"DESIGN AND DEVELOPMENT OF FIBER-OPTIC SOLAR ENERGY CONCENTRATION AND TRANSMISSION DAY-LIGHTING SYSTEM"

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Abstract - *Solar energy is abundantly and freely available energy source. Solar energy can be transformed into various useful forms. For conversation of solar energy various types of solar collectors can be used. Here system is used to convert the solar energy into day-lighting. The parabolic dish collector is used for sun radiation concentration. Fiber optic cables are used for transmission of the day light from concentrator to indoor. The fiber optic cables work on the principle of internal reflection. Due to the internal reflection the light can be transmitted within the fiber optic cables with minimum loss. In this system the direct sunlight is used for indoor lighting and there is no need for converting into electrical energy and further into light. The objective of this study is to study the solar concentrators and fiber optic cables, design and development of the solar day-lighting system. The ECBC are referred for day-lighting system design. The test results are taken after taking trials of the prototype system.*

Key Words: **solar daylighting, fiber optic cable, parabolic dish, lux**

1. INTRODUCTION

Solar energy is abundantly available in all the regions of the India. Solar energy can be used for many useful applications like solar water heating system, solar PV collectors for electricity production, solar cooking, solar day lighting, etc.

Power consumption in every sector is increasing day by day due to the technological advancements and it is also the main cause behind the rapid raise in greenhouse gas emission. Industries, commercial buildings, business spaces, hospitals, hotels, school, universities etc. all requires artificial lighting even in day time while abundant sunlight is available. Around 40-50 % of power consumption is used for electric lighting in the different buildings.

Solar energy using for energy production and the efficiency of conversion in solar PV is around 18-21 %, where the 75-80% of energy get wasted. Therefore instead of converting solar energy into electrical energy and further used for lighting, solar energy can be directly converted into light in fiber optic day lighting system.

There are different architectural designs for buildings have been introduced to effectively illuminate the building with the open spaces, windows and sky lighting but the availability of day light from the windows is reduces due to many reasons during the daytime. Hence there is need of day lighting system to illuminate the darker areas in daytime.

Solar day lighting system uses sunlight to convert directly into the light. The solar day lighting system can be used only with availability of sun in daytime. There is no need of any solar storage system in day lighting system.

The sun radiations are collected at solar collector and concentrated at the fiber optic cables placed at the focal point. The concentrated light is transmitted through the fiber optic cables in the day lighting system.

2. COMPONENTS OF DAY-LIGHTING SYSTEM

The main parts of the solar day-lighting system are parabolic collector, lens receiver, stand and fiber optic cable.

Sun radiation collection is the important factor of the day-lighting system. Parabolic dish is having wider collection area and therefore suitable for solar day-lighting system. The lenses used are of convex type which is thicker at the center and less thick at the outer edges. The fiber optic cables are used for transmission of direct sunlight to the indoor for day-lighting.

A. Parabolic Dish Collector

The parabolic dish collector is made of aluminum material. Aluminum is having higher reflectivity. At the surface of parabolic dish collector the light incident on every point of the parabola is concentrated at a single focal point. Radiations of sun which incident on each and every point of parabola is reflected as if would have hit the tangent plane of the parabola at the same point.

In this system, the distance between parabolic dish and lens receiver can be adjusted as the rollers are attached to the parabolic dish stand. The dish can be moved and the maximum output is achieved.

The aluminium dish is light in weight and easy to install the experimental setup.

Table -1 Parabolic Dish Specifications

Property	Value
Material of dish	Aluminium

Thermal conductivity of aluminium	205 W/mK
Absorptive aluminium	0.95
Emissivity aluminium	0.9
Reflectivity of aluminium	82%
Efficiency of collector	54%

B. Lens Receiver

The lenses used are of convex lens type. The convex lenses are thicker at the central part and thinner at edges. The convex lens focuses sun radiations at single point. The sun radiations from collector are received at the focus point of the convex lens. The amount of concentration of sunlight at the focus point of the lens directly affects the amount of day light at the output.

