Project

MEGASTACK: Stack Design for a Megawatt Scale PEM Electrolyser

JU FCH project in the Seventh Framework Program
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D 4.3 Technical validation report; full size single cell characterisation at a selection of operating conditions (temperature, pressure)

Nature of the deliverable	: Report
Associated Work Package(s)	: WP4: Stack design and manufacturing strategy
Lead beneficiary	: 2 / ITM POWER
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Content

Abbrerivations

MEA	Membrane Electrode Assembly
FCH JU	Fuel Cells and Hydrogen Joint Undertaking

1. Introduction

The objective of work package WP4 is the development of a large scale stack design for a PEM electrolyser. Task 4.3 of WP4 covers full size single cell verification at a selection of operating conditions. This deliverable couldn't be completed until the end of the project as it needed the stack test stand and the results.

- **Chapter 2:** looks at sealing and active area design verification.
- **Chapter 3**: looks at pressure test verification. ITM verification process includes several types of pressure tests; cyclic, temperature, hydrostatic, creep.
- **Chapter 4**: Statement of efficiency and its progress expected beyond the project

Figure 1 - as build stack test stand

2. Sealing and active area contact verification

Inputs from design process (earlier project deliverables)

- Details of changes in cell plates frames
- Impact from production process
- Mapped thickness of the plates
- End plate design and fitting to revised design
- Sealing tests with small frames

ITM design verification process includes two steps. The first is ‘design verification’ (DV) which comprises a series of computerized analysis steps (reported via WP4 earlier deliverables). Then the second step is referred to as ‘prototype verification’ (PV).
Note the prototype stages are also declined into several stages (A, B, C & D). Early prototypes (‘A’ type) are usually smaller scale versions. In this report only a sample of prototypes of ‘D’ types -close to production stage - is reported. Prototypes ‘D’ use production ready tools and methods.

2.1 External Sealing area verification

Sealing area contact application and pressure retention are vital to the electrolyser functioning as a pressure vessel. With up to 600 contact interfaces in a stack, a deep understanding of rules of construction has been developed to succeed in sealing the design. These have been developed at ITM over a number of years and as part of the project MEGASTACK and have been successfully applied.

The external sealing area is compressed using a hydraulic cylinder (to apply pressure to the stack sealing parts) set at a pressure ranging from 250 to 300 bar.

The uniformity of contact in the sealing area is verified by confidential mean reported in a report as part of earlier WP4 deliverables.

2.2 Active area

Active area contact application is vital to the electrolyser functioning as a series of electrochemical cells. The uniformity of contact in the active area is verified by means reported in confidential report as part of earlier WP4 deliverables.

3. Pressure tests verification

Inputs from design process:
- Testing of sinters at Fraunhofer ISE (see deliverable D4.2, published 2017-06-30)
- Fit test of sinters within frames

The table below is an extract of the design verification plan showing a verification of MEGASTACK component assembled in a single cell under various conditions. The pressure test conducted challenge the component structural integrity, cyclic and fatigue and primary creep response under various conditions illustrated in Table 1.

Table 1 - Pressure test results

Test No.	Description		Date built	Hydraulic pressure	Initial static Pressure Test		Number of cycles	Duration
	Differential pressure	Water temp			Value	Pass/Fail		
1	22	Ambient		280	33	Pass	CONFIDENTIAL	CONFIDENTIAL
2	22	55-60	05/07/2017	280	33	Pass	CONFIDENTIAL	CONFIDENTIAL
3	33	Ambient			49.5	skipped		
4	33	55-60	17/07/2017	280	49.5	Pass (40bar)	CONFIDENTIAL	CONFIDENTIAL
5	22-25	55-60	01/08/2017	280	33	pass	Continuous	CONFIDENTIAL
5.1	22-25	55-60	09/08/2017	280	22	Pass	CONFIDENTIAL	CONFIDENTIAL
5.2	22	55-60	21/08/2017	280	22	Pass	CONFIDENTIAL	CONFIDENTIAL

The regime details and values attained are confidential. We can state that some of these tests are accelerated and simulated up to 15 years of pressure cycles before they were stopped.

4. Short cell test

4.1 Current voltage performance for single test cell

Figure 2 shows the electrochemical performance of a 5-cell stack containing the final MEA, with the most commercially viable cost reduction concepts at the time of the project tests. The stack was operated under close to commercial conditions, at differential pressure (hydrogen at 20 bar, oxygen at ambient pressure).

