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The Occurrence Of Successive Temperature Inversions In A Non-Convective Pool Subjectedto Multiple Absorbing Layers

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ABSTRACT : *A survey on 'The occurrence of successive temperature inversions in a non-convective pool subjected to multiple absorbing layers" was conducted in Cross River University of Technology, Calabar. Temperature gradient data were generated by monitoring temperature variation with height for four experimental model pools D1,D2,D3 and D0 with one ,two, three and zero absorbing layers(transparent glass material of thickness 0.5cm) respectively, using high accuracy mercury in-glass thermometers. The model pools were drums of height 80cm, perforated at graduated distances where thermometers were inserted and lagged with insulating materials(Styropor) of thickness 25cm. The multiple absorbing layers were placed at the top of the drums at interval distances of 10cm between them. Temperature monitoring was carried out between 6am and 6pm daily for three months in two seasons (dry and wet season) on hourly basis. Results obtained from this study showed that multiple positive and negative inversion temperature points were observed across the three non-convective pools with pool D1 having it at 45.0cm, pool D2 at 35.0cm and pool D 3 at 22.0cm.This, The inversion temperature ranged between $1^{O}C$ to $10^{O}C$ and occurring at all times of the day with convex (negative) inversion being more prominent.*

I. GENERAL INTRODUCTION

The world over, the necessity for the development of an alternative energy source is borne out of the fact that fossil fuels are increasingly becoming higher in cost and causing global environmental problems. Energy required for heating and cooling of buildings is approximately 30% of the total world energy consumption. Natural ventilation and renewable energy utilization are widely used to improve the indoor air environment and reduce the energy consumption of air conditioning (Wang and Anguli, 2006). Renewable energy utilization has a direct link with passive solar architecture. The development and use of passive solar energy architecture also has its attendant effects.The behaviour of any passive solar energy collector system is attributed to its temperature gradient $(\frac{dT}{dx})$ (Barnard and Sctterwall, 2003). The gradient provides for free energy transfer from one point of the collector to another by a simple free convectional process. During this process, the solar energy reaching a particular region on the earth is being trapped. The trapping of energy leads to temperature increase based on energy transformation or decrease depending on the direction of the energy flow (Carring, 1968).). However, solar energy reaching any collector system exhibits regular cyclic characteristics defined by the Earth-Sun geometry. This is due purely to superimposed irregularities caused by the atmospheric conditions (Engel and Reld, 2006):). In almost all the passive solar applications, the time pattern of energy demand is not the same as the time pattern of energy reception .This is consequent upon the fact that some forms of energy stored is needed for use when the collector energy cannot meet the demand (wang et al.2006). In most collector systems like the non-convective pool (solar pond), convective solar pond and the atmospheric layer, the behaviour of energy transfer is the same. It is observed that the energy transfer in these media is transient. This is due to the temperature profile within these systems which has a linear relationship with the source producing it (Kooi, 1979).

During the process of energy transfer, there is an area within which the temperature either increases or decreases sharply. This phenomenon is called temperature inversion. The inversion temperature point has posed a big problem during solar energy transfer. When solar energy is to be applied, solar radiation in the form of electromagnetic waves is initially converted into heat on being absorbed by a collector surface and then used to heat up the system (Magal, 1990, Acra, 1996). Temperature gradients in both convective and non-convective pool systems play a vital role in the creation of inversion temperature points. These inversion points perturb the even distribution of energy in these systems. A non-convective pool (solar pond) is a body of water which acts as a solar collector with integral heat storage for supplying thermal energy. There are two types of solar pond; the convective and the non-convective solar ponds. A convective solar pond is a shallow body of water with a large bag that prevents evaporation but permits convectional processes (Dincer and Rosen, 2002). It has a glass cover on top and a blackened bottom to minimize heat loss. A non-convective solar pond is also a large body of shallow water between 1 to 5m deep. It is arranged in such a way that the temperature gradient is reversed from normal incidence. This is to allow the collection of radiant energy, storage of heat and transport of thermal energy at a temperature of 40-50^{0}C above normal (Hehne and Chen, 1998). Unlike a convective solar pond, a salt gradient solar pond (SGSP) maintains a layered structure with a defined density gradient that supports convection and offers thermal insulation effect. Temperature gradient is formed as a result of absorption of solar radiation at the base of the pool.

Temperature inversion is a natural phenomenon that occurs in both gaseous and liquid media alike. In gaseous media, these are various types of temperature inversions. These are classified by their positions in the atmosphere such as elevated or surface-based inversions. The other type is formed from radiation, turbulence or frontal inversions (Kooi, 1979).