Table -2 Lens Receiver Specifications

Property	Value
Material of Lens	Glass
Thermal conductivity of glass	1.05 W/mK
Absorptive of glass	0.92
Emissivity of glass	0.9
Reflectivity of glass	50-80%

C. Stand

PVC material is used for stand. There are several advantages of PVC material like corrosion resistance, lightweight, tough, chemical resistance, and durability.

This system consists of two component holding stands. One component holding stand is used for receiver assembly and another for fiber optic cables.

1) Stand for fiber optic cables assembly

The stand for fiber optic cables consists of PVC pipes and PVC collars. The lenses with metal pipe holders are mounted onto the pipes.

2) Stand for receiver assembly

The stand for receiver assembly consists of PVC pipes connectors and tee jointers.

D. Fiber optic cables

Fiber optic cable (FOC) is the cable made up of glass or plastic material to transmit the light from one end to another.

Fiber optic cable does not get affected by the electromagnetic interference. Fiber optic cable works on the principle ofinternal reflection. The incident light is passed to the other end without and transmission losses through the optical fiber cables.

3. DESIGN AND CALCULATIONS

A. Design Calculations of Parabolic Dish Collector

The parabolic dish collector is used to collect the sun radiations and the area and concentration ratio are important factor in system.

The total area of concentrator is,

$Ac = \pi /4 \times Dcon^2$

B. Design Calculations of Receiver

Lenses are used for receiving the solar radiations.

Receiver collects the maximum amount of reflected radiations from the parabolic dish concentrator to transmit the radiations through fiber optic cables.

1) Area of receiver

$$AR= \frac{\pi \times DR^2}{4}$$

2) Concentration Ratio

The concentration ratio (C) is the ratio of concentrator area and receiver area.

Concentration ratio = C = $\frac{A\,con}{A\,rec}$

3. EXPERIMENT AND RESULT

The experimentation and trials are carried out for three days at different time and the results are tabulated in the tables below.

Table -3 Experiment Result

Time	Amb. Temp.	Received Solar Radiations	Lux at output of FOC
	°C	W/m²	
8:30 am	21	429	105
9:30 am	22	438	120
10:30 am	26	473	182
11:30 am	29	485	240
12:30 pm	30	507	268
13:30 pm	31	514	270

14:30 pm	31	518	274
15:30 pm	32	520	277
16:30 pm	30	466	210
17:00 pm	30	423	180

On first day, the minimum temperature was 21°C, maximum temperature was 32°C. The maximum solar radiations were 520 W/m² and maximum lux output at fiber optic cable was 277 lux.

Table -4 Experiment Result

Time	Amb. Temp.	Received Solar Radiations	Lux at output of FOC
	°C	W/m²	
8:30 am	20	425	103
9:30 am	21	432	108
10:30 am	22	438	140
11:30 am	26	474	210
12:30 pm	30	498	248
13:30 pm	30	510	272
14:30 pm	32	521	280
15:30 pm	31	506	277
16:30 pm	30	490	232
17:00 pm	30	425	170

On second day, the minimum temperature was 20°C, maximum temperature was 32°C. The maximum solar radiations were 521 W/m2 and maximum lux output at fiber optic cable was 280 lux.

Table -5 Experiment Result

Time	Amb. Temp.	Received Solar Radiations	Lux at output of FOC
	°C	W/m²	
8:30 am	21	431	110
9:30 am	21	430	112
10:30 am	23	458	170
11:30 am	27	477	234
12:30 pm	31	514	265
13:30 pm	33	519	281
14:30 pm	33	519	278
15:30 pm	31	517	267
16:30 pm	30	493	220
17:00 pm	30	480	180

On third day, the minimum temperature was 21°C, maximum temperature was 33°C. The maximum solar radiations were 519 W/m2 and maximum lux output at fiber optic cable was 281 lux.

4. CONCLUSIONS

In this paper we studied the collectors used for day-lighting and their concentration ratios, fiber optic cables and lens used for day-lighting system. The main parameters of the day-lighting systems are sunlight collection, concentration and transmission for indoor lighting.

The testing of the day-lighting system is done with the reference of national standard ISO and Energy conservation building codes 2017.During the testing maximum collector temperature observed is 82 °C and the minimum collector temperature is 50°C.The lux reading at output of the fiber optic cable is 281 lux and minimum lux reading is 103 lux.

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