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| University of Cape Town |
| Evacuate Solar Heater |
| Designing a controller and monitoring the temperature |

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**Summary**

Designing a controller for an Evacuated Solar Heater.

This controller will be running one task at a given interval using the Input/ Output (I/O) system as the basis. The data is read from the sensors and sent to the Arduino where they are used to monitor the whole system. The same data is sent to the Personal Computer using Serial where a fie is created to store all the data.

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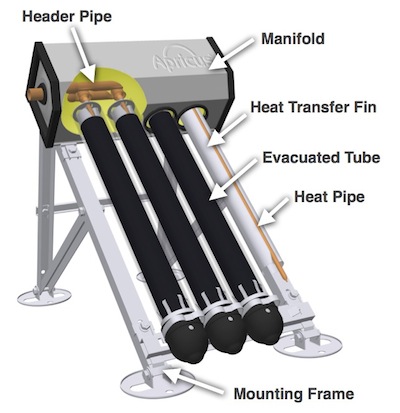
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1. **INTRODUCTION**

An Evacuated Solar Hear is a system made up of an Evacuated Tube Solar collector and a Storage Tank.

* 1. **Evacuated Tube Solar Collector**

It absorbs the solar energy from the surrounding and convert it into internal heat of the Tubes. This energy pass through the Heat Transfer Fin to Heat Pipe then the heat is transferred to the manifold where it is store to be absorbed by the water flowing through the Header pipes.



* 1. **Storage Tank**

This tank is an insulated tank which can carry up to 25 litres of water. It is insulated to prevent the water from losing its heat energy to the surrounding rapidly.

A pump is attached to the tank to pump the water to the Header pipe for heating.

1. **Apparatus**

Additional material:

An Arduino Uno

* This device was used to control the whole system. It is a single task device and easy to used especially for complex system that could be solved with simple coding skills and code execution.

Pump

* To pump the water from the water tank to the Header pipes and back to the tank.
* It is a 37W , 8~30V pump

Two LEDs

* To display if the water is flowing in the system.

Thermocouples

* Three LM35dz were used as temperature sensors. Two were installed in the manifold as the input temperature sensor and the other one was used as the output temperature sensor. The remaining LM35dz was installed in a side of the water Tank
* Maximum temperature (95 ºC).
* Any voltage above 3V.

1. **Design**
   1. **Code**

For this design an Arduino Uno was choose because of its simplicity, compatibility and availability for its libraries that are useful for learning the uses of Arduino in any field of electronics.

The aim of this code is to take data from the sensors then use them to monitor the operation of the system and store them for operational analyses.

Every time when this system is operating. The Arduino will read all the values using analogue inputs then the data is transferred through the Serial for every specified interval (depending on the user’s choice) then the data will be imported to the Python code. This Python code creates a file and deposit all the temperature values up until the specific amount of time (depending on the user’s choice) is reached when the Evacuated Solar Heater is shut down. Python then closes the file and place it into a folder. Comma Separated Values (CSV) type is used to store the files allowing the user to be able to easily read the values using excel or Notepad.

When the system starts operating it creates a new file. All the files are named using time at which the System started operating. These files could be used to analyse the operation of the system.

* 1. **Operation of the system**

The system is made to heat up the water and kept it at a desired temperature. It can only handle up to 90 ºC since the thermocouples(Lm35dz) that are used can handle up 95 ºC before they could be damaged.

This system used a type of system called Open loop system where the user is in charge of the amount of time at which the system is to operate and upload the information. This type of system was chosen because of the wide range of its application in different places. As some place turn to be more extremely cold or hot. These two extreme situation can result in over heating or freeze.

When there is too much heat transferred to the evacuated tubes which might be a result of too much sunlight or heat from the surrounding. The temperature of the water in the Header pipes will increase rapidly as the pressure of the system builds up resulting in overheating. This leads stagnation which mostly occurs during power failure, power blackout or component failure. The consequences of this process may be an expansion of a tank due to compressed vapour in the tank.

During harsh conditions such as snowy days the temperature of the surrounding is extremely low and less energy is transferred to the evacuated Tubes. The surrounding temperature could lead to freezing of the tube or the water circulation pipes which all result in stopping the operation of the system.

These two extreme condition could be minimised by installing a pressure releaser to let the pressure escape when it reaches as 75psi, as it is a good operation pressure for an Open Loop System. During extreme cold the water is to circulate from the tank to the Headers to prevent the circulation pipes from freezing up. This cannot go on for a long period as the water temperature in the system drops rapidly and eventually it reaches a freezing point where the whole system need to be shut down.

For the Overheating condition a one-way valve could have been used to prevent the building up of pressure by using the pressure to circulate the water in the whole system but using pressure for this system can be a problem because as the water gets more hotter the pressure in the tank also rises creating more pressure that will push the water to circulate more, which leads to massive rate of flow in the water circulation loop. If we had used this method this was going to result in creating a new system that will monitor the pressure of the system and temperature, at the same time also monitor the speed of the recirculating water in the loop. This means that when the pressure reaches a certain value the pressure releaser will have to release certain amount of pressure to reduce the speed to the flow to a normal speed of the operation.

1. **Conclusion**

This designing of a controller was not much bases on the creation of the code and making of the system but mostly based in the possibilities that the consumer might face when using this system as a home water.

1. **Recommendation**

I strongly recommend the use of this system for home water warming application as there is less electrical power used electricity directly to heat up the water. Also it is a long term investment as these evacuated tubes are built to last for more than 20 years if they go under maintenance every 5 years through a process called out-glassing.