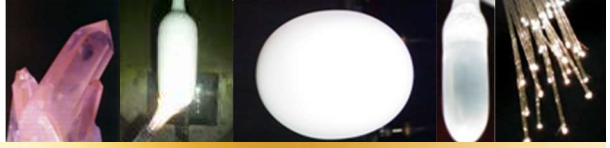


CIWC-2 2020

2nd Coatings and Interfaces Web Conference

15–31 May 2020

Chaired by Dr. Alessandro Lavacchi, Prof. Dr. Andriy Voronov

Low-cost solar heating reservoir manufactured by double-coating a water tank with polymeric materials

Brino Ruy Negri[1], **Marco César Prado Soares**[2*], Antônio Carlos Luz Lisboa[1] and Julio Roberto Bartoli[1,2]

[1]School of Chemical Engineering, University of Campinas, SP, Brazil

[2]Laboratory of Photonic Materials and Devices, School of Mechanical Engineering, University of Campinas, SP, Brazil

1. Introduction

Solar energy: interesting alternative for the generation of electricity and heat

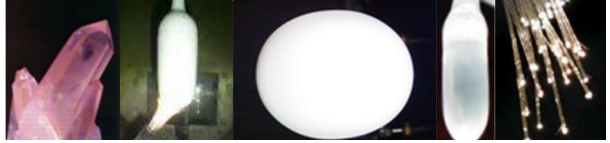
- Used on different aspects of daily life:
  - house heating;
  - water supply;
  - cooking;
- Solar thermal power plants completed and under construction in Europe, USA, Australia, and Africa.

1. Introduction – Challenges for the development of a sustainable energy system

- Solar irradiance, consumption and thermal accumulation are inherently transient and intermittent over space and time;
- Visible light (~44 % of the solar radiation, the fraction that is effectively converted) almost cannot be directly or effectively applied due to the low thermal efficiency of the collectors ;
- Consumption is usually not coupled with the solar irradiation daily profile: **a heat storage system is mandatory**.

2. Low-cost system

- Traditional reservoirs are made from high-cost materials: Cu, Al, glass, stainless steel, epoxy and steel, graphite composites, and metal alloys like Al-Mg-Zn, Al-Si-Sb, Cu-P-Si, and Cu-Si-Mg.
- Low-cost solar heat reservoir for domestic heat generation:
  - **water tank thermally isolated by means of two different coatings**, expanded and vulcanized nitrile butadiene rubber (NBR) and a metalized polyester layer.
  - **collector based on a poly(vinyl chloride), PVC, panel coated** with carbon black-filled glaze.



1 Stored Water

2 Medium Density Polyethylene Water Tank (100L)

3 Double Coating: expanded and vulcanized NBR covered with metalized polyester

Data Acquisition

Temperature

Thermocouple

Cold Water Inlet

Cold Water Outlet

Hot Water Outlet

Cold Water Inlet

Hot Water Inlet

Sunlight (Water Heat)

PVC Sunlight Collector (Black Paint for Efficiency Enhancement)

Domestic Applications

2. Costs and components required for the assembly

Component	Cost (BRL)	Cost (USD)	Total Required	Total (USD)
Water tank (100 L)	133.90	27.95	1	27.95
PVC panel (solar collector) of 0.78 m²	28.90	6.03	0.78 m²	6.03
Black paint (225 mL and yield of 5 m²)	11.90	2.48	0.78 m²	2.48
Coating of NBR and metalized polyester (1 m², thickness: 10 mm), plus adhesive	156.75	32.72	1 m²	32.72
PVC tubes (3 m, diameter: 32 mm)	24.90	5.20	6 m	10.40
Weldable sleeve (diameter: 32 mm)	2.79	0.58	2 units	1.16
Sliding sleeve for weldable pipe (diameter: 32 mm)	28.99	6.05	2 units	12.10
Weldable union (diameter: 32 mm)	18.99	3.96	2 units	7.93
Total low-cost system (100 L)	493.77	100.77	-	-
Commercial solar heat system (100 L, reservoir in stainless steel AISI 304 and copper collector)	1598.00	333.61	-	-

