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Comparative Thermal Analysis and Characteristic Optimization of Cram Bed Regenerator for Space Warmth Applications in Mountainous Areas

By

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Abstract

Sunlight is only present for a little time. As a result, a storage device is frequently needed to harness solar energy throughout the day so that it can be utilized in a variety of ways at night. The thermal insolation energy can be stored in a variety of ways depending on how it will be used. Space heating is a basic requirement of people who live in hilly areas during the winter. In certain areaswinter nights are too chilly for people to feel comfortable. This problem may be resolved by a mechanism for heat absorption that uses a photovoltaic solar air preheater and a daytime energy accumulation mechanism using [PEC]and provide comfort at night. For space heating, parameters relating to both replenishing and disposing of charge in[PEC]s must be adjusted. For a room heating application in Uttarakhand's hilly regions, the currently ongoing study investigates the enhancement of numerous key parameters of a mechanism for heat absorption, including [PEC] size, rocks dimension, the flow rate of air during charge accumulation in[PEC] , cycle time during [PEC] charging, and the desirable comfort inside a closed volume. There are four occupants and a 64 m3 volume in the room.For the purpose of researching the charge replenishing and disposingattributes of [PEC]s, a MATLAB computer algorithm has been developed. The algorithm is verified with earlier study data. The outcomes reflect that a [PEC] with a better design might offer soothing overnight warmth.

Keywords: Heat Bed Regenerator, Nylon, Clay (saturated), Rocks Particle Diameter, Mass Flow Rate, MATLAB, [PEC]i.e. [PEC].

I.Introduction

Solar insolation energy will always be necessary. Numerous photovoltaic usages currently exist, indicating its viability and sustainability. Solar energy can be utilized and stored in a variety of ways, including mechanical, electrical, and thermal energy. The simplest way to use solarphotovoltaic energy is to transform it into thermal energy. The energy content obtained, and the amount required by the load are out of balance due to sporadic and unpredictable nature of solar radiation. As an outcome, it became a necessity to include an accumulation system in between. The accumulation unit either retains received surplus energy of what is needed for the application or releases it if inadequate.When the quantity of photovoltaicenergy collected is nil or the sun is not visible at night, solar energy cannot be used without a storage device. With an emphasis on thermal storage devices, solar thermal applications such as control volume heating and crop drying may be further investigated. Thermal insolation energy can be accumulated chemically, as latent heat, or as perceptible heat.

