THERMAL ENERGY STORAGE FOR GREENHOUSE

Mit Golakiya[1], Harshil Vasani[2], Peris Savani[3] , Parth Limdiwala[4]

[1,2,3,4] B.tech , Automobile, Chhotubhai Gopalbhai Patel Institute of Technology, Bardoli, Surat, India

---***---

Abstract - *It has been developed methods of growing some high value crop continuously by providing protection from the excessive cold which is called as Greenhouse Technology. The temperature inside the greenhouse is maintained by heater or cooler. The phase change material can be replaced in addition to maintain the temperature inside the greenhouse. By putting phase change material inside the greenhouse, we can grow the seeds which will not be grown in off seasons with a good ratio with minimum cost. The effects of north brick wall on the energy consumption of greenhouses were studied and considered in model. Experimental validation of model was carried out in a single span, east-west orientated greenhouse for a typical day in winter.*

***Key Words*: phase change material inside the greenhouse, The effects of north brick wall on the energy consumption**

1.INTRODUCTION

The idea of growing plants in environmentally controlled areas has existed since Roman times. The Roman emperor Tiberius ate a cucumber-like[2] vegetable daily. The Roman gardeners used artificial methods (similar to the greenhouse system) of growing to have it available for his table every day of the year. Cucumbers were planted in wheeled carts which were put in the sun daily, than taken inside to keep them warm at night. The cucumbers were stored under frames or in cucumber houses glazed with either oiled cloth known as specularia or with sheets of selenite (a.k.a. lapis specularis), according to the description by Pliny the Elder.[3][4]

The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without its atmosphere.[5]

A Greenhouse (also called a glasshouse, or, if with sufficient heating, a hothouse) is a structure with walls and roof made chiefly of transparent material, such as glass, in which plants requiring regulated climatic conditions are grown.[1] These structures range in size from small sheds to industrial-sized buildings. A miniature greenhouse is known as a cold frame. The interior of a greenhouse exposed to sunlight becomes significantly warmer than the external ambient temperature, protecting its contents in cold weather.

Many commercial glass greenhouses or hothouses are high tech production facilities for vegetables or flowers. The glass greenhouses are filled with equipment including screening installations, heating, cooling, lighting, and may be controlled by a computer to optimize conditions for plant growth. Different techniques are then used to evaluate optimality-degrees and comfort ratio of greenhouse micro-climate (i.e., air temperature, relative humidity and vapour pressure deficit) in order to reduce production risk prior to cultivation of a specific crop.

Temperature and humidity control is important for higher crop production in greenhouse which requires large amount of electricity consumption. Primary aim of project is to reduce the overall energy consumption of greenhouse used to control the internal environment for higher crop production by implementation of phase change material. Additionally, we are in process where electricity production can be generated through photovoltaic cells.

The scientists all over the world are in search of new and renewable energy sources. One of the options is to develop energy storage devices, which are as important as developing new sources of energy. The storage of energy in suitable forms, which can conventionally be converted into the required form, is a present day challenge to the technologists. One of prospective techniques of storing thermal energy is the application of phase change materials (PCMs).

It has developed methods of growing some high value crop continuously by providing protection from the excessive cold which is called as Greenhouse Technology. So, greenhouse technology is a technique of providing favourable environment condition to the plant. A Greenhouse is a structure with walls and roof made chiefly of transparent material, such as glass, plastics, in which plants requiring regulated climatic conditions are grown. These structures range in size from small sheds to industrial-sized buildings. A miniature greenhouse is known as a cold frame. The interior of a greenhouse exposed to sunlight becomes significantly warmer than the external ambient temperature, protecting its contents in cold weather.

It is rather used to protect the plant from the adverse climate conditions such as wind, cold, precipitation, excessive radiation, extreme temperature, insects and diseases.

