FUPRE Journal

of

Scientific and Industrial Research

ISSN: 2579-1184(Print) ISSN: 2578-1129 (Online)

http://fupre.edu.ng/journal

Profiling Temperature Variation and Effect in a Static Vehicle in a Radiation Non-Interference Zone of the Niger Delta

AMADI, R. K. C.[1,*], *SOTONTE, E. J.*[2] *OYOKUNYI, E.*[3]

[1,2,3] *Department of Mechanical Engineering, Rivers State University, Port Harcourt.*

ARTICLE INFO

Received: 02/12/2022
Accepted: 10/03/2023

Keywords

Cracking, Niger-Delta, Pin-line, Vehicle, Temperature

ABSTRACT

This work is targeted at assessing the influence of closing all ventilation sources of an immobile vehicle exposed to direct sunlight in the Niger-Delta region. It involves experimental methodology in which two vehicles of different capacities and tinting levels were assayed simultaneously. Temperature measurement gadgets were the instruments utilized to record temperature at various positions of the vehicles. Records were also taken for convective heat purposes near the dashboard, front windscreen, rear windscreen and back windscreens. The windows were also cracked to various lengths and the effects recorded. Results revealed different levels of temperature build-up with time, with the dashboard having the highest temperature in both cabins and the tinted rear unit showing the lowest level of temperature rise. The pin-line effect was found to apparently reduce temperature at an infinitesimal extent. However, cracking the screen to a length of 15 to 25 cm proved reasonable with respect to cabin temperature reduction in a Niger- Delta zone. This result of achieving a reasonable cracking length compares favourably with the results of other works.

1. INTRODUCTION

It is no longer strange that small animals suffocate, materials get oxidized and life objects become asphyxiated when positioned in static locked vehicles. These attendant issues have raised curiosity on whether or not the nature of the climatic zone can be a panacea to the situation in such locked static vehicles.This study is aimed at determining the temperature profile and temperature effect on a motor vehicle cabin in a Niger-Delta environment. The objectives set out to achieve this task are as follows

i. To determine the temperature increment inside the vehicle cabin when exposed to direct sunlight.
ii. To make a comparison of temperature effect at time intervals

The Niger Delta is a climatic zone with high canopy vegetation that serves as both diffused radiation source and wind breaks. It is therefore essential to understudy the extent to which a closed packed cabin window should be cracked to achieve temperature drop, suitable for life comfort and survival.

Studies posit that temperature of a parked car's cabin will increase gradually when exposed to

*Corresponding author, e-mail: kemkom.amadi1@ ust.edu.ng
DIO

the sun. Solar radiation has been defined as transient energy which is a form of electromagnetic energy that travels as a harmonic wave consisting of the different bands and responsible for temperature rise (Amadi, 2022a). The interior and outside temperatures will be different compared to ambient temperature, and will be suitable for thermoelectric generators (Sunawar, 2019; Amadi, 2022b). Such cabins are designated confinements that separate the internal, temperature-controlled system from the outer surrounding of a vehicle. It is meant to give comfort to occupants of the cabin, by ensuring that thermal comfort and a luxuriant driving are achieved. To further give solution to the closed cabin effect, Chandru (2018) researched on the utilization of phase change material as a means of attaining heat removal in closed packed cabin under direct sun radiation for a period of 1 hour. It was shown that phase change materials competed favourably with the use of other techniques like air conditioners. Saleel *et al.* (*2019*), and Marshal *et al.* (*2019*),l noted that aside from hyperthermia, car fading and possible death of neonates, closed cars packed under sun become prone to increased fuel intake to assuage the built up heat. Saleel *et al.* (*2019*) further used Coconut oil was used as a phase change material to reduce built up heat in the cabin. In line with related literature's and agreeing with most scholars concerning the harm meted out by a radiant energy-exposed properly locked car, a phase change material integrated roof was developed to cater for the excess heat (Purusothaman *et al.*,2017). Srusti*et al.*,(2020) investigated the experimental and numerical ways of using appropriate PCM to stabilize vehicle temperature. The roof, head, bottom and feet were different points selected for *monitored by temperature sensors.

2. MATERIALS AND METHODS

The study area is on Latitude 4.7974^{o}N, Longitude 6.9803^{o}E in the Niger-Delta part located in southern section of Nigeria, very well known for its coastal climes and rich petroleum presence. Its attendant resources have led to massive evasion of its natural environment, sake of indiscriminate activities via oil and gas. This activity is pursuant to the aimless jettisoning of petroleum (both essential and refuse), which to an extent affects the level of radiation in the zone (Babatunde *et al.*,2019). The work involved the use of experimentation.

