CHAPTER – II

REVIEW OF LITERATURE

In India work on Solar Stills is started in 1950 at the National Physical Laboratory-New Delhi, where experiments were conducted on concentrator type and flat basin type stills .

The Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar started work on solar stills in 1946, first with a small laboratory model (basin area 0.316m^2) and subsequently with pilot plant solar still (basin area 377m^2, capacity 1990 lit/day). This institute installed plants at far off places like Narayan Sorovar in Kutch, which has the overall capacity of 2400 liters distillate collection per day. In Lakshadweep, a plant has the capacity of 5000 liters per day was installed. At Bhareli in Rajasthan, it is 8000 liters/day and in Amreli of Gujarat it is 15000 liters per day for developing a process of desalination of brackish water to produce drinking water. The design developed at CSMCRI is available in the published literature or can be obtained from NRDC of India. The Central Arid Zone Research Institute (CAZRI), Jodhpur worked on solar distillation. It was started in 1973 with the specific aims of optimizing the size of the domestic solar stills with a number of single or double slope solar stills both on ground (with and without ground insulation) and raised platforms where fabricated. The hourly data of the distilled water output and number of climatic parameters such as (solar radiation, ambient air temp, wind speed, humidity, etc.,) design parameters of (base insulation, glass insulation, orientation of stills, single sloped and double sloped etc.,) and operational parameters like (depth of water in basin, preheating, coloring etc.,) were experimentally studied.

India's first solar energized desalination plant to obtain potable water is being set up by the Tamilnadu public works department in Chennai. This plant will have a capacity to produce 500 litres of distilled water per day. The solar energy division of the Energy Research Center at I.I.T., Madras, is actively engaged in a Research Programmes, in collaboration with West Germany and BHEL to set up distillation plant.

The Government of Tamilnadu has set-up a solar desalination plant at Rameshwaram which provides 2200 liters of distilled water per day. In a many institutions in Tamilnadu many works on solar stills are in progress. Tube-type solar still integrated by a conventional still and a water distribution network suitable to the concept of desert plantation had been studied by **Kazuo Murase et al., (2006)**. Experimental data measured using infrared lamps showed the effectiveness of the method for productivity, the design of the basin tray and thermal efficiency up to 12.5%. The low cost prototype vertical solar still with a vertical flat absorber surface for distillate yield in arid land have been studied by **Boukar and Harmim (2004)**. Studies were conducted to find the parametric values affecting the performance of the still under desert climatic conditions: effects of saline water input and output temperature to the still, ambient temperature, cover glass temperature, solar radiation and orientation of the still and productivity of still. Results concluded that the productivity of the vertical still strongly depended on solar radiation, ambient temperature and still orientation.

A modular low-cost solar still was designed and tested for controlled environment agriculture (CEA) greenhouse by **Kudish and Gal (1986)**. It is observed that the annual average daily productivity and efficiency values were 2.35 l/m^2 and 30%. Annual and seasonal performance analysis of a single slope passive solar still with different water depths have been analysed by **Anil Tiwari and Tiwari (2007).** Results concluded that lower depth showed highest annual yield. The effect of various parameters like ambient air velocities, basin absorptivity have been found and compared for the different water depths in still. **Tripathi and Tiwari (2006)** had analyzed the thermal analysis of passive and active solar distillation system by using the concept of solar fraction inside the solar still. Analytical expressions for water and glass cover temperatures and yield have been derived in terms of design and climatic parameters. Experimental validation of the thermal model had been carried out by **Shukla and Sorayan (2005)** using modified heat transfer coefficients in single and double slope multi-wick solar distillation systems in quasi-steady state conditions.

Shruti Aggarwal and Tiwari (1999) analyzed the thermal model of a double condensing chamber solar still (DCS). Experiments were conducted for both the single slope conventional solar still (CSS) and double condensing chamber solar still (DCS) on an hourly basis for comparison of their performance. Obtained results confess that there is a fair agreement between the theoretical and experimental observations. **Badran (2007)** had studied the experimental performance of a single slope solar still using different operational parameters. Study showed that the daily production of still can be increased by reducing the depth of the water in the basin, the ambient conditions were found to have direct effect on the productivity and the night production in the absence of solar radiation contributed to 16% of the daily output.

