Proceedings of the
International Conference on Mechanical Engineering and Renewable Energy 2011
(ICMERE2011) 22- 24 December 2011, Chittagong, Bangladesh

ICMERE2011-PI-032

ABATEMENT OF ENERGY LOSS BY INSULATING SYSTEM AND DESIGNING AUTOMATIC WATER HEATER

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Abstract*-The most suitable temperature range for domestic purposes is about 20^0C to 26^0C .Besides, both cold and hot water appear to be essential frequently for industrial purposes. In summer bringing down the water temperature at a comfortable range causes significant energy consumption. This project aims at saving energy to control water temperature by making water tank insulated .Therefore applying better insulation system which would reduce the disparity between the desired temperature and the actual temperature and hence saving energy significantly. Following the investigation, this project used cotton jacket to insulate the tank and the tank was placed under a paddy straw shade with a view to attaining the maximum energy saving. Finally, it has been found that reduction in energy consumption is to be about 50-60% which is quite satisfactory. Since comfortable temperature range varies from person to person this project thus combines insulating effect with automatic water heater.*

Keywords: Tank water, temperature, insulation, energy, microcontroller

1. INTRODUCTION

In the face of high and rising energy prices as well as worsening climate problem, it is necessary to examine and realize the potential for saving energy in the energy sector. A recent study by Armacell shows, even in modern, well insulated houses energy can be achieved .through optimal pipe and tank insulation of space heating and domestic hot water distribution systems further energy savings accompanied by a reduction in CO_2 emissions are possible[1] .Moreover, It is reported that the insulation of double glazed windows can reduce heat loss by as much as 36 % [2].A survey can also be conducted for water heater storage tank insulation [3] . A search of the Solar Energy journal, Solar Energy Engineering journal, Renewable Energy journal and other energy journals shows that there were few research papers that reported on the effects of pipe insulation between collector and storage tank specifically for domestic split systems. While it is reported on system optimisation of most components, they overlooked the effect of supply and return pipes being uninsulated and simply assumed these pipes would be insulated at a specified level [4]. Nashar [5] conducted specifically examining "heat loss through the piping of a large solar collector field" but this was for large commercial systems and the results are not easily transferrable to small domestic systems. Lixing developed a model for heat losses from the storage tank to end-use points. These losses were estimated by the California Energy Commission to exceed 20 percent in many domestic systems [6]. The variation of temperature during summer & winter directly impacts on the contained water in the tank due to uninsulated piping. But comfortable temperature of water for drinking and for other purpose is about 20 °C (68 °F) to 25 °C (77 °F). Besides, the temperature of drinking water should be at comfortable range to save the energy of human body. In adult men and women the normal range for body temperature is 33.2–38.2 °C (92–101 °F). In addition to that, in processing the water during summer and winter, a significant energy is to be supplied. By using the insulation in the water tank and water pipe line, the energy needed to process the water can be reduced appreciably. At winter season in Bangladesh temperature generally varies from 7°C to 22°C and summer season from 25 °C to 40°C. So temperature of water inside the tank varies. Too low temperature and too high temperature of tank water affects the human comfort and create various troubles. Generally water storage tank placed at the roof of the house and takes water from underground. The temperature of underground water is comfortable .So for keeping tank water at underground water temperature it is necessary to find out better insulation techniques of water tank and pipe line. Heat transfer is the transition of thermal energy from a hotter mass to a cooler mass. When an object is at a different temperature than its surroundings or another object, transfer of thermal energy, also known as heat flow, or heat exchange, occurs in such a way that the body and the surroundings reach thermal equilibrium. Heat

transfer processes are classified into three types. The first is conduction, which is defined as transfer of heat occurring through intervening matter without bulk motion of the matter. By this mode, heat energy is passed through a solid, liquid or gas from molecule to molecule in a material. The second is convection, the transfer of thermal energy by the movement of molecules from one part of the material to another. And the last one is radiation, the transfer of heat energy through empty space. No medium is necessary for radiation to occur, for it is transferred through electromagnetic waves; radiation works even in and through a perfect vacuum.

2. EXPERIMENTAL SETUP AND TEST PROCEDURE

The experiments were carried out in both summer and winter season. Experimental results were also recorded for various insulating materials and insulating system. Finally the best insulating material and system has been adopted with the circuit-based water heater.

