ACCUSOL – Newsletter 6

"Elaboration of the novel cooling/heating system of buildings with the application of photovoltaic cells, solar collectors and heat accumulators"

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About ACCUSOL - aim and objectives

Title: Elaboration of the novel cooling/heating system of buildings with the application of photovoltaic cells, solar collectors and heat accumulators

Acronym: ACCUSOL

Duration: 02.2017-01.2020

Aim: Improvement of scientific cooperation between Partners from EU (WRUT Poland, UPCT Spain) and CELAC countries (PUCMM Dominican Republic, UA Chile) by building of the international consortium in order to increase the level of scientific research in the area of heat transfer and thermal energy storage (TES) with the use of solar collectors as the sources of energy and novel heat accumulators designed in this project and photovoltaic cells for the supplying of the air condition system.

This Project's main objectives are as follows:

- Development of an innovative hybrid heat accumulator comprising cascade of phase change materials (PCM), zeolite and metallic foams characterized by a high heat capacity and low heat losses during long term (eg. seasonal) accumulation of heat supplied from the solar collectors.
- Investigations of the heat transfer parameters, the charging and discharging characteristics of the system containing PCM, simultaneously the elaboration of the numerical modelling of the dynamics of charging and discharging of the heat accumulation system in order to identify the physical mechanisms of the heat transfer.
- Selection of the encapsulated PCM to be used as a heat storage media for building's solar heating applications.
- Development and test of photovoltaic air conditioning systems (PV-ACS) solution, including design, sizing methodologies, with included small zeolite based accumulator in the system for cooling purposes, analyzing of the different configurations of the cooling system in order to determine the technical and economic feasibility and developing of the energy management strategies.
- Economic evaluation of the solar and PVACS - cooling application and its comparison with other cooling alternatives.

About ACCUSOL - expected results and summary

Expected results: The expected results can be considered in the technical, economical and the sociological aspects. Technical aspects are connected with the improvement of efficiency of existing TES systems, mainly by elaboration and design of the novel heat accumulator, calculation of the encapsulated PCM for heating of buildings and investigations and on the efficiency of air condition systems supplied from PV cells. The lowering of the heating and cooling costs through the introduction of proposed solutions can effect on the better economy of exploitation of such systems. The possibility of generation of heat and coolness from the solar systems will effect on the better understanding of the environment pollution problems by the society and maybe will cause the another behaviour of the people in the range of the "ecological awareness", especially in the developing countries. The results and experience could be transferred by Consortium Members to Building companies, Ministry of Public Buildings, Energy Companies and in general to solar and/or Thermal Energy Industry in particular. Another way of exploring of the results of this proposal is a spinoff generation. This spin off development will commercialize the project result either by transferring of technology or by creating the marketable products.

Summary of the project: In this project the improvement of the efficiency of heat storage obtained from the solar cells for the domestic applications (heating, usable warm water) is proposed. Cooperation of WRUT (Poland) and UPCT (Spain). This goal will be achieved by the application of the three different heat containers: shell and tube container with bare tubes, shell and tube container with finned tubes and shell and tuber container with metallic foams containing chosen phase change material (PCM). On the other hand the improvement of the efficiency of cooling by the additional electric power supply of the air condition system from the photovoltaic system (PV) and the additional zeolite based accumulator included in the cooling system. PUCCM (Dominican Republic) and WRUT will be performed. Modeling of the efficiency of the heat storage by the encapsulated elements for the heating of buildings containing PCM will be realized by UAI (Chile), WRUT and UPCT. The calculation of the efficiency and the technical economic evaluation of the applied solar heating with the heat storage systems and the encapsulated elements containing PCM will be performed.

Consortium

Wrocław University of Science and Technology

Universidad Politécnica de Cartagena

UNIVERSIDAD ADOLFO IBÁÑEZ

PUCMM
Pontificia Universidad Católica Madre y Maestra

Funding

- Poland:

- Spain:

- Chile:

- Dominican Republic:

Quarterly report 1 - major achievements

WRUT

1) Testing of the KNO_3 based accumulator with Zn-Al foam
2) Organization of the Kick-off meeting

UPCT

1) Description of the flat-plate solar collector rig Solar
2) Defining of the operating conditions of the solar thermal collector

UA

1) Criteria definition for EPCM components selection
2) Theoretical Selection of a pool EPCM candidates
3) Thermodynamic model of the ensemble "solar collector – PCM container"
4) Gathering of thermophysical data for selected PCMs

PUCMM

1) Desing of the test cells
2) Thermal simulation of test cells enclosurethe model with experimental data is still pending.

