DESIGN, MANUFACTURE AND TESTING OF ALTERNATIVE FLOW-THROUGH REDOX FLOW BATTERY CELL TOPOLOGIES

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ABSTRACT Fused deposition modelling 3D-printing has emerged as an effective way to rapidly produce bespoke test cells to evaluate various flow cell topologies. This has been coupled with electrochemical and computational fluid dynamics modelling to design cells which promote improved mass transfer and enhanced reactant distribution. Improved test procedures have also been developed to improve repeatability of results during replicate testing.

FLOW THROUGH CELL COMPONENTS

1) Endplates
2) Current collectors
3) Flow plates
4) Porous electrodes
5) Gaskets
6) Membrane

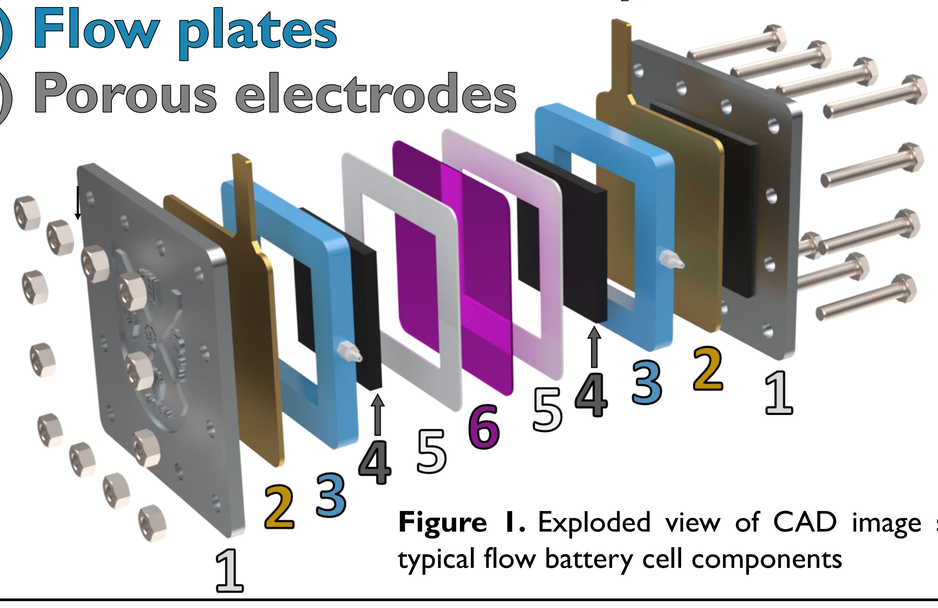

Figure 1. Exploded view of CAD image showing typical flow battery cell components

3D-PRINTED FLOW CELL DESIGN

Our group has developed a 3D-printing platform for flow cell design [1]. Fused deposition modelling is used to produce bespoke cells for electrochemical testing.

