A SHIFT IN INVERSION TEMPERATURE POINTS IN A NON-CONVECTIVE POOL SUBJECTED TO MULTIPLE ABSORBING LAYERS,

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ABSTRACT: *A survey on temperature inversions in a non-convective pool subjected to multiple absorbing layers was conducted in cross River University of Technology, Calabar. Temperature data were generated by monitoring temperature variation with height for four experimental model pools D_1,D_2,D_3 and D_0 with one, two,three and zero absorbing layers respectively(transparent glass material of thickness measuring 0.5 cm), using high mercury in-glass thermometers.The model pools were drums of height measuring 83 cm, perforated at graduated distances inserted with thermometers, and lagged with insulating materials(styropor) of thickness measuring 2.5 cm.The multiple absorbing layers were placed at the top of the drums at interval distances of 10 cm between them.Temperature monitoring was carried out between 6 am and 6 pm for two distinct seasons(dry and wet seasons) on hourly basis, Results obtained from this study showed that a shift in inversion temperature points occurred across the length of the three non-convective pools D1 having at 45.0 cm, D2 at 35.0 cm and D3 at 21.0 cm. The range of inversion temperature was between 0.1^{o}C to 15 ^{o}C and occurs at all times of the day with convex(negative) inversion being more prominent.*

KEYWORDS: A Shift in Temperature inversion, multiple absorbing Layers, Thermometer, non-Convective pools.

INTRODUCTION

Globally, solar energy research in both active and passive devices has reached an advanced stage. Though the distribution of energy in these systems before final conversion to the load, has created a vacuum in research findings that calls for an investigation into knowing why?Solar pond when compared with other forms of energy has provided the greatest advantage in terms of its environmental friendliness and pollution free mechanism. Clearly , Centuries ago fossils fuels have provided a greater percentage of the much needed energy due to its cheapness and convenience than alternative source of energy , until the recent environmental challenges became the world concerned. The natural conversion of solar radiation into electricity by use of ocean's natural thermal gradient is also a critical factor in energy generation.The ocean is one the largest collectors with different layers of temperatures defined by their gradient. The temperature difference between the top and bottomlayer ranging to several degrees can produce significant amount of power needed for energy generation (Carrier, 1968).

Solar pond technological designs use this natural ocean gradient to generate thermal power. This technology is in use globally and is a necessary and sufficient technology to be used in Nigeria if developed. Since most oceanic waters are salty, the harnessing potential here therefore becomes salt gradient pond (SGP). It may be important to know in future whether we could achieve this experimentally without salt gradient (Saillullah, Shahed and Saha, 2012).

However, different research findings in harnessing solar energy potentials through solar pond technology, thermosyphon and solar water heater, introduced a transparent absorber (gazing).The absorber transmits all short waves radiation and increases the heating effect by the trapped long wave radiation (Enumecal, 2005). In all, the behavior of temperature gradient in transferring energy along the profile of the model apparatus is observed to be linear. Empirical research byYamaha and Nobou (2001) on thermal energy generation observed a non-linear temperature profile which was called "collapsing temperature phenomenon". The lack of explanation to this effect therefore created a vacuum that necessitated research into knowing the cause of the anomaly.

Temperature gradient plays a vital role In the creation of inversion temperature points in almost all absorbing media. The inversion points perturb the even distribution of energy in these systems. Temperature inversion is a natural phenomenon that occurs in both gaseous and liquid media alike. In gaseous media, they are various types of temperature inversions which are classified by their positions in the atmosphere such as elevated or surface-based inversions. The other type is formed from radiation, turbulence or subsidence inversion (Kooi, 1979).

Inversion temperature is based on the processes that are principally responsible for their formation. Studies by Whiteman (1980) on valley temperature inversion showed that the atmospheric temperature normally decreases with height. He further observed an irregular behaviour in the linear temperature distribution, which followed a sudden increase. This, he called an "inversion".

Carrier (1968) conducted a study on atmospheric temperature distribution and observed that a convective boundary layer (CBL) is attributed to the presence of water vapour in the atmosphere.In thermodynamics, a CBL is usually considered as a layer in which potential temperature is independent of height. He further opined that an anomaly occurs when the temperature lapse rate is less than adiabatic lapse rate. This was called an inversion temperature.

Kamgba, Ekpe and Nnabuchi, (2014) in their study of the occurrence of successive temperatures inversion in a non-convective pool subjected to multiple absorbing layers, observed multiple temperature inversions across the pools. This is due to the fact that multiple reflections and local

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thermodynamic equilibrium exist within the interface of the absorbing layers, which results to loss of energy within the system. The non-convective pool system does not give room for energy transfer because of developed stratified layer. Note that at the point of inversion, changes in temperature over changes in height will equal zero $(\frac{dT}{dx} = 0)$, at this point the system temperature falls far below the prescribed distribution level or rises above the normal levels.

