Study Thermal Stratification Analysis of Solar Water Heating Systems

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Abstract

An Innovative design of hot water storage tank developed and tested. For innovative hot water storage tank design specification consist of MS plate, 50 mm puff insulation, outer-cladding used for side cover, inside coating with Fiber Reinforcement plastic and partition for hot and cold water in ratio of sixty to forty percent. In this paper compare thermal stratification of standard solar hot water tank with an innovative tank. In conventional hot water storage tank Maximum Thermal stratification found in morning while for innovative design Maximum Thermal stratification found in evening. By providing FPR coating night heat losses get reduced at expense of thermal stratification. Result shows that Thermal stratification significant in discharging process only while for charging its value nearly same for conventional as well as innovative hot water storage tank.

Keywords: *Solar Water Heater, Thermal Stratification*

1 Introduction

In a thermally stratified situation, the temperature of the contained liquid varies from the bottom to the top, being less at the bottom and more at the top. This situation is in contrast to that obtained in a well-mixed tank in which the liquid temperature is uniform throughout.

Thermal stratification is obviously desirable if the temperature difference (T_L-Ti) (Fig. 1), is significant. If the line taking liquid to the load at the required temperature T_L is located appropriately near the top of the storage tank, then only the liquid near this exit port has to be at the temperature T_L. The rest of the liquid in the storage tank can be at a lower temperature at all times. As a result, heat losses from the tank are reduced. A second advantage is that the collectors operate at a lower temperature level and deliver higher collection efficiency.

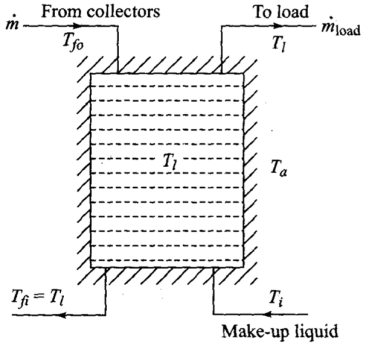

Fig 1 Thermal stratification in hot water storage tank

2. Design Specification of Tanks

For Conventional Tank
Capacity: 125 LPD
Diameter: 400 mm
Length: 1000mm
MS Plate: 2 mm thickness
Puff insulation: 50 mm thicknesses

For Innovative tank
Capacity: 125 LPD
Diameter: 400 mm
Length: 1000mm
MS Plate: 2 mm thickness
Puff insulation: 50 mm thicknesses

Material List		
Sr No	**Material**	**Specification**
1	Aluminum Casing	1.2 mm thickness
2	GI Color Coated back cover	1.1m*1.94m*0.0005m
3	Rock wool insulation	50 mm thickness
4	Header Tube	Ø0.025m, L = 1.05m
5	Copper riser	Ø0.012m, L= 1.89m
6	Fitment flanges	For Installation
7	Top cover toughened glass	0.0004m thick
8	FPC stand	For Installation
9	MS sheet	2 mm thickness
10	MS pipe nipple	1 inch
11	Puff insulation	50 mm thicknesses
12	Outer cladding	Side cover
13	Mounting Stand	For installation
14	Temperature sensor	PT 100
15	Bolt Mild Steel	M10*40
16	Fiber Reinforcment coating	inside coating
17	Absorber Unit aluminium	0.97m*1.810m*0.01m
18	Pipe Fitting	3/4 inch aqua pipe
19	Ball Valve	3/4 inch
20	Tank	300 L
21	Digital Indicator	12 Connection
22	Wire	10 Connection
23	MS wall Stand	For mounting Digital Indicator

