I.E.T Dr. RAM MANOHAR LOHIA AVADH UNIVERSITY
AYODHYA, U.P, INDIA
JUNE 2019

SOLAR WATER HEATING SYSTEM USING CONCRETE SLAB

PROJECT REPORT

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF

BACHELOR OF TECHNOLOGY

(Mechanical Engineering)

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This is certified that RITESH VERMA (15435), SANDEEP YADAV (15438), DAYANAND (15417), SAURABH PAL (15441) carried out the project in this major project entitled "**SOLAR WATER HEATING SYSYTEM USING CONCRETE SLAB**", for the award of "BACHELOR OF TECHNOLOGY" from "I.E.T, Dr. RAMMANOHAR LOHIA AVADH UNIVERSITY,AYODHYA" under my supervision .

The project embodies results of original work and studies carried out by students himself and the content of project do not form basic for any degree to candidate or anybody else from this or any other institution/university.

Signature of External Examiner

Signature of H.O.D

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Signature of the Supervisor

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CANDIDATE'S DECLARATION

We declare that this written submission represents our work and ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that We have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission.

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ACKNOWLEDGEMENT

We would like to place on record deep sense of gratitude to Miss. Kriti Srivastava (Assistance professor) Dept. of Mechanical Engineering, I.E.T, Ayodhya, India for her generous guidance, help and useful suggestions and supervision throughout the course of project work.

We express our sincere gratitude to Mr. Umesh Chandra Verma **(**H.O.D of Department of Mechanical Engineering I.E.T, Ayodhya **)** for his stimulating guidance, continuous encouragement.

We also wish to extend our thanks to all faculties of Mechanical Engineering Dept. for their insightful comment and constructive suggestions to improve the quality of this research work.

We are extremely thankful to Prof. Ramapati Mishra, Group Director, I.E.T, for providing me infrastructural facilities to work in, without which this work would not had been possible.

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ABSTRACT

With the advancement of new technologies the urban areas have widely developed. But we can’t say the same for rural areas, where still the traditional ways prevails. Domestic water heating is one of the things, in rural areas, which consumes non renewable energy sources like fossil fuels.

At this stage of energy crisis, it has become essential to switch towards renewable energy sources, one of which is solar energy. The solar panels used, in conventional water heating system, to harness the solar energy are so costly to afford for rural people. Therefore, an alternative option has been evolved for its replacement using concrete slab solar collector.The present dissertation work deals with the performance evaluation of concrete slab solar collector. In order to perform this experimentally, a concrete slab of fixed dimension (length,breadth, and thickness) would be considered. Selection of the various materials suitable for the desired purpose will be made. After that the fabrication of the experimental setup will be carried out. Then after performance of the concrete slab solar collector would be evaluated by considering the effect of various tilt angles on the temperature attained by the fluid. Further results would be plotted between time and temperature keeping other factors held fixed and the comparison will be made for all the cases.

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CHAPTER 1
INTRODUCTION

1.1 General Information

Energy is the most common word used nowadays. From academic to industrial, every field talks about energy. If we talk about its literal meaning, it is the capacity to do work, but its importance is far greater. It forms the basis of economic development or rather we can say the overall development, which includes economic as well as the technological development of any country. The economic development of a country is directly related to the energy demand and its consumption, as it is the measure of economic growth. But its relation is not straight forward linear i.e. one fold increase in country's Gross Domestic Product increases two fold or three fold of energy demand.Hence, for a country like India, with third largest economy [1] in the world and stillgrowing rapidly, the energy plays an unavoidable role for the development

The much talked energy basically occurs in different forms from various sources. The pie chart shown below shows the sources of energy worldwide. The various forms of energy occurring in the nature accounts for non-renewable sources of energy. This means that once they are finished, cannot be replenished or will have to wait for millions of years to regenerate them. According to International Energy Agency in 2010, [1] of the total energy sources in India, 33% of the sources produce oil, followed by 27% for coal/peat, and 21% for natural gas. Rest belongs to the minority group as it accounts to only 19% i.e. 10% bio fuel and waste, 6% nuclear, 2% hydro and 1% others.

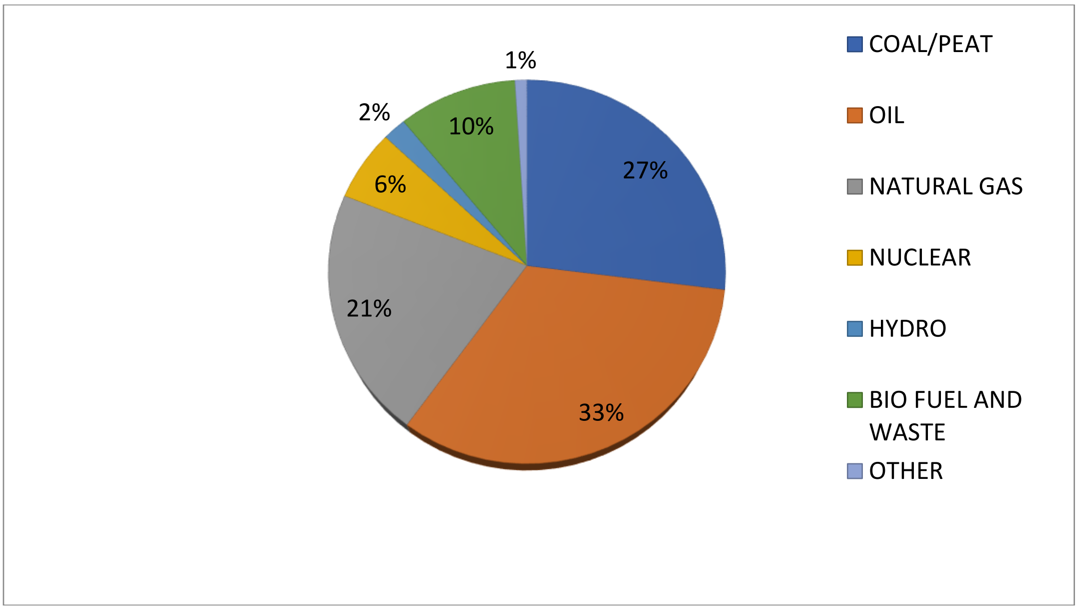

Figure 1.1 Worldwide Energy Source in 2010 (International Energy Agency)

1.2 Energy Consumption/Demand/Crisis

India's population contributes to 18% of the total world's population. Still it uses only 6% of the world's primary energy. If seen from the past, the energy consumption in India has almost doubled since 2000 and is expected to increase rapidly. Since it forms the key factor for the development of any nation its consumption is increasing at a faster rate. Now the situation has come where the sustainable development is required.

