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Design and Development of Car Umbrella to Reduce Temperature of Car Cabin in Parked Condition

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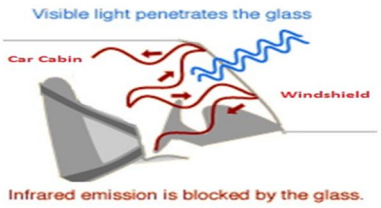
I. INTRODUCTION

Whenever a car is parked under direct sunlight, the inside temperature can soar to dangerously threatening levels. The principle behind this phenomenon is called Greenhouse Effect. The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without its atmosphere. If a planet's atmosphere contains radioactively active gases (i.e., greenhouse gases) they will radiate energy in all directions. Part of this radiation is directed towards the surface, warming it.

Therefore, sunlight falls on the carpet and plastic parts within the car and then they re-radiate that energy in infrared spectrum. Now, water vapor and CO in the air within your car will absorb this re-radiated IR energy and thus, the heat gets accumulated continuously. This heat is trapped inside the car as there is no exit point.

This is a general temperature profile within the car parked in direct sunlight:

10 Minutes – Car Interior: 43°C
20 Minutes – Car Interior: 48°C
30 Minutes – Car Interior: 51°C
1 Hour – Car Interior: 56°C
90 Minutes – Car Interior: 59°C



The Customer demand for thermal comfort requirement in the passenger cabin is infinite. The thermal management of the passenger cabin within a car in a parked condition is an active research area. Bright sunlight's will effectively increased temperature of car cabin in parked condition. The longer infrared wavelengths transfer through window glass in car cabin. These longer infrared wavelengths re-radiation from the heated objects in car cabin is unable to pass out from window glass also it cannot lose the energy by convection. The entrapment of this energy warms the interior of the vehicle.

Sunlight travels from the sun in the visible part of the spectrum (white light). The sunlight is absorbed by the surface of the car (e.g. dashboard and the carpet). Since sunlight is radiated energy, the impact surface heats up due to absorption of this radiated energy. A point that becomes especially apparent when you enter your car that's been parked in the sun; even if it's been there for just half an hour While we can't totally get rid of that 'driving in a furnace' feeling. So avoiding as much direct sunlight as possible will help dramatically. Cars overheat most often in very hot weather. It's rare with modern vehicles, but even a well-tuned automobile can overheat. If you find yourself in stop-and-go traffic or climbing a steep grade on an extremely hot day, and your dashboard temperature indicator starts to rise or a malfunction indicator light comes on, here's how to help your vehicle regain its cool.

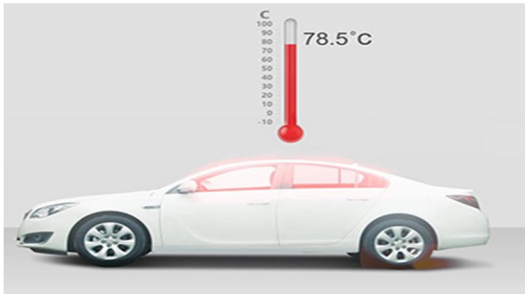


Fig : Temperature of car when parked in direct sunlight

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The sun and heat can be very damaging to a car. During testing conducted at the State Farm Vehicle Research Facility, interior air temperatures have been recorded well in excess of 62.77° C and vehicle interior surface temperatures on areas exposed to direct sunlight in excess of 90°C.But it's not just the dashboard and seats that you need to look out for, a car's finish and engine are also at risk. So whether you live in a warm climate year-round or just need protection during the summer months, it's always best to be safe and prepared.

