ARTICLE IN PRESS

Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Computational analysis and evaluation of thermal comfort environment of a space by reducing the inside air temperature

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ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Energy
Thermal comfort
Computational fluid dynamics
Heat transfer

ABSTRACT

The tents are used as temporary shelters and evenly they sometimes become a home for a number of years when the returns to permanent shelter is very slow or unaffordable for any person so that the comfort of these shelters are very much essential like home. This paper is primarily concerned with identifying the objectives of reducing the inside air temperature of shelter using different *retro*-reflective materials. In the present work computational fluid dynamics analysis have been performed for a shelter under the summer climatic conditions to reduce the inside air temperature of shelter using different *retro*-reflective materials like polyvinyl chloride, wood-fibre, polystyrene, aerogel and phenolic foam. For CFD analysis free stream temperature of air is set 311 K taken with constant heat flux of 900 W/m^2 solar radiations is used on roof, second order upwind discretization scheme is used to approximate the solution for momentum and pressure. Result show that that minimum temperature variation of 4.8 degreesK by using *retro*-reflective material as phenolic-foam and 18.74 % temperature percentage variation compared with other reflective materials.

Selection and peer-review under responsibility of the scientific committee of the 2nd International Conference on Recent Advances in Modelling and Simulations Techniques in Engineering and Science.

1. Introduction

Energy that can be generated from renewable sources is often referred to as clean energy because it is derived from naturally replenishable sources. There is nothing that is consistent in nature, like sunshine and wind, even if their availability varies according to the weather and time of the year. As the term implies, solar energy is the emission of energy from the Sun that can be used to create heat or chemical reactions, as well as electricity. In the current and future, there will be an enormous surplus of solar energy incident on earth compared to the world's current energy needs and those anticipated in the future. With the right means, this highly diffused source of energy can be harnessed to provide a type of energy which can eventually fulfil all future needs. A solar air heater is a procedure for heating air that uses energy from the sun in the form of insolation that has been captured by a material that absorbs the sunlight for use in heating the air. As the name suggests, solar air heating can be used to heat or condition air in buildings, or in applications where heat is needed for process purposes. In addition to being often the most efficient of all the solar technologies, such as in commercial and industrial applications, solar thermal systems are the most cost-effective of all the solar tech-

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https://doi.org/10.1016/j.matpr.2023.01.216
2214-7853/
Selection and peer-review under responsibility of the scientific committee of the 2nd International Conference on Recent Advances in Modelling and Simulations Techniques in Engineering and Science.

Please cite this article as: R. Raushan Kumar, S. Sharma, R. Saxena et al., Computational analysis and evaluation of thermal comfort environment of a space by reducing the inside air temperature, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2023.01.216

nologies because they tend to provide the highest level of energy extraction from the sun, particularly in regions with a cold climate, where the biggest use of energy is found in space heating and industrial process heating [1–37].

The tent is one of the most practical shelters for living outside. This shelter has a light weight and is easy to set up and dismantle, as well as being able to be carried long distances. Tents are available in a variety of sizes and shapes. Tents, despite their light weight, the fact that they can be quickly set up on most surfaces, the fact that they dismantle easily, and the fact that they are easy to transport, make them ideal for people in emergency situations when they have to frequently transform their workplaces and relocate their homes because of natural disasters or when they have to move temporarily. Hundreds of people can be accommodated in extremely large circus types. Small camping tents are usually only able to accommodate a few people. Even smaller ones only house one person. Nomadic peoples, or those who have no fixed domicile and roam from location to location, have also used tents as movable homes. These have included everything from Assyrian civilizations to 20th-century Bedouins. Tents present in the modern world can be classified into three basic designs based on their function. The letter "A" is shaped like the wedge tent. Pyramid tents are characterized by the bottom of them being wide and the top becoming narrower as they go up. There is no flap around the front of the baker tent, and it may or may not be closed so that the front of the tent is open. Several other shapes have developed from such three concepts. There were several tents there among them, including a campfire tent, a wall tent, a miner's tent, and an explorer's tent. One of the most popular tents is the miner's tent. It can be built with poles or by tying a rope to the top and throwing it over a tree limb, then securing it after the top has been raised. Tents conduct heat through a complex process of convection, thermal conductivity and radiation, which all combine to produce the transfer of heat. The tent envelope surface consists of a number of fundamental processes which take place, such as heat absorption, heat reflection, heat release, heat conduction, as well as the tent itself being able to reverberate as a result of both processes. The wall tent is similar to a wedge tent, but the lower portions of both sides form vertical slats. Further space for cots or storage is available with these types of walls. Solar-heated tents are a lifesaver when you are living at high altitudes and the electricity infrastructure has not yet been developed. In this case, the tent would be portable, and it would be heated by solar energy, which is a renewable energy source. Canvas or nylon are commonly used in modern tents. The majority of them have sewn-on entrance flaps. Many have carpeted floors and mosquito-netting-covered windows. Poles and ropes shape and hold tents in place. The ropes are usually tethered to neighbouring metal or wooden pegs. Depending on the tent style, poles are positioned indoor or outdoor. A vertical pole is positioned within the umbrella tent. This pole is topped with a number of shorter poles. The tent's roof is supported by these. Nylon as well as polyester are the most common materials used in modern camping tents. Cotton or canvas tents are still available, but due to their heavy weight, they are far less prevalent. Aluminium and fibreglass are the most common materials for tent poles. So, every sort of material has benefits and drawbacks, and they are best suitable for different types of camping. Furthermore, even if tents are made of the same material, their quality can vary greatly. The coating, seams, and material density all have an effect on how long lasting and water resistant the tent is. The difference between man-made synthetic fibres and cotton or canvas is significant. Because polyester and nylon are both synthetic fibres, they have a lot in common [38–40].

