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Steeple Analysis of the Double Glazing Solar Water Heater

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A B S T R A C T

In this work the performance of Double Glazing solar water heater is predict. Unlike the Thermosyphon systems, where the collector panels and the storage tank are separated, Double Glazing Built-in Storage water system has a storage tank integrated within the collector. The system proposed is composed of an absorber plate where the upper surface will be the insulator and the lower surface will be in direct contact with water. In this work various properties that will be discussed are mechanical and thermal properties such as static, fatigue, drop tests, stress, yield strength, young's modulus, hardness, elongation to failure, strain, thermal conductivity, and others. The mechanical properties of each part of the system will be represented in a 3D design approach using solid modeling with a software called "SolidWorks", through this optimize the performance and produce efficient 3D designs with accuracy and precision. The first steps consist of finding the different possible materials that could be used in the Double Glazing Built- in Storage water system then study the mechanical and thermal properties of each part of the system using SolidWorks that will give a clear idea of what the system looks like in a 3D perspective and its performance. . But conducting only a mechanical simulation analysis was not enough to decide which materials to be used because after all our main goal is to maximize the performance and minimize the costs. I have conducted also an economic analysis of the materials in order to compare and choose the best out of them.

Keywords: Steeple Analysis, Double Glazing, Solar water heater

1. Introduction

Flat-plate collectors use both beam and diffuse solar radiation, do not require tracking of the sun, and are low-maintenance, inexpensive and mechanically simple. Solar radiation enters the collector through the transparent cover and reaches the absorber. Here the absorbed radiation is converted to thermal energy.

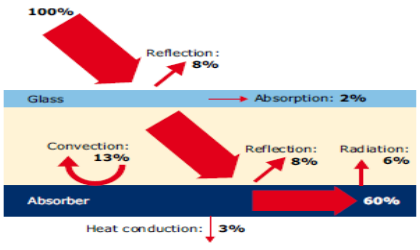

Fig 1 Mechanism of flat PLATE solar collector

A good thermal conductivity is needed to transfer the collected heat from the absorber sheet to the absorber pipes where the heat is finally transferred to the fluid. Usually a water/ glycol mixture with anticorrosion additives is used as the heat carrying fluid. The fluid also protects the collector from frost damage. The transparent cover is used to reduce convection losses from the absorber plate through the restraint of the stagnant air layer between the absorber plate and the glass. It also reduces radiation losses from the collector as the glass is transparent to the short wave radiation received by the sun. But it is nearly opaque to long-wave thermal radiation emitted by the absorber plate

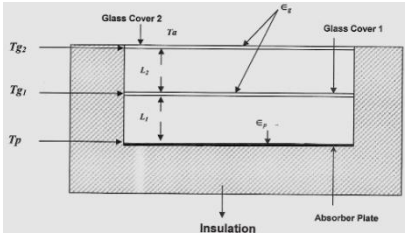

Fig 2 flat plate solar collector

1.2 Steeple Analysis

STEEPLE Analysis is a strategic decision model that consists of seven environmental factors in the analysis activity,

Table 1.1 Steeple Analysis of the Double Glazing SWH

Societal	Social behavioral'chances, population growth, social behavioral chances,
Technology	The emergence of cheap solar water heating systems
Environment	Solar water heater with integrated tank systems work one hundred percent with solar energy which is a renewable energy
Ethics	Save environment and decrease the energy consumption
Political	Rising gas prices require to find an alternative to this resource that is less costly
Legal	Everybody has the right to use solar energy
Economic	Solar water heating system enable less costly and more efficient and reasonable energy consumption

1.3 Previous Work

The present work is going to be a follow up on the work of a previous master Thesis of student "Tarik Nabih", in this thesis the student has focused on the design of the double glazing solar water heater system and he used a tank with a volume of 120 liters. The work done so far is a 3D design of the system and a flow simulation of the system using "SolidWorks", also some literature review on the different types of solar water heaters and especially the one with an integrated tank with a rectangular shape. Additionally, the previous study consists of comparing the theoretical results and experimental results done in collaboration with the company IntellCap. The data found has been analyzed, and using the software SolidWorks he found the 3D flow simulation of the double glazing solar water heater system. But the student did not cover the mechanical and thermal properties of the system.

