Investigation of the impact of packing morphology on hydrodynamics in a process intensification device: the rotating packed bed (RPB)

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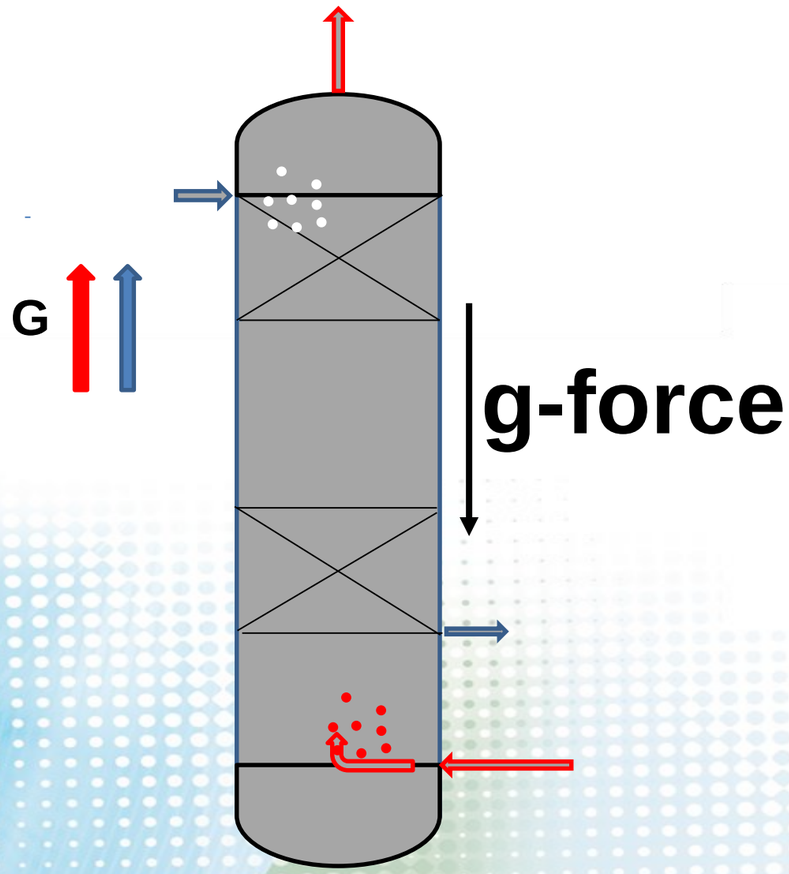
Outline

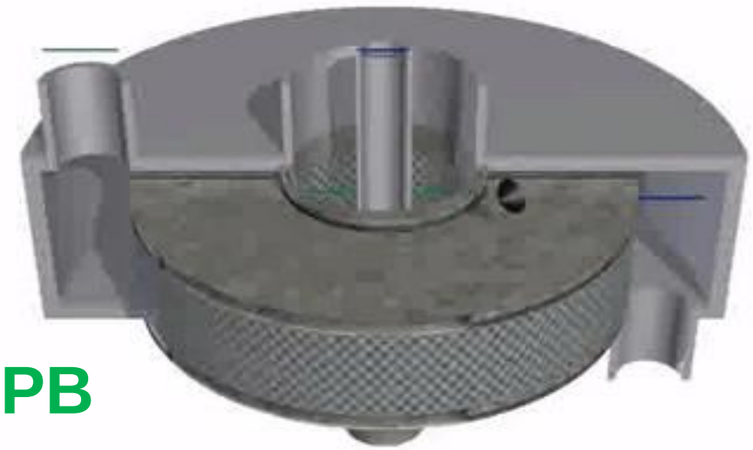
- Introduction
- Objective
- Methodology
- Results
- Conclusions and perspectives