Thermal analysis of four sloped glass surface basin type solar still is experimentally analysed by **Jairaj et al., (2004).** The efficiency of the system is calculated from the experimentally predicted data and is compared with the observed data.

Computer simulation model to analyze the effect of wind speed on the daily productivity of active and passive solar stills have been studied by **El-Sebaii (2004)**. Mathematical model to predict the productivity of a simple solar still under different climatic, design and operational parameters had also been analysed by **Al-Hinai et al., (2002)**. **Boukar and Harmim (2001)** made an attempt to study the effect of desert climatic conditions on the performance of a simple basin solar still and a similar one coupled to a flat plate solar collector. Study showed that the productivity of the simple basin and similar coupled to a flat plate solar collector strongly depends on the solar radiation and ambient temperature.

Selvakumar et al., (2008) studied the thermal performance of "V" type basin solar still with charcoal absorber. The internal heat transfer and external heat transfer modes are studied. Performance ratio of the still, variation of Nusselt number (Nu), Grashof number (Gr) and heat transfer rates were also calculated. **Aboul-Enein et al., (1998)** studied the thermal performance of a single basin solar still (SBSS) both experimentally and theoretically. It is inferred that the productivity of the still decreases with an increase of heat capacity of basin water during daylight and the reverse is the case overnight.

El-Swify and Metias (2002) induced the concept of planer reflector in a double exposure solar still. Still was theoretically analyzed and experimentally tested.

It is found theoretically that the double exposure still gained much more daily energy than that of the ordinary one. Theoretical studies of the thermal performance of a single-sloped basin still with enhanced evaporation and a built-in additional condenser have been investigated by **Hassan Fath and Hosny (1996)**. The effects of different design, operational, and environmental parameters on still performance are also studied.

Hamdan (1999), proposed an experimental and theoretical work to find the performance of single, double and triple basin solar still. It was found that the distilled water output of the triple basin was 24% higher than that of the single basin and 5.8% higher than the double basin, while the double basin output was 20% higher than that of the single basin output. Two modifications for solar desalination systems have been analysed by **Zeinab Abdel-Rehim and Ashraf Lasheen (2005)**. The modifications are using a packed layer formed from glass balls and rotating shaft installed in the bottom of the basin to increase the efficiency of the still. Energy absorbed by glass cover, basin water, packed layer and the required power of the rotating shaft are calculated to obtain the water productivity and efficiency of the present systems.

Singh et al., (1995) have been analyzed the orientation of the glass cover inclination for higher yield in a solar still. The effects of water depth on the hourly instantaneous cumulative and overall thermal efficiency and internal heat transfer coefficient have also been investigated. A simple single basin solar still have been analysed by **Muhammad Ali Samee et al., (2007)** with optimum inclination of glass cover. The average daily output of solar still was found to be 1.7 liters/day with 30.65% efficiency for basin area of 0.54 m^2.

Nijmeh et al., (2005) have been investigated the regenerative, conventional and double-glass-cover cooling solar still theoretically and experimentally. Several system parameters were also investigated with respect to their effect on the productivity, namely, water with and without dye in the lower basin, basin heat loss coefficient, mass of water in the basins and mass flow rate into the double-glass cover. **Bilal Akash et al., (2000)** have been investigated experimentally the basin type solar still with various cover tilt angles. Results showed that 35° was the optimum tilt angle for the production.

El-Sebaii et al., (2000) designed and fabricated a single slope single basin solar still with baffle suspended absorber (SBSSBA) as an alternate to external pre heater. Results concluded that the daily productivity of the SBSSBA is about 20% higher than that of the conventional still (SBSS). A single-basin solar still have been designed and analyzed by **Mohammed Farid and Faik Hamad (1993)**. Efficiency of the still was found to be independent of solar radiation, however, an increased diffused radiation lead to slight decrease in its efficiency. Still productivity increases with the increase in ambient temperature and decrease in wind velocity. **Hiroshi Tanaka and Yasuhito Nakatake (2007)** investigated outdoor experiments for vertical single-effect diffusion solar still and the proposed multiple-effect still has a very high rate of productivity in spite of its simple structure.