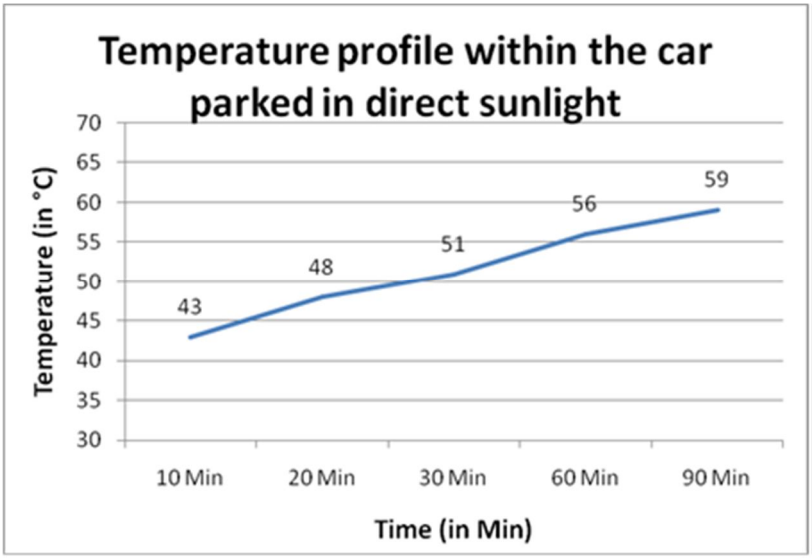

Fig : Temperature Profile within the Car Parked In Direct Sunlight.

A. Problem Definition

The closed stationary vehicles cabin temperature in direct sunlight can quickly rise to a level that may damage property and harm children or pets left in the vehicle. The problem that is faced by many car users today is a hot interior after certain minutes or hours of parking in open air or unshaded parking area. The accumulation of thermal energy inside the vehicle with undesired temperature rise would cause the interior parts to degrade because they normally are subjected to wear and tear. Degradation may shorten the life span of the various components inside the car. Passengers are also being affected with the thermal condition inside the vehicle itself. The car user is forced to wait for a period of time before getting into the car to cool down the interior condition either by rolling down the window or running the air conditioner at high speed that really affect the fuel consumption.

It happened to you at every time in summer season that you are going to travel somewhere and you want to take a pause due to car cabin temperature was very high while car in parked condition. Many times you circled and looked for parking in the shade or not found and you had to park at worst the sun and leave your car to be glowing. So, you need to minimize the car cabin temperature of parked car. As such any improvement in car cabin temperature of parked car with cost effective solution provide us a revolutionary thing with improvement in Human comfort.

B. Problem Description

High solar global isolation causes typically very high ambient temperature especially during summer season. During summer if the cars are parked directly under the sun, cabin inside the car will experience a kind of greenhouse effect this will lead to higher cabin temperature and cause problems inside the car like color fading and seat upholstery wear and tear and even cause damage to other cabin elements. The high temperature prevailing inside the vehicle parked under the sunlight is definitely unreceptive to the occupants when they arrive to take a drive.

Solar radiation energy invariably contributes towards a very dangerous phenomenon called greenhouse effect inside the vehicles cabin parked under the scorching sun. Vehicles parked under the daylight experience sharp rise in the cabin temperature due to the trapped solar radiation. The solar radiation which enters inside the car is to some extent trapped by the wind shields of the car hence contributing to the greenhouse effect. It’s often seen that, vehicles which are parked in the sun especially during hot summer day, experience drastic rise in the cabin temperature, especially steering wheel, seats, dashboards record temperature almost double that of ambient outside temperature.

Why umbrella used-

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Have your vehicle repaired and ready for the long journey? But there is one thing that bothers you year by year: every time you stop for the rest, the summer sun does the best, and increases the temperature of your vehicle to the unbeatable level. Therefore, you should need a car umbrella: an evolution car cover for your vehicles.

When car is parked in direct sunlight then which parameters affect -

1) Acid rain
2) Bird droppings
3) Dust and more.

Due to the above rain and heat can cause devastating damage both outside and inside. If you have found a parking lot, then you certainly know what I am talking about. Even if you have a covered place, you still have your car to park in open spaces very often, and the same conditions will affect your car in the long run. When prolonged exposure to rain damage the outer metal body of car reduce its life.

From the above, car is parked under direct sunlight, the inside temperature can soar to dangerously threatening levels which create a adverse effect on the comfort level of human who have to sit inside the car and travel further. So, to reduce such problem we find following several solutions which is cost effective:

II. SOLUTIONS

A. Car Umbrella

How many times has it happened to you that you are going to travel somewhere and you want to take a pause? Many times you circled and looked for parking in the shade or not found and you had to park at worst the sun and leave your car to be glowing. How many times did you go to the beach, alone or with your family, and upon returning home have to be uncomfortable.

Driving in a hot automobile? If you have experienced such inconvenience things, you need to start thinking about how to protect your car. There are two options: Traditional car covers with manual functions and innovative auto car covers that come with an automatic mechanism.