Chemical processes cause solar photovoltaicenergy to be accumulated in chemical storage devices. The unit'stemperature is increased by both sensible and latent heatcollectingtechniques however latent heat storage experiences a phase change as the temperature elevates while sensible heat collector does not. The sensible heat collection method was more economical than the other two storage methods. Sensible heat collection systems extract or store energy by warming or cooling a solid or liquidwithout changing its phase. Several substances, including water, oils, some inorganic semisolid salts, rocks, and refractories, can accumulate sensible heat. Compared to latent heat or thermochemical storage systems, sensible heat collection systems are simpler to construct. But they do have the disadvantage of being bigger. Storing energy in rocks is an efficient method to store sensible heat. It is constructed of rocks in a room with air ducts for intake and output that are heated by a solar preheater and function as a unit to supply energy for use at night. When the bed is being used, flow is maintained through it in two directions—downward for providing heat and upward for removing it. With average rock particle sizes ranging from 1 to 5 cm, 300 to 500 kilograms of rock are commonly used per square meter of collector surface for space heating. Numerous factors, including bed size, rock diameter, air flow rate, etc., have a considerable impact on the effectiveness of [PEC]as a whole and its applications. Rock-[PEC]is perfect for photovoltaic energy implementations due to a number of factors. The high heat transfer coefficient amidst the air and the solid, which is suitable for a storage unit, is a primary element that supports thermal stratification in a bed. In this scenario, a large amount of stratification is required because the storage unit doesn't reach a stable temperature right once. One advantage of using a [PEC] for storage is that it is relatively inexpensive when compared to other storage options. The [PEC] collection system does not suffer from the freezing and boiling problem that occurs with water storage systems.These advantages of the [PEC] collection unit necessitate a close investigation of the configuration and the growth of its many applications. In the winter, it seems that heating homes with a [PEC] collection unit is a great way to provide space heating, especially in mountainous areas where the daytime temperature is pleasant, but the nocturnal temperature drops below what is comfortable for people. For space heating, numerous variables relating to the replenishing and depleting of charge in[PEC] must be adjusted. Determine how much energy needs to be accumulated to maintain a suitable nocturnal temperature by calculating the heating load. A single, larger [PEC] can be sectioned into multiple beds, in accordance to the space available.Concerning space heating through the [PEC], there are a few technical ifs and buts that need to be clarified. There is a ton of knowledge available about using [PEC]s tremendous store heat. Numerous academics have carried out conceptual and investigational studies in this direction. 1929 Schumann: [1] Schumann's study was the first of many theoretical and practical investigations into the heat transmission into and through a flowing fluid to a [PEC]. He first noticed a liquid that was one consistent temperature and was flowing longitudinallyvia a suitable, porous prism. In 1930, Furnas most likely executed the initial experimental study on heat transmission from a fluid stream to a [PEC]. [2]. Colburn, 1931: [3] used granular materials, pebbles, porcelain balls, and zinc balls of varyingdimensions to perform experimental studies on heat flowamidst the air moving via tube filled with granular materials. Lof and Hawley, 1948: [4] found heat flowamidst air and discrete particles through investigation. The commanding equations for the [PEC] have been attempted to be solved using finite difference methods by Duffie and Beckman, 1974 [5], Klein, 1975 [6], and Mumma and Marvin, 1976 [7]. Hughes et al. (1976) [8] pointed out that determining temperature distribution in [PEC]can take up a considerable amount of the simulation's processing time.Sowell and Curry, 1980: [9] established a precise and effective model relying on convolution theoremwhose differentials are eliminated from the simulation equation to replace the finite difference methodology. Chandra and Willits (1981) [10] found that airflow rate, bed porosity, and rock size all affected the pressure drop. The only variables impacting the coefficient of heat transfer were rock dimension and rate of flow. The initial [PEC] temperature and the entering air temperature had the same heat transmission coefficient. In a solar system, Courtier and Farber, 1982: [11] used [PEC]s and rocks to store heat.They came to the conclusion that a standard and dependable technique was required when building [PEC], especially to find out the most important conditions, like (i) rate of air flow per unit face area of bed, (ii) Rock equivalent dimension, (iii) Bed length and bed face area. Saez and McCoy provided an arithmetic model to simulate the dynamic output of [PEC] column into a random time-depending input air temperature in 1982 [12]. It contains traits like axial thermal dispersion and conduction within particles, which are often disregarded but can be vital in photovoltaic energy applications. In their 1985 publication [13], Maaliou and McCoy proposed a model to enhance the design features of [PEC]. The primary purpose of thismodel was to establish a process for determining an appropriate air velocity, column length and dimension, collecting time, and particle diameter to maximize overallmonetary production from [PEC]. Choudhary et al. ran a theoretical study in 1995 [14] to determine how to best construct and operate a [PEC] thermal energy collectioninstrument coupled with a two-pass single-cover solar preheater. In 1998, Fath conducted extensive research on the various energy collectionmethods and substances used for sensible heat collection systems [15]. Stratified rock storage of solarinsolation energy was studied using numerical models by Crandall and Thacher in 2004 [16]. Aldo Steinfeld et al. in 2011 developed and practically verified a heat transfer device for storage purpose comprised of [PEC] of pebbles where air is functioning as the heat transmission fluid: [17]. To evaluate the chargereplenishing and depleting properties, a constrained analysis of [PEC] dimension, fluid flow rate, particle dimension, and solid phase material was conducted. Jacques Couturier and associates, 1982: [18] A general technique is used to resolve the differential equations characterizing the heat transmission mechanism in a rock substrate. Create a numerical model that takes the conduction effect and secondary phenomena, such as heat losses, into account.Mahmud S. Audi from 1992: [19] The development and testing of a tiny solar preheating device for room heating uses four different varietiesof natural Jordanian rocks as energycollection medium. The efficiency of collector equation, which establishes the system design constraints, is used for calculating the heat capacities of rocks in storage space environment. This research is utilized to preheat a 220 m^2control volume in Amman area. DL Zhao and associates (2011): In this work, a solar preheating system was modelled using TRNSYS for a 3319 m^2 space, by combining an air heating device comprised of overlapping glass plate collectors with a [PEC] for energy storage, Lof et al., 1963 [21] constructed a home close to Denver employing these concepts. According to the system's performance, well-designed air systems can last for yearsrequiringa minimal preservatory maintenance. Since 1970, various [PEC]control volume heating systems have been researched. [PEC] storage and optimization for control volume heating is presently a popular research area.The use of geometrical structures influenced by artificial roughness [22, 25, 32, 34], different geometrical shapes over solar plates [22, 25, 32, 34], various designs of heat channels with no regards to fins/inserts [26, 27, 30], and the usage of fins in electronic devices for extending the life of devices [28, 36] are all highlighted in previous literature. Several studies concentrated on nanoscale material fluid [27], fluid such as air or water [22, 25, 26, 28, 32, 34] for transmitting heat, while others concentrated on space heating material for thermal storage [21, 29, 31, 33, 35, 37]. Few of them [24, 38, 39] concentrated on examining the effect of various bio-oils' performance and emission traits when employed as a source of electricity and power for engines.

