STUDY AND DESIGN OF A SOLAR SWIMMING POOL HEATING SYSTEM

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ABSTRACT

A large amount of heat is required to maintain the thermal comfort of outdoor swimming pools in cold weather. This motivates the development of solar heating systems with the goal of reducing energy consumption. A solar water heating system has been designed for a swimming pool with 24 m^2 surface area located in Al kharj, Saudi Arabia. The system contains a group of EPDM solar collector, pump and the use of pool cover. The system was sized and mathematically modeled. Simulation using Matlab was developed to study the behavior of the system. A cost analysis permit a good estimate of the system cost.

CONSTRAINTS

Our study takes in consideration the following constraints:

- Economy
- Environment
- Safety
- Sustainability

OBJECTIVES

- Design the system: heat and mass transfer calculation, simulation.
- Choose and size the different components of the solar pool heating system.
- Study of the cost and Establish safety considerations.

DESCRIPTION

The Solar Swimming Pool Heating System consists of four main parts (fig 1): (EPDM) solar collectors, centrifugal pump, polyethylene foam pool cover and swimming pool as storage tank. The area of swimming pool is 24 m^2 and the volume is 36 m^3 . The desired temperature is 25 °C.

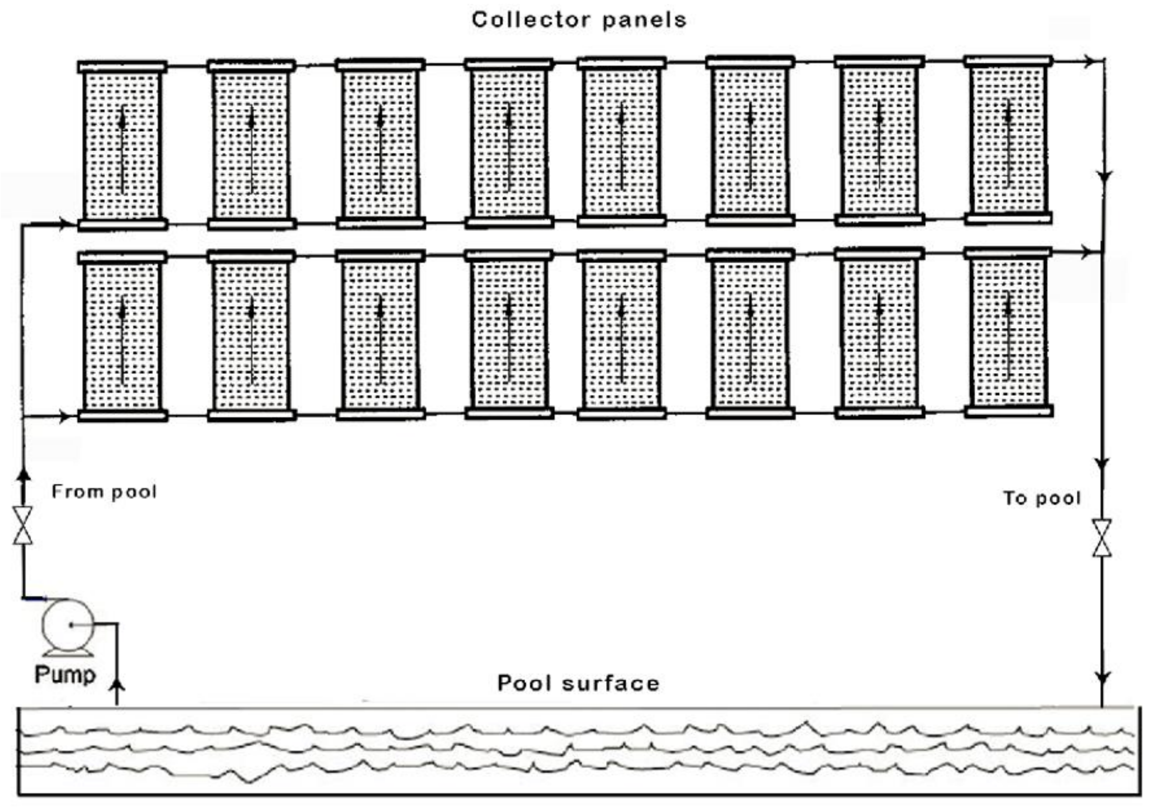


Figure 1: System configuration

THERMAL ANALYSIS

The energy balance of the pool water can be expressed as :

$$V_p \rho_w c_w \frac{dT_p}{dt} = \frac{Q_{gain}}{dt} - \frac{Q_{losses}}{dt}$$

Heat loss and gains as :

$$\dot{Q}_{gain} = \dot{Q}_{sol} + \dot{Q}_{col}$$

$$\dot{Q}_{losses} = \dot{Q}_{eva} + \dot{Q}_{rad} + \dot{Q}_{conv} + \dot{Q}_{cond} + \dot{Q}_{refill}$$

