FABRICATION AND PERFORMANCE EVALUATION OF A SOLAR POND

By

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PROJECT REPORT

Submitted in partial fulfilment of the requirement for the degree of

Bachelor of Technology
in
Agricultural Engineering

Faculty of Agricultural Engineering & Technology
Kerala Agricultural University

Department of Farm Power Machinery and Energy
Kelappaji College of Agricultural Engineering and Technology
Tavanur – 679 573
Malappuram

1993

DECLARATION

We hereby declare that this project report entitled Fabrication and Performance Evaluation of a Solar Pond is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

BALAKRISHNAN .A.

Tavanur,
30-10-'93

KAVITHA .K.S.

CERTIFICATE

Certified that this project report entitled Fabrication and Performance Evaluation of a Solar Pond, is a record of project work done jointly by **Mr. Balakrishnan** A. and **Miss. Kavitha K.S.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

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ACKNOWLEDGEMENT

We avail this opportunity to express our profound and sincere sense of gratitude and undebtedness to **Sri. V.R. Ramachandran**, Assistant Professor, Department of Farm Power Machinery and Energy for his valuable guidance, constructive criticism and constant encouragement which lead to the completion of this work.

We are grateful to **Dr. K. John Thomas**, Dean in-charge, K.C.A.E.T., Tavanur and **Prof. T.P. George** former Dean in-charge K.C.A.E.T., Tavanur for their valuable suggestions offered during the study.

Words fail to express our heartfelt thanks to **Sri. K.K. Vijayan** for his sincere suggestions and help duirng our fabrication work.

We also extend our deepfelt gratitude to all the staff and students of Kelappaji College of Agriculture Engineering and Technology, Tavanur.

At this moment we do remember the strenuous help, unfailing support and constant encouragement of our loving parents for the completion of this work.

Above all, we bow our heads before God the Almighty whose blessings have paved the way for this achievement.

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SYMBOLS AND ABBREVIATIONS

Agrl.	Agricultural
BC	Before Christ
°C	Degree Centigrade
cm.	Centimetre
Co.	Company
et.al.	and others
Fig.	Figure
G	Gauge
J	Joule
K.E.	Kinetic Energy
kg.	Kilogram
KW	Kilowatt
mW	
Ltd.	Limited
m	Metre
mm	millimeter
MJ	Mega Joule
MSSP	Membrane Stratified Saltless solar Ponds.
Pvt.	Private
%	Percentage
°	degree
=	equal to
/	per

INTRODUCTION

A developing country like India needs progressevely increasing amounts of energy to move forward to prosperity and modernisation. During the next few centuries the main burden of producing commercial energy will continue to be on fossil fuels namely petroleum, natural gas and coal. These fuels were formed in nature over a period of about 100 million years and will be exhausted soon. Petroleum is likely to be exhausted during 21^{st} century, although coal will last for a few more centuries, at the present rate of consumption. At the same time, with further industrial development energy consumption has been rising much more rapidly than the finding of new resources. A shortage of fossils is impending and the costs are escalating these leading to energy crisis. Hence there is a need to tap solar energy.

Sun is an inexhaustable source of energy. The amount of solar energy, intercepted by the earth is 170 trillion KW and amount 5000 times greater than the sum of all other energy inputs. Under favourable atmospheric conditions the maximum intensity observed at noon on an oriental surface at sea level is 1 KW/m^2.

Due to the dilute nature of radiations large collection areas are needed and hence the initial cost of installation is high. Even then with properly designed and constructed equipments solar heating and cooling of homes and buildings are cheaper than electrical heating or cooling.

About 30% of the solar radiation incident on the earth's surface is reflected to space, 47% is converted to low temperature heat and re-radiated to space, 23% powers the evaporation precipitation cycle of the biosphere; less than ½% is represented in the KE of the winds and waves and photosynthetic storage on plants. Only a tiny fraction of the released energy is intercepted by earth, although abundant the solar energy falling on the earth's surface is dilute in nature. In traversing the earth's surface, it is further diluted by local weather phenomena and air pollution. Moreover, solar energy is received intermittently at any point on the surface of the earth. The solar energy that receives at the surface of the earth is in two forms, direct radiation and diffuse radiation. The former is collimated and capable of casting a shadow, whereas the latter is disposed, or reflected by the atmosphere and is not collimated. In considering the efficient use of solar radiation, the ratio of direct to diffuse radiations become important. It varies with time and loation. The amount of direct radiation diminishes as skies become more cloudly and as their pollution increases.

From historicali time onwards, attempts have been made to trap and utilize solar energy. The first person known to have used the sun's energy on a large scale is Archimedes, who set fire to an attacking Roman fleet at Syracuse in 1212 B.C. Serious studies of the sun and its potential began in the seventeenth century, when Galilio and Lavoisier utilized the sun in their research. In 1700 AD diamonds had been melted and by early 1800s heat engines were operating with energy supplied by the sun. In the early twentieth century solar energy was used to power water distillation plants in Chile and irrigation pumps in Egypt. By 1920s and 1930s practical use was being made of the sun's energy in various parts of the world. In 1957 the International Solar Energy society was found by two international meetings. Since then a large international conference on solar energy has been organised every two years.

The most important solar energy collectors are flat plate collectors, focussing type collectors, solar cells, solar ponds etc. The collectors fabricated using materials such as glass, metals, wood etc. have size limitations and therefore a large number of them with suitable interconnections will be needed to collect large amounts of solar energy. Also to supply energy 'on demand' will require some sort of energy storage and reconversion system to smooth out the variations in the insolation due to cloud, waves, seasonal and divisonal effects etc. In order to reduce the cost of large solar thermal installations, it is necessary to devise more economical ways of collecting and storing solar energy. Solar pond promise an economical way by employing a mass of water for both collection and storage of solar energy. It is an artifi ally formed pond designed specifically to trap solar energy for subsequent energy use. The typical pond would have a depth of 1 to 2m the bottom of the pond would be painted black. A salt solution is introduced to establish a pronounced density gradient from top to bottom. At the top a non-convective saline layer of salt water, about 1m thick, provides the insulation. The bottom section provides a zone for heat storage and extraction. Solar ponds can be used for producing electricity. It can also be used for agricultural drying, desalination, greenhouse heating, heating of domestic hot water supply for large users, pre-heating of higher temperature hot water for industrial use and similar uses.

