Design and Fabrication of a Solar Chimney Power Plant

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A thesis submitted in partial fulfillment of the requirements for the degree of Bachelors of Engineering in Mechanical Engineering

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FINAL YEAR PROJECT REPORT

We hereby recommend that the dissertation prepared under our supervision by: Hussam ul Haq (NUST-201201441) and M. Safwan Aziz (NUST-201200389) Titled: Design and Fabrication of Solar Chimney be accepted in partial fulfillment of the requirements for the award of Bachelors of Engineering in Mechanical Engineering degree with (_____ grade).

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Declaration

We certify that this research work titled "*Design and Fabrication of a Solar Chimney Power Plant*" is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources it has been properly acknowledged / referred.

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Copyright Statement

Dedication

“Dedicated to our parents”

Acknowledgments

First of all we would thank ALLAH Almighty, who gave us knowledge and dedication to be able to complete this project. A part from this a number of people helped us during our way. In this regard, we are very much indebted and thankful to our project supervisor AP Muhammad Adnan Hanif who just not only gave us the valuable suggestions but also motivated and backed us in this long journey. Further, we want to thank Dr. Majid Ali the co-supervisor of our project and Dr. Adeel Waqas from CASEN for their constant help and guidance. We are also paying our gratitude to each and every member of DMRC SMME who helped us during the fabrication phase of our project. Last but not the least; we are thankful to our seniors who gave us valuable information regarding each and every step of final year project.

Abstract

In a power scarce country like Pakistan, a project undertaken in the field of renewable energy can be of some good. This was the thing in our mind prior to the selection of our project. This mindset led us to the selection of topic "Design and Fabrication of Solar Chimney Power Plant". A 'solar chimney power plant' sometimes also called 'solar updraft tower' or just 'solar tower' is a solar thermal power plant utilizing a combination of solar air collector and central updraft tube to generate a solar induced convective flow which drives pressure staged turbines to generate electricity. Air is heated by solar radiation under a low circular transparent or translucent roof open at the periphery; the roof and the absorber plate below it form a solar air collector. Selection of different dimensional parameters of solar chimney power plant on the basis of optimal performance was carried out. After the completion of design phase we moved on to the fabrication phase where we manufactured a scale down prototype of our model.

Keywords:

- Renewable Energy
- Solar Updraft Tower
- Solar Collectors
- Solar Air Heater
- Electricity Generation

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Symbols

A	Area
D	Diameter
h	Convective heat coefficient
C_p	Specific heat capacity
$\dot{m}$	Mass flow rate
P	Pressure
T	Temperature
P	Density
G	Gravitational acceleration
H	Height
r	Radius
a	Ambient
e	Earth
c	Collector
ch	Chimney
in	Inlet
out	Outlet
f	Fluid
$SCPP$	Solar chimney power plant

Chapter 1

Introduction

1.1 Background

Power generation is what people are working vigorously these days especially in energy scarce countries. Scientists are always sharing their new ideas and novelty they put in to their work for enhanced power generation.

There are a number of techniques used in modern era for the production of electricity ranging from thermal power plants to nuclear power plants, flow by river to electric generators. However, the recent trends are shifting towards the more cleaner and environment friendly methods of generating electricity which we often name as renewable energy sources. They primarily include generation through solar energy and wind energy. There are other techniques too that fall in this category but they are not used at larger scales.

Solar Chimney Power plant uses a well-known technique of convection currents and buoyancy effect that causes warm air to rise up and pass through a pressure driven turbine thus rotating the turbine which in turn is coupled with a generator producing the electricity.

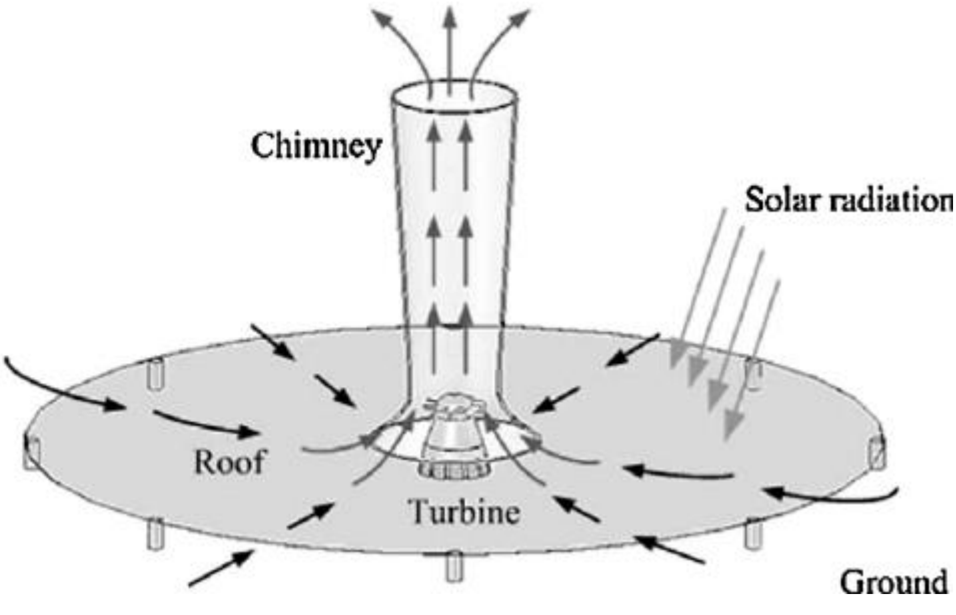

Figure 1-1: Schematic of a solar chimney

1.2 Aim and Objectives

Initially we were aiming for the design and fabrication of a working model of “Solar Chimney Power Plant” however, later on due to some restrictions explained in the coming part, we focused mainly on;

- Study of different dimensional parameters affecting the performance of solar power chimney power plant (SCPP).
- Selection of optimal parameters for the fabrication of a scaled down prototype.
- Fabrication of a scaled down prototype.
- Testing of prototype and data comparison between theoretical model and actual working model.

1.3 Work Methodology

The schematic of overall work methodology is shown in Fig 1.2

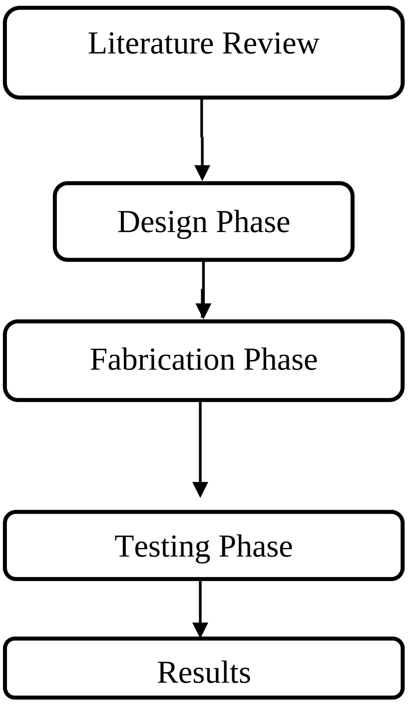

Fig 1-2: Overall Schematic work Methodology

1.4 Thesis Structure

The brief description of the contents of the remaining chapters in thesis is described below.

Chapter 2 Literature Review: Chapter provides a summary of the literature that has been reviewed and identified to be relevant to this project. This chapter also includes the basic definitions and workings of different components of a solar chimney power plant.

