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Senior Design Project Report

DAYLIGHT SYSTEM USING FIBER OPTICS.

In partial fulfillment of the requirements for the Degree of Bachelor of Science in Mechanical
Engineering Team Members

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ABSTRACT-

Solar day lighting through optical fiber cables in home and working place is a potential option to save energy associated with artificial lighting as well as enhance the visual comfort and human health by using natural solar lighting. In this study solar light system consists of optical fiber and parabolic dish coated with aluminum sheet was designed to bring sunlight into buildings. The effect of optical fiber diameter on the intensity and uniformity of light has been analyzed and discussed. This clean technology can reduce energy cost and contribute to solve climate change issues

ACKNOWLEDGMENT-

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1 INTRODUCTION-

1.1 PROJECT DEFINITION-

In today's modern world, many of the aspects that are most essential in life are being enhanced day by day. This includes the basic necessities of humans. That may include food and shelter which means that in today's world, new scientific inventions are made every day in order to make life easier for every human. Weather that was direct or indirect benefit. The day lighting using fiber optics can be a gateway for scientists and engineers to prove once and for all that solar energy is the most reliable and efficient source of energy known to human beings. Before the invention of artificial electricity, that was around the mid-20th century, solar energy was still reliable even though the means to use it were not so reliable. But as mentioned above, science is improving every day and with the technologies we have today, we can prove that even after the invention of artificial electricity but as mentioned above, science is improving every day and with the technologies we have today, we can prove that even after the invention of artificial electricity by a little over a century, solar energy remains the most effective and efficient source. Before if we were to compare the relationships between the intentional use the solar source or the unintentional use of it, humanity only requires artificial electricity for lighting after the sun sets. Because by applying the architectural methods and designs of all buildings depend largely on the windows to utilize solar lighting.

Day lighting using fiber optics can be briefly defined as the most efficient design of a light collecting system, that is the most reliable, most efficient and come up with a way to fit it into the architectural designs of our buildings, with the most effective cost. This can definitely be ensured if we take every little detail into consideration and use the right methodology and the right equipment's to achieve our goal. Throughout this research we will explain step by step and in the most minor details about each and every prospect of this study. i.e. day lighting using fiber optics.

1.2 PROJECT OBJECTIVES AND APPLICATIONS-

throughout the first stages of our research, we were completely focused on our primary objectives, and our secondary once. this system has to run through the best choices and calculations, and the following objectives will be focused on accordingly as mentioned below-

- this system should be designed in a way that it has the ability to run on a 24 hours basis. This could be done in such a manner that it draw , converts and saves the solar energy extracted from the sun during daylight, and then utilized when it is most needed that is after the sun sets. The main objective of this is to use fiber optics as the medium to transfer light from the solar source (the sun) to other sources of lighting that are used in our homes and other places. Even though we are willing to use fiber optics as our main medium, we are also willing to try and see if there are other more traditional choices that we can install or use as our secondary or substitute medium for the fiber optics.
- The next objective is to find a design that is both reasonable and operational in each and every step of the system and its functioning. This means that we have to make economical comparisons to make sure that the system is economically efficient. Other comparisons such as the efficiency of the day lighting system using fiber optics should be more efficient and accessible than any other conventional method used by engineers up to date.
- Last but not least, this is one of our primary objectives as it is very important to come out with the largest benefit through making the least harm in all aspects. That means that we have to give back to the environment that we are going to use In this project to solve a major problem that was created by our inventions of artificial electricity. This system has to be ecofriendly and environmentally green.

1.3 PROJECT SPECIFICATIONS-

CHAPTER 2- LITERATURE REVIEW-

2.1- PROJECT BACKGROUND-

This project is considered a focal point of many developed countries in the world in some way or the other. One of the main benefits from the day lighting system using optical fiber optics is that it consumes the solar light to the maximum with least negative outcomes, and that on itself is a major task that every country tries to solve because it benefits them on an economical and an ecological level. If this system was to be implemented on all the houses and the work place, this means that it would benefit us all as as community because it would eventually lead to a healthier life and a lower expenses bill at the end of the month. That on its own is responsible for the enhancement of our economic cycle and that too, that goal would be attained through an invention that was made on the lowest costs. As we were brainstorming and getting new ideas to help us proceed with this project, we came to an agreement that this system would initially need to be designed with optical fiber and parabolic dish coated aluminum sheets in order for us to ensure easy asscesablity and appropriate costs of our raw materials. Other factors like the intensity of light and its effect on the optical fiber diameter. While also going through other important aspects like the effect of the optical fiber diameter also on the uniformity distribution of light.