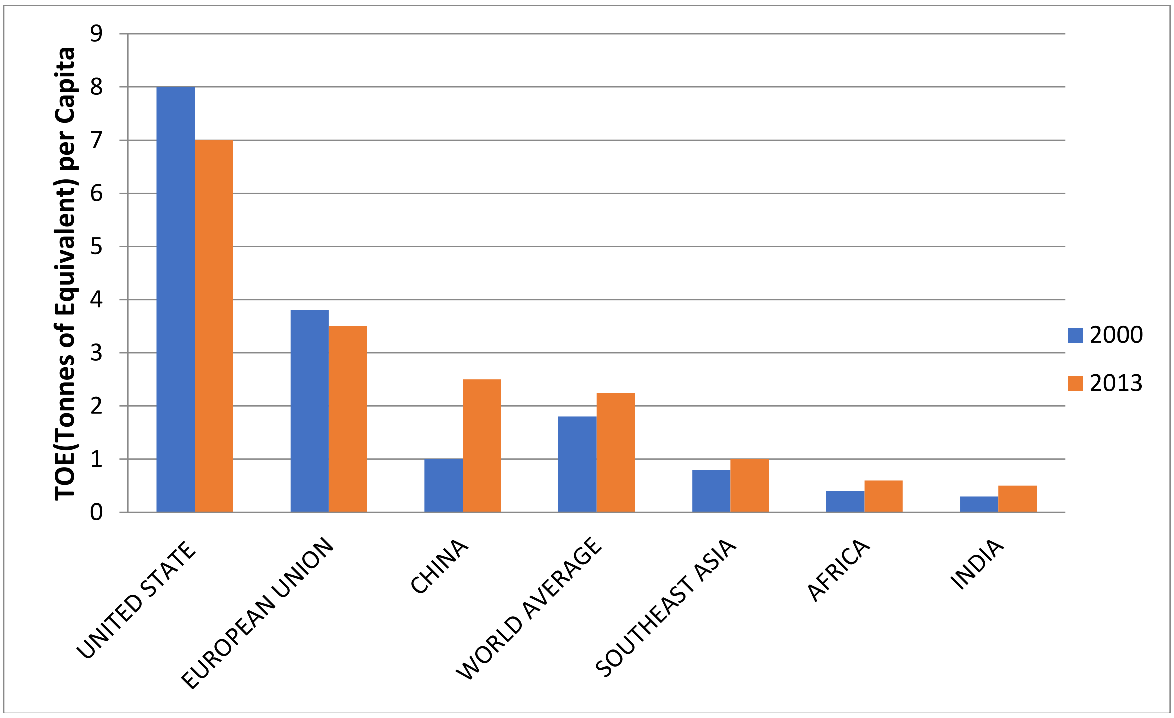

Figure 1.2 Per Capita Energy Consumption in India and Selected Regions

Per capita energy consumption for India and some other regions has been shown above. It can be seen that the energy consumption in India is much less as compared to other regions like United States, European Union or China. But if compared with the time, the consumption from 2000 to 2013 has been increased and is likely to be increased enormously in future.

Primary energy is the energy which is naturally available in the nature. It basically includes coal, oil biomass, natural gas and nuclear. These sources of energy, being easily available, are used at a large scale. The demand for these sources has increased many folds from 2000 to 2013. This increase in demand is depicted by a pie chart shown below. It can be seen that the demand for coal is increased from 34% to 44% from 2000 to 2013. The overall demand for primary energy source has increased from 441 Mtoe (million ton of oil equivalent) in 2000 to 775 Mtoe in 2013. [1]

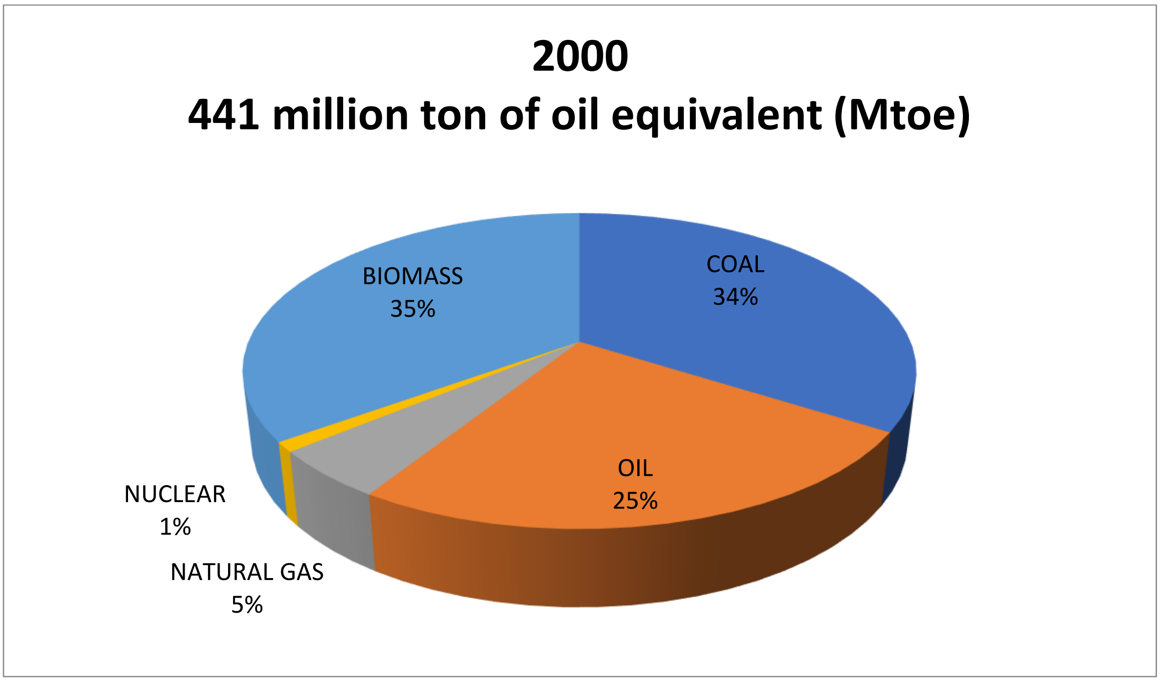

Figure 1.3 Primary Energy Demand in India by Fuel in 2000 [1]

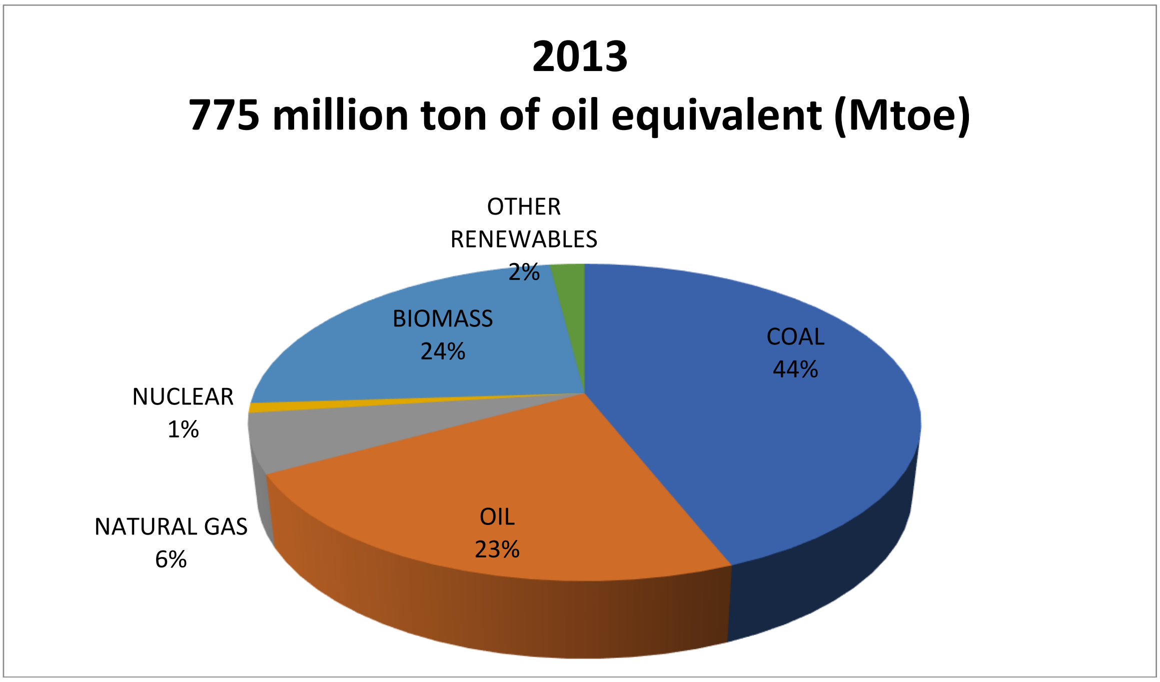

Figure 1.4 Primary Energy Demand in India by Fuel in 2013 [1]

One of the major forms of energy used is electricity. Most of the fuel consuming sector is electricity sector. From past few decades the use of electricity has been increased with the increasing phase of industrialisation. So this increase in electricity generation is met by consuming the naturally occurring fossil fuels like coal.

