Jurnal Kejuruteraan 34(5) 2022: 753-761
https://doi.org/10.17576/jkukm-2022-34(5)-01

Application of Thermal Energy Storage Materials for Solar Cooking: A Comprehensive Review

Romil Patel[a*] & Vikram Patel[b]

[a]*Mechanical Engineering Department, Ganpat University, Ganpat Vidyanagar, Mehsana, Gujarat, India*
[b]*Mechanical Engineering Department, L. D. College of Engineering, Ahmedabad, Gujarat, India*

**Corresponding author: romilpatel93@gmail.com*

Received 11 June 2021, Received in revised form 27 November 2021
Accepted 27 December 2021, Available online 30 September 2022

ABSTRACT

Food, cloth and shelter are three basic necessities of life. Food can be regarded as essential component for growth and survival of human being. So, the source of cooking is one of the most important things in our daily lives. There are various cooking sources of energy like kerosene, LPG, Firewood and Renewable sources etc. and one of them is solar cooking which is a renewable source of energy. Solar cooks are limited by the fact that cooking can only take place during daytime. If a thermal energy storage system is provided to solar cookers, food can be cooked during hours of evening or night. In the last few decades, the cooking sector has used various solar cookers, including the box type solar cooker, flat plate type solar cooker, parabolic dish type solar cooker, evacuated tube type solar cooker and Scheffler dish solar cooker with sensible heat, latent heat and Combined heat storage technologies for the solar cooker. As a result, this paper summarizes the investigation and analysis of the available thermal energy storage materials (sensible heat, latent heat and combined heat storage materials) to store heat during the daytime and use it for purposes other than daytime hours for use in solar cooking application. The current study also compares the Sensible heat, Latent heat and combined heat storage systems for cooking.

Keywords: Solar energy, Solar cooker, Sensible heat storage materials, Latent heat storage materials, Combine heat storage materials, Evening cooking, Energy storage

INTRODUCTION

Everyone in the world needs to know how to cook. 75% of rural Indians use non-commercial fuels like forest wood to cook their food, which causes deforestation and increases the greenhouse effect. LPG prices, on the other hand, are steadily rising as a major source of cooking energy. As a result, using renewable energy sources to cook is an alternative option. India is fortunate in that it receives plenty of sunlight. As a result, solar cooking becomes a viable option (Garg (1978), Mullick et al. (1987), Thulsidas et al. (1997)). Figure 1 shows the classification of solar cooker.

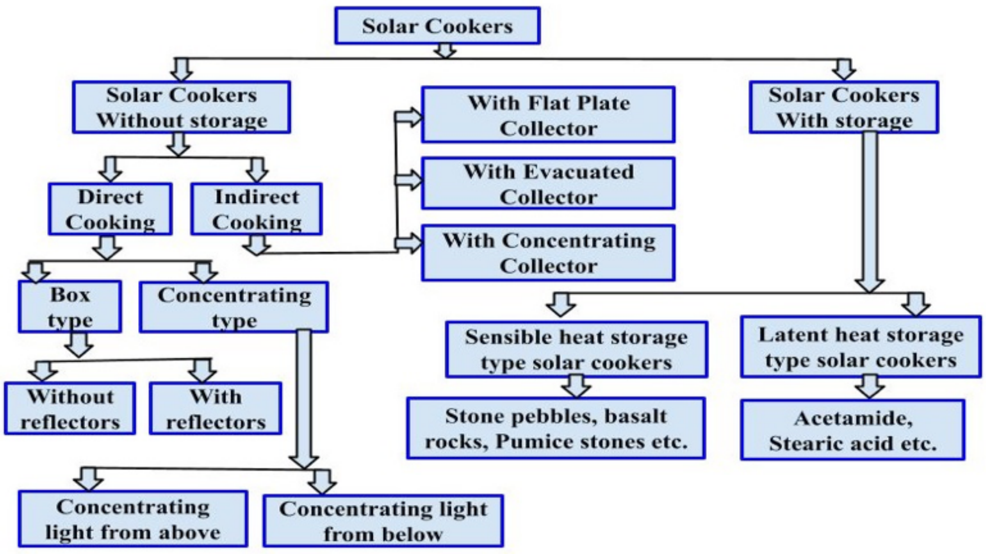

FIGURE 1. Classification of solar cooker (Garg 1978)

A solar cooker, as well as other solar applications such as a solar still, solar dryer, solar water heater, and others, necessitate the use of an energy storage system. In solar stills, more energy can be stored and re-used during the day so that it can be used later in the evening and at night. [Panchal and Shah (2012), Panchal and Patel (2017), Panchal and Mohan (2017), Panchal and Shah (2014), Panchal et. al. (2018), Panchal et. al. (2018), Panchal et. al. (2018), Patel and Patel (2020)] It is economically viable to use energy storage when it lowers energy consumption and can be used to replace another energy source. Figure 2 illustrates the various types of energy storage materials.