1.1 Types of Greenhouse

According to covering material:

1. Net base greenhouse,
2. Plastic base greenhouse

1.2 Thermal Energy Storage

Thermal energy storage (TES) systems can store heat or cold to be used later under varying conditions such as temperature, place or power. The main use of TES is to overcome the mismatch between energy generation and energy use.In TES systems energy is supplied to a storage system to be used at a later time, involving three steps: charge, storage and discharge, giving a complete storage cycle.

1.3 Need for TES

The concept of TES has existed for years, but is currently gaining momentum due to the increasing impact of scientific and technological advancements. The reason behind the significant attention given to TES technologies in recent years, as compared to earlier years can be due to the following needs or underlying conditions.

- A mismatch exists between the energy supply and energy demand.
- Intermittent energy sources are utilized for meeting the energy demand.
- An energy supply for catering the critical and part load demand is limited.
- Energy derivative equipment's to meet peak load requirements are undersized or oversized.
- Cost is involved in the operation of the cooling/heating systems during day-load and off-peak conditions.
- Rebates, economic credentials, and subsidies are available for the plant or system operation through energy redistribution schemes.

For most real-world applications, the implementation of TES technologies can be considered a bright option, which would offer better energy redistribution capacity and operational flexibility to energy consuming devices or systems. However, carrying forward such technologies often remains a question to be answered among scientific and engineering communities, despite the previously listed needs for their implementation and commissioning.

2. Review of Literature

Berroug, F., Lakhal, E. K., Omari, M. E., & Faraji, M.[7]

They had analyzed and discussed the thermal performance of a north wall made with phase change material (PCM) as a storage medium in east–west oriented greenhouse in terms of thermal load leveling and potential heating for a typical decade climate of January in Marrakesh (31.62°N, 8.03°W). $CaCl_2.6H_2O$ is used as a PCM. A numerical thermal model taken into account the different components of the greenhouse (cover, plants, inside air and north wall PCM) and based on the greenhouse heat and mass balance, has been developed to investigate the impact of the PCM on greenhouse temperature and humidity. Results showed that with an equivalent to 32.4 kg of PCM per square meter of the greenhouse ground surface area, 4 cm thick PCM NW as a storage medium, temperature of plants and inside air were found to be 6–12 °C more at night time in winter period with less fluctuations.

Kern and Aldrich[11] Application of PCMs in greenhouses for heating dates back to as close as the 1980s. In a study by Kern and Aldrich, 1650 kg of $CaCl_2.6H_2O$ in aerosol cans each weighing 0.74 kg was used to investigate energy storage possibilities both inside and outside a 36 m^2-ground area greenhouse covered with tedlar-coated fiberglass. PCM cans were placed in a store with 22.86 mm spacing and two stores containing different amounts of PCM was used, one inside and the other outside the greenhouse.

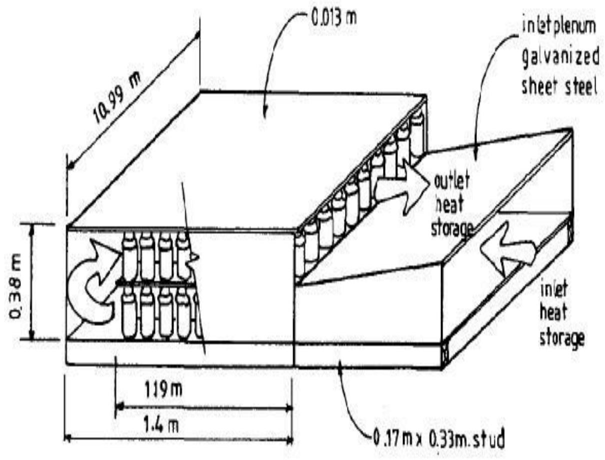


Fig-1: Energy storage unit inside the greenhouse

3. Aim and Objectives

3.1 Aim:

To reduce the power consumption in greenhouse by the use of phase change material.

3.2 Objectives:

Analyse greenhouse by ANSYS software and comparison with experimental data.The individual tasks involved in this research project will be evaluated and tested in the laboratory. The integration of these tasks for smart greenhouse operations will require the building of a scaled-down model greenhouse approximately 10' by 20' located on an available site either on UTU campus or in a nearby proximity.

