Scale-up of Oscillatory Helically Baffled Reactors (OHBRs)

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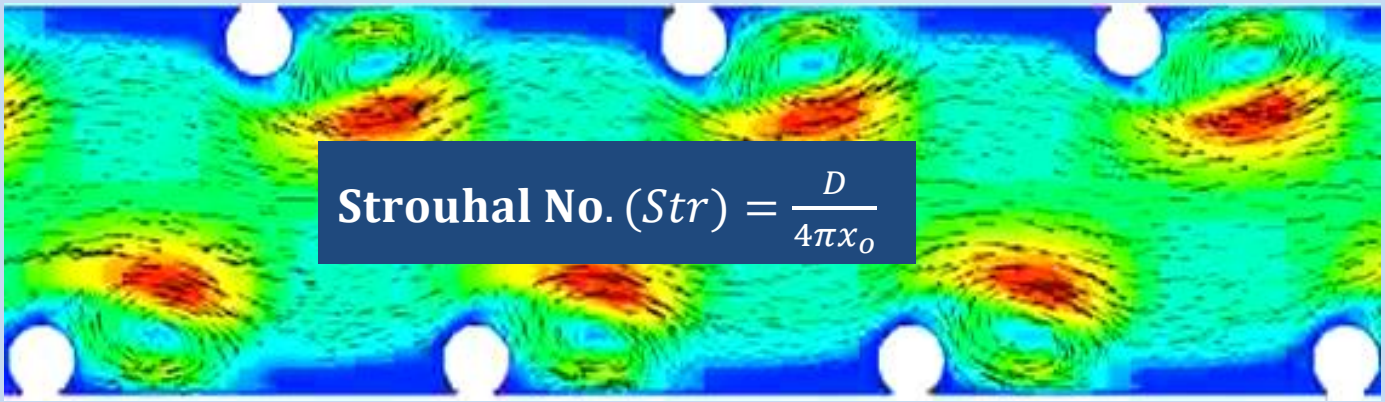
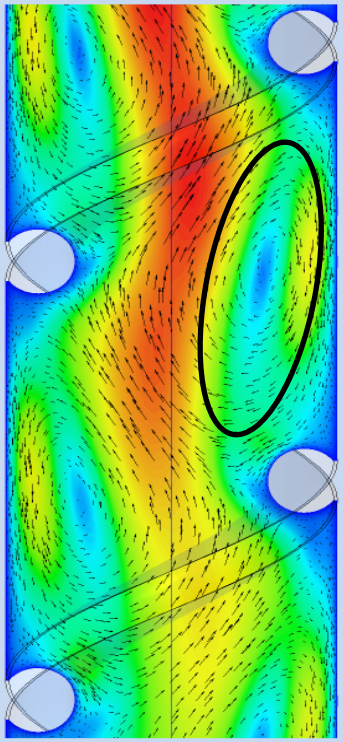
Outline

- Background
- Aim of study
- Devices and procedure
- Results
- Conclusions

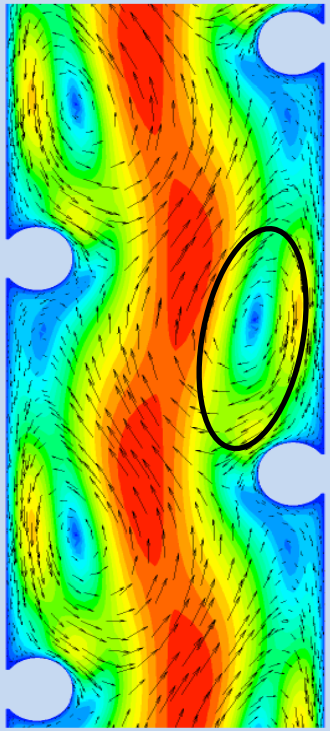
Oscillatory baffles reactor (OBR)