2.2 COMPARATIVE STUDY-

In concentrated solar energy applications, the parabolic reflector has gained popularity due to them being widely available for rapid manufacturing. They are “point-focus” concentrators that can achieve very high concentration ratios, sometimes even above 1000 suns. They are used to achieve a high concentration of sunlight in solar concentration systems. The idea behind the system is to capture sunlight and then focus it over the bundle of optical fibers. As parabolic reflector focused sunlight onto a small area, it didn't insert maximum light into optical fibers. The light needed to be achieved over the fiber bundle with uniform light flux. Each fiber should have the same intensity of light for the uniform distribution of light. To this end, we proposed a design in which collimated light is produced to solve the above issue. We mounted collimating lens upstream of the focal point of the parabolic reflector to produce uniform illumination.

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2.3 PREVIOUS WORK-

In this research, we proposed fiber-based day lighting system in which uniform light was inserted into each optical fiber. The proposed system included light capturing, transmitting, and distributing modules. To capture sunlight, we designed light collecting module using parabolic reflector. A collimating lens was used for uniform illumination over the fiber bundle. We achieved better efficiency in terms of luminance uniformity and more light flux at the light capturing stage than the previous approaches.

2.4 PROJECT BENEFITS AND ADVANTAGES-

Fiber optics, that miracle of modern communications, can also be used to deliver natural light to spaces deep in a building. An aluminum tube that's highly reflective on the interior transmits daylight down through an unheated attic to the space below--delivering the light through what appears to be a fairly standard light-diffusing ceiling fixture. It's a great technology--especially with the relative low cost, but it has some limitations. You need a relatively straight shot, and it's hard to extend the tubes through living space to reach first-floor spaces in multi-storey buildings.

2.5- REFERENCES-

- 1) https://www.researchgate.net/publication/281953353_Development_of_Optical_Fiber-Based_Daylighting_System_and_Its_Comparison/download
- 2) https://www.lightingassociates.org/i/u/2127806/f/tech_sheets/Daylighting_by_optical_fiber.pdf
- 3) <https://core.ac.uk/download/pdf/5165493.pdf>

CHAPTER 3- SYSTEM DESIGNS-

3.1) MATERIAL REQUIRED (W/ VISUAL AIDS) -

As shown in [figure 1](#), this is a parabolic reflector along with the key elements required to get our project running. As mentioned below, that parabolic reflector needs to have a collimating lens and a bundle of optical fibers attached to it. (Whang 2015)

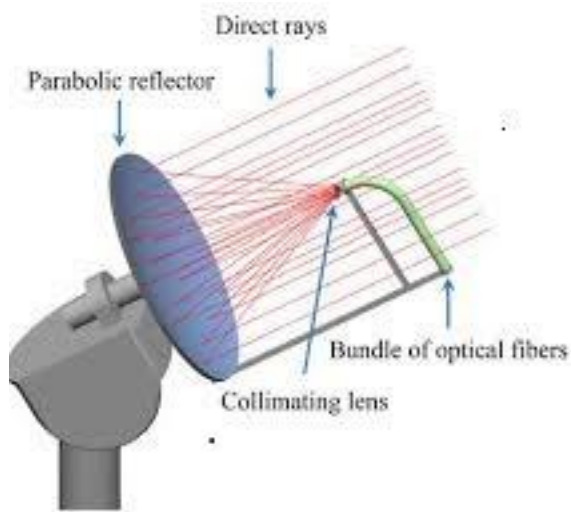


figure 1 parabolic reflector

in [figure 2](#), those are bundles of optical fiber to be used in our project. It is one of the main elements of this project. Fiber optics is based on the optical phenomenon known as total internal reflection. With the simplest form of optical fiber, light entering one end of the fiber strikes the boundary of the fiber and is reflected inward. The light travels through the fiber in a succession of zigzag reflections until it exits from the other end of the fiber. Other forms of optical fibers are designed in such a way that the zigzagging of the light is greatly reduced or virtually eliminated.



figure 2- bundles of optical fiber

as shown in [figure 3](#), this is what our goal is at the end of the project. Using accurate and very specific measures, we are willing to prove that day lighting using fiber optics can be a very reliable way of lighting up entire cities and even countries in the very near future.



figure 3- main goal and end product.

