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Flow and Heat Transfer on a Moving Flat Plate in a Parallel Stream with Constant Surface Heat Flux: A Stability Analysis

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Abstract

Numerical solutions for the moving flat plat in a parallel stream with heat flux is to be constant have been studied. By using non-similar transformation, the governing equations be able to reduced to an ordinary differential equation. Then, results of the equations can be solved by shooting method with maple implementation. Numerical results reveal that the velocity ratio parameter $\lambda<0$, the non-unique solutions do exist. Then, the analysis of stability is carried out into two non-unique solutions to determine which is more stable between both of the solutions by bvp4c solver in Matlab. From the result of stability analysis, the eigenvalues for the first solution is positive at the same time as second solution is negative.

Keywords: Dual Solution, Heat Flux, Moving Flat Plate, Parallel Stream, Stability Analysis

1. Introduction

There exists two ways of motion of heat transfer from a surface, either it is moving or stationary fluid. Whereas in engineering, the heat transfer's motion can be applied in many areas[1]. To the best of our knowledge, in[3–5] was the first who did a research about a moving surface in the boundary layer flow. Then, the problem within moving surface has been studied in different situations by many researchers such as[6–9,11]. However, as reported by[10], the papers by[12–15] shows the dual solution in their numerical results.

In general, constant for both wall temperature and surface heat flux are common applications with in heat transfer problem by researchers. For constant wall heat flux, the temperature is increasing with distance along the wall while for constant the wall temperature, the wall temperature is constant. In this study, the boundary condition is constant heat flux is considered.

Recently, a study regarding stability analysis had sparked an interest in research. This analysis is important in this fluid dynamics to identify which solution is stable if there are non–unique solutions exist in computation. However, the papers regarding this problem are limited in view since it is very new in our research. Some papers can be viewed towards this interest such as papers by[12,15–21]. In this present study, the aim is to examine the stability of the existence dual solution reported by[10].

Nomenclature

g	acceleration due to gravity
f	non-dimensional stream function
T	fluid temperature
T_∞	ambient uniform temperature
q_w	local heat flux
T_w	surface temperature
Pr	Prandtl number
C_f	skin friction coefficient
Re	Reynolds number
Nu	Nusselt number

Greek symbols

α	thermal diffusivity
ψ	stream function
η	similarity variable
λ	velocity ratio parameter
μ	dynamic viscosity
ρ	fluid density
ν	kinematic viscosity

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