Maestría en Ingeniería en Diseño de Bioprocesos

Title

Solar distiller prototype for the production of distilled water with the assistance of efficient heat interchangers in multiple phases

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"SOLAR DISTILLER PROTOTYPE FOR THE PRODUCTION OF DISTILLED WATER WITH THE ASSISTANCE OF EFFICIENT HEAT INTERCHANGERS IN MULTIPLE PHASES"

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Introduction

In the city of Puebla an important part hard water causing losses in household spending because the deposits that form as a precipitate in traditional gas heaters and/or damaged electrical equipment. Prototype designs presented by different authors are of one or two slopes and with steel tray containing water to evaporate, leading to the production of distilled water can be improved using certain proposals representing the basis of this work and that through theoretical mathematical model that comprises the phases beginning separately from the heat collectors, which is the substantial portion lies the initial project scope. A water softener that has the potential of becoming solar water distiller is an alternative, in the context of the implementation of alternative energy to produce water without salt. Using alternative energy and environmentally friendly and a chance to develop and streamline the technology for this purpose, to design a prototype -assisted water distiller heaters solar energy.

General Objective

Generate technology to produce distilled water for labs, throughout a solar distiller prototype

Especific objectives

1. Choosing the mathematic models of a solar collector prototype by evacuated tubes and parabolic concentrator, that will be auxiliary in the distillation process.
2. Propose mathematical model that leads to the design of a prototype for distilling water bas collector and a parabolic solar concentrator
3. Building and proving the proposed prototype, with water of different origins (potable, saltp water)
4. Analyzing the distilled water product following the reference policies.
5. Performing a financing study for the building and then the possible commercialization of th solar distillation equipment.