MATERIALS AND METHODS

The four model non-convective pools were steel drums of diameter measuring 57.0 cm and height of 83.0 cm,eleven thermometers were inserted at designated heights measured from the base. The thermometers occupied the height measuring between 7.0 cm to 63.0 cm. The process was followed by lagging with the insulator (styropo) of thickness measuring 2.5 cm and the introduction of water volume up to 60.0 cm. Finally, multiple absorbing layers (plane glass collector covers) were placed. 1-glass for pool 1, 2-glasses for pool two, 3-glasses for pool 3 and no glass for pool 4. The first glassescovered the surface of the drums,the second and the third glass were separated by a distance of 10 cm 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, Shahed and Saha, 2012). The values of temperature variation with height for four non-convective pools were monitored between 6 am to 6 pm daily for both dry and wet seasons. The data were tabulated and plots were made for specific days and hours (7 am and 8 am) as shown in Figure 1,2 and Tables 1, 2.

RESULT AND DISCUSSION

Table 1: Temperature Distrubution with height for four

Non-Convective pools at 7 am, Ta=24.9 ^{o}C, on Nov. 22,2012

Height(cm)	D_0 Temp(^{o}C)	D_1 Temp(^{o}C)	D_2 Temp(^{o}C)	D_3 Temp(^{o}C)
7.0	26.1	29.1	28.2	28.1
14.0	26.6	30.2	30.0	28.9
21.0	26.0	30.3	28.5	19.2
28.0	25.8	30.5	31.6	30.1

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35.0	27.5	28.5	19.2	30.9
42.0	26.5	29.0	30.0	31.0
45.5	25.9	30.0	30.0	31.5
49.0	26.9	19.0	30.7	32.0
52.5	27.0	30.1	29.5	31.4
56.0	26.2	30.0	31.5	31.0
63.0	25.1	31.0	30.1	28.1

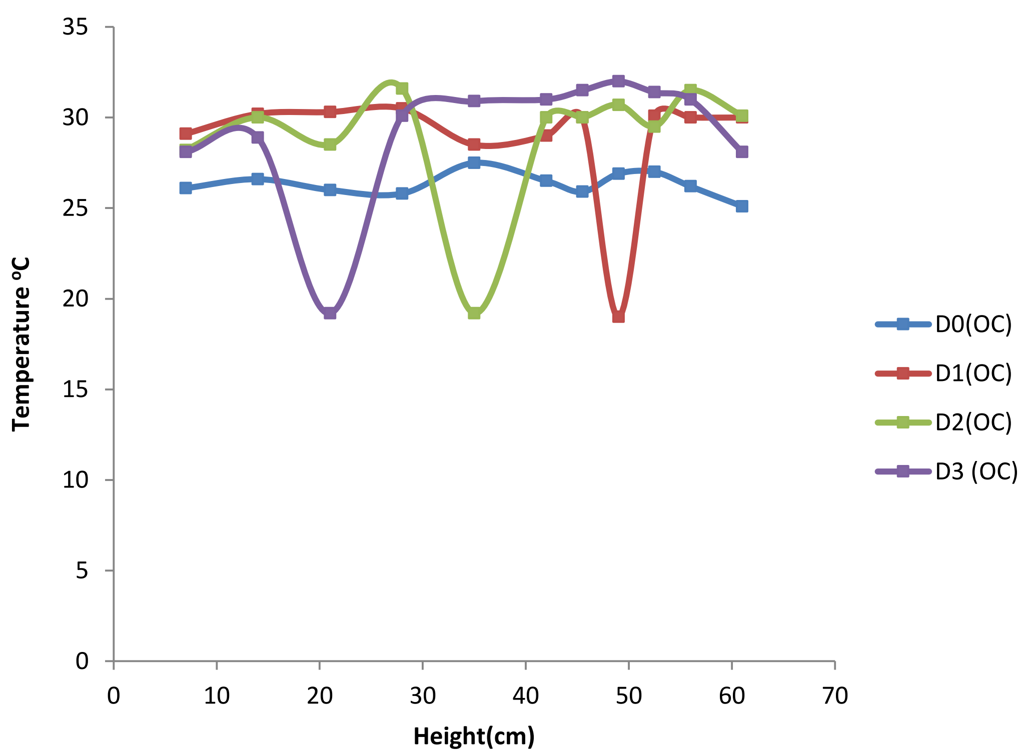

Figure1.0: A graph of Temperature Distribution against Height for Four

Non-Convective Pools at 7am, T_a = 24.9°C on Nov. 22, 2012

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Table 2: Temperature Distribution with Height for Four

Non-Non Convective Pools at 8am, T_a =28.6°C Nov. 22,212

Height(cm)	D_0 Temp(°C)	D_1 Temp(°C)	D_2 Temp(°C)	D_3 Temp(°C)
7.0	26.5	29.5	28.8	28.5
14.0	27.6	30.5	30.0	29.0
21.0	26.6	30.8	29.0	20.0
28.0	25.9	30.8	31.9	30.3
35.0	27.9	28.5	19.9	30.9
42.0	26.9	29.1	30.4	31.0
45.5	26.0	30.0	30.0	31.9
49.0	27.6	19.0	30.9	32.0
52.5	27.3	30.3	29.8	31.5
56.0	27.6	30.4	31.9	31.1
63.0	28.1	34.1	33.0	31.0

