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Effect of Lewis Number on Unsteady Double Diffusive Buoyancy Induced Flow in a Triangular Solar Collector with Corrugated Wall

Sourav Saha[a,*], Satyajit Mojumder[a], M.M.Rahman[b,c], M.A.H. Mamun[a], S. Mekhilef[b], R. Saidur[d]

[a]*Department of Mechanical Engineering, Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh*
[b]*Department of Electrical Engineering, Faculty of Engineering, University of Malaya, 50603, Kuala Lumpur, Malaysia*
[c]*Department of Mathematics, Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh*
[d]*Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia*

Abstract

A numerical investigation has been carried out in this paper to study the effect of varying Lewis number on the nature of heat and mass transfer in a triangular solar collector at unsteady condition. The triangular solar collector consists of two inclined glass covers and an absorber plate. The situation studied here resembles heat transfer phenomena in solar collectors and hence a thorough study on the effect of different parameters dictating this kind of heat transfer is essential. Bottom corrugated wall is subjected to high temperature and high concentration. Finite element method was employed to solve the unsteady dimensionless governing equations of continuity, momentum, energy and concentration of the problem. Calculations were carried out for Raleigh number ranging from 104 to 106 and for dimensionless time parameter = 0.1, 0.5 and 1. For the conditions mentioned here the effect of varying local and overall Nusselt and Sherwood number at those conditions are discussed. A comprehensive explanation follows each result.

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Keywords: Triangular solar collector; Glass covers; Corrugated wall; Heat and mass transfer

1. Introduction

Both industrial and non-industrial fields deal with problems related to heat transfer and for this reason different heat transfer problems have been given importance for the last 200 years. Mixed convection is a very common facet of this type of problem. Problems involving mixed convection are experienced widely in many household and industrial application fields like attic space heating, chemical processing, solar systems, food processing, electronics cooling, desalination, thermal and pollution control and so on[1,2]. Consequently thorough investigation is called for as to the

* Corresponding author. Tel.: +880-1946-922583
E-mail address: souravsahame17@gmail.com

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Nomenclature

C_p	specific heat (J kg-1 k-1)
g	gravitational acceleration (ms-2)
Gr	Grashof number
H	enclosure height (m))
k	thermal conductivity (Wm-1 k-1)
L	length of the enclosure (m)
Nu	Nusselt number
P	dimensionless pressure
Pr	Prandtl number
T	fluid temperature (K)
t	dimensional time (s)
U	dimensionless horizontal velocity component
V	dimensionless horizontal velocity component
X	dimensionless horizontal coordinate
Y	dimensionless vertical coordinate
Sh	Sherwood Number
Le	Lewis Number
N	Buoyancy Ratio
c	Concentration of species
α	thermal diffusivity (m2s-1)
β	thermal expansion coefficient (K-1)
ϕ	solid volume fraction
μ	dynamic viscosity (kg m-1 s-1)
ν	kinematic viscosity (m2 s-1)
τ	dimensionless time
θ	non-dimensional temperature
ρ	density (kg m-3)
ψ	stream function
Γ	general dependent variable

mixed convection paradigm of heat transfer problems. Among different parameters that dictate such thermal phenomenon Lewis number has a significant impact and this paper aims to study a particular problem in light of variation in Lewis number. The most common shapes which are extensively studied for the mixed and double diffusive condition both in steady and unsteady cases are square, rectangular, trapezoidal shaped enclosures [3–5]. Triangular shaped enclosures get a very little attention on this regard although triangular shaped enclosures are seen in so many practical applications. Among the studies on triangular shapes Hasanuzzaman et al.[6] investigated the effect of Lewis number on heat and mass transfer in triangular cavity and observed that when the Lewis number increases the heat transfer rate along with Nusselt number decreases and the mass transfer rate increases. So the increase of Lewis number has adverse effect on heat transfer while positive effect on mass transfer. Rahman et al. [7]studied the different geometrical parameter such as Raleigh number, Prandtl number for a steady double diffusive buoyancy induced flow in a triangular cavity and showed that the parameters have significant effect on heat and mass transfer. For triangular cavity these literatures [8,9]can be followed. Cheng [10] studied both heat and mass transfer in natural convection implementing a vertical wavy surface and concluded that for the wavy surface both the heat and mass transfer rate are higher than the plane surface. So in a corrugated bottom surface there should be an increase in the heat and mass transfer rate. Jang and Yan[11] also reported similar results for the mixed convection along vertical wavy surface. Solar energy is the most secure source of renewable energy. As a result it has been given a huge importance and different countries have taken policies on this regard. Solar energy is also environment friendly and cost effective. Nowadays solar technology has a wide range of applications such as solar thermal collector, solar PV cell, solar water heater, solar cooling and so on. In the solar thermal collector which is used in different solar thermal applications the heat transfer is associated