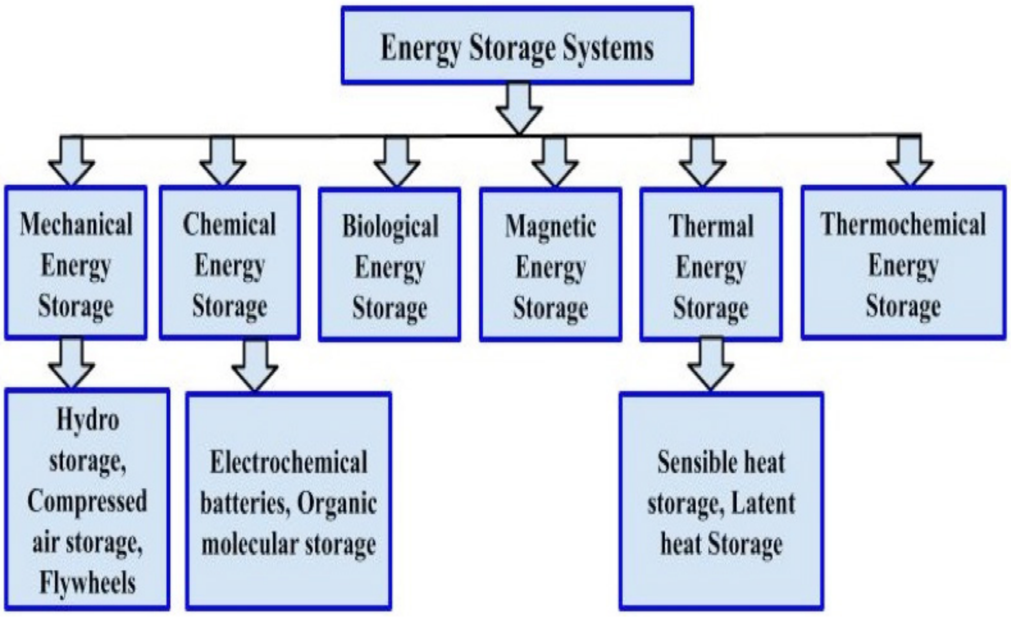

FIGURE 2. Classification of Energy Storage System (Mofijur et. al. 2019)

Thermal energy storage can be stored as a change in internal energy of a material as sensible heat, latent heat and combination of these.

Sensible heat storage:

In sensible heat storage (SHS), thermal energy is stored by raising the temperature of a solid or liquid. SHS system utilizes the heat capacity and the change in temperature of the material during the process of charging and discharging. The amount of heat stored depends on the specific heat of the medium, the temperature change and the amount of storage material [Sharma et. al. (2009)].

$$Q = \int_{T_i}^{T_f} m\, C_p\, dT \quad (1)$$

$$Q = \int_{T_i}^{T_f} m\, C_p\, (T_f - T_i) \quad (2)$$

Where, Q = quantity of heat stored (J), T_f = final temperature (^oC), T_i = initial temperature (^oC), m = mass of heat storage medium (kg), Cp = specific heat (J/kg K).

Latent heat storage:

Latent heat storage (LHS) is based on the heat absorption or release when a storage material undergoes a phase change from solid to liquid or liquid to gas or vice versa [Sharma et. al. (2009)].

$$Q = \int_{T_i}^{T_m} mC_p\, dT + ma_m\Delta h_m + \int_{T_m}^{T_f} mC_p dT \quad (3)$$

$$Q = m[C_{sp}(T_m - T_i) + a_m\Delta h_m + C_{lp}(T_f - T_m)] \quad (4)$$

Where, Q = quantity of heat stored (J), m = mass of heat storage medium (kg), T_i = initial temperature (^oC), T_f = final temperature (^oC), T_m = melting temperature (^oC), C_{lp} = average specific heat between T_m and T_f (J/kg K), a_m = fraction melted, Δh_m= heat of fusion per unit mass (J/kg).

Solar box cooker with thermal energy storage unit developed by Anilkumar et. al. (2021) for solar cooking in off-sun hours. Multi-criteria decision making (MCDM) techniques was used for selection of phase change material and selected erythritol as a PCM because erythritol required lesser quantity (6.06 kg) compared with magnesium chloride hexa-hydrate (16.02 kg) and acetanilide (13.25 kg).

The novel box type solar cooker integrated PCM was experimentally developed by Palanikumar et. al. (2021) for solar cooking application. Three different experiments [Solar box type cooker with PCM (waste cooking oil and $C_4H_4O_3$), with Nanocomposite – PCM ($MgAl_2O_4/Ni/Fe_2O_3$-PCM) and without Nanocomposite – PCM] study by the researchers. From study resulted that, the overall thermal performance of solar box cooker without Nanocomposite – PCM, with PCM, and with Nanocomposite – PCM was obtained as 24.90-33.90%, 24.77-45.20% and 31.77-56.21% respectively.