Bergkamp, Impa [41] discussed heat stress after flowering reduces grain-filling time and limits resource allocation to grains, resulting in reduced wheat productivity. Wheat grown in Kansas and the United States' Great Plains is frequently subjected to temperatures of 30 degrees Celsius throughout grain filling, resulting in lower productivity. In this study, seven different variants of Kansas were phenotype to determine how well they tolerated heat, which included a controlled chamber research and two experimental studies. Plants grown at 25 degreesC were transmitted to high day temperature (35 degreesC) chambers 10 days after first sign of anthesis to enforce heat stress in the managed chambers. Custom-built "heat tents" were positioned over through the plots ten days after 50 percent flower initiation and stayed in place until competence in field conditions. Heat stressed plants showed early senescence, implying a shortened grain filling period than control plants. Under extreme heat, early maturing variants had a higher percent reduced grain yield. Heat stress after flowering reduced 1000 kernel weight, grain quantity, harvest index, and grain yield significantly compared to the control. Under severe heat stress exposure in controlled situations, yield reductions ranged from 6 to 51 percent, while heat cause stress employing field-based tents resulted in yield reductions of 2–27 percent. SY was one of the variations that was put to the test. Both Monument and Larry performed admirably in whatever scenario, indicating that they have been probably more suited to locations that experience consistent heat stress during the post flowering stage. To incorporate larger heat stress resilience into continuing wheat breeding programmes, our results emphasize the requirement to discover wider genetic variation, along with wild wheat. Bhatt [42] explained Delhi is a city with many possibilities, but it also has many disparities. Groups like the homeless, who are almost dehumanised and reside in subhuman conditions, inhabit the most marginal contours of urban inequity. As the problem of urban homelessness worsens, the most disturbing example of this issue is its manifestation in the daily lives of the homeless, as well as the lack of attention it has received from both the state and civil society for a long time. This scientific report evaluates the temporary housing set up for the first time in Delhi in the winter of 2010–11 under the auspices of the Delhi government's Mission Convergence in collaboration with NGOs. The study demonstrates how, despite their gross inadequacy, temporary shelters serve as a source of success for the desperately poor and homeless who would otherwise be forced to live in complete poverty. We talk about how the welfare state has deteriorated, as well as the homeless' ability to expect or claim any assistance. Finally, it consider the various options for responding to the situation calmly. Castellani [43] discussed about RRMs reflect incoming radiation back in the direction it came from. The refrigerating potential of *retro*-reflective (RR) coloured plasters is calculated using a data analysis modelling approach in MATLAB R2019b at various latitudes, longitudes, and canyon directions in 8 various physical regions. At low latitudes, narrow canyons with an East-facing façade produce better results. Those certain months, especially for narrow canyons, have noticeable positive effects. RR use is recommended at middle latitudes, particularly for limited canyons. During the warmer months at high latitudes, the impact of RRMs is greater for narrow canyons, although it is unaffected by canyon geometry during other months. Longitude has no effect on RRM behaviour. RRMs have a considerable cooling sensation in urban centres at middle/high latitudes, but appear to have had no advantage in cities like Abu Dhabi or Singapore when it comes to diffusive materials. There is a need to pay more attention to assessing the penalties that will be incurred for heating demand during cold seasons. Dai, Sanchez [44] described about Microscale tents emerge as a typically realize for strain engineering of two-dimensional (2D) materials. Radial buckle delamination can be seen in the periphery of the tents, in which the 2D materials are endorsed by the substrate, but the formation mechanism and profile features are unknown. Researchers propose that tent-induced buckles are caused by the 2D membrane interface sliding outward inward, with interface adhesion as well as friction controlling their profile information and extensiveness. Researchers then use accurate closed-form solutions to FvK equations to acquire theoretical results for the extent of those buckles. Our conceptualizations of theory have the potential to provide a robust basis for the logical design of two-dimensional tents made of material. Eltahan [45] studied in heavy-duty fabrics, tearing strength is much more important. The purpose of this study was to evaluate the ways in which specific structural factors of the fabric can affect the tearing properties of tent materials. The experiment consisted of two phases, the first of which investigated the effect that the construction of the cloth had on its tearing strength. The same type of fibre was used in six different fabric designs. They were of varying degrees of tightness. The second step was to create fabrics for tents of various sizes and formats. Fabric specimens prepared in various sets. These tearing resistance tests were carried out on these samples in order to investigate the effects that structural characteristics like these have on the fabrics' ability to resist tearing. Calculations were done to determine how various structural characteristics affect tearing strength. Manni, Ragnacci [46] described the difficult social issues that non-governmental organisations face in planning, managing, and evolving refugee camps, alternate solution development policies have been evaluated. Technological innovations do indeed albedo materials to create cool oases in hot climates. The advantages of this proposed plan were explored by designed to simulate the use of high-albedo devices on shelters in Zaatari, after which the prevented carbon emissions could be encouraged for a long-term boost to the local economy. The current model suggests that high-District heating connections are among the most efficient solutions for reducing albedo materials, according to the literary works. The advantages of this proposition have been measured, as well as several scenarios have been discussed. The carbon greenhouse gas emissions from the construction sector are included in the Emissions Trading System. These processes necessitate large investments that are repaid via heat credits, and are approximated to be by designed to simulate the use of high-albedo devices on shelters in Zaatari, where the prevented carbon emissions were sold. Heat supply in the long term could reduce, as a result of changing weather patterns and building restoration initiatives, as measured and then several scenarios mentioned. The carbon going to prolong this same investment return policy in the structure of the Emissions Trading System. approximately 150,000 tonnes CO_2-eq [12]. Gaetz [47] explained an unbelievable level of knowledge on homeless people in Canada rise up over the last fifteen years. This type of work is applicable to a wide range of academic fields and areas of research (government, social and health services). This review of the literature presents an overview of Canadian lack of housing investigation, with a focus on something that is most pertinent to the Toronto area. The extensive list of books that accompanies the evaluation, which includes over 600 entries, provides a resource for all those intrigued in researching policy and practise related to homeless people. Key findings are discussed within every part of this study, highlighting major scientific instructions. Quality research has appeared that identifies passageways to severe housing problems. This process will focus to be vital as long as Canadian governments refuse to invest in housing and there is a demand for low-cost, appreciative, and transitional housing. Grommes, Harmon-Threatt [48] described Soil emergence tents (e-tents) are a useful technology for researching ground-nesting bees' nesting biology-based science. E-tents permit us to link nesting sites with particular soil properties; moreover, their effectiveness is limited by low success rates as well as long implementation times (greater than72 h). The addition of natural ingredients had no discernible impacts on the entire capture rate. Introducing scents to e-tents it seems to be taxon-specific in its effectiveness. Research examining halictid nesting biology may find that adding spearmint essential oil to e-tents improves their effectiveness, but more research is required to find an appropriate attractant for those other groups or entire towns. Hein, Wagner [49] explained a robust field-based system that was able to adequately enforce HNT stress. The system's top and side ventilation also permitted it to preserve near-ambient temperature changes during the day without having to constantly eliminate the tent from the field, whilst being able to freeze it up overnight to provide HNT stress exposure on numerous wheat genotypes in a set format. The system and research methods used showed that crop agronomic and physiological reactions to HNT can be appropriate components under realistic environmental condition, which can aid continuing breeding efforts targeted at enhancing crop adjust to environmental climates. Premised on some of the above suggestions, this system can be changed and evolved. Kim, Slafer [50] explained in recent decades, environmental variance has enhanced, and heat waves are expected to have a significant impact on wheat yield. As a result, methods to measure the impacts of increased temperatures in the field on wheat growth, yield, and yield-related traits are definitely needed. Researchers initially consider the different strategies to quantifying these impacts in this paper, briefly highlighting their benefits and drawbacks. The tent alters the wind, humidity, and evapotranspiration as well as lowering the intensity of the light, this technique has a disadvantage similar to other strategies. Researchers discuss the magnitude of the confounding effect. Researchers reported the findings of a field experiment that compared a "roof-only" treatment against an open, uncovered control. Two wheat cultivars with various grain numbers per m^2 and average grain weights were examined during these operations, which were carried out at the beginning of grain filling or during bootup. Zhang, Yu [51] stated that ultrathin envelope's low thermal inertia and poor thermal insulation, the indoor temperature surroundings in tents is exceedingly poor, and the inhabitants are tormented. All indoor air temperature and inner surface radiation temperature rise quickly in the presence of high solar radiation. As a result, lowering summer radiation heat increase is required to fine-tune the indoor temperature surroundings in tents. Because of their high reflectivity for solar radiation, *retro*-reflective materials are a good choice. A comparison experimental investigation was carried out underneath the summer climatic conditions of Chengdu city, China, to unveil the temperature environment advancement of tents by incorporating with *retro*-reflective materials. retro-reflective materials can reduce the tent's interior air peak temperature by more than 7.7 degreesC, and they can also limit the interior surface radiant temperature during the day by up to 4.8 degreesC. It demonstrates how *retro*-reflective materials can improve the temperature surroundings in tents. The top, east, and north walls are discovered to be improved choices for *retro*-reflective materials when compared to the walls in specific angles on which *retro*-reflective materials are explored, whereas the north wall has to be the worst preference for *retro*-reflective materials. Lei, Liu [52] explained Crystallographic interoperability assessment and a reconfigured phase field model with substrate restriction are used to investigate the formation and growth of SMA tents and tunnels. In tents and tunnels, martensite-martensite and austenite–martensite connections have indeed been recognised and designed to simulate. It is also documented how the system changes when subjected to cyclic thermal loads and various settings. Tunnels have a higher actuation strain, and may be advantageous in some applications. When heated from the elastic modulus energy position, tents as well as tunnels progressively deteriorate back to austenite. All of the analyses and simulated results corroborate the findings of the experiments. Other special SMA thin film structures can be analysed and simulated using this research methods. Lima, de Souza [53] state that many homeless people already have poor health, elevated rates of chronic illnesses, and weakened immune systems, that are factors in developing a more significant coronavirus infectious disease. Mentally ill people may have trouble recognising and replying to the danger of infection. Homeless people have less access to insurance suppliers who could purchase medical tests and, if affirmed, seperate them from of the rest of the population in collaboration with local health authorities. Lu, Koperski [54] described the Syrian civil war began in 2014, thousands of Syrian refugees have fled to Rukban, a desert area straddling the Syrian-Jordan border. Over the past few years, this region has seen a significant rise in the number of refugee shelters that are dedicated to housing Syrians who have been forcibly evacuated from their homes. It is therefore absolutely necessary for the long-term survival of the refugee shelter camps to have an accurate estimation of the number of tents and their locations. Manual process trying to count the shelters is time-consuming and, given the large number of them, sometimes impossible. In addition, the size and shape of these tents and shelters are often rather small, and they are dispersed unevenly across a vast region. This makes it challenging to detect using traditional imaging techniques, which in turn makes it difficult to employ image-based strategies. The FCN model outperformed the CNNs, SAM, and mask R-CNN models in terms of overall accuracy, precision, and precision, respectively, by 4.49 percent, 3.54 percent, and 0.88 percent, and by 34.61 percent, 41.99 percent, and 11.87 percent. Bernal [55] described the most diverse mating techniques of any mammal. Roost attributes can influence the social framework; for instance, if the roost is morally defensible and its accessibility is restricted, this becomes a precious asset that helps to identify the type of mating system. It has been recommended that males in species which use tents as roosting sites can defend the tent in way to lure and allow entry to females. The purpose of this study is to learn more about the development and consistency of the clusters that are formed by this species. One of the questions that will be investigated is whether the males protect the tent itself or the females that are contained within it in an effort to obtain copulations. This research was carried out in 2006 in Tirimbina, a Biological Reserve in Sarapiqu, Costa Rica, in which communities of bats (N = 38) were seized. The people were identified (N = 98) and their reproductive condition was calculated. Yazyev, Ujma [56] explained Tent frameworks was utilised in both chilly and warm climates all over the world. They're frequently used in cases of emergency, natural calamities, and numerous rescue missions. It is crucial to learn the insulation of the tent's external enclosures in order to evaluate the thermal environment within the tent. The thermophysical conductivity of a tent fabric are tested, as well as the value of the heat transfer coefficient of heat shields of a pneumatic tent. The tent covering's thermal insulation is made up of two woven fabric detached by an air pocket. The study was predicated on the presumption that the tent will be utilised in both cold and hot weather. The material's temperature and heat transfer conditions on its surfaces were calculated. The thermal variables of the tent's thermal shield were then determined using the measurement results. Wang, Liu [57] described with rapid urban development of structures that are both tall and packed closely together are becoming more common, resulting in a slew of urban thermal environment issues, such as the urban heat island. With traditional materials that are highly reflective, it is possible to reduce the amount of solar energy gained by structures in order to minimize urban heat islands by using diffuse reflection, but reflected solar radiation will also be absorbed by surrounding urban substrates, which results in an increase in urban heat gain because thermal radiation from buildings is assimilate into building groups multiple times. It was proposed to use retroreflective materials to reflect solar radiation along the direction of the incident radiation to conquer the underlying deficiency of reflective materials, and have progressively enticed much attention owing reflection characteristics. But even so, the overview on *retro*-reflective materials, which summarises the state of growth and developmental flaws in *retro*-reflective materials, has yet to be reported. The advancement, performance monitoring, and current progress of *retro*-reflective materials were the focus of the research, with regard to the effectiveness of the application of retroreflective materials on the urban thermal experience and the consumption of building energy. Finally, future research and application directions were suggested. Xu, Zhang [58] explained the overall implementation value of tent as a type of ultra-thin material, however, there are comparatively few relevant advancement assessments and in-depth research in this area. To enhance the indoor climate, three distinct comparison experiments employing active and passive methodologies, were chosen based on the analysis of the thermodynamic equilibrium model. In addition, the PCM in combination with night ventilation was taken into account in order to investigate an integrated approaches to improve the tent's thermal environment. PCM was tested and analysed in the field throughout the year, and the implementation of PCM with ultrathin envelopes was thoroughly examined. The test results were used to validate a simulation model of a tent. The simulation results revealed that phase change material > ventilation > *retro*-reflective material saves the most energy. Based on simulations of buildings made of phase change material (pcm) in major cities, it was discovered that Kunming has the best energy saving ratio, at around 80 %.