RESULTS

1. SELECTION AND CALCULATION EQUATIONS OF MATHEMATICAL MODELS 2. PROPOSED MODEL PROTOTYPE SOLAR STILL

Water heater evacuated tubes	Equations	Results
Collector area (m²)	$A_{col} = (m_{agua}\, Cp\, DT)\,(Q_{solar\,prom}\, h\, t_{calent})^{-1}$	0.580555
Number of tubes	$N_{tubos} = A_{col}\,(p\, D_{[illegible]}\, L_{tubo})^{-1}$	4
Convection coefficient (W/(m²°C))	$hconv = (5.7 + 3.8(Vel_{viento}))$	13.68
Radiation coefficient (external tube) W/(m²°C)	$h_{rad} = e_v\, s\,(T_1 + T_{ambiente})(T_1^2 + T_{ambiente}^2)$	5.577805
Radiation coefficient W/(m²°C)	$h_{rad\text{-}v} = e_p\, s\,(T_2 + T_3)(T_2^2 + T_3^2)$	0.366437
Convection thermal resistance (°C/W)	$R_1 = (h_{conv} * p * D_{ext\,tubo\,ext} * L_{(tubo)})^{-1} =$	0.338989
Thermal resistance for radiation in the environment = °C/W	$R_2 = (h_{rad} * p * D_2 * Lt)^{-1} =$	0.831399
Thermal resistance by convection and radiation in the environment = °C/W	$R_{1\text{-}2} = (1/R_1 + 1/R_2)^{-1}$	0.240805
Thermal resistance for the exterior tube partial conduction °C/W	$R_{[illegible]} = (\ln(r_4/r_3)) / (2pK_{vidrio}\, Lt)$	0.012105
Thermal resistance of radiation in vacuum (between int and ext tube) =(°C/W)	$R_4 = (H_{rad\text{-}v} * p * D_3 * Lt)^{-1} =$	16.873733
Thermal resistance for driving in wall plate absorption is zero due to the difference in null distances (°C/W)	$R_5 = (\ln(r_1/r_{placa})) / (2pK_{[illegible]}\, Lt)$	0.000000
Total circuit resistance of evacuated tubes (equivalent resistance) (°C/W)	$R_T = R_{1\text{-}2} + R_3 + R_4 + R_5 + R_6$	17.143029
Tube heat losses to the environment (W)	$Q_{perdTubo\,amb} = T_{placa\,del\,tubo} - T_{amb} / R_T$	2.356692
Resistance (internal diameter of tank)= (C/W)	$R_{tanq} = LN\,(r_{tanq}/r_{1\,tanq}) / (2pK_{tanq}\, Lt)$	0.000773
Thermal resistance to radiation tank insulation= °C/W	$R_{tanq} = LN\,(r_{[illegible]}/r_{tanq}) / (2pK_{[illegible]}\, Lt)$	2.388088
Resistance (between internal diameter of the insulation and armor)= (°C/W)	$R_3 = LN(r_{coraza}/r_{[illegible]}) = / (2pK_{[illegible]}\, Lt)$	0.618846
Thermal resistance of convection in the insulation (between the inner tank and armor)= (°C/W)	$R_4 = (h_{conv} * p * D_{coraza} * Lt)^{-1} =$	0.131906
Thermal radiation resistance of insulating (between the inner tank and armor) (°C/W)	$R_4 = (H_{rad\text{-}v} * p * D_2 * Lt)^{-1} =$	1.406567
Thermal resistance by convection and radiation environment (°C/W)	$R_{4\text{-}5} = (1/R_4 + 1/R_5)^{-1}$	0.120597
Total circuit resistance or Equivalent resistance in the hot water tank (°C/W)	$R_T = R_1 + R_2 + R_3 + R_{4\text{-}5}$	3.1283047
Tank heat losses to the environment (W)	$Q_{perdTanq\,amb} = T_{placa} - T_a / R_t$	12.914343
Lost heat in the heater tubes evacuated (W)	$Q_{per\,tubos} = (Q_{perdTanq\,amb}/N_{tubos}) + Q_{perdTubo\,amb}$	5.554539
Effective collector area(m²)	$A_{ef} = p\, D_{[illegible]}\, L_{tubo}\, N_{tubos}$	0.575037
Heat loss by radiation to the tube exists based on the surface of the inner tube and the outer tube (W)	$Q_{rad} = s(A_{[illegible]})(T_1^4 - T_2^4) / [(1/e_1) + (1 - e_2/e_2) + (D_{[illegible]}/D_{[illegible]})]$	1.401469
Heat lost (W)	$Q_{per} = Q_{rad} + Q_{perdtubos}$	6.96
Incident heat (W)	$Q_{inc} = Q_{[illegible]}\, t_{[illegible]}\, Q_{[illegible]}\, A_{[illegible]}$	490.163580
Useful heat (W)	$Q_{util} = Q_{inc} - Q_{per}$	490.163580
Collector efficiency	$h_{col} = Q_{util} / (A_{ef} * Q_{[illegible]})$	0.846715

Condenser	Equations	Results
Heat on the steam to condense (KW)	$Q_h = \dot{m}_h\, Cp_h\, DT_h$	0.330056
Cooling water heat (KW)	$Q_c = \dot{m}_c\, Cp_c\, DT_c$	0.330056
Ratio of heat capacity of hot fluid	$C_{min} = m_h Cp_h$	0.004715084
Ratio of heat capacity of cold fluid	$C_{max} = m_c Cp_c$	0.3344
Capacitance ratio	$C = C_{min} / C_{max}$	0.014100
Maximum heat transfer rate in exchanger	$Q_{max} = C_{min}\,(T_{h\,ent} - T_{c\,ent})$	0.35
Exchanger efficiency	$e = Q_c / Q_{max}$	0.933333
Number of Transfer Units (counter)	$NTU = (1/C-1)\; LN[(e-1) / (Ce-1)]$	2.733343
Exchanger area (m²)	$A_o = (NTU * C_{min}) / U$	0.366562
Length of the condenser (m) Whereas the inner pipe diameter= 0.019 m	$L = A_o / p\, D$	5.40937589
Number of tubes in the alternative of using shell and tube exchanger with length 1 m,	$n = A_o / pDL$	5.41 ≈ 6