3.2) SYSTEM INITIAL CALCULATIONS-

The designs that we have decided to use and take calculations on are listed below in details-
(ANDRE, DAYLIGHT BY OPTICAL FIBER 2002)

MATERIAL REQUIRED.	VALUE (MM)
1. DIAMETER OF PARABOLIC REFLECTOR.	320.
2. FOCAL LENGTH OF PARABOLIC REFLECTOR.	276.
3. DEPTH OF PARABOLIC REFLECTOR.	23.2
4. DIAMETER OF PLANO CONCAVE LENS.	18.
5. FOCAL LENGTH OF PLANO CONCAVE LENS.	18.7
6. DIAMETER OF THE BUNDLE OF OPTICAL FIBER.	14.4
7. DISTANCE BETWEEN REFLECTOR AND LENS.	261.

The LED light that we would like to sample after the completion of our project is a standard OSRAM LED. The data sheet of the OSRAM LED light is mentioned below, (MADDILA 2013)
(NGOC-HAI VU 2016)

PARAMETER OF LED.	VALUE
1. LED MODEL	LUW W5AM
2. COLOR, CIE1931 (43)	CX= 0.31, CY=0.32
3. COLOR TEMPREATURE	5700 K
4. LUMINOUS EFFICACY	104 lm/W
5. LUMINOUS INTENSITY	35 cd

3.3) Selected components for the prototype

Item	Diameter	Quantity
Satellite	60 cm	1
Optical fiber	1.2 cm	7
Light Collector	3.6 cm	1
Mirrors		
LENS	1.2 cm	7

In figure 3.3, this holder is used to set the satellite in the right direction and make it stay on the same position in order for us to ensure full efficiency.



1 figure 3.3 satellite holder



2 figure 3.4 satellite

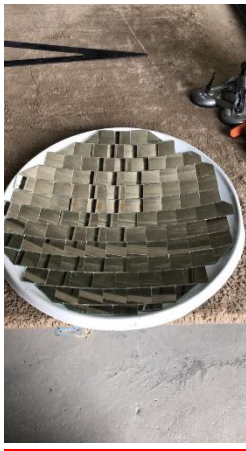
In figure 3.5, the light collector is used to collect the light from the main source.



3 figure 3.5 light collector

3.4) Manufacturing and assembly(Implementation)

In figure 4, this mirror reflector is going to be used to attract as much solar rays as possible.



4 miror reflector

3.5- SAFETY MEASURES-

1) Materials Safety

Fiber optic splicing and termination use various chemical cleaners and adhesives as part of the processes. Normal handling procedures for these substances should be observed.

2) Fire Safety

Note that fusion splicers use an electric arc to make splices, so care must be taken to insure no flammable gasses are contained in the space where fusion splicing is done.

3) Electrical Safety

You might be wondering what electrical safety has to do with fiber optics. Well fiber cables are often installed around electrical cables. Electricians are well-trained in electrical safety, but some fiber optic installers are not.

4) Eye Safety

Optical sources used in fiber optics, especially LEDs used in premises networks, are of much lower power levels than used for laser surgery or cutting materials. Even the output of OTDRs, WDM and fiber amplifier systems, which are much higher than LED systems, are still well below that used in laser surgery or machining.