Chapter 3 Calculations: This chapter contains a thorough set of calculations that are performed to justify the selection of different types of materials and different dimensional parameters associated with all the constituent components of solar chimney power plant. Further, this also contains set of calculations that were carried out to know the theoretical performance of SCPP.

Chapter 4 Results and Discussions: In this section we will present the process from which we attained data from the fabricated model of SCPP and then later on we will compare the values of different parameters we measured with the calculated theoretical values.

Chapter 5 Future Work: This chapter presents the conclusion of the performed project along with the proposed future work.

Chapter 2

Literature Review

We had to go through an extensive literature review before working on the designing of each component of the system was started. The following list shows the articles and research papers thoroughly studied for the initial stage of the project.

- An experimental study on the thermal performance of a solar chimney with different dimensional parameters
- Evaluation of the optimal turbine pressure drop ratio for a solar chimney power plant
- Experimental investigation and CFD simulation studies of a laboratory scale solar chimney for power generation
- Tracking collector consideration of tilted collector solar updraft tower power plant under Malaysia climate conditions
- Solar updraft tower power generation
- Thermodynamic analysis of a solar chimney power plant system with soil heat storage

2.1 SCPP an Overview:

The technology of SCPPs is not new in power generation sector. Air is warmed by solar radiation under a low circular transparent collector open at the periphery. As hot air is lighter than cold air, it rises up the chimney tower. At last, the air flow out the tower through the chimney exit. In the other words, the radiation heats fluid of collector, which is then forced by buoyancy forces to move as a hot wind through special turbines to generate electrical energy. Thus solar radiation causes a constant updraft of fluid in the chimney.

Figure 2-1: Our Fabricated model

Fig 2-1: Solar Chimney Power Plant (Our fabricated model)

2.2 Advantages:

The solar chimney power plant had been developed during the latter part of last century. Against the conventional alternative energy sources it has two advantages. Firstly, it is not technically difficult to realize and secondly it nearly needs nothing of natural materials. Conventional solar cells have the disadvantage of an expensive current and not environmentally friendly manufacturing and waste disposal. But the assumptions for a solar chimney power plant are: a considerable enough amount of space and a considerable enough amount of insulation. These assumptions have probability of existence in countries with desert regions. The building materials like glass & concrete are also readily available in those regions. So these power plants are an interest for developing countries for which they have been developed. The energy can be produced without using fossil or radioactive combustibles and no emergence of injurious waste products occur. Compared with other power stations the costs for operating the solar chimney power plant are affordable.

2.3 Components of a SCPP:

Following are the components of a SCPP;

i. A solar collector
ii. A vertical tower referred to as chimney
iii. A turbine
iv. A generator coupled with turbine

Now, let us briefly discuss each of the above mentioned components of the system

i. Solar Collectors:

A solar thermal collector collects heat by absorbing sunlight. A collector is a device for capturing solar radiation. Solar radiation is energy in the form of electromagnetic radiation from the infrared (long) to the ultraviolet (short) wavelengths. The quantity of solar energy striking the Earth's surface (solar constant) averages about 1,000 watts per square meter under clear skies, depending upon weather conditions, location and orientation.

There are a number of solar collectors that are available in the market depending upon the application, i.e. what we want to warm using captured solar radiations. In addition to this, solar collectors are also categorized as concentrating and non-concentrating types. . In the non-concentrating type, the collector area (i.e., the area that intercepts the solar radiation) is the same as the absorber area (i.e., the area absorbing the radiation). In these types the whole solar panel absorbs light. Whereas, concentrating type collectors have a bigger interceptor than absorber.

We have ruled out the use of concentrating solar air collectors in our project since they are expensive and not readily portable. So, considering the non-concentrating type we have;

The following types of non- concentrating solar air collectors;

a. Flat Plate Solar Collectors
b. Evacuated Plate Solar Collectors
c. Solar Air Collectors

a. Flat Plate Solar Collectors:

The absorber consists of a thin absorber sheet (of thermally stable polymers, aluminum, steel or copper, to which a matte black or selective coating is applied) often backed by a grid or coil of fluid tubing placed in an insulated casing with a glass or polycarbonate cover. In water heat panels, fluid is usually circulated through tubing to transfer heat from the absorber to an insulated water tank. This may be achieved directly or through a heat exchanger. As the ambient temperature gets cooler, these collectors become less effective. Most flat plate collectors have a life expectancy of over 25 years. The main use of this technology is in residential buildings where the demand for hot water has a large impact on energy bills. This generally means a situation with a large family, or a situation in which the hot water demand is excessive due to frequent laundry washing. Commercial applications include Laundromats, car washes, military laundry facilities and eating establishments.

Figure 2-2: Flat plate thermal system for water heating

b. Evacuated Plate Solar Collectors:

Evacuated heat pipe tubes (EHPTs) are composed of multiple evacuated glass tubes each containing an absorber plate fused to a heat pipe. The heat is transferred to the transfer fluid (water or an antifreeze mix—typically propylene glycol) of a domestic hot water or hydronic space heating system in a heat exchanger called a "manifold". The manifold is wrapped in insulation and covered by a protective sheet metal or plastic case. The vacuum inside of the evacuated tube collectors have been proven to last more than 25 years, the reflective coating for the design is encapsulated in the vacuum inside of the tube, which will not degrade until the vacuum is lost. The vacuum that surrounds the outside of the tube greatly reduces convection and conduction heat loss, therefore achieving greater efficiency than flat-plate collectors, especially in colder conditions. This advantage is largely lost in warmer climates, except in those cases where very hot water is desirable, e.g., for commercial processes. The high temperatures that can occur may require special design to prevent overheating.

Figure 2-3: Evacuated Plate solar collector

c. Solar Air Collector:

A simple solar air collector consists of an absorber material, sometimes having a selective surface, to capture radiation from the sun and transfers this thermal energy to air via conduction heat transfer. This heated air is then ducted to the building space or to the process area where the heated air is used for space heating or process heating needs. Functioning in a similar manner as a conventional forced air furnace, solar-thermal-air systems provide heat by circulating air over an energy collecting surface, absorbing the sun’s thermal energy, and ducting air coming in contact with it. Simple and effective collectors can be made for a variety of air conditioning and process applications.

Figure 2-4: Solar Air collector (One we fabricated)

On the basis of above descriptions of different types of solar collectors we choose solar air collector for our prototype since it’s the easiest and cheapest to fabricate and is portable as well.

Our solar air collector has the following configuration:

- A transparent 5mm glass sheet on top
- A black painted aluminum absorber plate
- A sheet of jumbolon at the bottom for insulation
- A circular wooden base.

ii. Vertical Tower/Chimney:

The ascending force emerges due to the fact that hot air is not as heavy as cold air. The only way for the hot air from the collector is along the glass roof up to the middle through the chimney. In the chimney exists a suction in cause of the small and cold (compared to the heated air) surface of the chimney. The hot air likes to get up the cold air and if the space for the air gets smaller the air accelerates. Further the air acceleration depends on the temperature difference between inside (mainly inside the chimney) and outside the plant. In case of the mentioned plant approximately 35 degrees. So, as high as the chimney is, higher will be the suction effect.
At this point it is to recognize that the effect of the ascending glass roof and the suction effect are superimposed.

iii. Turbine:

With turbines it is now possible to get power in form of rotational energy out of the vertical air current in the chimney. The turbines are basically more closely related to the pressure staged hydroelectric turbines unlike the speed stepped open air turbines. Similar to the water power plant the static pressure is reduced in a pipe. The efficiency is approximately eight times higher than the efficiency of speed stepped open air turbines. The velocity of the air is in front of and behind the turbine is the same. Relatively low air speeds allow maintenance and repair while the plant is operating.