I. Objective of Present Study

The following is the objective of the current work:

1. For derivation of appropriate hot air flow from solar preheater so that [PEC] heating may

occur at lower pumping costs and bed can fully charge during the day.
2. Calculating the heating load for a closed volume that will have a [PEC] heating while solar radiation isn't available. A typical mountainregion residential room is shared by four people and used for academic purposes.
3. To derive the flow rate and supplied air temperature for the comfort of the room at night.
4. Research on the characteristics of [PEC]s, such as their bulk, length, diameter, porosity, and porosity of [PEC].
5. Examine the charge replenishing and depleting characteristics of a [PEC] using MATLAB.

Material and Methedology

The most straightforward, least expensive, and non-polluting way for heating residential spaces is a sensible heat collection system or a [PEC]. Several [PEC] and space heating parameters need to be assessed and optimised while charging (during the day) and then utilised on the charged storage system to employ this technology (during the night). When solar isolation is possible, charging the [PEC] is done via using a solar preheater to warm the [PEC] all day long. The rock-based storage media receives heat energy from heated air that enters the [PEC] through the air heater. With the assistance of ambient cold air, the [PEC] is released. The ambient air heats up at night as it passes through the bed. This warm air warms the space.

A. [PEC]: Regenerator

"The finest storage choices for air-based photovoltaic heating devices are [PEC]. [PEC] storage is accomplished during solar insolation (during the day) by heating the rock with hot air using solar preheater, then using it as heat source during solar isolation (night). The [PEC] functions as regeneration unit during charge replenishing and depleting processes. In Fig.3.1, the [PEC] storage method is shown schematically. According to Coutier and Farber, a standard and dependable approach is required to build this storage unit, especially for determining the four crucial features given below (1982). that are:

- Air flow rate per unit of face area
- Rock equivalent dimensions
- Bed length
- Bed face area

B. Any application involves the evaluation of these four critical parameters, but those particularly involving space heating. The size of the volume to be heated and the internal temperature that must be constrained are the major points in choosing mentioned important criteria.

C. The elements of a [PEC]

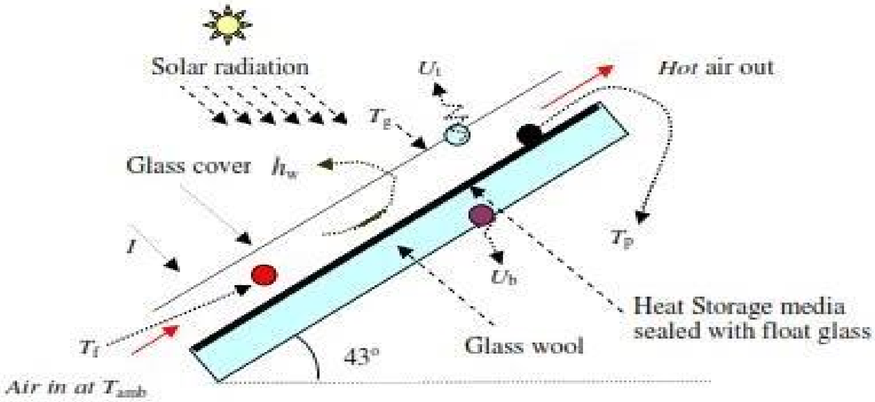
"The components of a [PEC] storage system are as follows: "

- Solar preheater
- [PEC]
- Rocks
- Flow circulation unit
- Ducts/Pipes

1. Solar preheater

a. The main energy source for the [PEC] storage system is solar preheater. A solar preheater absorbs thermal energy when sunlight strikes it, and if a cold fluid is then transported through it, the effect is an increase in the fluid's temperature at the exit. The [PEC] is charged using this heated fluid as a medium. Figure 3.2 depicts the heat transmission process of solarpre heater.

2. [PEC] chamber
3. “The motive of a [PEC] chamber is storing rock particles, and it must be well-insulated to reduce temperature losses during storage.
4. Rocks
5. [PEC] storage systems employ rocks to store thermal energy. There are numerousvarities of rocks that may store thermal energy. Table 3.1 displays some rocks and their characteristics
6. Ducts/Pipes
7. As they allow for air flow during the replenishing and depleting of the [PEC], ducts and pipes are a crucial component of the [PEC] storage system. To reduce thermal losses when moving heat from one location to another, the ducts and pipes should be well-insulated.



“

Figure3.2. *Heat transmission process in photovoltaic solar preheater*

Table 3.1. *Properties of different rocks or heat sensible materials*

S.No.	Rocks	Density kg/m^3	Specific heat J/kg-K	Thermal conductivity W/m-K
1	Stone, Marble	2600	800	2.07 – 2.94
2	Stone, Granite	2640	820	1.73 – 3.98
3	Stone, Limestone	2500	900	1.26 – 1.33
4	Stone, Sandstone	2200	710	1.83
5	Clay	2650	1381	0.15 - 1.8(dry) 0.6 - 2.25 (saturated)
6	Waste plastic and Hard rubber	940	1600	0.03 - 0.1
6	Nylon	1140	1670	0.2 - 0.25

- ***Flow circulation unit***

“When heating, charging, cooling, or removing air from a [PEC], forced air circulation equipment or fans are employed.