In a liquid medium, the trend is similar to that of a gas. A liquid remains an important object to be considered as a thermal mass. The liquid temperature is a function of the ambient temperature (T_a) condition and temperature gradients $(\frac{dT}{dx})$ .This shows that there is an increase in temperature with height (Benjan, 1995).A liquid layer in which the temperature decreases sharply with height defines the inversion temperature point. At the point of inversion,

$$\frac{dT}{dx} = 0$$ (changes in temperature with height equal zero)

II. MATERIALS AND METHOD

The model non-convective pools were made up of four steel drums inserted with eleven thermometers each at designated heights measured from their base. The drum is 80cm and the length occupied by the thermometers between 7cm to 61cm.This process was followed by lagging the drums with insulators of 25cm thick and the introduction of a volume of water up to a height of 60cm and finally multiple absorbing layers (plane glass collector covers) were placed, 1-glass for pool 1, 2-glasses for pool 2 , 3-glasses for pool 3 and no glass for pool 4.The first glass covered the surface of the drum, the second glass and third were separated by a distance of 10cm from each other. The experimental setup was carried out in an open field devoid of shade and placed on top of 6 inches thick blocks above the ground. This was to avoid interference and create maximum solar radiation reception from all angles. The inner surfaces of the pools were painted with black red oxide paint to conserve heat as described by (Sailullah,A. Z,Shahed,I and Saha,A, 2012).The values of temperature variations with height for the four non-convective pools were monitored between 7am to 6pm daily for a period of three months cutting across dry and wet seasons. The data were tabulated and a plots was made for specific days and specific hours (6am) as shown on Fig.1 and Table 1

Height cm	Do temp(^{O}C)	D1 temp(^{O}C)	D2 temp(^{O}C)	D3 temp(^{O}C)
7.0	26.3	29.0	28.2	28.1
14.0	26.0	30.2	30.0	28.9
21.0	26.0	30.9	28.8	19.3
28.0	25.8	30.9	31.0	30.1
35.0	27.4	28.0	19.0	30.9
42.0	26.5	29.0	30.0	31.0
45.5	25.9	30.0	30.1	31.9
49.0	26.9	19.0	30.9	32.0
52.5	27.0	30.3	29.5	31.5
56.0	26.2	31.0	30.5	31.0
61.0	25.0	32.9	31.3	28.0

III. RESULTS AND DISCUSSION

The result of the investigation into the occurrence of successive inversion temperatures in the non-convective pools are summarized in Table 1 and Figure 1 below

Table 1: Temperature distribution with height for four non-convective pools at 6am, $T_a = 24^oC$ on Nov. 22, 2002

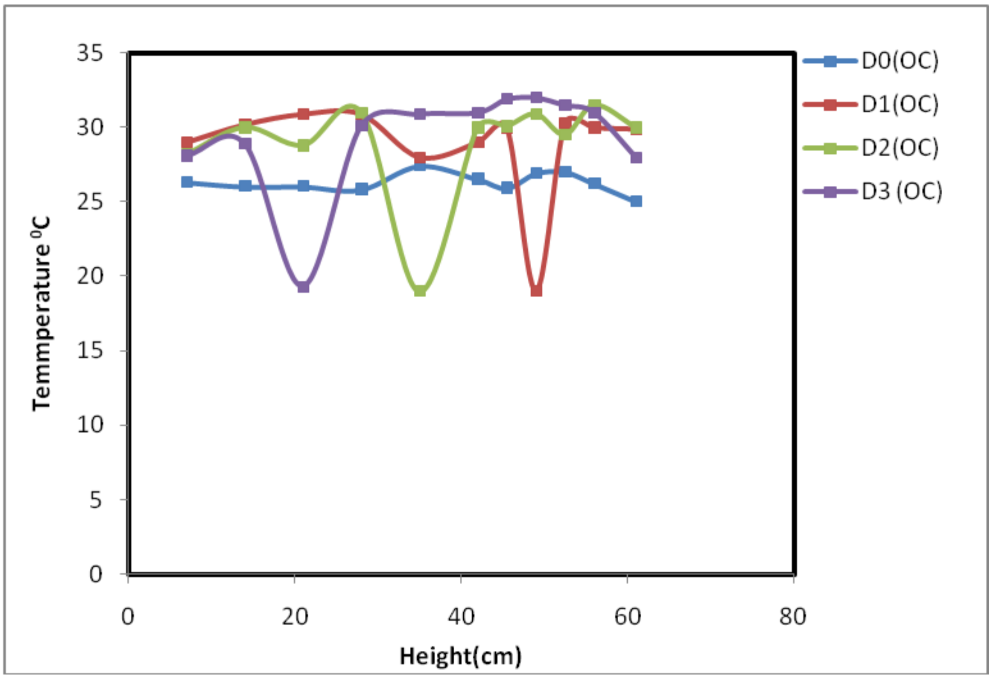

Fig. 1 A graph of temperature distribution with height for four non-convective pools at 6am, $T_a = 24^oC$ on Nov. 22, 2002