For a scaled down prototype we considered fan blades of toy airplanes to serve us the purpose of a turbine.

iv. Generator:

Generators used in solar chimney power plant are conventional. No special operational treatment is needed.

For our purpose we considered a variable voltage dynamo to serve us the purpose of a generator in a scaled down prototype.

Chapter 3

Calculations

3.1 **Equations used throughout:**

The energy balance of the warm air inside the collector and chimney yields:

$$T_f(r) = \frac{1}{2}[T_c + T_e + (2T_a - T_c - T_e)e^{\frac{2\pi h}{C_p \dot{m}}(r^2 - {r_o}^2)}]$$

The expression for inlet velocity of air into the collector can be written by using continuity equation as:

$$V_{in} = \frac{\dot{m}}{2\pi r H_C \rho}$$

The heat transfer due to radiations is:

$$\dot{Q}_{radiation} = \sigma \varepsilon A({T_s}^4 - {T_\infty}^4)$$

The convective heat transfer is:

$$\dot{Q}_{convection} = hA_s(T_s - T_\infty)$$

Maximum tower velocity:

$$v_{tower,\max} = \sqrt{2g * H_{tower} * \Delta T / T_0}$$

Power Output:

$$P_{total} = \Delta P_{total} * v_{tower,\max} * A_{collector}$$

Table below contains different values of different dimensional parameters of a solar chimney power plant (for scaled down prototype). Each of them is used to find out different output parameters and finally a set with most optimal results would be finalized for fabrication phase.

Parameter	Size (m)	Set 2(m)
Chimney radius	0.0762	0.10
Collector radius	0.6096	0.10
Collector height	0.06	0.10
Chimney height	1.524	0.95

Table 3.1: Different combinations of dimensional parameters compared in the calculations below

3.2: Selection of absorber plate's material justification:

Collector Radius	Max. Air Temp Inside the collector USING "ALUMINUM" AS ABSORBER PLATE(K)	Max. Air Temp Inside the collector USING "IRON" AS ABSORBER PLATE(K)
0	326.8316775	323.5933716
0.1	326.7953887	323.5614625
0.2	326.6828375	323.4624951
0.3	326.482339	323.2861946
0.4	326.1721632	323.0134539
0.5	325.7165702	322.6128463
0.6	325.0589002	322.0345502
0.7	324.1098359	321.2000281
0.8	322.7274266	319.9844613
0.9	320.6826615	318.1864782
1	317.5990954	315.4750667
1.1	312.8448664	311.2946239
1.2	305.3354579	304.6915233

Table 3.2: Absorber material selection

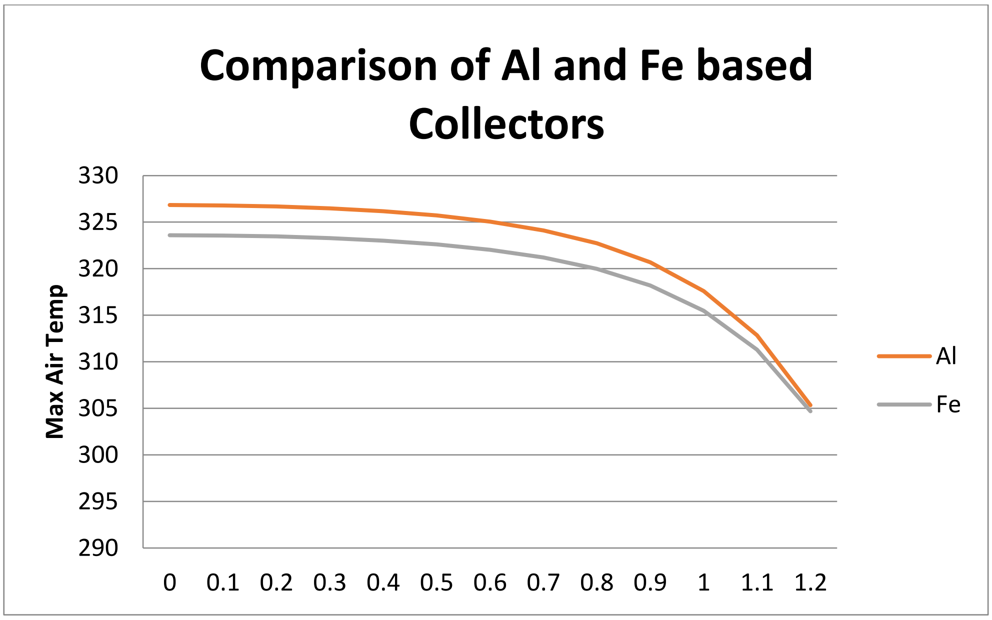

Figure 3-1: Comparison of different absorber materials

Result: It is evident from the above performed calculations that the maximum air temperature attained inside the collector is higher using aluminum absorber plate as compared with iron absorber plate. Due to this result we choose aluminum as our absorber material for the solar collector.

3.3: Absorber Plate:

Time	Global Solar Radiations (W/m^2)	Ambient Temp(K)	Sky Temp (K)	Absorber Plate Temp(K)	Temp Diff (K)
10:00AM	765	303	291.1407661	379.2022793	76.20227932
10:30AM	980	305	294.0280995	396.6695314	91.6695314
11:00AM	999	305	294.0280995	398.0049931	93.00499311
11:30AM	1002	308	298.3768691	399.9924883	91.99248831
12:00PM	994	307	296.9249151	398.838019	91.83801896
12:30PM	972	306	295.4753239	396.6981564	90.69815638
1:00PM	900	305	294.0280995	390.8931185	85.89311854
1:30PM	845	304	292.5832456	386.1364139	82.13641392
2:00PM	740	304	292.5832456	377.8310173	73.8310173
2:30PM	693	302	289.700665	372.5608255	70.56082553
3:00PM	650	301	288.2629463	368.1456489	67.14564888

Table 3.3: Absorber Plate Conditions

Note: Global solar radiations data, used in all the calculations, is measured using a pyranometer on 16th May, 2015.