Whilst the electrochemical performance of this particular MEA is not best in class, it is able to demonstrate it is capable of operating under these varied operating conditions and that there are no issues of mass transport at high current densities.

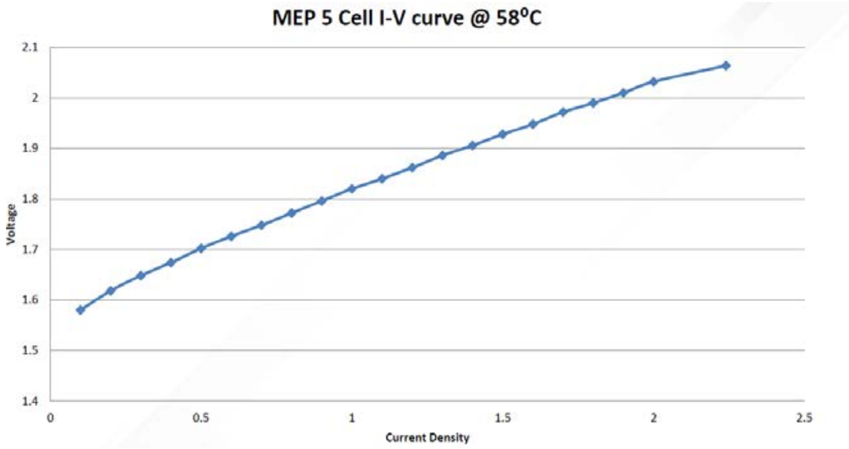

Figure 2 - Intial VI curve of the new MEP 5 Cell design at a temperature of 58 °C

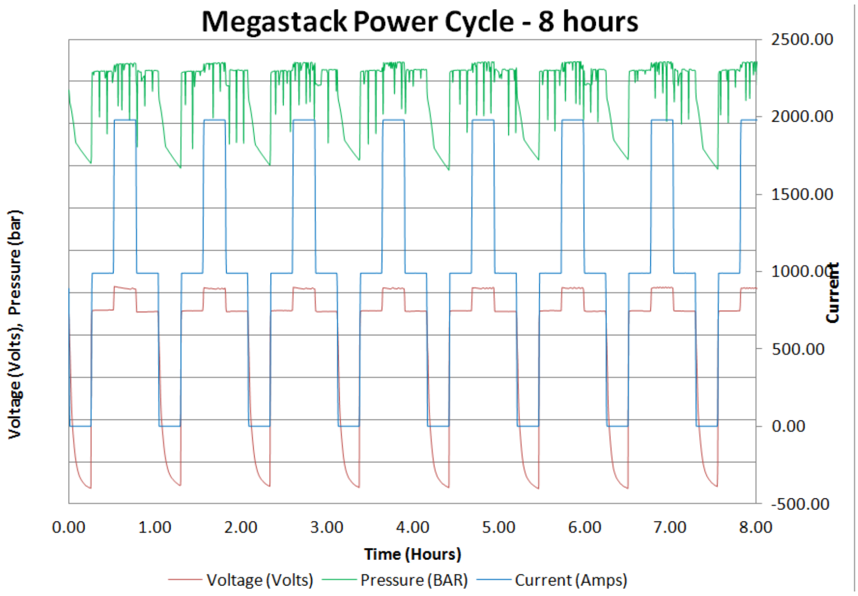

Figure 3 - Performance assessment realised under varied conditions

It is noteworthy to signal thinner MEAs have been successfully trialed as part of tests carried out in Table 1 (Chapter 3).
This permits the use of high efficiency MEAs in this system in the near future.

5. Summary and conclusions

This report describes the beginning of life of the very first cell components manufactured as part of MEGASTACK and the comprehensive set of verifications they are subjected to.

The design verification process includes defined practices ITM has been using and refining over 2 generations of stacks before this. ITM have honed this process with the MEGASTACK project (3rd generation) and trained new engineers in the process.

Starting with robust and defined parameters listed in deliverable D4.1, component characterization of D4.2, the design verification proceeded with most steps completed successfully at the first attempt.

The result of the design process have been

- Many sets of designs and engineering drawings
- Planning of verification
- recording and a sign off of verification results
- training of engineers and testers to the above

The downstream uses of the design process

- The completion of a bill of material and data input into MRP system
- Complete traceability and costing generated
- 3rd generation stack standard manufacturing procedure, later manufacturing routes
- Communication of outputs required from the supply chain with inevitable initial iterations.