2.1 Choosing Insulating Material

Several insulating materials like saw dust, cotton, wool, paddy husk etc. have been investigated for insulating the water vessel. Cotton however has been selected as insulating material due to its less thermal conductivity, low price , availability, ease to make desire shape. By minimizing heat transfer through the envelope, energy used to maintain the interior condition of water is similarly minimized. Table 1 shows properties of some insulating materials.[7]

Table 1: Properties of Insulation materials

SOME CHEAP
INSULATING MATERIALS:

NAME	THERMAL CONDUCTIVITY(w/mk)
Paddy husk	0.044
Wool	0.029
Cotton	0.03
Saw dust	0.08
Sand stone	0.75
Straw	0.09
Coark board	0.06
Clay	0.15-1.8
chalk	0.045

2.2 Experimental Setup for Insulating System

For circular tanks, insulation jackets are available in a range of standard sizes. The sizes are measured by the vertical height of the tank to the top of the dome and the overall diameter, so jacket of the correct size can be found readily. Most cylinder jackets are made up of a number of segments held together by a cord tied around the top of the cylinder and a number of 'belts' around the tank. Figure 1 shows the experimental insulating system. The jacket is wrapped around the cylinder without applying excessive pressure as this can compress and reduce the effectiveness of the insulation. Then, one of the belts has been wrapped around the jacket, fastened loosely

Fig1. Experimental setup for insulating system

. Likewise, other belts have been wrapped at different locations of the cylinder. It was confirmed eventually that the segments fully covered the tank with no gaps. To protect insulating material from environment effects water proof cloth has been used. Moreover, a roof was placed in the final arrangement to protect the direct heat transfer from the sun ray.

2.3 Eexperimental Setup for Temperature Control

The automatic water heater contains temperature sensor LM-35, it senses temperature and sends 10mV to the microcontroller for per degree increasing of temperature. ADC (analog to digital converter) converts this analog signal to digital. Microcontroller displays this digital signal by LCD monitor Figure 2 shows the water heater in operation along with a

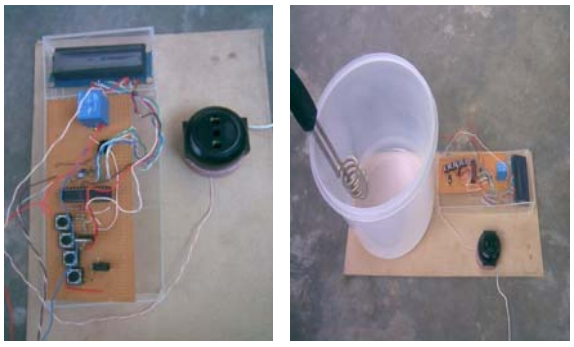

Fig.2. Photographs of temperature control system

electrical circuit which controls the heater as needed. Also microcontroller contains programmable data which guides the water heater to turn off and on due to the selected temperature range. When any push button is pressed, Vcc sends 5 volts to the controller.

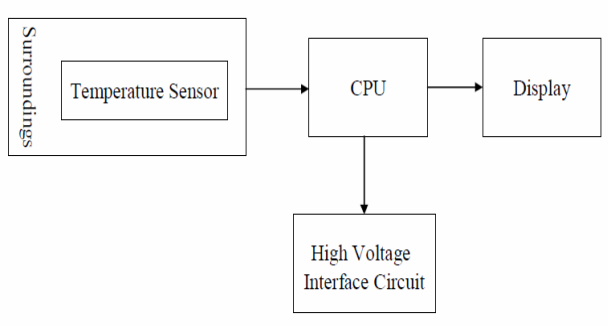

Fig.3: Block diagram of automatic water heater

Then the programme starts working. From menu buttons the upper & lower temperature range can be selected. When temperature of the storage water falls below the lower temperature limit, relay activates the circuit so that the water heater starts working.

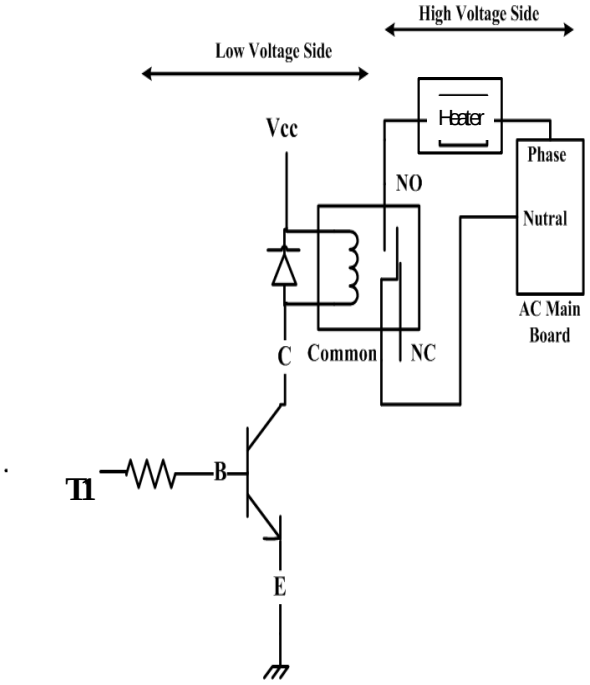

Fig .4: Circuit diagram for temperature control

If the temperature rises beyond the upper limit, the circuit makes the water heater idle. Figure 3 depicts the block diagram of the water heater employed in the current investigation. The circuit diagram of the electrical circuit used to control the heater's operation is shown in Fig.4.