The results as shown in both the Table 1and Figure1 above confirm absolute similarity in the nature of the data and phase of the curves. There is a linear trend in the temperature distribution from the point of interaction of solar radiation with the bottom of the pools as we migrate from top to bottom and from 6am to 6pm . The distribution of data from the table shows points of successive temperature inversion occurring across the pools. In pool 1(D1) , inversions occurred at 35cm and 49cm. In pool 2(D2), it occurred at 21cm,35cm and 52.5cm and pool 3(D3), it occurred at 21cm and 45cm.. The trend defines a convolution which affirms temperature inversions expressed in both convex and concave dimensions. Though there is an absolute maximum (positive inversion) and an absolute minimum (negative inversion) across the pools and between 6am and 6pm, but the trend of the distribution in pool D1 ,D2and D3 haven prominent inversions at 49cm,35cm and 21cm respectively. The values of the inversion temperature ranged between 0.1^oC to 10.0^oC for both prominent and minor inversion.At all levels of the experiment, pool Do, with no layer produced no prominent inversions temperature points, while pools D1, D2 and D3 specifying one, two and three layers respectively produced inversions at all prescribed ambient temperatures. This is obvious in view of the fact that, gaseous temperature inversion occurs at the stratospheric layer of the atmosphere where there is an ionic concentration. This ionic concentration could be likened to the multiple layered collectors as defined by Macree (1998), Enumetecal (2005) and Abdul (2011)

IV. CONCLUSION

The research on successive temperature inversions in a non-convective pool subjected to multiple absorbing layers was meant to investigate the distribution of energy in a pool system based on observed temperature gradient. The distribution of energy across the four non-convective pools when solar radiation impinges on the collector surfaces shows irregular non-linear energy transfer. The research reveals that, there is an undulating trend that is presented in a convex and concave dimension called positive and negative temperature inversions. The inversions are prominent at designated heights according to the number of absorbing layers, but there are multiple inversions within a specified pool system. The fall and rise in temperature that define the inversion points ranges between 0.1^{o}C to 10^{o}C across the number of hours under investigation despite the fact that data and analysis for 1 hour was done.

REFERENCES

[1] Abdul, J. N. (2011): Experimental Study of Temperature Stratification in a Thermal Storage Tank in the Static Mode for different Aspect Ratios: ARPN Journal of Engineering Applied Sciences Asian, Vol. 6 No.2 .pp. 250-69.

[2] Acra, C. R. (2006): Photosynthetically Active Component of global solar Radiation. Athens, Press Greece. Pp. 142-148.

[3] Barnard, N. and S ctterwall, F. (2003): Thermal Mass and Night Ventilation-Utilizing “Hidden” *Thermal Mass, Proceedings of Workshops IEA Annex 17, Index*

[4] Benjam, A., Vedz, P., Kroge, D.G (1999).Energy and Environment, Kilurier Academic publisher. Boston, London.

[5] Carring,W.H.(1968).Temperature of evaporation: Trans. Am. Soc. Heat Engr. 24,24 Pp 88

[6] Dincer, I.and Rosen, M.A.(1980).A worldwide perspective on Energy and Sustainable Development.

[7] Engel, T. and Reld, P. (2006): Thermodynamics .Statistical Thermodynamics and Kinetics, Pearson Education Inc. Sam fransisco USA Pp10-20.

[8] Enumetcal, K. J. (2005): Introduction to Solar Radiation. University of Dores. Salam Tanrimar. Pp.750.

[9] Hahne,,E.and Chen,Y.(1998):Numerical study of flow and heat transfer characteristics in hot water stores. *Solar Energy 64-1,P p 9-18.*

[10] Kooi, C.F (1979). The Steady State Salt gradient Solar Pond. *Solar Energy 23(37) pp.145-152*

[11] Macree, k. j. (1998): Energy and the Surface of Earth Academic Press, New York pp. 353-366.

[12] Magal, B.S.(1990):Solar Power Engineering. McGraw-Hills publishing company Ltd, New Dehi Idian

[13] Sailullah,A. Z,Shahed,I and Saha,A (2012):Salar pond and application to Desalination. *Asian Transaction* on Science and Technology.ATST:2221-4283 Vol(02) 1ssue 02

[14] Wang, L and Anguli, L. (2006): A numerical study of Trombe wall for enhancing stack Ventilation in Building.3rd Annual conference on Passive solar and Active solar energy Architecture, Gene, Switzaland.