Experimental results were carried out on a single basin solar still under various modes of operation by **Raj et al., (1990)**. The variation of daily distillate with water mass and salinity has been measured for an uncoupled still. An experimental setup have been investigate to evaluate the distillate yield for a double slope laboratory still under controlled conditions for basin water and collector temperatures within typical operating ranges by **Eduardo Rubio et al., (2000)**. **Sangeeta Suneja and Tiwari (1999)** investigated the transient analysis of a double basin solar still and derived the explicit expressions for the temperatures of various components of the inverted absorber double basin solar still and its efficiency. It has been observed that the daily yield of an inverted absorber double basin solar still increases with the increase of water depth in the lower basin for a given water mass in the upper basin.

Nafey et al., (2001) have analyzed a method to improve the productivity of a single basin solar still using black rubber or black gravel. Results concluded that black rubber improves the productivity by 20% and the black gravel improves the productivity by 19%. They also made an investigation on the main parameters affecting solar still performance under the weather conditions. **Singh and Tiwari (2004)** have analyzed the monthly performance of passive and active solar stills for different Indian climatic conditions. Effect of climatic, operational and design parameters of a single and double sloped solar still in Indian arid zone conditions have been analysed by **Garg and Mann (1976)**.

Ahmed et al., (1968) have investigated a study on the scope and development of solar stills for water desalination in India. The classification of distillation units have been done on the basis of literature survey by **Tiwari et al., (2003)**. The basic heat and mass transfer relation responsible for developing, testing procedure for various designs of solar stills have also been discussed. **Tiwari and Yadav (1987), Tiwari and Lawrence (1991)** have analyzed various conventional and multi-wick solar distillers, including two medium scale solar distillation plants and their performance is observed. They also proposed a modified heat and mass transfer relations for solar still.

Zheng Hongfei et al., (2002) investigated a group of improved heat and mass transfer correlations in basin type solar stills. It is concluded that the correlation group developed in this work can provide better predictions for the evaporation rate of basin type solar stills at the wide range of Rayleigh number and temperature. Thermal performances of a solar still coupled with flat plate heater along with an evaporator-condenser have been analyzed by **Réné Tchinda et al., (2000)**. Results concluded that the theoretical solar still productivity is in reasonably good agreement with the experimental distillation yields.

Miguel Angel Porta-Gándara et al., (1998) have investigated the overall heat transfer coefficient from water to cover in solar stills using yield measurements. Geometry under analysis represents a real solar still operating with laboratory-controlled temperatures and induced heat flows in steady-state. **Sanjay Kumar and Tiwari (1996)** have been proposed a thermal model to determine the convective mass transfer for different Grashof Number range in solar distillation process. The modified values of C and n for $Nu=C(GrPr)^n$, are proposed as C=0.0322; n=0.4114 for $1.794x10^6<Gr<5.724x10^6$ in a passive solar still and C=0.0538; n=0.383 for $5.498x10^6< Gr < 9.128x10^6$ in an active solar still. Transient analysis of a single basin solar still with an inclined glass cover have been analyzed to find the evaluation of evaporative, convective and radiative heat transfer coefficients by **Ahmad Taleb Shawaqfeh and Mohammed Mehdi Farid (1995)**. Results inferred that the proposed model is found to provide better prediction for the evaporation rate.

The effect of water depth on the internal heat and mass transfer in a single basin single slope plastic solar still have been analyzed by **Phadatare and Verma (2007)**. **Anil Kr. Tiwari and Tiwari (2006)** investigated the effect of water depth on evaporative mass transfer coefficient for a passive single-slope distillation system. Results shows that the heat transfer coefficients depends significantly on water depths and also observed that the nocturnal distillation is significant in the case of higher water depths because of reduced ambient and stored energy within it.

Sanjeev Kumar and Tiwari (1998) have been analyzed a thermal analysis of an active solar still for the optimization of collectors as well as the basin area for a higher yield for a given water depth. Expressions for the temperatures, the water and glass covers and the yield have also been derived. The role of thermophysical and transport properties of the working medium and their effect on the thermal behavior and performance analysis of solar distillation systems have been carried out by **Tsilingiris (2007)**. Results of the investigation conclude that the use of improper dry air data leads to a significant overestimation of the convective heat transfer coefficient. Single basin and double decker stills with still-sides insulation and the other without for of 12° and 36° top glass cover inclination have been investigated by **Al-Karaghouli and Alnaser (2004)**. Studies reveal that adding 2.5 cm of styrobore insulation material to the solar stills sides causes a noticeable increase in water production.