4. Proposed Model

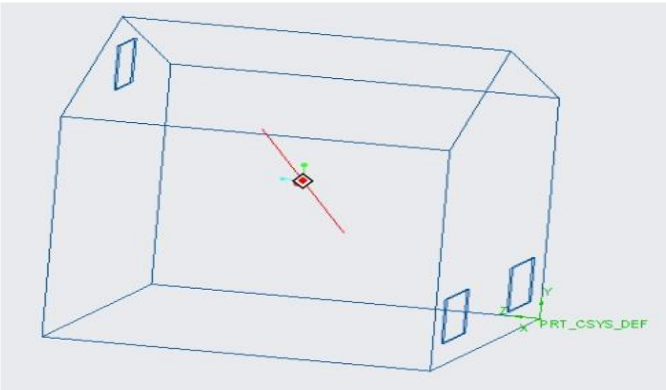


Fig -2: Proposed Model

4.1 Working Principle of Phase Change Material

Phase change materials (PCM) are "Latent heat storage" materials. The thermal energy transfer occurs when a material changes from solid to liquid, or liquid to solid. This is called a change in state or Phase. Initially, these solid–liquid PCMs perform like conventional storage materials; their temperature rises as they absorb heat. Unlike conventional (sensible) storage materials, PCM absorbs and release heat at a nearly constant temperature.

The effect of latent heat storage has two main advantages:

1. It is possible to store large amounts of heat with only small temperature changes and therefore to have a high storage density.

2. Because the change of phase at a constant temperature takes some time to complete, it becomes possible to smooth temperature variations.