1.4 Objectives

- Evaluate the materials used in solar water heater tank
- Determine the best cover material for optimum sunlight transmission
- Evaluate the effectiveness of the tank with different materials
- Determine the optimal number of cover plates taking into consideration the hydraulic pressure

- Analyze and simulate the different materials to be used for the Absorber
- Determine the optimal cover plate's thicknesses
- To identify the pressure breaking point of the absorber plate of SWH with a tank 120 liters.
- Determine the maximum hydrostatic pressure of water on the absorber plate of the SWH.

2. Design of Solar Water Heater System

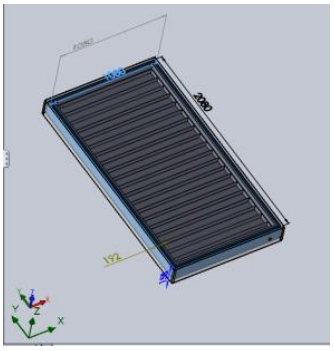

Fig 3 Design of the Solar Water Heater

The Tank, Collector, and Absorber are all assembled in one system to give the solar water heater adding to it an inlet and an outlet both having a diameter of 29 mm. This system is able contain water up to 120 liters which was calculated based on the requirements of people and also based on the energy available and the solar radiation in the Jabalpur(mp-india) as our main location for the study.

2.1 Properties of Potential Materials

FOR THE STORAGE TANK

MATERIAL	MODULUS OF ELASTICITY (N/M²)	POISSON RATIO	SHEAR MODULUS (N/M²)	DENSITY (KG/M^3)	THERMAL EXPANSION KELVIN	YIELD STRENGTH	TENSILE STRENGTH
RIGID POLYETHYLENE	*2.78e+006*	*0.3*	*1.9e+007*	*1600*	*124.2*	*2.2e+006*	*8.6e+007*
COPPER	*1.1e+011*	*0.37*	*4e+010*	*8900*	*2.4e-005*	*2.58646e+008*	*3.9438e+008*
POLYESTER RESIN	*1.9e+010*	*0.25*	*N/A*	*1160*	*0.000123*	*2.3e+008*	*1.9e+008*
STAINLESS STEEL	*2e+011*	*0.28*	*7.7e+010*	*7800*	*1.1e-005*	*1.72339e+008*	*5.13613e+008*

