CHAPTER - V

SUMMARY OF RESULTS AND CONCLUSION

Single slope solar still and pyramid solar still are designed and their performances are studied individually as well as with tar coated blue metal and phase change material (paraffin wax).

5.1 Single Slope and Pyramid Solar Still – Individual Performance:

The maximum water temperature obtained for the single slope solar still and the pyramid solar still are 57.5 ˚C and 58 ˚C respectively. The observed temperature values of these studies show that pyramid solar still attained maximum water temperature. The solar insolations received in all three modes of studies reported are almost equal.

The average distillate yield per day from (9am -6pm) including nocturnal output from (6pm -6am) is 1.6532kg for the single slope solar still and 1.6899 kg for pyramid solar still. A significant rate of increase in distilled yield is observed in pyramid solar still.

The instantaneous efficiency obtained for the single slope solar still without storage is in the range of 2.27 % to 27.30 %. Similarly the efficiency variations observed for pyramid solar still is 2.52 % to 32.73 % . The average efficiency for these studies is 19.55 % for the single slope solar still and 21.60 % for the pyramid solar still. The average efficiency revealed that the performance of the pyramid solar still is better than the single slope solar still. The performance improvement in pyramid solar still is due to minimization of insolation loss from the top cover. Even though the surface area of the top cover of the pyramid solar still is more, a small amount of insolation reflects back at the corners. Thus it creates a small amount of shadow to fall over the water surface during the morning time as well as in the evening time. This shadow effect does not affect the rise in water temperature.

The performance ratio observed for the single slope solar still and the pyramid slope solar still are in the range of 1.94 % to 7.05 % and 2.11 % to 7.25 % respectively. The performance ratio value for pyramid solar still is higher than that of

a single slope solar still. The performance ratio of the stills mainly depends on the rise in water temperature of the still.

5.2 Single slope solar still and Pyramid solar still with tar coated blue metal:

The performance of the single slope solar still and the pyramid solar still with tar coated blue metal is analysed independently (Chapter IV).

The maximum water temperature obtained for the combination of tar coated blue metal are given as 60˚C for single slope solar still and 61 ˚C for pyramid solar still. The maximum temperature obtained in the entire case is almost equal in both types but it differs for distilled yield .

The average distilled yield per day from (9am -6pm) including nocturnal output from (6pm -6am) is 1.874 kg for single slope solar still with tar coated blue metal and 1.9225 kg for pyramid solar still with tar coated blue metal. These results are attributed to higher values for pyramid solar still with tar coated blue metal. Even though the water temperature of the still attains a high order of temperature, it will make a difference in distilled yield . This variation is due to the structure of the top cover system. So the influence of the structure increases the performance ratio value and yield rate to a higher range.

The instantaneous efficiency obtained for the single slope solar still and pyramid solar still with tar coated blue metal are in the range of 4.41 % to 39.52 % and 4.41 % to 42.01 % respectively. The average efficiency observed by these studies is 32.62 % for the single slope solar still and 35.32 % for the pyramid solar still with the same material.The average efficiency revealed that the performance of the pyramid solar still is better than the single slope solar still. The efficiency improvement in pyramid solar still is due to minimization of insolation loss from the top cover, a small amount of insolation reflects back at the corners due to the greater area of the top cover. But it does not affect the rise in water temperature.

The performance ratio observed for single slope solar still and pyramid solar still with tar coated blue metal are in the range of 2.64 % to 8.28 % and 2.64 % to 8.66 % respectively.In this case performance ratio value for the pyramid solar still with tar coated blue metal is higher than that of a single slope solar still with the same

material.The performance ratio of the still mainly depends on the rise in water temperature of the still.

The overall efficiency observed for the single slope solar still and pyramid solar still with tar coated blue metal shows a higher value than that compared to individual performance of the system without any storage. This increase in efficiency is due to the transfer of heat from the tar coated blue metal to the water .As a result of this effect, the efficiency and the water collection rate is more than that in the individual performance.

5.3 Single slope solar still and Pyramid solar still with paraffin wax:

The performance of the single slope solar still and the pyramid solar still with phase change material (paraffin wax) is analysed and discussed in (Chapter IV).

The maximum temperature attained for this study is 59.5 ˚C and 60 ˚C respectively for single slope solar still and pyramid solar still with phase change material (paraffin wax). The maximum rise in water temperature is obtained for pyramid solar still with phase change material (paraffin wax).

Th paraffin wax with this still has a distinctive property which maintains a high temperature for a longer period due to its storage capacity.

The average distilled yield per day from (9am -6pm) including nocturnal output from (6pm -6am) is 2.2057 kg for single slope solar still with paraffin wax and 2.2955 kg for pyramid solar still with the same material. Results attribute higher values for pyramid solar still with paraffin wax.

The instantaneous efficiency obtained for the single slope solar still and pyramid solar still with paraffin wax is in the range of 4.41 % to 36.80 % and 4.42 % to 38.79 % respectively.

The average efficiency for these studies is 33.41 % for the single slope solar still with paraffin wax and 36.61 % for the pyramid solar still with the same material. The average efficiency revealed that the performance of the pyramid solar still with paraffin wax is better than that of the single slope solar still with paraffin wax. The performance improvement in pyramid solar still with paraffin wax is due to

minimization of insolation loss from the top cover. Even though the surface area of the top cover of the pyramid solar still is more, a small amount of insolation reflects back at the corners. Thus it creates a small amount of shadow to fall over the water surface in the morning time as well as in the evening time. This shadow effect does not affect the rise in water temperature.