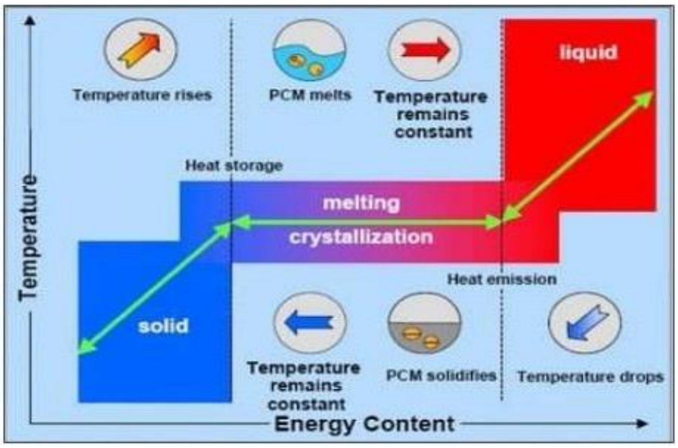


Fig-3: Working of PCM

5. CFD ANALYSIS

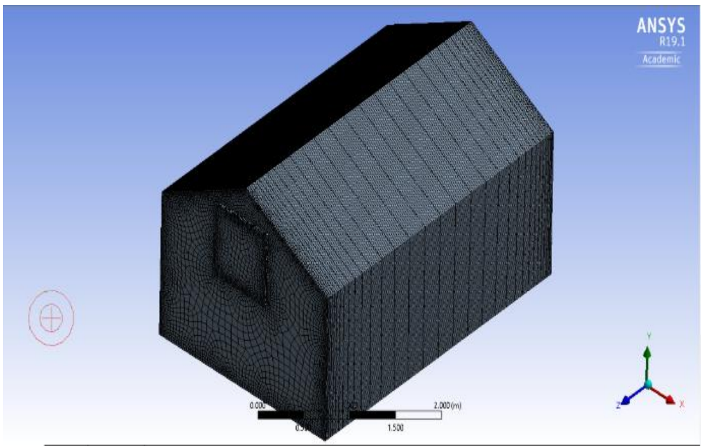


Fig-4: Mesh Model

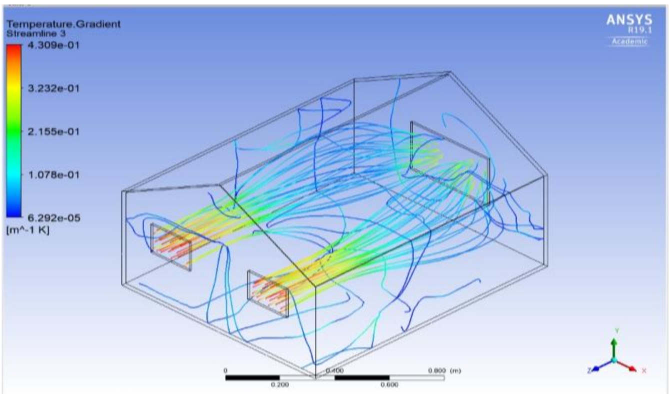


Fig-5 : Temperature Gradient inside Model

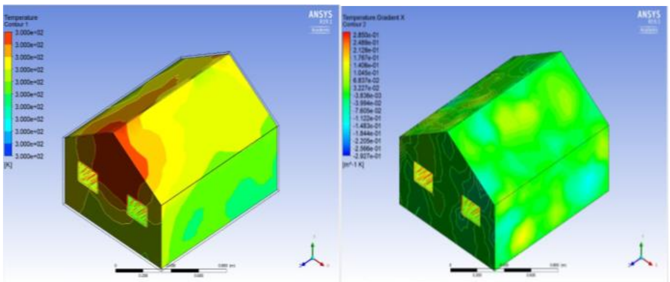


Fig-6 : Temperature And Temperature Gradient at Surface

5. RESULT AND DISCUSSION

5.1 Atmospheric data

5.1.1 Temperature data of Surat on January[18]

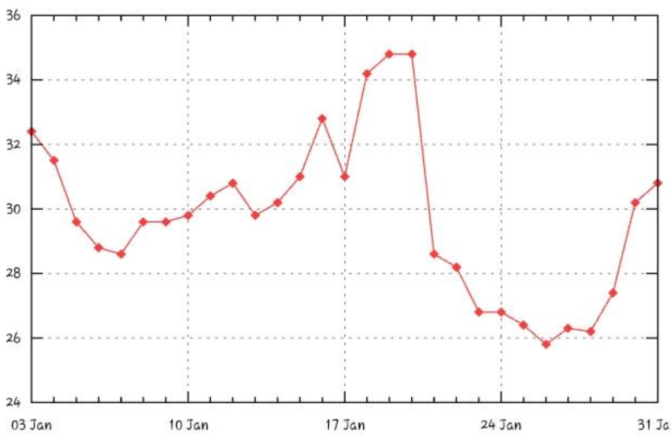


Fig-7: Maximum Temperature Vs day during January month

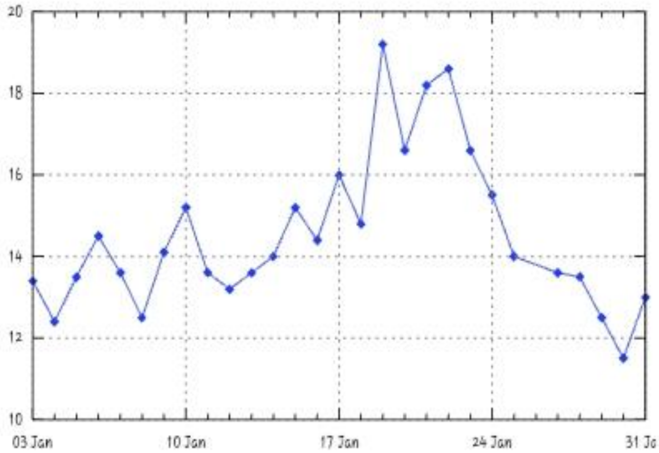


Fig -8: Minimum Temperature Vs day during January month

5.2 Humidity Data[18]

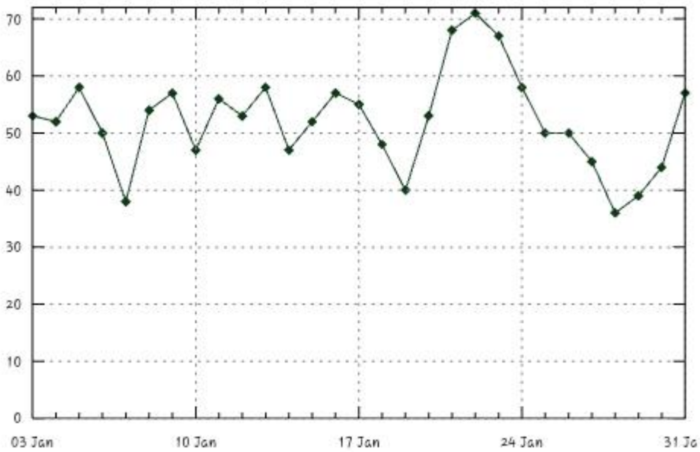


Fig-9: Humidity Vs day during January month

5.3 Actual Reading

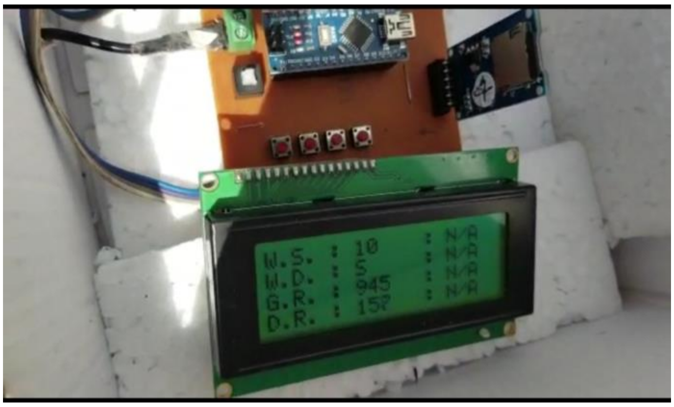
5.3.1 Reading of Pyranometer, Pyrheliometer, Anemometer

Table 1 : Reading of Anemometer, Pyranometer, Pyrheliomter

Date	Time	GR	DR	WS
2019/3/26	11:30:50	1208	977	18
2019/3/26	11:31:50	1208	974	9
2019/3/26	11:32:50	1208	974	17
2019/3/26	11:33:50	1208	974	18
2019/3/26	11:34:50	1209	974	5
2019/3/26	11:35:50	1209	973	18
2019/3/26	11:36:51	1208	972	7

2019/3/26	11:37:51	1208	971	11
2019/3/26	11:38:51	1207	969	4
2019/3/26	11:39:51	1208	970	8
2019/3/26	11:40:51	1208	970	11