The goal of this article is to reduce the internal temperature of a tent by employing several materials, like polyvinyl chloride, wood fibre, polystyrene, aerogel, and phenolic foam by using CFD approach.

2. Computational fluid dynamics analysis

The computational fluid dynamics tools used in this field diversify according to the various mathematical models and methods used in the field. They can also be integrated with other computational tools to form a complete computational model. Developing a robust and well-designed computational fluid dynamics tool is an essential step in the process of developing software for this field. There are various commercial software solutions and open-source software packages. Due to the nature of computational fluid dynamics, it is commonly used in various fields, such as aerospace and aeronautics analysis, weather simulation, and natural science. It can also be utilized in the design and analysis of industrial systems, as well as in the visual effects industry. The main basis of most computational fluid flow problems is the Navier-Stokes equation, which defines many single-phase flows. To simplify these problems, we remove terms that describe actions that yield the Euler equations. For more complex problems, such as those involving subsonic and supersonic flows, we can also linearize these equations.

The current study uses Ansys fluent to do a computer simulation for a tent made of several different materials. This computer study is carried out using system of equations such as the conservation equations, conservation of momentum, and continuity equation. Mathematical approaches for dealing with flow problems are at the heart of computational fluid dynamics. All computational fluid software feature comprehensive user interfaces for entering problem parameters and examining the statistics in order to just provide quick access to their solution capabilities.

Thermal analysis is the technique for maintaining temperature of something like the semiconductor connection within the operational range. Because the temperature difference and reduced power are predetermined in a design, the only approach to keep the temperature difference within operational range is to lower the interconnection to ambient temperature sensitivity. The current work's comprehensive thermal analysis is broken down into three primary steps includes pre-processor, solutions, and postprocessor. Pre-processor is mostly used to set up the model. The pre-processing steps includes the creation of CAD model, generation of meshing and defining of materials. The problem has been solved in this step by obtaining all of the required facts. The machine assumes charge at this point and answers the contemporaneous given formula by the numerical model approach. The nodal number of degrees of freedom values are the outcome of the solution, and they outline the fundamental remedy determined variables that define the component. The universal postprocessor is used to review analytical results throughout the whole model.