Below shows the total electricity generation in India by fuel i.e. the amount of electricity generated by every fuel. At the same time the increasing trends in the use of fuel for electricity generation has also been shown from 1990 to 2013. [1] It can be seen that the increase in the use of coal for generation of electricity has increased at a potential rate. This has to be controlled.

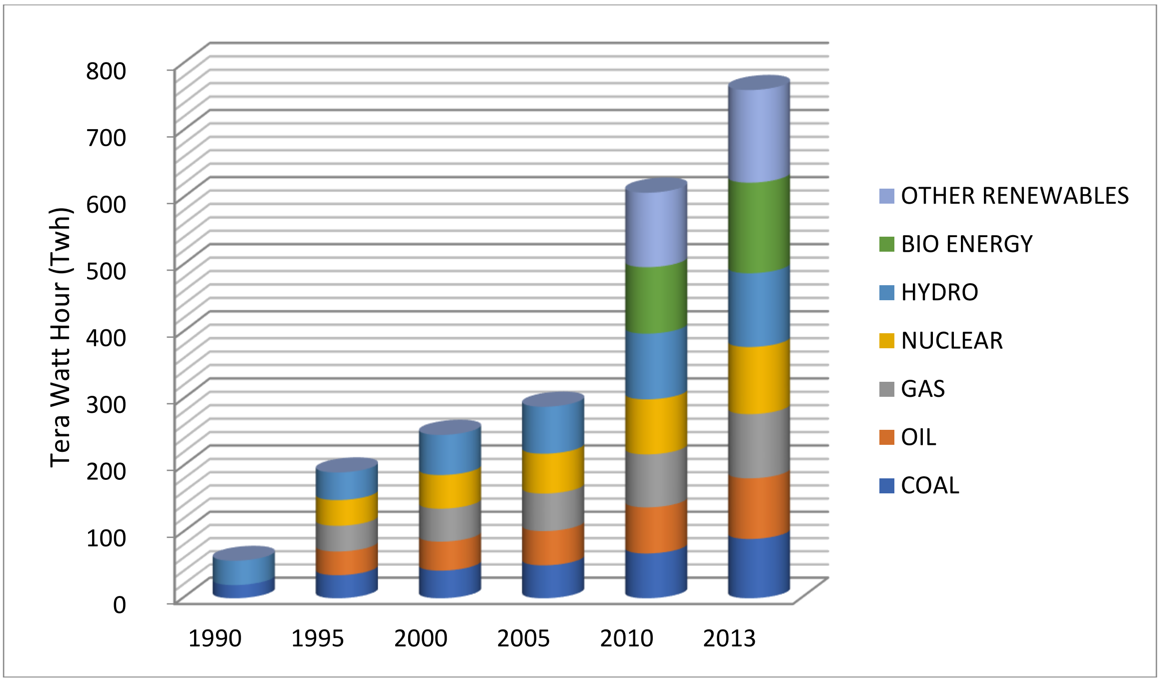

Figure 1.5 Total Electricity Generation in India by Fuel [1]

1.3 Need for Renewable Energy

In the above section we have seen the increasing trend in energy consumption, the ever growing energy demand and the upcoming energy crisis. Accounting to all these factors there is an immediate need for the use of renewable energy sources in replacement of non-renewable energy sources. In the above section we have talked about the sustainable development. It is a very essential and much focused topic of the present time. Sustainable development means the use of naturally occurring energy sources in such a manner so as to make it available to the future generation. Sustainability reduces the stress laid on the natural resources

.

Table below shows the number and share of people without access to electricity by state in India in 2013. It can be seen that even at this time of development, there is a large share of people who don’t have access to electricity, whether be rural or urban.

Table 1.1 Number and share of people without access to electricity by state in India,2013 [1]

	Population without access (million)			**Share of population without access (Percentage)**		
	Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**
Uttar Pradesh	80	5	85	54	10	64
West Bengal	17	2	19	30	7	37
Assam	11	0	11	45	9	54
Rajasthan	10	0	10	22	2	24
Odisha	10	0	10	32	4	36
Jharkhhand	8	0	8	35	4	39
Madhya Pradesh	7	1	8	16	3	19
Maharashtra	6	1	7	11	2	13
Gujrat	2	2	4	7	6	13
Chhattisgarh	2	0	2	14	6	20
Karnatakka	1	0	1	5	1	6
Bihar	62	2	64	69	19	88
Other States	3	2	5	2	2	4
Total	219	15	234	346	65	411

Since electricity, the primary and major form of energy, is an essential requirement for present generation. Hence there has to be another way to fulfil the need of electricity and at the same time reduces the use of natural source like coal for its generation. The only way out is to switch towards the renewable sources.

Also it is a very new concept for a developing country like India. So in the meanwhile when it takes leap, fossil fuel balance is very necessary. As shown below, a large share of fossil fuel like coal, crude, oil products, natural gas was produced during 2000 and some were exported also. But as the time passes by 2013, the production of these energy sources decreases. Rather its import and export increases. This induces a huge expenditure stress on the economy of nation.

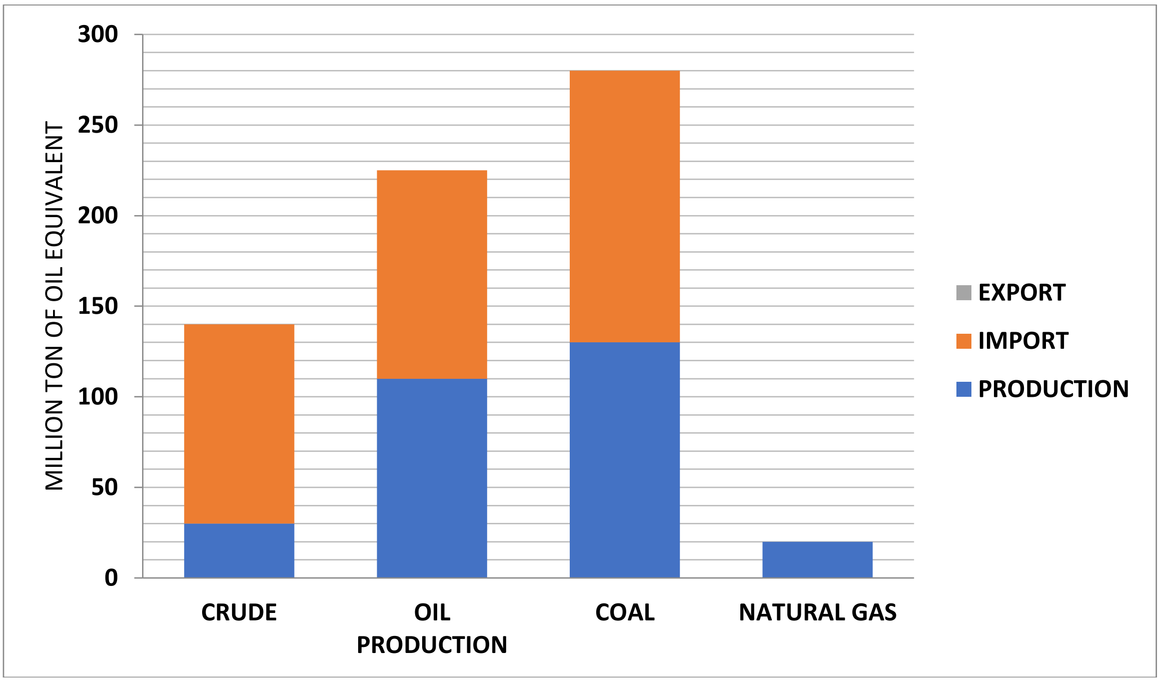

Figure1.6 Fossil Fuel Balance in India in 2000 [1]