2.1 Experimental Mode

The investigation carried out, implores experimental tips in arriving at results.It involves the selection of a very open area devoid of atmospheric and solar radiation interference. It incorporated the use of a mini-van vehicle with different levels of tinting at the glasses to assist in the assessment of their effect. The back, rear, and middle glasses had full tints while the front side glasses were plain. The front wind screen had partial upper tinting. A second vehicle- a Toyota Camry car with plain wind screens was also used. Temperature reading instruments like thermometers and thermocouples were placed at 4 distinct points (dashboard, front glass, middle glass and back (rear) glass) in the vehicles and readings recorded at specified periods. The experiment was conducted between 10.00 am and 3.00pm when the sun radiation was highest. Analysis involved the use of graphical expressions to present results, calculation of mean temperature in the mini-van and calculation of ambient heat load in the cabin.

2.2 Theories and Applicable Models

The implementation of this research work was actualized through the use of some numerical tools to investigate the affected properties. These include.

i. Mean Temperature

Mean temperature value is derived from common statistical measurement of averages as $T_m = \frac{\sum_{i=0}^{n} A_{Si} T_i}{\sum_{i=0}^{n} A_{Si}}$ (1)

Where T_m = Mean value of radiant temperature, T_i = surface temperature, A_{Si} = Surface area.

ii. Ambient Heat Load

This is simply the amount of heat developed by differential temperature between the interior and surrounding of the cabin. The mode of heat transfer being by convection. Convective transfer is used specifically since the material properties were not well known. As such, the values considered for the surfaces were those of the fluid in the surface neighbourhood which is properly heated up.

iii. Convective Heat Transfer

This employs the Newton's law of cooling which implies that the rate of heat exchange (Q) in a system is directly proportional to the difference in the temperatures between the system and surrounding. It is given as

$$Q = h_a \sum_{i=1}^{n} A_i (T_i - T_a) \quad (2)$$

Where $\mathbf{A_i}$= Surface area of heat transfer, h_a= air heat transfer coefficient, T_i= Temperature near object surface, T_a = Surrounding air temperature.

Given surface areas of Toyoto Sienna are:
Front screen = 13137 cm^2, Back screen =10441cm^2, Front Side screen = 3752.5 cm^2, Middle Side screen = 7585 $cm^{2,}$, Rear Side screen = 3560.5 $cm^{2,}$ dashboard area of 0.3$m^{2.}$

3. RESULTS AND DISCUSSION

3.1 The Temperature Effect when the Vehicle Windows are closed

The two vehicles were placed directly in the sun where the temperatures of the vehicles were taken simultaneously at different time intervals, The results obtained for both vehicles were recorded in Table1 for Toyota Sienna and Table 2 for Toyota Camry

Table 1: Temperature Readings for Toyota Sienna (Metallic colour)

Resident time (Min)	**Surrounding Temperature (T_a) (°C)**	**Front Temperature (T_f) (°C)**	**Front Difference (T_f - T_a)**	**Rear Temperature (T_R)(°C)**	**Rear Difference (T_R - T_a) (°C)**	**Side Temperature (T_{sd}) (°C)**	**Side Difference (T_{sd} - T_a) (°C)**	**Dash Board (T_D) (°C)**	**Dash Board Difference (T_D - T_a)(°C)**
0	41.5	41	-1.5	34	-7.5	36	-5.5	41^o	-0.5
10	43	47	4	42	-1	43	0	57	14°C
20	38	47	9	45	7	45	7	58	20
30	45	54	9	46	1	49	4	62	17
40	45	59	14	48	3	50	5	67	22
50	42	59	17	49	7	51	9	65	23
60	38	59	21	47	9	48	10	60	22
70	39	54	15	48	9	51	22	57	18
80	42.5	58	25.5	48.5	6	50	17.5	64	21.5
90	40	54	14	49	9	51	11	60	20

Table 1 revealed that the highest temperature change occurred with the dashboard at 80 minutes of exposure, yielding a value of 25.5°C. If a convective heat coefficient of 5 W/(m^2K) , dashboard area of 0.3m^2 is used, then the heat generated Q is 38 J. The rear had the lowest temperature change of 7 °C generated 12.46 J of heat energy