With the assistance of CAD model of Tent is generated which was adopted from Zhang, Yu [51]. The measurements of the tent are 600 mm × 600 mm × 600 mm, with two windows of 150 mm x150 mm in the centre of the front wall and two windows of 150 mm × 150 mm on the side wall-1, with a door of 100 mm × 480 mm in the centre of front wall and a door of 100 mm × 480 mm in the middle of the side wall-1. Fig. 1 depicts a three-dimensional model of the tent.

The CAD shape of the tent is then loaded into ANSYS Workbench for further computer simulation study, and meshing is the following stage. In finite element model, interweaving is a critical step in which CAD geometry is split into a huge number of little parts called mesh. To generate mesh, the component size is set to 5 mm, and the number of vertices produced in this work is 6239419, with 1,534,560 elements. Fig. 2 shows meshing of tent model.

Energy equation is used to find the air temperature field inside of the tent. For analysis the fluid as air and the solid as PVC, wood-fibre, polystyrene, aerogel, and polyphenol were selected. The flow initial temperature of air was set to 311 K as the ambient temperature. A constant heat flux of 900 W/m^2 as solar irradiation was used for the tent's roof. The tent's roof and walls have been designated as walls. To approximation the result for velocity and pressures, a second version advection finite difference approach is used. Material properties are the most important things to identify for any sort of analysis preceding moving on to the next step. Table 1 lists the properties of material.

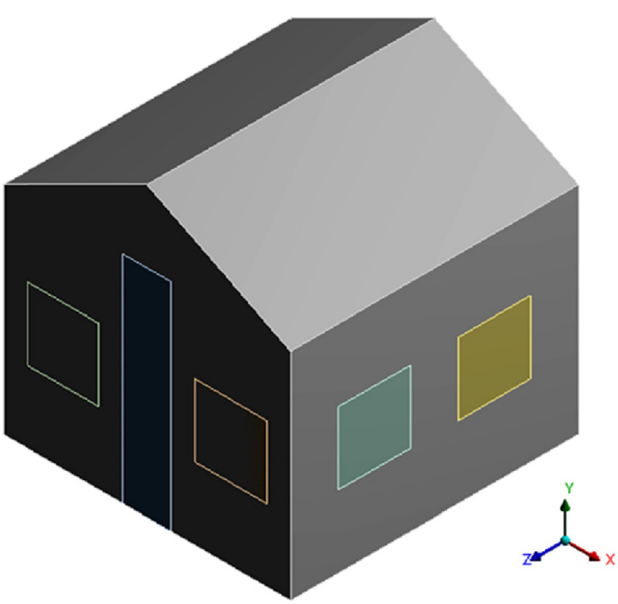

Fig. 1. CAD Geometry of Tent.

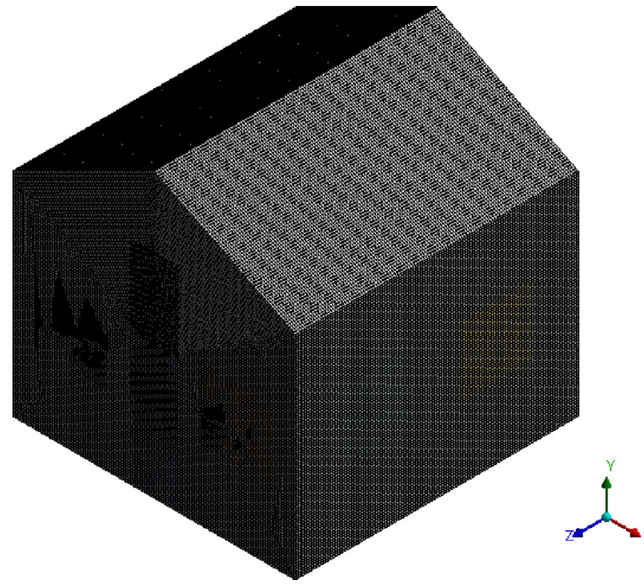

Fig. 2. Meshing of tent.

2.1. Model validation

To test the influence of different tent material elements just on surrounding temperature in tents using under summer climatic conditions, a comparable experiment has been conducted. The results demonstrate a 15 degreesC difference in exterior and internal air temp in the tent when PVS was employed as a tent material. To validate this work, the same design parameters were used to design a tent model and conduct simulation software simulation using the same substance (PVC). The results demonstrate a difference of 2.18 degrees between the external and internal air temperatures in the tent when PVS was used as a nostalgia fabric. That after current work was validated, different *retro*-reflective substances including such wood pulp, polystyrene, hydrogel, and phenol foam were utilized to reduce the exterior and inside air temperatures in the tent while maintaining the very same initial conditions.

3. Result and discussion

A CFD simulation analysis has been performed for a tent under spring time climatic conditions to start reducing of inside atmospheric temperature of both the tent using distinct components such as polycarbonate, timber, polystyrene, nanocomposite, and polyphenol. For different materials calculated results obtained from simulation are explained in the following subsections:

The highest air temperature on the inside of the tent is 324 degrees Kelvin, and the minimum ambient temperature is 311.15 degrees Kelvin, according to the results of a computer simulation of a tent using polyvinyl chloride.

Fig. 3 with varied colour contour, depict the dispersion of ambient temperature on the inside of the tent. The temperature of the inner air of the tent is 12.85 degreesK greater than the temp of the outside air. It also shows the overall result of a computer simulation analysis of a tent employing PVC as a material.

The highest ambient temperature inside the tent is 321.26 degrees Kelvin, and the maximum ambient temperature is 311.15 degrees Kelvin, according to the results of computer simulation of the tent employing wood-fibre. Fig. 4 with varied colour contours, depict the dispersion of ambient temperature on the

Table 1
Material Properties.

Material Properties	PVC	Wood-fibre	Polystyrene	Aerogel	Phenolic-Foam
Density [Kg/m^3]	1380	645	960–1050	3	35–200
Thermal Conductivity [W/m-k]	0.19	0.038–0.042	0.033	0.03–0.04	0.018–0.023
Specific Heat [KJ/Kg-k]	0.9	2.3	1.3	1.9–2.3	1.05

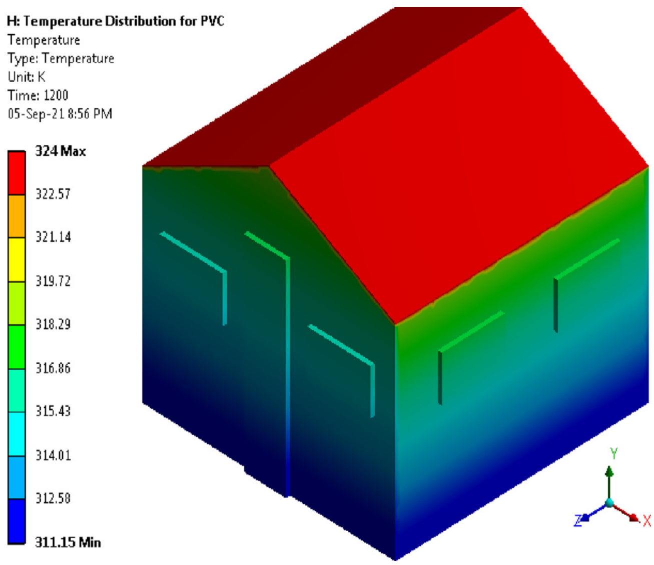

Fig. 3. Air temperature distribution inside the tent using PVC.