Under this background the present study was taken and the main objectives were

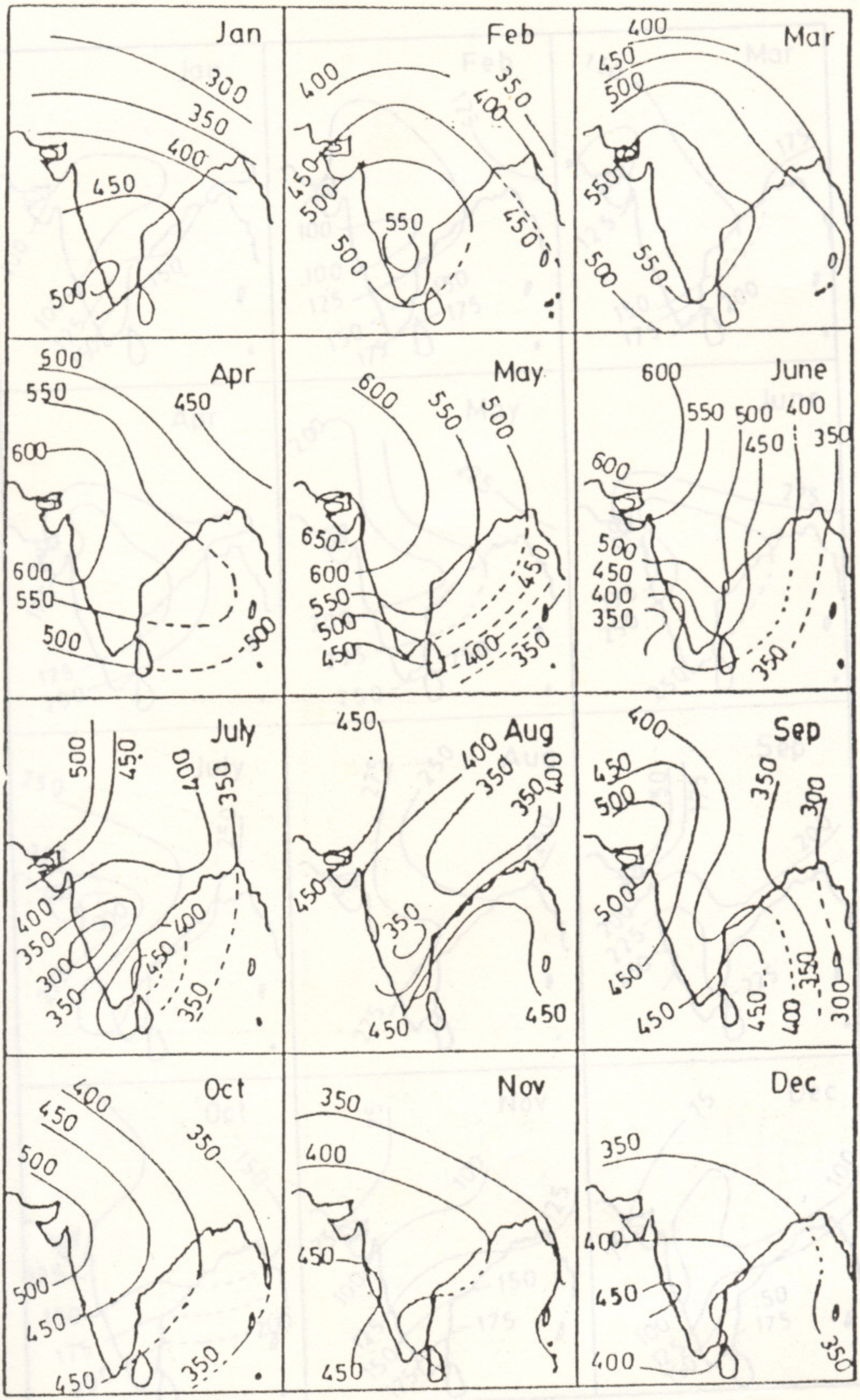
1. Fabrication of an experimental solar pond of 1 sq.m. area.
2. Performance evaluation of the solar pond.

REVIEW OF LITERATURE

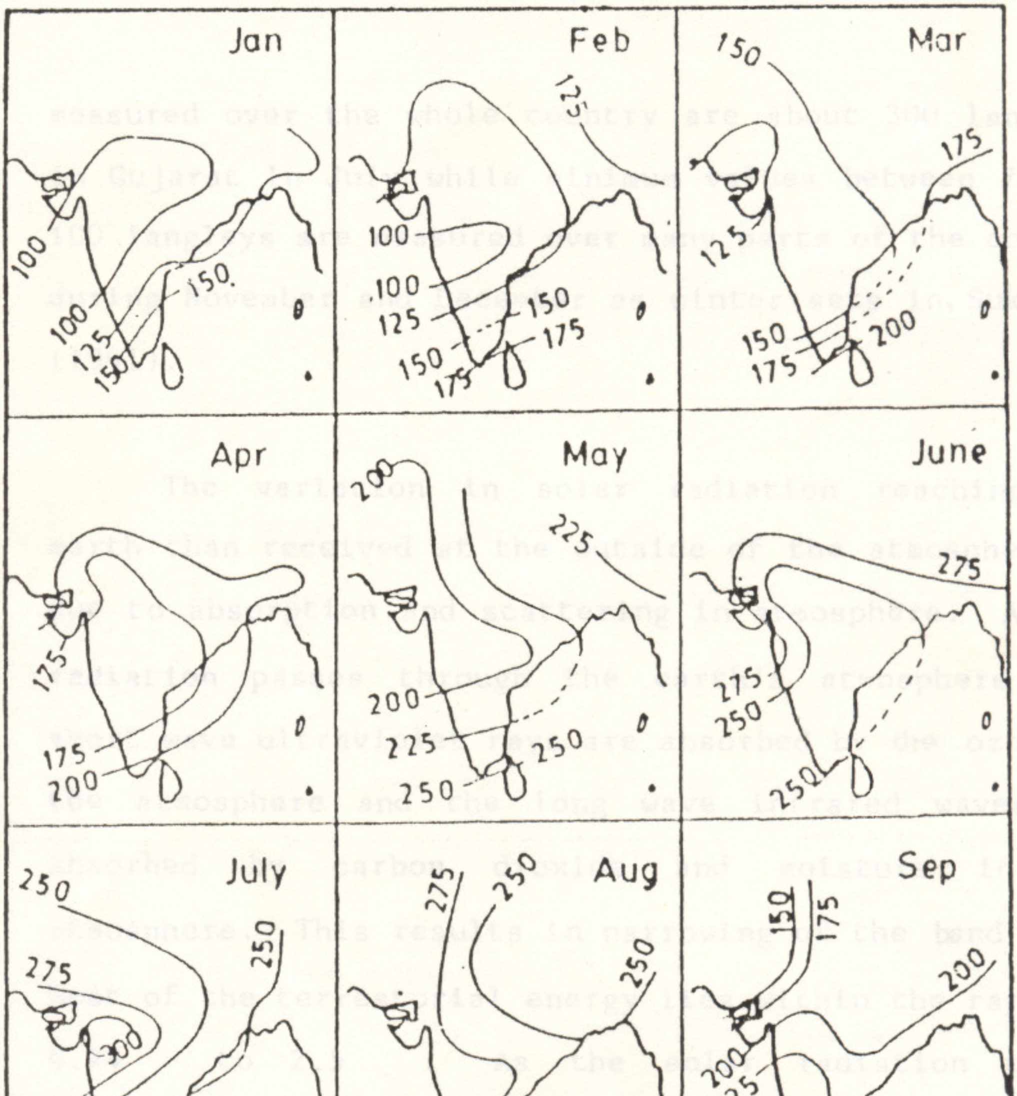
A brief review of solar radiation data, solar energy storage and available literature of past works conducted by different people on solar ponds are discussed here.

2.1. Solar radiation data:

Solar energy is a clean non polluting, non deploting energy available, almost everywhere, reaching the earth in the form of electromagnetic radiation which consists of 3% ultraviolet, 52% visible and 55% infra red. Availability of solar energy is not constant. It varies from region to region and even in the same region it varies from season to season. From the fig(1) it is seen that the annual average daily global radiation received over the whole country is around 450 langleys. Peak values are generally measured in April or May with parts of Rajastan and Gujarat receiving over 600 langleys. During the monsoon and winter months, the daily global radiation decreases to about 300-400 langleys. From fig(2) it is observed that the annual average daily diffuse radiation received over the whole country is around 175 langleys. The maximum values



Fig(1) Average daily global radiation over India in cal/cm²-day. From Mani and Chacko. Used with permission



Fig(2) Average daily diffuse radiation over India in cal/cm²-day. From Mani and Chacko. Used with permission measured over the whole country are about 300 langleys in Gujarat in July while minimum values between 75 and 100 langleys are measured over many parts of the country during November and December as winter sets in, Sukhatme (1991).

The variation in solar radiation reaching the earth than received at the outside of the atmosphere is due to absorption and scattering in atmosphere. As the radiation passes through the earth's atmosphere, the short wave ultraviolet rays are absorbed by the ozone in the atmosphere and the long wave infrared waves are absorbed by carbon dioxide and moisture in the atmosphere. This results in narrowing of the band width Most of the terrestorial energy lies within the range of 0.29 to 2.5 . As the solar radiation passes through the earth's atmosphere, the components of the atmosphere such as water vapour and dust scatter a portion of the radiation. A portion of this scattered radiation always reaches the earth's surface as diffuse radiation. These the radiation finally received at the earth's surface consists partly of beam radiation and partly of diffuse radiation. Rai (1991)

2.2. Solar Radiation Measuring Instruments:

The measurement of Solar radiation can be made by means of several types of instruments which will measure the heating effects of direct solar radiation and diffuse solar radiation. Commonly used instruments are pyranometers, pyrheliometers, pyrradiometers, pyrgeometers, sunshine recorder etc. Rai (1991)

2.3. Solar Energy Utilization:

Utilization of solar energy requires solar collectors. The function of a solar collector designed for the conversion of energy from the sun into heat depends on the selected shape and method and on the arrangements for the prevention of heat losses from the collector surfaces.

