418-22-extremera

# Device Modeling for GHE Experimental Test


***A.J. Extremera-Jiménez[1], C. Guitérrez-Montes[1], Pedro J. Casanova-Peláez[2], F. Cruz-Peragón[1]***

*International Conference on Renewable Energies and Power Quality.*

[1]Department of Mechanical and Mining Engineering
[2]Department of Electronic Engineering and Automatics
Higher Polytechnic School of Jaén (EPSJ), University of Jaén
Campus las Lagunillas s/n, A3, 23071 Jaén (Spain)
E-mail: ajextrem@ujaen.es; cgmontes@ujaen.es; casanova@ujaen.es; fcruz@ujaen.es

Universidad de Jaén

ingemer TEP-250

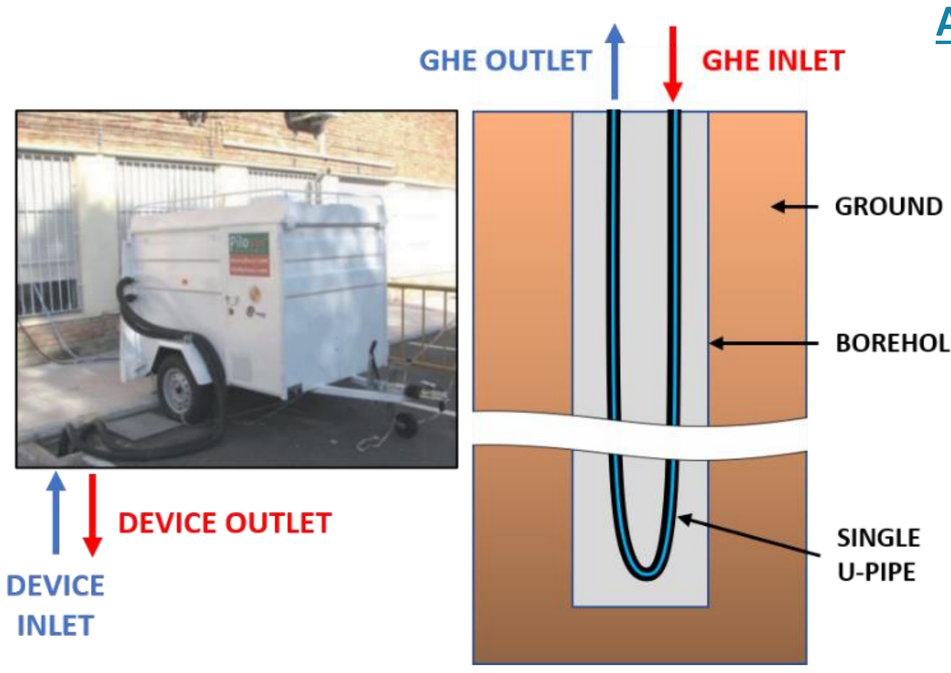

## 1. Introduction

Thermal Response Tests (TRT) are required for the evaluation of the thermophysical characteristics of the ground surrounding a Ground Heat Exchanger (GHE). The use of 3D models allow to obtain these characteristics more accurately. After parameters validation, it is crucial to be able to synthetically generate the fluid outlet temperature of the device so that the GHE can be evaluated in other conditions and even with a different geometry, what means there is no need of more experimental TRT tests.

The aim of this work is to simulate the TRT device performance. For this purpose, it has been analysed the influence of both the behaviour of the TRT device and its materials in contact with the water on the fluid outlet temperature of the equipment. Thus, it has been developed an equation which considers the heat exchange inside the device to the water as well as to its internal elements at the beginning of the tests.

