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REVIEW OF PHASE-CHANGE MATERIALS AND THEIR APPLICATIONS IN SOLAR COOKERS AS ENERGY STORAGE MEDIUM

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Abstract

Solar thermal energy is used in a wide range of applications. Cooking, water heating, space heating, power generation, and agriculture drying are all applications of solar thermal energy. This article addresses the theory and classification of solar cookers, as well as the factors that affect their efficiency and an energy study of solar cookers.Cooking in solar devices in the evening or during off-Sunshine hours is possible by using auxiliary power or different phase shift materials in solar cookers. This research involves the proper selection of phase change material that will be appropriate for cooking.This shows that a phase change material can be used as a storage medium in solar cookers. The sun generates huge quantities of renewable solar energy that can be transformed into heat and electricity; a solar cooker needed only solar energy, which was a free fuel from the sky, to operate, with the idea of using this free fuel from the sun in mind.Because of the advantages of high energy storage density and isothermal charging and discharging methods, latent heat thermal energy storage is an especially appealing technique among all thermal energy storage systems. Solar cookers with solar thermal energy storage can cook food even when the sun isn't shining, extending their usefulness.Solar ray intensity is unpredictably variable, particularly during the rainy and winter seasons. The collected energy is transferred and poorly processed, decreasing the device's overall performance. As a result of the lack of heat storage, the time needed to cook the food increases. Solar energy should be used as a source of energy because it is sustainable and has no harmful effects on the atmosphere or human health. Due to their high energy storage capacity, PCM are a promising candidate for consideration as heat storage media. A small-sized pcm storage device may be used as a source of the same.Providing a significant amount of heat to an object quickly. As a result, PCM is a decent way to store solar energy during the day and use it for cooking in the evenings or when the sun isn't shining.

Keywords:PCM; Solar Energy; Renewable Energy; Energy Storage.

Introduction

The sun generates huge quantities of green solar energy that can be turned into heat and electricity; a solar cooker needed only solar energy, which was a free fuel from the atmosphere, to operate, with the idea of using this free fuel from the sun in mind.Solar cookers with solar thermal energy storage can cook food even though the sun isn't shining, extending their utility. Sensible heat thermal energy storage and latent heat thermal energy storage are two feasible solutions for storing thermal energy for solar cookers.Solar ray intensity is unpredictably variable, particularly during the rainy and winter seasons. The collected energy is transported and improperly processed, limiting the device's total performance. As a result of the lack of heat storage, the time needed to cook the food increases.Solar energy should be used as a source of thermal energy for cooking because it is clean and has no harmful impacts on the atmosphere or human health. Because of their high storage density and steady operating temperature, phase shift materials for storing heat in the form of latent heat have been identified as one of the areas to provide a lightweight and effective storage device. A small-sized pcm storage device may be used to quickly supply a huge amount of heat to an item. As a result, pcm is a good choice for storing solar energy during the day and can be used for cooking in the evening or when the sun is not shining. Solar thermal energy is used for a variety of purposes. Solar thermal energy can be used for frying, heating, and cooling. In solar cookers, auxiliary power can be used or various phase shift materials can be used. This research involves the proper selection of phase change material that would be appropriate for cooking. This shows that a phase shift material can be used as a storage medium in solar cookers.

Literature Review

LameckNkhonjeraa, Tunde Bello-Ochende, Geoffrey John, and Cecil K. King'ondu investigated how the thermal diffusivity of the storage medium and design parameters such as cooker category and cooking vessel layout in relation to the storage medium affect cooking capacity.unit, as well as improved heat flow in the storage medium and from the solar collector to the storage medium. The findings suggest that the upper cycle temperature has a significant impact on the amount of melting and freezing cycles that can be achieved, as well as the degree of subcooling, rate of change of degree of subcooling, phase change enthalpy, and temperature. ThirugnanasambandamSivasankar, Sunil Geddam, G. Kumaravel Dinesh (2015) With the highest cooker load, the efficiency of box-type solar cookers was achieved. Using PCM (paraffin) as a tool to improve the thermal energy storage ability of the box style solar cooker proved to be very useful for energy conservation. With the aid of PCM medium, food cooked in a solar cooker can be kept hot for 3–4 hours. V.P. Sethi, D.S. Pal, K. Sumathy(2014) stated that an optically inclined box type solar cooker with single reflector is presented along with the design and development of a novel parallele piped shaped cooking vessel design for efficient cooking.Using