2.3.1. Flat plate collectors:

A flat-plate collector basically consists of a flat surface with a high absorpitivity for solar radiation called the absorbing surface. Heat is transferred from the absorber plate to a point of use by circulations of air or some other fluid across the solar heated surface. Thermal insulation is usually placed behind the absorber plate to prevent the heat losses from the rear surface. Flat plate collectors can be designed for application requiring energy delivery at moderate temperatures.

2.3.2. Focussing type Solar Collectors:

Focussing collector is a device to collect solar energy with high intensity of solar radiation on the energy absorbing surface. Such collectors use optical system in the form of reflectors or refractors. It is a special form of flat plate collector modified by introducing a reflecting surface between the solar radiations and the absorber. It can be used for electric power generation when not used for heating or cooling.

2.3.3. Photovoltaic Solar Cells:

This is the most useful way of harnessing solar energy in which solar radiations when incident on solar cells, generate D.C. electricity. This simplicity of operation in principle makes photovoltaic cells an ideal solar energy technology.

2.3.4. Solar greenhouses:

Greenhouses are effective solar collectors. A solar greenhouse optimises the received sunlight and heat while reducing heat losses to a practical minimum with the objective of providing stored heat for use over night time and on cloudy days. It is often feasible to obtain adequate solar energy to sustain plant growth throughout the day and night.

2.3.5. Solar Chimney

Solar Chimneys absorb the solar energy and convert it into electricity. The solar radiation heats up the land surface and the warm air close to the surface. When confined in space by a canopy and made to escape through a tall chimney, drives a turbine inside it. This in turn drives a generator producing electricity.

2.3.6. Extra terrestrial use

Proposals have been made to put into earth's orbit large arrays of solar electric cells, transmitting back power to earth with microwaves or lasers. But the energy beamed back to earth could have serious adverse environmental consequences and would have to be collected on large areas away from population centres. The loss in collection, conversion, transmission and distribution on earth would be large and the cost would also be immense.

There are many problems associated with the use of solar energy. The main problem is that it is a dilute source of energy. Even in the hottest region on earth, the solar radiation flux available rarely exceeds 1 KW/m^2, which is a low value for technological utilization. Consequently large collecting areas are required in many applications and these results in excessive costs. Another problem associated with the use of solar energy is that its availability varies widely with time. The variation in availability occurs daily because of the day-night cycle and also seasonally because of the earth's orbit around. In addition variations occur at a specific loaction because of local weather conditions. Thus the energy collected when the sun is shining must be stored for use during periods when it is not available. The need for storage also adds significantly to the cost of any system. Thus the real challenge in utilizing solar energy an energy alternative is of an economic nature. One has to strive for the development of cheaper methods of collection and storage so that the large initial investments required at present in most applications are reduced. The importance of solar pond a system which acts both as collection and storage unit comes here. Charles et. al. (1989)

2.4. Solar Energy Storage:

The need for storage arises in many situations where there is a mismatch between the availability of solar energy and the needs for its appliation. It stores energy when the collected amount is in excess of requirement of the application and discharges energy when the collected amount is inadequate. The commonly adopted methods used for storing solar energy are:

1. As sensible heat storage. here a liquid or solid is heated without changing its phase.
2. As latent heat storage, the process underneath this is to heat a material which undergoes a phase change, usually melting. The amount of energy stored in this case depends on the mass and latent heat of fusion of the material.
3. Using heat to produce a certain chemical reaction and then sotring the products. The heat is released when the reverse reaction is made to occur.

A typical solar energy storage system consists of solar collectors, storage units, conversion devices, loads and energy supplier and control systems. The characteristics of the system as a whole is the characteristics of the individual elements.

Energy storage complicates solar energy utilization in two ways. First the energy storage sub system must be large enough to carry the system over the periods of inadequate sunshine. Alternately, one should have a back up energy supply which means both capital investment that remains idle until the backup period comes. Another major problem imposed by energy storage is that the primary collecting system must be large enough to rebuild the stored energy during the sunny periods between cloudy or partial isolation periods. The additional collecting areas means an additional capital investment. Mathew (1990)

As mentioned earlier, solar ponds perform an efficient method of collection as well as storage of solar energy. It is the most economical way of producing electricity, at regions here salt is available cheaply.

2.5. Types of Solar ponds:

Apart from salt gradient solar ponds, the other types of solar ponds are shallow solar ponds, viscosity stabilized solar ponds and membrane statified saltless solar ponds.

2.5.1. Shallow Solar pond

A shallow solar pond is a body of water with shallow depth acting as a large collector and a storage of solar radiations. It is a large area low cost collector where water is directly exposed to solar radiation. It is enclosed in a thermal insulating base material and one or two sheets of glazing. Water temperature in the range of 45-70°C can be obtained which can be used for industrial process or for electricity generation.

2.5.2. Viscosity stabilized solar ponds:

In a viscosity stabilized pond, a kind of gel is used in water, making it non convective. The idea of viscosity stabilized solar pond appears to be promising, but requires studies in depth and presently is not economically competitive with salt gradient solar ponds.

2.5.3. Membrane statified saltless solar ponds (MSSP)

In a conventional salt gradient solar pond, there are three salt zones, while in a MSSP there are only two zones. The upper non convective zone at the top serving insulating layer and the lower convective zone at the bottom serving as heat storage. The basic difference between the SCSP and MSSP is in the mechanism for maintaining nonconvection in the NCZ. A few advantages of MSSP are;

1. Since no salt is used in a MSSP this pond can be made maintenance free and low cost.

2. There is no environmental or geological hazard with the MSSP.

3. There is no UCZ in a membrance statified pond, these making the same more efficient when compared to SCSP.

4. A large depth of LCZ can be maintained in a MSSP resulting in seasonal storage, less durinal temperature variation and higher collection efficiency.

The economics of salty solar ponds depends heavily on local availability and price of salts. The optimum solar pond design is sight dependent and application dependent. A slatless pond with the same thermal mass as a salty pond will experience wide variations in storage temperature. If this temperature flatuation has to be controlled a saltless pond must have more thermal mass than the salty pond and hence it must be made deeper.

2.6. Development of Solar pond technology:

The concept of solar pond is derived from the observation that in some naturally occuring lakes, a significant temperature rise of the order of 40°C to 50°C does occur in the lower region.

The first solar pond was constructed at solem by

National Physics Laboratory of Israel in 1959. It had an area 25 x 25m and a depth 1m. A peak temperature of 96°C was recorded in the pond. However, experiments had to be eventually discontinued because of decay of walls.

A second pond with reinforced walls was constructed adjacent to the first pond which was of the same size in 1961. It was not ideal because of a porous bottomi resulting in a loss or gain of water.

The third pond at Attith was 25x55m and 1.5m. deep. It was constructed at ground level by building up the walls in 1963. Extensive instrumentation was incorporated in the design. Despite the fact that the pond could not be made fully operative, some information was obtained. A temperature rise of 1.3°C per day was obtained, prior to the onset of building. From this it was calculated that about 12.5% of the solar radiation was being collected at a bottom temperature of 70°C eventhough the pond was not clear.

A solar pond having an area of 100m^2 was constructed in Australia in 1966. The maximum temperature recorded was 65°C which may be due to poor clarity, algae growth and high upward heat loss due to low thickness - 37cm of non convecting layer.

For power production and operating experience on large solar ponds, a solar pond having an area of $200m^2$ was constructed in Australia in 1968. The pond is fully instrumented and is presently being heated and monitored. This pond will supply heat to a 2KW turbine.

In India, a solar pond was in operation at the central salt and Marine Chemical Research Institute, Bhavnagar in 1972 and was used for the production of salt. The pond recorded a maximum temperature around 80°C at the bottom. The pond worked only for two years.