3. Setup assembled

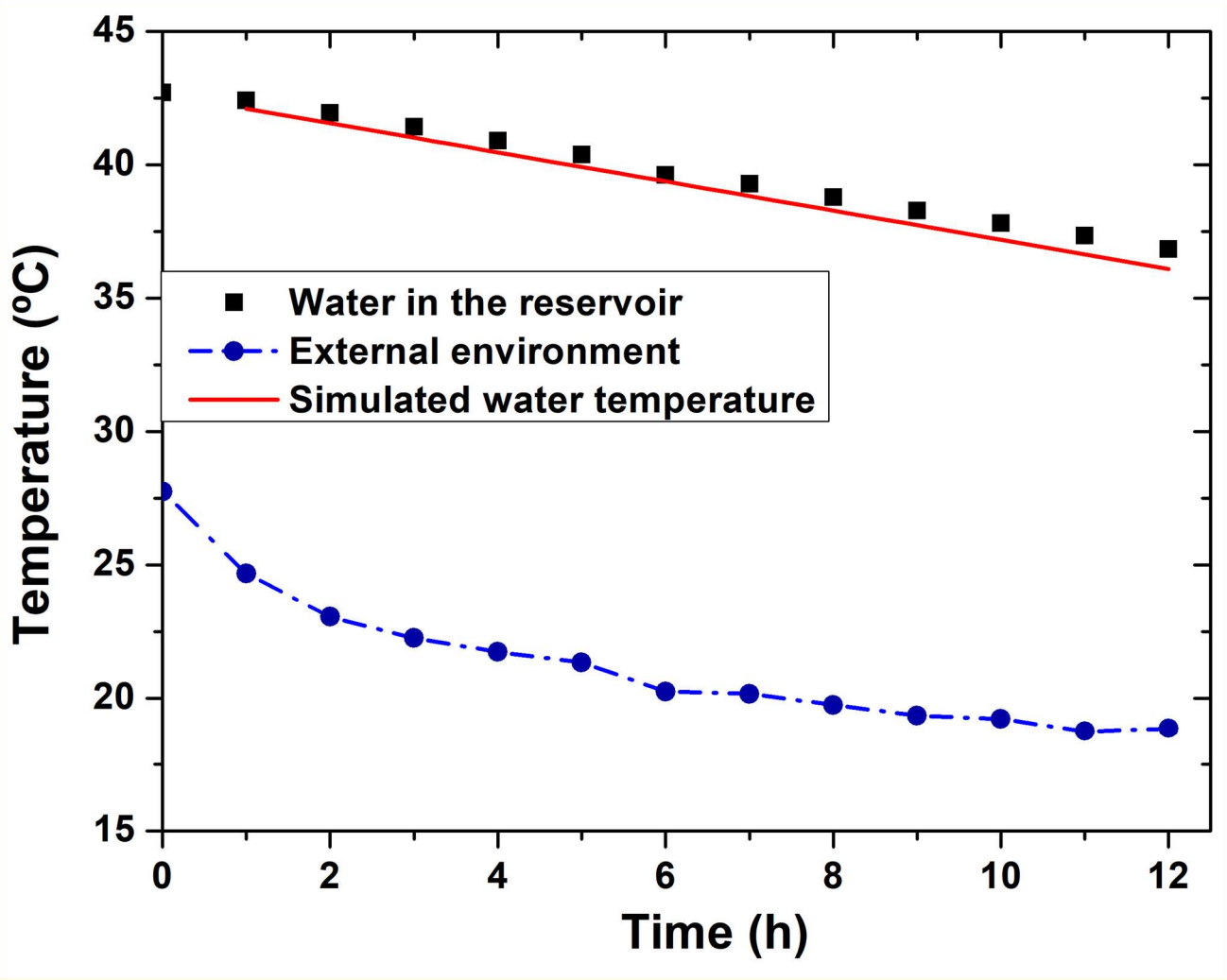
- Coating positioned externally to the tank;
- No connections for external use (domestic application);
- The glaze of the PVC liner enhances heat absorption;
- Due to the presence of tubes and connections, the area effectively used of the liner **decreases from 0.78 to 0.75 m²**

3. Performance analysis of the double-coated heat reservoir

- **The water temperature inside the tank** was monitored with the thermocouple for **12 hours** (from 18:00 p.m. to 6:00 a.m.), and **the external environmental temperature was simultaneously assessed**.