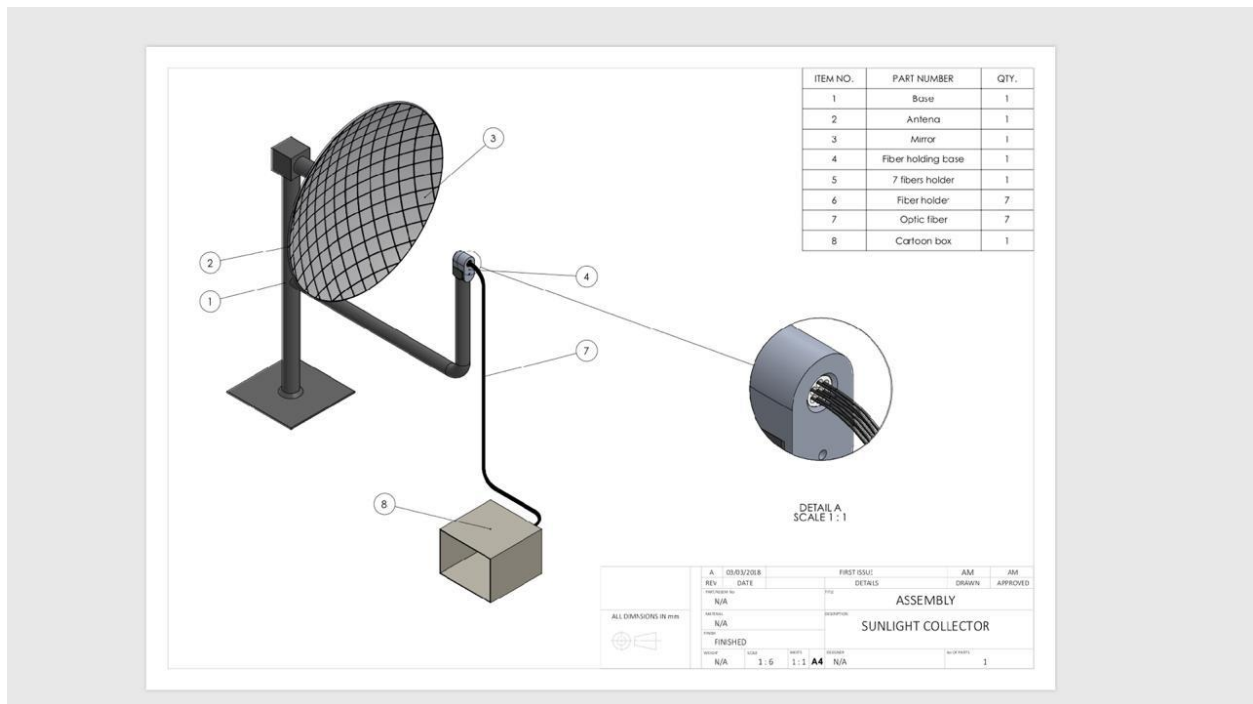


figure 6.1 - 2D image of final project.

In figure 6.1, This is the how we are aiming to make the final product look like. It is the most reliable way we have found in order for us to make the most out of this project. This means that we need to perform this in the most accurate way and using elite materials in order for it to run in the same way that we plan it on running.