Parabolic Solar Concentrator	Equations	Results
Energy (KWh)	$E = V\, Cp\, r\, DT$	0.0803766
Parabolic Trough Area(m²)	$A_s = b\, h$	2
Instant power on the parabolic trough (KW)	$P_{aa} = A_s\, P_{[illegible]}\, F_c$	1
Efficiency of the energy used on the concentrator	$h_{uen} = (E_{entrada} - E_{salida})\, x100 / E_{entrada}$	91.962336

3. CONSTRUCTION OF PROTOTYPE OF SOLAR DISTILLER

Figure 1. Prototype solar distiller

The component parts are listed:
1. Water heater evacuated tubes,
2. Parabolic Solar Concentrator,
3. Simple step evaporator,
4. Condenser, y
5. Container stocker distillate.

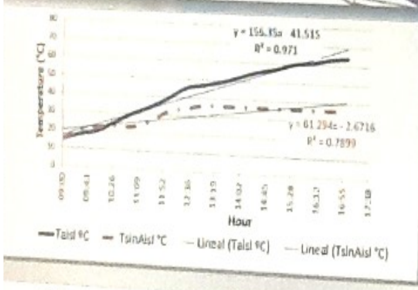
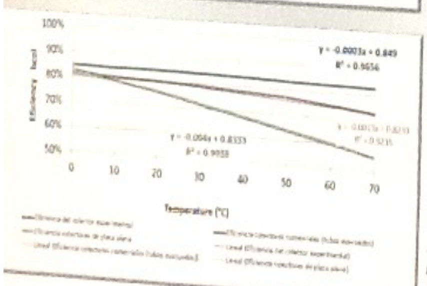


Figure 2. Temperatures obtained in the empirical test of solar collector evacuated tubes different isolation conditions

Two tests were performed with the solar collector by tubes evacuated
1. Heating test in conditions of no insulation
2. Heating test in isolation.



The efficiency obtained in the heating test for evacuated tubes manifold shown in the figure 3, and compared with the efficiencies reported [14], [7] for evacuated tube collectors and flat plate.

Figure 3. Comparative efficiency of solar collectors with evacuated tube collector prototype solar distiller

5. FINANCIAL ECONOMIC SURVEY FOR CONSTRUCTION AND POST MARKETING TEAM SOLAR DISTILLATION (IN PROGRESS).

The project is directed to the small business specifically the Institutional Sector with potential projection generated a company that builds distillation equipment for water softening.

Social Impact: Sector benefited from these teams is the society of the State of Puebla that has the problem of not having soft water, while generating hot water that provide for domestic use.

Ecological impact. Without the need to resort to spending on fossil or electrical energy, salty water (hard) for example also makes more soap and detergents for cleaning is spent, which brings consequences environmental damage, by discharging water excess detergent, which hardly degrades.

Segment the Target Market: The product is aimed at consumers with a level of minimum income of $ 8,000.00 per month, about the age of these can vary but is defined to people over 18 who have the need to cover their demand for fresh water, and / or hot water in their homes.

Distribution and marketing your product-sales Through different media outlets such as. Internet, leafleting, particular sale, Plazas and commercial centers (Home Depot and Stores related to the sale of water heating equipment).

Main quality that differs from the other competitors is that teams do not manufacture this kind, so the distiller tends to diversify and you can switch use as water heater.

Approximate amount of financial resources for the project investment. It plans to invest $ 80,000.00 start as seed capital.

Financing sought: to get credit for PYMES and obtain funding

Cost of Solar Distiller	Cost
Water heater evacuated tubes,	3266
Connecting pipes to Parabolic Solar Concentrator,	386.61
Parabolic Solar Concentrator,	5000
Simple step evaporator, (Recycled) and connecting pipes and accessories	232.2
Condenser connection pipes	250
Condenser	1377.4
Total	**10512.21**

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