EVALUATING THE PERFORMANCE OF THE PUF (POLY-URETHANE FOAM) INSULATION FOR A SOLAR WATER TANK WHILE DELIBERATING ON ALTERNATIVES FOR THE FUNCTION

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INTRODUCTION
This work makes an assessment of the present insulating material (Glass Wool) used for insulating the Solar Water Tank. The hot water (at about 55 to 65 deg Celsius) is stored in the tank and is expected to maintain the temperature through the evening and dawn till the next day for using the same for sanitary usage. The drop in temperature normally at 10 to 12 deg Celsius over-night is aimed to be reduced to about 8 deg Celsius. The heat transfer through the insulating material would be studied and alternative materials or alternative methods of cladding would be proposed. The analysis would be done using CAE (Computer aided engineering) approach along with mathematical treatment for the data. Conservation of fuel is the key to any nation’s economic success; while on the other hand limitation of pollution through such fuel combustion is a must for the nation’s health. At a time when rising fuel costs are bearing on the economy of the country, at the same time rising pollution levels are playing havoc with the health of the multitudes. The focus therefore is continuously on, how best to save fuel with an eye on reducing the elevated emissions levels. The dynamics of combustion of hydrocarbon fuel has forever been a subject of intense research the world over as also the problems associated with it such as decrease in equipment efficiency through incomplete combustion, consequent carbon deposits and high emission levels, the aim being, to reduce exhaust emission levels. Traditional methods have always focused on use of additives to achieve the means which leads to a recurring cost and poor impact on the life of the combustion systems in the long run.

LITERATURE REVIEW:
Cynthia et al. [1] investigated the performance of solar domestic hot water (SDHW) systems by computer simulation. An important aspect of system performance is storage heat loss characteristics; these represented by an average heat loss coefficient that does not account for the complex geometry of the thermal storage. He assume that the tank temperature profile is one-dimensional and that conduction within the tank wall is negligible. To investigate these effects, tests were conducted on a typical thermal storage used in SDHW applications and included a cool-down test and a heat diffusion test sequence. The values derived from these test were compared to computer predictions based on estimated thermal properties.
Abdul et al. [2] He carried experiment on Phase Change Materials (PCMs) which may be incorporated in solar thermal energy systems to act as latent heats storage media offering a high storage capacity compared to sensible heat storage. In this work, a storage solar collector that consists of six 80-mm diameter copper pipes connected in series is integrated with a back container of paraffin wax as a PCM thermal storage media. The performance of the system is evaluated by calculating the various performance factors of the collector. During off-sunshine hours, the liquid PCM transferred heat to the absorber, part of which was conducted as a useful heat in the circulating water. Therefore, the water continued to get heated after sunset, as the PCM acted as a heat source.

Shuangmao et al. [3] This paper is aimed at analyzing the thermal characteristics of packed bed containing spherical capsules, used in a latent heat thermal storage system with a solar heating collector. Myristic acid is selected as phase change material (PCM). The following conclusion can be drawn: (1) the heat released rate is very high and decreases rapidly with time during the liquid cooling stage, it is stable at the solidification cooling stage, then it decreases to zero at the solid cooling stage. 2) compared to the HTF (Heat transfer fluid) inlet temperature and flow rate, the influence of porosity of packed bed on the time for complete solidification is not so significant.

Tay et al. [4] He studied Phase change materials (PCMs) which can store large amounts of heat or cooling in a small amount of material, they potentially have less weight and volume compared with other thermal energy storage materials. Bruno et al. [5] He worked on A computational fluid dynamic (CFD) model for tubes in a phase change thermal energy storage system has been developed and validated with experimental results. The heat transfer fluid (HTF) flows in tubes which are configured in a unique arrangement during the charging and discharging processes. Water was used as the phase change material (PCM) which was contained in a cylindrical tank with four tubes coiled inside it. Experiments were conducted for both freezing and melting processes. A three-dimensional CFD model using Ansys code was developed and validated with experimental results. The inlet and outlet HTF temperatures as well as nine temperature locations in the PCM were compared with the CFD results.

Belen et al. [6] Thermal energy storage in general, and phase change materials (PCMs) in particular, have to find. In this work, a review has been carried out of the history of thermal energy storage with solid–liquid phase change. Three aspects have been the focus of this review: materials, heat transfer and applications. The paper contains listed over 150 materials used in research as PCMs, and about 45 commercially available PCMs.
Muhsin et al. [7] He carried work and study on thermal energy storage systems which keep warm...
and cold water separated by means of gravitational stratification have been found to be attractive in low and medium temperature thermal storage applications due to their simplicity and low cost. This effect is known as thermal stratification, but main problem is that both cold and warm water is get mixed.