Evacuated tube solar collector with cooking pot and phase change material (palm oil) deloved and investigated by Hebbar et. al. (2021) for off-sunshine hours cooking application. From study resulted that, temperature of oil reaches a maximum value during late afternoon oil will remain high in the evening time.

The objective of this review paper is to review about solar cooking and its applications to preserve fresh foods using sensible heat, latent heat and combined heat storage. The review paper makes a comparison of the solar cooking systems with sensible heat, latent heat, and combined heat storage materials.

REVIEW ON LATENT HEAT STORAGE MATERIALS

Phase change materials (PCMs) have recently gained a lot of attention as a component of latent heat thermal energy storage units (LHTES). Many researchers have worked into the effects of solar cookers using PCMs.

Cooking during the night is a challenge, so Domanski et al. (1995) investigated the effectiveness of materials that store latent heat. A phase change material (PCM) was used in a solar cooker made of two cylindrical vessels with a gap filled with stearic acid or magnesium nitrate hexahydrate. An experiment was conducted using a solar simulator to produce the desired amount of solar radiation and concluded that important parameters like solar intensity and the mass of the cooking medium are in terms of cooking performance.

Box type solar cooker with three reflectors and PCM storage unit designed and manufactured by Buddhi et al. (2003) for storing energy during the day and cooking food at night during the winter, commercial acetanilide has been used as a phase change material. Cooking experiments has been done with and without PCM. The experimental results have shown that evening cooking is possible in a solar cooker with three reflectors along with latent heat storage unit.

An evacuated tube solar collector (ETC) with a PCM storage unit was used by Sharma et al. (2005) to investigate the thermal performance of a prototype solar cooker. Cooking experiments with various loads and loading times were conducted throughout the day and evening. Cooking with a PCM storage unit in the evening versus noon was found to be faster. Using erythritol as a PCM, researchers were able to cook food to a temperature of 130°C during dinner time.

A noval indirect solar cooker based on a flat plate collector (FPC) with PCM storage and cooking unit was investigated by Hussein et al. (2008). Wickless heat pipes were used in the solar cooker, which had an elliptical cross section. As a PCM, magnesium nitrate hexa-hydrate was used. The results shows that the feasibility of elliptical cross-section indirect solar cooker can be used to cook in the evening and to heat food in the daytime using wickless heat pipes and PCM. Figure 3 illustrates the main components of solar cooker.

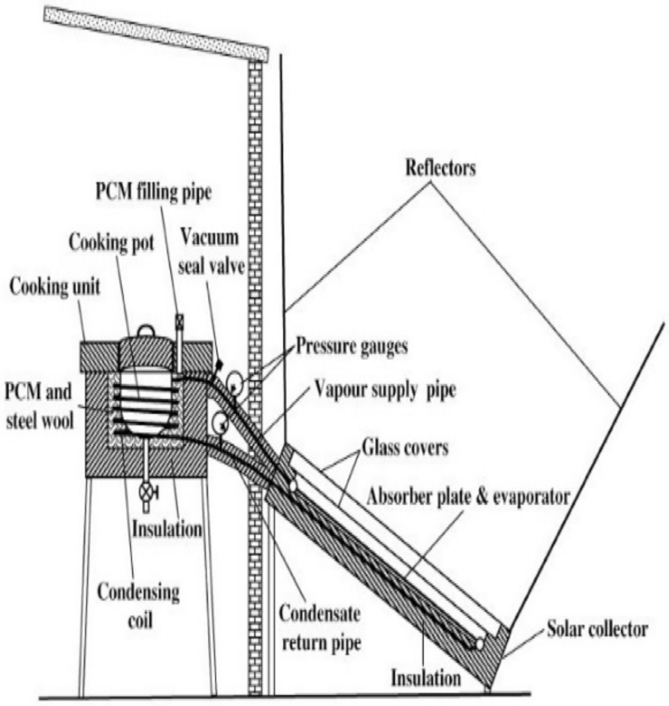

FIGURE 3. Cross sectional side view of the indirect solar cooker based on a flat plate collector (Hussein et al. 2008)

Using a parabolic collector with solar thermal system, Umanand and Prasanna (2011) developed a hybrid cooking system. The band graph method was used to model the system. For various flow rates (2 m^3/s, 3 m^3/s, 4 m^3/s, 5 m^3/s, 6 m^3/s, 7 m^3/s) examined the simulation results against the experimental results to see which was more accurate. Thermosyphon flow rate efficiency is increased by approximately 6% at optimum flow rate.

They presented literature on various box type solar cooker developments by Saxena et al. (2011), considering major parameters such as box cooker geometries and glass systems as well as cooking vessel designs that store heat efficiently while also being thermally insulated. These developments have led to improvements in box cooker performance, even at low ambient temperatures. As well as being a good way to cook at night, paper suggests that PCM is an excellent way to store solar energy.

Using a box-type solar cooker, Yuksel et al. (2012) investigated the use of paraffin wax with metal shavings as a PCM in the daytime and/or night. It was resulted that the designed cook can be used effectively at a 30° at a reflecting angle with a thermal efficiency of 18.35% when tested under various isolation conditions and on different days.