3)REFERENCES-

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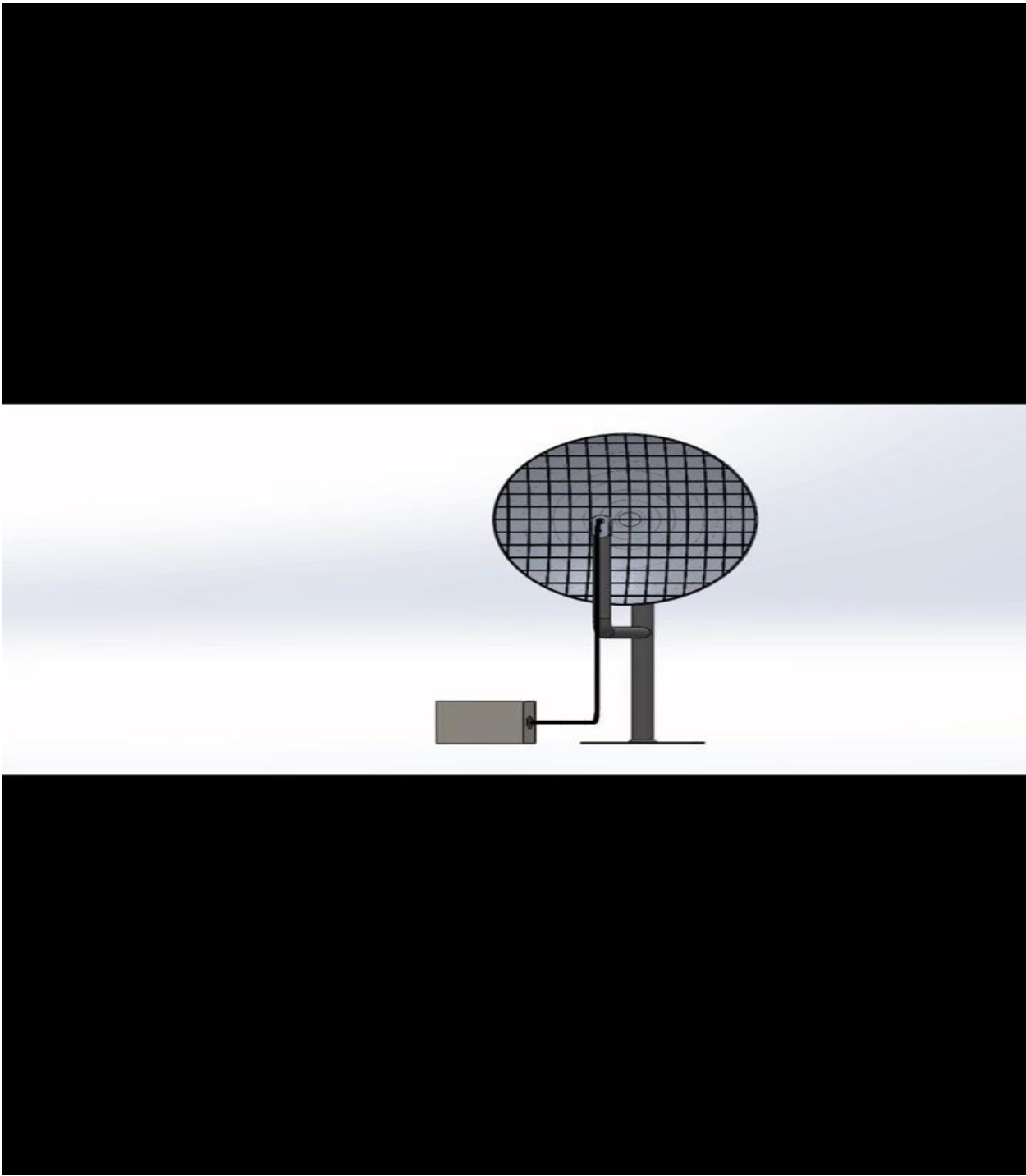


figure 6.2 3D image of current work progress.