- ***Terminologies in Present Study***

“The following terms are employed in the current study:

- ***Porosity, ϵ***

Porosity is ratio of packed volume tototal volume , which is related to the packing of [PEC]. In mathematics, it is denoted by:

$$\epsilon = \frac{\textbf{Solid Volume in the [PEC]}}{\textbf{Total volume of the [PEC]}}$$

According to available literature, the porosity ranges from 0.38 to 0.41 for a [PEC] with solid spherical rocks. For analyzing the [PEC] in this study, an assumption of =0.4 is made.

- ***Specific area, as***

It is mathematically defined as:

$$a_s = \frac{6 * (1 - \epsilon)}{\mathbf{dp}}$$

- ***Bed length, Lb***

The term "length of bed" refers to room’s size. The bed’s length is a crucial factor in determining the pressure dip and heat storage capacity of the [PEC]. For the sake of this work, 1.6 m is assumed.

- ***Bed diameter, Db***

"Bed diameter" refers to chamber's diameter. In the current work, section 3.6.2 calculates Db.

- ***Cross sectional area of bed, Ac***

The bed's cross sectional area is determined as follows:”

$$\mathbf{A_c} = \frac{\pi * (\mathbf{D_b}^2)}{4}$$

- ***Rock properties***

The density (s) and specific heat (Cps) of the limestone rocks employed in this investigation are 2500 kg/m3 and 900 J/kg-K, respectively.

- ***Rock particle dimensions, dp***

The storage medium's rocks are spherical in shape. These particle diameters, 0.001 m, 0.02 m, 0.025 m, and 0.050 m were subjects of research.

- ***Heating space volume***

The heating space volume is measurement of the area that will get [PEC] heating. 4x4x4m3 spatial volumes are employed in this investigation.

- ***Charging air temperature***

The solar preheater’s air temperature is considered as the charging temperature while a [PEC] is being charged. In this analysis, there is an assumption that the air from solar preheater has a constant temperature of 40 0C while the charge replenishing period.

- ***Discharging air temperature***

The air entering the [PEC] is considered as air exiting the bed when a bed is used for heating a room. In this analysis, assumption is taken that throughout the whole discharge operation, air discharges the bed at a constant temperature of 10°C.

- ***Air properties whilecharge replenishing and depleting***

At any time during operation, the air's density (rg), dynamic viscosity (m), and specific heat (Cpg) are measured at the bulk mean temperature. The mean of air and solid temperatures at any given time is known as the bulk temperature, or Tb.

$$\mathbf{T_b = \frac{Tsolid + Tair}{2}}$$

The traitsofair near Tbis were derived from Yunus A. Cengel's Heat and Mass Transfer (2011).

- ***Mass velocity, G***

The mass flow rate per unit area of the [PEC] is called to as mass velocity.

- ***Volumetric heat transfer coefficient, hv***

The volumetric convective heat transfer coefficient expression proposed by Coutier and Farber [1982] is utilizedfor calculating the value and is as follows:

$$\mathbf{h_v = 700 * (\frac{G}{dp})^{0.76}}$$

With G in kg/m^2-s, dp in m, h_v in W/m^3-^{0}C

- ***Air velocity, v***

Calculating the air velocity in a [PEC]enlistedbelow:

$$\mathbf{v = \frac{G}{\rho_g * (1 - \epsilon)}}$$

- ***Charging time***

The period of time from when the [PEC] is in its coldest state, or 10°C, until it reaches hot airtemperature, or 40°C, is called the charge replenishing time of the [PEC].

- ***Discharging time***

Discharging time is timespan before the air released from the [PEC] reaches the same temperature as the supply.

- ***Overall building heat transfer coefficient, Uwall&Uroof***

Conduction and convection work together to create an overall heat transfer coefficient, often known as the overall building heat transfer coefficient.

- ***Supply air temperature***

Temperature of air that will be utilized for heating to make up for any heat losses from the heating room and keeping the space at a suitable temperature is supply temperature

- ***Cmm***

The term cmmstands for the amount of air flowing at a given pace in cubic meters per minute.

- ***Space heating load***

The space that the [PEC] will heat has the following loads:

- ***1-Ventilation load***

The magnitude of clean air that each individual needs to maintain comfort, health, and air quality. According to the book Refrigeration and Air conditioning by Arora, P.C. [2000], ventilation is needed at 0.56 cm per person. This value determines the load for the current work.

The hot air from bed is combined with this quantity of ventilation air during the discharge procedure.

- ***2-Sensible heat gain***

The current study makes the assumption that someone is inside the room working little, and it uses the norm of Arora, P.C. [2000] that the metabolism rate is 90 W/person. It is assumed that the load of the electric appliances is 200 W.