Solar cooking was used to evaluate the new design of a portable parabolic type heating system by Lecuona et al., (2013). Making the dish required the two traditional coaxial cylindrical cooking pots. the hollow space between the two conical pots is filled with phase change material (PCM). The results show that it is possible to cook the three meals for family during sunny days in summer as well as in winter.

Mussard and Nydal (2013) used solar parabolic trough collector with two different kinds of thermal storage systems (thermal oil storage and aluminium based storage). The loop connecting the collector and storage unit served as a self-circulating thermal fluid for the latent heat storage unit. Thermal oil storage reduces thermal losses in the pipe and absorber much better than an aluminum-based storage unit. Figure 4 illustrates Schematic representation of self-circulated loop used in experiment.

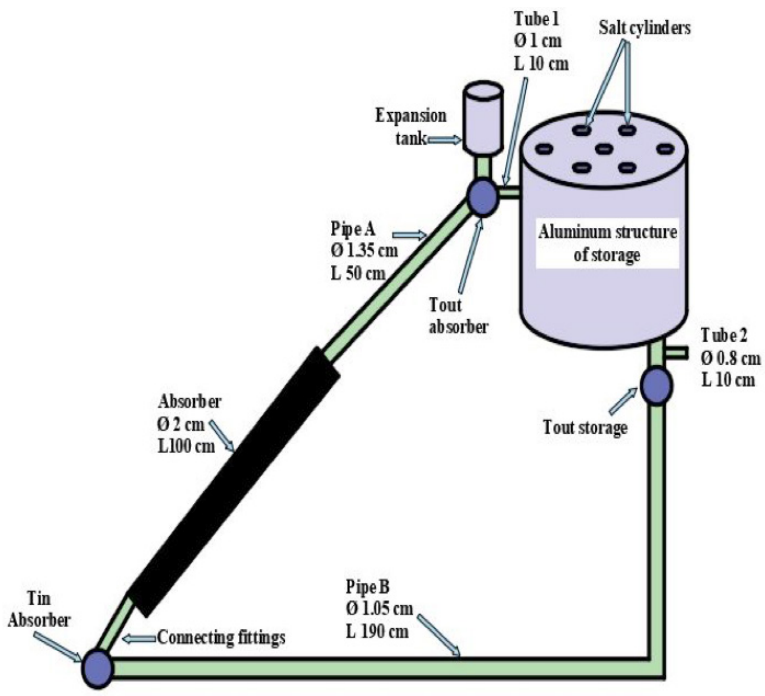

FIGURE 4. Schematic representation of self-circulated loop (Mussard and Nydal 2013)

Chaudhary et al. (2013) investigated a solar cooker based on a parabolic dish collector with phase change material (acetanilide). It was noted that a solar cooker with a dark colored (Black) exterior and glazing stores 32.3% more heat compared to PCM in a standard solar cooker.

Farooqui Suhail (2013) developed a Fresnel lens collector-based solar cooker. Mirror strips mounted on a wooden framework to make up the cooker and required single axis solar tracking system. In experiment's maximum temperature was 250 ^{o}C. The heat absorption capacity of this collector was five times higher than the conventional box type solar cooker. Fig. 5 Shows Schematic diagram of the cooking chamber with various components.

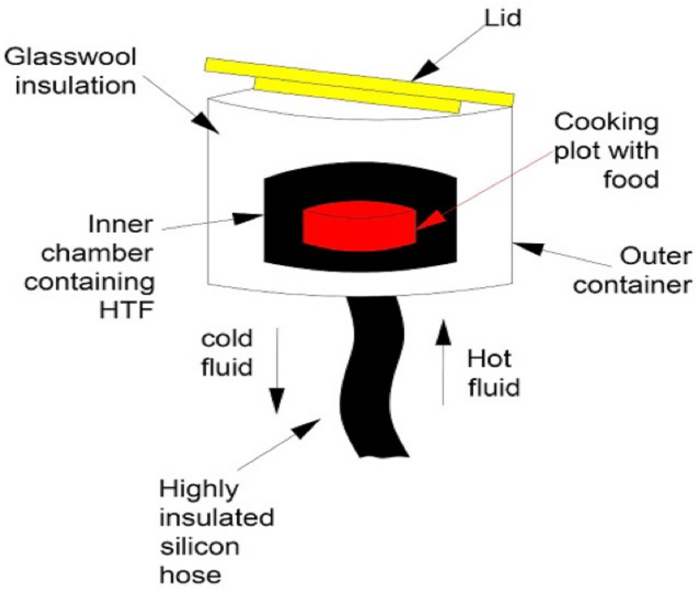

FIGURE 5. Schematic diagram of the solar cooker with the pot (Farooqui Suhail 2013)

Ashmore Mawire et al. (2014) test the thermal performance of three different types of solar thermal oil (Sunflower Oil, Shell Thermia C and Shell Thermia B) during the charging period. A 20 L insulated tank was used for the experiment. The results show that Sunflower Oil was better than other thermal oils under high power Charging.