Quarterly report 2 - major achievements

WRUT

1) Testing of the heat accumulator based on the paraffin with the additional Al-Si pin fin structure enhancing the heat storage
2) Development and adjusting of 3D printing technology for the models preparation
3) Developing of guidelines and design for the novel heat accumulator

UPCT

1) Definition of the different PCM materials to be employed in the facility
2) Development of a heat transfer model of the phase change in the PCM, and implementation into an overall thermodynamic model
3) Conceptual design of the hydraulic rig
4) Definition and numerical model of the PCM and the PCM container

UAM

1) Single EPCM configuration and review of main thermal properties
2) PCM preselection according to different criteria and building conditions
3) SHELL materials preselection according to different criteria and building conditions and validation through numerical simulation4) Gathering of thermophysical data for selected PCMs
4) Thermal modelling of EPCM: geometry characterization, model of heat transfer process of an EPCM's

PUCMM

1) Design of the PV system
2) Sizing of the air conditioner system
3) Building the test cells and the test façade
4) Selecting the sensors and transductors and determining of the data acquisition system requirements

Quarterly report 3 - major achievements

WRUT

1) Testing of the heat accumulator based on the paraffin with the additional Al-Si honeycomb and perforated honeycomb structures structure enhancing the heat storage
2) Elaboration of the design for the novel heat accumulator

UPCT

1) Implementation of a heat transfer model of the phase change in the PCM, into an overall thermodynamic model
2) Selection of commercial solar collectors
3) Definition of the required volume of PCM at the UPCT solar test facility
4) Designing of the PCM Containers
5) Dimensioning of hydraulic components
6) Numerical modelling of the heat transfer between a heat carrier fluid and the PCM (geometries under study: three tubes, three finned tubes, seven tubes, seven finned tubes; effect of using different PCMs)
7) Numerical simulation strategies of modelling the melting and solidification process of Phase Change Materials (PCM), embedded in a metal foam matrix as a heat transfer enhancement element technique for Latent Heat Thermal Energy Storage (LHTES)

UAJ

1) Thermo-mechanical modelling E-PCM at unit scale single EPCM
2) Computational model implementation and numerical solution

PUCMM

1) Photovoltaic generator modelling
2) Maximum power point tracking model
3) PV inverter model (DC / AC converter)
4) Building the test cells and design a monitoring plan

Quarterly report 4 - major achievements

WRUT

1) Preliminary trials for the zeolite based heat accumulator were performed concerning the absorption and desorption process.
2) Project of hybrid accumulator was elaborated.
3) Heat transfer within the accumulator with the pin-finned structure was successfully simulated and compared with the experimental results.

UPCT

1) Conceptual design of the modified test rig:
- description of the existing rig,
- instrumentation,
- inclusion of latent heat accumulators,
- design of latent heat accumulators and hydraulic arrangement of the system.

2) 1D modeling of the coupled rig.
3) Definition of the required volume of PCM at the UPCT solar test facility.

UAM

1) Paper ISI, International Scientific Indexing, published in Energies review.
2) Paper for Solar PACES 23 Annual Conference 2017.
3) Oral presentation at Solar PACES 23 Annual Conference 2017.

PUCMM

Quarterly report 5 - major achievements

WRUT

1) Elaboration and comparison of the performance of the composite PCM based accumulator with the honeycomb core (vertical or horizontal) or foam.
2) Design and preliminary attempts to manufacture the prototype of the hybrid heat accumulator.

UPCT

1) Pressure drop in the test rig:
- Pressure drop in solar collectors
- Pressure drop in ducts
- Pressure drop in valves

UAI

1) Thermal modeling of bulk E-PCM and Thermo-fluid-mechanic coupling in bulk E-PCM
2) Qualitative validation of model and numerical results

PUCMM

1) Acquisition and installation of air conditioner units
2) Acquisition and construction of PV system equipment and materials

Quarterly report 6 - major achievements

WRUT

1) Elaboration and comparison of the performance of the zeolite based accumulator (adsorption and desorption with and without the metallic structures inserted within the accumulator).
2) Manufacturing of the prototype of the hybrid heat accumulator: readily manufactured zeolite chamber and PCM chamber under construction.

UPCT

1) Use of honeycombs for latent thermal energy storage
2)Use of multi-tubular geometries

UAI

1) EPCMs composition, energy density and material cost
2) Energy density and heat transfer rate comparison
3) Thermal energy storage evolution
4) Volume and cost of EPCMs comparison

PUCMM

1) Acquisition of sensors
2) Acquisition of data acquisition system and data storage system
3) Acquisition of PV system equipment and materials

Quarterly report 7 - major achievements

WRUT

1) Elaboration and comparison of the performance of the zeolite based accumulator (adsorption and desorption with and without the metallic structures inserted within the accumulator).
2) Execution of steering and control system the hybrid heat accumulator.
3) Manufacturing of the prototype of the hybrid heat accumulator: readily manufactured zeolite chamber with operational steering and control system and PCM chamber under construction.