Rodriguez et al.[8] He carried experimental work on an excessive storage volume could not result more efficient in many residential applications, which is costly, extreme in space consumption and in some cases too heavy. A proprietary transient simulation program has been developed and validated with a detailed measurement campaign in an experimental facility. In environmental data have been obtained through a whole year of operation. This program has been used to obtain the design and dimensioning criteria of DHW (Domestic hot water) solar plants under daily transient conditions throughout a year and more specifically the size of the storage tank for a multi storey apartment building.

Bouhdjar et al. [9] He investigated that in order to improve thermodynamic system efficiency, stratification should be promoted much more. To this scope, this article presents a numerical study of transient mixed convection. The study investigates the use of different fluids as a heat storage medium in cylindrical cavities with different aspect ratios. The effect of the fluids is made through the variation of physical properties represented through the Prandtl number. Transient, two-dimensional, mixed convection flows in a thermal storage tank have been studied using finite volume method.

Darci et al. [10] He analyzed and studied a numerical analysis of the three-dimensional temperature and velocity fields in horizontal cylindrical storage tanks was performed. The phenomena of laminar natural convection and vertical stratification of temperature were considered. The developed three-dimensional transient computing code solves the equations of energy and momentum through the finite volume method, a correlation was proposed for determining the degree of thermal stratification inside the tank regarding thermal and geometrical parameters, the global efficiency of the system increases with the thermal stratification degree of the working fluid. The tank was connected to solar collectors, aiming at investigating the influence of the inlet jet position with and without a baffle plate on the preservation of the thermal stratification. Results showed that the baffle plate modified the velocity and temperature fields close to the inlet jet, allowing a better thermal stratification.

**CONCLUDING REMARK:**
1. A solar water heater is the most competitive alternative to conventional water heating methods such as electric geysers and fuel-fed boilers.
2. It makes an attractive and sustainable option, with its global distribution, pollution free nature, virtually inexhaustible supply and near-zero operational cost. Solar water heaters run on a free fuel (i.e. sunshine), thus saving on energy costs that help recover its initial cost in just 2-4 years.
3. The efficiency, effectiveness, simplicity and cost reduction of solar water is improving every generation.
4. It reduces heat conduction and convection rate.

**SCOPE OF WORK:**

All the performance parameters of Solar system are to be calculated & emission characteristics have to be measured and compared with old system. The efficiency of the solar system is increased by reducing the heat conduction consumption & emissions.

**OBJECTIVES:**

1. Analyze the thermal efficiency of the existing SWH (solar water heater) to ensure the baseline design by conducting Field / Lab experiment.
2. Build 3D model of SWH and perform Finite element analysis for thermal efficiency.
3. Identify the best insulation material based coefficient of thermal conductivity and ensuring by lab test, FEA, mathematical calculation and correlation from the given samples.
4. Perform the FEA analysis with new insulation model to analyze the change in efficiency.
5. Build prototype assembly of SWH with new insulation and perform the comparative field test with baseline SWH.

Determine the heat loss and improved efficiency by critically analyzing all the captured data.

**PROPOSED WORK:**

**Methodology/ Planning of work**

1. Efficiency of the base line SWH to be tested in the field. The peak temperature of the water at the outlet to be recorded on the average sunny day time and the lowest reading on the next morning and record the temperature deference and find the heat loss.
2. Build simplified 3D model of the SWH assembly along with existing insulation using Design Software (Uni-graphics / Catia), and Perform the Finite element analysis on the existing SWH to capture the heat loss.
3. Identify the new insulation material or redesign existing insulation.
4. Perform the FEA analysis on new SWH.
5. Build the prototype model or representative schematic experimental setup for SWH or developed pilot production sample of the SWH with the new material for insulation
6. Conduct field test for the new SWH.
7. Recommend the best alternative

a) **Theoretical work:-**

Principle of Heat Transfer:
The baseline solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the heat to the riser pipes underneath the absorber panel. The water passing through the risers get heated up and delivered the storage tank. The re-circulation of the same water through absorber panel in the collector raises the temperature to 80°C (Maximum) in a good sunny day. The total system with solar collector, storage tank and pipelines is called solar Hot water system.
This project is to improve the efficiency of the existing SWH design. The identified scope is to improve the performance of the insulation of the hot water tank to minimize heat loss caused by lower atmospheric temperatures.