This study used an experiment by Singh et al. (2015) to investigate the effects of using acetanilide as a latent heat storage material in solar cookers. They circulate heat through a thermosiphon using two different types of heat transfer fluid (water and thermal oil). When using thermal oil as a working fluid, it was observed that the temperature of the thermal oil was 10-24°C higher than the water as a working fluid. Food was cooked twice daily, with the evening cooking rate being higher than the noontime.

REVIEW ON SENSIBLE HEAT STORAGE MATERIALS

Sand was used as a sensible heat storage material in an experiment by Ramadan M.R.I. et al. (1998) on a flat plate solar cooker (FPSC) during clear sunny days. Temperatures in the solar cooker and sand were measured using thermocouples. After experimentation, Sand has been found to be an effective storage material and a reliable source and provide three hours per day indoor cooking.

Using engine oil as a sensible heat storage material, Nahar N. M. (2003) investigated the conventional box type solar cooker. Using engine oil as a sensible heat storage medium increased the solar cooker efficiency by 27.5%.

Schwartzer K. and Silva. MEV. (2003) studied a flat plate solar cooker using vegetable oil as a sensible heat storage. Vegetable oil has been found to be an effective ingredient in keeping food warm for an extended period of time.

Box type solar cooker was studied by Pinar Mert Cuce (2018) and compared to a box type solar cooker with a conventional solar cooker, with and without thermal energy storage materials. They have used Bayburt stone as a sensible heat storage material. After experiment, found that Bayburt stone cooker had an energy efficiency of 35.3 - 21.7%, while conventional solar cookers had an efficiency of 27.6-16.9%. They also found that Bayburt stone significantly improved the thermal performance of solar cookers.

For short-term storage, Haraksingh et al. (1996) investigated a flat plate collector solar cooker with double glazing and Maxorb foil. Natural convection was used to transfer heat, with coconut oil serving as the heat transfer fluid. Temperatures around 150°C can be obtained between 10:00 hr and 14:00 hr when 25 $MJm^{-2}day^{-1}$ with a maximum value of 1000 Wm^{-2}.

A study conducted by Mussard et al. (2013) compared the performance of two types of solar cookers. one was the parabolic type cooker (SK14) and other was a prototype of a solar concentrator (parabolic trough) with storage unit. The heat storage system, cooking efficiency was evaluated through tests involving boiling and frying. Simulation was used to add and improve the system. Cooking on heat storage with optimize surface contact is proved to be competitive with conventional solar cookers or other cooking devices.

REVIEW ON COMBINED (SENSIBLE & LATENT) HEAT STORAGE MATERIALS

Nallusamy et al. (2007) had experimentally studied the thermal efficiency of a packed bed of a combined thermal energy storage unit for sensible and latent heat energy as thermal energy storage (TES). A TES unit has been designed, constructed and integrated with constant temperature bath/ solar collector to study the performance of the storage unit. The TES device contains paraffin as a PCM filled with spherical capsules packed in a cylindrical isolated storage tank. In order to transfer heat from the constant bath / solar collector to the TES tank, the water used as HTF. Charging tests are performed at constant and varying input fluid temperatures to determine the effects on the efficiency of the storage unit of the inlet fluid temperature and HTF flow rate. Discharge experiments are conducted by both continuous and batchwise processes in order to recover the stored heat. The discharge experiments show that the combined storage system employing batchwise discharging of hot water from the TES tank is best suited for applications where the requirement is intermittent. Figure 6 shows the experimental setup of combined storage with use of solar collector.

FIGURE 6. Experimental setup of combined storage with use of solar collector (Nallusamy et al. 2007)

In order to ensure continuous energy supply in the absence of the availability of solar energy, the intermittent existence of solar energy needs an energy storage system with solar collector units. The use of phase change material (PCM) and heat storage rock beds has been investigated by Okello et al. (2014). They carry out the thermal behaviour of thermal energy storage with rocks and PCM, through an experimental comparison. The PCM material ratio was 60:40 percent mixture of NaNO3 and KNO3. The results showed that the injection of PCM cylinders into a rock bed to store heat not only increases the storage energy content, but also the vertical thermal conductivity. The increase in vertical thermal conductivity is due to the PCM container material having a high thermal conductivity.

Andrea Frezzica et al. (2016) had conducted experiments, the research work on the hybrid combined storage for the hot water applications for domestic purpose. They used two PCMs (commercial paraffin and a mixture of hydrate salts). They checked various volume ratios between PCM and water. The resulting showed that the heat storage capacity per unit volume improved dramatically, except for small fractions of the PCM used, to 10% of heat storage increases with the addition of a 1.3 dm^3 hydrate salt mixture. Figure 7 shows the vertical heat storage with thermocouples location.