$$\text{Strouhal No. } (Str) = \frac{D}{4\pi x_o}$$



Str=0.13

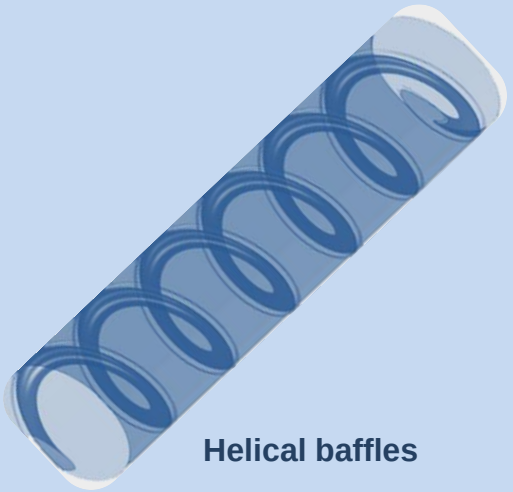


Str=0.2

OHBR
3mm, 2Hz @ time step=0.5s

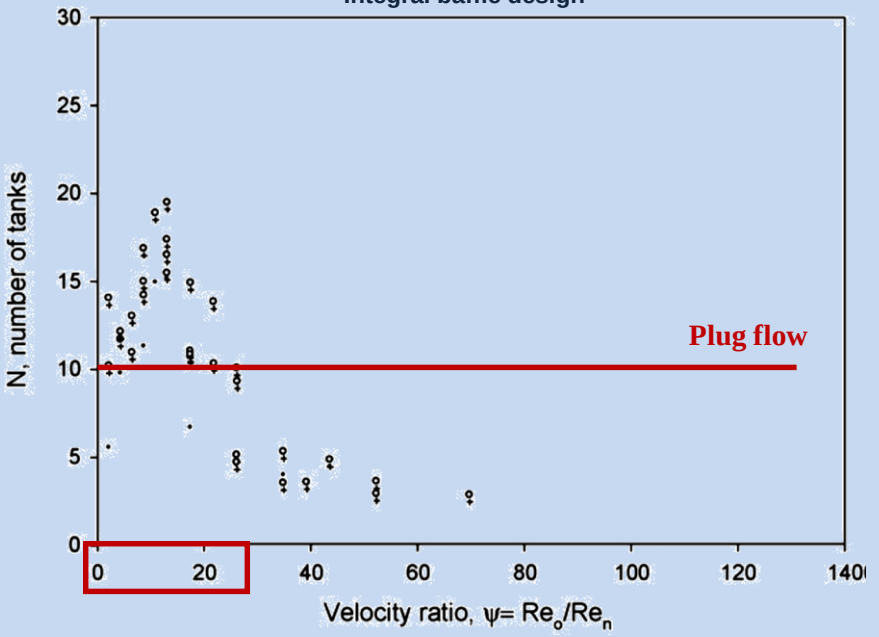
OHBR
2mm, 2Hz @ time step=0.5s

Baffles designs

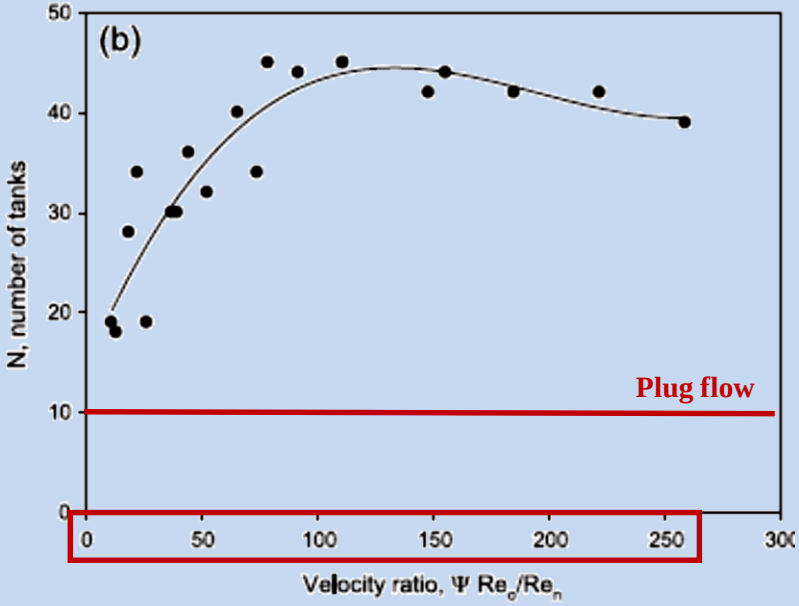


Helical baffles

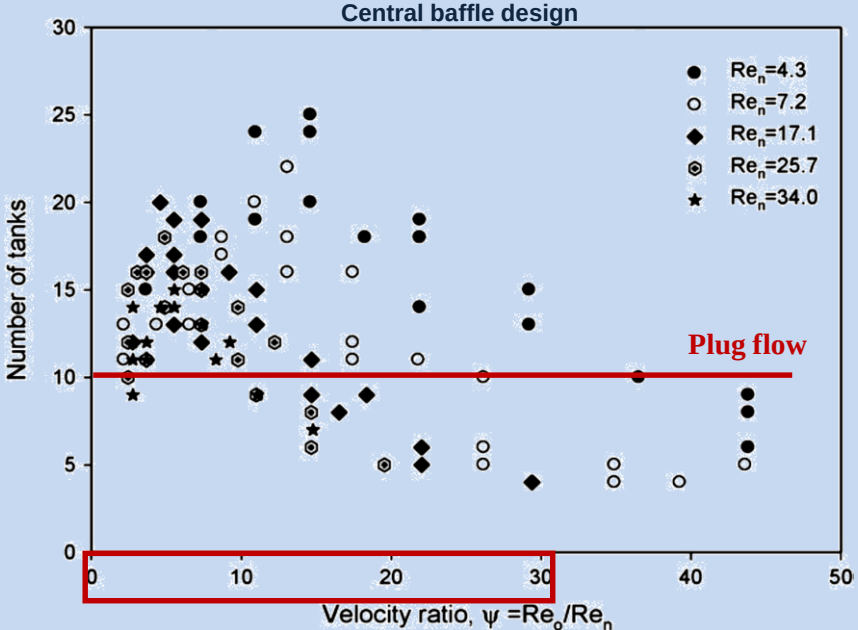
Integral baffle design