3. EXPERIMENTAL RECORDS AND RESULTS

3.1. Effect of Temperature Variation (Cavity Wall Insulating System):

Figure 5 shows the effect of temperature variation in summer with and without insulation. After 90 minute water temperature without insulating surpasses the atmospheric temperature whereas with Insulation the water temperature always lowers than the atmospheric temperature which is desirable. More importantly, Fig.5 evidences that with insulation the water temperature is about seven degree lower than the atmospheric temperature.

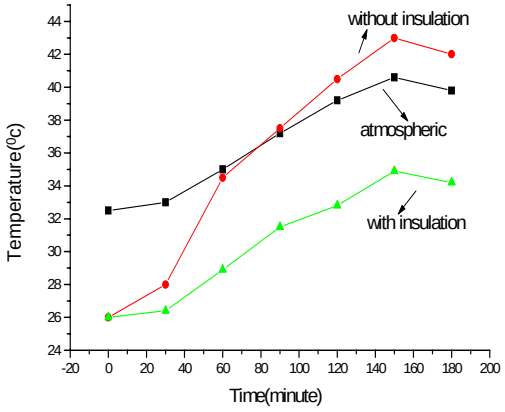

Fig.5: Effect of temperature variation (Cavity wall insulation system)

3.2. Effect of Temperature Variation (Jacket System)

Figure 5 shows the effect of temperature variation in Winter with and without insulation after 90 minute water temperature without insulation comes below the atmospheric temperature whereas with insulation water temperature always higher than the atmospheric temperature which is desirable.

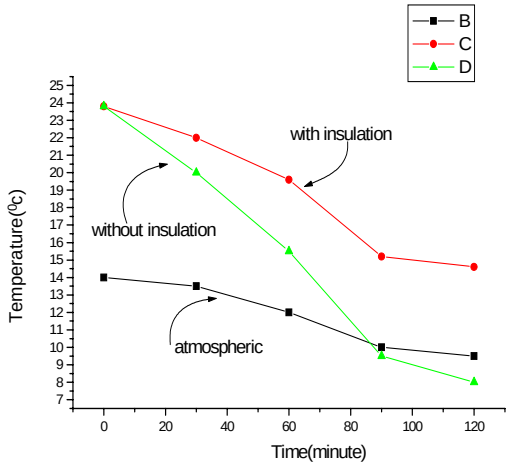

Fig. 6: Effect of temperature variation (jacket system)

More importantly, Fig.6 tells that with Insulation the water temperature is about eight to ten degree lower than the atmospheric temperature.

The overall assessment of Fig.5 and Fig.6 suggests that a significant temperature variation exists due to insulation system during both summer and winter season.

3.3 Performance Test of an Automatic Water Heater:

Table 2 shows the performance of automatic water heater within different temperature range.

Table 2: Performance test of automatic water heater

Ob No.	Selected lower temp. (˚C)T1	Selected upper temp. (˚C)T2	water temp. below T1	water temp. above T2
1	8	20	on	off
2	16	25	on	off
3	24	30	on	off
4	32	35	on	off

From table it is clear that when the water temperature crosses the lower or the higher limit of temperature, the water heater goes on off mode which is desired to save power consumption.

4. CONCLUSION

The objective of the current investigation is fulfilled by using insulating material (cotton) & jacket insulating procedure. It was observed that by using insulating material (cotton) heat transfer rate reduced about 15% & the temperature variation between without and with insulation has been found to be 7(°c) to 10(°c) . Much amount of energy is therefore saved for cooling water during summer season and heating water during winter season. Also a device has been fabricated which can sense the temperature and automatically on or off the switch of the water heater. The device has also an option to regulate the comfortable temperature range. Eventually, insulating system reduced energy consumption of about 50-60% which is quite satisfactory.

5. REFERENCES

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6. NOMENCLATURE

Symbol	Meaning	Unit
T	Temperature	(K)
P	Pressure	(Pa)
A	State transition matrix	Dimentio-nless