Pool solar heat gain (W)

$$\dot{Q}_{sol} = I A_p \alpha_w$$

Collector solar heat gain (W)

$$\dot{Q}_c = \dot{m} c_w (T_c - T_{in})$$

The energy balance of the solar collector:

$$\rho c V \frac{dT_c}{dt} = I A_c(\alpha\tau) - U_L A_c (T_{av} - T_a) + \dot{m} c_w (T_{in} - T_c)$$

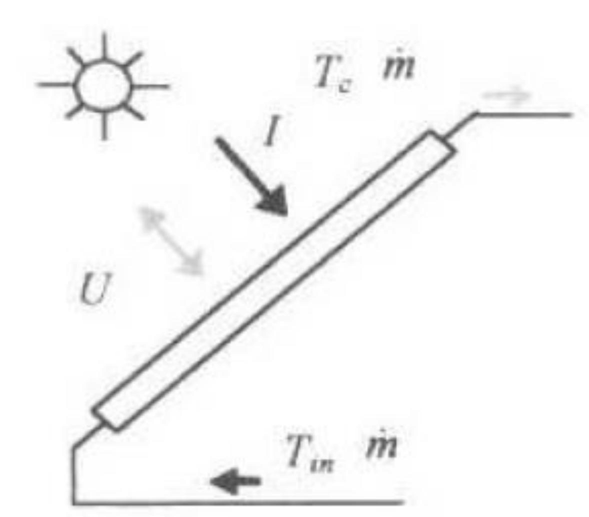


Figure 2: Heat balance of a solar collector

(a) (b) (c)

Figure 3: (a) Ethylene-propylene-diene-monomer (EPDM) collector, (b) Pump UPS 43-100F, (c) polyethylene foam 5 mm thickness.

SYSTEM SIMULATION

The ordinary differential equations describing the energy balance of the system are solved using MATLAB program:

