Arab J Sci Eng (2011) 36:1113–1124
DOI 10.1007/s13369-011-0066-4

RESEARCH ARTICLE - MATHEMATICS

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On Thermal Radiation and Joule Heating Effects in MHD Flow of an Oldroyd-B Fluid with Thermophoresis

Received: 28 January 2011 / Accepted: 15 May 2011 / Published online: 16 August 2011

Abstract In this article we investigate heat and mass transfer effects in the magnetohydrodynamic (MHD) flow of an Oldroyd-B fluid in a porous space. In addition, thermal radiation, Joule heating and thermophoresis are considered. The relevant equations are first developed and then computed by the homotopy analysis method. The local Nusselt and Sherwood numbers are also analyzed. The dimensionless velocity, temperature and concentration fields are displayed and discussed for various emerging parameters of interest.

Keywords Thermal radiation · Oldroyd-B fluid · Stretching surface

Mathematics Subject Classification (2000) 76BXX · 76VXX

الملخص:

نبحث في هذه الورقة آثار نقل الحرارة والكتلة في الدفق المغناطيسي – الهيدروديناميي (MHD) لسائل أولدروید – ب في فضاء مسامي. بالإضافة إلى ذلك، نعتبر الإشعاع الحراري وتسخين جول والرحلان الحراري. يتم أولاً تطوير المعادلات ذات العلاقة ومن ثم يتم حسابها بطريقة تحليل التشوه المستمر. يتم أيضاً تحليل أرقام نسلت وشيروود المحلية. يتم عرض ومناقشة السرعة غير البعدية ودرجة الحرارة وحقول التركيز لعدد من الوسائط الناشئة المهمة.

1 Introduction

The subject of steady and unsteady flows of non-Newtonian fluids is important in many industrial and engineering applications such as the biological, chemical, food and pharmaceutical industries. Hence, non-Newtonian fluids have been broadly investigated in view of such applications during the last few decades. At present the literature on such flows is quite sizeable; some recent attempts in this direction can be found in the studies [4,8,9,15,17,21,25,32,37,38] and several references therein.

In general, non-Newtonian fluids are classified under three categories: differential, integral and rate types. The Oldroyd-B fluid is a subclass of rate type fluids. Because the relaxation and retardation time effects can be easily described, this fluid model is quite popular among researchers. For example, Fetecau et al. [5] studied the decay of a potential vortex in a generalized Oldroyd-B fluid. In another attempt, Fetecau et al. [6] discussed some exact solutions for the helical flow of a generalized Oldroyd-B fluid in a circular cylinder. Unsteady helical flows of Oldroyd-B fluids were investigated by Jamil et al. [22]. Hayat et al. [12] investigated the hydromagnetic Couette flow of an Oldroyd-B fluid in a rotating system. Unsteady flow of an Oldroyd-B fluid generated by a constantly accelerating plate between two side walls perpendicular to the plate was presented by Fetecau et al.

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