III. DESIGN & MODELING

A. Case Study

Car- Renault kwid

Specifications:	The specification of the umbrella are as follows:
Overall lengh-3679 mm	Length of long linkage: 2814mm
Height-1478 mm	Length of short linkage: 1800
Breadth-1579 mm	Angle between two adjacent linkage: 25°&45°
Wheel base-2422 mm	Length of single long link: 580mm
Ground clearance-180 mm.	Length of singlr short link:290mm
Temperature- 35°c	

B. Linkage Analysis

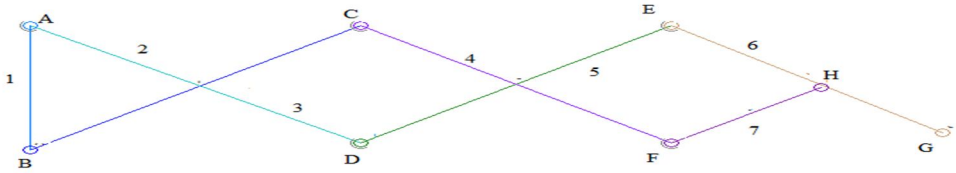

Fig. linkage mechanism

Link: The link is that part of machine which has motion relative to some other parts it is resistant body or assembly of resistant bodies connected in such way that they from single part of it having no relative motion between them.

In above linkage mechanism the total no of links is 7.

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C. Binary Joints

If two links are joined at same point it is called as binary joint. Each link has two ends for connections. We have A, B, C, D, E, F as six joints.

No of joints = 6

D. Ternary Joint

In this joints three links are connected at same point, it is equivalent to binary joint,

No of joints = 1 (H)

Conversion to binary joint= (l-1) = (3-1) × 1= 2

We know the, Kutzbatch equation,

N= 3 (l-1) - 2j - h

Where,

No of link = l =7

No of joint = j = 6+2 = 8

No of higher pair = h = 0

By formula we put the values,

N= 3 (l-1) - 2j - h

N= 3 (7-1) - 2×8 – 0

N = 18-16 = 2

If N = 2, then the mechanism is known as two degree of freedom. So we required two motions from two sides.

E. Design of Link

1) *Air Force Calculations:* Depending on the measuring instruments used, different sets of equations for the calculation of the density of air can be applied. Air is a mixture of gases and the calculations always simplify, to a greater or lesser extent, the properties of the mixture.

$$\therefore \rho = P / (R(specific.) * T$$

Where,

ρ = Air Density (kg/m^3)

P = Absolute Pressure (Pa)

T = Absolute temperature (k)

R(specific)= Specific gas constant of dry Air (J/kg.k)=287.58(J/kg.k)

Quality of change its molecular structural on their location.

Temp in ℃	Speed of sound in m/sec.	Density of air in $\rho . kg/m^3$	Acoustic impedance(Ze)
35	351.88	1.1455	403.2

temp. Sheet

Altitude of Ashta city from sea level=576m so Air pressure at this height from sea level is 95116.65 Pascal at a Temperature of 35°c.

F. Stress Calculations

We know that,

Px = force on X limb.

Py = force on Y limb.

σx = Stress on X limb

σy = stress on Y limb

FOS = factor of safety =5

b = breadth of limb.

h= height of limb.

σmax= ultimate tensile strength

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Resolving force on X limb& Y limb ,
We know that,

$$\sum Fx = -Pxcos\ \theta + Pycos\ \theta = 0$$
$$\sum Fy = -Pxsin\ \theta - Pysin\ \theta - P = 0$$

∑Fx = -Pxcos 32 + Pycos 32 = 0…….i
∑ Fy = -Pxsin 32-Pysin 32-26125.52 = 0 ……..ii
By solving Equation i and Equation ii, we get the value of Px and Py,
Px = - 24651 N (negative sign indicates that the force is compressive).
Py = 24651 N

Stress,

$$\sigma = \frac{P}{A}$$

For finding Value of stress, we know the formula,
FOS = (allowable stress) / (ultimate tensile stress)

$$FOS = \frac{\sigma}{\sigma max}$$

Where ,

Ultimate tensile strength of Aluminium 290 N/mm^2.