2019/3/26	11:41:51	1208	969	14
2019/3/26	11:42:51	1209	971	8
2019/3/26	11:43:51	1210	973	7
2019/3/26	11:44:51	1208	973	5
2019/3/26	11:45:51	1208	974	2
2019/3/26	11:46:51	1208	974	3
2019/3/26	11:47:52	1209	973	2
2019/3/26	11:48:52	1208	971	7
2019/3/26	11:49:52	1208	971	11
2019/3/26	11:50:52	1208	967	5

6. PHOTOS OF PROJECT



7. FUTURE WORK

In this project, used traditional plastic base greenhouse. Also install weather data logger which consisting Anemometer, Pyranometer, Pyrheliyometer, Temperature and Humidity Sensors. Latent Heat Storage and Phase Change Material will remaining to install in this project. Now, this project takes over by junior.

8. CONCLUSIONS

The calculations were carried out for a 2 m×2 m greenhouse situated at Uka Tarsadia University in Surat city, located in the southern part of Gujarat, at geographical location of (21.1667° N, 72.8333°E) with elevation of 34 m above the sea level under the environmental conditions throughout the year 2018- 2019, Which are helpful to indicate the hourly energy balance and average temperature distribution inside the greenhouse.

As per this climate extra heating is needed only for November to February. For March to October only storage unit can absorb the available heat and supply whenever required.