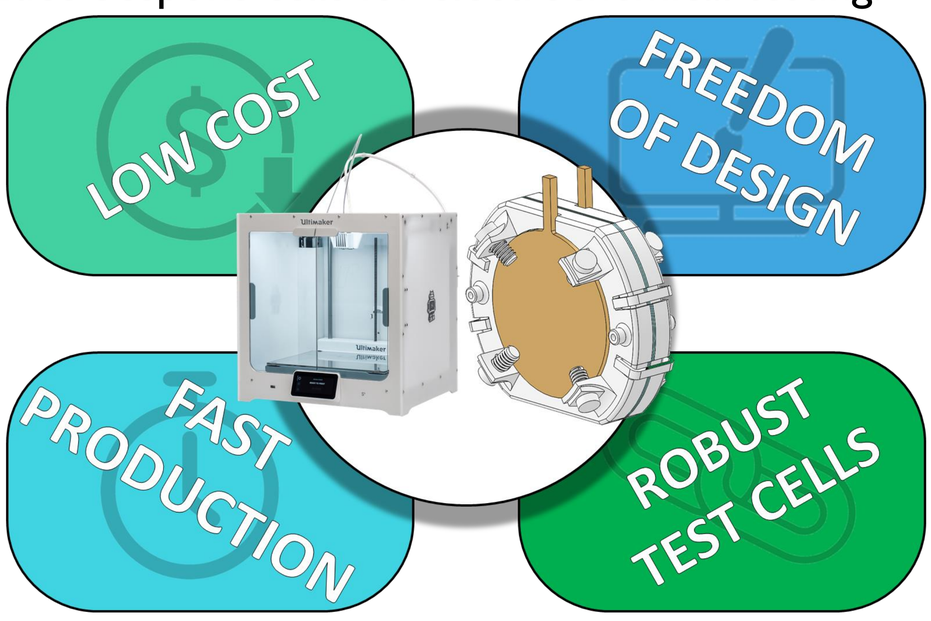

Figure 2. Advantages of 3D-printing platform vs commercial test cells

CFD/ ELECTROCHEMICAL MODELLING

To evaluate cell designs before 3D-printing and manufacture, a coupled computational fluid dynamics and electrochemical modelling approach is used [2,3].

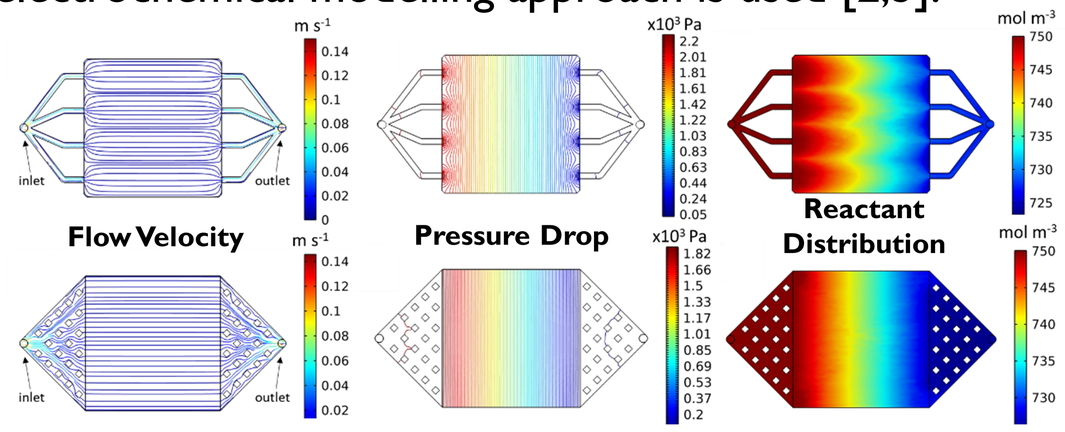

Figure 3. Electrochemical/ CFD modelling results showing comparisons between an unoptimised and optimised manifold design to improve cell performance.

TEST CELL GEOMETRY STUDY

The performance of cell geometries designed to enhance reactant distribution through the cell [4,5] has been tested using our 3D-printing platform. While preliminary results indicate improved performance in circular and radial designs, work is ongoing to refine testing protocols to ensure statistically significant performance gains. Modelling is also being used to compare the performance of various topologies at a range of operating conditions.

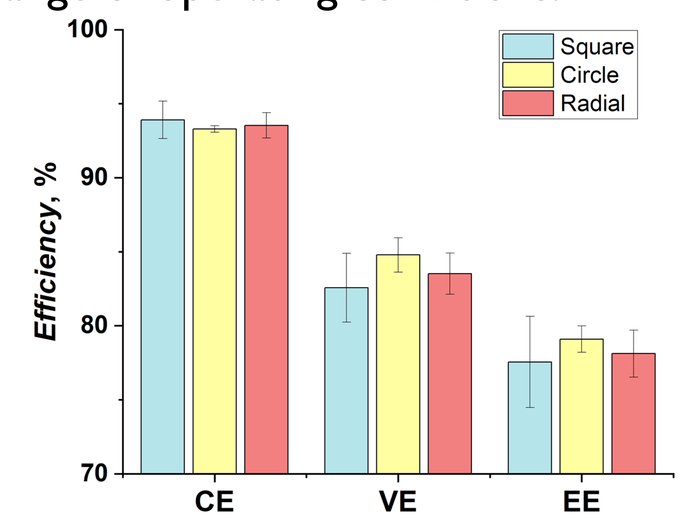

Figure 4. Bar chart showing columbic, energy and voltage efficiencies for three of the geometries tested