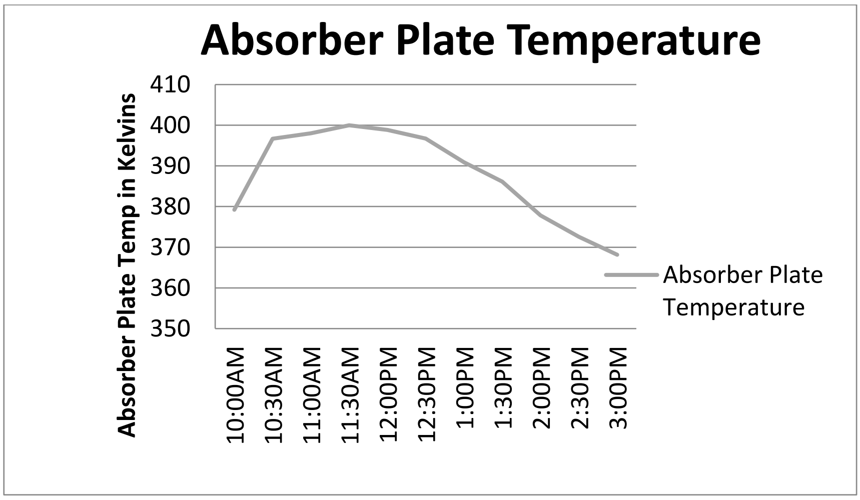

Figure 3-2: Absorber Plate Temperature with time

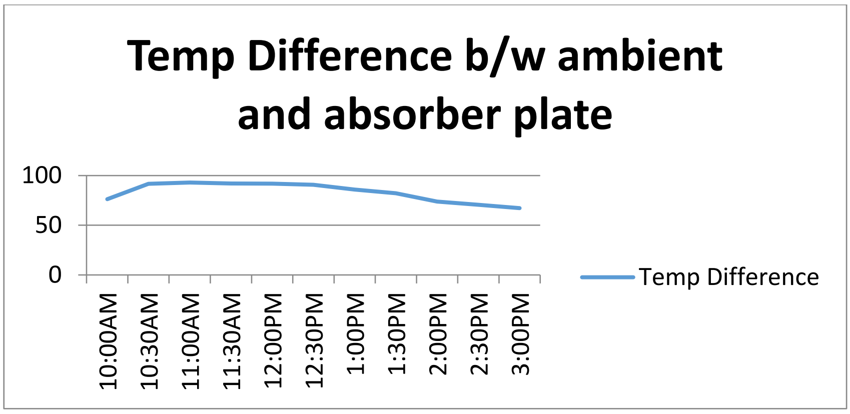

Figure 3-3: Temperature difference between ambient and absorber plate

Result: It can be seen from above figures that the maximum temperature of collector plate using aluminum as absorber theoretically is approximately 400K and its difference with ambient conditions is as high as 100K approximately.

3.4: **Air Temperature inside the collector:**

Global Solar Radiations(w/m^2)	Time*(sec)	Maximum Air Temp inside the collector(K)	Max. Temp Difference b/w ambient and hot air	Maximum Air Temp inside the collector in C
765	10:00AM	312.8286938	9.828693791	39.82869379
980	10:30AM	317.5910064	12.59100643	44.59100643
999	11:00AM	317.8351178	12.83511777	44.83511777
1002	11:30AM	320.8736617	12.87366167	47.87366167
994	12:00PM	319.7708779	12.77087795	46.77087795
972	12:30PM	318.4882227	12.4882227	45.4882227
900	1:00PM	316.5631692	11.56316917	43.56316917
845	1:30PM	314.8565311	10.85653105	41.85653105
740	2:00PM	313.5074946	9.507494648	40.50749465
693	2:30PM	310.9036403	8.903640258	37.90364026
650	3:00PM	309.3511777	8.351177731	36.35117773

Table 3.4: Maximum air temperature inside the collector

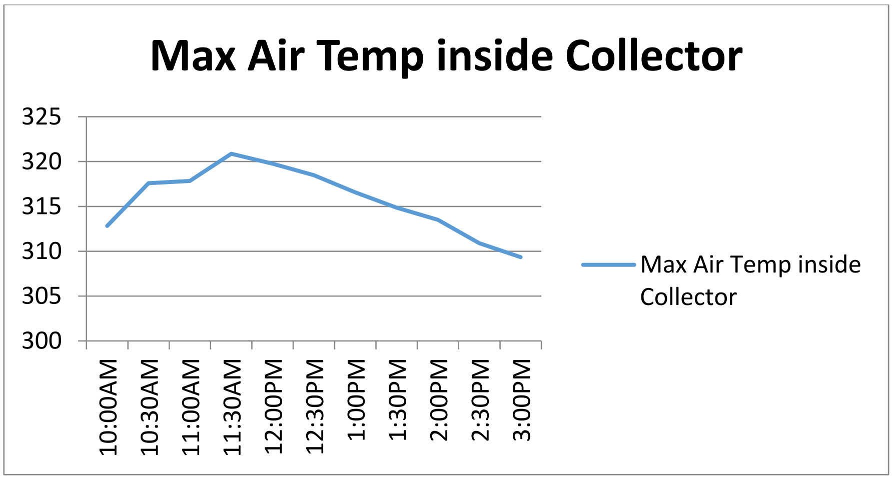

Figure 3-4: Maximum air temperature inside the collector

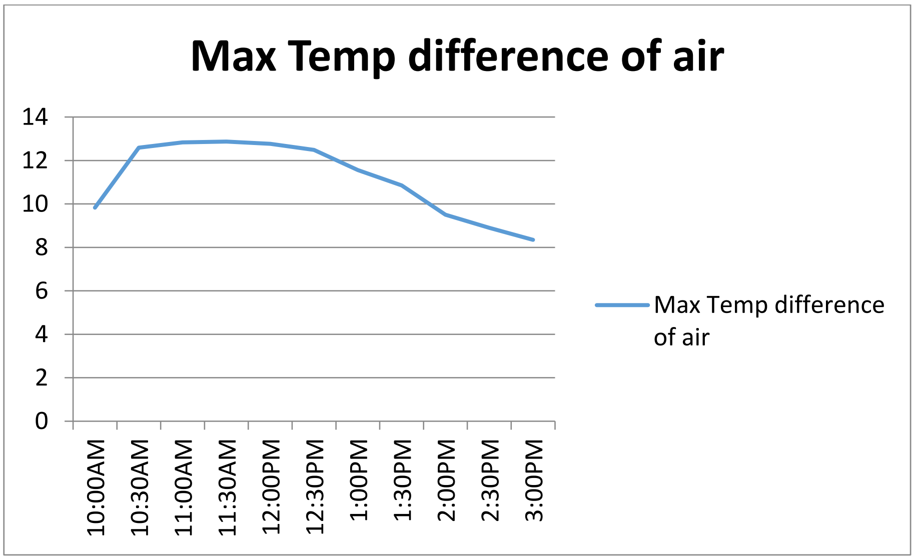

Figure 3-5: Maximum temperature difference between air inside the collector and ambient air

Result: It can be seen from the above graph that the maximum temperature difference between ambient air and the air inside the collector can be as high as 13 degrees.

3.5: **Collector Height:**

Maximum Air Temp inside the collector (K)	Max. Temp Difference b/w ambient and hot air	Mass flow Rate(kg/s)	Collector Radius(m)	Inlet Velocity with 6cm collector Height(m/s)	Inlet Velocity with 10cm collector Height(m/s)
312.8286938	9.828693791	0.077446103	0.1	1.835	1.1
317.5910064	12.59100643	0.077444167	0.2	0.9175	0.55
317.8351178	12.83511777	0.077444167	0.3	0.611666667	0.366666667
320.8736617	12.87366167	0.077444167	0.4	0.45875	0.275
319.7708779	12.77087795	0.077444167	0.5	0.367	0.22
318.4882227	12.4882227	0.077444167	0.6	0.305833333	0.183333333
316.5631692	11.56316917	0.077444167	0.7	0.262142857	0.157142857
314.8565311	10.85653105	0.077444167	0.8	0.229375	0.1375
313.5074946	9.507494648	0.077444167	0.9	0.203888889	0.122222222
310.9036403	8.903640258	0.077444167	1	0.1835	0.11
309.3511777	8.351177731	0.077444167	1.1	0.166818182	0.1