- ***3-Transmission load***

There will be transmission losses due to temperature gradient in the heated chamber and its surroundings. Convection and conduction losses from the study space's walls are taken into account. Standard figures for the material and thickness of walls and roofing, along with the overall heat transfer coefficient, are obtained from Arora, P.C. [2000].

- ***Occupancy***

It is anticipated that a family of four will be living in the space being evaluated for heating load.

- ***Methodology***

The procedures below are used to study and optimize a [PEC] parametrically for use in space heating:

- Adjusting the desired parameters and the input
- Calculate the heating load
- Create a computer program
- Run the program using various inputs
- Plotting the parameters of chargereplenishing and depleting
- Optimization criterion
- Choosing the most appropriate constraints: Optimization

Result and discussion

The arithmetic model used in this investigation is covered in the chapter before. In the current work, MATLAB software evaluates, solve, and validate this mathematical model. Any use of space heating must put the needs of people first. The night-time heating of a 444 m^3 room with 4 inhabitants is examined in the currently ongoing analysis. The heating for the chamber was provided via[PEC]. A solar preheater helped charge it during daytime, and it should release a steady stream of 40°C air while charging process. The heating requirement for the space was computed at night under the presumption that outside temperature would stay at 10°C. The current work also consists of a constrained study of the [PEC] in charge replenishing and depletingmodel, alongwith the determination of the [PEC] characteristics for charge replenishing and depletingwith various particle diameters, mass velocities during charge replenishing and depleting, and pressure drops during charge replenishing across the bed. There are typically 3 to 4 hours each day when sun radiation is present. With a minimum charge time of 4 hours and a maximum discharge period of more than 8 hours, control volume heating is used for optimisationof bed. Pumping power should be kept to a minimum for lowerexpense and power savings. The [PEC] charging that causes the smallest pressure loss over the bed is a further optimization requirement.

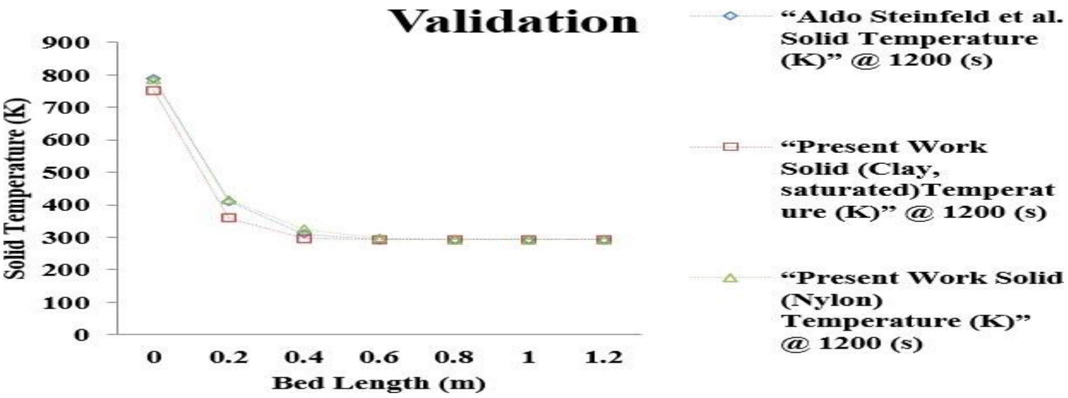


Figure 4.1. *Temperature variation at different column length of previous work and current work*

Currently, the space is heated using three [PEC]s that are 1.12 m in diameter and 1.6 m long. Additional parameters must be established for optimising the complete system. The diverse parts that follow provide details on the analysis of parameters and system optimization. The validation the present work has been done successfully. The validation of present work with past work is shown in Figure 4.1.

D. Effect of Temperature Gradient in Charging of [PEC] on Rock Particle Diameter

Figure 4.1 displays three varying temperature gradients while charging a [PEC] with various particle diameters while maintaining the same values for the bed's length, diameter, and mass velocity. In Aldo Steinfeld's earlier work [2011], similar tendencies of charging profiles with various particle diameters were found. Figure4.2 is therefore verified. Temperature gradient in the [PEC] rises as the rock particle diameter, dp, decreases. Smaller rock particles have larger surface area, which explains this. The surface area increases as the diameter decreases. When compared to a particle diameter with a larger diameter, the bed heats up uniformly and relatively quickly.

1-Charging Profiles of [PEC] (G=0.450 kg/m2-s)

With particle diameters of 0.001 m, 0.01 m, 0.02 m, 0.0250 m, and 0.050 m and a mass velocity of 0.450 kg/m^2-s, the temperature profiles of [PEC] during charging are shown in Figure4.3. The results make it evident that charging takes less time when the bed reaches its maximum temperature than when charging at 0.225 kg/m^2/s mass velocity.

