POSTER 6

CMAC FUTURE MANUFACTURING RESEARCH HUB

# In-line Process Reactor Test Bed & Sensor Development

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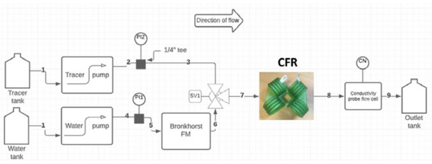
- Experimental tests are used for characterising reactor performance,
- Different geometrical features of the reactor (internal diameter, coil diameter, number of turns and layers) will have a different effect on the mixing
- Systematic study is required to establish relationship between geometrical properties and resulting residence time distribution
- By adapting online measurement we are able to experimentally measure and rank reactor performance

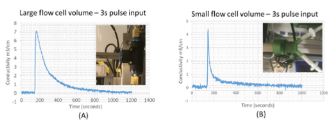
- Transitioning from batch to continuous process requires measurement techniques that are fast responding
- Importance of interface between reactor and measurement probes
- Minimising the connection tubing and dead zones for tracer accumulation
- Size of the reactors is limited by 3D printer's build platform
- Dimensional scaling approach proven to be suitable for reactor testing

## PID & sensor integration

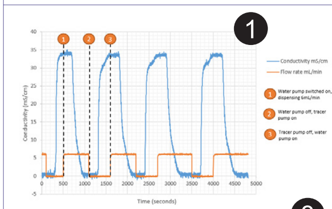


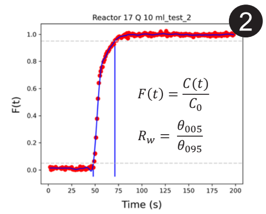

- MilliQ water and Tracer (NaCl) run in parallel fluid loops (1-6)
- Identical pumps, tubing and flow rates are used on both lines
- SV1 is solenoid valve that alternates water and tracer line
- Flow Rate measurement is only on the MilliQ water side

- Minimising flow-cell volume
- Angle of tracer feed to the probe
- Pulse response time improvement from (A) to (B)




## Testing methodology

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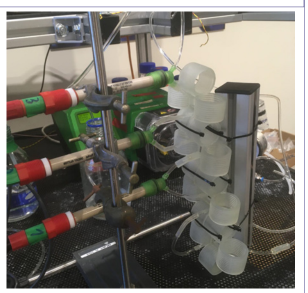
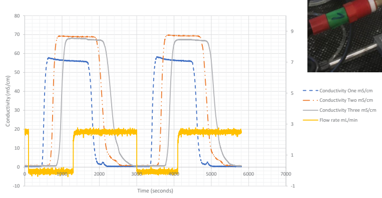
| Reactor 17 Q 10 ml_test_2 | Mean Residence Time (s) | Variance (s^2) | R min (s) | R max (s) | RTD (s) | Rw |
|---|---|---|---|---|---|---|
| Step 1 | 59.602 | 82.9613 | 51.165 | 71.4368 | 20.2718 | 0.7162 |
| Step 2 | 58.2736 | 169.2537 | 49.355 | 70.805 | 21.4499 | 0.6971 |
| Step 3 | 57.7846 | 255.9218 | 48.72 | 70.93 | 22.21 | 0.6869 |
| Step 4 | 58.4694 | 188.5502 | 49.9999 | 71.555 | 21.5551 | 0.6988 |
| Average | 58.2 | 205 | 49 | 71.1 | 21.7 | 0.69 |
| Stdv | 0.4 | 71 | 1 | 0.4 | 0.8 | 0.01 |

1. Step signal from MilliQ water to tracer. Actuation time marked by flowrate time (orange). Test repeated 4 times
2. Each step fitted with **continuous function.** Rw (0.00 – 1.00) presents speed of response where 1 is perfect step input.
3. Each step analysed with standard deviation and average of 3 readings used as reactor performance figure.

## Multilayer testing

- Multilayer testing is analogous to single-layer procedure
- 3 conductivity probes are installed after layer 2, 3 and 4
- In separate tests each of the 4 layers was tested as single unit as described in Testing Methodology.

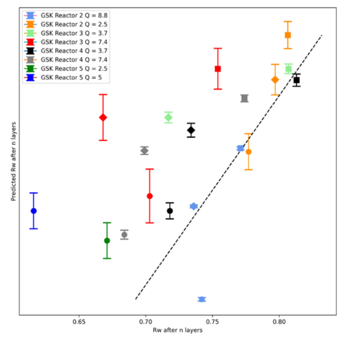





- Maximum conductivity value does not match between probes. Data is normalised because time of rise is of importance.

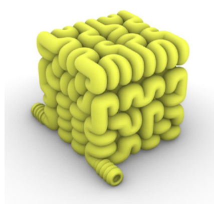
## Multilayer results

- Training the machi




- Over 50 experimental data points collected to feed into Machine Learning model
- Robust data processing system developed to handle sensitive recorded data
- Successful characterisation of single layer and multi layer reactors to obtain Rw
- Accuracy of measurement on small scale beneficial to the full size system

- Test additional multilayer designs
- Design probe holder integrated into 3D printed multi-layer reactor construct
- Minimise experimental variance
- Translate methodology to alternative reactor designs



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