Table 3.5: Collector height selection calculations data

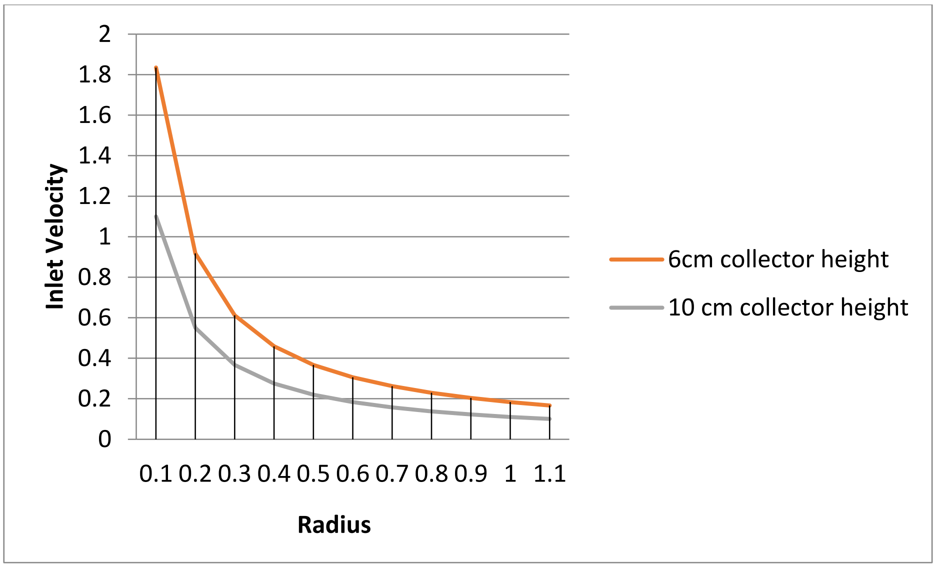

Figure 3-6: Inlet Velocity with collector radius

Result: It can be seen that the velocity of air entering the solar air collector us maximum at the center for a collector height of 6cm as compared with the collector height of 10 cm. Therefore, for our model on the basis of this calculation we selected the collector height as 6cm.

3.6: **Tower Height:**

Ambient Temp(K)	Maximum Air Temp inside the collector in C	Pressure Difference w.r.t 0.95m tower height(Pa)	Pressure Difference w.r.t 1.524m tower height(Pa)	Max Velocity Inside Tower w.r.t 0.95m tower height(m/s)	Max Velocity Inside Tower w.r.t 1.524m tower height(m/s)
303	39.82869379	0.3448215	0.55316628	1.565265531	1.982525137
305	44.59100643	0.50791275	0.81479898	1.650764124	2.09081546
305	44.83511777	0.50791275	0.81479898	1.655276472	2.096530683
308	47.87366167	0.671004	1.07643168	1.702096854	2.155832178
307	46.77087795	0.50791275	0.81479898	1.685116292	2.134325034
306	45.4882227	0.50791275	0.81479898	1.66456238	2.108291977
305	43.56316917	0.3448215	0.55316628	1.631627881	2.066577985
304	41.85653105	0.3448215	0.55316628	1.601976454	2.02902225
304	40.50749465	0.3448215	0.55316628	1.575949163	1.996056751
302	37.90364026	0.17241075	0.27658314	1.529495817	1.937220135
301	36.35117773	0.17241075	0.27658314	1.500331748	1.900281675

Table 3.6: Tower height selection justification

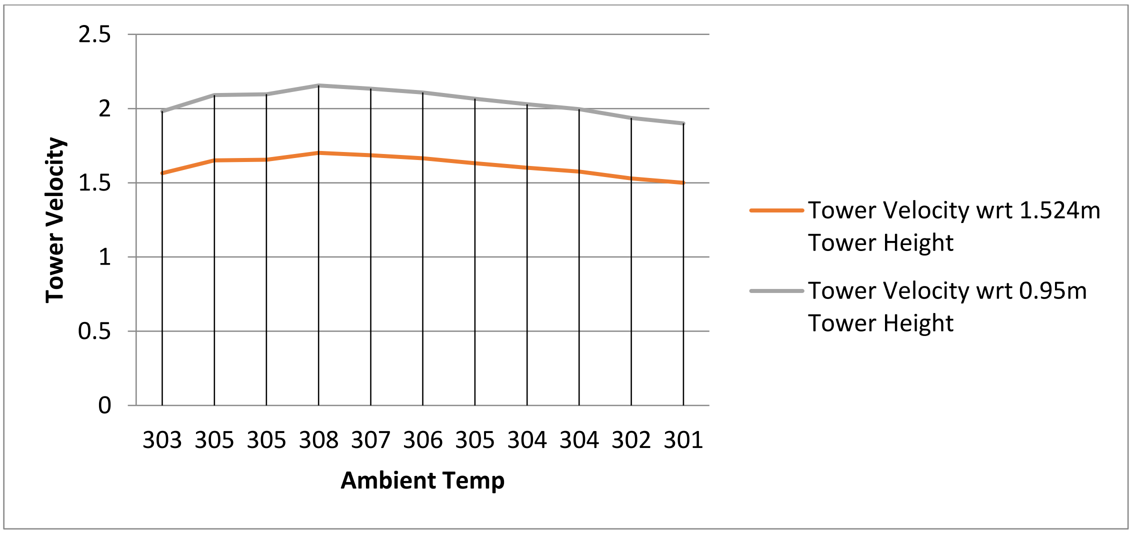

Figure 3-7: Velocity inside the tower w.r.t different tower heights

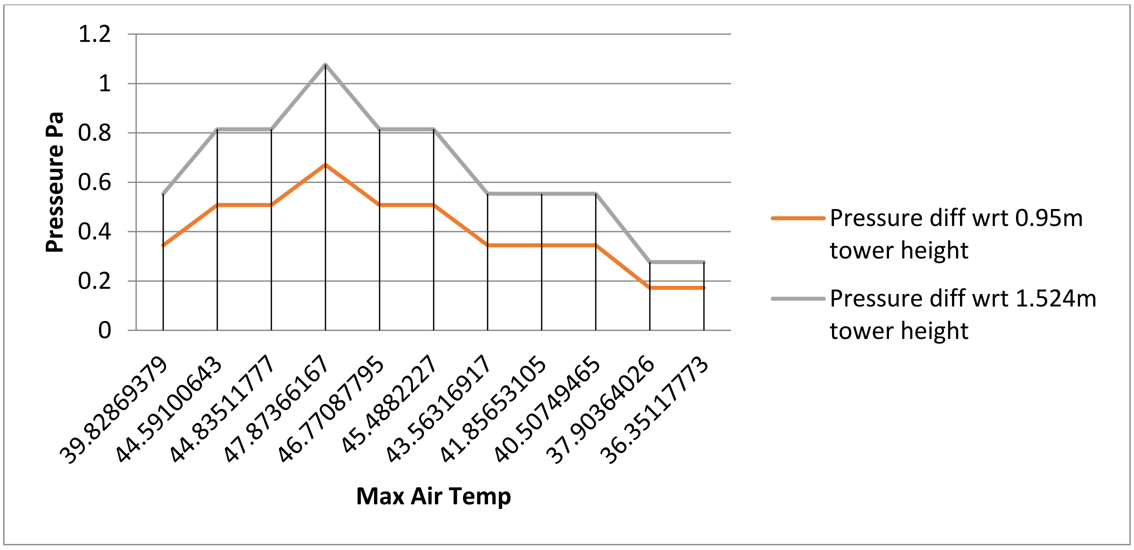

Figure 3-8: Pressure difference w.r.t different tower heights

Result: It is evident from above calculations and the graphical representation that both the velocity and pressure difference are maximum for a tower height of 1.524m inside the tower/chimney instead for the height of 0.95m. Therefore, we selected the tower height of 1.524m for our scaled down prototype of SCPP. On the basis of calculation form 3.1 to 3.6 the set of dimensional parameters we chose for our prototype is:

Parameter	Size (m)
Chimney radius	0.0762
Collector radius	0.6096
Collector height	0.06
Chimney height	1.524

3.7: The Design:

On the basis of above performed calculation we designed different components of our prototype on solid works. The Cad model is given below:

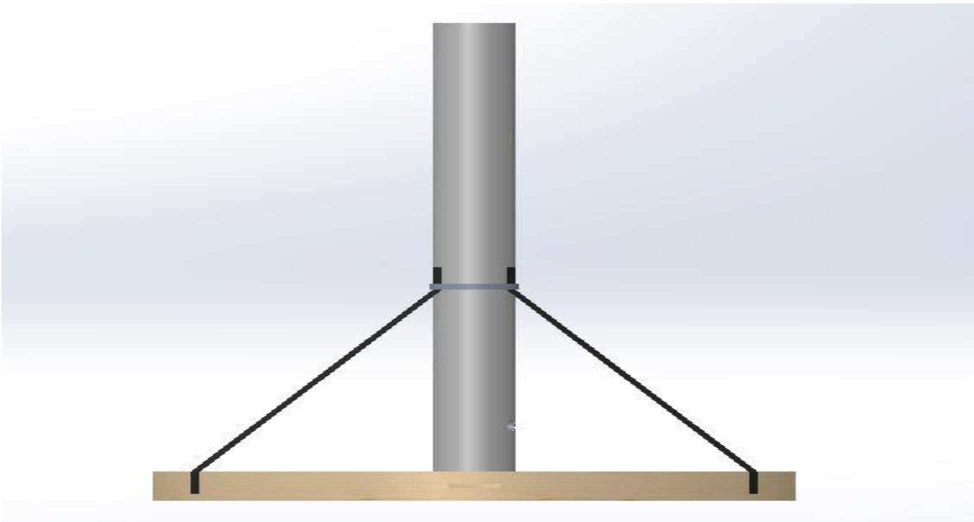

Figure 3-9: CAD model

3.8: **Maximum Calculated Output:**

On the basis of above selected parameters, the maximum electrical power output calculated is:

Time	Max Pressure Diff (Pa)	Max Velocity m/s)	Max Power Output (W)
10:00AM	1.565265531	1.982525137	5.121430477
10:30AM	1.650764124	2.09081546	7.955785399
11:00AM	1.655276472	2.096530683	7.977532461
11:30AM	1.702096854	2.155832178	10.83723027
12:00PM	1.685116292	2.134325034	8.12134417
12:30PM	1.66456238	2.108291977	8.022285491
1:00PM	1.631627881	2.066577985	5.338563068
1:30PM	1.601976454	2.02902225	5.241545842
2:00PM	1.575949163	1.996056751	5.156386514
2:30PM	1.529495817	1.937220135	2.502197338
3:00PM	1.500331748	1.900281675	2.454486024

Table 3.8: Electrical power output data

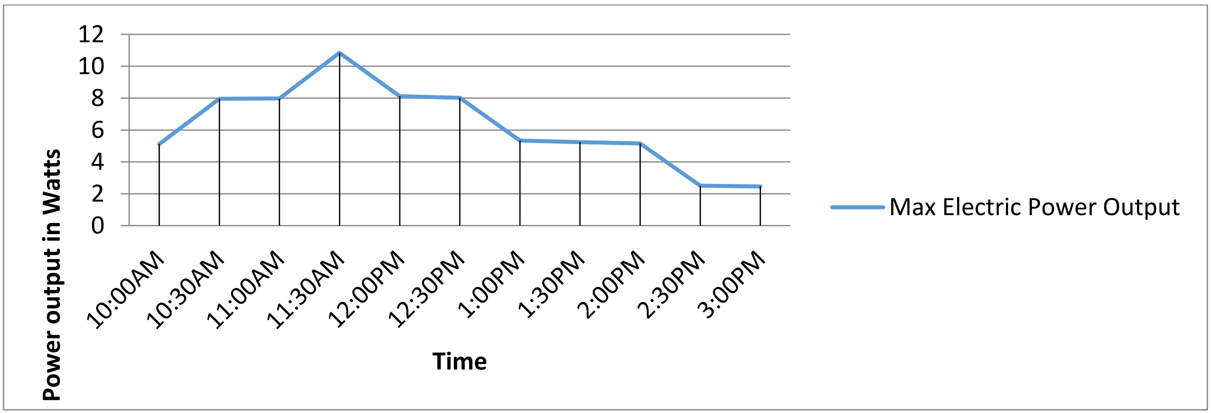

Figure 3-10: Power output

Result: With above calculation and graphical representation we concluded that the maximum possible theoretical power output of the system we will fabricate is going to be 10.83W at 11:00 A.M since during this time of the day the global irradiations are the maximum on the day of data collection.

Chapter 4

Results and Discussion

4.1 The Temperature measuring circuit:

The LM35 series of temperature sensors are rated to operate over a -55 °C to 150°C temperature range. These sensors do not require any external calibration and the output voltage is proportional to the temperature. The scale factor for temperature to voltage conversion is 10 mV per °C. The LM35 series sensors come in different packages. The one we used is in a hermetic TO-46 transistor package where the metal case is connected to the negative pin (GND).

The measurement of negative temperatures (below 0°C) requires a negative voltage source. However, this project does not use any negative voltage source, and therefore will demonstrate the use of sensor for measuring temperatures above 0°C (up to 100°C). The circuit diagram for this setup is as under:

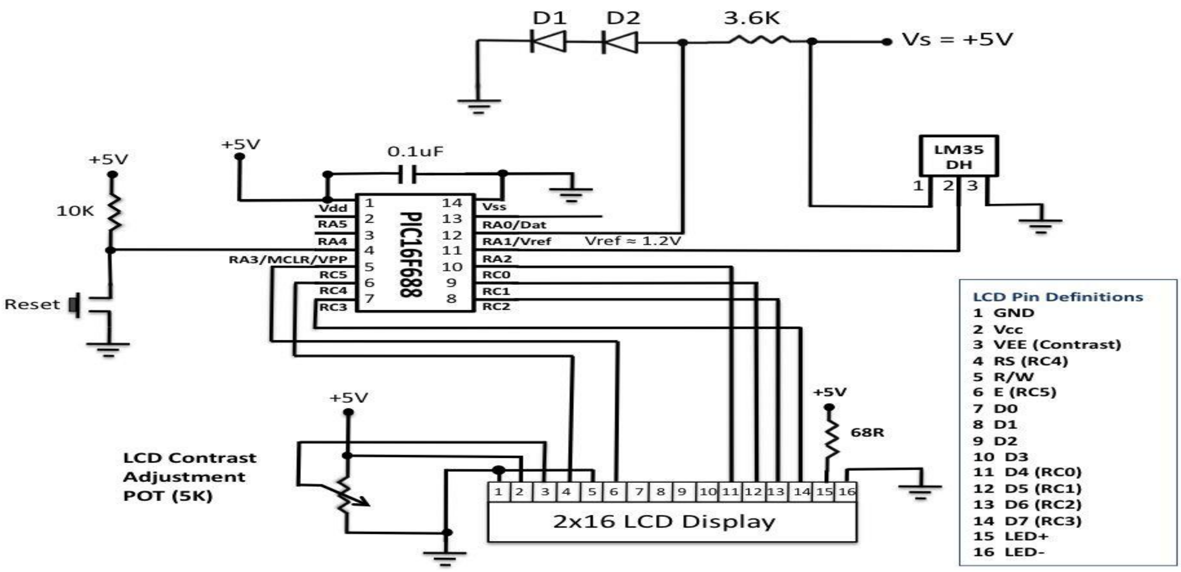

Figure 4-1: Temperature measuring circuit

On the basis of above circuit diagram we made a circuit to measure three temperature values for us at a time and display them on an LCD. The three temperature values that we can measure now will be used to measure the ambient temperature, the temperature of absorber plat and the temperature of air inside the solar air collector.