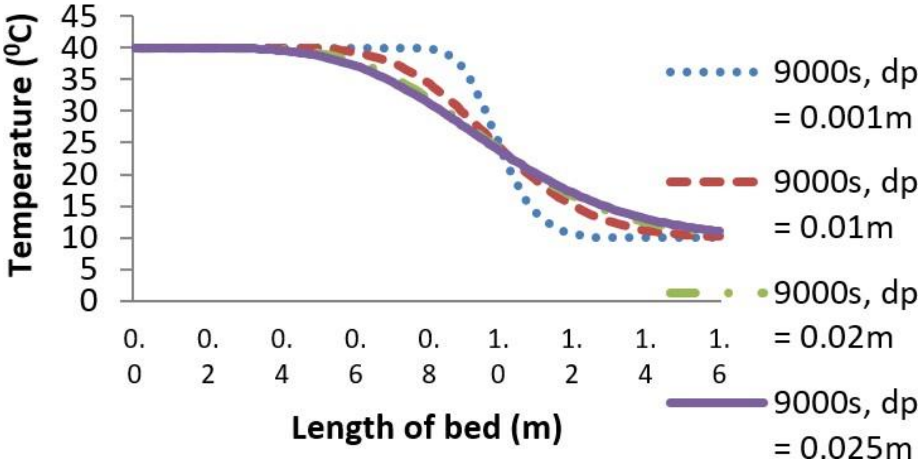


Figure4.2. *Variation in temperature profiles at 9000 seconds (2.5 hours) with different particle dimensions with G=0.225 kg/m^2-s, D_b=1.12 m, L=1.6 m*

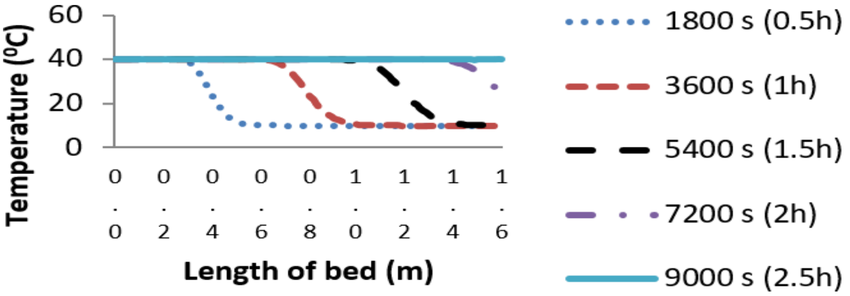


Figure4.3. *Temperature profile of charging [PEC] with 0.450 kg/m^2-s mass velocity, L=1.6 m, D_b=1.12 m, ϵ=0.40, dp=0.025 m*

2-Discharging Profiles of [PEC]

The temperature profiles of the particles being discharged at a mass velocity of 0.225 kg/m^2/s are shown in Figure4.4. Discharging time must be at its maximum for the area to remain warm throughout the night. [PEC] is thus discharged at a mass velocity that is half that of charging mass (0.225 kg/m^2-s). If the mass velocity of discharge is 0.450 kg/m^2/s, then either count of beds must be inflated, or be length must be increased.

E. Effect of Mass Velocity of Air in Charging of [PEC]

The effect of mass velocity on charging profile of the [PEC] is depicted in **Figure4.5.** Aldo Steinfeld's earlier writings [2011] show a similarity in charge profile and mass velocity. Figure4.5 is therefore verified by Aldo Stienfeld [2011]. As the mass velocity increases, the charge replenishing temperature profile of rock substrate becomes straighter. This is caused by an elevated particle heat transfer coefficient. This means that if bed is charged at a higher mass velocity, it will consume lesser time to saturate the [PEC] with charging air of a consistent temperature. If a charge replenishing time of 4 hours is assumed, then charge replenishing mass velocity of 0.450 kg/m^2-s is most acceptable for control volume heating in the current research. Maximum solar insolation is accessible between 11:00 AM and 3:00 PM.

F. Effect of Rock Particle Diameter on Pressure Dip across Bed in Charging of [PEC]

Pressure loss is used forcalculating pumping power. As the pressure decreases, the pump's power will rise. Figure4.6 shows the pressure drop over the bed during charge replenishing with particle diameters of 0.001 m, 0.01 m, 0.02 m, 0.025 m, and 0.050 m and a mass velocity of 0.450 kg/m^2-s. It should be noted that in the current study, the minimal particle dimension is ideal for control volume heating since pressure drop reduces with increasing particle diameter.