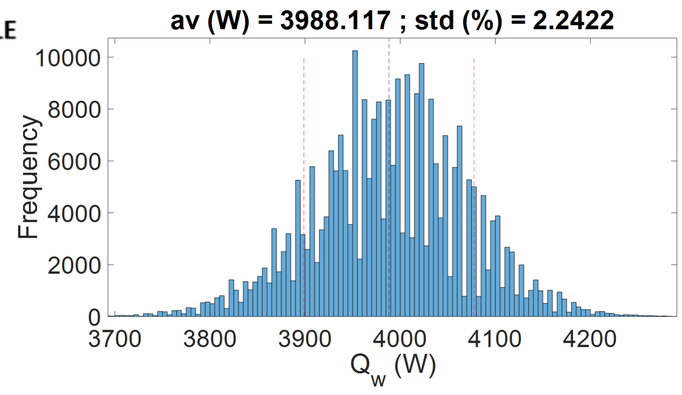
## 2. Materials and Methods

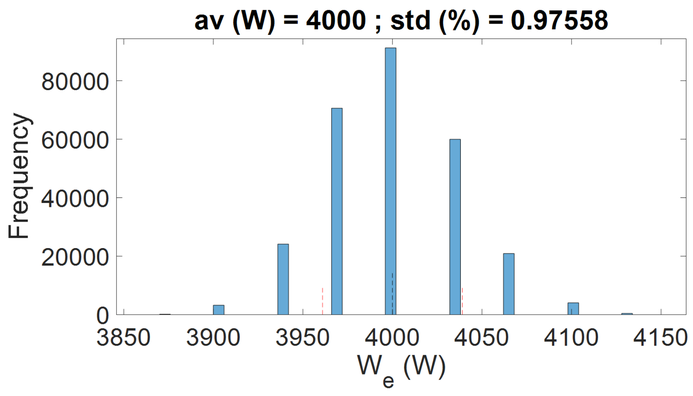
### A) Experimental facility




The heat flow is provided to the fluid by an electrical resistance and is assessed through sensors installed at the inlet and outlet of the equipment.

During the test, the control system modifies the electrical power, $\dot{W}_e(t)$, in order to supply a steady heat rate, $\dot{Q}_w(t)$, with high fluctuations in the firt time steps.




### B) Model of TRT equipment

The outlet temperature of the device (GHE inlet) can be determined through a model if the fluid temperature is known at the device inlet (GHE outlet). This model is based on the application of the First Law of Thermodynamics:

$$\dot{W}_e - \dot{Q}_w = \frac{dU}{dt} = C_{eq} \cdot \frac{dT_d}{dt}$$

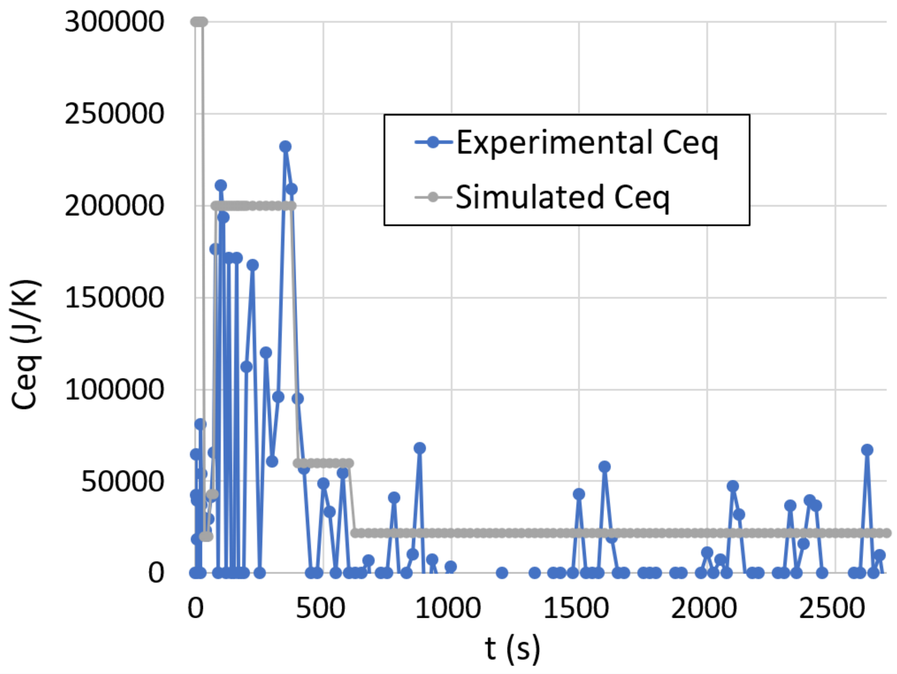
After substituting the terms of the equation and discretising time, the outlet temperature at the later time step of the machine, $T_{o,j}$, can be determined:

