Co-currently downward flow regime transition in solid SiSiC foams: Flow regime prediction and measurement

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INTRODUCTION & MOTIVATION

- Solid foams are promising novel reactor internals for chemical multiphase processes
- SiSiC (silicon-infiltrated silicon carbide) foams combine high porosity, large specific surface areas and low pressure drop

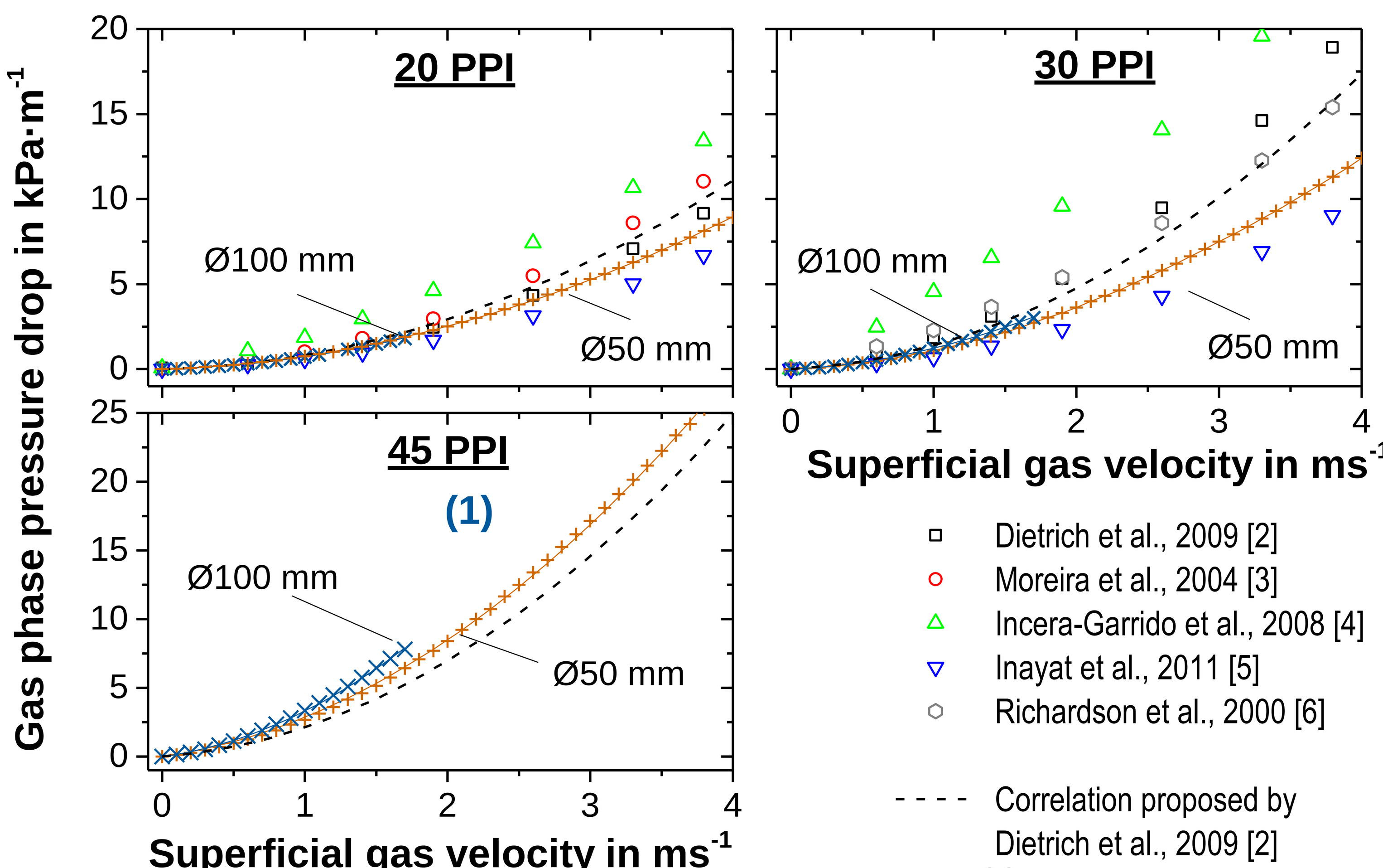
Pore density	Packing diameter	Porosity	Surface area
20 ppi	50 mm; 100 mm	0.90	~1000 m^2/m^3_S
30 ppi	50 mm; 100 mm	0.89	~1600 m^2/m^3_S
45 ppi	50 mm; 100 mm	0.86	~ 2000 m^2/m^3_S

