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A EXPERIMENTAL STUDY OF THERMAL ENHANCEMENTS ON SOLAR COMPONENTS

Srikanth Boda, Research Scholar, Dept of Physics, Monad University, Hapur

Dr Jaidev Sharma, Professor, Dept of Physics, Monad University, Hapur

ABSTRACT

The study of matter and energy is called physics. Our daily actions depend heavily on matter, energy, and the interaction of these three elements. The stuff releases energy because its temperature is higher than absolute zero. Electromagnetic waves are the energy that is released. Matter is impacted by electromagnetic waves. The sun, for instance, radiates energy and has a temperature range of 6000 K to 15.7 million K. Electromagnetic waves are the form that the sun emits energy. The radiated energy interacts with matter and can be transformed into a variety of energy types, including chemical, electrical, and thermal energy. Plants absorb radiation energy and transform it into chemical energy when photons from the radiation fall on them. The radiated energy is transformed into electrical energy if photons from the radiation energy strike solar cells. The radiated energy is transformed into thermal energy if the same photons strike solar collectors. We can efficiently use the radiated energy and its transformed forms of energy in our daily operations. Samples of tempered special and nano-textured glasses, each measuring 400 cm^3, were obtained for the current study. They spent four hours being cooked to 200 0C in an oven. After the experiment's predetermined amount of time, the sample pieces were removed from the oven. Next, the heated sample pieces were doused with water. In order to detect any cracks, the top coverings were examined. It was discovered that the top covers utilized in the solar collectors did not exhibit any cracks. The top covers under consideration were thought to be able to tolerate the extreme temperatures found outside based on the test findings. Additionally, it was thought that the top covers could resist an unexpected downpour in the daylight.

KEY WORDS: *Energy, Thermal Enhancements, Electromagnetic, Absorber, Nano-Textured Glasses.*

INTRODUCTION

While the absorber should have sufficient thermal endurance, the top cover should have sufficient thermal stability. The insulating material should also have a suitable thermal resistivity at the same time. It is important to note that the thermal characteristics of a solar collector, such as its durability, resistivity, and thermal stability, may affect its thermal performance. In this regard, the individual thermal characteristics of the flat plate collector's essential parts were examined, and the findings of the tests were published.

Sample absorber pieces (with traditional coatings) measuring 400 cm2 each were used in the current study. For two hours, they were baked at 175 degrees Celsius. Following the experiment's predetermined duration, the samples were removed from the oven. The heated samples were then allowed to cool to room temperature. The absorbers were examined to check for any signs of coating fading, peeling, or flittering. It was discovered that the absorbers utilized in the solar collectors did not experience coating peeling. Additionally, it was discovered that the absorbers utilized in the solar collectors did not experience the coatings' fading and flickering. In a similar manner, 400 cm2 of sample nano-composite coated absorbers were taken, each with an absorptive coating that differed in composition between carbon and aluminium oxide. For two hours, they were baked at 175 degrees Celsius. Following the experiment's predetermined duration, the samples were removed from the oven. The heated samples were then allowed to cool to room temperature. The absorbers were examined to check for any signs of coating fading, peeling, or flittering. It was discovered that the absorbers with nanocoating's utilized in the solar collectors did not peel. Additionally, it was discovered that the nano-coated absorbers utilized in the solar collectors did not fade or flicker. Based on the test findings, it was concluded that both the newly created and conventional solar absorbers could survive high temperatures under both working and stationary situations. Additionally, it was believed that both traditional and recently created solar absorbers could efficiently absorb solar radiation when the sun was shining.

In the current study, rock wool was chosen as the insulating material to be used in the construction of the water heating collector. Furthermore, the innovative wool was chosen to be used as an insulating material for building a water heating collector. Samples of the appropriate thickness insulation material were collected from the base and border. They were delivered to the Coimbatore solar industry's test laboratory. A resistance monitor was used at the test laboratory to examine the samples. According to the test report, the thermal resistance of conventional insulation material at the base and border was 0.94 m2 oC/W. The test report also revealed that the innovative insulation material's base and border thermal resistance was 0.96 m2 oC/W. The acquired results showed that the thermal resistivity values were in line with the BIS criteria. Based on the test results, it was concluded that conduction and convection heat losses could not occur with rock wool or new wool.

The stagnation temperature and stagnation factor of cylindrical tubes determine their thermal efficacy. In this regard, an experimental estimate of the standard cylindrical tube's stagnation temperature was made. The standard cylindrical tube's stagnation temperature was discovered to be 185.6 °C. Furthermore, the field conditions were utilized to estimate the stagnation temperatures of cylindrical tubes that were coated with conventional coatings, aluminium-based nano-absorptive triple layer coating, copper-based nano-absorptive triple layer coating, and copper-based nano-absorptive triple layer and anti-reflective coatings. The findings indicated that the stagnation temperature of cylindrical tubes coated with zinc, aluminium, copper, and zinc-based nano-absorptive and anti-reflective coatings, respectively, was 198.6oC, 210oC, 232.8oC, and 250.0oC. According to study studies, the thermal performance of a cylindrical tube coupled device can be determined by the type of absorptive coating. The study reviews also demonstrated that the thermal performance of cylindrical tube coupled devices might be determined by the diameters of crystallites in the absorptive coating.