Lowering of air temperature during peak sunny hours and increasing during the night due to use of shading nets would become favourable for growing off-season vegetables in naturally ventilated greenhouse. Based on the predicted air and plant temperatures inside the greenhouse, crops to be grown inside it can be decided. Also, based on the predicted air temperature, heating or cooling requirements for maintaining a suitable thermal environment for a particular crop inside the greenhouse can also be known to obtain better plant growth and yield.

9. REFERENCES

[1] Oxford English Dictionary (3rd ed.). Oxford University Press. September 2005. (Subscription or UK public library membership required.)

[2] Janick, J; Paris, HS; Parrish, DC (2007). "The Cucurbits of Mediterranean Antiquity: Identification of Taxa from Ancient Images and Descriptions".

[3] Pliny the Elder with John Bostock and H. T. Riley, trans., Natural History (London, England: Henry G. Bohn, 1856), vol. 4, book 19, chapter 23: "Vegetables of a cartilaginous nature – cucumbers. Pepones.", p. 156.

[4] rogue classicism: Roman Greenhouses? Cartilaginum generis extraque terram est cucumis mira voluptate Tiberio principi expetitus Nullo quippe non die contigit ei pensiles eorum hortos promoventibus in solem rotis olitoribus rursusque hibernis diebus intra specularium munimenta revocantibus

[5] "Annex II Glossary". Intergovernmental Panel on Climate Change. Retrieved 15 October2010.

[6] Benli, H., & Durmus, A. (2009). Performance analysis of a latent heat storage system with phase change material for new designed solar collectors in greenhouse heating. Solar Energy(83), 2109-2119.

[7] Berroug, F., Lakhal, E. K., Omari, M. E., & Faraji, M. (2011). Thermal performance of a greenhouse with a phase change material north wall. Energy and Buildings(43), 3027-3035.

[8] Bouadila, S., Kooli, S., Skouri, S., Lazaar, M., & Farhat, A. (2014). Improvement of the greenhouse climate using a solar air heater with latent storage energy. Energy, 64, 663-672.

[9] F. Berroug, E. L. (2011). Thermal performance of a greenhouse with a phase change material north wall. Energy and Buildings(43), 3027-3035.

[10] Gupta, M., & Chandra, P. (2002). Effect of greenhouse design parameters on conservation of energy for greenhouse environmental control. Energy, 27, 777-794.

[11] Hu¨seyin Benli, A. D. (2009). Performance analysis of a latent heat storage system with phase change material for new designed solar collectors in greenhouse heating. Solar Energy(83), 2109-2119.

[12] Lazaar, M., Bouadila, S., Kooli, S., & Farhat, A. (2014). Conditioning of the tunnel greenhouse in the north of Tunisia using a calcium chloride hexahydrate integrated in polypropylene heat exchanger. Applied Thermal Engineering, 68, 62-68.

[13] Liguo Li, Y. W. (2014). Thermal environment regulating effects of phase change material in Chinese style solar greenhouse. Energy Procedia (61), 2071-2074.

[14] Liguo, L., Yuxin , W., Wei, R., & Shuang, L. (2014). Thermal environment regulating effects of phase change material in Chinese style solar greenhouse. Energy Procedia(61), 2071-2074.

[15] Mariem Lazaar, S. B. (2014). Conditioning of the tunnel greenhouse in the north of Tunisia using a calcium chloride hexahydrate integrated in polypropylene heat exchanger. Applied Thermal Engineering, 68, 62-68.

[16] Ozturk, H. H. (2005). Experimental evaluation of energy and exergy efficiency of a seasonal latent heat storage system for greenhouse heating. Energy Conversion and Management, 46, 1523-1542.

[17] B. B. H. Ö. Paksoy, "Thermal energy storage (TES) systems for greenhouse technology," in Advances in Thermal Energy Storage Systems, Turkey, Elsevier, 2015, pp. 533-548.

[18] https://www.weatheronline.in/weather/maps/city.