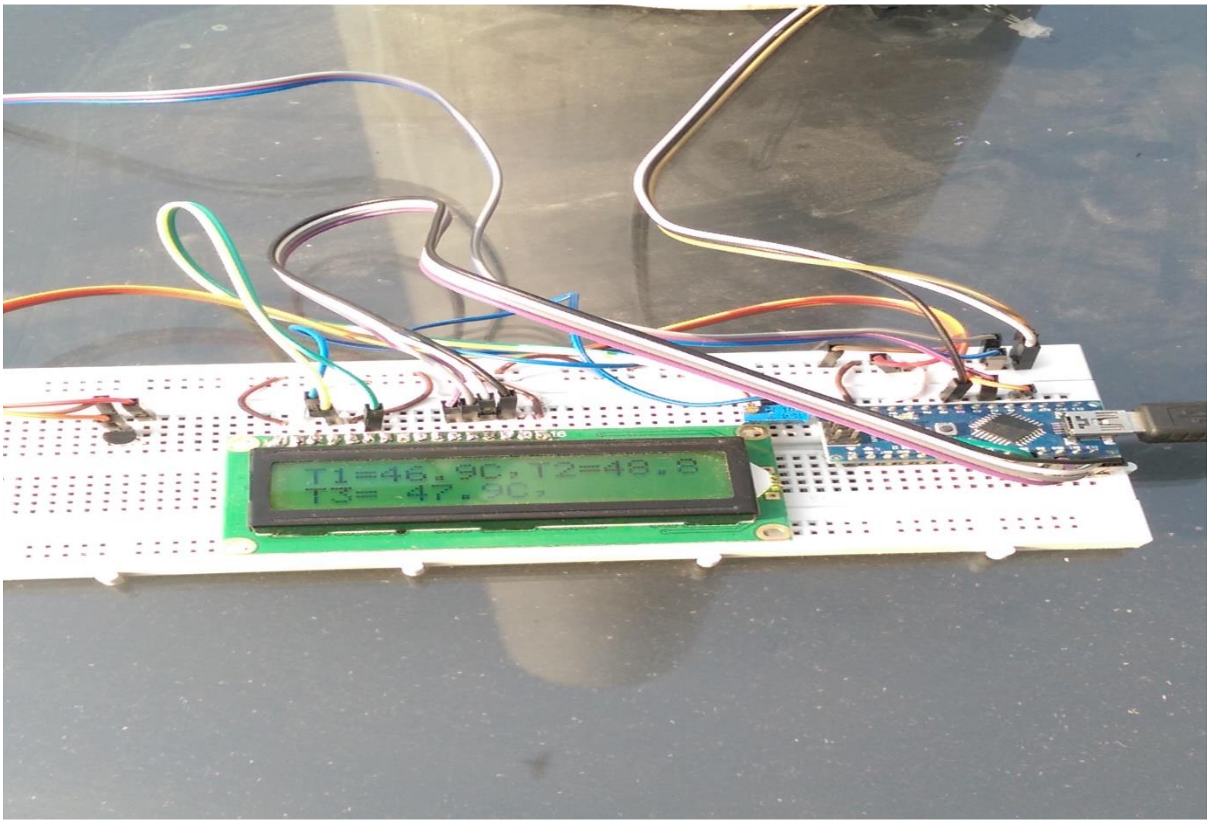

Figure 4-2: The circuit we made

4.2: Comparison of Absorber Plate Temperature (Measured and Calculated):

Flux	Time	Absorber Plate in K (Experimental)	Absorber Plate in K (Theoretical)	Absorber Plate in K (Experimental) in C	Absorber Plate in K (Theoretical) in C
765	10:00AM	335	379.2022793	62	106.2022793
980	10:30AM	340	396.6695314	67	123.6695314
999	11:00AM	341	398.0049931	68	125.0049931
1002	11:30AM	343	399.9924883	70	126.9924883
994	12:00PM	340	398.838019	67	125.838019
972	12:30PM	338	396.6981564	65	123.6981564
900	1:00PM	336	390.8931185	63	117.8931185
845	1:30PM	335	386.1364139	62	113.1364139
740	2:00PM	334	377.8310173	61	104.8310173
693	2:30PM	332	372.5608255	59	99.56082553
650	3:00PM	331	368.1456489	58	95.14564888

Table 4.2: Measured and calculated values of absorber plate

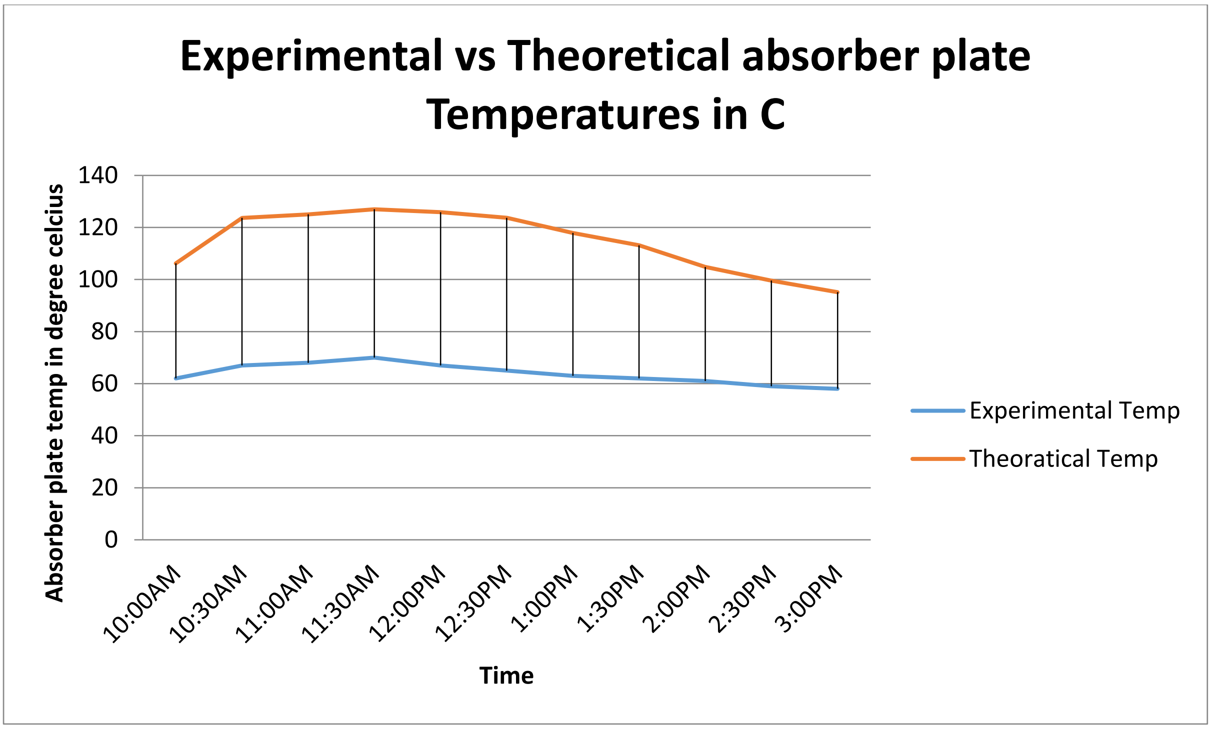

Figure 4-3: Graph showing measured and calculated values of absorber plate

Note: The values of temperature are measured on 19th May, 2016.

