Predictive control strategies for tankless gas water heaters: a hardware-in-the-loop approach

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encontro CIÊNCIA '21

ENCONTRO COM A CIÊNCIA E TECNOLOGIA EM PORTUGAL

28 a 30 JUNHO 2021

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2021PORTUGAL.EU

1. Scope

One of the most relevant drawbacks of tankless gas water heaters (TGWH) is the difficulty to maintain stability of the outlet hot water temperature as changes in water demand can be very fast and unpredictable.

Different configurations and advanced control strategies, such has adaptive and gain scheduling model predictive control (MPC), have the potential to improve transient response, reducing energy and water waste, and increasing user comfort.

A virtual test bench, based on hardware-in-the-loop-simulation methodologies, is proposed to support design control through all product development phases, even before prototypes are available.

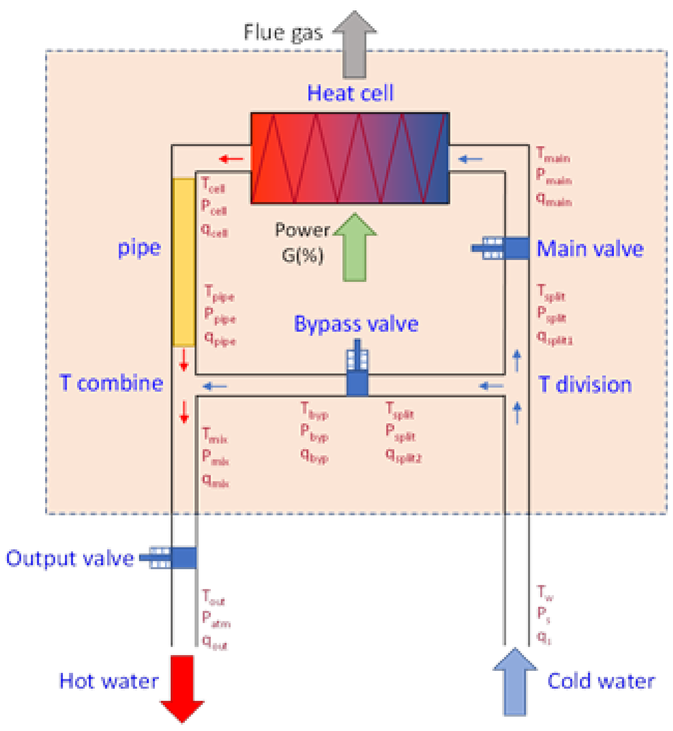
2. Modelling

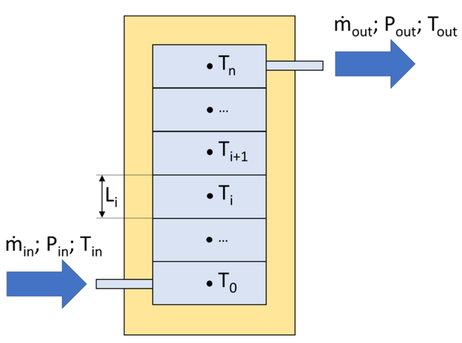
Models for individual components of TGWH.

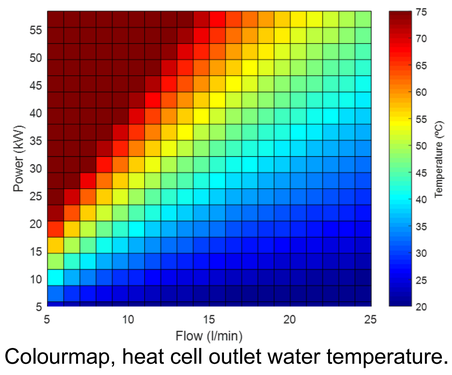
Lumped space approach, with thermal, fluidic and mechanical dynamics.

Semi-empirical model compatible with real time simulation.

Simulation for different configurations and scenarios.







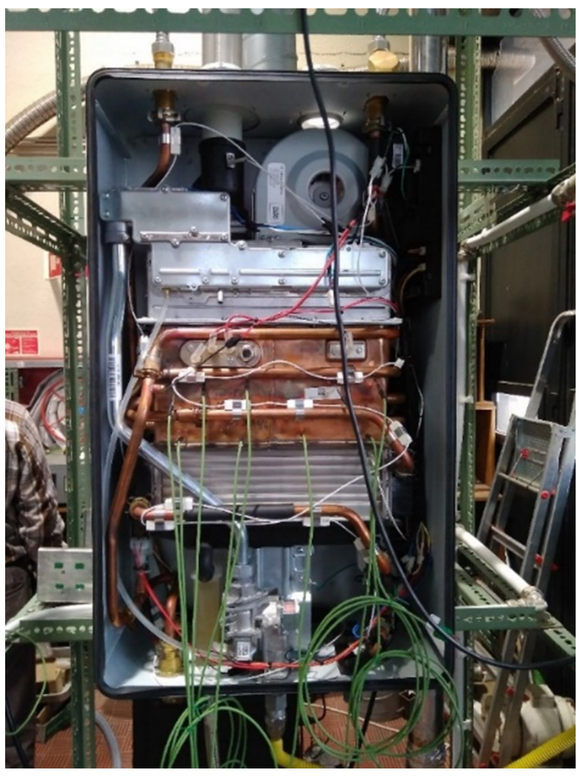
Colourmap, heat cell outlet water temperature.