Helical baffle design



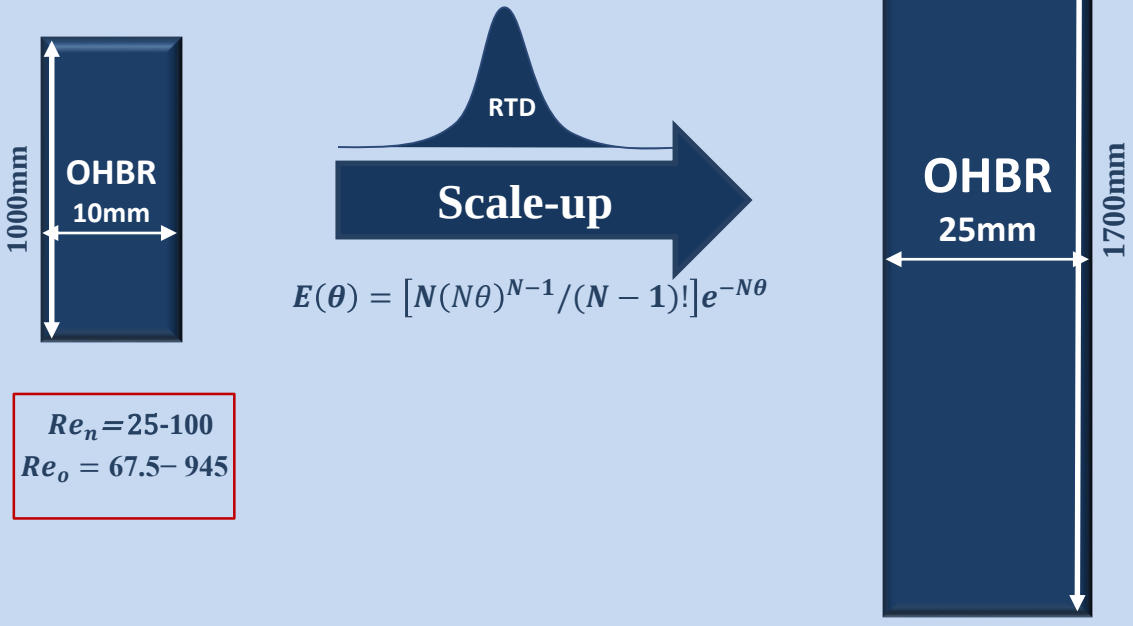
Central baffle design



Scale-up criteria

Similarity

l=1.2D
S^2 = 70%
Str=0.37, 0.27, 0.17
ψ=0-30

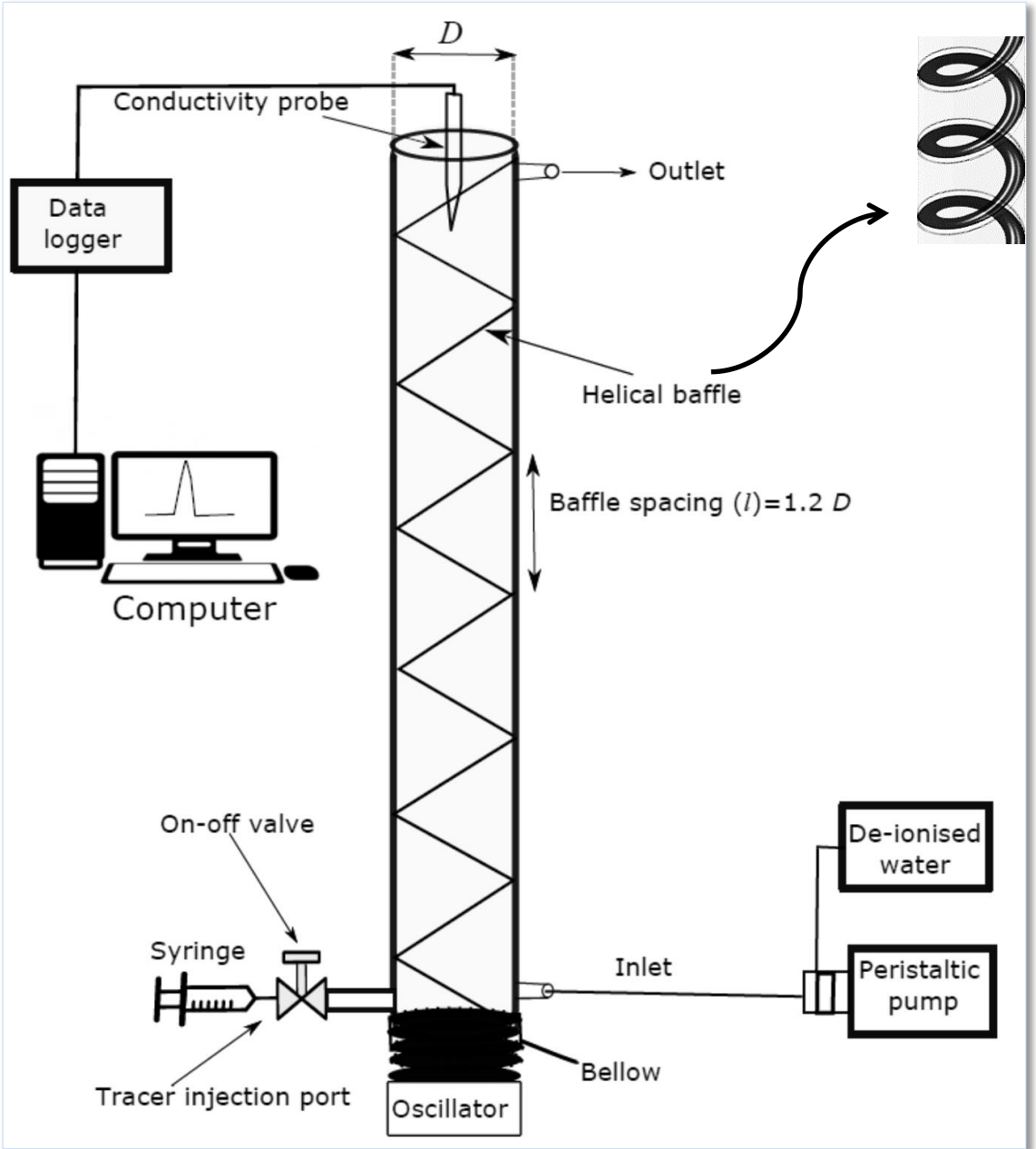


$$E(\theta) = \left[N(N\theta)^{N-1}/(N-1)!\right]e^{-N\theta}$$

Re_n=25-100
Re_o = 67.5– 945

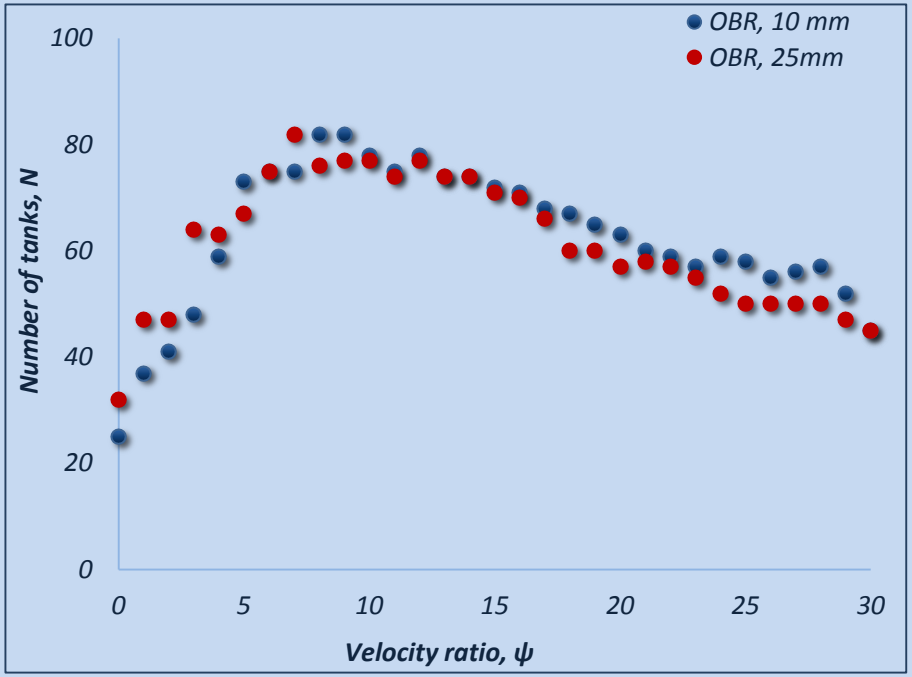
Re_n=100-250