Table 1 Material List

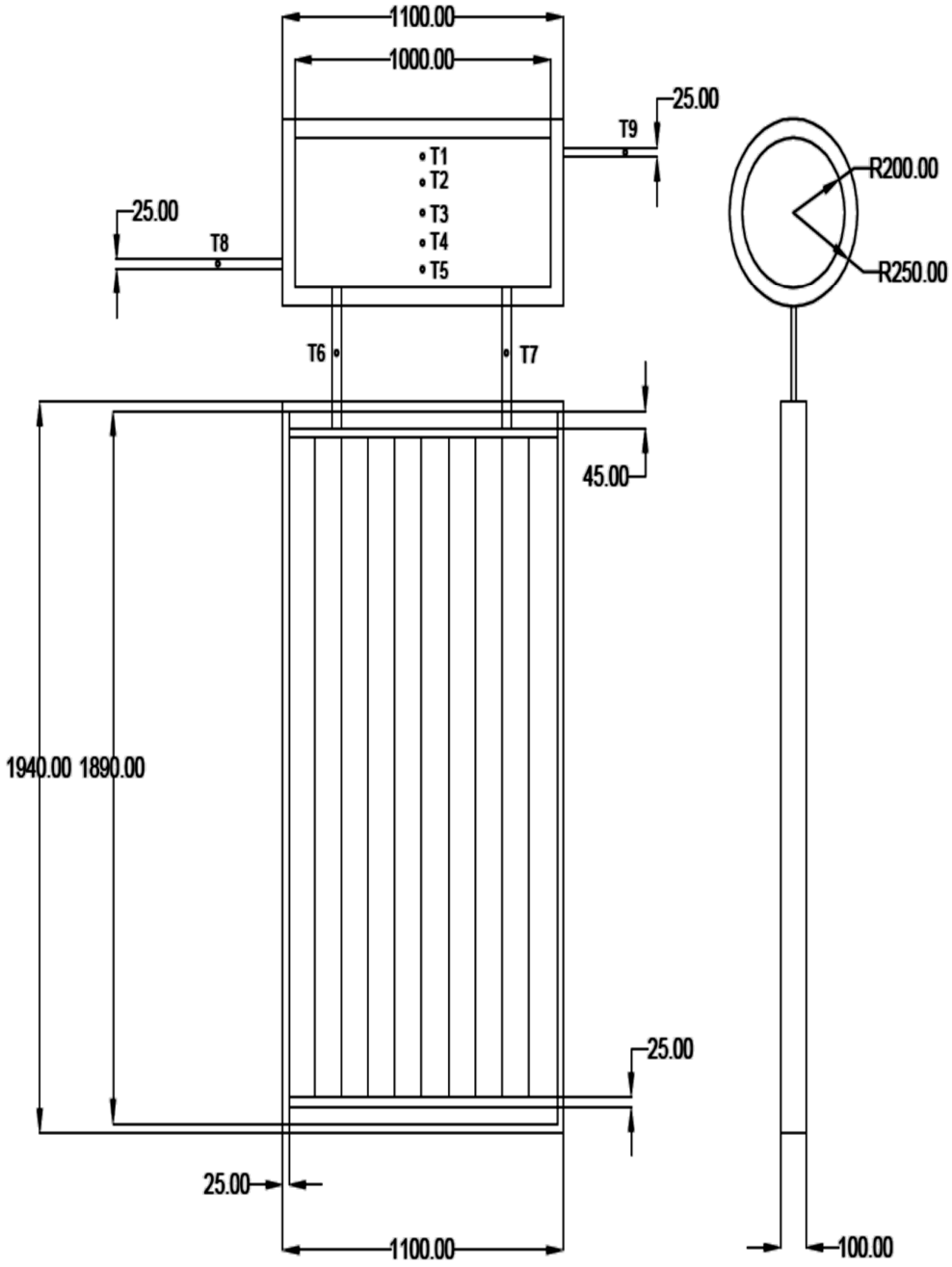

Fig 2 Standard Solar Water Heating System

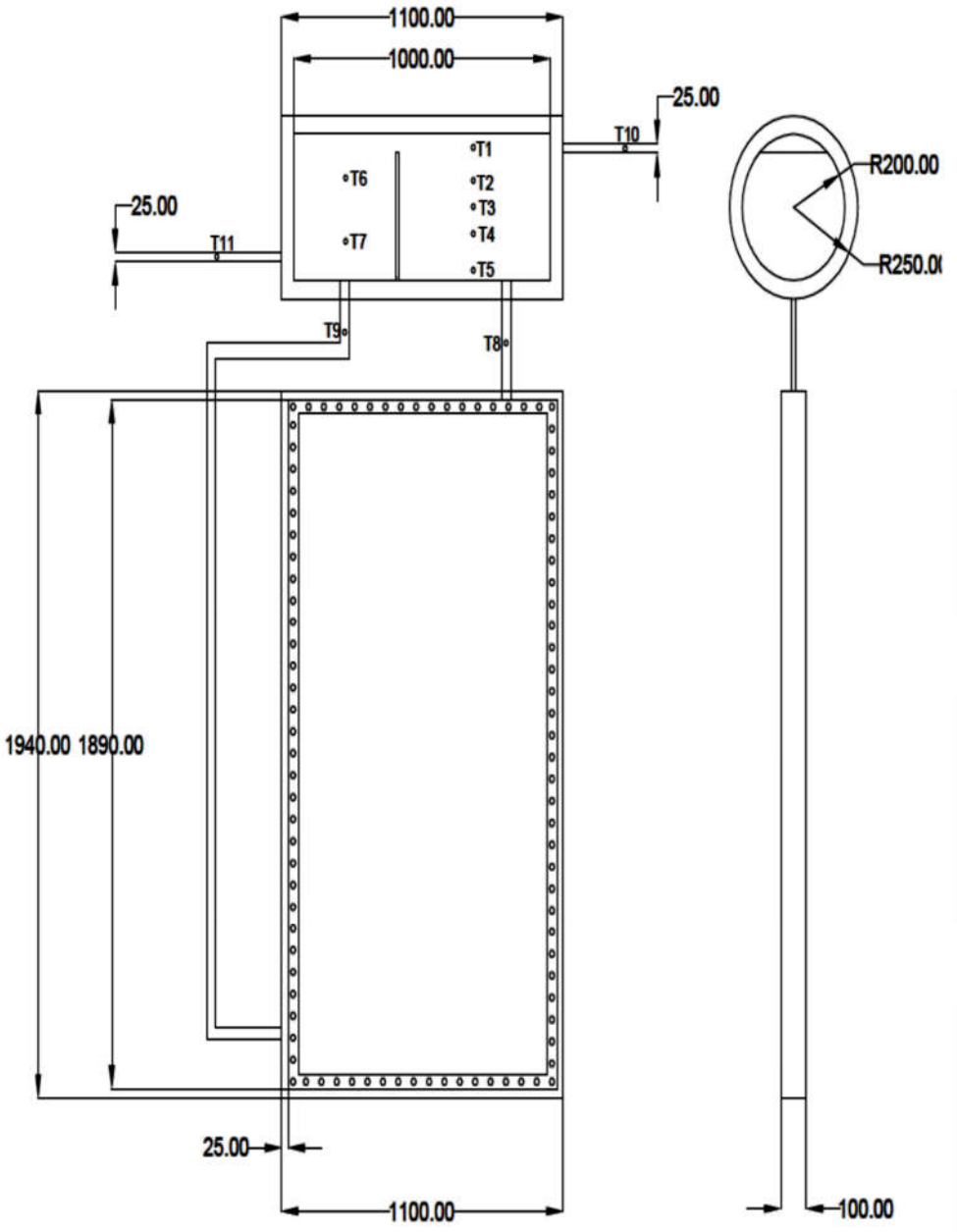

Fig 3 Modified Solar Water Heating System

3. Experimental work:

Day 1 Time : 04:30 PM					
Conventional Hot water Tank			Modified Hot water Tank		
SENSOR	LOCATION	Temperature	SENSOR	LOCATION	Temperature
T_1	Layer 1 (From Top)	75.2	T_1	Layer 1 (From Top)	63.3
T_2	Layer 2	75.2	T_2	Layer 2	63.4
T_3	Layer 3	75	T_3	Layer 3	63.1
T_4	Layer 4	74.7	T_4	Layer 4	63.1
T_5	Layer 5	73.8	T_5	Layer 5	60.5

Table 2 reading in Evening

			Day 2 Time : Time : 10:30 AM		
Conventional Hot water Tank			Modified Hot water Tank		
SENSOR	LOCATION	Temperature	SENSOR	LOCATION	Temperature
T_1	Layer 1 (From Top)	66.6	T_1	Layer 1 (From Top)	56.6
T_2	Layer 2	66.6	T_2	Layer 2	56.5
T_3	Layer 3	66.5	T_3	Layer 3	56.4
T_4	Layer 4	65.9	T_4	Layer 4	56.3
T_5	Layer 5	64.3	T_5	Layer 5	55.2

Table 2 reading in Morning

4. Result & Discussion:

For conventional hot water storage tank & innovative tank design reading were taken in morning & evening time. Maximum thermal stratification is 2.3^0C for conventional hot water storage tank in morning while Maximum thermal stratification is 2.8^0C for innovative tank design in evening.

