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**RESEARCH ARTICLE**

# GRAPHITE-ZnO NANOCOMPOSITE BASED ABSORPTIVE COATING FOR SOLAR ABSORBER WITH SINGLE SIDED BAFFLE ARRANGEMENTS: PREPARATION, XRD CHARACTERIZATION AND THERMAL ANALYSES

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**ABSTRACT**

Nanocomposite based absorptive coatings can not only augment the absorption of incident solar radiation but also augment the heating of the working fluids that flow in contact with the absorber. In these perspectives, solar absorbers in small and standard sizes with graphite and ZnO mixed nanocomposite coatings were prepared in the present research work. While the small size solar absorber was used for characterization studies, the standard size solar absorber with single sided baffle arrangement was utilized for thermal analyses in outdoor atmosphere. The research results revealed that the grain size in the absorptive coating was 29.65 nm and the developed absorptive coating could be used in solar absorbers that would be used in stagnant and outdoor conditions. The research results also revealed that temperature on the solar absorber ranged between 32.2° C and 46.2° C. On the basis of the research outcomes pertaining to nanocomposite based absorptive coating and nanocomposite absorptive coating based solar absorber, it could be concluded that nano-graphite, nano-zinc oxide and solar absorptive solution coated solar absorber would be utilized not only for effective absorption of solar radiation but also for effective heat transfer to the working fluid in application sectors.



## INTRODUCTION

Solar collector is a central device of any solar thermal system. It is reported that the structural, optical and thermal characteristics of the conventional absorptive coatings on absorber sheet in solar collector determine the thermal enhancements of working fluids in solar thermal system (4). It is also reported that the alternate absorptive coatings with variations in structural, optical and thermal characteristics are to be developed and deposited on absorber sheet in solar collector for obtaining desirable thermal enhancements of working fluids in the same solar thermal systems (5, 6).

In these perspectives, the objectives such as i) development of nano graphite based solar absorptive coating ii) deposition of the prepared coating on solar absorbers iii) estimation of thermal enhancement in absorber sheet used in solar collectors were framed for the present investigation.

All these objectives were materialized by using standard materials, standard methods and standard test procedures and the research outcomes have been documented in this research paper for the benefits of manufacturers, researchers and end users worldwide.

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## MATERIALS AND METHODS

### *Preparation and deposition of absorptive coating on solar absorber*

Graphite blocks were commercially procured and they were made into nano-graphite powder. This powder was mixed with nano sized ZnO in varied compositions. The mixed powder of nano sized graphite and zinc oxide was stirred thoroughly in the solar absorptive solution. The developed absorptive solution was coated on metal absorber by conventional spray coating method (2).

### *Characterization of absorptive coating on solar absorber*

The XRD is an ideal technique for the assessment of the structural characteristics of the material. In this connection, the structural characterization with reference to XRD was carried out on the developed sample. The particle size in the coating was calculated by using the Scherrer formula that has been presented in equation 1

$$D = x\,\lambda / \beta cos\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where D is particle size, x is correction factor, λ is wavelength of X-ray used and $\beta$ is the FWHM of the observed peaks (1).

The generated diffractogram along with the particle sizes in absorptive coatings has been incorporated in this research paper as scientific supports for the recorded temperature enhancements in solar absorber in the outdoor atmosphere.

***Measurement of temperature on solar absorber***

In the present investigation, an absorber plate of standard size of 2m X 1m was prepared. Metal baffles with the length of 0.80 m, breadth of 0.04 m and thickness of 0.50 mm were fixed at 0.2 m equidistances on single side of the absorber plate. The absorber plate was coated with the newly prepared nanocomposite based coating and the developed sample was dried in favorable meteorological conditions.

As an experimental part, the absorber plate was kept at 30º inclination in dust and shadow free outdoor conditions. The meteorological conditions like incident solar radiation, ambient temperature and wind speed were noted periodically. The temperature of the absorber plate was also noted at different points on absorber plate with single sided baffle arrangement. It is worth mentioning here that all the measurements, tests and field experiments were carried out by using calibrated instruments.