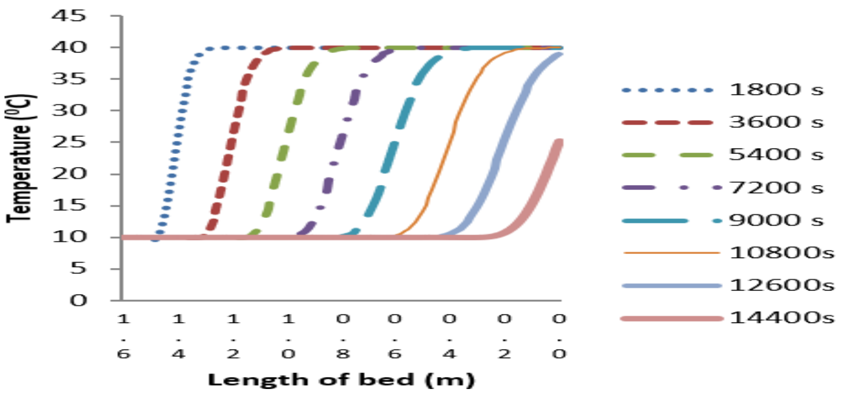


Figure4.4. *Temperature profiles of discharging air with G=0.225 kg/m^2-s, D_b=1.12 m, L=1.6 m, dp=0.001 m, ϵ =0.40*

G. *Parameters of [PEC]: Charging*

The charge charts discussed before can be distilled as illustrated in Table 4.2. The following criteria are for parameter optimization:

1. charge replenishing of [PEC] in 14400s (4h)
2. Lowest pressure drop.

H. *Parameters of [PEC]: charge depletion*

Table 4.3 provides a summary of the discharging graphs. Similar criteria are used for charging along with discharging parameter optimization.

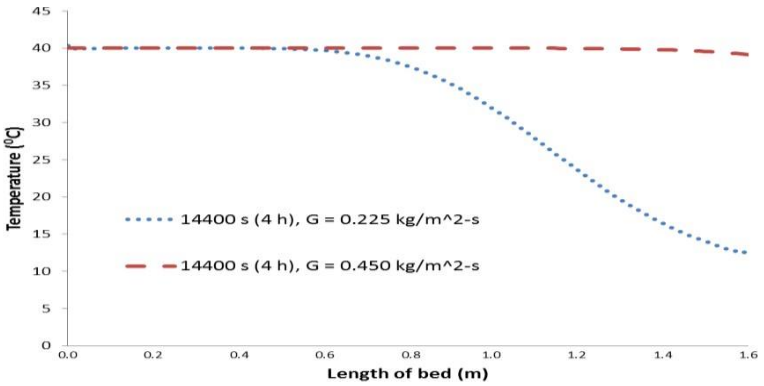


Figure4.5. *Temperature profile of [PEC]charge replenishing at different mass velocities (G) at 14400 s (4 hours) with dp=0.025 m, D_b=1.12 m, L=1.6 m*

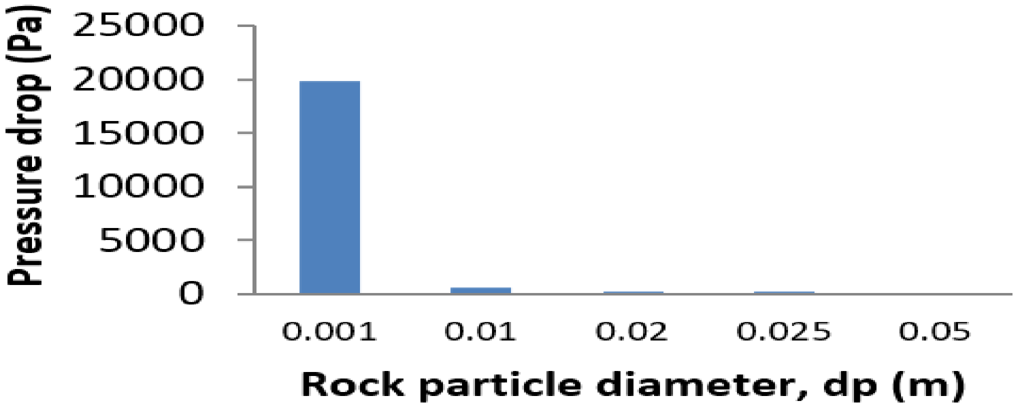


Figure4.6. *Pressure dip across bed with various particle dimensions, G=0.450 kg/m^2-s*