The value of Factor of safety is5.

$$\sigma = fos * uts$$

Stress=5*290=1450 N/mm^2

We know that,

$$\sigma = \frac{P}{A}$$
$$1450 = \frac{24651}{A}$$
$$d2 = \frac{24651}{0.78 * 1450}$$

d = 5mm

G. Design of Link

Links in the were used to connect the upper fix point with the another link. This links were subjected to buckling load and bending load tending to break or cause bending of the links. The suitable material for the link was Aluminum.

H. Design of link for Bending

We know that,

$$\therefore \frac{M}{I} = \frac{\sigma b}{y}$$

Where,
M= Maximum Bending moment on the link considered as beam.
I= Moment of inertia
Y= Distance of neutral axis from the ends.
The material is Aluminum, its tensile strength is 290 N/mm²,

$$\therefore \sigma b = \frac{Syt}{F.O.S} = \frac{290}{5} = 58 \text{ N/mm}^2.$$

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For a link design it has been considered that the load was acting on a half of link length. The total length is 580 mm.
Therefore length is given by,

$$\therefore \frac{580}{2} = 290\text{mm}$$

At 290 mm the load will act by the air. The load on link is UVL due to inclination with horizontal. The calculation done for link in height position that is angle made by link with horizontal is 10°.
We know that,

$$P = \frac{f}{A}$$

Where,
P= pressure acting on point, N/mm²
F= force, N
A= area (Π/4)×d^2
As the case study of Vehicle, The dimensions of roof of the Renault Kwid are as follow foe calculating the Area so,

$$\text{Area} = l \times b$$
$$\text{Area} = 1739.5 \times 1579$$
$$\text{Area} = 2.7466 \times 10^6 \text{ mm}^2$$

We know that,

$$P = \frac{f}{A}$$

$$P \times A = F$$

$$0.00951195 \times (2.7466 \times 10^{6}) = F$$

$$F = 26.12 \times 10^3 \text{ N/mm}^2$$

Actual load on link one ‘

$$26120\cos 10° = 25720$$

Now,

$$25720 = \tfrac{1}{2} * 290 * W$$
$$W = 177.37 \text{ N/mm}^2.$$

Maximum Bending Moments = (WI^2) / 9*1.732
= (177.37)* (290^2) / 15.58
= 957.43*10^3 N/mm^2
Let we know that ,

$$Y = d/2$$
$$Y = 10/2$$
$$Y = 5\text{mm}$$

$$I = 981.74 \text{ n/mm}^4$$

We know that,

$$\therefore \frac{M}{I} = \frac{\sigma b}{y}$$

$$\sigma b = (957.43*10^3)*10 / 981.75$$

$$\sigma b = 9752.2 \text{ N/mm}^2$$

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Design of link for buckling:

According to Euler's Formula Method

$$critical\ load = Pcr = \pi^2 EI \div 2Le^2$$

Where,
I = Moment of inertia
E = Modulus of Elasticity
We know that, in our condition one end was fixed and other end was free. Therefore, by standard consideration Equivalent length of link = 2 x Length of the link Length of link = 580mm
Also, Modulus of Elasticity (E) = 210 GPa =210 x 10^3 N/mm²
Therefore,