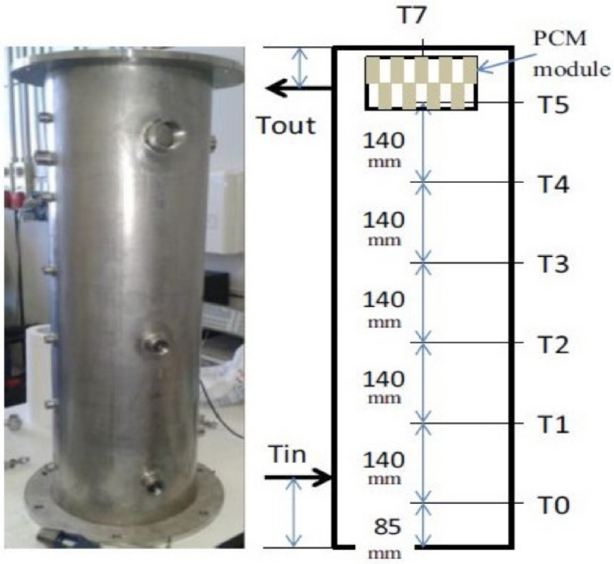

FIGURE 7. The vertical heat storage with thermocouples location (Andrea Frezzica et al. 2016)

Table 1 shows comparison sensible, latent, combined (sensible and latent) heat storage systems.

Table 2 shows summary of comparisons and various research works on sensible, latent, combined (sensible & latent) heat storage systems.

TABLE 1. Comparison of sensible, latent, combined sensible-latent heat storage systems

Features	Sensible heat storage	Latent heat storage	Combined heat storage (Sensible and latent)
Principle	Unlike storage media which changes in temperature, energy is not stored by any phase shift.	Energy is stored as latent heat of fusion by adjusting the phase of the storage medium.	The latent heat of fusion determines the amount of energy contained.
Storage material	Rocks, sand, bricks, molten salt, and sunflower oil are some of the materials used.	Eutectic products, paraffin, non-paraffin, nitrate salts, hydrates salts.	Combination of sensible and latent materials.
Working temperature	Low (Up to 50 ^{o}C-200 ^{o}C)	Medium (Up to 400 ^{o}C)	Medium (Up to 400 ^{o}C)
Merit	No threat of obsolescence	moderate charging and discharging	Temperature on charge and during discharging
Demerits	Thus, lower energy density is needed	Due to reduced thermal conductivity, Vitality of existence is bounded	Thermal waste losses are greater
Material cost	Low	High	Medium

TABLE 2. Comparison of various researchers work on sensible, latent and combine heat storage systems

Sr. No.	Author's name	Type of Solar Cooker	Application	Type of Material	Name of Material
1	Buddhi and Sahoo (1997)	Box type solar Cooker	Cooking	Latent heat storage material	Commercial grade stearic acid
2	Buddhi et al. (2003)	Double glazed (glass covers) box type solar cooker	Cooking	Latent heat storage material	Commercial grade acetanilide
3	Sharma et al. (2005)	Evacuated tube solar collector	Cooking	Latent heat storage material	Commercial grade erythritol
4	Ramadan MRI et. al. (1998)	Flat plate solar cooker	Cooking	Sensible heat storage material	Sand
5	Nallusamy et al. (2007)	Solar flat plate collector	Heat storage	Combined heat storage	Packed bed and paraffin
6	Andrea Frezzica et al. (2016)	Boiler	Hot water for domestic purpose	Combined heat storage	Macro-encapsulated, commercial paraffin and hydrate salts

CONCLUSION

Solar cooking is an efficient, economical, Pollution-free, easily accessible and low-maintenance system used by solar energy. But due to a lack of awareness, it is unpopular in the domestic sector. From the previous literature study, the following points are concluded:

1. Thermal energy storage materials have good ability to store the energy during the sunshine hours and release heat during off sunshine hours for solar cooking.
2. Sensible heat storage materials are easily available and low in cost but energy storage time is 2 to 3 hours only.
3. Comparing sensible and latent heat storage materials, the time needed to store energy in latent heat storage materials is longer.
4. Sensible heat storage material required more quantity than latent heat storage material for the same amount of heat storage.
5. In comparison to a single heat storage system, a combined heat storage system performs better because it utilizes both sensible and latent heat benefits.

ACKNOWLEDGEMENT

This work was supported by the Ganpat University Mehsana, Gujarat, India.

DECLARATION OF COMPETING INTEREST

None

REFERENCES

Andrea Frazzica, Marco Manzan, Alessio Sapienza, Angelo Freni, Giuseppe Toniato and Giovanni Restuccia. 2016. Experimental testing of a hybrid sensible-latent heat storage system for domestic hot water applications. *Applied Energy* 183: 1157-1167. DOI: https://doi.org/10.1016/j.apenergy.2016.09.076.

Anilkumar, B. C., Maniyeri Ranjith & Anish, S. 2021 Optimum selection of phase change material for solar box cooker integrated with thermal energy storage unit using multi-criteria decision-making technique. *Journal of Energy Storage* 40: 1-13. DOI: https://doi.org/10.1016/j.est.2021.102807.