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1-D finite variations, the ensemble is thermally simulated. For the internal action of the utensil exposed to external radiation, a lumped elements model with convective heat transfer correlations is used. The utensil prototype here suggested can be used to prepare the three meals for a family on both sunny summer and winter days.A wiper-type system has been developed and addressed with a new constructed cooking vessel to extract vapour droplets from the bottom of glazing during the cooking process. The findings also show that the impact of jar content thickness on the melt fraction is negligible, according to C.R. Chena, AtulSharmaa, S.K. Tyagib, and D. Buddhi (2008).

Material with a Phase Transition

Thanks to their high energy storage capacity, PCM are heat storage media. PCM is a feasible choice for storing solar energy during daytime hours and can be used. And below are summaries from different writers.

No	Author	PCM material	Latent heat of fusion(KJ/Kg)	M.P. (º C)	Type of collector	PCM temperature achieved (º C)
1	Atul Sharma	Stearic acid	161	55	Box	80
2	Buddhi And Sahoo	Acetanilide	222	118.9	Box	130
3	S.D. Sharma	Erythritol	339.8	118	Evacuated	140
4	A.Lecuona	Paraffin	140	100	Parabolic	164
5	R.M. Muthusivagami	Acetanilide	222	118.9 P	Parabolic	186.3
6	YelizKonuklu	xonotlite	144.7	76.3P	Box	92
7	OrkunErsoy	erythritol	234	111P	Evacuated	76
8	S.K. Tyagib	hexahydrate,	234	128	Parabolic	67
9	S.P. Pandey	magnesium nitrate	187	59	Parabolic	89

for cooking when the sun isn't shining, the chemical bonds within the PCM break up as the source temperature increases, and the substance transforms from solid to liquid. Liquid to solid, solid to liquid, solid to gas, and liquid to gas phase transitions will all be used to store latent heat. PCMs, on the other hand, will only go from solid to liquid or liquid to solid. Although the heat transformation (processing) of liquid to gas transitions is higher than that of solid to liquid transitions, liquid to gas phase exchanges is inefficient for thermal large storage because golden volumes of high press are needed to blind the materials in their gas phase. Solid-solid phase exchanges are usually sluggish and gaunt has a poor heat transformation rate (processing). The method of changing phases the most effective means of storing thermal energy is latent heat storage. Unlike sensible heat storage, latent heat storage has a much larger storage capacity and a smaller temperature differential between retaining and releasing heat. Any object absorbs heat during a heating process when the temperature is continuously increasing.a reverse cooling process, the heat stored in the material is released into the atmosphere, and the temperature of the material continues to drop. The temperature of PCM and the surrounding area remains approximately constant during the entire melting period. As the temperature rises, PCM absorbs heat and stores it in the liquefied phase shift material; when the temperature drops, PCM re-evaporates.

Application with PCM Technology

There is a lot of concern in energy conservation and the use of alternative energy sources. PCMs are an underutilized option for designing new energy storage devices that reduce greenhouse gas emissions.They work at constant temperature; as heat is applied to the material, the temperature stays constant, but the heat causes the material to transition to a higher energy process. A PCM stores heat as latent heat of fusion, which is approximately 100 times greater than sensible heat.PCMs that melt at a wide variety of temperatures contain hydrated salts, paraffin waxes, fatty acids, and eutectics of organic and non-organic compounds. The configuration of a thermal storage device is determined by the PCM's unique melting point. Applications of PCM of solar energy are covered in this module. as well as buildings and cars, were examined. Since the 1960s, solar heaters have been widespread, and PCMs have been used to store the sun's precious energy since the 1980s. They've been used extensively in solar cookers, especially in third-world countries, to reduce the cost of heating.Since the cookers do not use gasoline, they help to minimize emissions in the air. PCM may be used to regulate temperature by reducing heat loss or gain by building walls. They've been used in buildings to absorb solar heat and reduce temperature variations.Furthermore, since only a small amount of PCM is needed to store solar energy, thermal comfort can be accomplished without adding significantly to the weight of the building materials. PCMs are increasingly being used in transportation. Refrigeration units currently control refrigerated vehicles, but the use of PCMs is a feasible choice for preventing food denaturation during transport.Furthermore, PCM allows Li-ion batteries with high energy density to be used in high-power applications. With the support of PCMs, the produced energy during discharge or drive mode can be transferred from the battery's body to the atmosphere. With good thermal control, battery packs can be held at an ideal temperature.PCMs is yet to become a