$$critical\ load = Pcr = \pi^2 (210000 * 981.75) \div 2 * 580^2$$

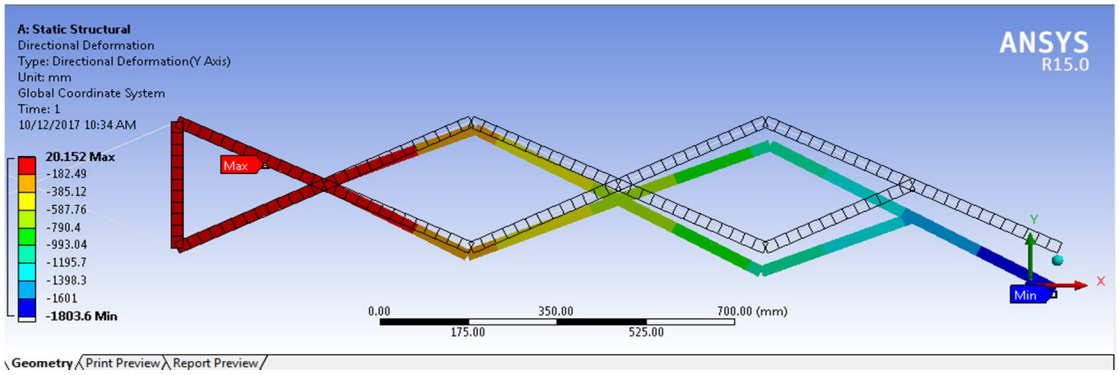
Pcr = 1.754×10^6 N

I. Final Dimension of Mechanism

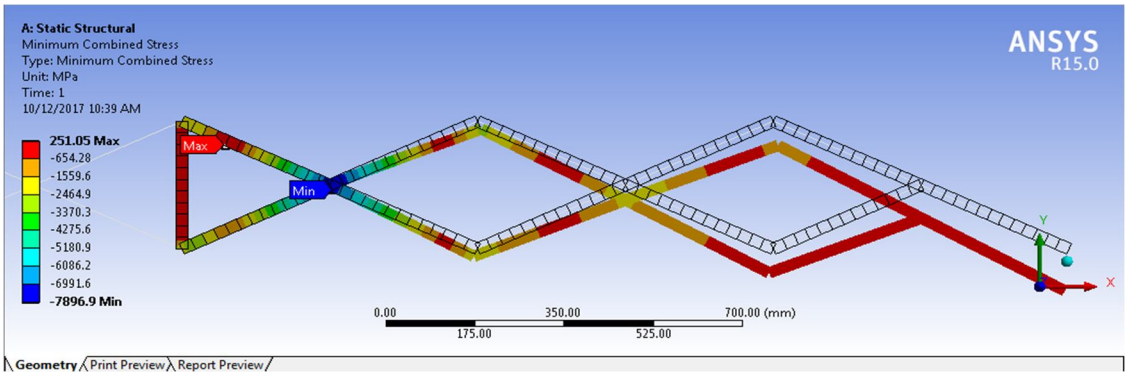
From the above design calculations we obtained following value:
Length of long link : 580mm
Length of short link : 290mm
Length of long linkage: 2814mm
Length of short linkage: 1800
Angle between two adjacent linkages: 25°&45°

IV. ANALYSIS OF LINKAGE MECHANISM

Maximum Directional deformation in Y-axis of the model=2.5394 mm



Minimum Combine Stress = 251.05 MPa



Total Bending Moment = 8.0519 X 10^6 Pa

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V. EXPERIMENTAL TESTING AND RESULTS

A. Testing without Umbrella

We conduct testing on the " Maruti Suzuki Ciaz" vehicle without the car umbrella for checking the temperature in summer season from the duration of 10:00Am to 4:00pm. For checking the Internal temperature of the passenger compartment of the vehicle, with and periodic interval of time span of 1 hours for each reading. From that we are compare the temperature difference of the both atmospheric temperature and passenger compartment temprature.

Fig. Testing Ciaz without umbrella

From the testing between the 10:00Am to 4:00Pm we get the following results, at the various points in the passenger compartment like as front seat, driver seat, rear side at right , rear at left side and atmospheric temperature from every hour .

B. Various Temperature without umbrella are as follows

Time	Atmospheric Temperature	Temp. At Driver Seat	Temp. At front left seat	Temp. at rear left seat	Temp. At rear right seat	Average Temperature inside car
10 A.M.	38	60	60	57	64	60.25
11 A.M.	39	75	72	74	78	74.75
12 Noon	39	78	75	76	78	76.75
1 P.M.	39	78	76	80	82	79
2 P.M.	39	75	74	78	80	76.75
3 P.M.	39	77	72	77	74	75
4 P.M.	39	72	70	72	73	71.75

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C. Testing with Umbrella

From the testing between the 10:00Am to 4:00Pm we get the following results by using car umbrella, at the various points in the passenger compartment like as front seat, driver seat, rear side at right , rear at left side and the temperature between umbrella and the roof of vehicle and atmospheric temperature from every hour .