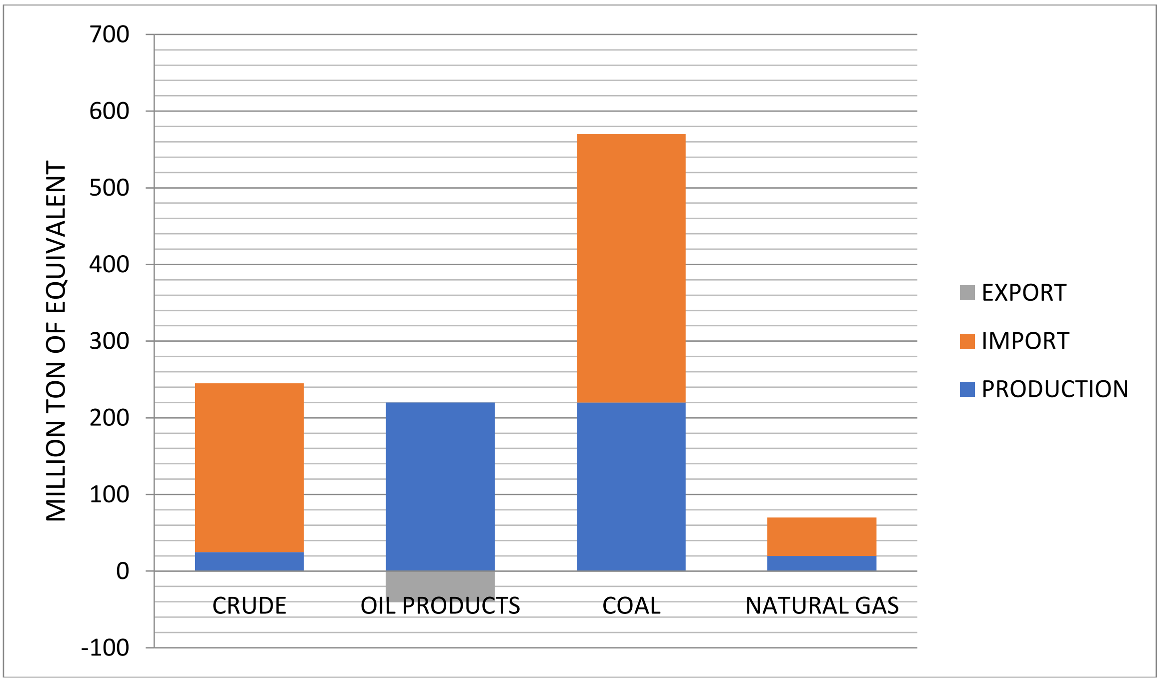

Figure1.7 Fossil Fuel Balance in India in 2013 [1]

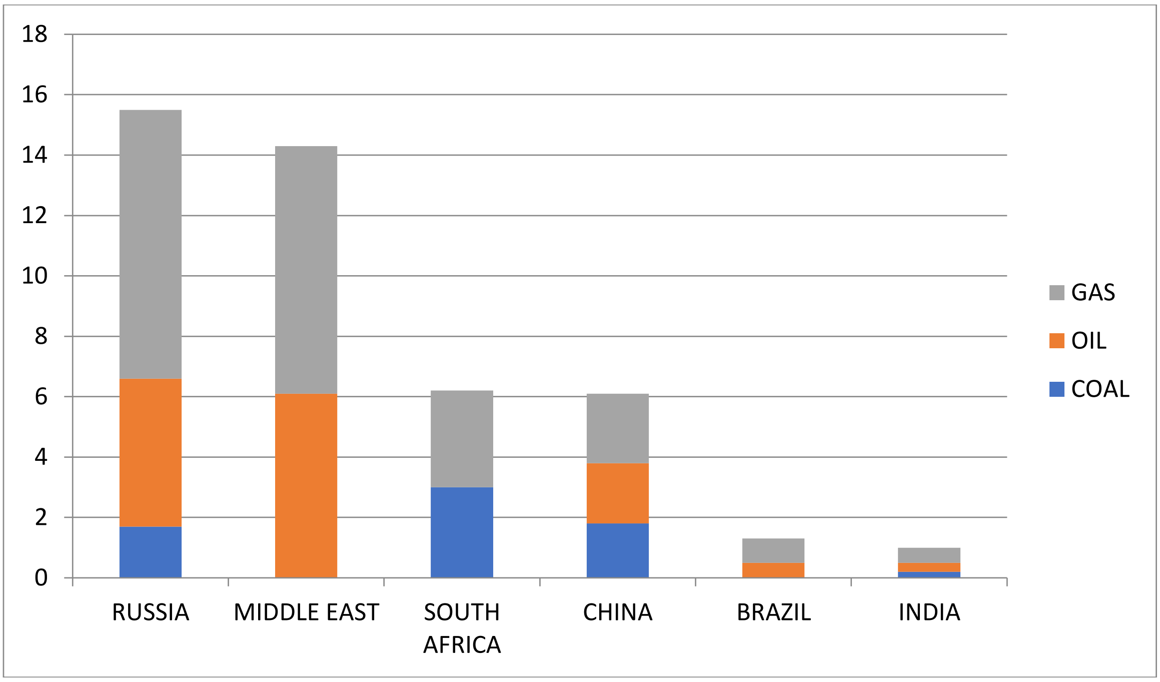

Figure1.8 Fossil-fuel production and demand per capita by selected countries, 2013 [1]

In the figure 1.8 shown above denotes the production of gas, oil and coal in different countries. The small star denotes the demand of total fossil fuels.

Hence, to avoid stress on the non -renewable natural resources, the researchers have been studying on alternative energy resources like wind energy, solar energy, hydro,geothermal, etc. These are termed under renewable energy sources. One more important benefit of using these alternatives is that these are eco-friendly. That means these energy sources impose no harm to the surrounding environment which is an important point to be noted.

1.4 Scope of Solar Energy in India

There is a wide scope for solar energy in India reason being the geographical location of the country. It is in the tropical region which receives solar insolation almost throughout the year, which amounts to 3000 hours of sunshine. It can be estimated that 4-7 kWh of solar insolation per sq meters is received by all parts of India. Indian states like Bihar,Haryana, Gujarat, Andhra Pradesh, Orissa, Punjab, Rajasthan, Madhya Pradesh, and West Bengal have great benefit of location for tapping solar energy. Since 70% of the population of India lives in rural area, hence there is much scope for promoting solar energy in these areas. Using solar energy reduces the use of firewood or cow dung for rural house hold.

Many large projects have been started in the field of solar energy:

- Present Prime Minister Narendra Modi inaugurated India's biggest solar power plant (MW)at Diken in Neemuch district of Madhya Pradesh, on 1st March, 2014.
- Solar power policy of Gujarat aims to achieve 1,000 MW of solar energy generation.
- In July 2009, $19 billion solar power plan was disclosed. It was estimated to produce 20 GW of solar power by 2020.
- The Jawaharlal Nehru National Solar Mission (JNNSM) launched by the centre is targeting 20,000 MW of solar energy power by 2022.