Force fields in separation processes

g is superimposed by a_c



Conventional packed column

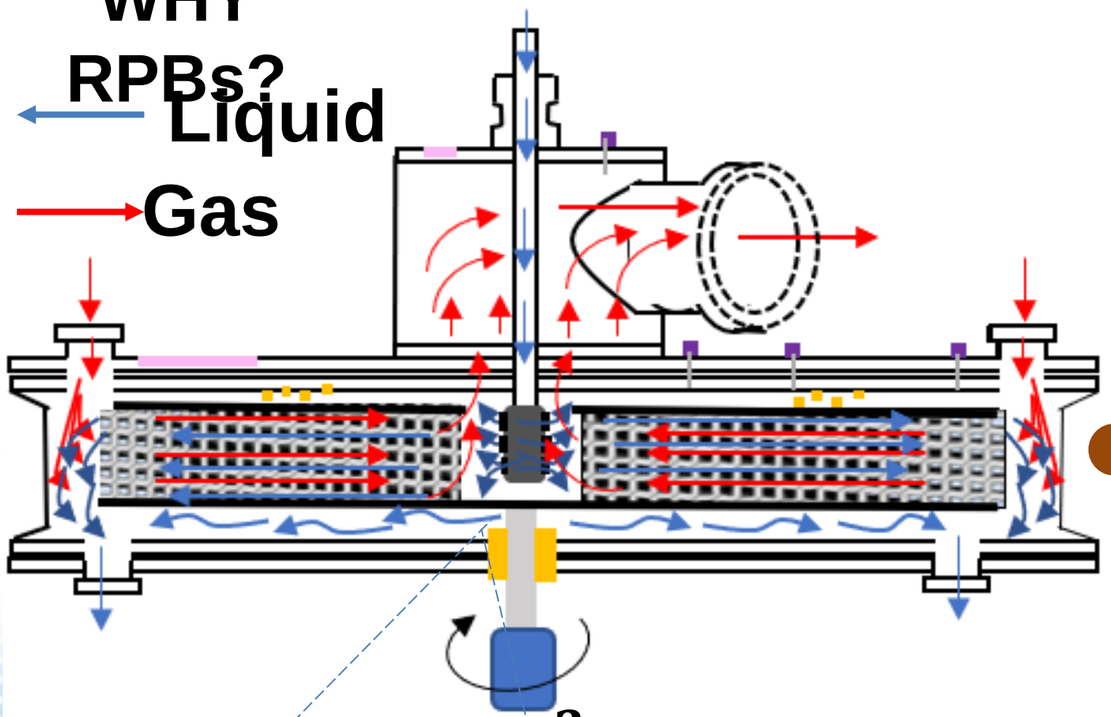


RPB

WHY RPBs?