Fig. Testing Maruti Ciaz with umbrella

D. Various Temperatures with umbrella are as follows

Time	Atmospheric Temperature	Temp. At Driver Seat	Temp. At front left seat	Temp. at rear left seat	Temp. At rear right seat	Temp. between umbrella and roof of vehicle	Average Temperature inside car
10 A.M.	36	51	50	49	47	35	44.66
11 A.M.	39	52	53	49	46	37	46
12 Noon	39	54	54	51	50	37	47.5
1 P.M.	39	58	55	54	51	39	49.33
2 P.M.	39	59	56	54	52	39	49.83
3 P.M.	38	57	55	54	51	38	48.83
4 P.M.	38	55	53	51	49	37	47.16

Fig. Temperature reading with umbrella chart

E. Percentage Difference between both Average temperatures of passenger compartment temperature of the Maruti Ciaz

The percentage difference between both with and without umbrella testing temperature of the passenger's compartment of the vehicle is shown in the following table. Here is shows that from an experimental results the total temperature difference is in percentage is about 34.89 ^{0}c .which is near about the 35^{0}c.

Time	Atmospheric Temperatures	Average Temperature inside car without umbrella	Average Temperature inside car with umbrella	% change in temperature
10 A.M.	36	60.25	44.66	25.88
11 A.M.	39	74.75	46	38.46
12 Noon	39	76.75	47.5	38.11
1 P.M.	39	79	49.33	37.56
2 P.M.	39	76.75	49.83	35.07
3 P.M.	38	75	48.83	34.89
4 P.M.	38	71.75	47.19	34.23
		Total % change in temperature		34.89

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The graph is shows change in temperatures:

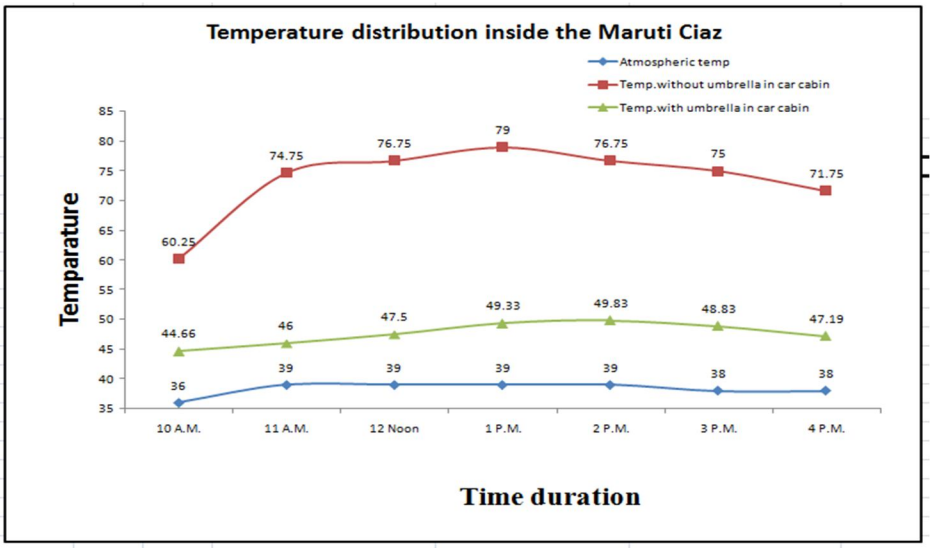

Fig. Graph temp vs time

From above graph , here is noticed that the inside temperature of the maruti ciaz without car umbrella during parking condition is very high is near about average of total reading is 71.75^{0}c is in percent . so passenger compartment is become hotter and increase in temperature. But by using the car umbrella the temperature difference is of average temperature near about 34.89^{o}c is in percentage. So by using the car umbrella for parking condition the temperature is reduced ,as per above readings it shows the difference between both readings with car umbrella and without car umbrella. In every reading there is difference of 20^{0}c to 25^{o}c in with using umbrella and without using umbrella. so the graph is shows the average temperature readings and time duration hence from experimental readings and from graph the average temp difference is 34.89^{0}c.

VI. CONCLUSION

It happened to you at every time in summer season that you are going to travel somewhere and you want to take a pause due to car cabin temperature was very high while car in parked condition. Many times you circled and looked for parking in the shade or not found and you had to park at worst the sun and leave your car to be glowing. So, you need to minimize the car cabin temperature of parked car. As such any improvement in car cabin temperature of parked car with cost effective solution provide us a revolutionary thing with improvement in Human comfort.