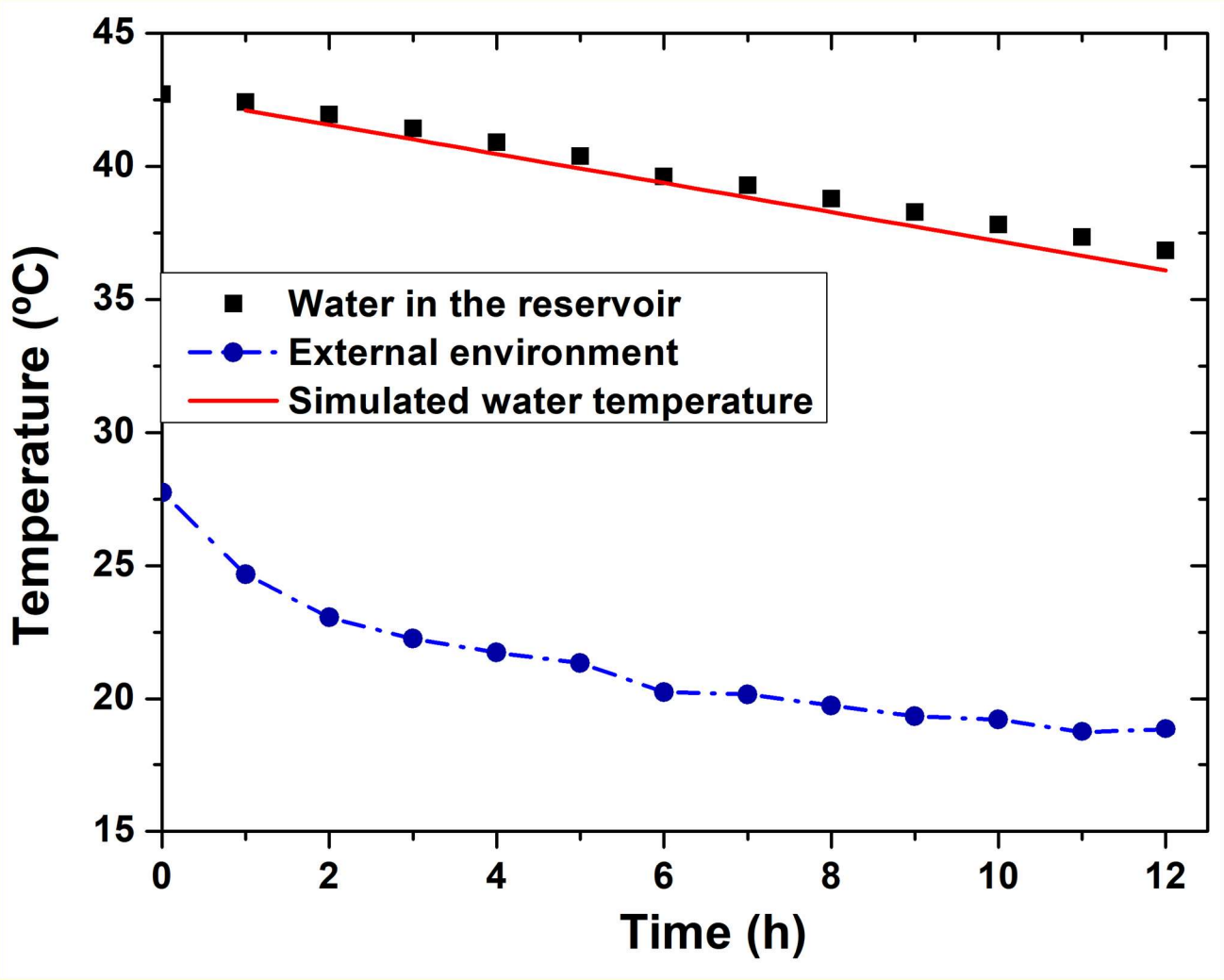
- **The results of the water temperature were com**pared to numerical simulations performed by the software **ArmWin Professional Insulation Thickness Calculator** (Armacell, Capellen, Luxembourg). This software is based on **ISO 12241:2008**.

3. Performance analysis of the double-coated heat reservoir



- The system is capable of **maintaining the reservoir approximately 18 °C above the environmental temperature** even during the coldest moment of the day.
- The water inside the tank goes from **~42.7 to 36.8 °C** as the environmental temperature drops from **27.8 to 18.9 °C** over 12 hours.

3. Performance analysis of the double-coated heat reservoir



- The water results, in turn, are in almost perfect accordance with the simulations performed by the software ArmWin, **validating the quality of the monitoring system**.
- the low-cost system presents a cost **70 % inferior than the commercial equipment**.

3. Examples of successful applications: benefitting low-income houses, institutions and families in the region of Campinas, SP, Brazil

Casa de Repouso Bom Pastor, 2005 (Barão Geraldo – Campinas-SP)

3. Examples of successful applications: benefitting low-income houses, institutions and families in the region of Campinas, SP, Brazil

Associação Carisma de Cultura, Recuperação e Intergração Social, 2005 (Jaguariúna –SP)

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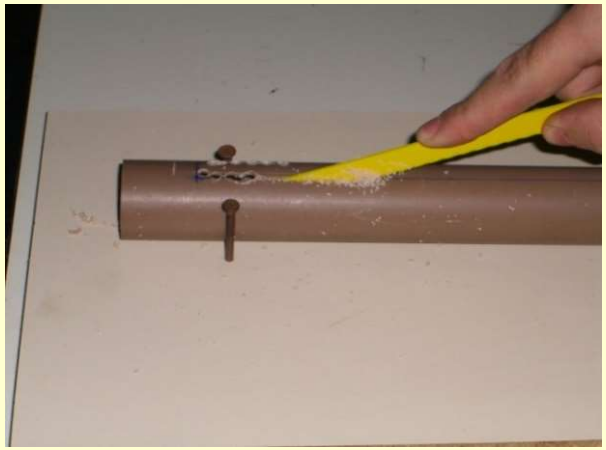