Bilal Akash and Mousa et al., (1998) studied the effect of using different absorbing materials in a single basin solar still to enhance the productivity of water. Experimental results showed that the productivity of distilled water was enhanced by 38% for black rubber mat absorber, 45% for black ink and 60% for black dye absorber. Experimental and theoretical works were carried out on a single basin solar still under various modes of operation by **Morcos (1994)**. The effects of distillation with and without addition of a small quantity of black dye to the basin water and flat plate collector coupled to the still with film distillation were studied.

Mathematical models to predict the thermal performance of a spherical solar still have been analyzed by **Naresh Dhiman (1988)**. **Hiroshi Tanaka and Yasuhito Nakatake (2007)** studied a numerical analysis to investigate the effect of the vertical flat plate external reflector on the distillate productivity of the tilted wick solar still. It is found that the external reflector increase the distillate productivity. **Mowla and Karimi (1995)** mathematically simulated a solar still. The rate of production of fresh water from sea water is calculated as a function of different meteorological parameters and the solar still specifications.

Production of potable water from sea water or brackish water using a solar pond as a heat source coupled to a desalination unit have been studied by **Tamás Szacsvay et al., (1999)**. Performance and layout data were obtained both from computer simulation and experimental results with a small-sized pond and desalination subsystem. **Osamah Al Hawaj and Darwish (1994)** have been studied a simulation model pond which is viable for desalination of seawater in an arid environment with performance ratio reaching more than twice the amount than that in a conventional system. Simulation model investigated by **Osamah Al Hawaj and Darwish (1994)** to incorporate the pond with solar still viable for providing desalinated sea water to arid environment with performance ratio reaching more than twice the conventional system.

Tsilingiris (1995) developed a simple dynamic computer model to investigate the performance and operational behavior of a large solar seawater desalination system based on a multi-effect distillation plant and a solar pond. The effects of various design and operational parameters on system behavior were investigated. **Al-Karaghouli and Alnaser (2004)** investigated single basin and double decker solar stills with the still sides insulated and without insulation. Solar still characterized by two basins superimposed upon each other with top plastic cover have been investigated by **Cappelletti (2002)**. **Hay (1973)** reported a technical and patent literature on plastic solar-still elements. The advantages of plastic solar still covers were analyzed in detail with the properties of various plastics and **Badawi Tleimat and Everett Howe (1969)** have investigated the productions of the double-strength window-glass covered and plastic-film covered solar still.

El-Kassaby (1991) designed and investigated solar still using a line concentrator of parabolic reflector type and a comparison of results are made with the theoretical ones. **Porta, et al., (1997)** have studied the dynamic effects in shallow solar stills. Result shows that the thermal inertia of these systems reside in the glazing, tray materials, insulation and brine. Experimental investigations have been carried out by **Eduardo Rubio-Cerda, et al., (2002)** in an attic-shaped solar still subject to natural conditions of Grashof numbers. Performance of the still was carried out by condensing covers under two still orientations. The pyramid and the single slope solar still comparison were made analytically under thermal as well as economic aspects by **Fath et al., (2003)**.

The optimum angle of a flat plate reflector and the optimum orientation of vertical multiple-effect diffusion solar still coupled with a reflector throughout the year were numerically determined by **Hiroshi Tanaka and Yasuhito Nakatake (2007)**. Results concluded that the daily productivity of the proposed still was predicted to be more than 30 kg/m^{2}day at any latitude throughout the year except for the winter season (from November to January) at 40°N latitude. Theoretical analysis of a basin type solar still with an internal reflector (two sides and back walls) and an inclined flat plate external reflector on a winter solstice day at 30° N latitude were investigated by **Hiroshi Tanaka and Yasuhito Nakatake (2007)**. **Selvakumar et al., (2008)** studied the thermal performance and distillate yield analysis of a single sloped green house solar still for growing plants in cold climates through better utilization of the available sunlight. The internal heat transfer and external heat transfer modes along with the thermophysical properties were studied.

Experimental Investigation to study the effect of coupling a flat plate solar collector on the productivity of solar stills was carried out by **Badran and Al-Tahaineh (2005)**. Other different parameters (i.e. water depth, direction of still, solar radiation) to enhance the productivity were also studied. **Ali Badran, et al., (2005)** have also been studied combined effect of a single-stage basin-type solar still and a conventional flat-plate collector to study the effect of augmentation on the still.