The performance ratio observed for single slope solar still with paraffin wax and pyramid solar still with the same material are in the range of 2.64 % to 10.64 % and 2.72 % to11.3 % respectively. The performance ratio value for pyramid solar still with paraffin wax is higher than that of a single slope solar still with paraffin wax. The performance ratio of the still mainly depends on the rise in water temperature of the still.

5.4 Overall Conclusion

The overall efficiency of the pyramid solar still observed with paraffin wax shows a higher value than that compared to all other performance studies of the single slope and the pyramid slope solar still.

Even though a very slight increase in the efficiency is observed for still with paraffin wax, the distillate yield and efficiency is maintained even at off sunshine hours due to slow transfer of heat from the phase change material (paraffin wax). As a result of this effect, the overall efficiency and water collection obtained for still with paraffin wax is increased at off sunshine hours.

Even though the achievement of slight increase in efficiency, it does not affect the water collection rate i.e., the water collection rate is more with paraffin wax than that of the individual still and still with tar coated blue metal.

High performance ratio value is obtained for pyramid slope solar still with paraffin wax as a result of the storage effect of heat in paraffin wax, which is utilized at off sunshine hours. But a steady state is achieved only in both stills with tar coated blue metal due to high water temperature maintained during warm up period until the insolation receives over the surface.

In still with thermal storage media (tar coated blue metal) the water collection rate of yield is obtained only during the period of sunshine hours. The yield rate

attained in the still with phase change material (paraffin wax) is almost equal to the yield rate obtained by the still with storage media (tar coated blue metal) during the period of sunshine hours.

But in the case of still with phase change material (paraffin wax) water collection rate is obtained even at off sunshine hours.

The thermophysical properties such as saturation vapour pressure, dynamic viscosity, thermal conductivity, latent heat and density of water and also dimensionless quantity like Grashof number and Nusselt number are estimated and their importance are discussed for all the studies in Chapter IV.

The simulation model is developed for single slope solar still and compared with experimental data (Chapter III). As the simulation model is of one dimensional only, the values will not exactly coincide with experimental data but a similarity can be observed. The maximum theoretical temperature obtained for water and cover in the simulation study is 55.71 ˚C to 45.59 ˚C respectively.

This fruitful attempt made to analyse two different types of stills in different modes of operations (individual, with tar coated blue metal absorber and paraffin wax). These results revealed that the pyramid solar still with paraffin wax showed higher rate of distillate yield.

- The water collection yield can be further increased by adopting top cover cooling process.
- The yield rate may also be increased by coupling these types of solar stills with a long term storage capacity solar ponds like salt gradient solar pond, viscosity stabilized solar pond and partitioned solar pond.
- These analysis are also suggested as a method to produce a low cost distillation unit for acquiring high pure distilled water.

The following conclusions are drawn from experimental results.

The average efficiency and distillate output were found out for single slope solar still and pyramid top cover solar still individually and with tar coated blue metal and with paraffin wax.

The distillate output exposes that it increases linearly during the morning time due to the increase of insolation, reaches a maximum value around noon time and then decreases late in the afternoon.

In both the cases, the efficiency and distillate outputs were also calculated experimentally and theoretically and found to be closer.

Techno economic analysis done for the system shows that the solar still exposed to solar insolation is profitable than the still with electrical temperature controller.

The physical and chemical analyses were done for the water sample and the quality of the distillate water is found to be superior in terms of turbidity, dissolved solids, hardness and pH value.

Graphical analyses have been done for the still to evaluate the performance with various influencing parameters.

Various analyses done indicate that the performance of the still depends on various meteorological parameters such as ambient temperature, solar insolation and wind velocity. Maximum output is possible with higher insolation.

Solar energy is a free, infinite and non-polluting source of energy. The amount of distillated water is maximum at higher insolation. Distilled water amount is maximum at temperatures 59.5°C (single slope still with phase change material (paraffin wax), 60°C (pyramid still with phase change material (paraffin wax), 60°C (pyramid solar still with electrical backup). The still output set at temperatures 40°C, 50°C,and 60°C during night time with the supply of electrical energy to cause evaporation is found to be more or less same. Appreciable results are obtained from the still with and without electrical temperature controller.

The distillate output of the solar still utilizing solar insolation is more or less the same as that of still with electrical temperature controller. But the Cost of the solar still utilizing electricity for evaporation is 15 times greater than that of the solar still with the use of solar insolation. This analysis shows that solar still which is exposed to solar energy is highly economical and profitable.

On comparing the techno economic analysis, it is clear that the conventional still performance with the use of direct solar energy is cost effective than the still with electrical temperature controller. Performance of the still utilizing solar energy is economically viable. It is concluded that, conventional solar still exposed to solar insolation is profitable.

Limitations:

- Use of AC electrical temperature controller, may cause electrical shock.
- Difficulty in handling of the pyramid top cover.
- Difficulty in measuring the temperature profiles, for the still with electrical temperature controller

Suggestions:

- The yield may be increased by increasing the insulation thickness.
- The performance of the still can be improved by fixing external reflectors.
- The productivity can be increased by decreasing the depth of water.