PhD Position on Mathematical Modeling of Rock Bed based Thermal Energy Storage

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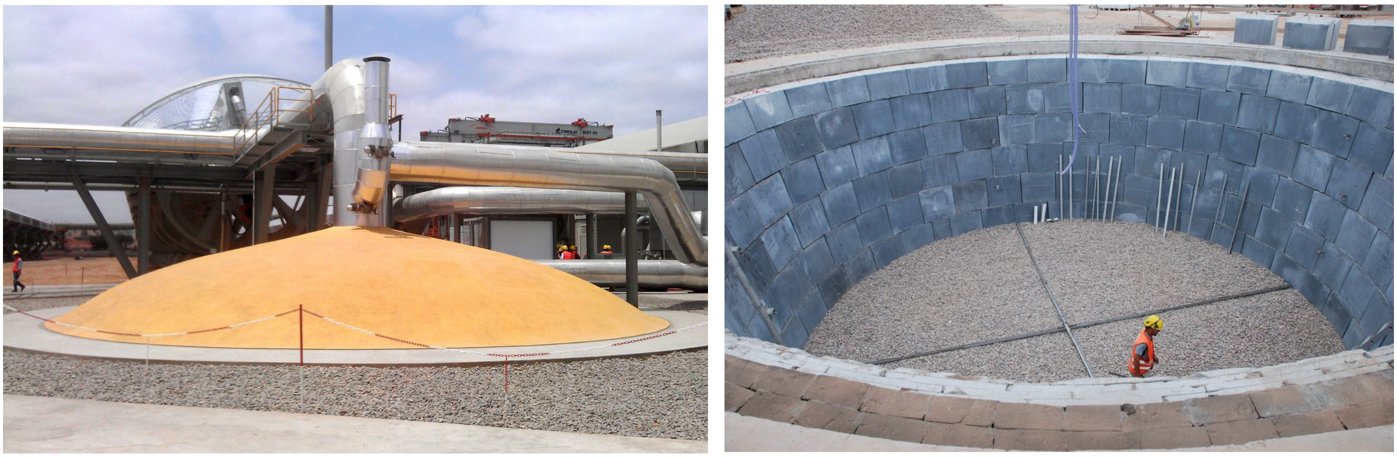
BACKGROUND AND MOTIVATION

The transition to a 100% carbon-free energy supply represents a fundamental goal for the actual efforts to mitigate the ongoing climate change triggered by mankind's wrong-doing. In order to achieve that transition, the storage of large amounts of energy is required in order to cope with the intermittent character of renewable energy sources like the Sun, wind, tides, etc. Many different energy storage solutions are in development nowadays, depending on the amount of energy to store (MWh, GWh, etc), on the kind of energy to store (electrical, thermal, etc), and on the desired storage time (minutes, hours, days, etc).

One such solution is the storage of large amounts of thermal energy in rock beds. These systems consist in large reservoirs filled with volcanic rocks, and through which a hot air stream (100-700ºC) is blown that ceases its heat to the rock bed, emerging then from the reservoir at a significantly lower temperature. If the stored heat is to be recovered, the air is blown in the reversed direction. These rock bed based thermal energy storage systems can be used in concentrated solar power (CSP) plants, adiabatic compressed air energy storage (ACAES) plants, waste heat recovery systems, district heating, etc.



Rock bed based thermal energy storage in Ait Baha, Morocco, operating in a concentrated solar power plant

The **Department of Fluid Mechanics and Aerospace Propulsion** is working since 2011 in the theoretical modeling of geothermal heat exchangers, successfully using for it the methods of scale analysis and asymptotic expansion techniques borrowed from the research fields of fluid mechanics and aerospace engineering [1,2,3,4,5,6,7,8]. Now, the Department is interested in extending the employed research methodology to rock bed based thermal energy storage systems, which represent a challenging problem with a high breakthrough potential for the renewable energy industry. The here proposed collaboration represents, therefore, a outstanding opportunity to contribute from academia to an industry relevant problem.

DESCRIPTION OF THE OFFERED PHD POSITION

The person to hire will work on the theoretical modeling of rock bed based thermal energy storage systems and its application to real world installations. The work to perform is mainly theoretical, although numerical simulations will have to be performed using commercial software packages, in-house developed codes, and own-developed programs. Comparisons with a possible pilot plant to be constructed in Bolivia exists.

The person to hire will start his/her work before March 2019.

Requirements: The candidate applying to the offered position must hold, or be close to holding, an MSc degree in Engineering, preferably Mechanical or Aerospace, and must have a solid background in Heat Transfer, Fluid Mechanics, and Applied Mathematics.

Duration: Doctoral studies at UPM extend over a 4-year period during which the PhD student receives a salary as an employee of the Department. Doctoral students are expected to engage in full-time study and research, and to participate actively in the Departments' activities.

Location: The candidate will perform his/her work at the following address:

Department of Fluid Mechanics and Aerospace Propulsion
Escuela Técnica Superior de Ingeniería Aeronáutica y del Espacio
Universidad Politécnica de Madrid
Plaza Cardenal Cisneros 3
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REFERENCES

[1] M. Hermanns and J. M. Pérez, *Asymptotic analysis of vertical geothermal boreholes in the limit of slowly varying heat injection rates*, SIAM Journal on Applied Mathematics 74 (2014), pp. 60–82.

[2] S. Ibáñez and M. Hermanns, *On the steady-state thermal response of slender geothermal boreholes*, SIAM Journal on Applied Mathematics 78 (2018), pp. 1658-1681.

[3] M. Hermanns and S. Ibáñez, *Thermal response of slender geothermal boreholes to sub-annual harmonic excitations*, Submitted to SIAM Journal on Applied Mathematics, (2017).

[4] M. Hermanns and S. Ibáñez, *On the ill-posedness of the g-function model for the thermal response of geothermal heat exchangers*, Submitted to International Journal of Thermal Sciences (2018).

[5] M. Hermanns, *An order 10^2 speedup in the computation of the steady-state thermal response of geothermal heat exchangers*, in 14th International Conference of Computational Methods in Sciences and Engineering, Thessaloniki (Greece), 2018.

[6] M. Hermanns and S. Ibáñez, *Harmonic thermal response of thermally-interacting geothermal boreholes*, Submitted to SIAM Journal on Applied Mathematics (2018).

[7] M. Hermanns and S. Ibáñez, *Application of matched asymptotic expansion techniques to the analysis of geothermal heat exchangers*, in 2nd IGSHPA Research Conference, Stockholm (Sweden), 2018.

[8] M. Hermanns and S. Ibáñez, *Unsteady thermal response of slender geothermal boreholes*, In preparation for SIAM Journal on Applied Mathematics.