UPCT

1) Measurement of the wall temperature along the tubes of the accumulator.
2) Elaboration of comb-type sensor arrays for measuring the temperature of the PCM.

Substantial advances have been made in order to simulate the coupling between a latent thermal energy storage device and a solar collector.

Likewise approach a numerical for coupling a 2D geometry of a TES system (namely, the cross section of the accumulator) with a solar collector have been developed. This will allow for ultra fast simulations. Discussions on the applicability of the 2D simplification are also included.

UA

PUCMM

1) In T.2.1, the integration of the model was completed to carry out simulations connected to the electrical network, with or without a storage system (batteries).

Quarterly report 8 - major achievements

WRUT

1) Development of the technology of producing metallic foams to improve heat transfer in PCM batteries.

UPCT

1) 2D modelling of the shell and tube accumulator.

UAI

PUCMM

1) The PV system is complete. We have installed two PV generators with a peak power of 1980Wp and a battery bank of 370Ah.

Quarterly report 9 - major achievements

WRUT

1) Elaboration of the performance of the zeolite based accumulator with more advanced fogger (adsorption and desorption without metallic structures inserted within the accumulator).
2) Manufacturing of the prototype of the hybrid heat accumulator: readily manufactured zeolite chamber with operational steering and control system and adjusted and insulated PCM chamber.

UPCT

1) 2D modelling of the shell and tube accumulator

UAI

1) Scenario selection for economically evaluating the technology (characterization of the location and the building where it will be analyzed).
2) Identification of the facilities of the building, a house in Santiago de Chile.

PUCMM

1) In T.2.1, the integration of the model was completed. However this model will be undergoing a process of continuous improvement throughout the project. The validation of the model with experimental data is still pending.

Quarterly report 10 - major achievements

WRUT

1) Elaboration of the performance of the zeolite based accumulator with more advanced fogger and hot steam humidifier (adsorption and desorption without metallic structures inserted within the accumulator).
2) Manufacturing of the prototype of the hybrid heat accumulator: readily manufactured zeolite chamber with operational steering and control system and adjusted and finished PCM chamber. Investment casting of Al-Si honeycomb inserts for PCM chamber and immersing them in paraffin.

UPCT

UAI

PUCMM

1) In task T.2.3 (Validation of energy management strategies and comparative analysis of different system configurations) has started with scenario simulation, testing the influence of the size of the PV system and the positioning of the solar panels over the air-conditioning PV system.

Quarterly report 11 - major achievements

WRUT

1) Advanced trials evaluating the performance of the hybrid zeolite and PCM based accumulator with hot steam humidifier: adsorption and desorption with spatial metallic structures (heat transfer enhancers) inserted within the accumulator. Adjusting the unit in a closed loop system with implementation of HPM. Proved beneficial value of developed spatial metallic structures in heat distribution enhancement inside of the cascade heat accumulator.

UPCT

1) DATA REDUCTION OF EXPERIMENTAL RESULTS OF THE ACCUMULATOR

- Melting dynamics
- Performance evaluation

UAI

PUCMM

1) In T.2.1, the integration of the model was completed.

2) On the experimental facility, we continue with the data acquisition for some subsystems that are ready.

3) The beginning of the acquisition on weather data.

Quarterly report 12 - major achievements

WRUT

1) Advanced trials evaluating the performance of the hybrid zeolite and PCMbased accumulator with hot steam humidifier; adsorption and desorption with spatial metallic structures (heat transfer enhancers) inserted within the accumulator. Adjusting the unit in a closed loop system with implementation of HPM. Proved beneficial value of developed spatial metallic structures in heat distribution enhancement inside of the cascade heat accumulator.

UPCT

1) A shell and tube accumulator with metallic foams was built, based on a 16 kg storage capacity and 9 tubes foe heat transfer fluid distribution

UAL

PUCMM

1) On the experimental facility, we continued with the data acquisition for some subsystems that are ready and started with to look for some bias that could happened due to material/construction defects.

2) Task T.2.3 (Validation of energy management strategies and comparative analysis of different system configurations) has continued with scenario simulation.

Project meetings

THE KICK-OFF MEETING:

The kick-off meetings for the ACCUSOL project was successfully organized and took place:

-on 7-8 March 2017 in Wroclaw – Poland,

-on 30-31 January 2019 in Santiago de Chile – Chile,

-on 25-26 September 2019 in Cartagena – Spain,

- on 28-29 January 2020 in Wroclaw and Swieradow Zdroj – Poland.