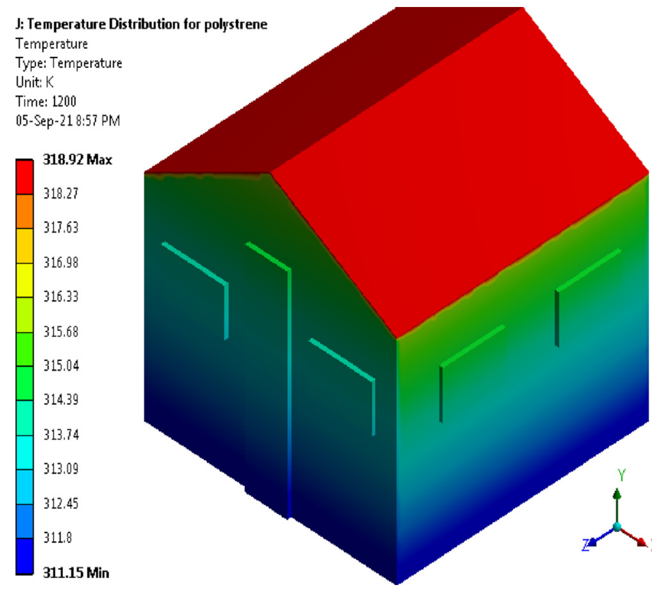

Fig. 5. Air temperature distribution inside the tent using polystyrene.

inside of the tent. The temperature of the inner air of the tent is 10.11 degreesK warmer than the surrounding of the outside air.

The highest ambient temperature outside the tent is 318.92 degrees Kelvin, while the lowest ambient temperature inside of the tent is 311.15 degrees Kelvin, according the results of a computer simulation employing polystyrene. Fig. 5 with varied colour contours, depict the dispersion of ambient temperature within the tent. The warmth of the inner air of the tent is 7.77 degreesK warmer than the surrounding of the outside air. It also shows the overall result of a computer simulation assessment of a tent utilizing Polystyrene.

The highest air temperature outside the tent is 317.26 degrees Kelvin, while the lowest ambient temperature inside the tent is 311.15 degrees Kelvin, according to the results of a computer simulation employing aerogel. Fig. 6 with varied colour contours, depict the dispersion of ambient temperature on the inside of the tent. The temperature of the inner air of the tent is 6.11 degreesK higher than the temp of the outside air. It also shows the overall result of a computer simulation of a tent employing Aerogel.

The highest ambient temperature from the inside of the tent is 315.95 degrees Kelvin, as well as the maximum ambient tempera-

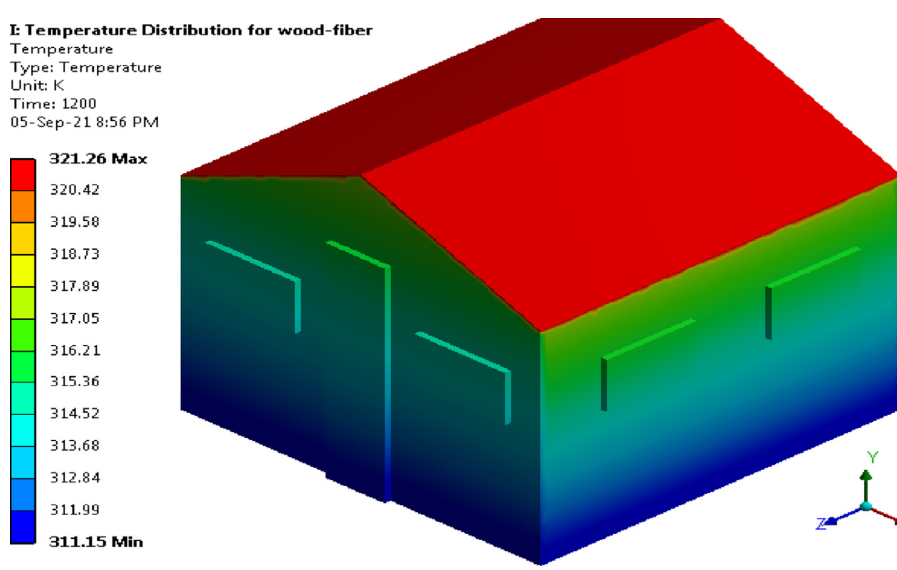

Fig. 4. Air temperature distribution inside the tent using wood-fibre.

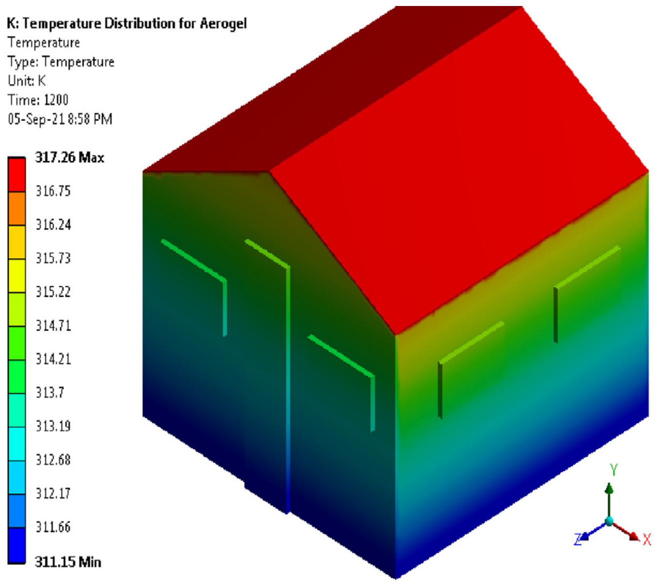

Fig. 6. Air temperature distribution inside the tent using aerogel.

ture is 311.15 degrees Kelvin, according to a computer simulation of the tent employing phenolic foam. Fig. 7 with varied colour contours, depict the dispersion of air temperature within the tent. The temperatures inside of the tent is 4.8 degrees Celsius greater than the temperatures outside. It also shows the overall result of a computer simulation of a tent employing phenolic foam.

Fig. 8 shows the comparative result of distribution of air temperature inside the tent from ground surface to top. A tent using PVC, the maximum average temperature inside the tent is 324 degrees Kelvin, and the lower limit ambient temperature inside the tent is 311.15 degrees Kelvin. A tent using wood-fibre, the maximum average temperature inside the tent is 321.26 degrees Kelvin, and the lower limit ambient temperature inside the tent is 311.15 degrees Kelvin. A tent using polystyrene, the highest average temperature inside the tent is 318.92 degrees Kelvin, while the minimum ambient temperature inside the tent is 311.15 degrees Kelvin. A tent using aerogel, the highest ambient temperature on the inside of the tent is 317.26 degrees Kelvin, and the minimum ambient temperature inside the tent is 311.15 degrees Kelvin. A tent using phenolic foam, the highest ambient temperature inside the tent is 315.95 degrees Kelvin, and the minimum ambient temperature inside the tent is 311.15 degrees.