3. Analysis of the Double Glazing Built-Instorage Water System

3.1 Stress Analysis

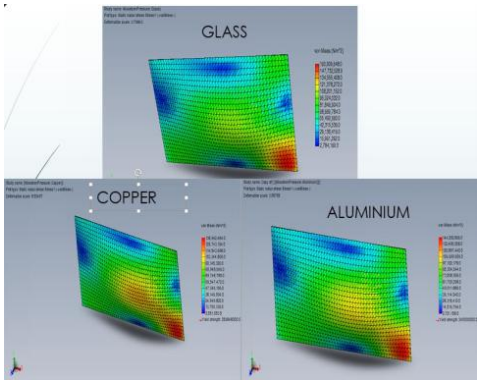

Fig 4 Stress Analysis

3.2 Displacement Analysis

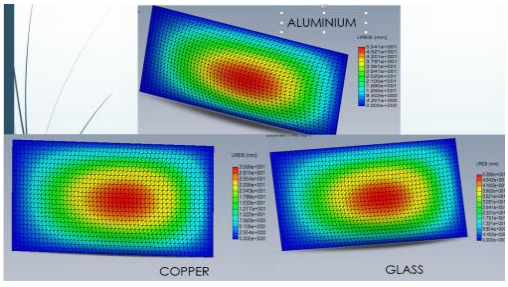

Fig 5 Displacement Analysis

3.3 Strain Analysis

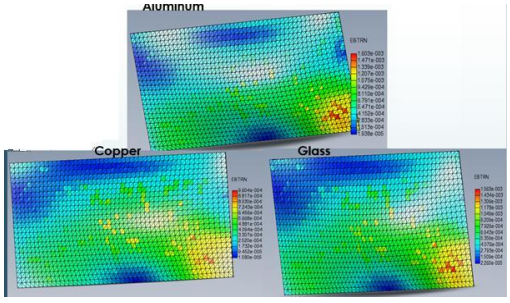

Fig 6 Strain Analysis

4. Analysis of the Interior Layer of the Storage Tank

4.1.Stress Analysis

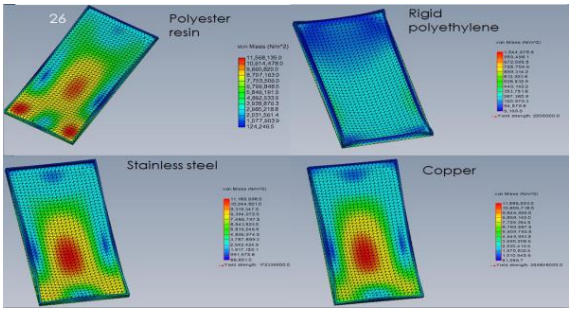

Fig 7 Stress Analysis

4.2 Displacement Analysis

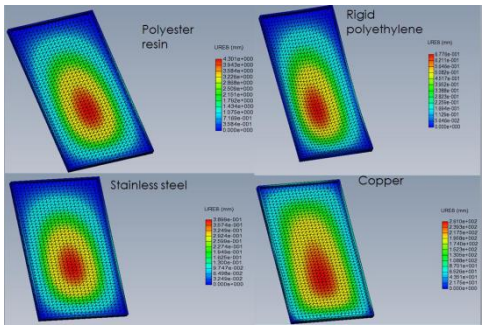

Fig 8 ***Displacement Analysis***

4.3 The strain analysis

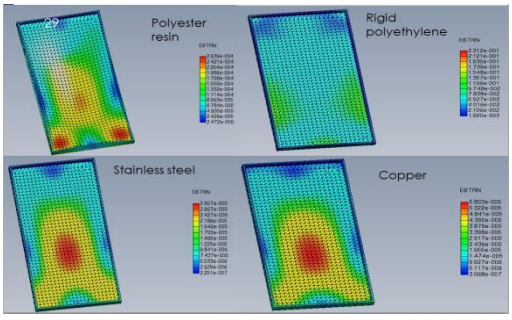

Fig 9 Strain analysis

Results explanations After running the simulation of the pressure we tend to got the strain, strain associated displacement figures of various materials then I even have done an analysis of every property to search out the most effective materials to be used for the tank of the double glazing built-in system. At the top I came to the conclusion that the most effective material to be used for the tank is that the Rigid polythene and this can be due to: initial as a result of it's a high ratio adequate22.32 and second as a result of it's the smallest amount displacement of all the opposite 3 materials: chrome steel, fibreglass and Polyester rosin which implies that the pressure load has less impact on the rigid polythene tank than it's on alternative studied materials. The last purpose is regarding the strain analysis, once analyzing the simulation we tend to see that the most effective out of the four materials is that the Rigid polythene thus for a much better performance and sensible potency the most effective material to be employed in the inner layer of the tank ought to be Rigid polythene

5. Economic Analysis of the Double Glazing Solar Water Heater

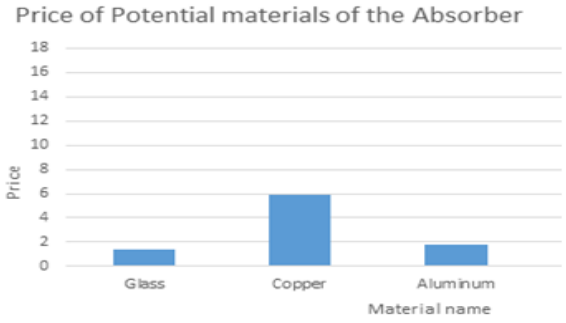

Fig 10. Cost of Materials of the absorber plate of the Solar Water Heater

From the Graph we see that the least costly material is glass. So in addition to its good mechanical properties, Glass is the less costly which will allow us to make the final choice about the material to be used in the absorber plate

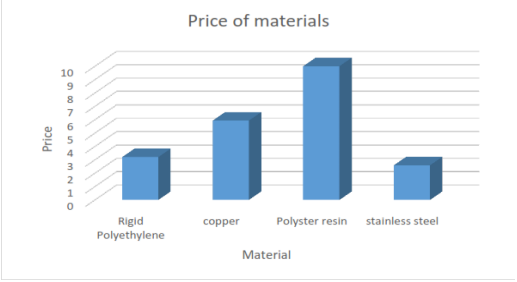

Fig 11. Cost of Materials of the storage tank of the Solar Water Heater

From the graph we can observe that stainless steel is the cheapest material, but in the simulation analysis we have found that this material is not a vice selection in terms of hydraulic pressure, for this reason we will dis-select this material and instead of this we will choose Rigid Polyethylene which is also cheaper and has proven to be efficient and resistant to hydraulic pressure