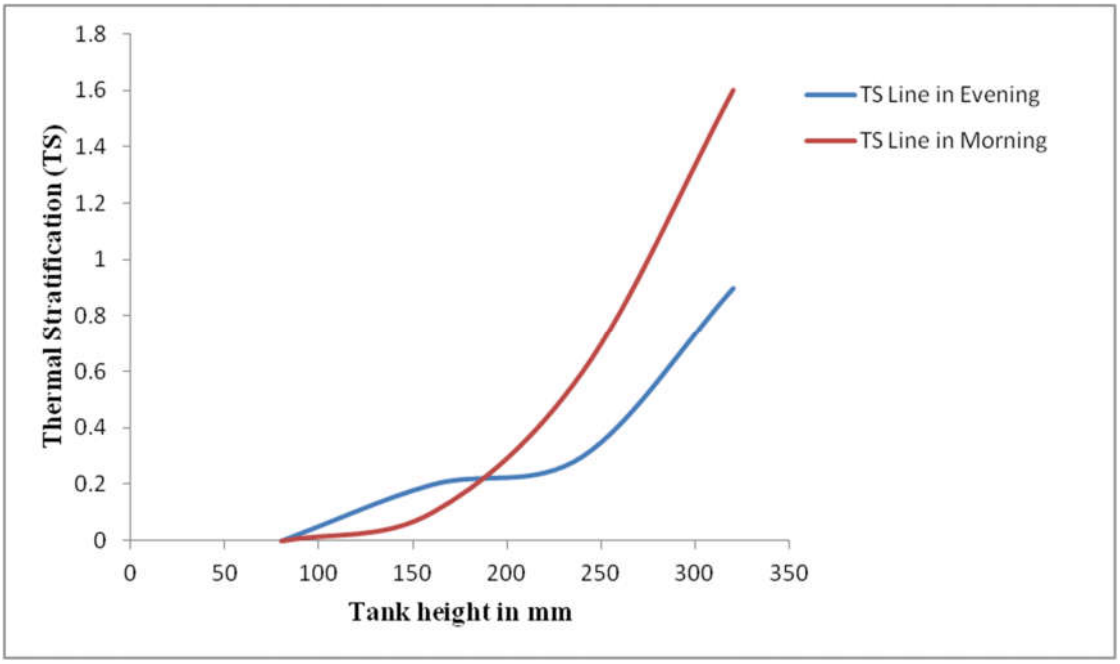

Fig 4 Thermal Stratification for Conventional hot water tank

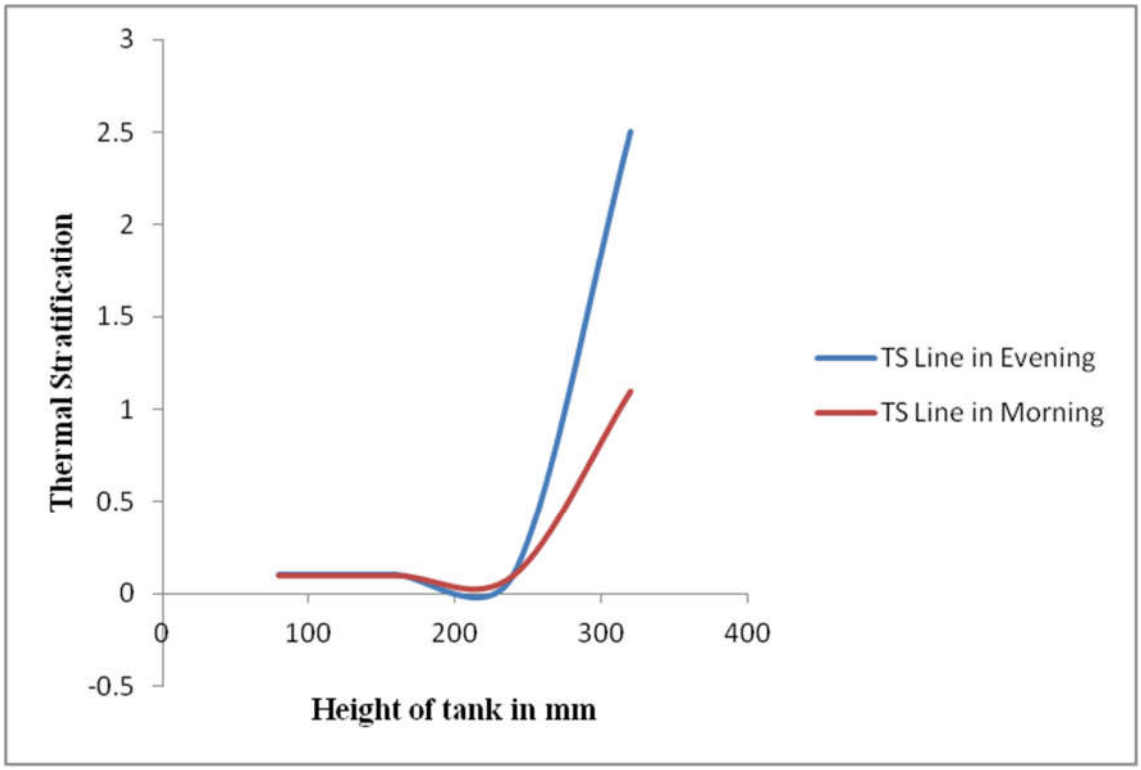

Fig 5 Thermal Stratification for Innovative hot water tank

5. Conclusions:

For conventional hot water storage tank Maximum Thermal stratification found 2.3^{0}C in morning & minimum Thermal stratification found 1.4^{0}C in evening while for innovative design Maximum Thermal stratification found 2.8^{0}C in evening & minimum Thermal stratification found 1.4^{0}C in morning. By providing FPR coating night heat losses get reduced at expense of thermal stratification. Thermal stratification is desirable and its natural process but if night heat losses reduce by any technique it will reduce thermal stratification. It's not possible to get both advantages at same time. Result also shows that Thermal stratification significant in discharging process only while for charging its value nearly same 1.4 for conventional as well as innovative hot water storage tank.

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References

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