Liquid

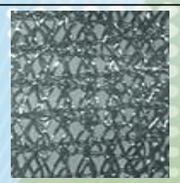
Gas



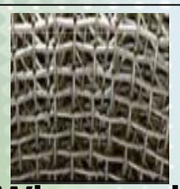
$$a_c = \omega^2 r \sim 10g - 1000g$$

Different Packing morphologies

Foam



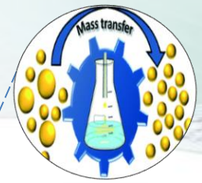
Knit mesh



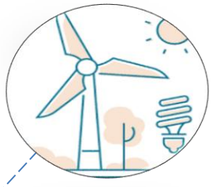
Wire mesh

Grid

Expanded mesh

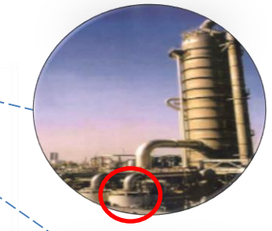


High **mass transfer** rate



Lower **energy** consumption

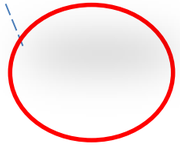
Fewer **by-products**



Reduced **footprints**

Enhanced **safety**

Reduced **costs**



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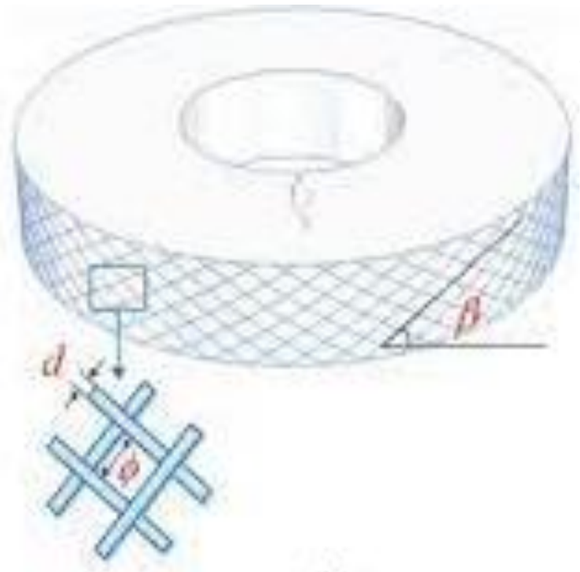
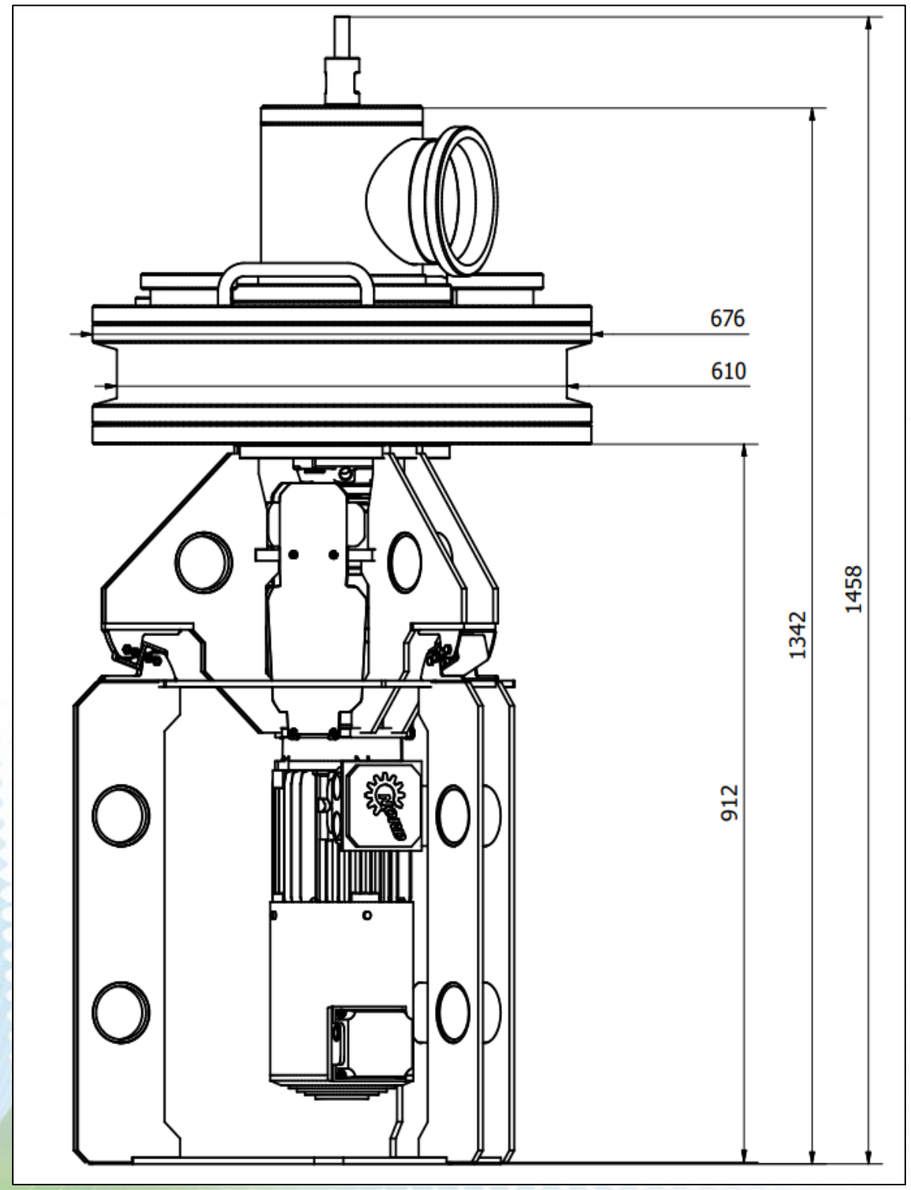
Investigate impact of RPB packing forms and structures on ΔP