1.5 Main Intention to Choose the Problem

With the advancement of new technologies the urban areas have widely developed. But we can't say the same for rural areas, where still the traditional ways prevails. Domestic water heating is one of the things, in rural areas, which consumes non renewable energy sources like fossil fuels. At this stage of energy crisis, it has become essential to switch towards renewable energy sources, one of which is solar energy, saving electricity, fuel, increased utilization of solar energy etc. Conventional solar panels used, in conventional water heating system, to harness the solar energy are so costly to afford for rural people. Therefore, an alternative option has been evolved for its replacement using concrete

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Concrete slab solar collectors have been investigated by a smaller number of researchers; hence limited literature survey is recorded. Studies are still going on, on the performance of the concrete slab solar collector. The various materials and dimensions taken have their own set properties and essentiality. The variation of the above parameters and its affect on the efficiency of the collector in terms of temperature rise of water has been studied. The result of various researchers has been tabulated below.

Table 2.1 Review Analysis

	Parameters						
Researcher	**Slab dimension (m)**	**Metal Scrap**	**Pipe Material**	**Pipe Dimension (dia,length in mm)**	**Pitch (mm)**	**Testing angle**	**Maximum Temperature (°C)**
P.B.L Chaurasia [2]	1.2x0.62	_	Al	19,1820	60	Horizontal	28
						41° due to south	50
A.A Keste [4]	2x1	Mild Steel	Cu	12,2500	80	33° due to south	58
S.V Bopshetty [5]	_	_	PVC	20,4500	60	Horizontal	34
M.S Murthy [6]	2x1	Al	Cu	_	_	45° due to south	60
Paolo Blecich [7]	_	_	Cu	10,109000	50-450	Horizontal	45
M.A Alsaad [8]	1x1	_	GSP	16.4,1350	100	32° due to south	34
			Propylene Glycol	13,1350	100	32° due to south	30.7
			PVC	13.5,1350	100	32° due to south	32.9

M. S. Murthy et.al.(2011) [6], in their study, used a concrete slab imbibing a network of copper tubing as the solar heat conducting device. Metal powder or metallic scrap had been used in the making of concrete slab to increase its heat conducting properties. Their work on such equipments shows promising results. The temperature of the water in the tank could be increased from 30°C to 60°C (for a 100kg capacity) on the day of average sunshine with ambient temperature at 33°C Their main objective of reducing the cost of solar water heating system was accomplished by about 75% in comparison with the conventional solar water heating system. Calculations shows that 3.39625 Kg coal can be saved per day by using solar water heater of the model described, with the assumption that 200 tons of coal per hour produces 200 MW of power. Thus, 1.239 Tons of coal can be saved per annum per house hold.

Another study as suggested by Keste et.al.((2009) [4], used metal fibre reinforced concrete, having advantage of increased thermal conductivity due to inclusion of metal fibers, as the solar collector. The thickness of the slab taken is 2cm. Mild steel scrap of approximately 15kg is used in the fabrication of the slab, which increases its thermal conductivity as well as the structural strength. The copper tubes are embedded on the top of the slab, in such a manner that 70% of its portion along the length, remains inside the concrete slab and 30% remains exposed directly to the sunlight as suggested by Chaurasia et.al.((2000) [3].The tube spacing taken is 80mm. A 100 litres capacity of storage tank is connected to the collector. From J. K. Nayak et.al.(1992) [9], a comparison of the performance of the collectors having pitches 150,100, and 80 mm, has been made. It was seen that the reducing the pitch from 15cm to 10cm increases the Efficiency appreciably. But if the pitch is further reduced to 60mm, the increase in the efficiency is not that significant.

It is observed that if the roof of the concrete structure is blackened, more hot water can be taken. If the cold water from the overhead tank of the house is drawn from the copper pipes embedded in the concrete structure it can easily supply the hot water at a moderate temperature of to Keste et.al.[4].About 25-40 liter of hot water above can be drawn daily after slight modifications from one square meter area of roof structure in the regions where the horizontal solar insulation exceeds 4kWh/m_2 [10]. The inbuilt cement concrete solar roof system for solar water heating can also be made during the construction of the house. This solar roof can also be employed as a pre- heater to any water heating system. This concrete slab solar water heating system can also be used in the summer season for supplying the hot water at relatively higher temperature that can be used according to the requirements of the buildings [11].

Further studies same as Murthy were performed by changing the material of the pipes used. P.B.L. Chaurasia et.al.(2000) [2] performed the same experiment but with the aluminium pipes embedded in the concrete slab.The absorbing surface area of each slabwas about 1.06 m^2 (dimensions 1.72 m x 0.62 m). The aluminium pipes were embedded over the top surface which acts as the absorbing surface for water heating. Ten aluminium pipes were used percement slab having equal spacing of 60 mm. All the aluminium pipes were inter-connected by high density PVC tubes to make a continuous water flow in the system. The absorbing surface was painted with black board paint to see its effect for enhancing the water heating in the open space. The slabs were uniform and had a thickness of 55 mm to give enough structural strength to it. In his study the collectors have been studied in two positions during winter season. One is the horizontal plane and other with 41° facing due south. The inlet cold water temperature was to in this experiment. The results are summarized as follows:

1.) The cement concrete collectors inclined at optimum 41º due south gave better results for water heating as compared to vertical (south facing) or horizontal cement concrete solar slab collector sets during the winter season.

2.) The temperature rise of water was also found increased if the absorbing surface was painted with black board paint (single coating) as in the case of the second unit inclined at 41º due south. This study revealed that the temperature rise of cold water was enhanced by to by simply blackening the absorbing surface.

3.) The results of this experimental study of the solar water heating from both cement concrete solar collector sets without glazing at the top and insulation at the base have been found to enhance the temperature of cold water by to (inlet cold water temperature to) during the daytime from 10 a.m. to 4 p.m. It only requires the cold water to flow from the overhead tank through a network of aluminium pipes embedded in the cement concrete solar collectors and hot water output at moderate temperature can be drawn and used for various domestic purposes.

M. A. Al-Saad et.al. (1993) [8], in their work have compared the performance of the collector using three different materials for the flow passage i.e. the tubes used in the 12 collectors. The three materials used are Galvanised Steel Pipes (GSP), Propylene Glycol (Thermo pipe) and Polyvinyl Chloride (PVC) pipes. The slab has a total surface area of 1 m^2 with 50 mm thickness. The slab is painted black with the blackboard paint to increase its absorbance power. The main focus of this study is the materials used for flow passage. The diameters of the tubes used are 16.4 mm for GSP, 13 mm for Propylene Glycol, and 13.5 mm for PVC. All the tubes are of 1350 mm length. The optimum spacing kept between the two tubes was 100 mm. The tubes were embedded near to the surface of the concrete slab. The inlet temperature of water for all the three materials was same i.e. The outlet temperature obtained after the heating through solar insolation was for GSP, for Propylene Glycol and for PVC. The results shows that the GSP material was as good as local metallic conventional collectors which has a daily efficiency as high as 40% compared with 45% for the local metallic conventional one.

Paolo Blecich et.al. (2012) [7], in their work studied the performance of domestic water heating system using solar concrete collectors. They have performed a mathematical analysis using a numerical code based on finite volume method. They developed a numerical code to solve the transient three-dimensional heat conduction in the concrete slab having serpentine pipe inside it. The performance of the concrete slab solar concrete is studied by varying the various parameters like pipe spacing, pipe length, pipe depth, tilt angle and solar absorption of the concrete slab.

