THE UNIPD 9-kW/26-kWh IS-VRFB EXPERIMENT

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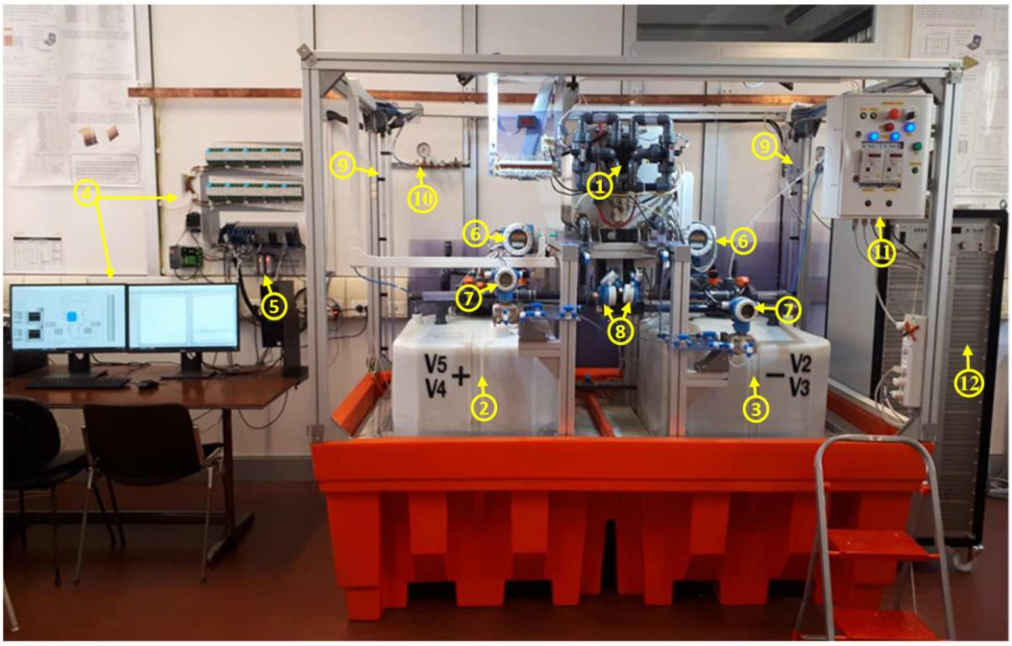

1- Stack
2- Positive electrolyte tank
3- Negative electrolyte tank
4- Labview-based acquisition and management system
5- External PLC
6- Flowmeter
7- Differential pressure transmitter
8- Thermo-resistance
9- Special differential pressure gauge
10- Nitrogen line
11- Electric power board
12- Stack power supply

Figure 1. IS-VRFB test facility and its main components

Redox flow batteries (RFBs) have a strong potential for future stationary storage, related to the expansion of renewable energy sources and smart grids. Their future success largely depend on the research on new materials for electrolytic solutions, membranes and electrodes, which is typically carried out on small single cells but very little research is reported in the literature on the development of large RFB systems, which is also of paramount importance for achieving optimized and more competitive system.

In order to develop of high-power RFBs, an Industrial-Scale Vanadium RFB (IS-VRFB) test facility has been designed, constructed and put into operation in the Electrochemical Energy Storage and Conversion Laboratory of the University of Padua (UNIPD). It is rated 9-kW/26-kWh and its architecture is directly transferable to industrial production, but is also fully instrumented for accurate measurement campaigns in laboratory-controlled conditions. The stack consists of 40 600-cm^2 cells, and the vanadium solutions are stored in two 550-L tanks. Their layout, conceived for high accessibility, is shown in Figure 1. The tanks are hermetically sealed and filled with inert gas to prevent vanadium species from oxidizing after air contact. Two feedback-controlled pumps driven by two inverters provide solution circulation and hydraulic ports are provided for the future installation of small stacks for testing new materials and cell architectures. Bidirectional power flow is provided by a static converter power management system (PMS) that is controlled both locally and remotely. The plant is fully instrumented with electrical, thermal and fluid-dynamic probes. The system supervisor has been built around a desktop computer with a Labview environment and a National Instruments (NI) compact data acquisition (Compact DAQ) interface. Operations are controlled and data are acquired and processed by the system supervisor. This device has been built around a desktop computer with a Labview environment and a National Instruments (NI) compact data acquisition (Compact DAQ) interface that allows fully customizable high-level SCADA-like (Supervisory Control And Data Acquisition) data management and experiment control. A multichannel electrochemical impedance spectroscopy (EIS) diagnostic is under implementation. The main parameters are reported in Table 1: “present records” refer to data achieved in the early experimental campaign (i.e. not the stack limits). Early polarization curves and power curve were acquired at different SOCs and at a top flow rate of 29.5 L/min (1.25 mL/min per square centimeter of electrode active area), in charge and discharge. Curves for SOC 10%, 50%, and 90% are shown in Figure 2.

