

MATHEMATICAL MODEL OF RESIDENTIAL STORAGE WATER-HEATING SYSTEM

ABOUT THE COMPANY AND BUSINESS CONTEXT

MClimate is an IoT company for intelligent climate control. Our aim is to develop devices that can retrofit to your old appliances and make them smart. But what does smart exactly mean? It all comes down to our philosophy. All of our products obey the same rules:

- know your preferences and habits / will know what's needed to make you comfortable
- know when are you going to come home
- analyze your heating & cooling systems in order to make them more energy-efficient.

INTRODUCTION

The low-cost commonly available water heater is inherently a lossy device and this means that a good percentage of the energy consumed heating water ends up being lost as heat to the surroundings. Informal measurements and practice show that if a family of four persons switches on and off the water heater just when required savings of up to 80% are recorded.

Our goal is to use model of the water heater to perform energy saving calculations and help the customer operate their water heaters in the most energy-efficient way.

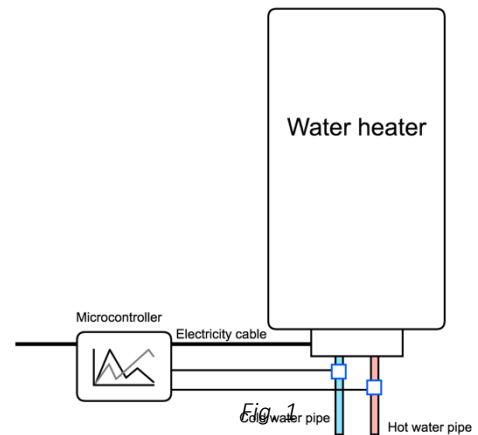
Modelling is nothing but converting physical information in to mathematical form. Mathematical model plays vital role for identification and analysis of the system. The model updates the simulated temperature of the mass of water periodically where the rate of change in temperature depends on the system inputs, outputs and losses

PROBLEM – MATHEMATICAL MODEL OF HOME WATER HEATING

SYSTEM

An electric water heater consists of: an inner steel tank, that holds the water being heated, insulation that surrounds the tank so as to decrease the amount of heat loss, pipe to allow cold water to enter the tank, pipe to allow hot water to leave the tank, thermostat that reads and controls the temperature of the water inside the tank, heating element that heats the water by means of electricity and other components for safety and maintenance.

Water temperature inside the heater is controlled by the mechanical thermostat. The temperature may usually be set by the user somewhere in between 40 and 70°C.



A microcontroller is used to gather realtime information from a water heater. The information is collected by different sensors (fig. 1) and consists of data about: current temperature of the cold water pipe, temperature of the hot water pipe, environment temperature (home temperature), electric current and voltage. Important notice – the temperature sensors of the cold and hot water pipes are installed ONTO the pipe itself. There is significant temperature loss depending on the pipe diameter, material and others.

The task is to create model of the dynamics of the water heater:

- The water heater model should simulate the temperature variations over time.
- For the model we can assume that the user has set the mechanical thermostat to 70°C.
- The model should take into account that the temperature in the tank is updated by:
 - Energy input from the heater;
 - Heat loss through the insulation;
 - Heat loss due to cold and hot water mixture when consuming hot water;
 - Unknown consumption of hot water throughout the day.
- The water heater model should be validated against measured data (fig. 2).
- Measured data and more information can be found at seemelissa.com/esgi2016

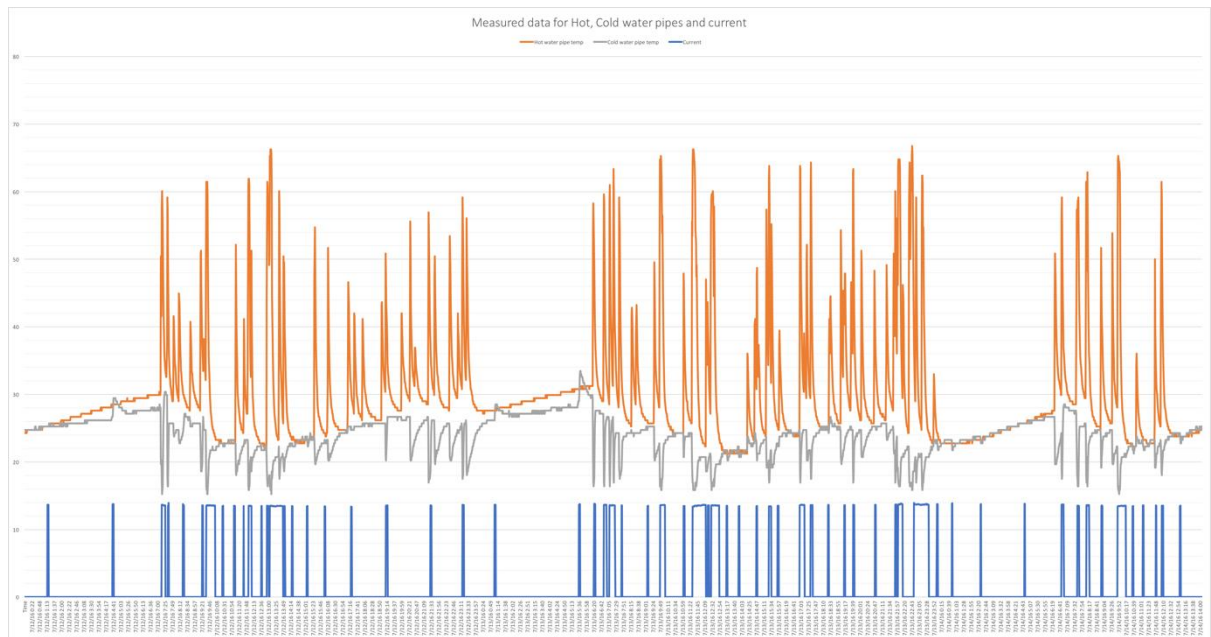


Fig. 2