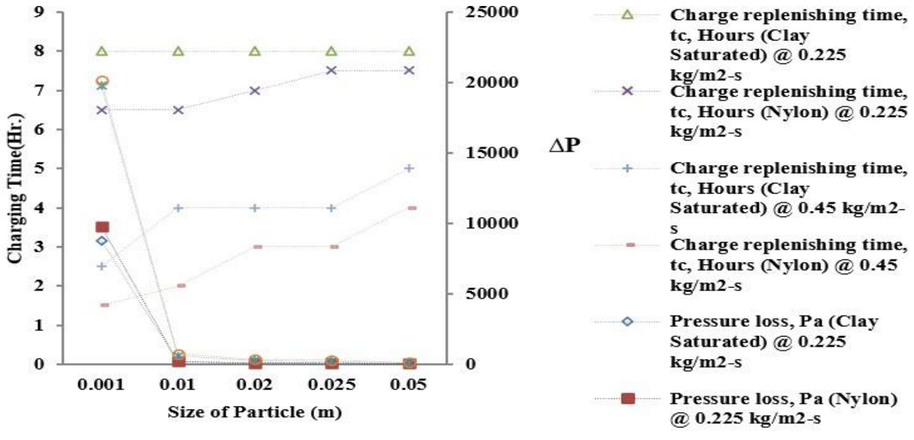


Figure 4.7. *Pressure Variation with respect to Particle Size during charging*

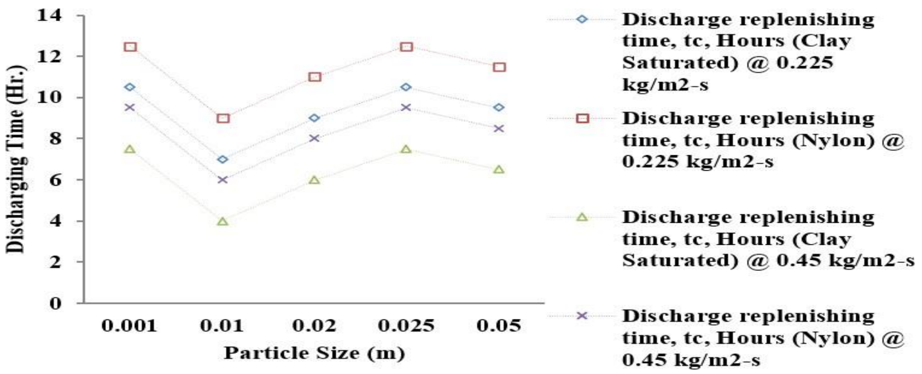


Figure 4.8. *Time Variation with respect to Particle Size during discharging*

I. Optimization

Figure 4.9 depicts the pressure decrease over the bed and how long it takes for the bed to charge. The position where the mass velocity is 0.450 kg/m2/s and the particle dimension is 0.025 m in abscissa axis is the only one where both of the aforementioned optimization conditions are satisfied, as shown by this Figure. It is shown as a transverse line in this figure.

1- Optimized Bed Parameters

The following are the optimal conditions in the current work for air when the bed is charged at 400C (constant) and discharged at 100C (constant):

- Length of bed = 1.6 m
- Dimension of bed = 1.12 m
- Bed count = 3
- Mass velocity of hot air = 0.450 kg/m^2-s (Charge replenishing)
- Mass velocity of cold air = 0.225 kg/m^2-s (Charge depletion)
- Particle diameter = 0.025 m

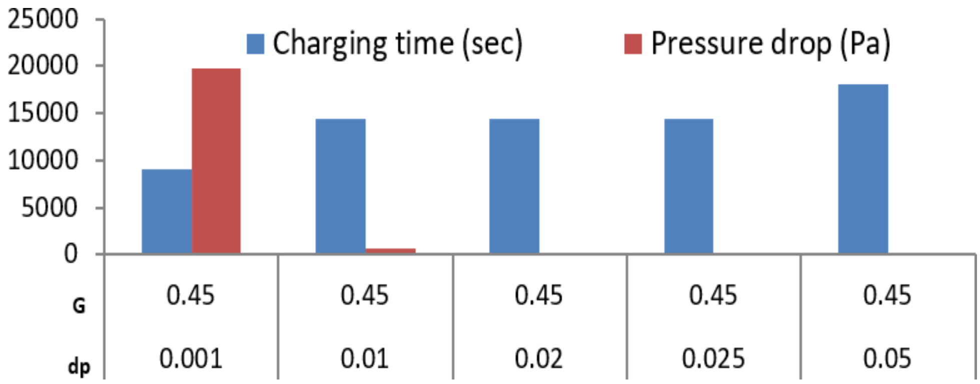


Figure4.9. *Optimization of particle dimension and mass velocity*

Conclusion

A parametric analysis of [PEC] was done to determine the best bed parameters for heating a 4x4x4 m^3 room. The results depict that the study improved bed characteristics can be utilized to heat a room in winter with the minimal energy content while keeping it at a temperature where people can sleep comfortably. It is assumed in the current study that the air temperature will not change as the bed is charged and discharged. This is untrue since solar radiation and charging air fluctuate while charging takes place. Atmospheric temperature will also vary as night falls. These temperature changes will be taken into account in the study's future scope. The following cargoes are depicted in alphabetical order: The ventilation load comes to be 506.58 W, the transmission load comes to be 2838.8 W, internal heat increment is 560 W, and the net heating load is 2.785 kW. Supplied air temperature is 0.1437 kg/s. Temperature profiles during bed charge replenishing and depleting with various particle sizes, such as 0.001 m, 0.01 m, 0.02 m, 0.025 m, and 0.050 m, are charted using these numbers. These figures depend upon the previously indicated variables of mass velocity (G), bed length (L), and bed diameter (Db). For charge replenishing and depleting, the ideal flow rate is 0.225 kg/m^2/s, while the ideal particle dimension is 0.025 m. Nylon have good thermal properties and it is good in quick thermal absorption and slow thermal libration as compared with clay (saturated).

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