## RESULTS AND DISCUSSION

Preparation and deposition of nano absorptive coating, characterization of nano absorptive coating and estimation of thermal enhancement on solar absorber are the integral aims of this research investigation. While the technical specifications of solar absorber have been presented in Table 1, the diffractogram and the results of field experiments have been presented in Figure 1 and Table 2 respectively.

**Table 1**Technical Specifications

| Solar absorber | Material / Dimension |
|---|---|
| Length | 2 m |
| Breadth | 1 m |
| Thickness | 0.50 mm |
| Number of baffles on absorber | 9 |
| Distance between the baffles | 0.2 m |
| Material | Aluminium |
| Coating | Absorptive coating |
| Coating composition | Nano graphite, nano zinc oxide and solar absorptive solution |

**Table 2** Temperature enhancement on solar absorber

| Level of solar radiation ($W/m^2$) | Temperature of solar absorber (° C) | |
|---|---|---|
| | Minimum | Maximum |
| < 300 | 32.2 | 36.6 |
| 300 to 600 | 36.6 | 41.0 |
| > 600 | 41.0 | 46.2 |

The material used as solar absorber in the present investigation was aluminium. The choice of this absorber material in solar collector was not only on the basis of its cost effectiveness but also on the basis of its heat transfer characteristics to the working fluid. This metal absorber was coated by using nano-graphite and ZnO based absorptive solution so as to have effective thermal absorption of solar radiation. The thermal test on the prepared solar absorber revealed that there were neither fading of the coating nor peeling of the deposition (7). The developed solar absorber would be integrated in solar collector and the fabricated solar collector would be utilized not only in stagnant conditions but also in operating conditions in outdoor atmospheres (3, 7).

In the present investigation, the structural characterization of solar absorber was performed by XRD measurement by using X-ray diffractometer of make BRUKER ECO D8 ADVANCE operating at 40 kV and 20 mA with normal $\theta$-$2\theta$ scanning. The required parameters were obtained from the diffractogram and they were substituted in Scherrer formula. The grain size was calculated and it was found to be 29.65nm (1).

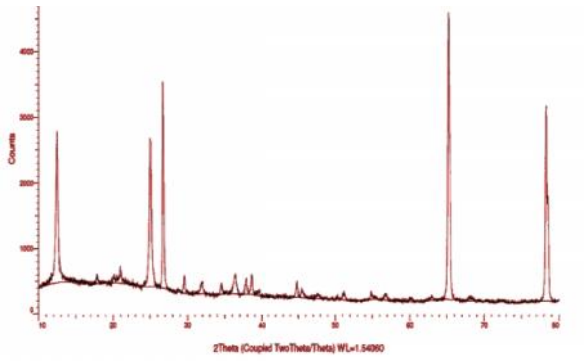

**Figure 1** XRD pattern of nano-graphite based absorptive coating

The thermal enhancement on solar absorber was measured periodically in diverse meteorological conditions in outdoor atmospheres. It was found that the temperature on absorber plate varied from 32.2° C to 36.6° C in low radiation conditions. It was also found that the temperature on absorber plate ranged between 36.6° C and 41.0° C in moderate radiation conditions. The test results also revealed that the temperature on absorber plate had the minimum of 41° C and the maximum of 46.2° C in high radiation conditions. Even though the recorded temperatures on solar absorber would be correlated with the material of absorber, nano absorptive coating and related convective losses, it could be asserted that the temperature enhancements could be specifically correlated with presence of large number of absorbing particles on absorber plate (1).

## CONCLUSION

On the basis of the research outcomes pertaining to nanocomposite based absorptive coating and nanocomposite absorptive coating based solar absorber, it could be concluded that nano-graphite, nano-zinc oxide and solar absorptive solution coated solar absorber would be utilized not only for effective absorption of solar radiation but also for effective heat transfer to the working fluid in application sectors.

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