Previous studies' findings showed that the cylinder tube's composition could affect a cylindrical tubular collector's thermal performance. Previous studies' findings also showed that the thermal performance of a tubular collector might be influenced by the degree of in cylindrical tubes. Accordingly, the diameters of the crystallites in the absorptive coating and the type of absorptive coating of the cylindrical tube collector may be connected to the observed stagnation temperature. According to Farzad Jafarkazemi and Hossein Abdi, there may be a correlation between the observed stagnation temperature and the vacuum levels inside the cylindrical tubular collector as well as the material of the cylindrical tubes. After that, the stagnation factor for each cylindrical tube was calculated. The calculated stagnation factor may reveal the cylindrical tube's unique thermal properties. For the cylindrical tube to be used in application sectors according to temperature requirements, the predicted stagnation temperature and the computed stagnation factor would be helpful.

The thermal performance of the flat plate collector integrated solar heating devices is determined by the thermal parameters of the solar components, particularly the solar absorbers. Studying the thermal improvements in the traditional solar absorbers is therefore crucial. Studying the thermal improvements in solar absorbers coated with nanocomposite materials and absorptive coatings with varying aluminium and carbon oxide compositions is also crucial.

RESEARCH METHODOLOGY

In the current study, superfine charcoal was ground using a traditional grinding technique to create carbon nano powder. The powdered aluminium oxide at nanoscale was purchased commercially. Simultaneously, the solar product producers provided the specifically manufactured solar absorptive solution for the purpose of absorbing incident sun energy. The appropriate ratios of 25:75, 50:50, and 75:25 was used to combine the nanosized carbon and aluminium oxide particles, and they were each given a separate stir in the solar absorbent solution. The cleaned zinc, magnesium, aluminium, and copper absorbers were sprayed with the nano-composite mixed absorptive solution. The solar water heating collectors were combined with these absorbers coated with nanocomposite, and the collectors underwent testing in compliance with the guidelines established by the MNRE and the Bureau of Indian Standards.

There were eight absorbers selected for the experiment. The six absorbers have nano-composite coatings on them, as was previously indicated. One absorber had a traditional coating on it, but the other absorber was left uncoated. These sun absorbers were all placed equally apart outside, and the increases in temperature were recorded. In addition, concurrent monitoring was done for the affecting factors, which included wind speed, ambient temperature, and incoming sun radiation. The solar absorber with the greatest temperature was chosen for additional study based on the database created in relation to the experiments on thermal increases on solar absorbers.

Variables like sun radiation, ambient temperature, entrance temperature, and output temperature were periodically measured during the experiment. A class I pyranometer was used to measure the incident sun radiation. This radiation measuring device had a measurement range of 0 to 1360 W/m2 and a precision of 0.1 W/m2.

RESULTS AND DISCUSSION

The ambient temperature was measured using the dry and wet thermometers. The temperature monitoring devices have a precision of 0.1oC and a measurement range of 0 to 80oC. The temperatures at the entrance and outflow were measured using Pt1000 thermometers. Their measurement ranges, with a precision of 0.1oC, were 0 to 200oC. The wind speed was measured using an anemometer with a precision of 0.1 m/s in the range of 0 to 20 m/s. Using calibrated measuring tapes, the collectors' gross and aperture areas were determined. For additional analysis, all of these experimentation measurements have been tallied in tables.

SIZES OF SOLAR COMPONENTS

The calibrated measurement tools were used to quantify the sizes of the primary and secondary components. Furthermore, the same calibrated measurement tools were used to quantify the sizes of the storage tanks and collectors. The thickness of the absorber and top cover were found to be 0.2 mm and 4.00 mm, respectively. Additionally, it was noted that the base region's and the border's insulation material had respective thicknesses of 25 and 50 mm. The observation revealed that the base sheet, channel sheet, and enclosing sheet had respective thicknesses of 0.70, 1.40, and 0.04 mm. The thickness values of these significant components were found to be within acceptable ranges in accordance with the specifications, specified in Indian standards. The solar collector's dimensions were measured and found to be 2040 mm in length, 1040 mm in width, and 100 mm in height. The values that were ascertained about the collector sizes were deemed suitable in accordance with the guidelines outlined in Indian Standards. It is important to note that the current solar collector sizes were chosen with acceptability in mind for the design, tolerance for the fabrication process, and tolerance for the scaling up process.

Using calibrated measuring tools, the sizes of the solar cylindrical tubular device's component parts were measured. The thickness of each solar tube collector was found to be 2.0 mm. Additionally, the same solar tube collector's length of 1800 mm was noted. The concentrator that was mounted beneath the solar cylindrical collector measured 0.5 mm in thickness, 1800 mm in width, and 1000 mm in length (4x250 mm), in that order. The concentrator sizes were chosen to completely cover the solar tubular collectors' base area. In addition to increasing reflectance, the improved concentrator sizes would improve the thermal performance of solar collectors. The solar tubular device's supporting base measured 2100 mm in length, 1050 mm in width, and 0.80 mm in thickness. The diameters of the supporting base were chosen to hold the entire heating device and to grab and support the cylindrical tubes and concentrators.