Blecich et.al. in their work have used copper tubes of 10 mm diameter. The total pipe length is 109 m with 450 mm spacing between them. The number of tubes is 11. The study has been done keeping the slab horizontal, that means the tilt angle β is 0^{o}. The first variation studied was of tilt angle. It was found that the collectors having tilt angle from 15^{o} to 45^{o} offers the best efficiency in the period from May to September. The second variation studied was of tube spacing. It has a great influence on solar concrete collector efficiency. It is varied from 5cm to 45 cm. It was seen that the collector efficiency deteriorates as the tube spacing is decreased.

2.2 Identified gaps in literature:

- From the above review analysis it is clear that there are various parameters affecting the performance of solar collectors. A lot of research has been done on tube materials, its diameter, length, spacing, slab dimensions etc.
- Very little or no work has been done on analysing the effect of tilt angle on the performance of concrete slab solar collector.
- Hence the present work is to be done to analyse the effect of tilt angle on concrete slab solar collector and finally determine the optimum tilt angle for a particular location.

2.3 Objective:

- The main objective of this project is to heat the water by solar energy with the help of concrete slab.
    - Conversion of solar energy into heat by cheap and efficient way.

CHAPTER 3
WORKING AND METHODOLOGY

The present work deals with the performance analysis of the concrete slab solar collector. This is done at 30° tilt angle. The affect of tilt angle is studied through setting up an experimental model. Concrete slab solar collector (CSSC) is basically a substituted version of flat plate solar collector hence its basic construction is similar to it. It consists of a slab in which water tubes are imbibed through which water flows. This water is then further stored in an insulated tank and can be used further.

Various researchers have used different types of material for different purpose as already discussed in literature review. In the present work, with the help of this review analysis, best suited materials have been taken as explained further in this chapter.

3.1 Design Material with Specification

The following table gives a brief idea about the design materials selected and its specification.
Table 3.1 Design Material and Specification.

S. No.	Design material/Parameters	Specifications/Details of material
1.	Solar heating systems	Based on cement concrete slab
2.	Gross dimension of concrete slab	0.8m x 0.5m
3.	Thickness	30 mm
4.	Absorbing surface area	0.4 m^2
5.	Metal scrap	Aluminium
6.	Thermal conductivity of Aluminium	205 W/mK
7.	Absorbing paint	Black paint
8.	Glass cover Thicknrss	4mm
9.	Spacing between the slab and glass cover	5mm
10.	Flow pipes in heating system	Network of copper pipes embedded at top of absorbing surface
11.	Thermal conductivity of copper	385 W/mK
12.	Copper pipes (a) Diameter (b) Spacing between two pipes	 15 mm 60 mm
13.	Overhead tank (a) Capacity (b) Insulating material	 20 liter Foam
14.	Storage tank	12 liter

Gross dimension of the slab indicates the total surface area exposed to the sunlight which absorbs the solar insolation. For more effective rise in temperature of the water it is required that more insolation are trapped which is possible when the surface area of the collector is large. But with the increasing size the weight of the slab also increases which makes it difficult to handle. Therefore, optimum size of the collector is required. The size of the collector normally taken by various researchers was 2 m X 1 m. In the present work the size is 60% scaled down. Now the gross dimension of the slab taken is 0.8 m X 0.5 m. Therefore the total absorbing surface area is now 0.4 m^2. The thickness of the slab is 30 mm .It is kept as small as possible so that the insolation reaches the whole of the slab. Also it is to be noted that it should not be kept much small so as to compromise with the strength of the slab.

Figure 3.1 Concrete slabs as a collector

The materials used for the construction of the slab are the common building materials like cement, sand, pebbles, rods, wires, etc. An additional material is added to the slab i.e. aluminium. This aluminium is added to the concrete mixture as a scrap in the form of small pieces. The purpose of adding aluminium is to increase the thermal conductivity of the slab. It is added near to the surface so that the heat is transferred to the water via tubes easily. Other materials can also be used. Here aluminium is used because its thermal conductivity is 205 W/m K (at room temperature) and is easily available. Easy availability with reasonable cost is a big factor in choosing the material for scrap.

Figure 3.2 Aluminium scrap

Another important part of this concrete collector is the tubes used for the flow of water. From the review analysis it is clear that different materials can be used depending upon the requirement. PVC pipes can be used where cost is the deciding factor. But if the efficiency of the collector not to be compromised then copper tubes are the best options. Its thermal conductivity is 401 W/m K (at room temperature) much larger than any other reasonable material like aluminium or PVC etc. Reasonable is used here as there are lot of material whose thermal conductivity is greater than that of copper like diamond with 1000 W/m K or silver with 429 W/m K thermal conductivity but it can’t be used from economical point of view. Hence, in the present work copper tubes are used for water flow pipe system.

Figure 3.3 Copper tube

After the material selection, the dimensions of the tubes are another key factor affecting the flow of the water. The tube used is of 15 mm diameter. The diameter of the tube is taken from the base paper. It ranges from 10 mm to 20 mm as it can be seen from the review analysis. The serpentine tubes are used i.e. the tubes are arranged in serpentine manner. It is done, so that the water flowing in the tubes remains in contact with the copper tube and exposed to the sun's insolation for longer period of time. Like this it gets longer period of time to get heated up and much increase in temperature can be achieved.

Pitch is the spacing between the two tubes used in the slab. From the study it is found that as the pitch decreases from 150 mm to 100 mm the efficiency of the collector starts increasing. This means that the pitch has an inverse relation with the efficiency but up to a certain limit. If the pitch is further reduced below 60 mm, the efficiency starts decreasing. Hence the optimum pitch for highest efficiency of the slab is 60 mm and the same is used in the present work. The number of tubes used in the slab is 6.

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Figure 3.4 Copper tube arrangements inside the slab

A glass cover over the slab is used so as to provide a greenhouse effect. This means that the heat energy coming from the sun in the form of insulation gets trapped inside the glass cover as it starts behaving like an opaque body. In the present work the glass cover is normally a glass of 4mm thickness. A study was conducted to determine the effect of glass cover of various thickness like 3 mm, 4 mm, 5 mm, and 6 mm. and it was found that the glass cover of thickness 4mm gives the maximum efficiency [15] The vertical spacing between the slab and the glass cover is taken 8 mm. [8] The heated water is stored in an insulated tank. The whole slab is painted with black paint so that it absorbs the maximum of the insulation.

3.2 Experimental Setup

To carry out the objective of the present work an experimental setup has been established. It consists of a concrete slab as the main collector part and the stand at which the slab rests and the overhead tank is kept.

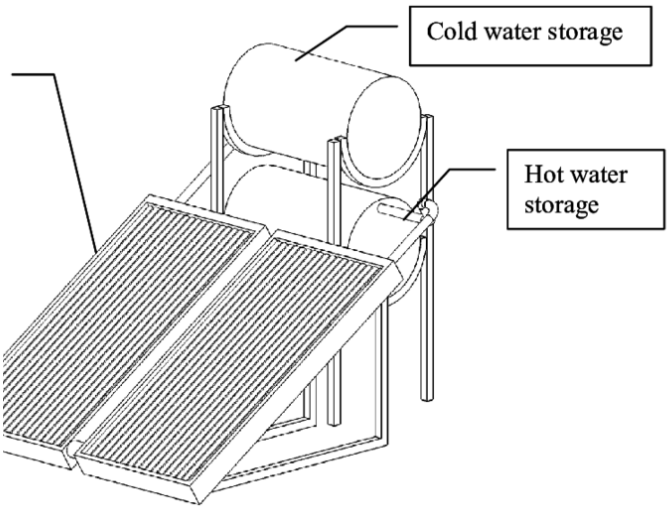

Figure 3.5 Schematic representation of concrete slab solar collector

The aluminium scraps are spread over the surface and the whole slab is kept for two to four days in sunlight. The whole of the slab is covered with the glass cover. The gap between the slab and the glass cover is kept 5 mm. It is made air tight by sealing it with putty.