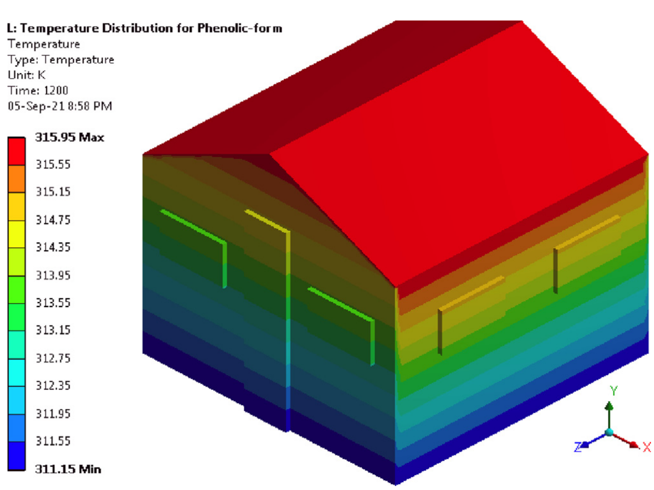

Fig. 7. Air temperature distribution inside the tent using phenolic foam.

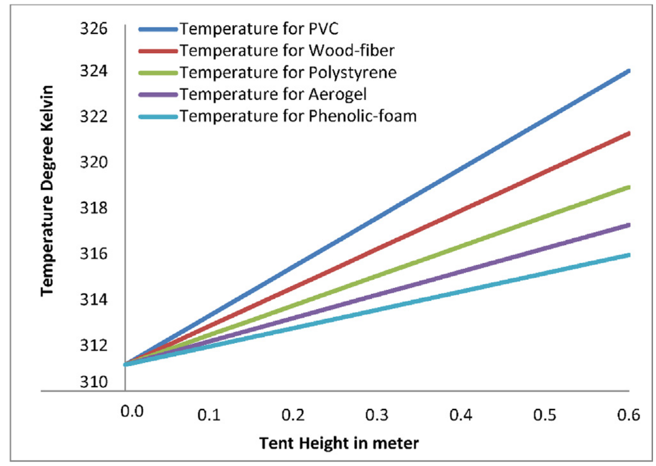

Fig. 8. Comparative result of distribution of air temperature inside the tent from ground surface to top.

Fig. 9 shows the maximum temperature of air inside the tent for different *retro*-reflective materials. It can be seen that maximum temperature corresponds to PVC while minimum temperature corresponds to phenolic foam.

Fig. 10 shows the percentage variation of temperature with respect to PVC. When compared to PVC as a tent material the temperature differences of 5.68 %, 11.06 %, 15.23 % and 18.74 % are observed for wood-fibre, polystyrene, aerogel and phenolic foam respectively as a tent material.

4. Conclusions

In this study, distinct materials (polyvinyl chloride, wood-fibre, polystyrene, aerogel, and phenolic foam were used to decrease an inside atmospheric temperature of a tent. A CFD simulation was carried for a tent under July and August environmental conditions and the following outcomes were recorded:

1. The highest ambient temperature in inside tent is recorded as 324 degrees Kelvin, which is 12.85 degrees Kelvin hotter than the external temperature when using polyvinyl chloride as tent materials.
2. The maximum average temperature inside the tent is recorded as 321.26 degrees Kelvin, which is 10.11 degrees Kelvin hotter than the external temperature when using wood-fiber as tent materials. It is observed that a temperature difference of 5.68 percent is recorded between PVC and wood-fiber.
3. The maximum average temperature inside the tent is recorded as 318.92 degrees Kelvin, which is 7.77 degrees Kelvin hotter than the external temperature when using polystyrene as tent materials. It is observed that a temperature difference of 11.06 percent is recorded between PVC and polystyrene.
4. The maximum average temperature inside the tent is recorded as 317.26 degrees Kelvin, which is 6.11 degrees Kelvin hotter than the external temperature when using aerogel as tent materials. It is observed that a temperature difference of 15.23 percent is recorded between PVC and aerogel.
5. The maximum average temperature inside the tent is recorded as 315.95 degrees Kelvin, which is 4.8 degrees Kelvin hotter than the external temperature when using phenolic foam as tent materials. It is observed that a temperature difference of 18.74 percent is recorded between PVC and phenolic foam.

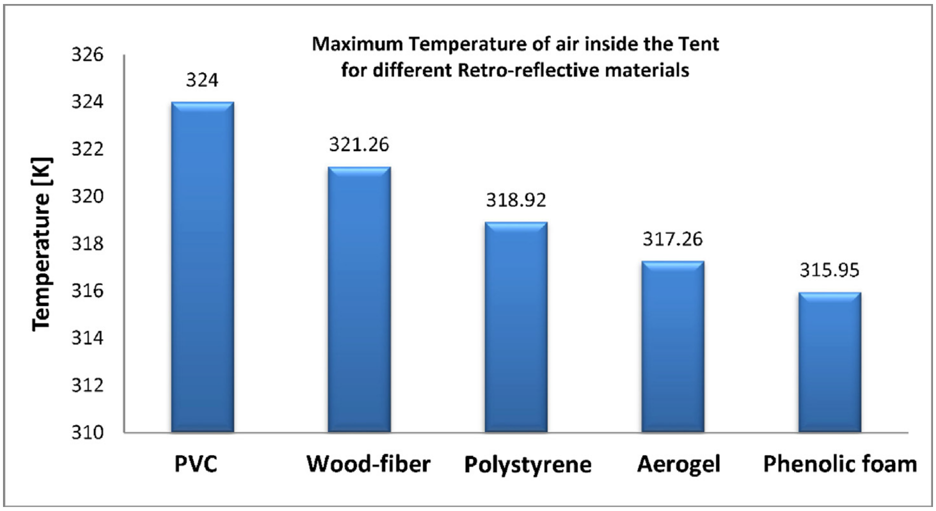

Fig. 9. Maximum temperature of air inside the tent for different *retro*-reflective materials.

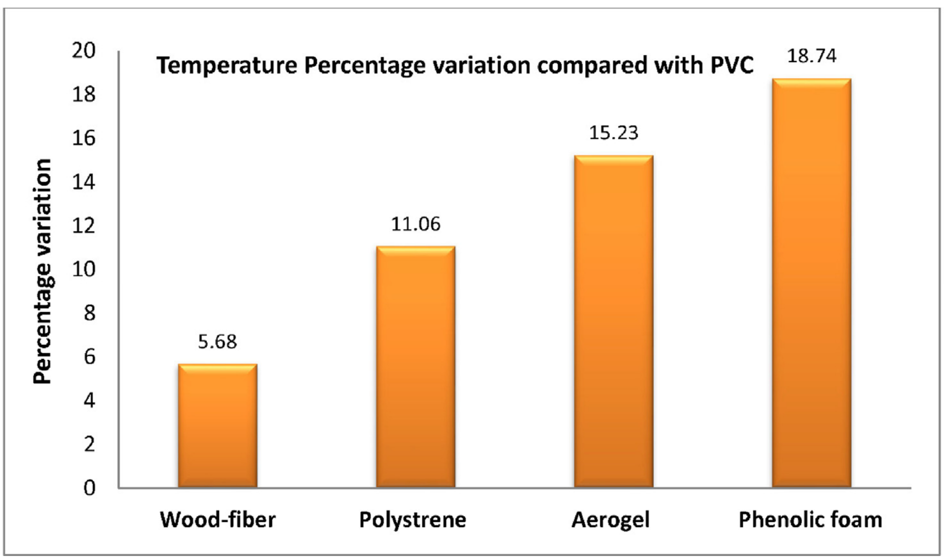

Fig. 10. Temperature Percentage variation compared with PVC.

