A Novel Approach in Using Solar Panels on the Outside of Composite Walls

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A NOVEL APPROACH IN USING SOLAR PANELS ON THE OUTSIDE OF COMPOSITE WALLS

TO ACT AS INSULATORS FOR WALLS AND ALSO HARNESS SOLAR ENERGY AT THE SAME TIME CONSEQUENTLY BRINGING DOWN ENERGY EXPENDITURE AND RELEVANT COSTS

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Abstract-- **In today's generation solar energy produced by nuclear fusion in the sun is a non-vanishing renewable resource of energy and the need of the hour. The realization of drastic climatic change, the sudden need of sustainable development and growing awareness of people regarding environmental changes has resulted in a strong interest among people in developing more scientific ways to produce electricity and conserve energy at the same time. The primary aim of this paper is to inform the public about the working of a commercial photovoltaic cell, its importance, and the novel and beneficial idea of using photovoltaic solar cells on the outside of walls in our homes. This will serve two purposes. Firstly, it will act as insulation and will allow lesser heat to permeate through the walls and inside the room, thus requiring less energy to cool the room than without insulation. Secondly, the solar panelling will also serve the purpose of harnessing the solar energy, thus providing a clean and renewable source of energy.**

Keywords-- **photovoltaic cell, solar panel, renewable energy, composite walls, insulation**

I. INTRODUCTION

As discussed by Ashok Upadhyay et.al. in the paper that with the increasing demand of energy , conversion has regained the spotlight of the global energy activities. Furthermore, reliable solar technology has to be complemented by an energy storage system to accommodate the daily and seasonal variations in the solar radiation. From this perspective, many countries have formulated their long term solar energy utilization roadmap. All such projects and roadmaps are, however, only a part of the country-specific long term energy vision, with solar energy aiming to supplement conventional energy technologies. None of these initiatives, at this stage, claim to replace the existing fossil fuel based systems immediately. Solar Power, a clean renewable resource with zero emission, has got tremendous potential energy which can be harnessed using a variety of devices. With recent developments, solar energy systems are easily available for industrial and domestic use with the added advantage of minimum maintenance. Solar energy could be made financially viable with government tax incentives and rebates. Most of the developed countries are switching over to solar energy as one of the prime renewable energy sources. The current architectural designs make provision for photovoltaic cells and necessary circuitry while making building plans. Because of its location between the Tropic of Cancer and the Equator, India has an average annual temperature that ranges from 25°C – 27.5 °C. This means that India has huge solar potential.

II. HOW SOLAR CELLS WORK

1.1 When light reaches the p-n junction, the light photons can easily enter in the junction, through a very thin p-type layer. The light energy, in the form of photons, supplies sufficient energy to the junction to create a number of electron-hole pairs. The incident light breaks the thermal equilibrium condition of the junction. The free electrons in the depletion region can quickly come to the n-type side of the junction. Similarly, the holes in the depletion can quickly come to the p-type side of the junction. Once, the newly created free electrons come to the n-type side, and cannot further cross the junction because of the barrier potential of the junction. Similarly, the newly created holes once come to the p-type side cannot further cross the junction and become of the same barrier potential of the junction. As the concentration of electrons becomes higher in one side, i.e. n-type side of the junction and concentration of holes becomes more in another side, i.e. the p-type side of the junction, the p-n junction will behave like a small battery cell. A voltage is set up which is known as photo voltage. If we connect a small load across the junction, there will be a tiny current flowing through it. Fig. 1 illustrates this phenomenon.

1.2 Essential requirements for solar energy generation:-

1. High solar radiation at a particular site.
2. Proper approach to site.
3. Techno-economic selection of solar panels.
4. Scientifically prepared layout.

1.3 How do solar panels work?

When photons hit a solar cell, they knock electrons loose from their atoms. If conductors are attached to the positive and negative sides of a cell, it forms an electrical circuit. When electrons flow through such a circuit, they generate electricity. Multiple cells make up a solar panel, and multiple panels (modules) can be wired together to form a solar array. The more panels you can deploy, the more energy you can expect to generate.

