Review on "To Maintain the Temperature of Overhead Water Tank"

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Abstract— To introduce "To Maintain the Temperature on Overhead Water Tank" which is to be insulated by the different layers of material, so that the temperature of water stored inside does not get affected by outside condition & heat transfer through tank should be reduced. The concept behind deals with the low thermal conductivity (k) & high specific heat (CP) of material used for insulation of tank so that the heat transfer through tank is reduced. These overhead tanks & storage reservoirs are used to store water & liquids in any weather condition. In summer & winter season, the insulating materials Foam, Polystyrene (Thermocol), Aluminium Foil, Virgin Plastic(White) resist the heat flow in & out of the system. We use Virgin Plastics layer inside and outside of tank. After an inner layer of Virgin Plastic, it is insulated by a thin layer of Aluminium foil and after that a thick layer of Polystyrene (Thermocol) is used as an insulator, which is also insulated by Aluminium foil. After Aluminium foil a thick layer of foam is used to insulate the tank.

Keywords: Heat and Mass Transfer (HMT), Solar Radiation Law of Thermodynamics, Quasi-Static process, Heating of Domestic storage water tank

I. INTRODUCTION

The main aim behind advances in engineering and technology has to raise the standard of living of man and to make his life more comfortable. Manufacturing is an essential component for industrial and domestic purposes.

Water is necessary for human's life; therefore, the storing of water is necessary. The need of water tanks is as old as civilization to provide storage of water for drinking and for many other applications. These containers were naturally occurring, some are manmade and a few of these tanks are still in service.

For domestic purpose the plastic water tanks are used as overhead tanks. The water stored in plastic tank gets hotter in summer and gets colder in winter than the normal temperature. Depending upon the weather the temperature of water stored inside tank varies from high to low which should be maintained at normal temperature(24°C-27°C)as per human's requirement.

In the modern economy the human comfort is also plays the major issue for the engineers. Therefore, keeping in mind for human comfort the temperature of water stored inside the tank should be maintained appropriately. Thus for the same our proposed design can be used for maintaining the temperature of water inside the tank in any weather condition.

II. METHODOLOGY

A. Heat

It is apparent that neither δW or δQ are exact differentials and, therefore, any integration of elemental quantities of work or heat which appear during a change from state 1 to 2 must be written as

$\int_1^2 \delta W = W_{1\text{-}2}$ or ${}_1W_2$ (or W), and
$\int_1^2 \delta Q = Q_{1\text{-}2}$ or ${}_1Q_2$ (or Q)
Thermal Conduction Resistance $(R_{th})_{cond.}$

$$(R_{th})_{cond.} = \frac{dx}{kA}$$

B. Why insulation of the Tank Is Required?

It is observed that in different weather like summer and winter the temperature of water stored inside the tank varies depending upon the outer temperature of the tank, like in summer the water gets hot by taking the heat from outside and in winters the water becomes cold due to the outer temperature.

To get rid out off this problem, we proposed to insulate the water tank to maintain the temperature of stored water at normal temperature in any weather conditions.

C. Insulation Advantage and Materials Properties Required:

After insulation, the liquid stored inside the tank should be maintain at normal temperature, also the heat transfers from the inside and outside of the body is to be reduced.

The material with low thermal conductivity and high specific heat is required for insulation of the tank. In simple words, material with high thermal conductivity leads to higher rate of heat transfer through inner & outer surface of the material, if this happens insulation gets fails. Also materials selected should be cheap; so that tank doesn't get too much costlier than conventional plastic tanks used.

III. RESULT & DISCUSSION

A. Insulating Material Used

The following insulating materials are used for insulating the water tank.

- Virgin Plastic
- Aluminum Foil
- Polystyrene (Thermocol)
- Foam

1) Aluminum Foil

Foil is a very thin sheet tensile properties. The thickness of foil range from the thinnest currently produced commercially at 0.0065 mm to the defined upper limit of 0.2 mm is defined as sheet or strip. Aluminum foils thicker than 25 µm are impermeable to oxygen and water.

2) Virgin plastic:

Virgin means fresh plastic is being used to make the product. We must be knowing that most of the plastics are recyclable and to reduce the wastage during manufacturing process. Most of the industries reuse the rejected product by recycling the same.