6. Conclusion

main goal of this work is to optimize the performance of the system and simulate the behavior and mechanical properties of solar water heater using the available and efficient materials. Using SolidWorks I have been able to study the mechanical performance of different materials especially for the absorber and the storage tank. After getting the stress, strain and displacement plots and tables, I analyzed the results and I came to the conclusion that the best materials to be used for the system would be: Glass for the absorber and Rigid Polyethylene for the storage tank. But conducting only a mechanical simulation analysis was not enough to decide which materials to be used because after all our main goal is to maximize the performance and minimize the costs. I have conducted also an economic analysis of the materials in order to compare and choose the best out of them. For the potential materials of the absorber plate I found that the cheapest material was glass and it is in accordance with our simulation study since the glass performed well under pressure conditions so the choice was to choose glass as our main material for the absorber and coat it with a black coating that has absorption coefficient equal to 0.94. Last for the comparison of potential materials that might be used for the tank I actually have found that the most affordable material is stainless-steel however since it failed to perform well struggling conditions the selection was to settle on Rigid polythene since isn't costly and it's incontestable a decent resistance to hydraulic pressure

REFERENCES

1. The impact of a double glassed flat plate solar water heater collector performance . By.Hanan Mohammed Akbar, Suad Hassan Danook, Kamal Jalal (International Journal of Engineering Inventions e-ISSN: 2278-7461, p-ISSN: 2319-6491 Volume 8, Issue 1 [January 2019] PP: 63-70)

2. M. Z. H. Khan, M. R. Al-Mamun, S. Sikdar, P. K. Halder, M. R. Hasan, "Design, Fabrication, and Efficiency Study of a Novel Solar Thermal Water Heating System: Towards Sustainable Development", *International Journal of Photoenergy*, vol. 2016, Article ID 9698328, 8 pages, 2016. https://doi.org/10.1155/2016/9698328

3. Medium-temperature solar collectors with all-glass solar evacuated tubes Jian Wanga, Zhiqiang Yina, Jing Qia, Guangbai Mab, Xijie Liu(2018)

4 .Amin, Sakib and Nuarey Mithila, Nuzhat, The Importance of Using Solar Water Heater as an Alternative Eco-Friendly Technology in Global Market: Some Lessons of Experiences for Bangladesh Economy (March 7, 2017). USAEE Working Paper No. 17-299, Available at SSRN

5.Comparison Study of Solar Flat Plate Collector with Single and Double Glazing Systems by *H.Vettrivel and P.Mathiazhagan - International Journal Of Renewable Energy Research 2017*

6 .Ahasanul Haque Chowdhury, Design and Animation of Automated Alternative Solar Water Heater System at the BRAC University Roof Top by Using SolidWorks and Implement the Controller Using GAL Technology , May, 2012 Retrieved from: http://dspace.bracu.ac.bd/bitstream/handle/10361

7. Glass cover temperature and top heat loss coefficient of a single glazed flat plate collector with nearly vertical configuration. By -Suresh Kumar, S.C.Mullick "Ain Shams Engineering Journal (2012)"

8. Parametric studies of top loss coefficient of double glazed flat plate solar Collector by -*Bisen, P.P Das, Rajeev Jain* (2011*)....MIT International journal of*

mechanical engineering vol. 1 aug 2011

9. Efficiency improvement of flat plate solar collector using reflector By Himangshu Bhowmik, Ruhul Amin… Energy Reports 3 (2017)(Elsevier)

10. "Energy and exergy analysis of a thermosiphon and forced circulation flat-plate solar collector using MWCNT/Water" nanofluid BY- Mahmoud Eltaweel, Ahmed A. Abdel-Rehim Case Studies in Thermal Engineering 14 (2019) 100416(Elsevier)

11. N.Akhtar, S.C. Mullick, Computation of glass-cover temperatures and top heat coefficient of flat-plate solar collectors with double glazing, Energy [32-2007) 1067–1074]

12. Anand Bisen Parametric study of Top Heat Loss coefficient of double glazed Collectors IJME vol. 1 No. 2 Aug 2011 [page No.71-78]

13. S.P Sukhatme, "Solar energy principal of Thermal collection and storage ''Tata McGraw Hill Publications Co. Delhi1984.

14. An Introduction to Engineering Design With SolidWorks®, SolidWorks Corporation 1995-2008, Retrieved from :http://edweb.tusd.k12.az.us/mcalhoun/Solidworks%20Activities.pdf

15. Billy Anak Sup, Effect Of Absorber Plate Material On Flat Plate Collector Efficiency, DECEMBER 2010 retrieved.