- Prediction of occurring flow regimes crucial for multiphase applications
- Regime transitions in foam packing of 0.8 m packing length investigated under co-current ambient downflows of water/aqueous liquids and air
- Pore density, packing diameter, liquid injector and liquid properties varied

Fluid	Surface tension in $N \cdot m^{-1}$	Density in $kg \cdot m^{-3}$	Viscosity in mPa·s
Air		1.2	0.02
Deionate	0.0724	1000	1.0
Tergitol 1 µL/L	0.0502	1000	1.0
Glycerin 51w%	0.0686	1130	6.5

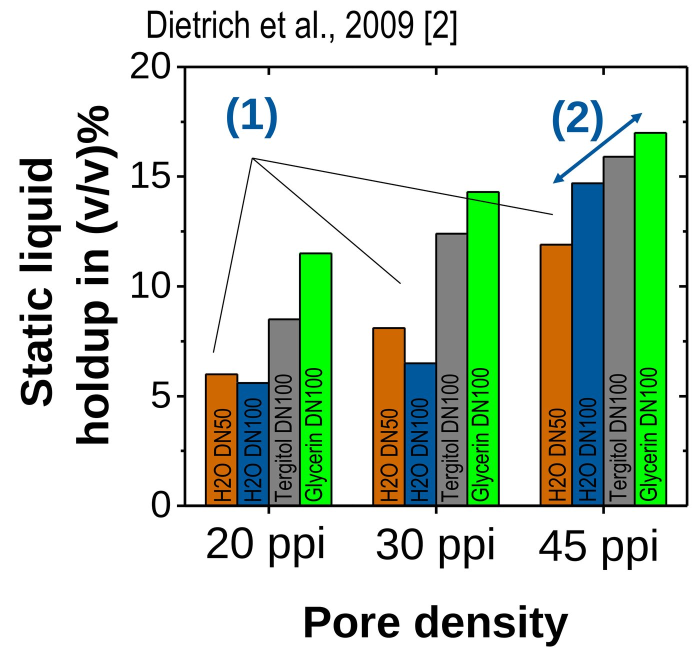
TRANSITION MODEL ADAPTION

- Adaption of predictive relative permeability model of Grosser et al., 1988 [1] to foam specific parameters
- Model requires dry pressure drop, static liquid holdup and permeability coefficients for force balances



$$\frac{\Delta p}{\Delta L} = E_1 \cdot \frac{(1-\varepsilon)^2 \cdot \mu \cdot S_V^2}{\varepsilon^3} \cdot u + E_2 \frac{(1-\varepsilon)^2 \cdot \rho \cdot S_V}{\varepsilon^3} \cdot u^2$$

Pore density	Ø50 mm E_1	Ø50 mm E_2	Ø100 mm E_1	Ø100 mm E_2
20 ppi	672	2.1	524	2.2
30 ppi	695	2.2	571	2.8
45 ppi	738	2.7	697	3.7



(1)→ Pressure drop and static liquid holdup vary with pore density and packing diameter

(2)→ Static liquid holdup increases with lowered surface tension and increased viscosity