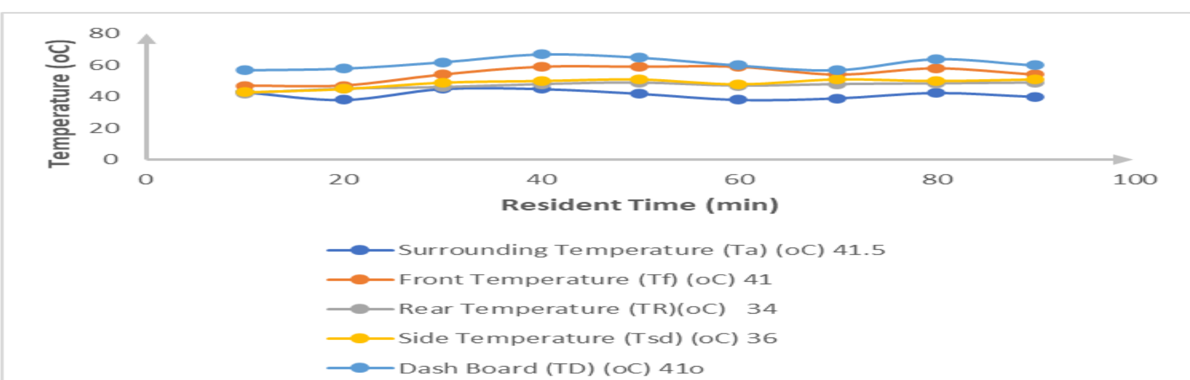

Figure 1: Temperature variation profile for Toyota Sienna

The trend in Figure 1 shows an overall increase in the temperature of all the investigate parts, though there was a few fluctuations as can be seen

Table 2: Toyota Camry

Resident time (Min)	Surrounding Temperature (T_a) (ºC)	Front Temperature (T_f) (ºC)	Front Difference ($T_f - T_a$)	Rear Temperature (T_R)(ºC)	Rear Difference ($T_R - T_a$) (ºC)	Dash Board (T_D) (ºC)	Dash Board Difference ($T_D - T_a$)(ºC)
0	41.5	37	-4.5	38	-3.5	40	-1.5
10	43	51	8	55	12	59	12
20	38	52	14	56	18	63	15
30	45	55	10	58	13	67	14
40	45	58	13	62	17	69	9.5
50	42	59	17	62	20	67	15
60	38	56	18	62	24	69	18
70	39	53	14	58	19	67	17
80	42.5	57	14.5	60.5	18	58	15.5
90	40	56	16	60	20	57	17

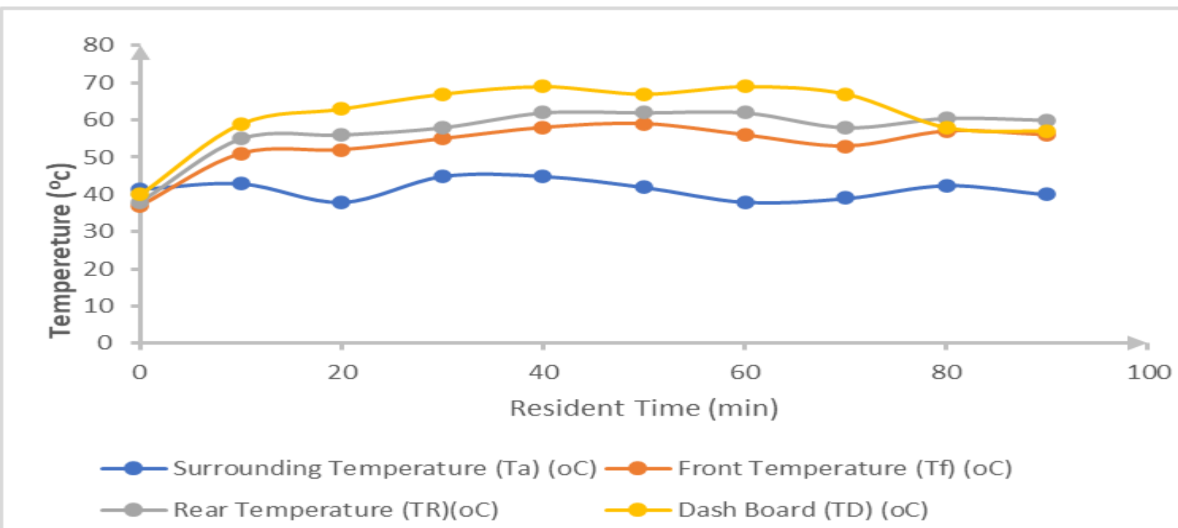

Figure 2: Effect of Resident time on Temperature

Figure 2 was used depict the presence of variation in temperature when the vehicle was exposed to sunlight at specified time interval. Basically, the surrounding temperature showed an undulating form which was adduced to be as a result of air motion . This result on surrounding temperature is in consonance with the provisions of (Amadi & Sodiki, 2022). The top most curve represents the temperature of dashboard, there is however an increment in the vehicle temperature on the variation.