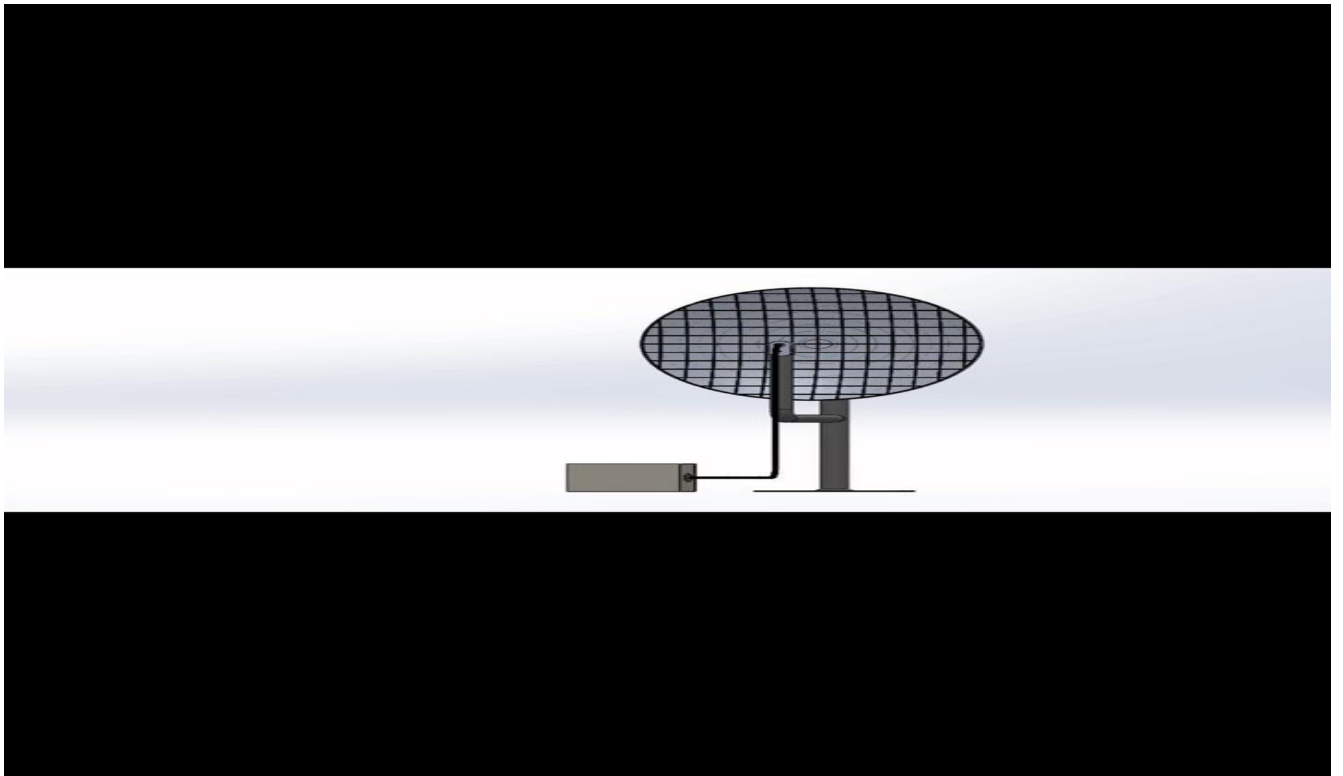


figure 6.3 3D image of work in progress.

CHAPTER 4- Day Lighting System by Fiber Optics-

Abstract

Fiber Optic day lighting system is an innovative method to capture and transmit the excess sunlight available outside to illuminate the interior of buildings. In the present situation, the usage of renewable energy resource to conserve energy and reduce pollution is an important agenda for many national governments. In addition, numerous studies have demonstrated that natural lighting can increase worker productivity and sales, workplace satisfaction and has numerous health benefits.

Fiber optic day lighting technique is the most applicable method for bringing continual sunlight into the core of the structure whilst retaining the dimension of control required by inhabitants and all the while moderating the inconsistency, intensity of brightness, dissemination and thermal solace issues of customary day lighting systems.

Introduction

NASA and much other public and private sector organizations are doing research to harness and harvest solar power. An arrangement of lenses present in the roof or fixed in the front side of the building is used to trap and collect the solar energy. Through fiber optics technology the sunlight is then steered into the core of the building to illuminate the rooms with sufficient natural light. The four major day lighting technologies used at present are Hybrid lighting system, Himawari, SOLUX and Parans SP3. The first method uses a reflective parabola to harvest sunlight and the other three techniques use Fresnel lenses to harness the power of solar energy.

Fiber optic cable can transmit light over long distances as the light travels as an oscillating wave bounces off the cladding without much absorption. The degradation in the transmission of the signal is due to impurities present in the fabricating material like glass or plastic. Therefore, the wavelength of light, length and quality of the cable are some of the factors that determine the degradation of light transmission. (Jadhav, Gode, Gardi & Bhandari, 2016)

Methods

Parans SP3 consists of solar receivers to accumulate and harness the solar power and fiber optic cables to transmit solar light through the building, and the luminaires to illuminate the interiors of the building.

A solar collector is used to track the sun and harness solar power. Stepper motors are utilized to rotate the collector 360° around its vertical axis and are tilted between 0° and 180° . The solar collector consists of a matrix of 36 Fresnel lenses with the focus of each lens concentrated into an optical fiber. The materials in the Fresnel lens that do not add to the optical features of the lens are separated.

The lens is connected to the optical fiber through a filter. The application of the filter is to limit the transmitted light to a wavelength threshold. The optical fibers are then heaved into six fiber cables, which is then connected to a shielded flexible channel. Even though the losses incurred in the plastic fiber cable is greater, it is used in SP3 instead of glass fiber. The losses are due to the absorption of vibration in the CH- bindings present in the Poly Methyl Meth Acrylate

(PMMA) molecule. The optical fiber cable is connected to the electrical cable, which is then connected to the luminaries present in the interior of the buildings.