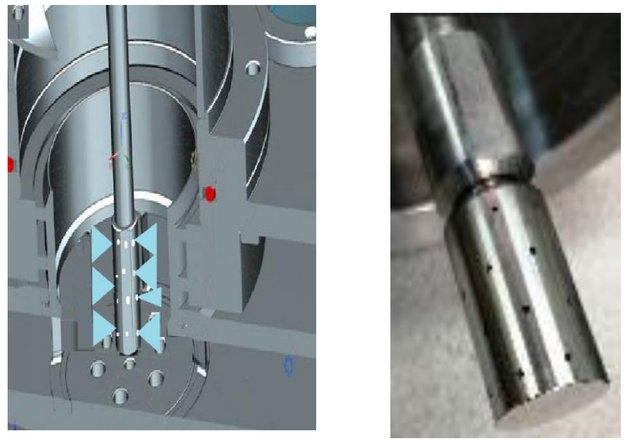

676
610
912
1342
1458

- **Design parameters:**
  - Packing characteristics:
    - Stainless steel wire mesh
    - ε = 0.86
    - a_p= 2400m^{2}m^{-3}
  - Liquid distributor: perforated, single central pipe
- **Operating parameter:**
  - ω: 200 – 1500 rpm
  - V_G: 100 – 300m$^3{}_{norm}$/h
  - V_L: 10.8 – 54.6 m^3/h
  - Air/water system
  - T = 20 °C,
  - p = 1 atm

Average high gravity factor, $\bar{\beta} = \frac{2\omega^2(r_i^2+r_i r_o+r_o^2)}{3(r_i+r_o)g}$

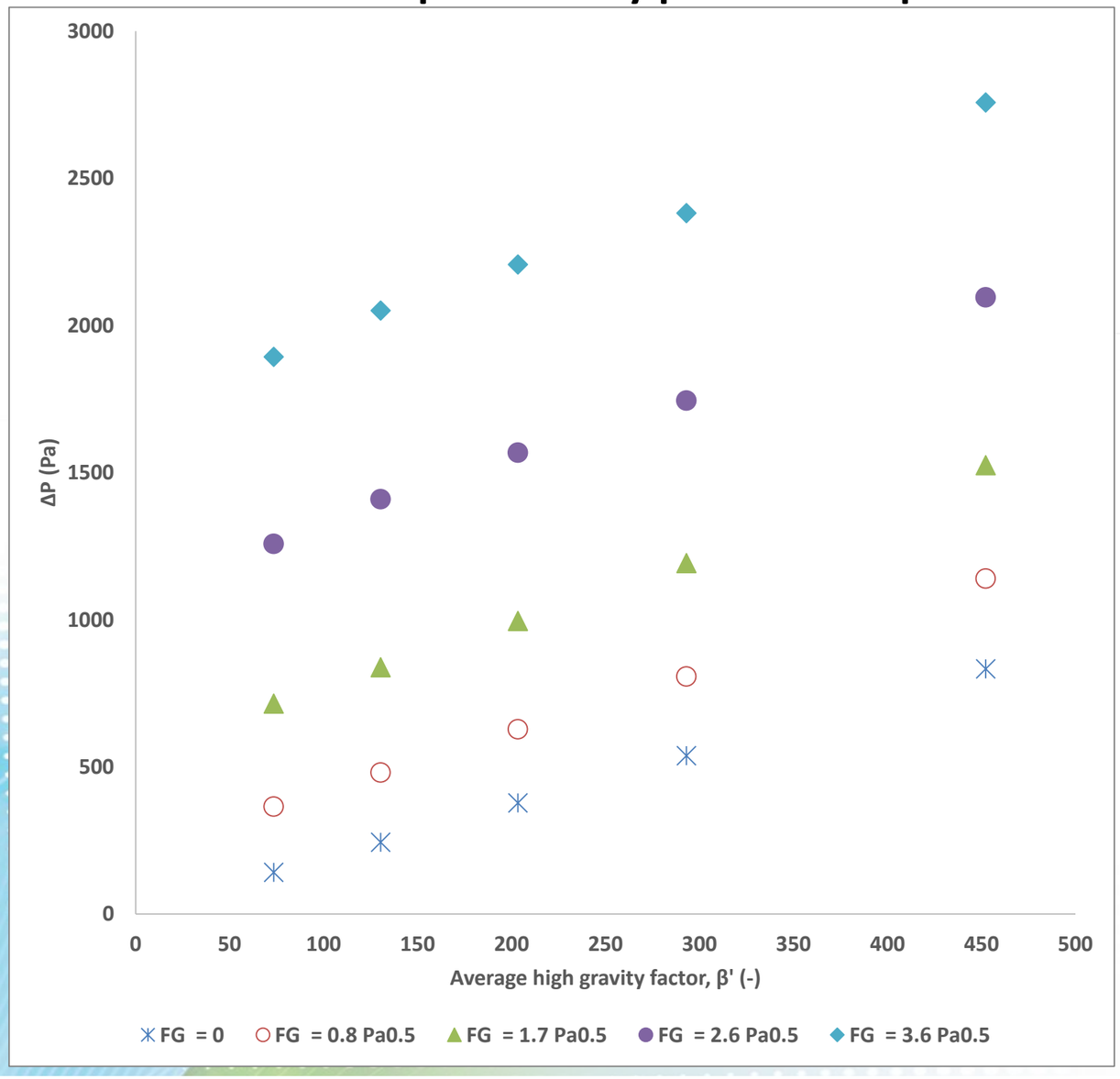
$Gas\ capacity\ factor,\ \bar{F}_G = \frac{\dot{V}_G}{2\pi(r_o-r_i)h_p} ln\left(\frac{r_o}{r_i}\right)\sqrt{\rho_G}$

