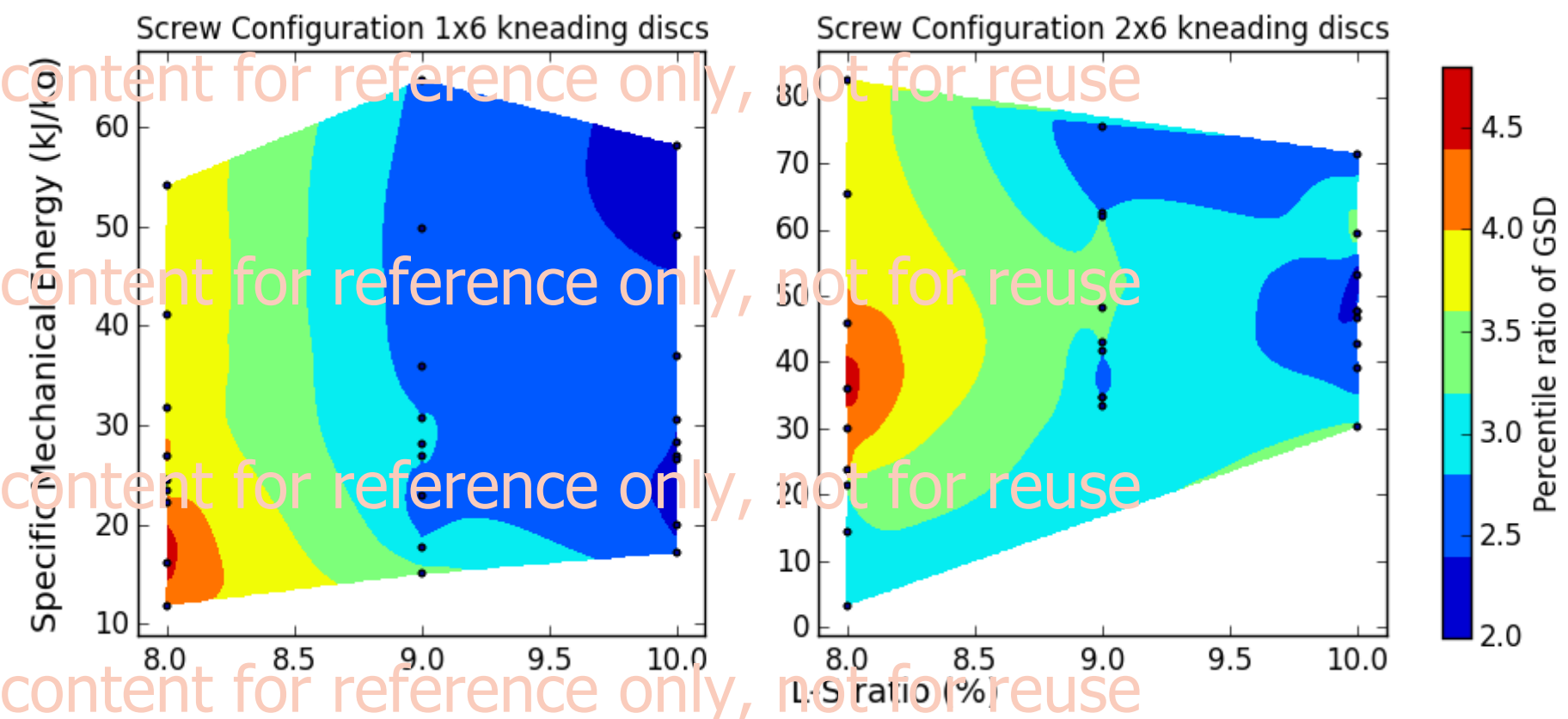
Summary

..the liquid addition should be kept at an intermediate level.

.. the throughput and screw speed should be increased simultaneously to improve the granulation yield.

.. more regime maps for other formulations are necessary due to the likely differences in the granulation behavior.

18

Perspectives

Formulation properties
D_p, Υ, γcosθ...

Process parameter
RPM, P_{input}, shear..

Propose most relevant
dimensionless groups

Generalised
regime map

Aknowledgements

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Fien De Leersnyder

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21