Results

The focal length is found to be 83 mm for the Fresnel lens with a size of 6.5mm x 6.5 mm and a numerical aperture (NA) of 0.36. The length of the optical fiber is 10m. The relationship between the refractive index of core and cladding determines the characteristics of the optical fiber. The incident angle is equal to the output angle of the light and the intensity is high near the axis of the fiber.

In this experimental procedure, a thick glass fiber of 0.2mm is used. The optical spectrum analyzer is used to measure the maximum intensity of Spectral Power Distribution (SPD), FWHM (Full Width at Half Maximum) and double FWHM. Due to chromatic aberration, the blue light is refracted to the outside of the focal spot.

Due to the absorption in CH – bindings of the PMMA molecule of the fiber, the transmittance power is reduced for 545nm, 625nm and 730nm. In order to obtain the luminous flux intensity to illuminate the buildings, the optical fibers are assembled into bundles and then connected to the electrical cable.

Discussion

The solar collector probes the sky in expanding rectangles until it identifies the position of the sun using a light sensor. The path of the sun is traced and gathered by the solar collector for use in the consecutive days. Two different methods are used to control the tracking system of the solar collector. The first method uses a photovoltaic cell to determine the light intensity and regulates the stepper motors to position the collector in the direction of maximum sunlight. In the second method, electronic microcontrollers are used to analyze and evaluate the celestial behaviour of the sun in relation to the earth and the position of the solar collector is decided correspondingly.

Low manufacturing cost is the main advantage of Fresnel lenses, which is designed with refractive parts of a lens placed side by side. Each lens absorbs only the direct constituent of the solar light. The filter reflects the near-infrared and ultraviolet rays of the sun. Both these rays can cause damage to the plastic optical fiber. Therefore, a durable and high-performance filter is necessary to improve the efficiency of the system.

The sunlight is then directed with the use of optical fibers to illuminate the interiors of the building. The light is transmitted using the principle of total internal reflection, which happens at the intersection of core and cladding. The refractive index of the core is larger than the casing. The light transmitted through the core has low attenuation whereas the light guided through the cladding has high attenuation due to the leaky modes present. When a continuous optical fiber is used, the attenuation is caused only by the absorption of the material. Besides these losses, the intensity of the light transmitted is reduced significantly due to losses in the coupling of the fiber which accounts for around 15% of losses per coupling. Proper axial alignment and end-face geometry across optical fiber coupling is impossible and requires a distinct design procedure.

Parans SP3 uses PMMA, a synthetic polymer for efficient light transmission. PMMA is preferable for solar lighting applications as it is ideally suited for visible spectrum applications. In PMMA fibers, minimum attenuation of 64, 73 and 130 dB/km happen at 520, 570 and 650nm respectively. Therefore green, yellow and red light are transmitted admirably well by the PMMA

fiber. Even though liquid core and silica glass fibers have lower attenuation coefficients, PMMA fibers are preferred for their low manufacturing cost and easier installation procedures. (Mohapatra, Mohapatra & Ravi Kumar, 2014)

Conclusion

Building measures and designing practices have inclined toward integrated, whole-building configuration approaches with a goal to maximize the quality of the interior environment, inhabitant responsiveness and complete functionality of the structure. As power costs proceed to increment and worries about environmental change drive the necessity to improve the effectiveness of sustainable sources and diminish the application of non-renewable energy reserves. Transmission of daylight through optical fibers supports the wavelength and frequencies of the visible spectrum of light while decreasing the infrared and ultraviolet rays, reducing thermal solace issues experienced in customary day lighting configuration. Further advancement is expected to address configuration issues, such as merging natural and artificial sources of light, expelling abundance heat from components and fibers, expanding the life cycle of the system, and building up guidelines for design, installation and support. However, improved innovations, development of design standards, emerging commercial markets and rising energy prices will make fiber optic based day lighting system to be more practical and economically suitable for an extensive scope of applications. (Werring, 2009)

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