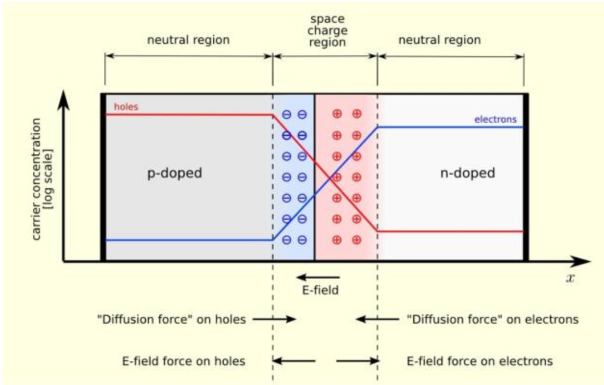

Fig. 1 (courtesy: common.wikimedia.org)

III. NOVEL APPROACH

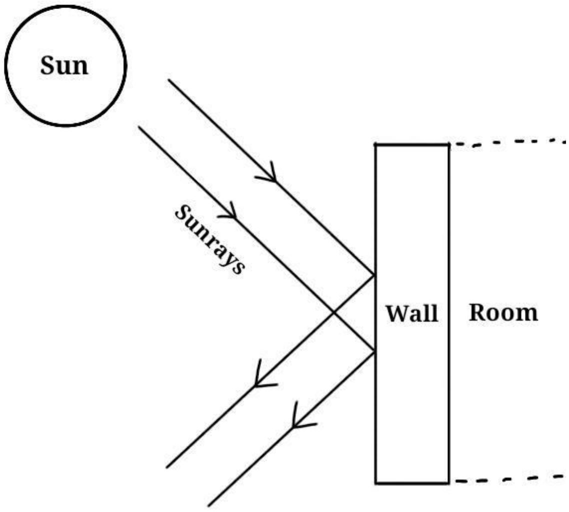

Fig. 2

Let us consider a homogenous, isotropic unit of thickness ‘δ’ with constant thermal conductivity ‘k’ and constant cross-sectional area ‘A’ conducting heat in one dimension. One side of the wall is facing outside towards the sun having a constant temperature ‘t1’ and the other side of the wall is facing the room thus is at room temperature of ‘t2’ which is also assumed to be constant. It is observed that temperature varies only in the direction normal to the wall and the temperature potential causes heat transfer in the positive x-direction. (See Fig. 3).

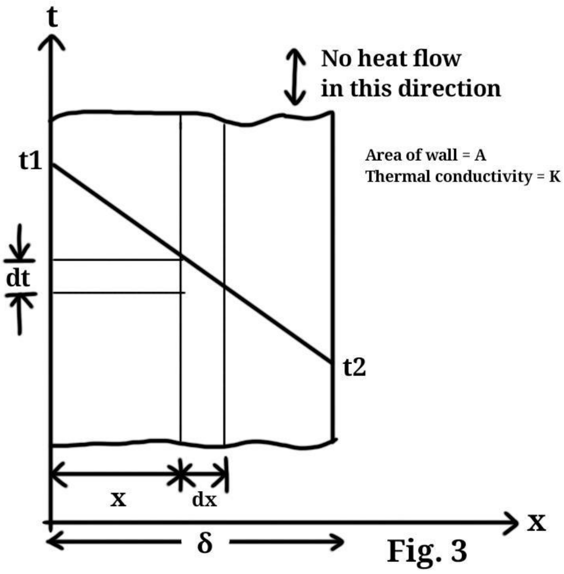

Fig. 3

The attention is focused on an elementary strip of thickness dx located at the distance x from the reference place. The temperature difference across the strip is dt and thus the gradient of temperature is assumed to be dt/dx . Heat flow rate is taken as 'Q' and is assumed to be constant because the system is assumed to be in steady state. Therefore integrating the fourier rate equations using the correct limits we get,

$Q0dx = -kA\ t1t2dt$

$Q\ \delta = kA\ (t1-t2)$

$Q = kA\ (t1-t2)/\delta = (t1-t2)/(\delta/Ka)$----(1)

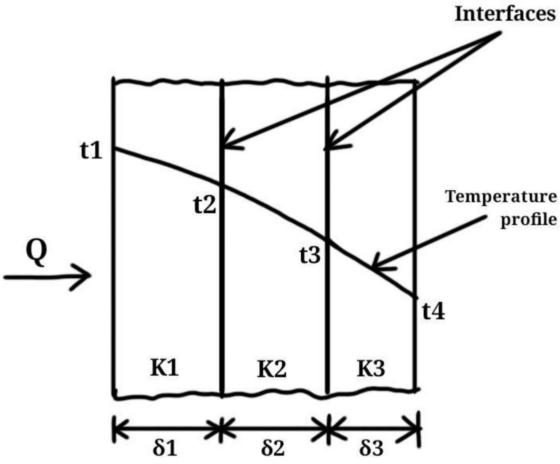

Fig. 4

For the purpose of our research , we took a plane composite wall of area A in a four walled room with one of its sides facing the sun outside and one side facing the room . The heterogenous wall is assumed to be made of three layers, two cement layer on either side and one brick layer in between. Fig. 4 shows the aforementioned composite wall having two layers of cement and one layer of brick tightly fitted to one another. The layers have the thickness δ1, δ2, δ3 and their thermal conductivities are k1, k2, k3 respectively.The surface temperature of the walls is t1 (outside) and t4 (inside) and the temperature at the interfaces are t2 and t3.