Re_o = 168– 14820

Devices and Methods

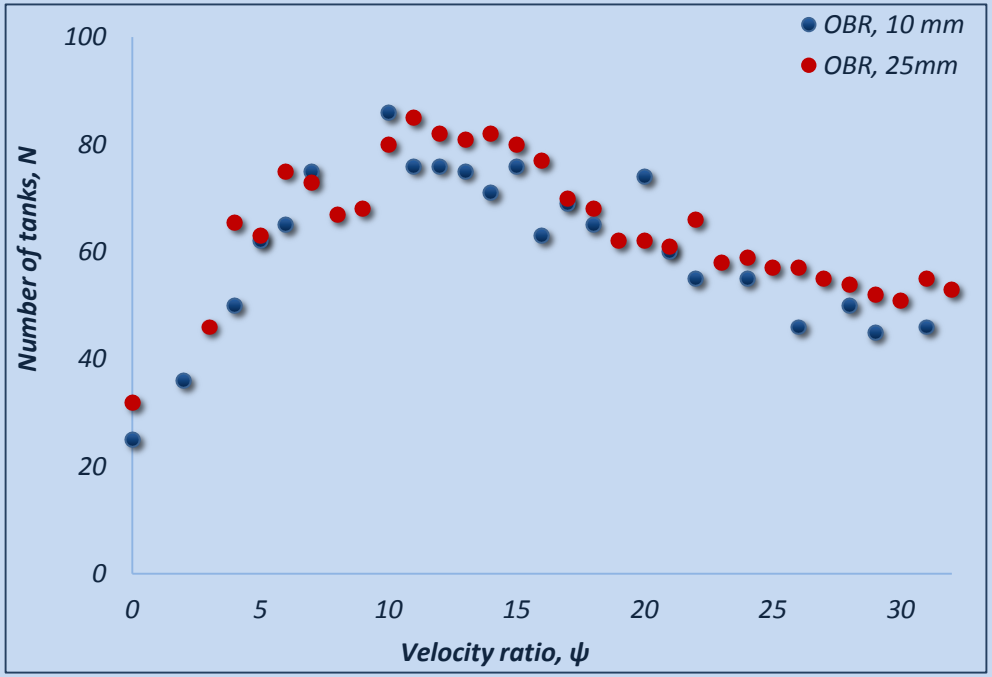


RTD comparison at both scales

Str =0.37



Str =0.17



Scale up correlation

$$\frac{N}{N_o} = 11.76\, Str^{-0.3}\, {Re_n}^{-0.6}\, \psi e^{-0.1\psi} + 1$$

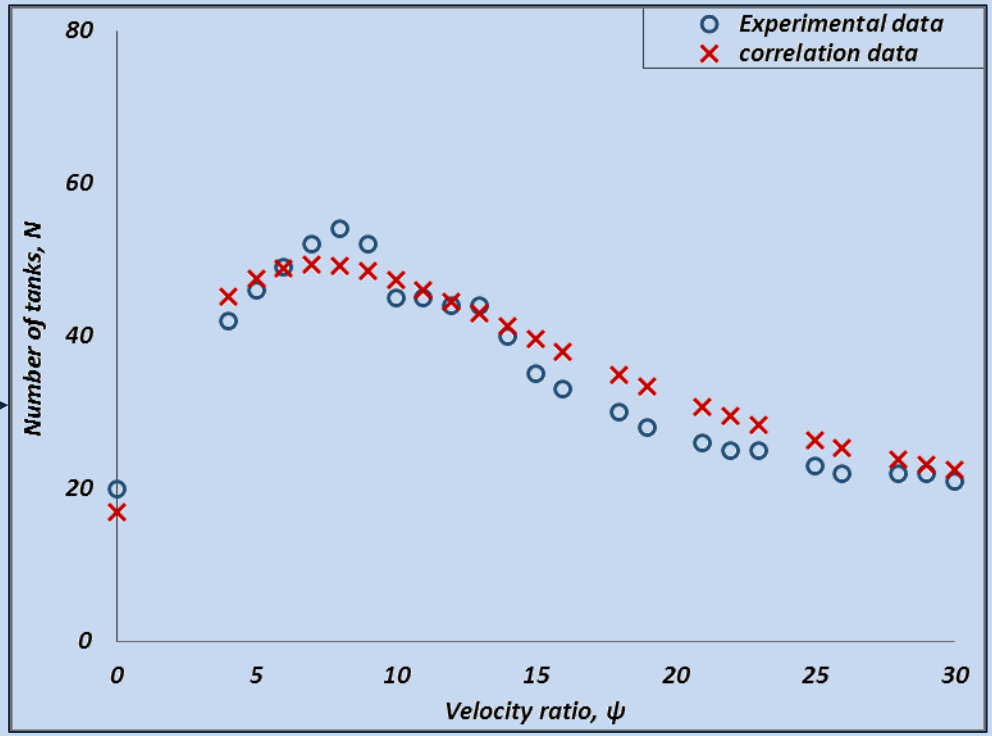
Similarity

l=1.2D
$S^2 = 70\%$
Str= 1
ψ=0-30

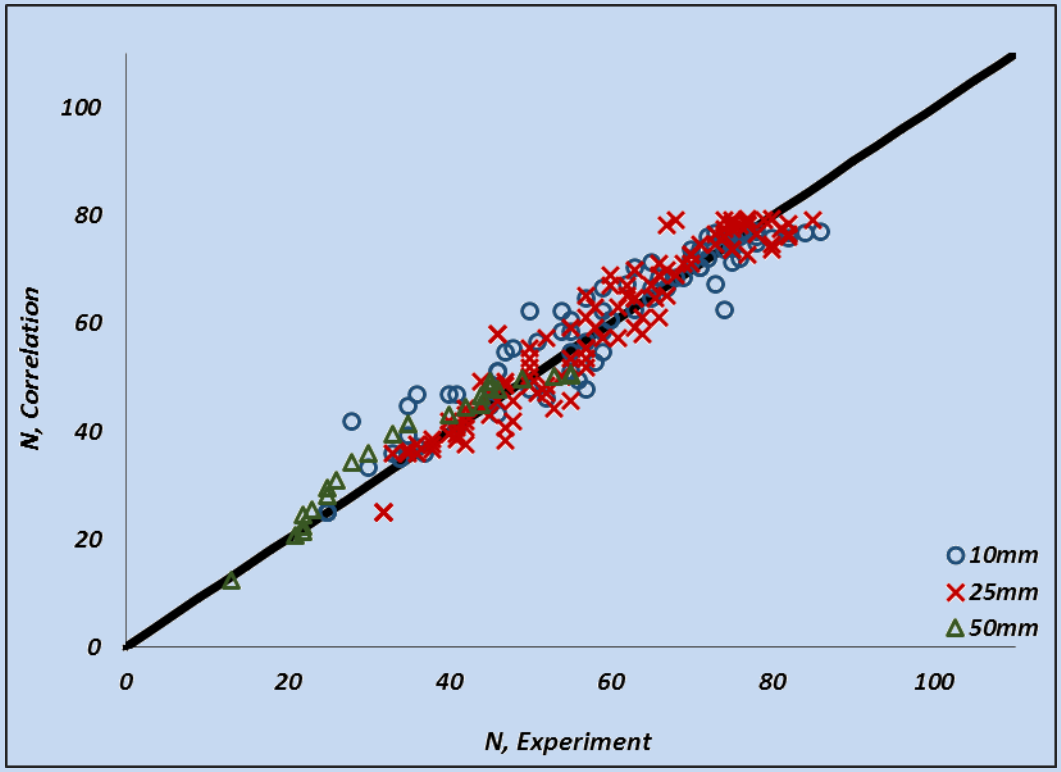
Predicted data by the correlation

Experimental data by OHBR 50mm i.d.

comparison



Scale-up validation



Conclusions

- The residence time distribution (RTD) of OHBRs were characterised over a wide range of net and oscillatory flows.
- The OHBRs were scaled up successfully based on RTD .
- A scale-up correlation of OHBRs was developed.
- The scale-up correlation was validated.

References

[1] Stonestreet, P. and Van Der Veeken, P.M.J. (1999) 'The Effects of Oscillatory Flow and Bulk Flow Components on Residence Time Distribution in Baffled Tube Reactors', Chemical Engineering Research and Design, 77(8), pp. 671-684.

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[4] Smith, K.B. and Mackley, M.R. (2006) 'An Experimental Investigation into the Scale-up of Oscillatory Flow Mixing in Baffled Tubes', Chemical Engineering Research and Design, 84(11), pp. 1001-1011.

[5] Zheng, M., Skelton, R.L. and Mackley, M.R. (2007) 'Biodiesel Reaction Screening Using Oscillatory Flow Meso Reactors', Process Safety and Environmental Protection, 85(5), pp. 365-371.

Thanks

Newcastle University