Liquid load, $\overline{LL} = \frac{\dot{V}_L}{2\pi(r_o-r_i)h_p} ln\left(\frac{r_o}{r_i}\right)$

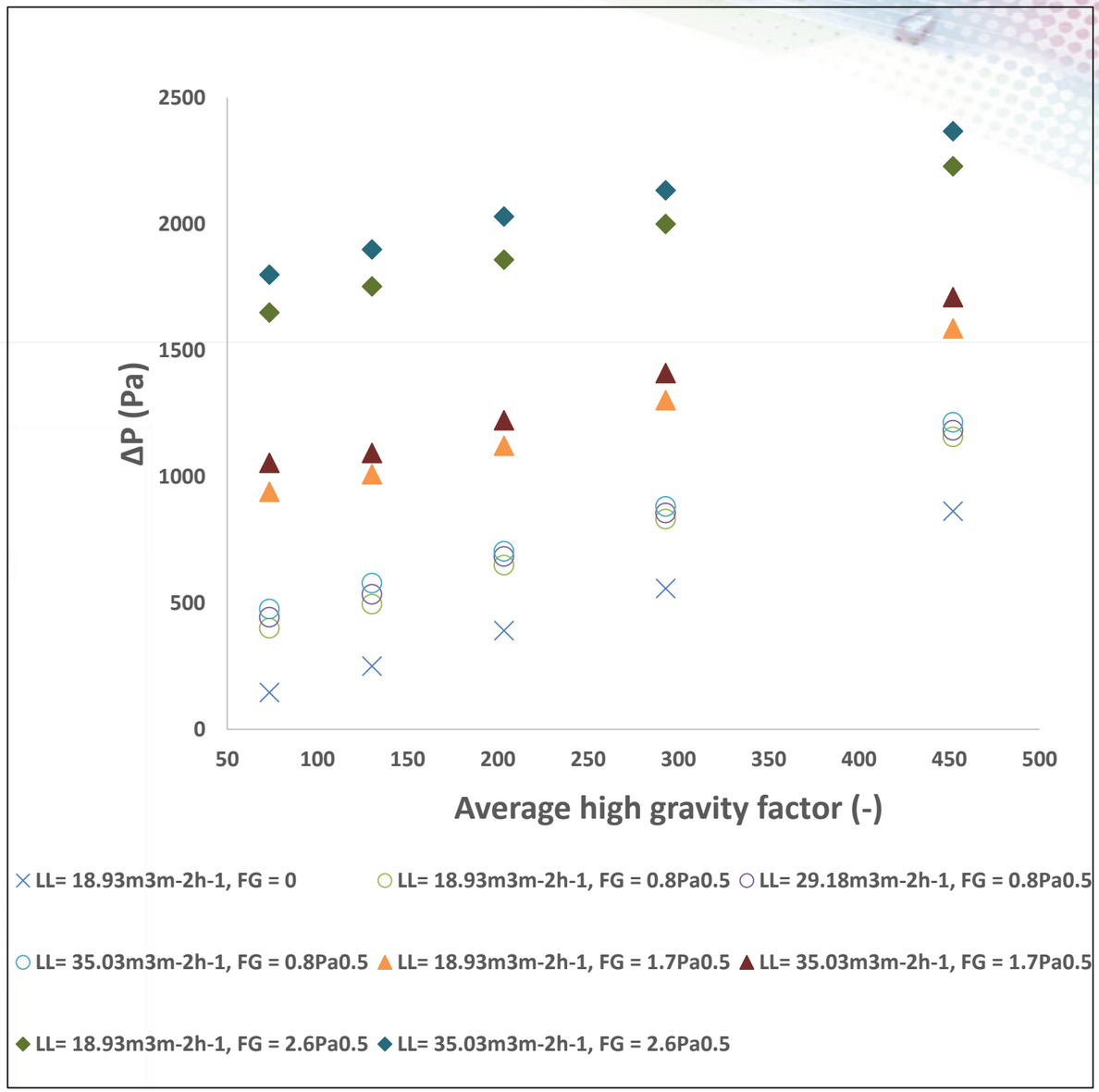