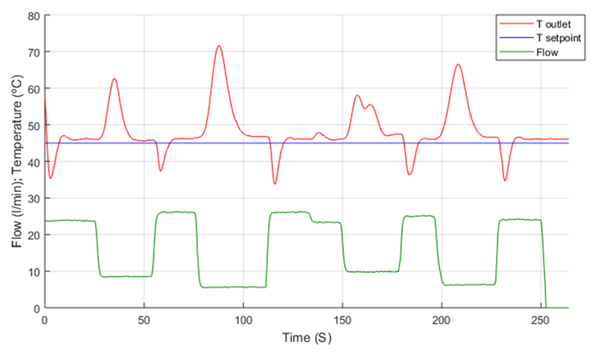
3. Experimental tests

Laboratorial tests performed for models calibration and validation.

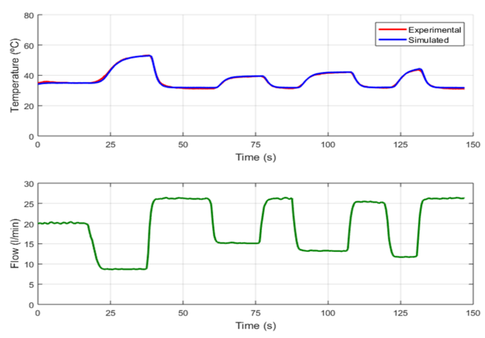
Tests in steady-state and transitory regimes.

Open loop (constant thermal power) and closed loop thermostatic control.





Closed loop, outlet water temperature values, bypass disabled.



Open loop, outlet water temperature values.

4. Virtual test bench

Innovative methodology proposed for the design of control strategies in all development phases, even before real components exists.

Prototype developed, implemented, tested and experimentally validated.

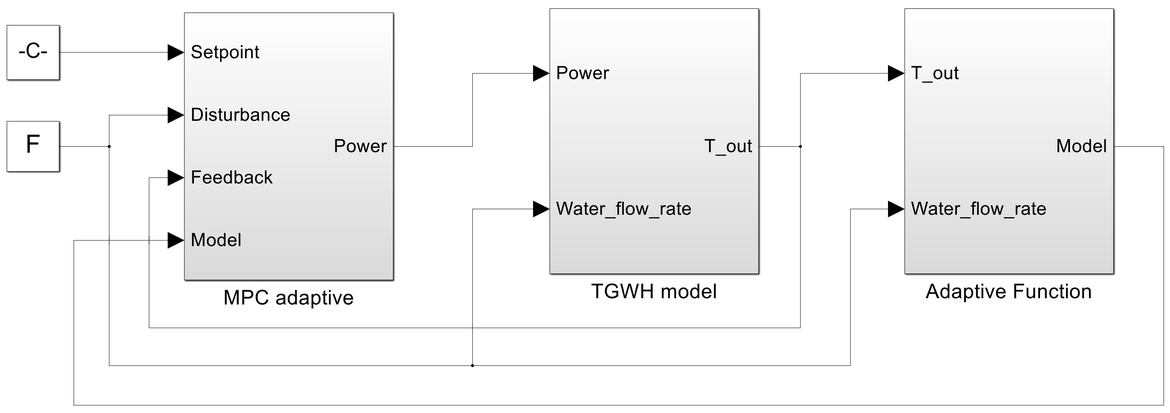
Hardware-in-the-loop applied for evaluation of embedded control performance.

5. Embedded predictive control

Model predictive control based on linearized TGWH models.

Adaptive and gain scheduling strategies implemented and assessed.

MPC embedded in microcontrollers with limited computational resources.



6. Conclusions and future work

Advanced control strategies can improve TGWH efficiency and user comfort.

Virtual test bench allow faster development of control algorithms.

Encouraging results with model based predictive control strategies.

Ongoing embedded MPC implementation presents challenges.

Acknowledgements

Fundação para a Ciência e Tecnologia, PhD studentship SFRH/BD/145713/2019

Smart Green Homes Project [POCI-01-0247 FEDER-007678]

TEMA projects UIDB/00481/2020 and UIDP/00481/2020, PORTUGAL 2020

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FCT Fundação para a Ciência e a Tecnologia

European Union European Social Fund