A group of Russian Scientists at the Uzlek Academy of Science has been actively engaged in very detailed and sophisticated research of the relevant physics underlying solar pond in 1973.

In 1974 the work in Israel was restarted and since then two demonstration units have been constructed. A $1500m^2$ pond built im Yavne has been used for operating a 6KW turbo - generator while a $7000m^2$ pond build at Ein Bokek has provided 150KW of peak power. Operating temperature in both the units are around 90°C.

To conduct research, understand the physics and behaviour of materials of the solar pond, a solar pond was built by Ohio State University, Columbus in 1975. The pond was $200m^2$ in areas and successful heat extraction experiments were conducted which established the existance of finite thickness gradient zone and correlation between salt and thermal gradient at stable zone boundary. The clarity got reduced due to wind blown debris.

Ohio Agricultural Research And Development Centre, USA constructed a solar pond in 1975 for greenhouse heating. But it started leaking after one year due to poor design and materials. Cover and reflector were found ineffective and a maximum efficiency of 12% was observed. Chemical treatments were developed to maintain clarity.

In 1975 University of New Mexico Albuquerque developed a solar pond to conduct experiments on gradient maintanance, heat extraction and stability with NaCl with an area of $167m^2$. Boiling temperature was reached and successful experiments of heat extraction were conducted for one complete year. Thermal efficiency of about 8% was observed.

Styries et al. (1976) examined application of non convecting solar ponds for heating building and providing process heat in Rich land, Washington. They determined that a major cost factor in the operation of solar ponds is the quantity of salt necessary to substain the salinity gradient.

For power generation and operating experience on large ponds, Ormat Turbine Comapny, Yavne, constructed a solar pond having an area of $1500m^2$. The pond is supplying hot brine at a temperature of 80 - 90°C, to the boiler of an Organic Rankine tubine. The pond is working since 1977 and supplying eletrical power on a 24 hour basis.

The largest solar pond operating in the USA was constructed in 1978 by DOE Mound Lal. Miamisburg with an area of $2020m^2$ and depth 3m. It worked well for one year and then linear started leaking.

By World's largest solar pond project of Israel, the first pond was completed in 1978. For power generation multistage desalination and air conditioning ponds having areas of $7000m^2$, $1,00,000m^2$ and $10,00,000m^2$ were constructed. The first pond is providing 150KW of peak power. Future work include the development of 5000 KW and 10,000 KW power station.

Kovi (1979) reported a numerical analysis of the static salt gradient solar pond in which he found that the efficiency equation had the same form as that of a conventional flat plate collectior.

Patel et al. (1980) have constructed and opeated a small solar pond in Pondicherry. The pond has a diameter of 11.5m and a depth of 2m thus giving an effective area $100m^2$. The objective of construction was to gain experience in solar pond operation and maintanance in India's difficult climate, evolve criteria for the materials to be used, monitor thermal performance study the physical behaviour of gradient zone. Various problems like leaking through linings, algal growth, and mineral impurities were observed. The pond is fully instrumented, gradient stabilization by using hot brine injection, and algal control by using a submerged chlorinator have been successfully tied.

For power production and desalination a salt gradient solar pond having an area of $1600m^2$ was constructed in Bhavnagar in 1981. It is designed to supply heat to a 20 KW Rankine Cycle turbine.

Bryant et al. (1981) reported that a salt gradient solar pond of the university of New mexico reached a temperature of 109°C and boiled during July of 1980. The stability of the salt and temperature gradients were substaintially disrupted when the pond began to boil. Since this pond was of a relatively smaller size ie. having 13m. diamenter it is reasonable to expect that larger ponds would be even more susceptible to boiling unless heat is extracted.

Laboeuf (1981) investigated the possibility of using solar ponds to provide hot water for residential Subdivisions. The study indicated that it would be technically and economically feasible to use solar ponds to supply the thermal requirements of a community.

Measurements and several observations of a small scale pond temperature and salinity profiles has been carried out by R.P. Beldom and J.F. Lane in 1982.

Y.F. Wang and A. Aklarzadesh (1983) obtained Mathematical correlations of the pond collection efficiency similar to that for flat plate collectors.

Kamal and Hassal (1984) have conducted a theoritical study of a small-scale solar pond augmented with an outer planar reflector to examine the influence of the main design features of the pond on its performance. They showed that an increase of 15% was obtained in the energy reaching at the pond bottom during the year by attaching a reflector of an area equal to that of the pond.

In 1984 scientists at the Indian Institute of science set up $240m^2$ solar pond, which provided long term data on continuous heat extraction from small solar ponds.

A 300 square metre solar pond is being built to supply hot water for student hostel in an engineering college in Karnataka in 1985.

Elhadidy and Mimmo (1986) studied the various parameters that effects the performance of salt gradient solar ponds.

Lund and Keinonen (1987) studied the effect of various salts including impure salts on salt pond performance.

Mohammed Afeef and Mullet (1987) studied the transmission of solar energy in salt gradient solar ponds and arrived at the conclusion that not only is water extremely transparent for the purpose, but sodium and magneisum chloride solutions are less obscuring than those of salts with other radial and given enough time will clear themselves.

Shafey _et al_ (1988) studied the performance of a covered small scale solar pond with a planar reflector. The pond performance was evaluated by a collection efficiency based on overall energy balance of the pond. The effect of the planar reflective tied angle reflection characteristics of the pond's inside wall on the pond efficiency were studied. Leniar correlations were obtained for both instantaneous and average pond collection effiencies.

A small scale salt gradient solar pond having 2x2m aperture area and 0.5m depth was constructed on the roof of the heat laboratory at Assicet University in Egypt, by Shefey et al. (1989) and the following conclusions were made. A temperature level of 65°C was obtained in a simple open pond while a level of 72°C was attained in a covered pond augmented with a planar reflector with heat extraction. Heat removal upto 5MJ/m^2. day at a temperature level of 55°C is quite applicable during sun hours in summer without significant changes in pond storage temperature. In winter, this value is reduced to 3MJ/m^2. day. Ponds having inside black painted walls are more efficient than those having reflecting walls.

An experiment was done with the aim of producing mobile, experimental and domestic solar pond by Akoshile (1991). NaCl solution was used and temperature difference as high as 18°C within shallow depth of 0.28m was attainable on ordinary darkened clay pot. Pot temperature gradient of 0.46°C/cm was obtained.

MATERIALS AND METHODS

This chapter deals with the materials of construction fabrication, location and the method of study of the experimental solar pond.

An experimental solar pond of size 1mx1mx0.55m was constructed using 24G GI sheet. It consisted of two tanks of dimensions 1mx1mx0.3m and 1x1x0.25m, the latter being placed over the former. A 3cm outward folding was given on both sides of the top tank and at the top of the base tank. This was to facilitate proper seating of the tanks. An angle iron of size 0.025x0.025x0.003m was used to make frames to given suport to both tanks.

A thin transparent plastic sheet of size 1.2x1.2m was fixed in between the two tanks. This was provided to prevent mixing of seperate layers of water in both tanks as well as to act as a good insulator of heat. This would also help in the transmission of solar radiation into the bottom layer. Single layer of rubber sheet packing of 3mm thickness and 3cm. wide was glued to the folding faces of both tanks, coming into contact. The plastic sheet separation was kept in between the packing sheets. Holes were punched out on the angle iron frame, the sheet foldings, packings as well as on the transparent sheet, so that all the holes coincided and rendered firm water tightness using nuts and bolts.

Inlet to each tank was constructed on the same side by punching out holes of 0.025m diameter and attaching bends of 0.025m diameter and by gas welding. Each bend was given a GI coupling which was closed on top by welding a suitable shield. This arrangement was given to fill the tanks with water and to close for water tightness after filling. This could present the escape of water through the inlets.

A thermometer was fixed to each tank using rubber cork glued to them. A hole was punched on one side of the tank and the rubber cork with a collar was pasted to it. A hole was made in the cork using heated rod inorder to insert the thermometer firmly to prevent leakage. In addition, a coating of fevicol was given on the rubber cork to make it leak proof.