Table-1: Sizes of cylindrical tubes

Parameters	**Sizes**
Diameter (Inner tube)	40 mm
Diameter (Outer tube)	60 mm
Thickness (Inner tube)	2 mm
Thickness (Outer tube)	2 mm
Length	1800 mm

Table-2: Specifications of cylindrical tubes

Parameters	**Specifications**
Material (Inner tube)	Borosilicate
Material (Outer tube)	Borosilicate

Absorptive coating	Metal oxide coating
Vacuum pressure	5 x 10^{-3} Pascal
Shape	Cylinder

Table-3: Sizes and specifications of concentrators

Parameters	**Dimensions**
Length	1800 mm
Breadth	250 mm
Thickness	0.5 mm
Material 1	Metal corrugated sheet (LG) with nano-composite coating
Material 2	Metal corrugated sheet (MG) with nano-composite coating
Material 3	Metal corrugated sheet (HG) with nano-composite coating
Number of concentrators	4

The physics of solar collectors and solar componentry has been the focus of this research project. In this regard, measurements were initially taken of the solar components' diameters, including those of the top cover, absorber, insulator, cylinder tubes, concentrators, and other auxiliaries. Second, an investigation was conducted on the optical properties of the basic components. Thirdly, research was done on the basic components' thermal characteristics. Fourthly, XRD and SEM analysis were used to examine the samples with conventional coatings and coatings based on nanotechnology. Finally, a study was conducted on the temperature differences between standard and advanced solar absorbers. The standard methodology was followed for examining the structural, optical, and thermal characteristics of the solar absorptive coatings on the solar collector components, even though the calibrated equipment were utilized to determine the sizes of the components. To investigate the thermal uniqueness of solar absorbers, standard test protocols were used. This chapter contains a summary of all the research findings related to physics-based parameters, such as solar component sizes, absorber thermal distinctiveness, optical properties of basic components, structural characteristics of absorptive coatings on absorbers, and thermal properties of basic components. Global producers, scholars, and consumers of solar devices would benefit from the combined research findings (Fabio Struckmann, 2008).

As is well knowledge, the cylindrical tube, top cover, absorber, insulator, and concentrator are the basic parts of solar cylindrical and flat plate collectors. The encircling support, channel support, base support, riser tube, and header tube are the additional parts of the same cylindrical and flat plate collectors. The cylindrical tubes' dimensions (diameter, thickness, and area) were measured for the current study project. Using calibrated instruments, all the sizes (in terms of thickness, diameter, and area) of the primary and secondary components were also measured.

Table-4. Sizes and specifications of supporting base

Parameters	**Specifications**
Material	Stainless steel with anti-rust coating
Length	2100 mm
Breadth	1050 mm
Thicknelss	0.80 mm

Table-5 Sizes and materials of glass plate

Parameters	**Specifications**
Material	Tempered special
Length	2040 mm
Breadth	1040 mm
Thickness	4 mm

Table-6 Sizes and materials of glass plate

Parameters	**Specifications**

Material	Nano-textured
Length	2040 mm
Breadth	1040 mm
Thickness	4 mm

Table-7 Sizes and materials of absorbers

Parameters	**Specifications**
Materials	Zinc, Magnesium, Aluminum and Copper
Coatings	Nano carbon coating Nano carbon and aluminum oxide coating Nano chromium oxide coating
Length	2020 mm
Breadth	1020 mm
Thickness	0.2 mm
Number of fins	8

Each of the essential parts of the flat plate collector has had its optical properties examined in detail, and the test findings have been published. According to Maatouk Khoukhi and Shigenao Maruyama (2005), the top cover has optical properties including transmittance, reflectance, and absorptance. All of these properties may have an impact on the solar panel's thermal performance gatherer. All of these optical properties were investigated in the field in relation to this.

CONCLUSION

The solar collector in the current study uses a specially designed tempered cover. The tempered special glass cover's reflectance was measured at 12.5%, whilst its transmittance was determined to be 84.8%. The absorptance of the top cover was computed by replacing the transmittance and reflectance values. 2.7% was determined to be the absorptance of the identical tempered special glass top cover. When the transmittance values were compared, it was discovered that the tempered special cover's transmittance value was higher than the traditional plain glass covers. Concurrently, it was discovered that the tempered special glass cover's reflection value was less than that of the traditional plain glass cover. From the manufacturer's reports, it was observed that the tempered special glass covers were made expressly to be used in solar collectors, with the goal of having a lower reflectance and a higher transmittance than those of the conventional covers. Upon inspection, the solar collector's tempered special cover revealed no bubbles or uneven surfaces. According to the research reviews, the tempered glass coverings shown a good degree of resistance against breaking throughout the thermal cycling procedure. The study evaluations also demonstrated that tempered glass covers had a high level of resistance to breaking during natural disasters. Previous studies showed that the tempered glass covers were more expensive than the standard plain glass covers. Because of its advantageous optical and thermal resistance qualities, tempered glass was chosen to be used in solar collectors even though it was more expensive than regular plain glass.

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