S No.	Material	Thermal Conductivity (w/mk)	Specific Heat (Kj/kg-k)
1.	Brick	1.6	0.84
2.	Cement Mortar	1.73	0.75
3.	Cement Block	2.07	0.48
4.	Cast Iron	58	0.025
5.	Polystyrene	0.028	1.4
6.	Aluminium Foil	0.03	1.25
7.	Foam	0.033	1.3

Table 1: Different Material Requirment Thermal Conductivity

Material	Thermal Conductivity(w/mk)
Wood husk	0.08
Slag wool	0.042
Glass wool, Fiberglass	0.04
Cotton wool	0.029
Carbon dioxide(gas)	0.014
Vermiculite granules	0.065
Balsa wood	0.048
Cork	0.04
Cotton	0.04
Urethane foam	0.021
Wax	0.08
Foam glass	0.04
Perlite	0.00137
Plastics	0.03

Table 2: Materials Suggested

B. Working

It works on principle of thermal insulation, thermal resistance & low heat transfer. Different types of insulators are used for maintaining the temperature of stored water, constant in different weather conditions.

C. Construction

Tank is insulated by different thermal insulating material such as Aluminium Foil, Polystyrene (Thermocol) and Foam, these are compactly intact so as to reduce the Heat Transfer and Thermally Insulate the tank.

The inner layer of virgin plastic is wrapped by no. of layers of aluminium foil.

Secondly this layer is surrounded by layers of polystyrene which is again wrapped by the aluminium foil. These three layers of insulation are again coated by wrapping layer of foam over it. Now the outermost protective covering of virgin plastic (white) is used to cover the whole system which makes tank durable, protective and weather proof.

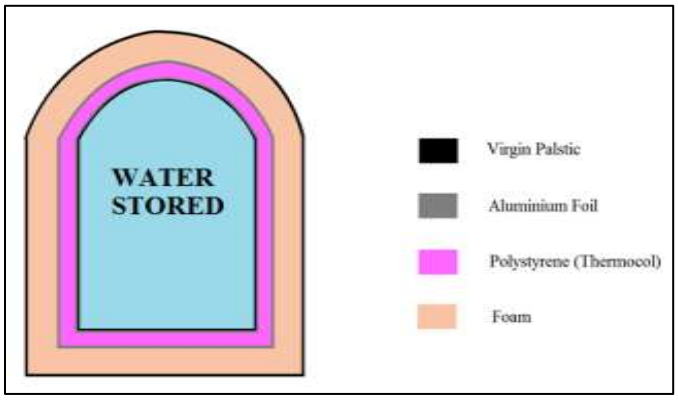


Fig. 1: Storege Tank

S.no.	Material	Thermal conductivity(W/mK)	Thermal convectivity(W/m^2K)	Temperature (˚C)
1.	Virgin plastic	0.35	-----	300
2.	Thermocol	0.028	-----	240
3.	Aluminum foil	0.03		340
4.	Foam	0.033		115
5.	Air	-----	200	-----
6.	Water	-----	100-1200	-----

Table 3: Properties of Materials

S.No.	Layer of Material	Thickness(mm)	Radius(mm)
1.	Virgin Plastic	15	500
2.	Thermocol	80	500.33
3.	Aluminum	0.24	660.33
4.	Foam	60	660.66
5.	Virgin Plastic	15	840.66

Table 4: Thickness of Material

IV. CALCULATION

Without Insulation

Calculation for Cylindrical:

Heat transfer Q = $\frac{\delta T}{\Sigma Rth}$

δT = Inner temperature – outer temperature

$\Sigma Rth = \frac{1}{2\pi L}\left[\frac{1}{hiri} + \frac{1}{k1}\ln\left(\frac{r2}{r1}\right) + \frac{1}{h0r2}\right]$

$\Sigma Rth = \frac{1}{2\pi \times .38}\left[\frac{1}{1000\times 0.5} + \frac{1}{0.03}\ln\left(\frac{500.33}{500}\right) + \frac{1}{200\times 0.50033}\right]$

$\Sigma Rth = 0.4188[2\times 10^{-3} + 0.0219 + 9.993\times 10^{-3}]$

$\Sigma Rth = 0.0142$

Heat Transfer (Q) = $\frac{55-25}{0.0142}$

$= \frac{30}{0.0142}$

$= 2112.67$

Heat Transfer = 2112.67 Watt.

With Insulation

Calculation for Cylindrical:

Heat transfer Q = $\frac{\delta T}{\Sigma Rth}$

δT = Inner temperature – outer temperature

$$\Sigma Rth = \frac{1}{2\pi L}\left[\frac{1}{hiri} + \frac{1}{k1}\ln\left(\frac{r2}{r1}\right) + \frac{1}{k2}\ln\left(\frac{r3}{r4}\right) + \frac{1}{k3}\ln\left(\frac{r4}{r3}\right) + \frac{1}{k4}\ln\left(\frac{r5}{r4}\right) + \frac{1}{k5}\ln\left(\frac{r6}{r5}\right) + \frac{1}{h0r6}\right]$$

$$\Sigma Rth = \frac{1}{2\pi\times.38}\left[\frac{1}{1000\times0.5} + \frac{1}{0.03}\ln\left(\frac{500.33}{500}\right) + \frac{1}{0.028}\ln\left(\frac{660.33}{500.33}\right) + \frac{1}{0.03}\ln\left(\frac{660.66}{660.33}\right) + \frac{1}{0.033}\ln\left(\frac{840.66}{660.66}\right) + \frac{1}{0.35}\ln\left(\frac{855.66}{840.66}\right) + \frac{1}{200\times0.8556}\right]$$