The inner side of the base tank was painted black. This was done to absorb as much radiation as possible than any other coloured surface. The gap between the side walls and the bottom of the base tank which was gas welded earlier was filled with molten battery compound to render it leak proof. The two tanks were assembled using nuts and bolts of 0.025mx0.0062m size.

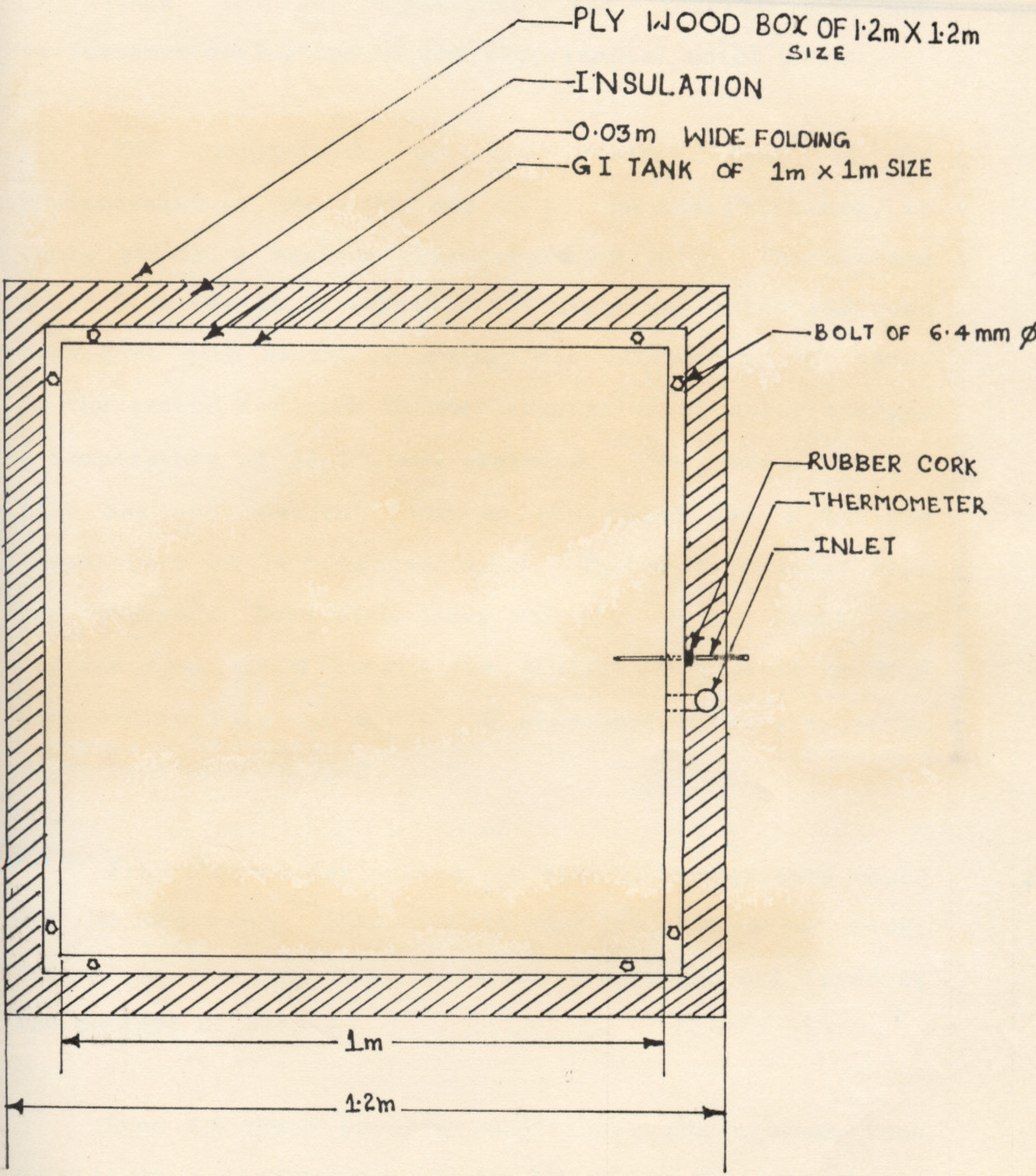
An insulation box of size 120x120x65xm was constructed from plywood sheets. An angle iron fram was made, holes drilled and the walls and base of the box were fixed to it using 0.019x0.006m nuts and bolts. A 0.02m thick insulation layer was given on the base of the plywood box. The metal tank was placed inside it and the gap between the tank and the box was filled using saw dust and straw. This was to prevent loss of heat by convection currents of air and by radiation. Thus whatever heat developed inside would be stored without losses.

3.1. Testing of the experimental set up:

The Cohole set up was installed on a firm platform near the side of the thermodynamics lab of the college. The place receives abundant rays of sun. Water was filled in the bottom tank at first and later on in the top tank. Leaking at the junctions were found and was remedial immediately using battery compound and M seal. The initial room temperature and temperatures of both tanks were noted down. The solar flux in MW/cm^2 was also noted down initially. Similar readings were taken at 1hr. interval till 6 PM. Similarly next day's observations began at 8AM and continued till 6PM and the observations were tabulated.

Plate - 1. Overall view of the structures.

Plate - II. Side view of the structures.


PLY WOOD BOX OF 1·2m X 1·2m SIZE
INSULATION
0·03m WIDE FOLDING
G I TANK OF 1m x 1m SIZE
BOLT OF 6·4 mm ø
RUBBER CORK
THERMOMETER
INLET
1m
1·2m

PLAN

RESULTS AND DISCUSSIONS

This section highlights the results of the performance evaluation of the experimental solar pond.

The temperature of the storage tank at he commencement of the study was 29°C. On the first day, it could attain a maximum temperature of 34°C. The average solar flux was 34.54 mW/cm^2. The night was rainy and even then that much amount of energy was retained in the tank. In the second day with further absorption of solar energy, a temperature of 37.5°C was observed. The average flux on that day was 44mW/cm^2, and on the third day a maximum temperzture of 39°C was recorded. The average solar flux was 54mW/cm^2. Even with heavy rainfall in the night, the storage tank could retain the stored temperature with a very little loss of 4°C. The atmospheric temperature at night came down to 25°C.

From the 4th day onwards, a rise in temperature could not be attained. This may be due to low solar flux, leakage in the base tank, sediment water, and oil layer at the surface of water.

Even in these adverse conditions, the storage tank maintained a temperature 4°C to 7°C above the atmospheric temperature, with a collection area of $1m^2$ at a collector height of 30cm.

4.1. Conversion efficiency:

On the First day,

Heat developed at the bottom of the tank	= mCpdT
	= 300Kg x 4.174KJ/KgK x (34-29)°K
	= <u>6261</u> KJ
Average solar radiation	= 34.54 mW/cm^2
	= 12434.4 $KJ/10\ hr.m^2$
Conversion efficiency	= $\frac{6261}{12434.4}$
	= 50.35%

On the Second day

Heat developed Q=mCpdT	= 300Kg x 4.2KJ/Kg°K x 3.5°K
	= <u>4410</u> KJ
Average solar radiation	= 3600 x 0.44 x 10 KJ/ 10 hr m^2
	= <u>15840</u> $KJ/10\ hrs.m^2$
Conversion efficiency	= $\frac{4410}{15840}$
	= 27.8%

