Diagnosis-aided control for SOFC power systems

DIAMOND

GA-No 621208

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HyGear Fuel Cell Systems
www.diamond-sofc-project.eu

PROJECT OVERVIEW

- Call topic: SP1-JTI-FCH.2013.3.3
- Application Area:
  Stationary Power and CHP Fuel Cell System Improvement Using Improved Balance of Plant Components/Sub-Systems and/or Advanced Control and Diagnostics Systems (e.g. Transportation & Refuelling Infrastructure)
- Project duration: 01/04/2014 - 31/03/2017 (36 months)
  50% project duration passed
- Total budget: €3,613,488.40;
  FCH JU contribution: €2,101,808.00

Institut "Jožef Stefan" Ljubljana, Slovenija

HYGEAR cea liten VTT HTceramix INEA

- The DIAMOND project aims at improving the performance of solid oxide fuel cells (SOFCs) for CHP applications by implementing innovative strategies for on-board diagnosis and control. Advanced monitoring models will be developed to integrate diagnosis and control functions with the objective of having meaningful information on the actual state-of-the-health of the entire system. The new concepts will be validated using two different SOFC systems.

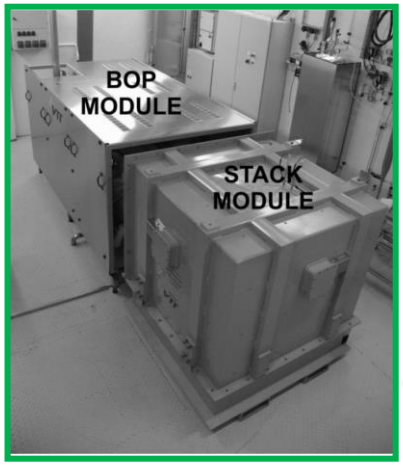
PROJECT TARGETS AND ACHIEVEMENTS

Programme objective/target	Project objective/target	Project achievements to-date	Expected final achievement
		MAIP	
Electric efficiency Durability	35%-45% 30,000 hrs.	50%, first reported for DIAMOND C system in 2013 No system test done yet	50% 10 years, >85,000 hrs.
		AIP	
Advanced controls and diagnostics	Capable of optimizing efficiencies	Diagnostic tools are being developed: • Soft sensors to determine max stack temperature and O/C ratio developed • Applicability of THDA explored from SRU to stack System model validated	Strategies to guarantee optimal operation

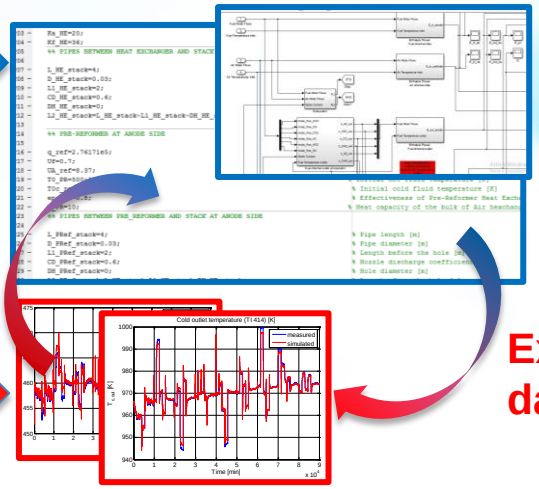
PROJECT TARGETS AND ACHIEVEMENTS

Programme objective/target	Project objective/target	Project achievements to-date	Expected final achievement
AIP			
Advanced controls and diagnostics	Capable of optimizing efficiencies	Low-level feedforward-feedback control loop designed A dynamic model of Diamond C developed and validated. FSM development procedure through FTA and model simulations has been defined.	Strategies to guarantee optimal operation