$\Sigma Rth = 0.4188[2\times10^{-3} + 0.0219 + 9.90 + 0.0166 + 7.3014 + 0.505 + 5.843\times10^{-3}]$

$\Sigma Rth = 7.434$

Heat Transfer (Q)= $\frac{55-25}{7.434}$

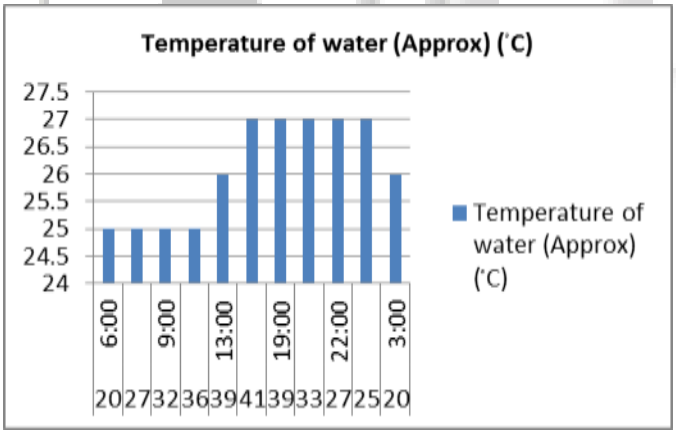
$= \frac{30}{7.434}$

$= 4.03$

Heat Transfer = 4.03 Watt.

S. No.	Atmospheric Temperature (˚C)	Time	Temperature of water (Approx) (˚C)
1.	20	06:00	25
2.	27	08:00	25
3.	32	09:00	25
4.	36	10:00	25
5.	39	13:00	26
6.	41	16:00	27
7.	39	19:00	27
8.	33	21:00	27
9.	27	22:00	27
10.	25	01:00	27
11.	20	03:00	26

Table 5: Temperature Variation with Respect to Time in Summer Season:



Graph 1: Temperature Variation with Respect to Time in Summer Season

A. Cost Analysis:

At present the conventional tanks which are available in market, has approx. cost of Rs.2500 (500Ltrs). After insulating the same conventional tank by Aluminium foil, Thermocol, Foam. Cost of the tank will be increased by Rs.1000 (approx.).

Calculation:

Cost analysis of 500 ltrs tank

Height of tank :- 0.38m

Material	Side wall (m^2)	Top & Bottom (m^2)
Aluminium Foil	4	8.86
Thermocol	2.1	8.86
Foam	2.5	8.86

Table 6: Material required for insulation

Material Cost	Price(Rs.)
Aluminium Foil	130
Thermocol	310
Foam	600
Total Cost	1040

Table 7: Manufacturing Cost

Gross Cost of a tank:

Insulation Cost - Rs. 1040

Cost of conventional tank- Rs. 2500

Total Cost - Rs. 3540

V. CONCLUSION

The conclusion of our project is that we are insulating the tank with different layers of insulating materials so as to reduce the heat transfer in and out of the tank. This is done in order to maintain the temperature of water stored in tank.

Advantages Recognized

Several advantages were found over the conventional tanks.

- Maintains the temperature of liquid constant stored in tank.
- Can be used in any weather condition.
- Works effectively between atmospheric temperature range 20˚C – 50˚C.
- Cheap, Effective & Durable.
- Low initial setup cost.

VI. FUTURE SCOPE

- Can be used in tanks, used for transportation purpose of liquids & chemicals which requires maintained temperature.
- Can replace the conventional tanks.

Uses:

Mainly the overhead tank is used in two different places.

- Industrial
- Domestic

Industrial: -

- In the Industries, the overhead tank used to contain the feeding fuels, supply into the industry.
- In the Industries, the overhead tank is also used to store the water as fire suppression.
- Some of the Industries need cooling towers, where the overhead tank used as a cooling tower.
- In the Industries, overhead tank is used for generating the electricity by running turbine.

Domestic:

- The overhead tank is used to store and supply the water at home for different applications.
- The overhead tank stores water in agriculture field, which can be used for farming.

Can be treated as best alternative for overhead tanks used in domestic purposes.

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