On the Third day

Heat developed Q = 300 x 4.2 x 4.5 KJ

Average Solar radiation = 3600 x 10 x 0,3083 KJ/10hr. m^2

Conversion efficiency = 51.05%

On the Fourth day

Heat developed = 300 x 4.2 x 3 Kg x KJ/Kg°K x °K

= 3780 KJ

Average Solar radiation = 3600 x 10 x 0.403 KJ/10 hr. m^2

= 14508 KJ

Conversion efficiency = $\frac{3780}{14508}$

= 26.05%

On the Fifth day

Heat developed = 300 x 4.2 x 5 Kg x KJ/Kg°K x °K

= 6300 KJ

Average Solar radiation incident = 3600 x 10 x 0.2733 KJ/10 hr. m^2

= 9838.8 KJ

Conversion efficiency = 64.03%

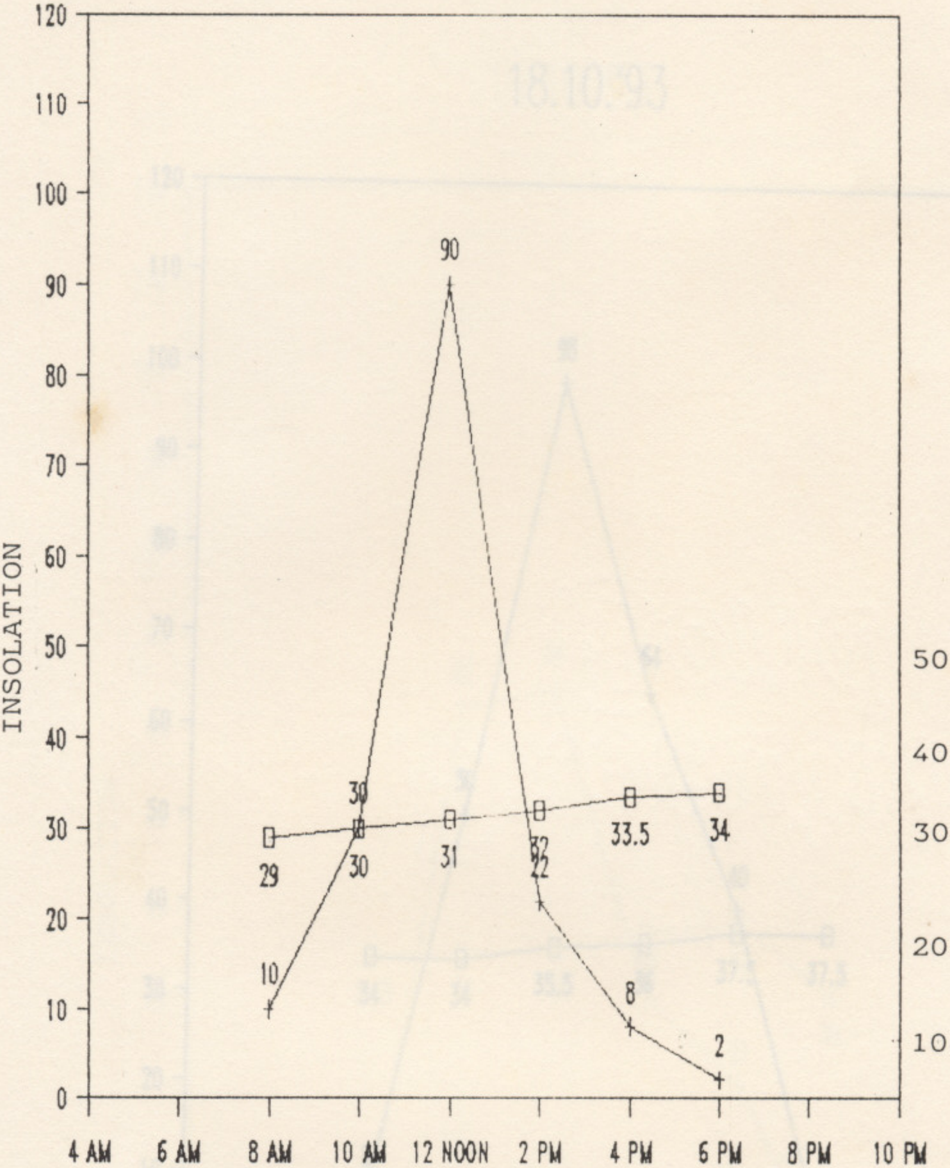
∴ Net average concerssion efficiency of the pond = 39.5%

Suggestions for further study:

As a result of the present study conducted the following areas are considered important for further investigations.

1. In the present study, the collector height was limited to 0.3m. Performance of the pond with varied collector height can be attempted for further studies.
2. The height of the upper tank may be varied for studying the insulating effect of water.
3. Heat development in the pond at different salt concentrations is another area for further investigations.

17.10.'93



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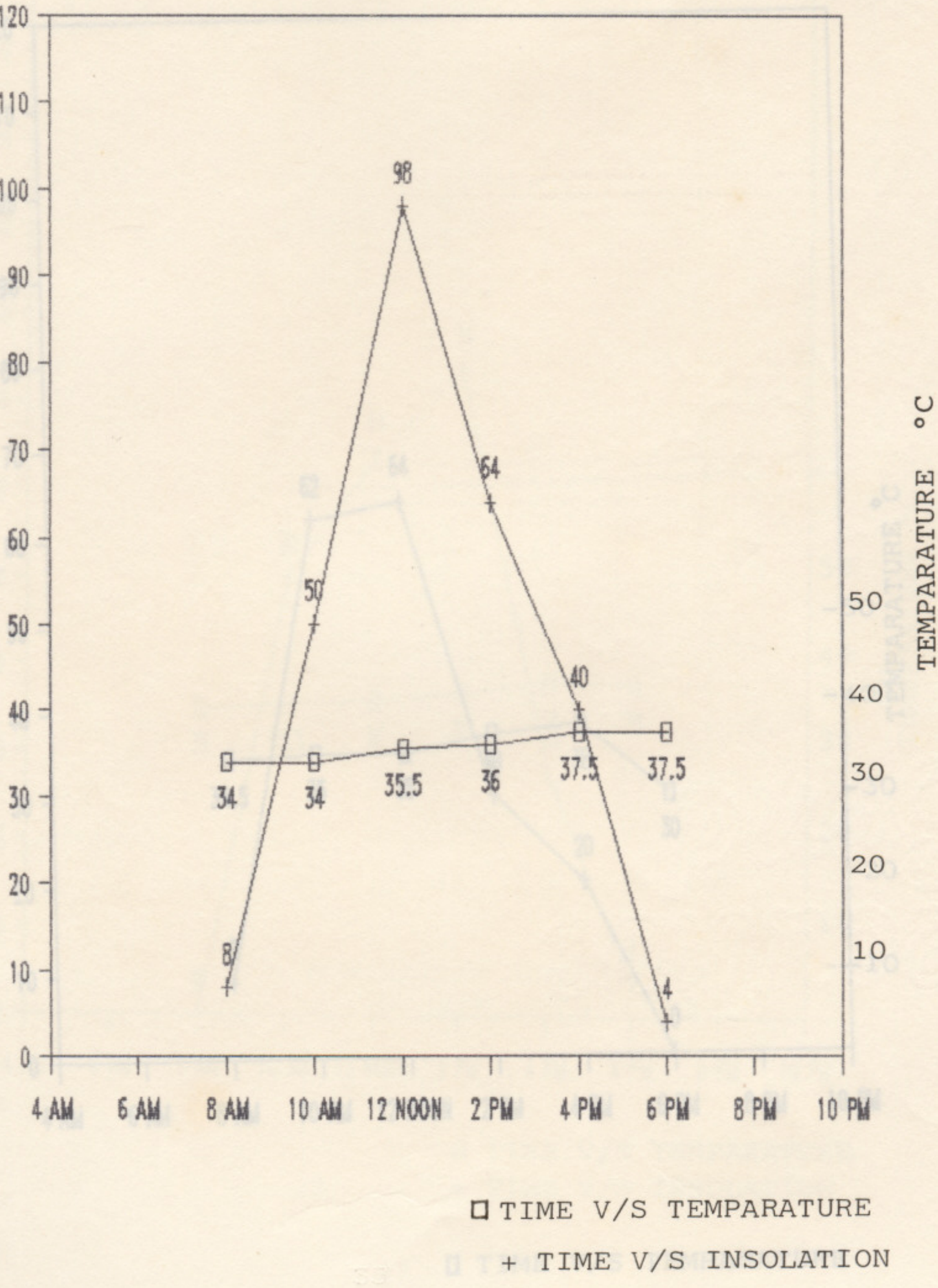
18.10.'93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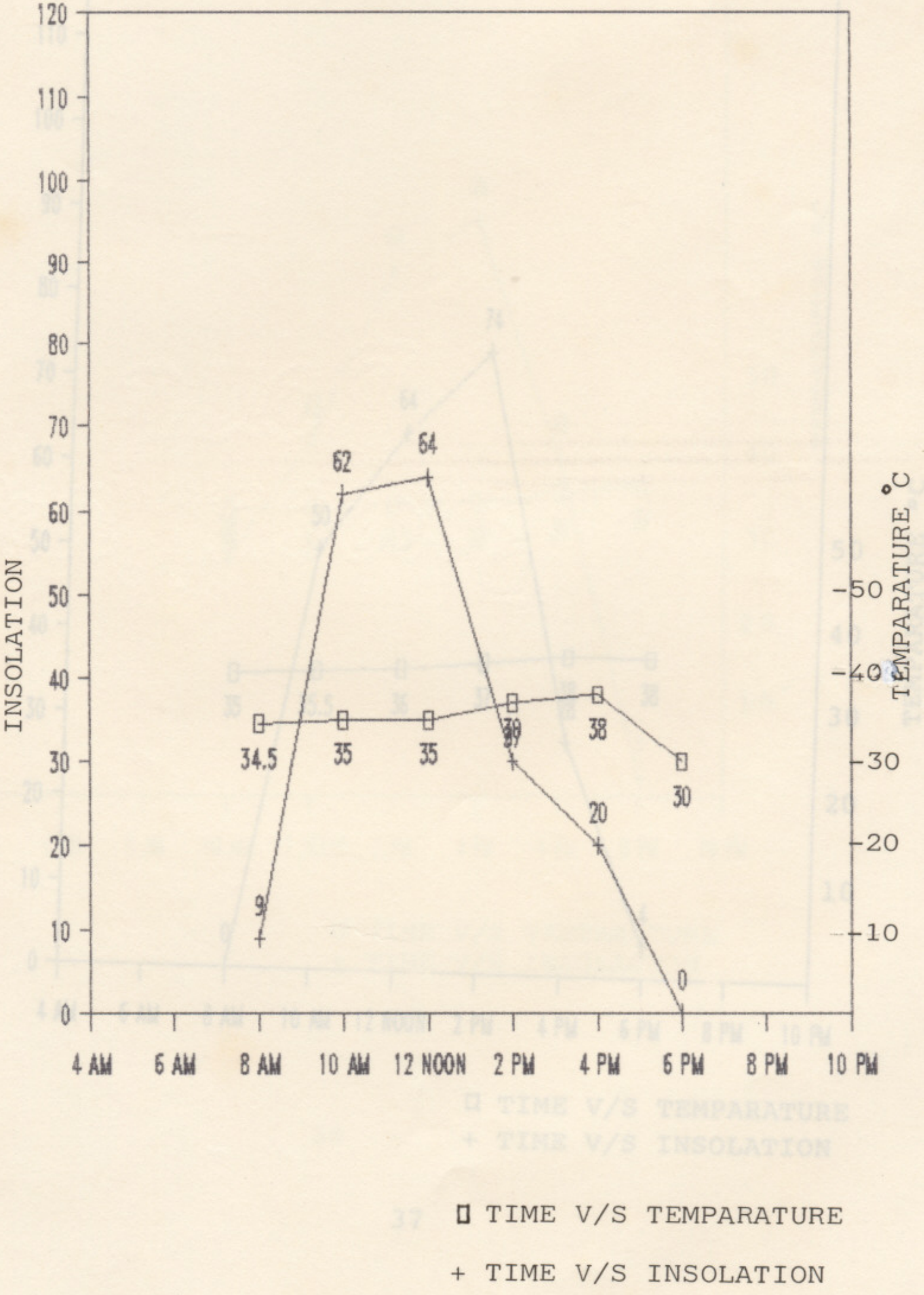
19.10.'93