$$T_{o,j} \approx \frac{\dot{Q}_{w0} \cdot 0{,}5 \cdot (F_{q,j} + F_{q,j-1}) \cdot \Delta t + 0{,}5 \cdot \dot{m} \cdot c_p \cdot (T_{i,j} + T_{i,j-1}) \cdot \Delta t + T_{o,j-1} \cdot (C_{eq} - 0{,}5 \cdot \dot{m} \cdot c_p \cdot \Delta t)}{C_{eq} + 0{,}5 \cdot \dot{m} \cdot c_p \cdot \Delta t}$$

Where $C_{eq}(J/K)$ is the equivalent heat capacity of the set and $F_q$ is the relation between $\dot{W}_e(t)$ and the desired steady heat flow, $\dot{Q}_{w0}$.

## 3. Results

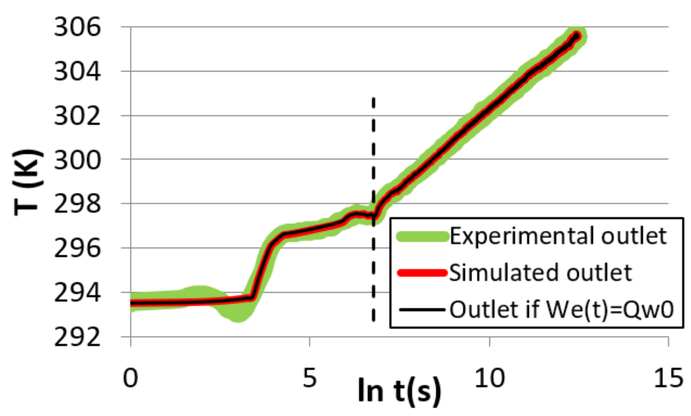
The variable $C_{eq}$ is analysed as a time-varying term. This function should follow the trend obtained directly from experimental data.

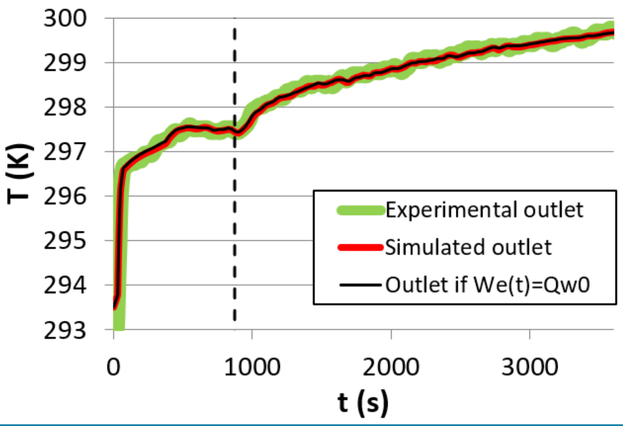



From this curve, $C_{eq}$ can be defined as a function composed of $n$ step values within a temporal sequential superposition, where each of those $C_{eq,i}$ originates from a different step '$i$', in the form:

$$C_{eq}(t) = \sum_{i=1}^{n} \left( C_{eq_i} - C_{eq_{i-1}} \right)$$

Now, the defined $C_{eq}(t)$ can be introduced in the model to determine $T_{o,j}$. For a particular test, an accurate simulation of the $T_{o,j}$ was achieved:




## 4. Conclusions

i. Synthetic data can be generated and the performance of the GHE modeled in other untested conditions, without significantly increasing the computational cost due to the model simplicity.

ii. There is no error induced due to device materials heating, removing the need to model the process control.

iii. It is demonstrated that other simple submodules can be integrated into a 3D GHE model.


## Acknowledgement

Authors are thankful for to the projects executed by the University of Jaén, with codes 2406 and 2439, and for the financial support.