PROJECT TARGETS AND ACHIEVEMENTS



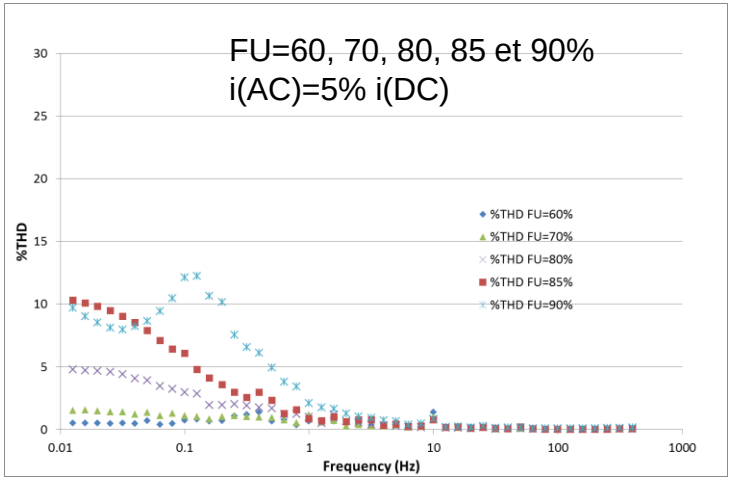
Fault diagnosis



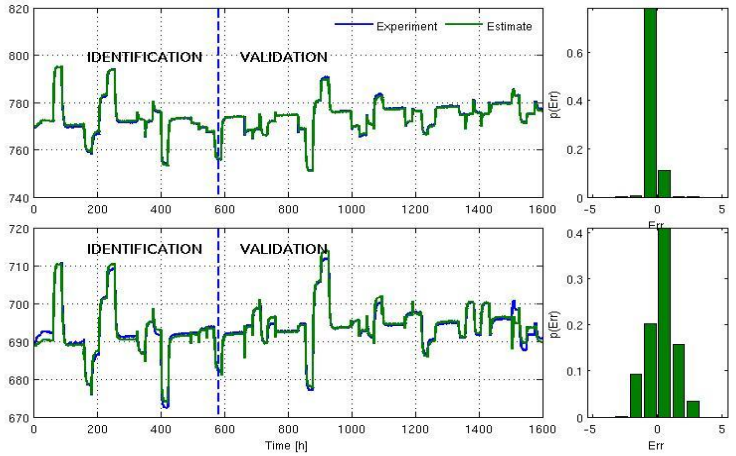
Monitoring model

Experimental data

Total Harmonic Distortion (THD) analysis



Soft sensor for max. & min. stack temp.



RISKS AND MITIGATION

Risks	Mitigation
Delay of operability of DIAMOND C system	Use existing DIAMOND C data for setting up the stack and BoP models
Delay in HoTbox delivery	Use data from Design project to set up models

SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

- DIAMOND is using knowledge and experience from previous projects like, Genius and Design

- A Joint workshop with FCH-JU project ENDURANCE was held on September 14 at the Università di Genova
- Project partner are also involved in similar projects like: D-CODE, HEALTH-CODE and FCGEN

HORIZONTAL ACTIVITIES

- Training activities
  - Internship of S. Nitto from Politecnico di Torino at HyGear
  - Internship of B. Dolenc (IJS) at UNISA (8m)

- Public awareness
  - A newsletter is released regularly
  - 2 lectures delivered by Prof. Pianese (UNISA) for the Slovenian Control Society and Slovenian Simulation Society

DISSEMINATION ACTIVITIES

- Workshops
  - A Joint workshop ENDURANCE/DIAMOND September 14, 2015, at the Università di Genova
  - Dissemination Workshop during the PIERO LUNGHI CONFERENCE EFC15 on December 16th
- Conferences
  - The Bruges Workshop Series for Fuel Cell Systems, June 2 and 3 2015
  - ECS Conference on Electrochemical Energy Conversion & Storage with SOFC-XIV (Glasgow, July 26-31, 2015);
    3 presentations given
  - 9th IFAC Symposium on Fault Detection, Supervision and Safety for Technical Processes **SAFEPROCESS'15** (Paris, September 2-4 2015); 1 poster
- Publications
  - B. Dolenc, D. Vrecko, D. Juricic, A. Pohjoranta, J. Kiviaho, C. Pianese. Soft Sensor Design for Estimation of SOFC Stack Temperatures and Oxygen-to-Carbon Ratio. Proceeding of the ECS Conference on Electrochemical Energy Conversion & Storage, July 26-31 2015, Glasgow, Scotland.
  - D. Vrecko, G. Dolanc, B. Dolenc, D. Vrancic, B. Pregelj, D. Marra, M. Sorrentino, C. Pianese, A. Pohjoranta, D. Juricic. Feedforward-feedback control of a SOFC power system: a simulation study. Proceeding of the ECS Conference on Electrochemical Energy Conversion & Storage, July 26-31 2015, Glasgow, Scotland.
  - D. Marra, M. Sorrentino, A. Pohjoranta, C. Pianese, J. Kiviaho, A Lumped Dynamic Modelling Approach for Model-based Control and Diagnosis of Solid Oxide Fuel Cell System with Anode Off-gas Recycling, ECS Transactions, 68 (1) 3095-3106 (2015)

EXPLOITATION PLAN/EXPECTED IMPACT

- The major advancement the project will bring is the improvement of the durability of SOFC systems

Expected project results (M36)	Exploitation modalities (partners, strategy)	Expected outcome: product, service, process… >5 years after project
Control algorithms for the regulation of SOFC system operation under faults	Highly potential result for the industrial partners and their system integration work	A part of the system controller, which enables the SOFC system to operate more reliably, more efficiently and longer than before
The sequence formed by the nominal system tests, the algorithm evaluation tests, the test planning and the test results	Certain important empirical experience is obtained on the systematic test procedures required for system control and diagnosis development	A systematic and efficient process for creating the empirical data required to design, implement and verify a new function in the system control software
Soft sensors that enable prediction and estimation of important system information (e.g. time till next maintains, estimation of gas compositions based on system operation information)	Bilateral contracts between inventor and integrator to adopt the sensors to commercial products and implement the sensors into the control software.	Increased maturity and reliability of the SOFC power systems and decreased maintenance costs.