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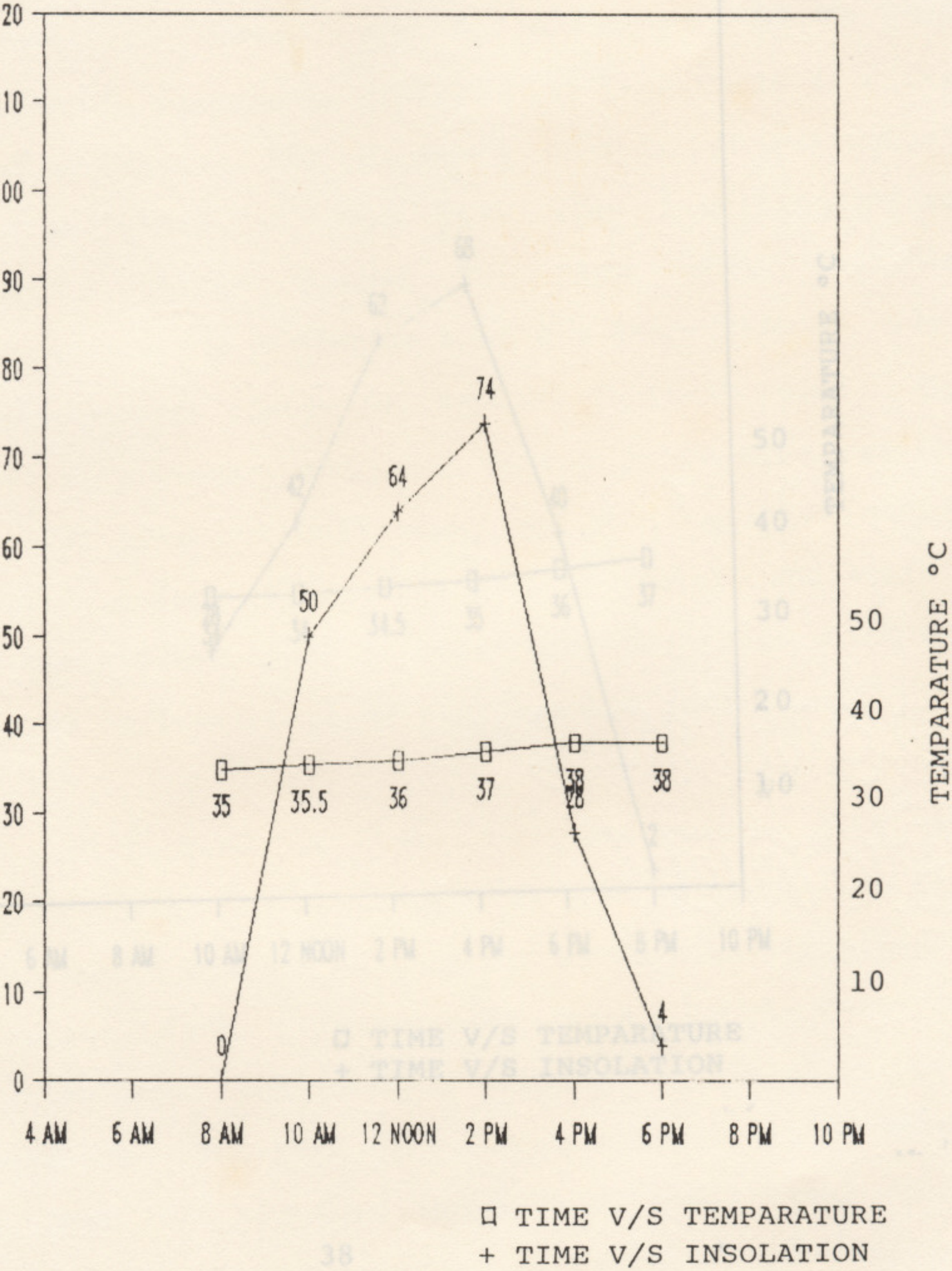
10 PM
□ TIME V/S TEMPARATURE
+ TIME V/S INSOLATION