Transient analysis of a single basin solar still coupled to a solar collector using a thermosiphon mode of operation have been studied by **Yadav (1989)**. It is observed that the system with the forced circulation mode of operation performs slightly better than the system operating using the thermosiphon mode. Further a transient analysis is made under a double-basin solar still coupled to a solar collector. Analyses have been carried out for both the natural (thermosiphon) and forced circulation of water between the collector and the still **Yadav (1991), (1989), Yadav and Jha (1989).** Explicit expressions also been derived for the temperatures of the upper glass-cover, the water in the upper basin, the lower glass-cover, and the water in the lower basin, as well as for the distillate output and system efficiency.

Hiroshi Tanak et al., (2005); Hiroshi Tanak and Yasuhito Nakatake (2004) made a parametric investigation theoretically on the vertical multiple-effect diffusion-type solar still and coupled with a heat-pipe solar collector. It was found that productivity increased with an increase in the number of' partitions and the temperature of the saline water fed to the wicks, and with a decrease in the ratio of the solar collector area to each partition area, the thickness of the diffusion gaps between partitions and the feeding rate of saline water to the wicks. The behaviors of the solar still-storage tank system have been studied by **Voropoulos et al., (2003)** to investigate the operation under real conditions by keeping tank water temperature constant at different levels. It has been found that this design leads to higher water outputs as the water temperature increases but more important is the shift of water production towards night periods.

Thermal analyses of a concentrator assisted regenerative solar distillation unit in forced circulation mode have been studied by **Sanjay Kumar and Sinha (1996)**. It is concluded that the yield of the concentrator assisted regenerative solar still is much higher than any other passive/active regenerative or non-regenerative solar distillation system and the overall thermal efficiency increases with an increase in the flow rate of the flowing cold water over the glass cover. Thermal performances of a regenerative active solar distillation system working under the thermosyphon mode of operation have been studied by **Singh and Tiwari (1993), Tiwari et al., (2003)** for Indian climatic condition. It is concluded that (i) there is a significant improvement in overall performance due to water flow over the glass cover and (ii) the hot water available due to the regenerative effect does not enhance the output. They derived expressions for water and glass temperatures, hourly yield and instantaneous efficiency for both passive and active solar distillation systems.

Yadav (1993) have been studied the performance analysis of a double basin solar still coupled to a heat exchanger. An overall system efficiency have been derived which incorporates both direct solar gain to the still and the heat gain via heat exchanger. It is observed that the efficiency of the proposed system is considerably less than that of a comparable double basin solar still without heat exchanger.

Comparative studies of a single basin solar still under various modes of operation have been studied by **Dutt et al., (1988)**. Simple transient analyses of all the modes under the same meteorological conditions have also been presented. Experimental measurements to determine conditions necessary for efficient solar desalination have been studied by **Tiris et al., (1996)**. The effects on performance of using various different absorber materials together with the integration of flat-plate collectors with storage systems in basin type solar stills are investigated. They have been studied a basin solar still incorporated with flat plate collector to enhance the productivity of the still. Results show an increase in the distillate productivity by **Tiris, et al., (1996).**

Comparison between theoretical and experimental analysis of a mini solar pond assisted solar still have been analyzed by **Velmurugan and Srithar (2007)**. The average daily production of solar still is found to be increased considerably, when it is integrated with a mini solar pond. Theoretical analyses were made using conservation of energy and the results obtained give very good agreement with the experiments. Thermal performances of a solar pond under an open cycle continuous flow heating mode for heat extraction with serpentine heat exchanger have been investigated by **El-Sebaii et al., (2006), Ramadan, et al., (2004).** Effects of the design parameters of the heat exchanger tube on the performance have been investigated. The outlet temperature of the heat exchanger fluid is found to increase with increase of the heat exchanger length and it decreases with increase of the mass flow rate of the heat exchanger's fluid mass flow up to typical values for these parameters. Effects of the water-depth, wind speed, the side and back insulation thicknesses as well as the height and width of the outer mirror have also been investigated by **Aboul-Enein et al., (2004)**. Comparisons between experimental and theoretical results showed that good agreement has been achieved.