Figure 3.6 Glass cover over the slab

Now the other part of the whole setup is the stand. It is in two parts. One is to keep the tank and the other one called frame is to keep the slab which rests on the first part. The main purpose of stand is to provide support and keep the equipments at a particular location.

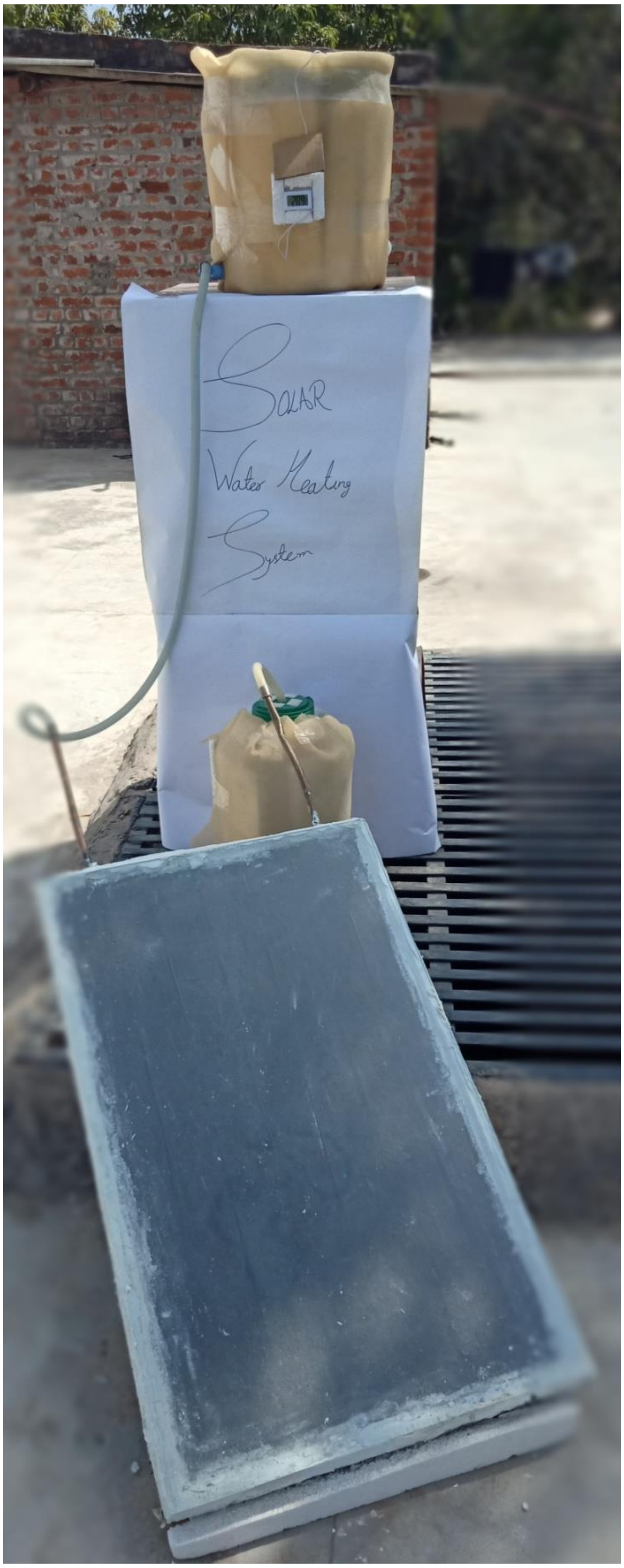

Figure 3.7 Experimental Setup

3.3 Working Principle

CSSC works on the simple principle similar to conventional solar collector. It has one inlet and one outlet. Inlet and outlet is determined by the flow of hot and cold water inside the collector. A solar insolation emitted by the sun is particularly electromagnetic energy of which about half is in the visible short wave part of the electromagnetic spectrum. The other half is in the range of near infrared part and a small portion in the ultraviolet part of spectrum. This is mainly responsible for solar heating.

As the insolation fall on the slab it starts absorbing the insolation and gets heated up.This is due to two main reasons. One is that the slab is painted black which absorbs maximum insolation. And the other factor responsible is the glass cover which allows the insolation to enter but prevents them from going out resulting in the trapping of the heat. This insolation is absorbed by the slab and transformed into heat which is transferred to the cold water flowing inside the copper tubes by conduction. This raises the temperature of the water resulting in its heating.

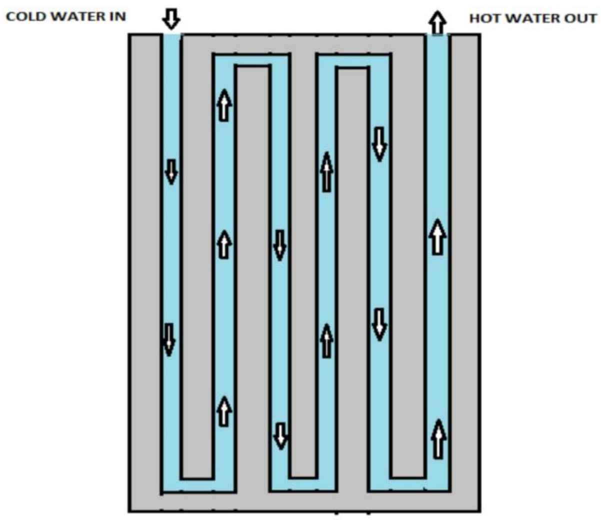

Figure 3.11 Schematic flow of hot and cold water

The flow rate of input water from insolation tank is controlled with the help of stopper. At different time in a day solar insolation is different. In order to maintain proper heating in a day , it requires various flow rate of water. The flow rate is maximum when solar insolation is maximum. The heated water is store in another insolated tank. This process continues and the hot water is stored in the insulated tank and can be further used as per the requirement.

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3.4 Equipment required for measurement

Digital Thermometer- Thermometer is used to measure the temperature. It gives the value at

the point wherever the temperature is to be determined just by touching it by the tip of the thermometer . Temperature range of the Digital thermometer is 0°C to 110C°.

Pyranometer- It is a device used to measure the solar insolation incident on the earth. It gives the value of solar insolation every minute. The model used is SR20-T2. This is an ISO 9060 secondary standard pyranometer which measures the solar insolation in a full sphere of the sky. The spectral range varies from 285 to 3000 x 10^{-9} m. Its rated operating range temperature range is -40°C to 80°C

Figure 3.13 Pyranometer

Anemometer- It is basically used to measure the wind velocity. and it also gives the ambient temperature. The model used is BTH 401. The velocity range is 0.4-20 m/s, temperature range is 10°C to 50°C.

Figure 3.14 Anemometer

3.5 Temperature measurements

After all the necessary settings have been done the temperature of the water is to be measured. It is done with the help of a Digital Thermometer. The ends of the thermometers wire are inserted in the input storage tank and the output storage tank.

3.6 Closure

In this chapter the selection and calculation of various parameters such as length, width, etc. of the concrete slab solar collector have been done. After that the selection of suitable material for the fabrication of the experimental set-up has been done. Further the working of the experimental set-up has been explained.