EXPERIMENTAL & MODELLING RESULTS

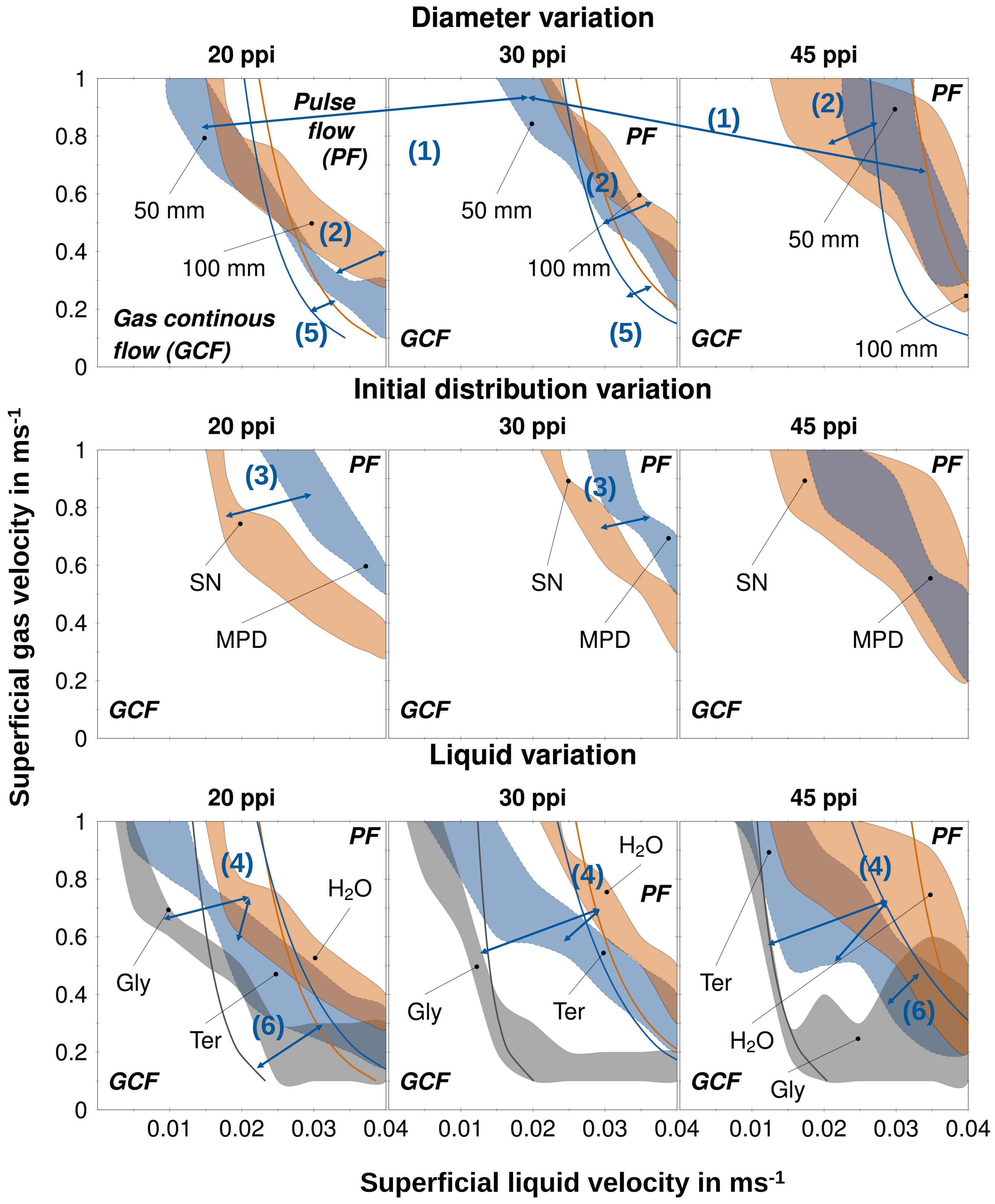
- Regime transition acquired by visual observation
- Onset of flow instabilities = regime transition between gas continuous flow (GCF) and pulse flow (PF)

(1)→ 20 and 30 ppi foam show similar behavior, 45 ppi foams differ clearly

(2)→ Packing diameter affects transition due to liquid barrier probability

(3)→ Due to liquid pre-channeling multipoint distributor (MPD) shifts transition to higher fluid fluxes than more homogeneously distributing spray nozzle (SN)

(4)→ Lowered surface tension (Ter) and increased viscosity (Gly) provoke blocking barriers at lower fluxes due to improved wetting homogeneity and thicker liquid films



Lacking of permeability coefficients, estimated transition curves fitted to experimental data

(5)→ Qualitative acceptable prediction of transition shifts

(6)→ Model not capable of more accurate transition prediction due to

- Inadequate model assumptions
- Insufficient flow and packing homogeneity
- Different flow physics in foams and random fixed beds

CONCLUSION

- Various parameters affect flow regime transition
- Qualitatively, model predicts most variation effects correctly
- Inadequate model assumptions prevent more accurate prediction

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