Celestino Angeli et al., (2006) proposed a one-dimensional mathematical model and a finite-difference approach to problem of the development of salt concentration profiles in a solar pond. A novel scheme of heat extraction from the solar pond is presented, along with preliminary two-dimensional computational fluid dynamics (CFD) simulations. An alternative method of heat extraction from salinity-gradient solar ponds have been investigated by **Andrews and Akbarzadeh (2005)** with the aim of increasing the overall energy efficiency of collecting solar radiation, storing heat and delivering this heat to an application.

Heat transfer models for solar pond systems with continuous heat extraction have been investigated by **Kishore et al., (1986)**. A method of obtaining wind effects on the heat transfer between two covers is presented. Results indicate that (i) the heat transfer model developed for water bed-heat exchanger fluid adequately represents the true conditions, (ii) the convective heat transfer coefficients in the water bed correlate with the solar radiation absorbed in the bed. A theoretical model to validate experimentally the performance of a solar still was carried out by **Ali and Akhlaghi (1987)**. The theoretical and experimental results show good agreement.

Kishore et al., (1987) proposed the constructional and fabricational details of a portable pond with three different glazing configurations. The costs of the SSPs indicate that they can form a major part of a potentially low cost solar DHW system suitable for middle income groups. Theoretical models were formulated to predict the thermal behaviour of various solar systems, viz. pond water heater, built-in-storage type solar water heater, isolated non-air conditioned room and cubical collector-cum-storage system provided with transparent insulation by **Prakash et al., (1992)**. The numerical simulation of these models for the winter conditions of Delhi shows that the systems with transparent insulation present a better performance than those without transparent insulation.

The transient collection and storage performance have been examined for a pond water heater (solar tank) with a semitransparent, multilayer surface insulation system by **Kamiuto and Oda (1991)**. Both experimental and theoretical studies have been carried out for different numbers (zero to three) of surface-insulation layers.

El-Sebaii, (2005) have been studied a pond integrated with a baffle plate both theoretically and experimentally. A transient mathematical model along with the energy-balance equations for various parts of the pond are solved analytically using the elimination technique. Comparisons between experimental and theoretical results indicated that the theoretical model could be used for estimating the ponds performance with good accuracy.

Jayaprakash and Perumal (1998) had studied the solar pond of area 5.712 m^2. The stability of density and temperature profile, variation of salt flux due to temperature and depth, temperature loss during night time, and the evaporation losses at the surface were analyzed. A simple straight forward transient analysis of a Solar Pond (SSP) water heater by incorporating the effect of a baffle plate have been studied by **Dutt et al., (1987)**. Explicit expressions for the water temperature of the proposed system have also been obtained. It is observed that the results obtained by the proposed model are nearly the same as reported earlier by rigorous analysis. **Madhuri and Tiwari, (1986)** have been also analysed the transient analysis of a solar pond (SSP) water heater fitted with baffle plate. Results concluded that the SSP can also be used as a built-in storage water heater with better performance being achieved with the use of a baffle plate.

Tiwari et al., (1985) made a simple analysis of an underground solar pond water heater. The effects of a thermal trap at the top of the system have also been incorporated in the analysis. It is concluded that the system with thermal trap gives better performance in comparison with a system with a movable insulation system. **Tiwari et al., (1984)** made an investigation on inexpensive under ground pond water heater and its performance in detail. The effect of various parameters, viz duration of covering the system by insulation, duration of flow rate, flow rate, insulation thickness, water mass, etc. have also been discussed. **Kudish and Wolf (1978)** have constructed and tested a prototype pond unit as an alternate for water heater. Study were performed using a solar reflector by means of an aluminized mylar film affixed to the inner side and it was thermally insulated so as to enable the overnight storage of the heated water.

A simplified analytical model to predict the performance of a pond water heater which combines both collection and storage in a single unit have been analysed by **Sodha et al., (1981)**. The performance of the water heater, both during the day and night time, can satisfactorily be predicted by this theoretical model. The theoretical calculations are found to be in good agreement with the experimental observations reported earlier. **Ashok Kumar and Tiwari (1988)** analysed the transient analyses of a collection-cum-storage water heater (i.e., built-in-storage/solar pond) by incorporating the effect of a heat exchanger placed inside the system. The effects of various parameters, viz. flow rate, constant collection temperature, movable insulation, heat capacity etc., on the water temperature and efficiency of the system have also been studied.