Liquid distributor

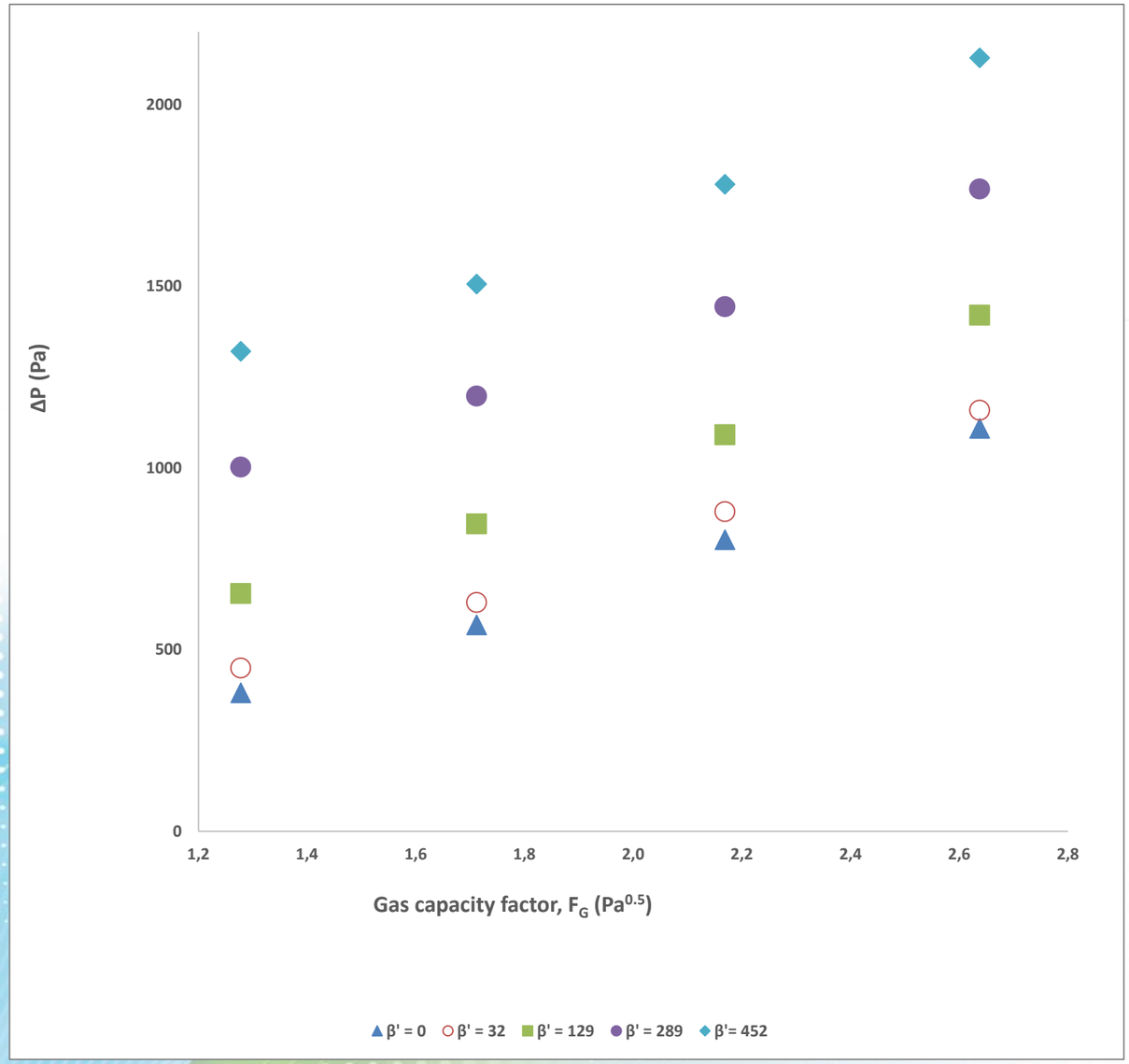
Effect of rotor speed on dry pressure drop