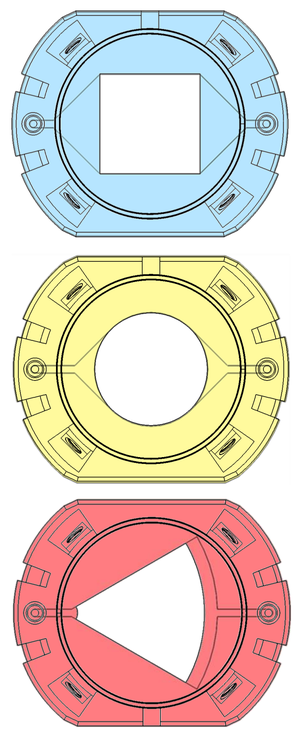

Figure 5. Schematics showing 16 cm^2 square, circle and radial geometries

TESTING PROCEDURE REFINEMENTS

To improve the repeatability of test results in replicate testing, a number of refinements to test procedures have been identified. Some key factors found include membrane handling, the use of fresh electrode material which is accurately matched to cavity size and precise pumping.

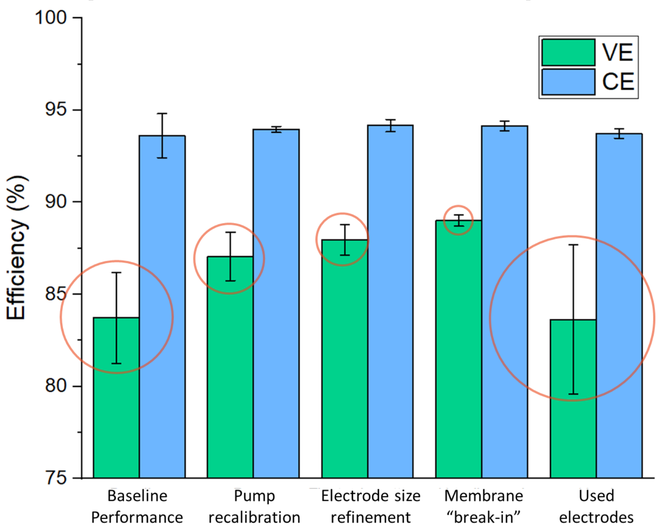

Figure 6. Bar chart showing improvements in the standard deviation between tests for voltage efficiencies

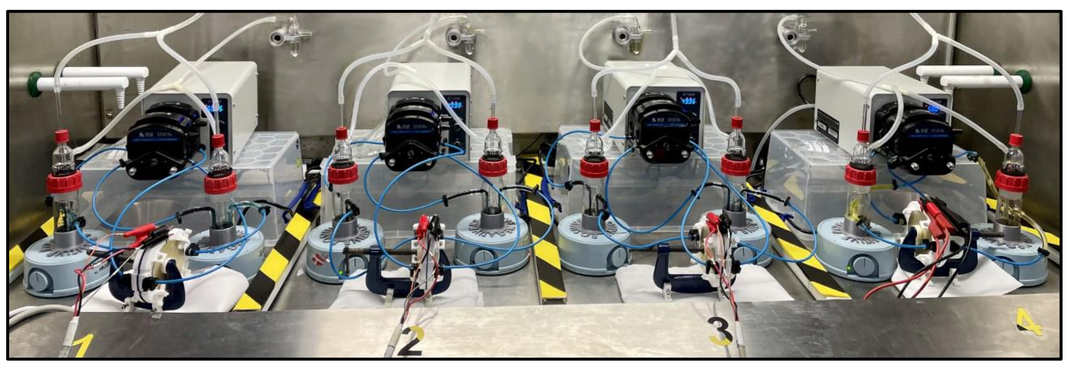

Figure 7. Photo showing multiple cells being tested simultaneously

REFERENCES

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