Thermal energy extractions from a small salinity-gradient pond have been studied by **Jaefarzadeh (2006)**. Results concluded that the pond may deliver heat with a relatively high thermal efficiency in a transitional stage for a limited period of time. It can also be utilized continuously with a lower efficiency. An experimental and theoretical investigation of temperature distributions in an insulated solar pond have been investigated by **Karakilcik et al., (2006)**. Results show a good agreement between experimental and theoretical temperature profiles. Mathematical models have been developed to predict the performance of a shallow solar pond water heater with a heat exchanger by **Bansal et al., (1984)**.

A simple transient model for predicting the thermal performance of collector/storage solar water heaters for generalised demand patterns were made by **Kaushik et al., (1982)** The time dependence of the water temperature for the withdrawal of hot water from the system at constant flow rate constantly or intermittently have been explicitly evaluated. They have also made an experimental and analytical investigation of the transient thermal processes in a salt gradient stabilized pond for short-term storage applications.

Theoretical simulation of an affordable small scale solar water desalination plant was analyzed by **Mahmoud Shatat et al., (2013); Xiaohua Liu et al, (2013); Francesco Calise et al., (2014).** The experimental and theoretical values for the total daily distillate output were found to be closely correlated also the performance of the system could be improved to produce a considerably higher amount of fresh water, namely up to 17.5 kg/m^2 day.

Transient numerical analysis and techno economic assessment of a solar still had been carried out by **Xiaohua Liu et al, (2013), Francesco Calise et al., (2014), George Ayoub and Lilian Malaeb, (2014), Abdel Hakim Hassabou, (2013)**. This analysis yielded results that further justify the economic feasibility of the new modified solar still, particularly for seawater desalination. A thermo-economic analysis is also presented, aiming at determining the optimal values of the most important design variables.

Cascade solar still integrated with and without latent heat thermal energy storage system (LHTESS), was analyzed with the view of enhancing productivity by **Mohammad Dashtban and Farshad Farshchi Tabrizi, (2011), Farshad Farshchi Tabrizi, (2010), Omar Ansari, (2013)**. Paraffin wax is selected as the phase change material (PCM) which acts as a LHTESS. Results conclude that the use of heat storage system of paraffin wax beneath the absorber plate keeps the operating temperature of the still high enough to produce distillated water during the lack of sunshine, particularly at night. The results showed that the productivity of the still with PCM was theoretically 31% higher than that of without PCM.

Use of built in phase change material (PCM) storage is found to produce consistent air outlet temperatures throughout the day or night by **Edward Summers, (2012)**. It is found that a PCM layer below the absorber plate is sufficient to produce a consistent output temperature close to the PCM melting temperature with a time-averaged collector thermal efficiency of 35%.

An overview of the energy situation, solar energy potential, TES concepts and technologies used in solar applications were analyzed by **Al-Ibrahim, et al., (1988), Uros Stritih et al, (2013), Veera Gnaneswar Gude et al., (2012)**. Results from this theoretical study confirm that thermal energy storage is a useful component of the system for conserving thermal energy to meet the energy demand when direct solar energy resource is not available.

In this present work, an attempt has been made to construct two different types of solar still such as: Single Slope and Pyramid Solar Stills. Two solar stills were analyzed with and without thermal storage media such as tar coated blue metal and paraffin wax. Effect of electrical backup was also analysed for the two stills. Distillate yield in these solar stills are observed individually and the study is also carried further by combining thermal storage media with them in order to increase the performance of the stills. Thermal storage media are used to boost up the distillate yield in this study.

The Main objectives of the Present Work

a) To construct a single slope and a pyramid solar stills.

b) To study the thermal performance of the single slope and pyramid solar still.

c) To analyse the thermal performance of the two stills (Single Slope and Pyramid Solar Still) with tar coated blue metal (TCBM)

d) To analyse the thermal performance of the two stills with phase change material (Paraffin wax).

e) To analyse the thermal performance of the pyramid solar still with electrical back up.

f) To study the instantaneous and over-all efficiencies of these stills.

g) To develop a simulation model for the solar still.

h) To analyse the internal and external heat transfer modes in the stills with and without storage materials.

i) To analyse the chemical and physical properties of water in all performance studies.

j) To analyse the behaviour of Nusselt, Grashof, Prandtl and Rayleigh numbers in the performance studies.

k) To analyse improvement in distilled yield in the two stills (Single Slope and Pyramid Solar Still) with and without storage material