Under steady state conditions , heat flow Q does not vary across the wall i.e. it is the same for every layer. Thus Fourier equation for a composite wall can be written as,

$Q=(t_1-t_2)/\{(\delta 1/k1*A)+(\delta 2/k2*A)+(\delta 3/k3*A)\}$—(2)

Assuming the dimension of one side of a four walled room facing the sun to be 3m*10m, we get the wall area A=30m2 . Now assuming standard dimension of the brick to be 190*190*190(mm), δ2 comes out to be 90mm=0.09 metres. Also assuming 15 mm cement layers on either side of the bricks we get δ1=δ3=0.015m. Also taking Kolkata as point of interest for our study, where average temperature in the month of May is around 36°C. Let a air conditioning setup is running inside the room, with it cooling and keeping the room temperature constant at 25°C (t2) . Now obtaining the thermal conductivity values of cement and brick from relevant sources we get k1=k3=1.73W/m°C and k2=0.8W/m°C.

Therefore from equation (2), we can calculate the heat flow rate,

$Q=(t1-t2)/ \{(\delta 1/k1*A)+(\delta 2/k2*A)+(\delta 3/k3*A)\}$

$Q=(36.5)/\{(0.015/1.73*30)+(0.09/0.8*30)+(0.015/1.73*30)\}$

Or, $Q= 2.541*103$ J/s = $2.541*103$ Watt

Now let us introduce a solar panel to the outside of the wall such that it covers it entirely and receives the sunlight directly. Fig. 5 shows the new arrangement of the solar panels and the walls. From three we get the thermal transmittance value to be value to be 11.6 W/m2 ºC giving us a thermal conductivity value of 13.92 W/mºC for the solar panel.

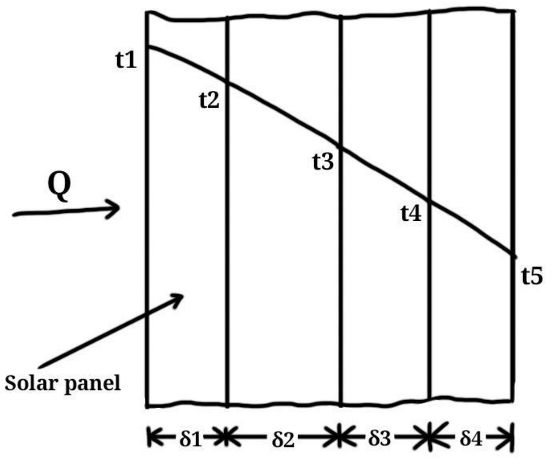

Fig. 5

Assuming all condition and parameters to be same as before , standard thickness (δ1) of the solar panel to be 40mm and Q to be same as before, we get

*Q=(t1-t2)/{(δ1/k1*A)+(δ2/k2*A)+(δ3/k3*A)+(δ4/k4*A)}*

*or, 2.541*103=(36.5-tS)/{(0.04/13.92*30)+(0.015/1.73*30)+(0.09/0.8*30)+(0.015/1.73*30)}*

Or, t5=24.76ºC

IV. CONCLUSION

Following conclusions can be drawn from this study-

1. Introduction of solar panel at the outside of a wall facing the sun causes it to act as an insulator, reducing the load on the air conditioning system installed inside the room.

2. By using photovoltaic solar cells to harness solar energy , the energy thus derived can be used to power the air conditioning unit and other appliances inside the room , deriving down energy bills and serving as an eco-friendly energy alternative.

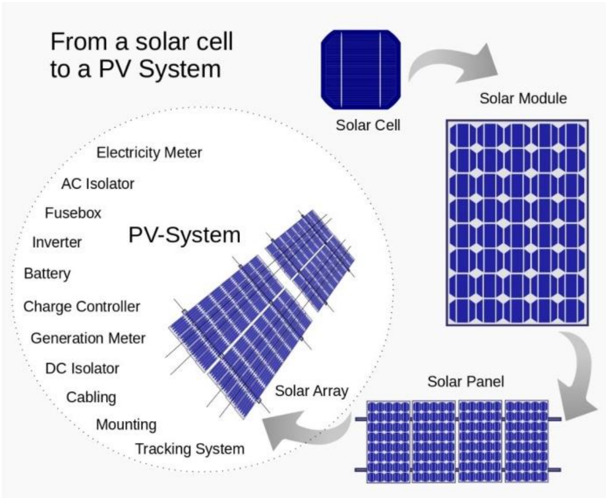

Fig. 6 (courtesy: common.wikimedia.org)

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