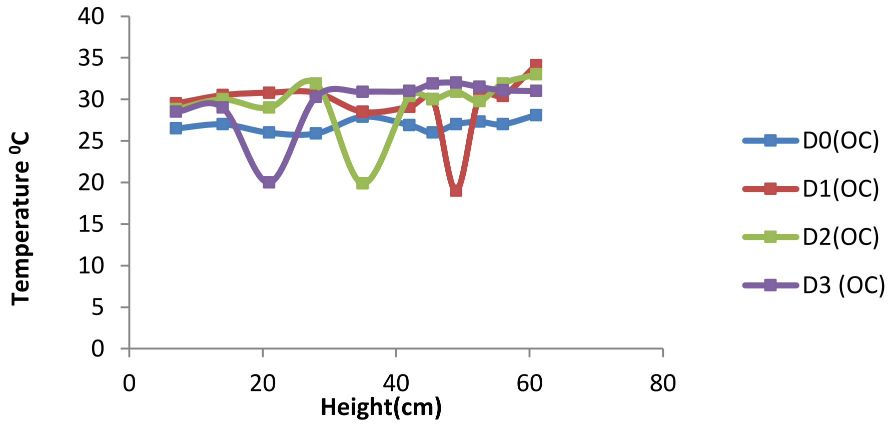

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Figure 2: A Graph of a Temperature Distribution against Height for Four Non-Convective pools at 8am,T_a = 28.6^oC on Nov. 22,

The results presented in tables 1 and 2 , figures 1 and 2 at 7 am and 8 am respectively show similarities 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 radiant energy and the collector plate at the bottom of the pools as we migrate from top to bottom and from 7 am to 8 am. The distribution of data from the tables show points of shift in inversion temperatures occurring acoee the three pools. In pool 1(D_1), inversions occurred at 49.0 cm with temperature of 19.0 ^oC. In pool 2 (D_2), it occurred at 35.0 cm with temperature of 19.9 ^oC and 19.2 ^oC. At pool 3 (D_3), It occurred at 21.0 cm with a temperature of 20.0 ^oC and 19.2 ^oC respectively.The trend defines a convulation which affirms temperatures inversion expressed in both convex and concave dimemsions. Though there is an absolute maximum (positive inversion) and an absolute minimum (negative) across the pools and between 7 am through 8 am, but the trend of the temperature in pool D_1, D_2 and D_3 having prominent inversion temperature ranged between 0.1^oC to 13.0 ^oC for both prominent and minor inversions.

Atall levels of the experiment, pool D_1, with no absorbing layer produced no prominent inversion temperature points, while D_1,D_2 and D_3 specifying one, two and three absorbing 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. Th ionic concentration could be likened to the multiple layered collectors as defined by Macree (1998), Enumetecal (2005) and abdul (2011).

CONCLUSION

The research on temperature gradient in a non-convective pool subjected to multiple absorbing layers was meant to investigate the distribution of energy in a pool system based observed temperature gradient. The distribution of energy in the pool system is based on temperature gradient. The distribution of energy across the four non-convective pools is facilitated by solar radiation absorption in the collector media, which shows irregular or non-linear energy transfer.The research reveals that, there is an undulating trend that is presented in convex and concave dimensions called positive and negative temperature inversions. There is a shift in inversion temperature points at designated heights according to the number of absorbing layers. The fall and rise in temperature that defines the points of inversion ranges between 0.1oc to 13.0oc across the number of hours under investigation despite the fact that data analysis was done for a period of two hours.

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REFERENCES

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.

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

Benjan, A. Kenney, D.W and Kenith,F (1981). Second Law Analysis and Synthesis of Solar collector Systems.*Journal of Solar Energy Engineering.Vol. 1103. Pp:20-29*

Barnard, N. and Sctterwall, F. (2003). Thermal Mass and Night Ventilation-Utilizing "Hidden" *Thermal Mass, Proceedings of Workshops IEA Annex 17, Index*

Carrier, H.W. (1968). The Temperature of evaporation: Trans. Am. Soc. Heat Engr. 24,24Pp: 88

Dincer, I. and Rosen, M. A. (1980).A worldwide perspective on Energy and Sustainable Development *int.journal of .Energy. 22(11)pp: 305-21*

Engel, T. and Reld, P. (2006). Thermodynamics .Statistical Thermodynamics and Kinetics, Pearson Education Inc. San francisco USA Pp:10-20.

Enumetcal, K. J. (2005). Introduction to Solar Radiation.University of Dorset, Salam Tanrimar.Pp: 750.

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

Kamgba, F. A., Ekpe, O. E and Nnawuchi, M. N *(2014).*The Occurrence Of Successive Temperature sInversion in a Non-Convective Pool Subjected to Multiple Absorbing Layers**.** *Internation Journal Of Engineering And Science Inovention(Ijesi) Vol(3)7*

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

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

Magal, B.S.(1990). Solar Power Engineering. McGraw-Hills publishing company Ltd, New Dehi India

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

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, Switzerland.

Whiteman, C. D and McKee, T. B. (1980). A Time – Dependent model of Temperature Inversion Structure in Mountain Valley PreceedingsAms/APCA Second joint Conference on Air Pollution Meteorology, Boston

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