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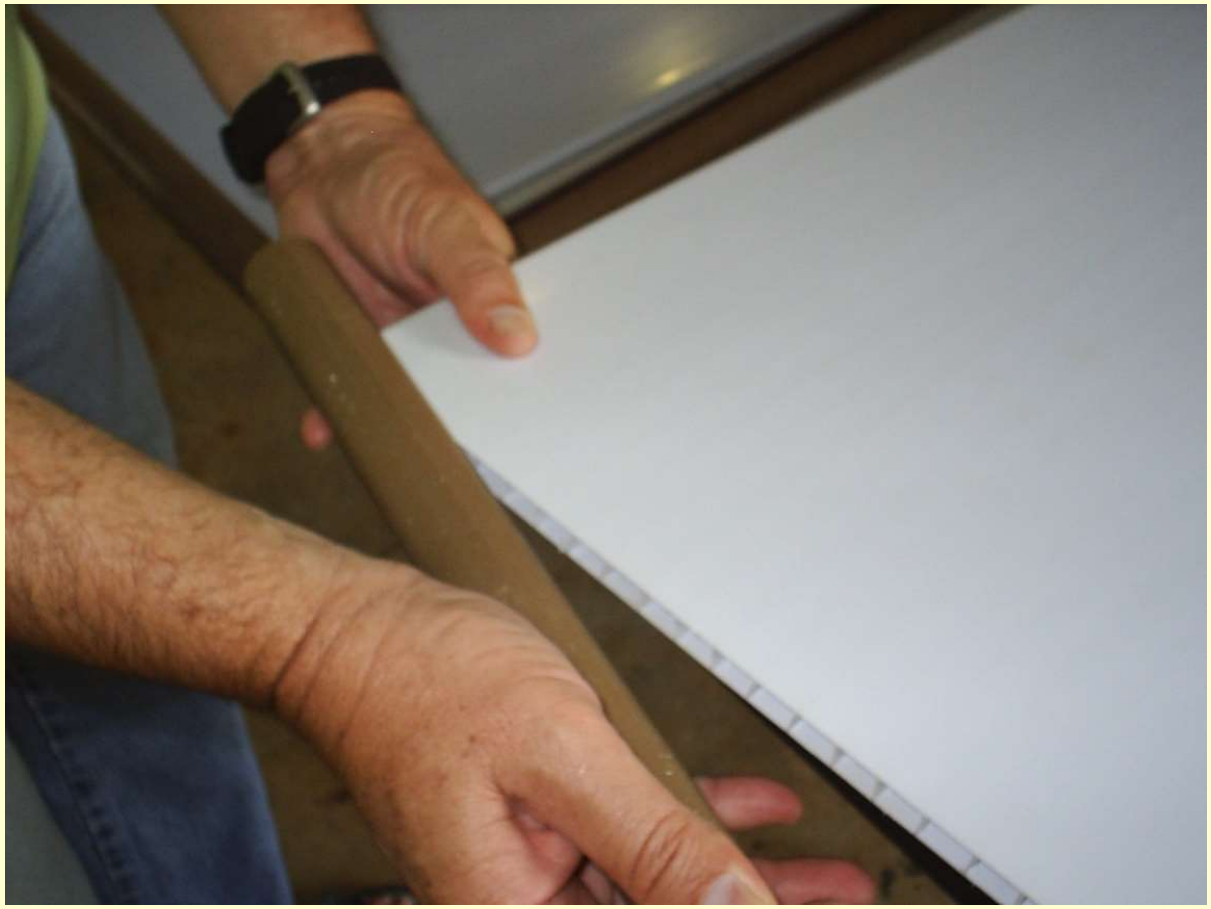

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4. Conclusions

- **A low-cost solar energy reservoir for domestic heat generation was demonstrated.**
- It is comprised of a **water tank thermally isolated by NBR and by a metalized polyester layer**.
- **The tank is coupled to a PVC panel coated with carbon black-filled glaze for enhancing the sunlight absorption**.
- The materials present wide commercial availability and are easily handled, providing a **simple and easy-scalable system that may be even self-manufactured by the final user.**
- The temperature results showed the efficiency of this system: the **water is kept ~18 °C above the environment**, even during the coldest moments of the day.
- This system is especially **destined to the social function of benefitting low-income houses, institutions and families**. As demonstrated, the estimated economy of fabricating it is almost **70 % of the costs necessary for acquiring a commercial solar heat equipment**.

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Thank you for your attention!

Questions?

marcosoares.feq@gmail.com
bartoli@unicamp.br

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