For reducing the temperature passenger compartment, we manufactures car umbrella which completely covers roof of passenger cabin and front and rear windscreen. After using the car umbrella the here is maintain the car passenger compartment temperature about overall average of 34.89^{o}c as per the experimental results. By using the car umbrella for parked condition helps to maintain the inside car temperature at high amount at lower maintenance as well aas it is protect from dust, rain and dirt and protect the rear and front windscreen of the vehicle. So by using the car umbrella for parking condition the temperature is reduced ,as per above readings it shows the difference between both readings with car umbrella and without car umbrella. In every reading there is difference of 20^{0}c to 25^{o}c in with using umbrella and without using umbrella. so the graph is shows the average temperature readings and time duration hence from experimental readings and from graph the average temp difference is 34.89^{0}c

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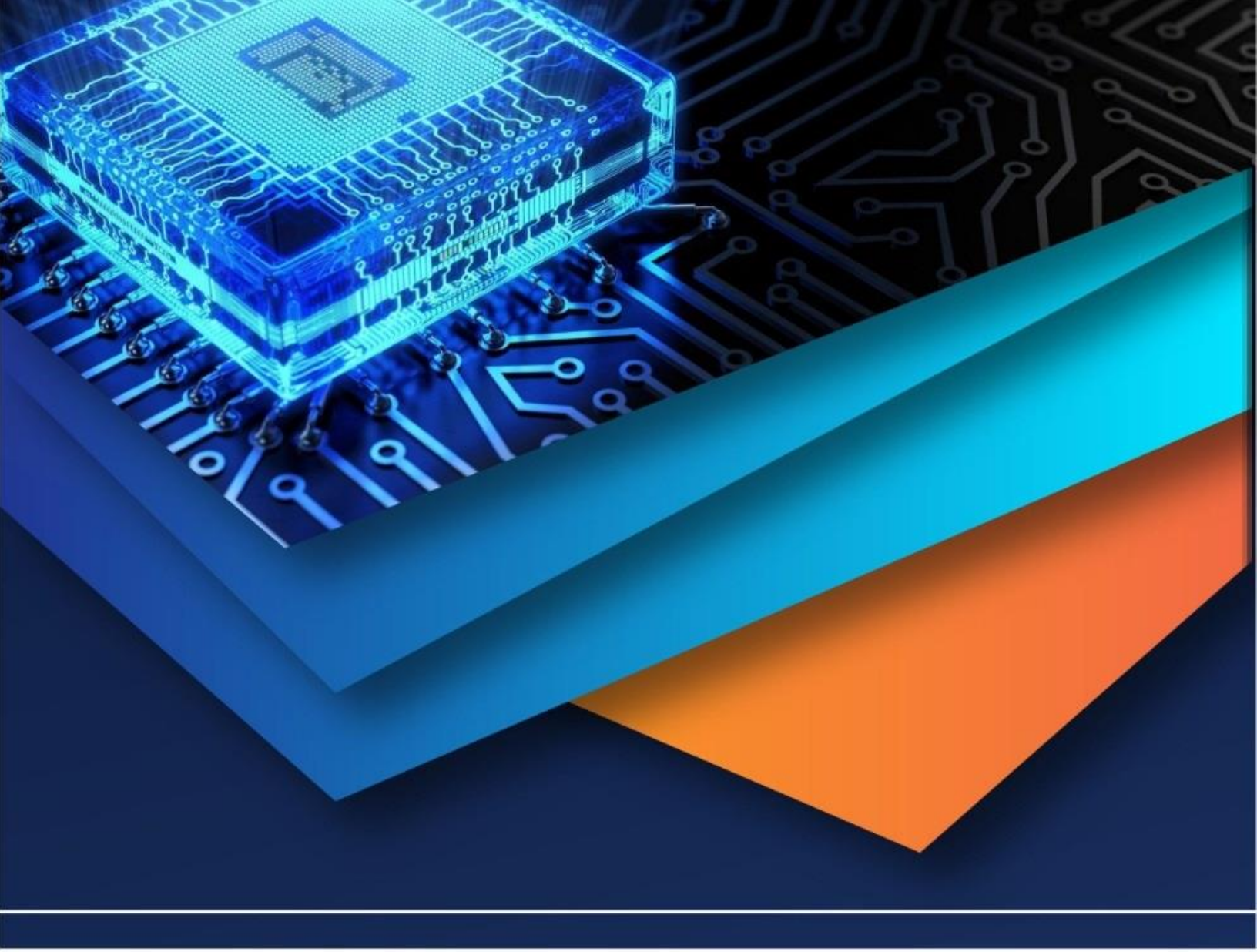

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