CRediT authorship contribution statement

Rakesh Raushan Kumar: Conceptualization, Visualization. **Shashikant Sharma:** Writing – original draft. **Rajiv Saxena:** Supervision. **Pavan Kumar Singhal:** Software. **Rajan Kumar:** Writing – review & editing, Validation. **Geetesh Goga:** Supervision. **Subhendu Chakroborty:** Validation. **Manmohan Singh:** Software. **Yogesh Agrawal:** Methodology. **K Viswanath Allamraju:** Formal analysis. **Vikas S. Pagey:** Supervision.

Data availability

No data was used for the research described in the article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] A.S. Yadav, A. Agrawal, A. Sharma, A. Gupta, Revisiting the effect of ribs on performance of solar air heater using CFD approach, Mater. Today:. Proc. 63 (2022) 240–252.
[2] A.S. Yadav, J.L. Bhagoria, A CFD analysis of a solar air heater having triangular rib roughness on the absorber plate, Int. J. ChemTech. Res. 5 (2) (2013) 964–971.
[3] A.S. Yadav, A. Agrawal, A. Sharma, S. Sharma, R. Maithani, A. Kumar, Augmented artificially roughened solar air heaters, Mater. Today:. Proc. 63 (2022) 226–239.
[4] A. Kumar, R. Maithani, A.S. Yadav, S. Sharma, Effect of 450 protruded and dimpled rib height on the performance of triangular duct solar heat collector, Mater. Today:. Proc. 63 (2022) 253–258.
[5] A.S. Yadav, J.L. Bhagoria, Numerical investigation of flow through an artificially roughened solar air heater, Int. J. Ambient Energy 36 (2) (2015) 87–100.
[6] V. Shrivastava, A.S. Yadav, A.K. Sharma, P. Singh, T. Alam, A. Sharma, Performance comparison of solar air heater with extended surfaces and iron filling, Int. J. Vehicle Struct. Syst. 14 (5) (2022) 607–610.
[7] A.S. Yadav, M.K. Dwivedi, A. Sharma, V.K. Chouksey, CFD based heat transfer correlation for ribbed solar air heater, Mater. Today:. Proc. 62 (2022) 1402–1407.
[8] A.S. Yadav, A. Gattani, Revisiting the influence of artificial roughness shapes on heat transfer enhancement, Mater. Today:. Proc. 62 (2022) 1383–1391.
[9] A.S. Yadav, A. Gattani, Solar thermal air heater for sustainable development, Mater. Today:. Proc. 60 (2022) 80–86.