Result: It can be seen from the above graph that the measured values are approximately half as the calculated values of absorber plate temperatures.

4.3: Maximum Air Temperature inside the collector (Calculated Vs. Measured):

Flux	Time	Air Temp in K Theoretical	Air Temp in C Theoretical	Ambient Air Temp in K	Ambient Temp in C	Air Temp measured in C	Actual Temp Diff
765	10:00AM	312.8286938	39.82869379	303	30	33	3
980	10:30AM	317.5910064	44.59100643	305	32	36	4
999	11:00AM	317.8351178	44.83511777	305	32	36	4
1002	11:30AM	320.8736617	47.87366167	308	35	40	5
994	12:00PM	319.7708779	46.77087795	307	34	39	5
972	12:30PM	318.4882227	45.4882227	306	33	38	5
900	1:00PM	316.5631692	43.56316917	305	32	37	5
845	1:30PM	314.8565311	41.85653105	304	31	35	4
740	2:00PM	313.5074946	40.50749465	304	31	34	3
693	2:30PM	310.9036403	37.90364026	302	29	32	3
650	3:00PM	309.3511777	36.35117773	301	28	31	3

Table 4.3: Air temp measured Vs. Calculated

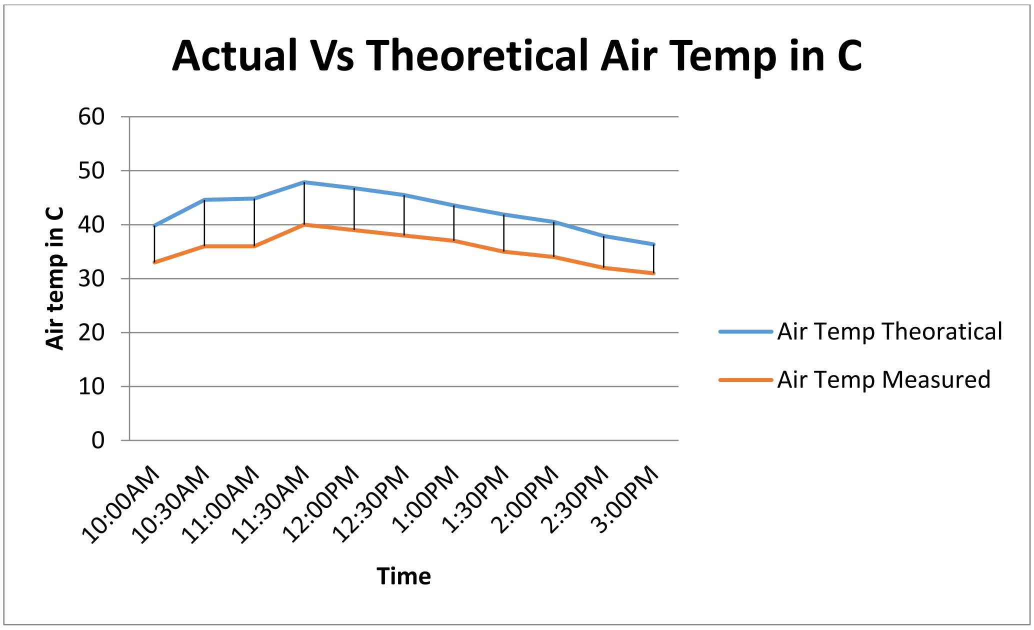

Figure 4-4: Graph showing measured and calculated air temperatures

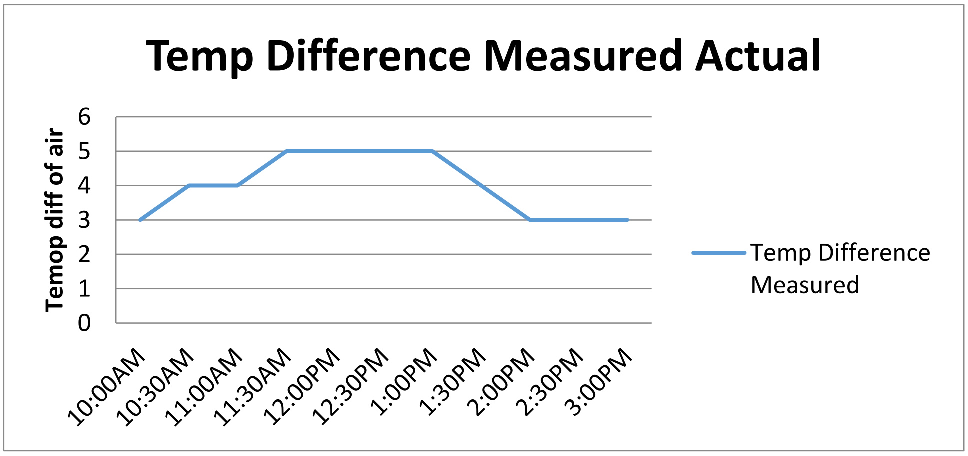

Figure 4-5: Measured temperature difference of air inside the collector with ambient

Result: It can be seen from the above graph that we are successful in achieving the air temperature rise of 5 degrees at most.

Chapter 5

Future Work

What we have achieved in this project is of some significant importance however, there is always some room for improvement. As discussed in the previous chapter we were able to achieve to main things.

- Absorber Plate Temperature of around 80 degree centigrade.
- Air temperature rise of 6 degree centigrade.

However, the main objective of our project was not achieved by the model we fabricated and that was the generation of electricity. The different factors that contributed in the failure of our prototype are listed down under as;

- The scaled down version has its limitations. Since, we were working with very small air collector and small tower heights for our reasons of portability and cost effectiveness this lead to less air flow into the collector. In addition to this, small tower height added a further problem of generating less pressure difference for the fan blades acting as turbines in the system to rotate.
- The most important factor to mention in this regard is the design of solar air collector's top surface, which was in fact a glass sheet of 5mm thickness in our case. We were unable to give a curved effect to this top surface glass sheet. If happened otherwise it would have provided a proper path for the air to flow upwards in the tower that was rising up due to convection currents and buoyancy effects generated to solar irradiations falling on the collector.

In the light of above mentioned points, we recommend two of the most important points to take into consideration for any future reference:

- Scale down your prototype to an extent that it will generate something fruitful for you.
- Give a proper curvature to the top surface of collector that is in fact a glass sheet so that it will provide a proper path for air to flow upwards and into the tower.

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