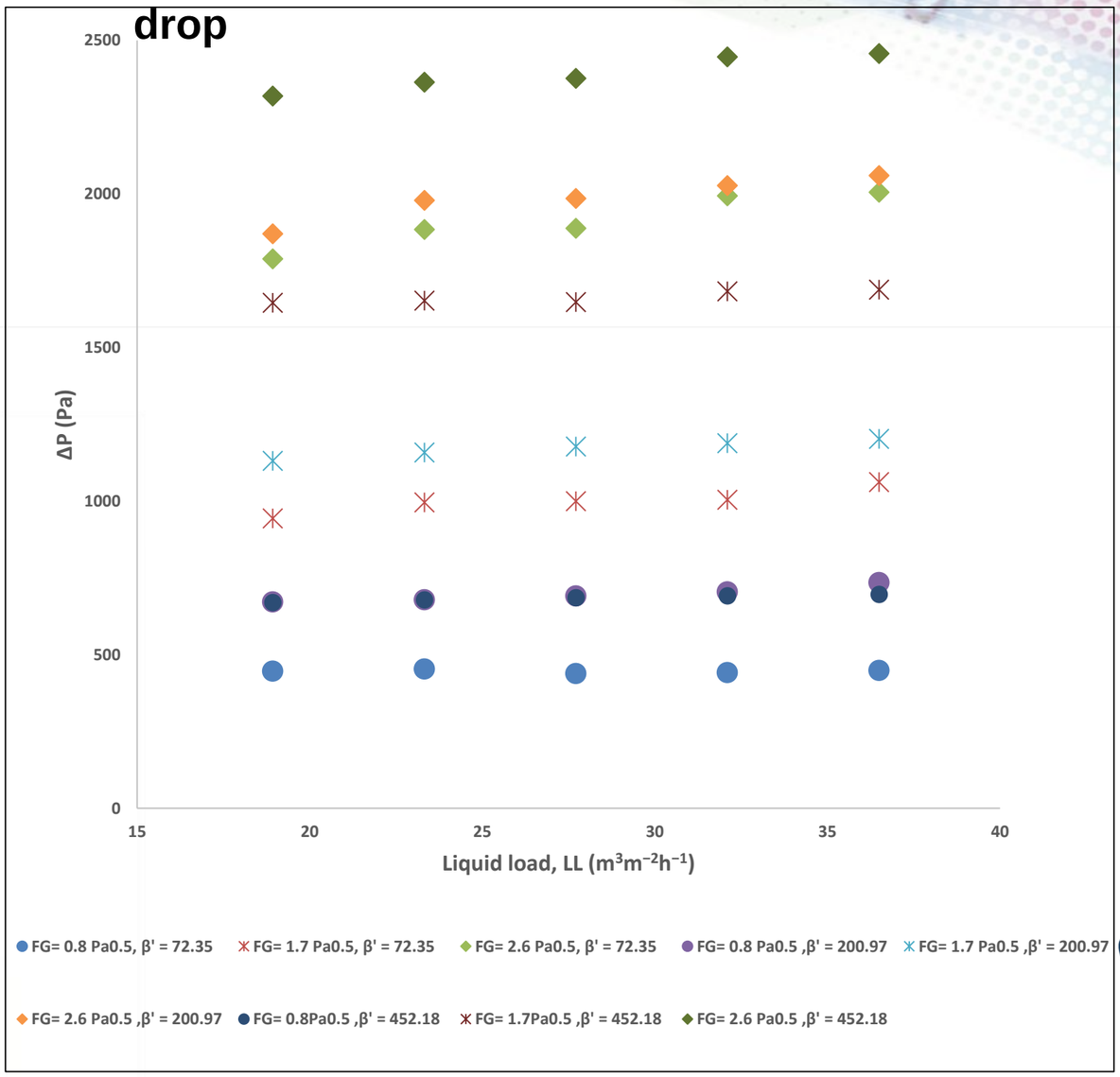
Effect of rotor speed on wet pressure drop