Table 1: IS-VRFB test facility features

Performance	**Design**	**Present records**
Stored energy	26 kWh	26 kWh
Stack OCV at SOC=50%	55 V	55 V
Steady state current	72 A	380 A
peak power at SOC=90%	4000 W	8900 W
Current density	120 mA cm^{-2}	635 mA cm^{-2}

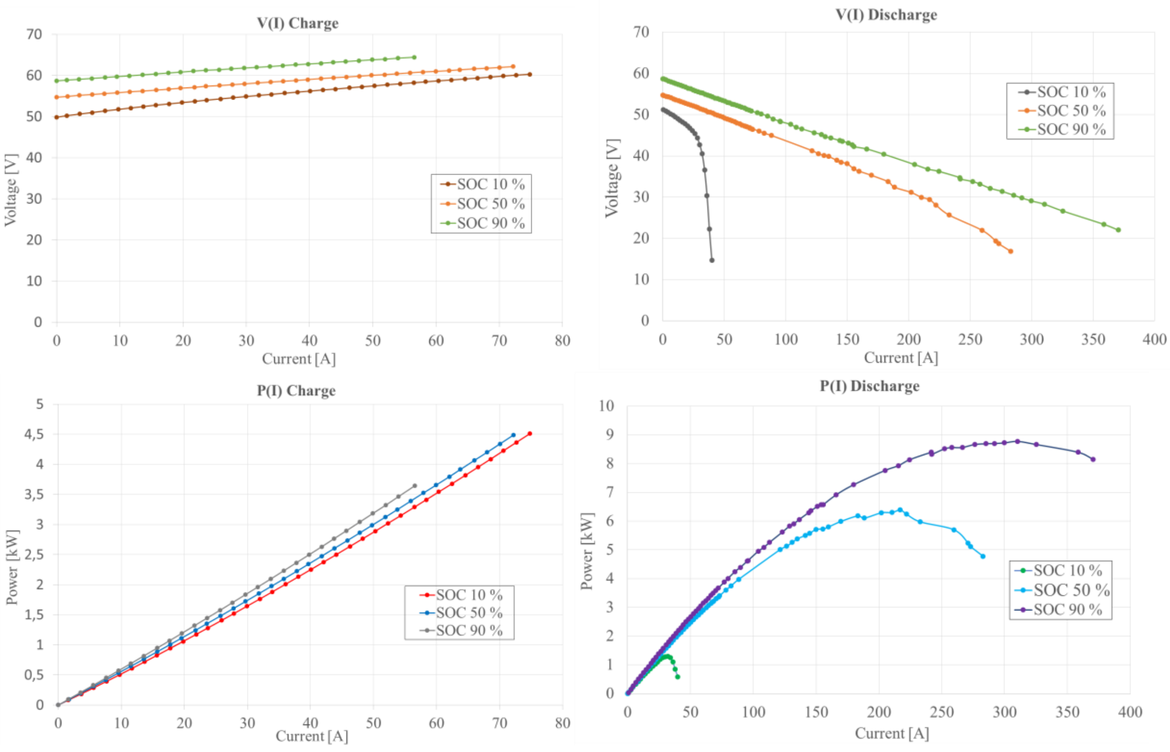

Figure 2: Polarization and power curves at SOC 10%, 50%, 90% and flow rate of 29.5 L/min in charge (up to 75 A) and discharge (up to 380 A PMS + passive load).

References

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[2] F. Moro, A. Trovò, S. Bortolin, D. Del Col, M. Guarnieri, “An alternative low-loss stack architecture for vanadium redox flow battery: comparative assessment”, *Journal of Power Sources*, 340 (2017): 229-241.

[3] M. Guarnieri, A. Trovò, A. D’Anzi, P. Alotto, “Developing vanadium redox flow technology on a 9-kW 26-kWh industrial scale test facility: design review and early experiments,” *Applied Energy*, under revision.