Buddhi, D. and Sahoo, L. K. 1997. Solar cooker with latent heat storage: design and experimental testing. *Energy Conversion and Management* 38 (5): 493-498. DOI: https://doi.org/10.1016/S0196-8904(96)00066-0.

Chaudhary, A., Kumar, A. and Yadav, A. 2013. Experimental investigation of solar cooker based on parabolic dish collector with phase change thermal storage unit in Indian climatic conditions. *Renewable & Sustainable Energy* 5(023107): 1-12. https://doi.org/10.1063/1.4794962.

Denis Okello, Choo W. Foong, Ole J. Nydal and Eldad J. K. Banda. 2014. An experimental investigation on the combined use of phase change material and rock particles for high temperature (~350°C) heat storage. *Energy Conversion and Management* 79: 1-8. DOI: https://doi.org/10.1016/j.enconman.2013.11.039.

Domanski, R., El-Sebaii, A. A. and Jaworski, M. 1995. cooking during off-sunshine hours using PCMs as storage media. *Energy* 20(7): 607-616. DOI: https://doi.org/10.1016/0360-5442(95)00012-6.

Farooqui, S. Z. 2013. A vacuum tube based improved solar cooker. *Sustainable Energy technologies and Assessments* 3: 33-39. DOI: https://doi.org/10.1016/j.seta.2013.05.004.

Garg, H. P., Mann, H. S. and Thanvi, K. P. 1978. Sun: Mankind's future source of energy. 3: 1491–1496.

Haraksingh, I., Mcdoom, L. A. and Headley, O. S. T. C. 1996. A natural convection flat-plate collector solar cooker with short term storage. *Renewable Energy*. DOI: https://doi.org/10.1016/0960-1481(96)88387-X.

Hebbar G., Hegde S., Sanketh B., Sanith L.R. & Udupa, R. 2021. Design of solar cooker using evacuated tube solar collector with phase change material. *Materials Today: Proceedings* 46: 2888-2893. DOI: https://doi.org/10.1016/j.matpr.2021.03.629.

Hussein, H. M. S., El-Ghetany, H. H. and Nada, S.A. 2008. Experimental investigation of novel indirect Solar cooker with indoor PCM thermal storage and cooking unit. *Energy Conversion and Management* 49: 2237-2246. DOI: https://doi.org/10.1016/j.enconman.2008.01.026.

Lecuona, A., Nogueira, J. I., Ventas, R., Hidalgo, M. D. C. R. and Legrand, M. 2013. Solar cooker of the portable Parabolic type incorporating heat storage based on PCM. *Applied Energy*. DOI: https://doi.org/10.1016/j.apenergy.2013.01.083.

Mawire, A., Phori, A. and Taole, S. 2014. Performance comparison of thermal energy storage oils for solar cookers during charging. *Applied Thermal Engineering* l73: 1323-1331. DOI: https://doi.org/10.1016/j.applthermaleng.2014.08.032.

Mofijur, M., Mahlia, T., Silitonga, A., Chyuan Ong H., Silakhori, M., Heikal Hasan, M., Putra, N. and Rahman, S. M. 2019. Phase Change Materials (PCM) for solar energy usages and storage: An overview. *Energies* 12: 1-20. DOI: https://doi.org/10.3390/en12163167.

Mullick, S. C., Kandpal, T. C. and Saxena, A. K. 1987. Thermal test procedure for box type solar cooker. *Solar Energy* 39: 353–360. DOI: https://doi.org/10.1016/S0038-092X(87)80021-X.

Mussard, M. and Nydal, O. J. 2013. Comparison of oil and aluminum-based heat storage charged with a small scale solar parabolic trough. *Applied Thermal Engineering* 58: 146-154. DOI: https://doi.org/10.1016/j.applthermaleng.2013.03.059.

Mussard, M., Gueno, A. and Nydal, O. J. 2013. Experimental study of solar cooking using heat storage in comparison with direct heating, *Solar Energy* 98: 375-383. DOI: https://doi.org/10.1016/j.solener.2013.09.015.

Nahar, N. M. 2003. Performance and testing of a hot box storage solar cooker. *Energy Conversion and Management* 44: 1323–31. DOI: https://doi.org/10.1016/S0196-8904(02)00113-9.

Nallusamy, N., Sampath, S. and Velraj, R. 2007. Experimental investigation on a combined sensible and latent heat storage system integrated with constant/varying (solar) heat sources. *Renewable Energy* 32: 1206-1227. DOI: https://doi.org/10.1016/j.renene.2006.04.015.

Palanikumar, G., Shanmugan, S., Chithambaram, V., Gorjian, S., Pruncu, C. I., Essa, F. A., Kabeel, A. E., Panchal, H., Janarthanan, B., Ebadi, H., Elsheikh, A. H. & Selvaraju, P. 2021. Thermal investigation of a solar box-type cooker with nanocomposite phase change materials using flexible thermography. *Renewable Energy* 178: 260-282. DOI: https://doi.org/10.1016/j.renene.2021.06.022.