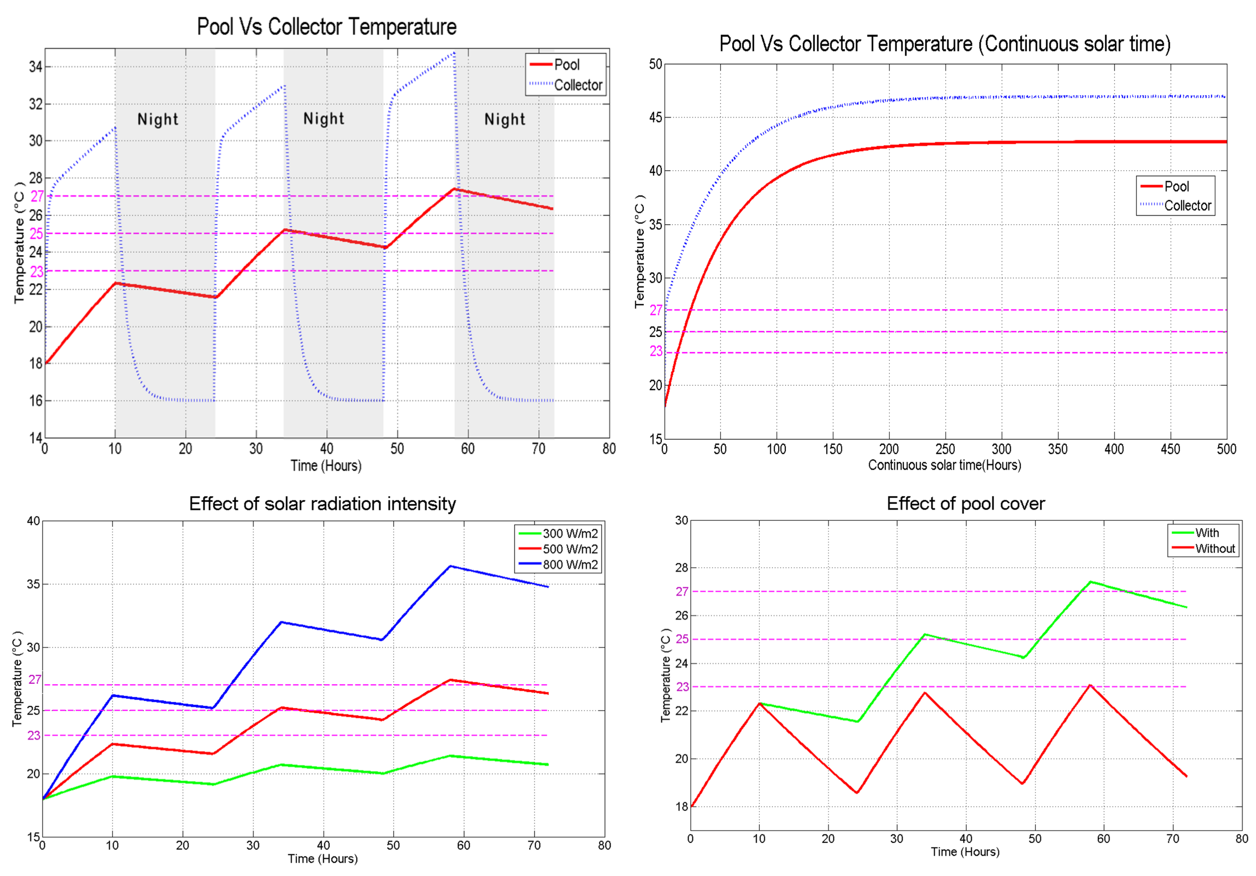
$$V_p \rho_w c_w \frac{dT_p}{dt} = \dot{Q}_{gain} - \dot{Q}_{losses}$$

$$\dot{Q}_{gain} = I A_p \alpha_w + \dot{m} c (T_c - T_{in})$$

$$\dot{Q}_{losses} = A_p h_{eva} \left(P_{v,sat(Tp)} - P_{v,a}\right) + A_p \sigma \varepsilon (T_p^4 - T_{sky}^4) + A_p h_{conv} (T_p - T_a)$$

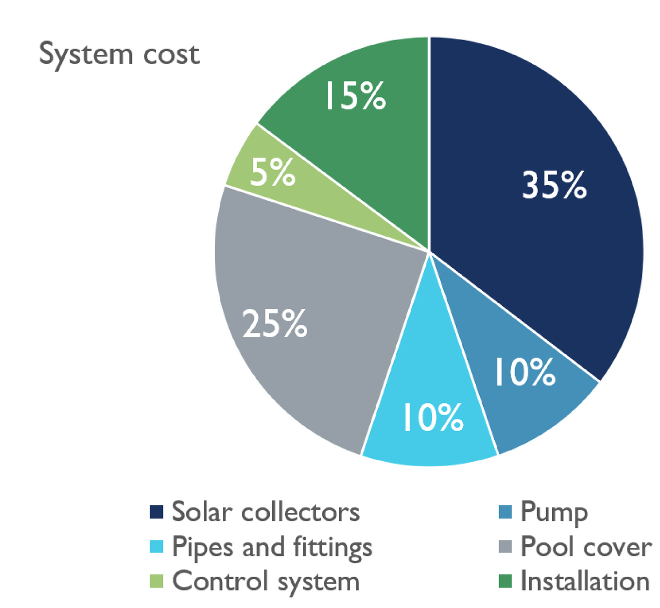
$$\rho c V \frac{dT_c}{dt} = I A_c(\alpha\tau) - U_L A_c (T_{av} - T_a) + \dot{m} c_w (T_{in} - T_c)$$

The pool temperature has to be controlled in the range between 23°C to 27°C.



COST ANALYSIS

The solar collector and the pool cover are the most contributing part of the cost. The total fixed cost of the system was **13,497 SAR**.



CONCLUSION

The solar thermal system designed for swimming pool heating is Costly reasonable for long run and environmentally sustainable and Safety rules should be followed. Based on the analysis of the designed system a Solar swimming pool heating system is a feasible option for heating swimming pools.

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