[10] V.K. Chouksey, A.S. Yadav, S. Raha, V. Shrivastava, S.P. Shrivas, A theoretical parametric analysis to optimize the bed depth of packed bed solar air collector, Int. J. Green Energy 19 (07) (2021) 775–785.
[11] A.S. Yadav, S. Gupta, A. Agrawal, R. Saxena, N. Agrawal, S. Nashine, Performance enhancement of solar air heater by attaching artificial rib roughness on the absorber Plate, Mater. Today:. Proc. 63 (2022) 706–717.
[12] R. Kumar, S.K. Verma, S.K. Mishra, A. Sharma, A.S. Yadav, N. Sharma, Performance enhancement of solar air heater using graphene/cerium oxide and graphene-black paint coating on roughened absorber plate, Int. J. Vehicle Struct. Syst. 14 (2) (2022).
[13] A.S. Yadav, A. Mishra, K. Dwivedi, A. Agrawal, A. Galphat, N. Sharma, Investigation on performance enhancement due to rib roughened solar air heater, Mater. Today:. Proc. 63 (2022) 726–730.
[14] A.S. Yadav, O. Prakash Shukla, B.R. Singh, Recent advances in modeling and simulation techniques used in analysis of solar air heater having ribs, Mater. Today:. Proc. 62 (2022) 1375–1382.
[15] Agrawal Y, Yugbodh K, Ayachit B, Tenguria N, Kumar Nigam P, Gautam A, et al. Experimental investigation on thermal efficiency augmentation of solar air heater using copper wire for discrete roughened absorber plate. Materials Today: Proceedings. 2023;In press.
[16] A.S. Yadav, V. Shrivastava, V.K. Chouksey, A. Sharma, S.K. Sharma, M.K. Dwivedi, Enhanced solar thermal air heater: a numerical investigation, Mater. Today:. Proc. 47 (2021) 2777–2783.
[17] A.S. Yadav, V. Shrivastava, M.K. Dwivedi, O.P. Shukla, 3-dimensional CFD simulation and correlation development for circular tube equipped with twisted tape, Mater. Today:. Proc. 47 (2021) 2662–2668.
[18] A.S. Yadav, V. Shrivastava, A. Sharma, S.K. Sharma, M.K. Dwivedi, O.P. Shukla, CFD simulation on thermo-hydraulic characteristics of a circular tube having twisted tape inserts, Mater. Today:. Proc. 47 (2021) 2790–2795.
[19] V. Shrivastava, A.S. Yadav, N. Shrivastava, Thermal performance assessment of greenhouse solar dryer, in: R. Kumar, A.K. Pandey, R.K. Sharma, G. Norkey (Eds.), Recent Trends in Thermal Engineering, Springer, Lecture Notes in Mechanical Engineering Singapore, 2022, pp. 75–82.
[20] A.S. Yadav, V. Shrivastava, A. Sharma, M.K. Dwivedi, Numerical simulation and CFD-based correlations for artificially roughened solar air heater, Mater. Today:. Proc. 47 (2021) 2685–2693.
[21] A.S. Yadav, O.P. Shukla, A. Sharma, I.A. Khan, CFD analysis of heat transfer performance of ribbed solar air heater, Mater. Today:. Proc. 62 (2022) 1413–1419.
[22] A.S. Yadav, CFD investigation of effect of relative roughness height on Nusselt number and friction factor in an artificially roughened solar air heater, J. Chin. Inst. Eng. 38 (4) (2015) 494–502.
[23] Prasad R, Yadav AS, Singh NK, Johari D. Heat Transfer and Friction Characteristics of an Artificially Roughened Solar Air Heater. In: Saha P, Subbarao PMV, Sikarwar BS, editors. Advances in Fluid and Thermal Engineering, Lecture Notes in Mechanical Engineering. Singapore: Springer; 2019. p. 613-26.
[24] A.S. Yadav, T. Alam, G. Gupta, R. Saxena, N.K. Gupta, K.V. Allamraju, et al., A numerical investigation of an artificially roughened solar air heater, Energies 15 (21) (2022) 8045.
[25] A.S. Yadav, J.L. Bhagoria, Modeling and simulation of turbulent flows through a solar air heater having square-sectioned transverse rib roughness on the absorber plate, Scient. World J. 2013 (2013).
[26] A.S. Yadav, J.L. Bhagoria, Heat transfer and fluid flow analysis of solar air heater: a review of CFD approach, Renew. Sustain. Energy Rev. 23 (2013) 60–79.
[27] A.S. Yadav, J.L. Bhagoria, A CFD (computational fluid dynamics) based heat transfer and fluid flow analysis of a solar air heater provided with circular transverse wire rib roughness on the absorber plate, Energy 55 (2013) 1127–1142.
[28] A.S. Yadav, J.L. Bhagoria, A numerical investigation of turbulent flows through an artificially roughened solar air heater, Numer. Heat Transf., Part A: Appl. 65 (7) (2014) 679–698.
[29] A.S. Yadav, J.L. Bhagoria, Heat transfer and fluid flow analysis of an artificially roughened solar air heater: a CFD based investigation, Front. Energy 8 (2) (2014) 201–211.
[30] A.S. Yadav, J.L. Bhagoria, A numerical investigation of square sectioned transverse rib roughened solar air heater, Int. J. Therm. Sci. 79 (2014) 111–131.
[31] A.S. Yadav, J.L. Bhagoria, A CFD based thermo-hydraulic performance analysis of an artificially roughened solar air heater having equilateral triangular sectioned rib roughness on the absorber plate, Int. J. Heat Mass Transf. 70 (2014) 1016–1039.
[32] A.S. Yadav, A. Sharma, Experimental investigation on heat transfer enhancement of artificially roughened solar air heater, Heat Transfer Eng. 1–14 (2022).
[33] A.S. Yadav, M.K. Thapak, Artificially roughened solar air heater: experimental investigations, Renew. Sustain. Energy Rev. 36 (2014) 370–411.
[34] A.S. Yadav, M.K. Thapak, Artificially roughened solar air heater: A comparative study, Int. J. Green Energy 13 (2) (2016) 143–172.
[35] Shrivastava V, Yadav AS, Shrivastava N. Comparative Study of the Performance of Double-Pass and Single-Pass Solar Air Heater with Thermal Storage. In: Kumar A, Pal A, Kachhwaha SS, Jain PK, editors. Recent Advances in Mechanical Engineering, Lecture Notes in Mechanical Engineering. Singapore: Springer; 2021. p. 227-37.
[36] Yadav AS, Sharma SK. Numerical Simulation of Ribbed Solar Air Heater. In: Sikarwar BS, Sundén B, Wang Q, editors. Advances in Fluid and Thermal Engineering, Lecture Notes in Mechanical Engineering. Singapore: Springer; 2021. p. 549-58.
[37] Yadav AS, Shrivastava V, Ravi Kiran T, Dwivedi MK. CFD-Based Correlation Development for Artificially Roughened Solar Air Heater. In: Kumar A, Pal A, Kachhwaha SS, Jain PK, editors. Recent Advances in Mechanical Engineering, Lecture Notes in Mechanical Engineering. Singapore: Springer; 2021. p. 217-26.
[38] S.A. Khan, T. Alam, M.S. Khan, P. Blecich, M.A. Kamal, N.K. Gupta, et al., Life cycle assessment of embodied carbon in buildings: background, approaches and advancements, Buildings 12 (11) (2022) 1944.
[39] R. Kumar, Y. Anupam Rao, A.S. Yadav, A. Balu, B. Prasad Panda, M. Joshi, et al., Application of phase change material in thermal energy storage systems, Mater. Today:. Proc. 63 (2022) 798–804.
[40] M.A. Alam, R. Kumar, D. Banoriya, A.S. Yadav, G. Goga, K.K. Saxena, et al., Design and development of thermal comfort analysis for air-conditioned compartment, Int. J. Interact. Des. Manuf. (IJIDeM) (2022).
[41] B. Bergkamp, S.M. Impa, A.R. Asebedo, A.K. Fritz, S.V.K. Jagadish, Prominent winter wheat varieties response to post-flowering heat stress under controlled chambers and field based heat tents, Field Crop Res. 222 (2018) 143–152.
[42] S. Bhatt, Temporary shelters for the homeless in Delhi: a study-based reflection, History Res. J. 1 (2) (2019).
[43] B. Castellani, Application of retro-reflective materials in urban canyon at different geographical locations, Build. Environ. 193 (2021).
[44] Z. Dai, D.A. Sanchez, C.J. Brennan, N. Lu, Radial buckle delamination around 2D material tents, J. Mech. Phys. Solids 137 (2020).
[45] E. Eltahan, Structural parameters affecting tear strength of the fabrics tents, Alex. Eng. J. 57 (1) (2018) 97–105.
[46] M. Manni, F. Ragnacci, M. Filippucci, V. Coccia, F. Bianconi, F. Cotana, et al., Refugee camps as an opportunity for promoting alternative development strategies based on carbon credits, Energy Procedia 148 (2018) 281–288.
[47] S. Gaetz, Understanding research on homelessness in Toronto: A literature review, Wellesley Central Health Corporation, York University, Toronto, 2014.
[48] A.C. Grommes, A.N. Harmon-Threatt, N.L. Anderson, Adding essential oils to emergence tents has taxon-specific effects on trapping efficiency of ground-nesting bees, Apidologie 52 (2) (2021) 378–387.
[49] N.T. Hein, D. Wagner, R. Bheemanahalli, D. Sebela, C. Bustamante, A. Chiluwal, et al., Integrating field-based heat tents and cyber-physical system technology to phenotype high night-time temperature impact on winter wheat, Plant Methods 15 (2019) 41.
[50] J. Kim, G.A. Slafer, R. Savin, Are portable polyethylene tents reliable for imposing heat treatments in field-grown wheat?, Field Crop Res 271 (2021).
[51] L. Zhang, Y. Yu, L. Xu, W. Zhang, Q. Shen, Experimental study on indoor air thermal equilibrium model of the tent, Int. J. Low-Carbon Technol. 12 (1) (2017) 36–42.
[52] C.H. Lei, Y. Liu, W. Chen, Formations and evolutions of martensitic tents and tunnels in shape memory alloy thin films, Mech. Mater. 134 (2019) 9–17.
[53] N.N.R. Lima, R.I. de Souza, P.W.G. Feitosa, J.L.S. Moreira, C.G.L. da Silva, M.L.R. Neto, People experiencing homelessness: their potential exposure to COVID-19, Psychiatry Res. 288 (2020).
[54] Y. Lu, K. Koperski, C. Kwan, J. Li, Deep learning for effective refugee tent extraction near Syria-Jordan border, IEEE Geosci. Remote Sens. Lett. 18 (8) (2021) 1342–1346.
[55] Bernal R-H. Hanging out in tents: social structure, group stability, male behavior, and their implications for the mating system of Ectophylla alba (Chiroptera: Phyllostomidae). Mammal research. 2019;v. 64(no. 1):pp. 11-7-2019 v.64 no.1.
[56] B. Yazyev, A. Ujma, J. Jura, Thermal insulation of the tent's heat shield in cold and hot climates, E3S Web Conf. 281 (2021).
[57] J. Wang, S. Liu, X. Meng, W. Gao, J. Yuan, Application of retro-reflective materials in urban buildings: a comprehensive review, Energ. Build. 247 (2021).
[58] L. Xu, W. Zhang, W. Wang, B. Gao, M. Chen, Impact of different improvement measures on the thermal performance of ultra-thin envelopes, Energy 203 (2020).