Panchal Hitesh and Indra Mohan. 2017. Various methods applied to solar still for enhancement of distillate output. *Desalination* 415: 76–89. DOI: https://doi.org/10.1016/j.desal.2017.04.015.

Panchal Hitesh and Patel Sanjay. 2017. An extensive review on different design and climatic parameters to increase distillate output of solar still. *Renewable and Sustainable Energy Reviews*. 69: 750–758. DOI: https://doi.org/10.1016/j.rser.2016.09.001.

Panchal Hitesh and Pravin Shah. 2012. Effect of varying glass cover thickness on performance of solar still: In a winter climate conditions. *International Journal of Renewable Energy Research* 1(4): 212–223.

Panchal Hitesh and Pravin Shah. 2014. Enhancement of upper basin distillate output by attachment of vacuum tubes with double-basin solar still. *Desalination and Water Treatment* 55(3): 587–595. DOI: https://doi.org/10.1080/19443994.2014.913997.

Panchal Hitesh, Patel Romil, and K. D. Parmar. 2018. Application of solar energy for milk pasteurisation: A comprehensive review for sustainable development. *International Journal of Ambient Energy* 42: 1–4. DOI: https://doi.org/10.1080/01430750.2018.1432503.

Panchal Hitesh, Romil Patel and Ravishankar Sathyamurthy. 2018. Investigation and performance analysis of solar milk pasteurisation system. *International Journal of Ambient Energy* 42: 1–23. DOI: https://doi.org/10.1080/01430750.2018.1557552.

Panchal Hitesh, Romil Patel, Sudhir Chaudhary, D. K. Patel, Ravishankar Sathyamurthy, and T. Arunkumard. 2018. Solar energy utilisation for milk pasteurisation: A comprehensive review. *Renewable and Sustainable Energy Reviews* 92: 1–8. DOI: https://doi.org/10.1016/j.rser.2018.04.068.

Pinar Mert Cuce. 2018. Box type solar cookers with sensible thermal energy storage medium: A comparative experimental investigation and thermodynamic analysis. *Solar Energy* 166: 432-440. DOI: https://doi.org/10.1016/j.solener.2018.03.077.

Ramadan, M. R. I., Aboul-Enein, S. and El-Sebaii, A. A. 1998. A model of an improved low-cost indoor solar cooker in Tanta. *Solar and Wind Technology* 5: 387–93. DOI: https://doi.org/10.1016/0741-983X(88)90005-7.

Romil Patel and Vikram Patel. 2020. Scheffler reflector for cooking application: A review. *International Journal of Ambient Energy* 1-13. DOI: https://doi.org/10.1080/01430750.2020.1758778.

Saxena, A., Varun, Pandey, S. P., and Srivastav, G. 2011. A thermodynamic review on solar box type cookers. *Renewable and Sustainable Energy Reviews* 15: 3301-3318. DOI: https://doi.org/10.1016/j.rser.2011.04.017.

Schwartzer, K. and Silva, M. E. V. 2003. Solar cooking system with or without heat storage for families and institutions. *Solar Energy* 75: 35–41. DOI: https://doi.org/10.1016/S0038-092X(03)00197-X.

Sharma, A., Tyagi, V. V., Chen, C. R. and Buddhi, D. 2007. Review on thermal energy storage with phase change materials and applications. 13: 318-345. DOI: https://doi.org/10.1016/j.rser.2007.10.005.

Sharma, S. D., Buddhi, D., Sawhney, R. L. and Sharma, A. 2000. Design, development and performance evaluation of a latent heat storage unit for evening cooking in a Solar cooker. *Energy Conversion and Management* 41: 1497-1508. DOI: https://doi.org/10.1016/S0196-8904(99)00193-4.

Singh, G., Singh, H., Saini, K. and Yadav, A. 2015. Experimental investigation of the solar cooker during sunshine and off-sunshine hours using the thermal energy storage unit based on a parabolic trough collector. *International Journal of Ambient Energy* 36: 1-12. DOI: https://doi.org/10.1080/01430750.2015.1023836.

Thulasi Das, T. C., Karmakar, S. and Rao, D. P. 1994. Solar box-cooker. *Part I. Modeling, Solar Energy*, 1994, 52: 265–272. DOI: https://doi.org/10.1016/0038-092X(94)90493-6.

Umanand, L. and Prasanna, J. R. 2011. Modeling and design of a solar thermal system for hybrid cooking application. *Applied Energy* 88: 1740-1755. DOI: https://doi.org/10.1016/j.apenergy.2010.11.042.

Yuksel, N., Arabacigil, B., and Avcl, A. 2012. The thermal analysis of paraffin wax in a boxtype solar cooker. *J. Renewable Sustainable Energy* 4: 063126. DOI: https://doi.org/10.1063/1.4768547.