3.1.1 The Temperature Effect when the Vehicle Windows was remediated (reduced) by a Pin Line of 1.1cm

The two vehicles were placed directly under the sunlight with its windows opened by 1.1cm where the temperatures of the vehicles were taken simultaneously at different time intervals, The results obtained for both vehicles were recorded a

Table 3: Toyota Sienna at 1.1cm

Resident (min)	Surrounding (ºC)	Front T_f(ºC)	Front change T_{f1} - T_{f2}(ºC)	Rear T_R (ºC)	Rear Change T_{R1} - T_{R2} (ºC)	Dash board T_D (ºC)	Dash Change T_{D1} - T_{D2}
0	38	48	0	47	0	55	0
10	38	49	-1	46	1	53	2
20	40	46	3	48	-2	59	-6
30	38	43	3	47.5	0.5	54.5	3.5
40	41	40	3	47	0.5	57	-2.5

Table 4: Toyota Camry at 1.1cm

Resident (min)	Surrounding (ºC)	Front T_f(ºC)	Front change T_{f1} - T_{f2}(ºC)	Rear T_R (ºC)	Rear Change T_{R1} - T_{R2} (ºC)
0	38	51	0	52	0
10	38	51	0	53	-1
20	40	53	-2	56	-3
30	38	51	2	54	2
40	41	51.5	-1.5	55	-1

From both cases at a pin line space of 1.1cm on Tables 3 and 4, there were no clear-cut fall or rise in temperature due to fluctuation of radiation level as shown by temperature change. it is also very difficult to determine what parameter to base the temperature measurement (final temperature - initial temperature) since the level of radiation is not considered and, the experiment was conducted in an uncontrolled environment (open atmosphere), where the temperature varies with radiation level and other factors. From mechanics of the fluid at 1.1cm pin line, the rate of accumulation of system convected air surpasses the change in inflow and outflow, making the forced convection in the system very minimal. A random check carried out however showed a sharp drop in system temperature due to increased air mass flow rate in and out of the vehicles as such, increasing free convection.

For both cars, at 15- 25cm cracking width, the value obtained in 5 to 10 minutes range placed the vehicle at near ambient temperature except for near the dashboard which had upto 4-5 degrees celcius variation from the atmospheric temperature.

4. CONCLUSION

In order to determine the mode of temperature when a vehicle was packed in the sunlight without the effect of shades, the effect of temperature increment was investigated. It was realized that temperature varied at different position in the vehicle with the dashboard giving the highest value.

A comparison of the effect of temperature at different positions with time also indicated that temperature increased with time. The maximum amount of heat was generated at the dashboard and the minimum amount was generated at the rear side. this increment was seen to be remediated with the introduction of a pin line at the windows.

Closed cabin had a rapid increment in temperature. Pin-line had slight effect which increased rapidly which high level cracking of the windows in terms of cooling the car. The average ambient temperature of the car approaches the environmental temperature to a great with time.

Reference

Amadi, R.K.C. (2022a). Exergy Analyses of Solar Irradiation Exposed Photovoltaic Panel and Water Film Effect. *Journal of Modern Thermodynamics in Mechanical System 4*(2), 15-22.

Amadi, R.K.C. (2022b). Cooling degree days: an energy audit tool for hospitals. *Nigerian Journal of Oil and gas Technology, 4* (1), 1-10.

Babatunde, B. B., Sikoki, F. D., Avwiri, G. O., & Chad-Umoreh, Y. E. (2019). Review of the status of radioactivity profile in the oil and gas producing areas of the Niger delta region of Nigeria. *Journal of environmental radioactivity*, *202*, 66-73.

Chandru Deva Kannan, P. (2018). *Extraction of heat inside the car cabin using phase change material to maintain human comfort.* Doctoral dissertation, Mechanical Engineering, PEC, Pondicherry University, india.

Marshall, G. J., Mahony, C. P., Rhodes, M. J., Daniewicz, S. R., Tsolas, N., & Thompson, S. M. (2019). Thermal management of vehicle cabins, external surfaces, and onboard electronics: An overview. *Engineering*, *5*(5), 954-969.

Purusothaman, M., Sam Cornilius, C., & Siva, R. (2017). Experimental investigation of thermal performance in a vehicle cabin test setup with pcm in the roof IOP Conference. *Mater Sci Eng*, *197*(1).

Saleel, C.A., Mujeebu, M.A. & Algarni, S. (2019). Coconut oil as phase change material to maintain thermal comfort in passenger vehicles. *J Therm Anal Calorim* **136,** 629–636

Srusti, B., Aravind, S., Yadhu, K., Aashish, V., & Kumar, M. S. (2020, October). Experimental and Numerical

Investigation of Car Cabin Temperature under Solar Load Condition using Phase Change Materials. In *IOP Conference Series: Earth and Environmental Science* (Vol. 573, No. 1, p. 012024). IOP Publishing.

Sunawar, A., Garniwa, I., & Hudaya, C. (2019). The characteristics of heat inside a parked car as energy source for thermoelectric generators. *International Journal of Energy and Environmental Engineering*, *10*(3), 347-356.

.