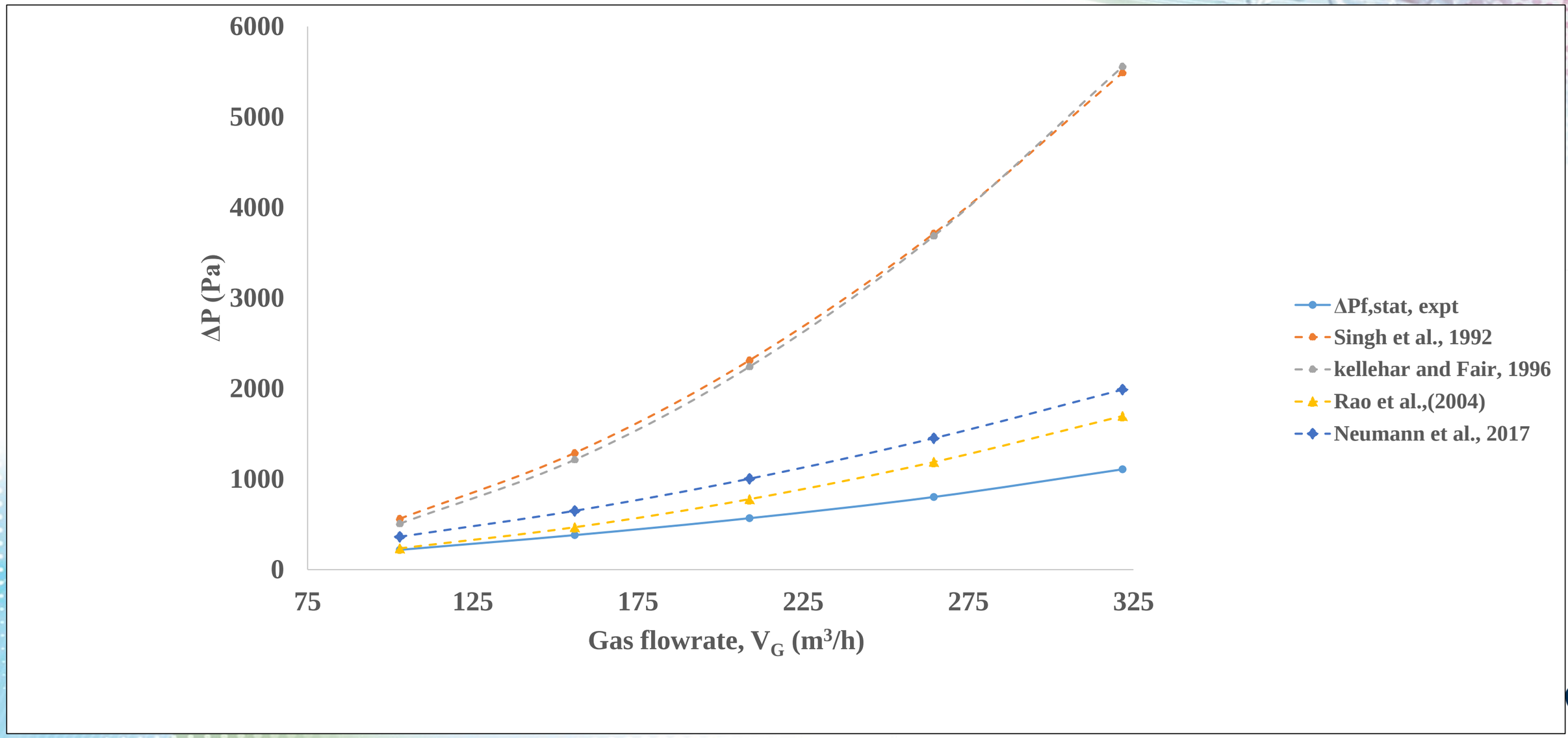
Effect of gas flowrate on dry pressure drop



Effect of liquid flowrate on wet pressure drop



Comparing data of different morphologies



CONCLUSIONS & PERSPECTIVES

Conclusions

- ✓ Understanding the morphology of RPB packings is essential for its design, modelling and scale-up
- ✓ Packing morphology has significant impact on the hydrodynamics (ΔP) of RPBs
- ✓ The effect ranking of operating parameters of RPBs is $V_G > \omega > V_L$
- ✓ V_G contributes 40-70% of the pressure drop of RPBs

Perspectives

- ➢ Develop a robust anisotropic RPB packing with a new morphology via 3D printing.
- ➢ Study the hydrodynamic characteristics of the newly developed packing.
- ➢ Develop an empirical model to represent the relationship between packing morphology and ΔP.

Thank you for your attention