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commonly used technology for renewable energy in a number of fields (e.g. solar cookers, homes, and vehicles). Many customers are ignorant of the advantages of PCMs; as a result, users should be told about PCM applications and benefits. The sun is still out there, freely transferring its resources, so we need to do something to control it.

Working of PCMs

The cooking jar is mounted at the focal point of a focusing mirror in concentrating solar cookers. Solar cookers that operate on one or two axes monitoring and have a concentration ratio of up to 50 and a temperature of up to 300o C are ideal for cooking.To achieve high temperatures, concentrating cookers use lenses called parabolic concentrators. They are common with concentrating cookers since the focus is far smoother and sharper than those of other types of reflectors. At the same time, the plant is very sensitive to even minor changes in the sun's location.As a consequence, using such reflectors necessitates continuous monitoring. This is the most efficient method of capturing solar radiation. Parabolic cookers cook at a higher temperature and faster than solar box cookers, but they are more difficult to produce and use. Collector of Parabolas Parabolic collectors are a type of solar thermal collector that is curved and has a parabola, as well as being lined with polis.The energy of sunlight that reaches the mirror parallel to its glides of symmetry is centered around the focal length, which is where heated objects are placed. When the trough is aimed so that the sun is in its plane, food will be put at the focal length, allowing the food to be fried.Because of the parabola's structure, incoming light rays that are parallel to the dish's axis will be mirrored into the focus, regardless of where they arrive on the dish. The dish is oriented with its axis pointed at the sun, causing almost all incoming radiation to be mirrored towards the focal point of the dish. Light from the sun arrives at the Earth's surface almost absolutely parallel, and the dish is aligned with its axis pointing at the sun, allowing almost all incoming radiation to be reflected towards the focal point of the dish.The majority of errors in these collectors are caused by flaws in the parabolic form and poor reflection. The losses caused by atmospheric scattering are usually minor. On a hazy or foggy day, though, light is diffused in both directions from the atmosphere, reducing the effectiveness of a parabolic dish substantially.Appropriate suggestions are taken in order to improve the present efficiency of solar cookers, and the technology's future potential is assessed. The resulting solar cooker power curve was found to be a valuable tool for assessing a solar cooker's capability and heat storage efficiency. Intensive efforts have been made, especially in recent years, to improve the cooking capability.Many scholars have performed various theoretical, computational, and experimental studies on novel solar cooker designs. Solar cooking technology is currently very promising in terms of its ability to bridge the divide between green and traditional energy sources. The most effective method of storing thermal energy is heat storage.Unlike sensible heat storage, latent heat storage has a much larger storage capacity and a smaller temperature differential between retaining and releasing heat. Any object absorbs heat during a heating process when the temperature is continuously increasing.Via a reverse cooling process, the heat stored in the material is released into the atmosphere, and the temperature of the material continues to drop. The temperature of PCM and the surrounding area remains approximately constant during the entire melting period. PCM absorbs heat as the temperature rises.Equipment for Cooking vessels are solar cooker components that come into contact with the absorber plate in an indirect manner. Both are involved in receiving and transferring the consumed usable energy to the food. Cooking pots in various shapes may be used, but rectangular and cylindrical shaped cooking utensils made of aluminum or copper are preferred.Aside from that, with the available thermal energy storage technologies for solar cookers, food can be cooked in the late evening, which was previously impossible with a basic solar cooker. Any component of a solar cooker is critical and has a direct impact on the solar cooker's success in every environment.Any substance may exist in one of three states: solid, liquid, or gas. The latent heat of a substance causes it to change state.Kuznik et al. have given a comprehensive description of how PCM stores and releases latent heat. The external heat applied to a PCM is used to break the lattice's internal bonds, absorbing a large volume of latent heat at phase temperature. When the PCM cools out, the temperature drops. To pass the energy barrier, phase shift temperature (also known as sub-cooling or under-cooling) is used.As phase reversal occurs, the temperature of P.C.M. increases (due to phase reversal).At phase shift temperature, the release of latent heat occurs, followed by phase reversal. Returning the residual heat to the atmosphere Sub-cooling or under-cooling is required for phase reversal.P.C.M. has an essential property that governs its applicability in specific applications.P.C.M.'s latent heat is several orders of magnitude greater than the real heat of materials. As a consequence, in a temperature interval of 20oC, P.C.M. will share 2-3 times more heat or cold per volume or mass than can be contained as sensible heat in water. Since heat exchange occurs within a small temperature range,Temperature smoothing can also be achieved using this phenomenon.