**b) Experimental set-up:**

1. Calculates the performance and operating cost savings of solar domestic hot water heating systems.
2. Incorporates the solar option with other water heating equipment as a backup fuel source and instantly produces operating cost comparisons when combined with Right.
3. Uses industry standard f-chart calculations with built-in libraries of solar and weather conditions.
4. Accounts for orientation of the collector types, such as the slope and azimuth, to produce “what if” scenarios in the placement of the collector types.

Right-Solar DHW uses f-Chart calculations, widely accepted as the benchmark design method for solar systems and developed by the Solar Energy Laboratory at the University of Wisconsin. In combination with a built-in library of solar and weather data, Right-Solar DHW can produce accurate results for any project in any location. The program also fully integrates the solar option with other water heating equipment, which allows the contractor to select any back up fuel source to instantly produce operating cost comparisons that showcase the advantages of a solar system. Depending upon the modules owned, the contractor could also instantly generate a complete bill of material and a professional sales proposal for the homeowner to sign on the spot.

**EXPECTED OUTCOME:**

1. To save energy.
2. To improve the efficiency.
3. To reduce the emissions & energy consumption.
4. Pollution free
5. To reduce cost and make it compact.

### BASIC TYPES OF INSULATION

<table>
<thead>
<tr>
<th>Type</th>
<th>Form</th>
<th>Temp. Range</th>
<th>Mean Temp. C (F)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLASS CELLULAR</td>
<td>Pipe Covering Block</td>
<td>-29.8°C to 42.7°C to 89.9°C</td>
<td>0.048 (3.3) @ 4° (40°F)</td>
<td>Good strength, water and vapour resistant, non-combustible, poor abrasion resistance.</td>
</tr>
<tr>
<td>GLASS FIBER</td>
<td>Pipe Coating 50</td>
<td>-45°C to 85°F to 100°F</td>
<td>0.035 (2.4) @ 4° (40°F)</td>
<td>Good workability, non-combustible, water absorbent. Readily available. Vapour retarder required. Low compressive strength.</td>
</tr>
<tr>
<td>ELASTOMERIC FOAM</td>
<td>Pipe Sheet 2</td>
<td>-6°C to 10°C to 22°C</td>
<td>0.038 (2.7) @ 10° (50°F)</td>
<td>Closed cell good workability, finish not required. Limited thickness to meet flame spread/smoke. Required UV protection.</td>
</tr>
<tr>
<td>POLYSTYRENE (Expanded)</td>
<td>Pipe Coating 50</td>
<td>-4°C to 74°C to 9°C</td>
<td>0.035 (2.4) @ 4° (40°F)</td>
<td>Lightweight, good workability. Checks manufacturer's data. Combustible. Some are treated for fire retardancy. All are closed cell except polystyrene expanded.</td>
</tr>
<tr>
<td>POLYSTYRENE (Expanded)</td>
<td>Pipe Coating 50</td>
<td>-4°C to 74°C to 9°C</td>
<td>0.036 (2.5) @ 4° (40°F)</td>
<td>Lightweight, good workability. Checks manufacturer's data. Combustible. Some are treated for fire retardancy. All are closed cell except polystyrene expanded.</td>
</tr>
<tr>
<td>POLYURETHANE</td>
<td>Pipe Coating 50</td>
<td>-4°C to 70°C to 6°C</td>
<td>0.025 (1.8) @ 4° (40°F)</td>
<td>K-value may change as these materials age. Combustible.</td>
</tr>
<tr>
<td>POLYURETHANE</td>
<td>Pipe Coating 50</td>
<td>-70°C to 100°C to 6°C</td>
<td>0.036 (2.5) @ 10° (50°F)</td>
<td>High flame spread and smoke.</td>
</tr>
<tr>
<td>POLYSOXYLANURATE</td>
<td>Pipe Coating 50</td>
<td>90°C to 20°C to 2°C</td>
<td>0.025 (1.8) @ 4° (40°F)</td>
<td>Lightweight, good workability. Checks manufacturer’s data. Some are treated for fire retardancy. K Values may change with age.</td>
</tr>
</tbody>
</table>

**REFERENCES**