20.10.'93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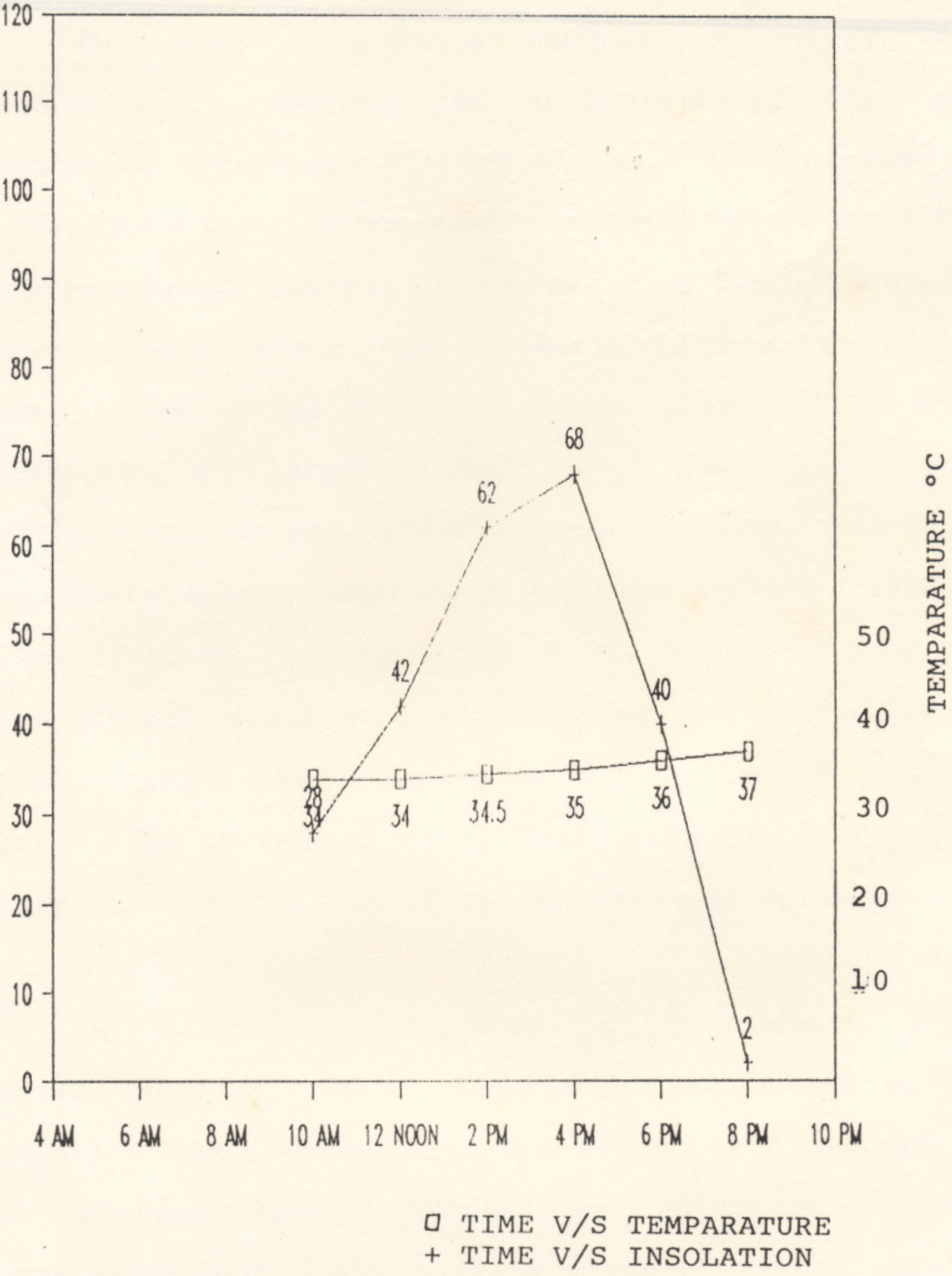
□ TIME V/S TEMPARATURE
+ TIME V/S INSOLATION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□ TIME V/S TEMPARATURE
+ TIME V/S INSOLATION

SUMMARY

Man needs increasing amounts of energy to move forward to prosperity and modernisation. The present sources of energy are limited and will be exhausted within a few centuries. Hence there is the intense need to find more economical sources of energy. The importance of solar energy comes here. The presently used solar collectors made up of glass or wood have size limitations and therefore a large number of them with suitable interconnections are needed to meet the requirements. Also a separate storage system is required in these cases. But an artifically constructed pond called solar pond perform an efficient means of collecting and storing solar energy by employing a mass of water as both collection and storage media. The present study is dealt with the fabrication and performance evaluation of an experimental solar pond.

A solar pond of area $1m^2$ and depth 55cm was fabricated using 24G GI sheet. It was tested on no load condition and a maximum temperature of 39°C was obtained in the storage tank. Tempeatures were taken for five consecutive days. The maximum temperature was obtained on the third day. The days were cloudy and the nights were rainy. Even then the pond could store the thermal energy with very little loss. Lowering of surrounding temperature,

cloudy days, rainy nights, and loss of heat due to leakage may be reasons for not attaining higher temperatures. Even in these adverse conditions, the solar pond performed well.

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OBSERVATIONS:

17.10.1993

Time	at: temperature	Storage tank temperature	Top tank temperature	Solar flux mW/cm^2
8 AM	28°	29°C	28°	10
10 AM	28.5°	30°C	28.5°C	30
12 Noon	31°C	31°C	31°C	90
2 PM	32°C	32°C	34°C	22
4 PM	28°C	33.5°C	35°C	8
6 PM	27°C	34°C	36°C	2

Average Solar radiation = 27.33 mW/cm^2

18.10.1993

Time	at: temperature	Storage tank temperature	Top tank temperature	Solar flux mW/cm^2
8 AM	25°C	34°C	28°C	8
10 AM	26°C	34°C	30°C	50
12 Noon	30°C	35.5°C	34°C	98
2 PM	31	36°C	36°C	64
4 PM	30	37.5°C	36°C	40
6 PM	28	37.5°C	36°C	4

Average Solar radiation = 44 mW/cm^2

19.10.1993

8 AM	26°C	34.5°	32°C	9
10 AM	28°C	35°C	34°C	62
12 AM	31°C	35°C	36°C	64
2 PM	32°C	37°C	38°C	30
4 PM	31°C	38°C		20
6 PM	30°C	30°C	35°C	0

Average Solar radiation = 30.83 mW/cm^2

20.10.1993

Time	at: temperature	Storage tank temperature	Top tank temperature	Solar flux mW/cm^2
8 AM	25°C	35°C	32°C	0
10 AM	29°C	35.5°C	32.5°C	50
12 Noon	33°C	36°C	33	64
2 PM	32°C	37°C	34	74
4 PM	33°C	38°C	35°C	$28mW/cm^2$
6 PM	31°C	38°C	35°C	$4mW/cm^2$

Average Solar radiation = $36.6mW/cm^2$

21.10.1993

8 AM	30°C	34°C	32°C	$28mW/cm^2$
10 AM	31	34	33	$42mW/cm^2$
12Noon	33.5	34.5	35	62
2 PM	33	35	35.5	68
4 PM	30	36	36	40
6 PM	29	37°C	36	2

Average Solar radiation = $40.3mW/cm^2$

FABRICATION AND PERFORMANCE EVALUATION OF A SOLAR POND

By

BALAKRISHNAN. A.

KAVITHA. K. S

ABSTRACT OF THE PROJECT REPORT

Submitted in partial fulfilment of the requirement for the degree of

Bachelor of Technology in Agricultural Engineering

Faculty of Agricultural Engineering & Technology
Kerala Agricultural University

Department of Farm Power Machinery and Energy
Kelappaji College of Agricultural Engineering and Technology
Tavanur – 679 573
Malappuram

1993

ABSTRACT

This project was taken with the objectives of fabrication and performance evaluation of an experimental solar pond.

The solar pond was fabricated and tested on no load condition. The maximum temperature obtained was 39°C. The temperature readings were taken for five consecutive days. The maximum temperature was obtained on the third day. The days were cloudy and the nights were rainy and the room temperature came down to around 25°C. The storage tank showed a decrease in temperature only by 2-3°C, thus serving as an effective storage device. The cloudy days and rainy nights, lowering of surrounding temperature and the loss of heat due to leakage may be the reasons for the lowering of temperature and not attaining higher temperatures during day time. The pond performs well even in adverse conditions.