CHAPTER 4
RESULT AND DISCUSSION

In the present project work the performance of the concrete slab solar collector is analysed at 30° tilt angle due to south at the various time in a day, in the month of june. Many researches show that the optimum tilt angle is 30° for maximum temperature of output water.

4.1 At Tilt angle = 30º

In this case the slab is kept at a tilt angle of 30º. The temperature is recorded per hour from 10 a.m. to 4 p.m. The variation of solar insolation with time is also recorded for every hour. It has been tabulated below.

DAY- 1

Sr. No.	Time	Ambient Temperature (°C)	Input water Temperature (°C)	Output water Temperature (°C)	Quantity of Output water(liter)	Solar insolation (W/m²)
1.	10 am	36	32.2			548.24
	11 am	38		40	2	
2.	11 pm	38	32.3			704.40
	12 pm	40		45	2	
3.	12 pm	40	32.6			756.16
	1 pm	44		51	3	
4.	1 pm	44	33			761.86
	2 pm	43		57	2	
5.	2 pm	43	34.6			683.61
	3 pm	42		56	2	
6.	3 pm	42	35			585.64
	4 pm	40		55	2	414.58

DAY-2

Sr. No.	Time	Ambient Temperature (°C)	Input water Temperature (°C)	Output water Temperature (°C)	Quantity of Output water(liter)	Solar insolation (W/m^2)
1.	10 am	36	30.2			469.79
	11 am			46.8	1	
2.	11 am	37	30.9			594.76
	12 am			55.3	3	
3.	12 pm	39	31.9			616.45
	1 pm			59	3	
4.	1 pm	40	30.3			657.81
	2 pm			57.1	2	
5.	2 pm	41	31.2			702.37
	3 pm			56	2	
6.	3 pm	41	32.5			680.18
	4 pm			55	2	490.64

DAY-3

Sr. No.	Time	Ambient Temperature (°C)	Input water Temperature (°C)	Output water Temperature (°C)	Quantity of Output water(liter)	Solar insolation (W/m^2)
1.	10 am	35	34.8			590.34
	11 am			43	1	
2.	11 am	37	35.3			706.77
	12 pm			53.5	1	
3.	12 pm	40	36.6			786.34
	1 pm			56	2	
4.	1 pm	42	37.4			749.03
	2 pm			61.2	2	
5.	2 pm	43	38.1			754.33
	3 pm			61.4	2	
6.	3 pm	44	39.6			644.48
	4 pm	43		55	2	489.78

DAY-4

Sr. No.	Time	Ambient Temperature (°C)	Input water Temperature (°C)	Output water Temperature (°C)	Quantity of Output water(liter)	Solar insolation (W/m²)
1.	10 am	35	33.4			489.87
	11 am			44	1	
2.	11 am	37	33.9			602.27
	12 pm			52	3	
3.	12 pm	38	34.5			709.22
	1 pm			54	2	
4.	1 pm	40	32.5			711.35
	2 pm			53	1	
5.	2 pm	41	33.2			643.87
	3 pm			54.5	2	
6.	3 pm	42	34.1			539.49
	4 pm	42		53	2	360.39

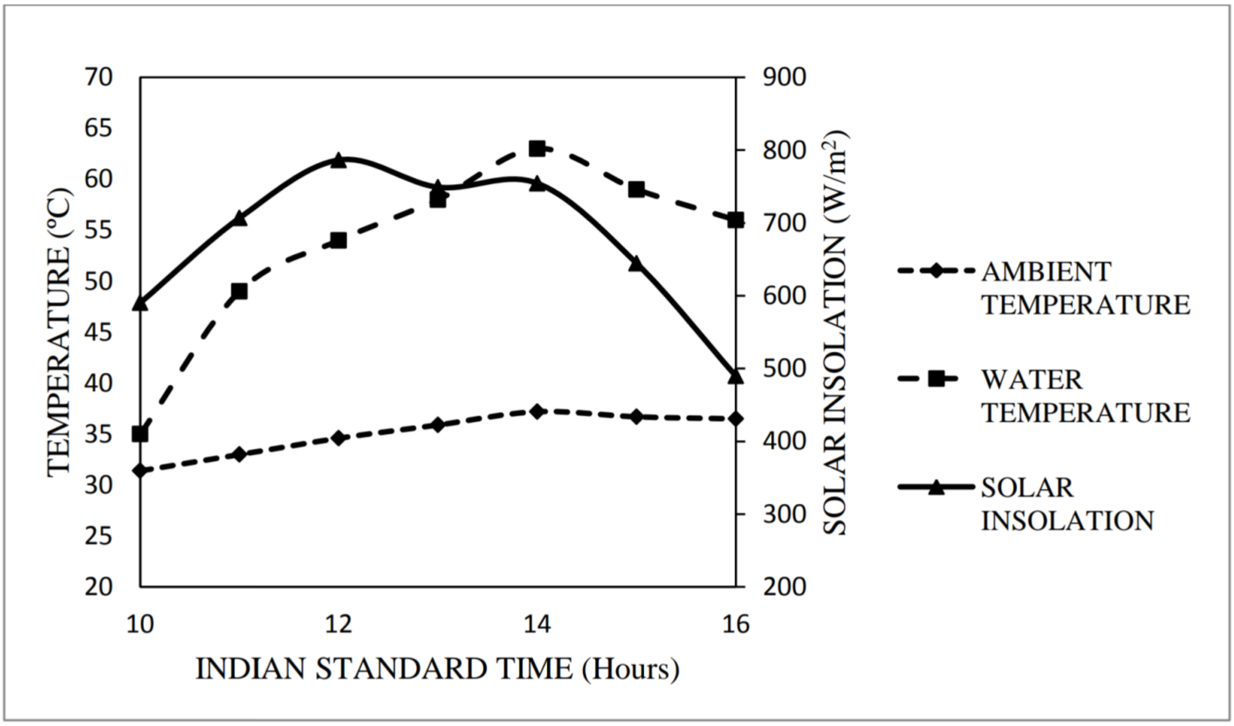

Figure 4.3 Variations of Temperature and Solar Insolation with Time for 30° Tilt angle

4.1 Closure.

We have taken 30° tilt angle due to south at I.E.T Dr. Ram Manohar Lohia Avadh University Ayodhya the temperature for heated water was found to be maximum at this angle keeping the solar insolation as well as the time constant. The maximum temperature obtained was 61.4 ºC for the tilt angle of 30º.

CHAPTER 5
CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

The current project work involved performance analysis of water heating system using concrete slab solar collector on the basis of single performance parameter i.e. tilt angle.This has been done by taking different sets of readings of hot water at 30° for entire day from 10 a.m. to 4 p.m. At the same time the solar insolation and the ambient temperatures were also recorded. From the results obtained in the present project work following conclusions can be drawn:

- The maximum output temperature of water at I.E.T Dr. Ram Manohar Lohia Avadh University,Ayodhya is obtained between 2 pm to 3 pm at 30° tilt angle due to south at constant flow rate of water in a day.

- This result would be very beneficial if the system is implemented in the campus.

- It is also found that the output temperature of water increases from 10 am to 3 pm and decreases from 3 pm to 4 pm at constant flow rate of water in a day.

- This system of water heating is economical and is easily affordable. Also it requires less maintenance cost and skill.

5.2 FUTURE SCOPE

The present project work is on concrete slab solar collectors which is a promising solution for economising the high cost flat plate collectors. It can provide a wide scope of utilization of solar energy at domestic level. The further work can be done to optimize the size of the concrete slab because it is very heavy and is difficult to handle.

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