Solution to General Problem Related with PCMs

Various disadvantages associated with various types of PCM necessitate certain preventative steps. Bauer and Wirtz, Mehling et al., Py et al.,Stark, and Morcos, among others, have made significant contributions to this sector. Each of the following methods can be used to solve the issue of incongruent melting: A few of these methods are discussed below:

(i) mechanical stirring,
(ii) encapsulating the PCM to minimize isolation, and
(iii) applying thickening agents to keep the solid salts from settling by keeping it in place.
(iv)by using an unnecessary volume of water to ensure the melting crystals do not create a supersaturated solution

(iv) by altering the system's chemical composition and creating incompatible materials

General Electric scientists are working to solve the issue of phase segregation andsuper cooling of salt hydrates. A rolling cylinder heat storage system was proposed by the Electric Company of New York. The device is made up of a cylinder. Two sets of rollers are placed horizontally on the vessel. A 3-rpm rotation rate was adequate for motionof the substantial content.

(i) to achieve successful chemical equilibrium,
(ii) to avoid solid crystal nucleation on the walls, and
(iii) to assume fast axial equilibrium in long cylinders.

Since a single PCM cannot have all of the desired properties, such as thermo physical, chemical, and kinetics, while still being cost-effective, a suitable device must be built to compensate for the aforementioned inadequacy. Metallic fins, for example, can be used to compensate for low thermal efficiency.Super cooling can be prevented by using a nucleating agent or a ‘cold' substance to increase the conductivity of PCMs.Inorganic materials, on average, have almost twice the volumetric latent heat storage capacity (250–400).Chemical molecules (128–200 kg/dm3) have a lower density (128–200 kg/dm3). Because of their vastly different thermal and chemical properties. The action of each subgroup, as well as the properties of each subgroup, have an effect on the nature of latent heat thermal energy storage.

Conclusion

According to the findings, there are a variety of choices for meeting end-user demands using both industrial and non-commercial energies. The use of traditional fuels such as wood pellets, dung cakes, and kerosene must be reduced with the established solar cooker.Human drudgery will be minimized as a result of this. Such an initiative would be beneficial not only to people's quality of living but also to the world. This paper reflects on the advantages of solar energy, such as the fact that it is a free supply of energy from the atmosphere, that it is environmentally sustainable, and that it is readily accessible in almost every area.Low or no operating costs, decent savings, monthly utility bill minimization, accident-free, less attention needed, and so on. Aside from that, with the available thermal energy storage technologies for solar cookers, food can be cooked in the late evening, which was previously impossible with a basic solar cooker.Any component of a solar cooker is critical and has a direct impact on the solar cooker's success in every environment. Many PCMs are being tested for solar cooking, but Acetanilide is the most widely used due to its ease of availability and cost-effectiveness. It is more suitable for use in solar collectors of the parabolic form.

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