Re-examination of similarity transformations on MHD boundary layer flow over a nonlinear stretching sheet via Homotopy perturbation sumudu transform method

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1. INTRODUCTION AND OBJECTIVE

In this study, the similarity transformation is the focus. The authors evaluate similarity transformations in several works on stretching sheet problems where the dimensionless similarity variable is a function of a single independent variable due to this the findings obtained exhibit some signs of degradation. The similarity variable was not a dimensionless quantity in the majority of stretching sheet articles that involved non-linear stretching. Furthermore, the stretching velocity is also not of appropriate dimension. So, in this study, we made an effort to satisfy these conditions by deriving a new set of similarity transformations, in which the similarity variable is dimensionless and appears in the formulation as a function of all independent variables. The Runge Kutta Fehlberg 4-5th methodology was used to solve the modified equations numerically and for the first time, the homotopy perturbation sumudu transformation method (HPSTM) was used to obtain the analytical solution for the transformed momentum and energy equation. The comparison with the numerical results demonstrates the precision of the present work. The repercussion of unique components on thermal and velocity plots are explained in graphical records. This paper demonstrates that using improper similarity transformations results in significant errors in the solution.

The idea that the effects of friction are only felt extremely close to an object moving through a fluid, proposed by 29-year-old scientist Ludwig Prandtl in 1904, revolutionised fluid dynamics. Subsequently, the Sakiadis [1] started researching barrier layer flow through a continuously moving solid surface. The similarity transformations is defined to be the equation that involves the transformation of independent and dependent variables, where the number of independent variables in the transformed equation is at least one lower than in the original equation. Pakdemirli and Yurusoy [2] scrutinized on similarity transformation for partial differential equation. Following are few stretching sheet studies where the researchers looked of the similarity variable as a function of single independent variable. A linearly extending, continuous surface with changeable wall temperature that is sensitive to suction or blowing was explored by Vajravelu et al [3]. Gireesha et al. [4] investigated the impact of the Biot number on magnetohydrodynamic flow and heat transfer characteristics of nanofluid incorporating embedded dust particles. The authors discovered a set of similarity transformations for several stretching sheet papers with non-linear stretching in which the similarity variable is not a non-dimensional quantity. Moreover, the stretching velocity, is not of appropriate dimension i.e.,ms^{-1}. Some of these are, the sluggish flow and heat transport across a nonlinearly extending surface were investigated by Cortell [5]. Ganesh Kumar et al [6] studied the flow of tangent hyperbolic fluid over a moving stretched surface.

Table 1: Performance of a numerical approach is compared to HPSTM, when $n = 1/2$.

η	HPSTM results of $f'(\eta)$	Numerical results of $f'(\eta)$
0	1	1
0.1	0.925427674	0.925427675
0.2	0.855657424	0.855657499
0.3	0.790484398	0.790484688
0.4	0.729698303	0.729698856
0.5	0.673085585	0.673086456
0.6	0.620431375	0.620432878
0.7	0.571521151	0.571524297
0.8	0.526142000	0.526149316
0.9	0.484083448	0.484100397
1	0.44513776	0.445175098

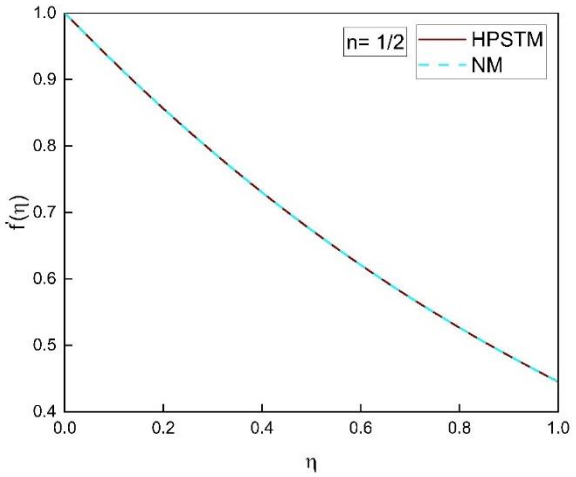

Figure1: Comparison of HPSTM and Numerical results in velocity profile.

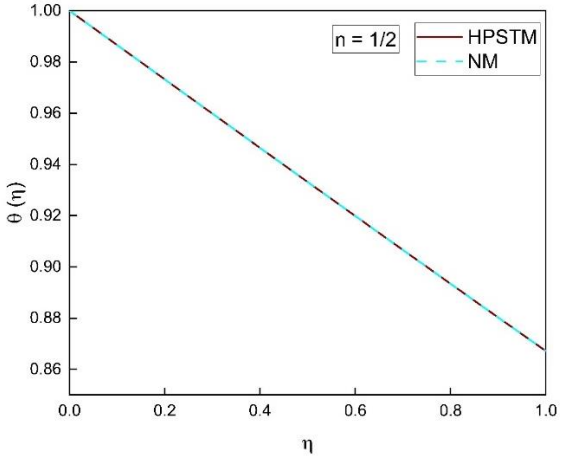

Figure 2: Comparison of HPSTM and Numerical results in thermal profile

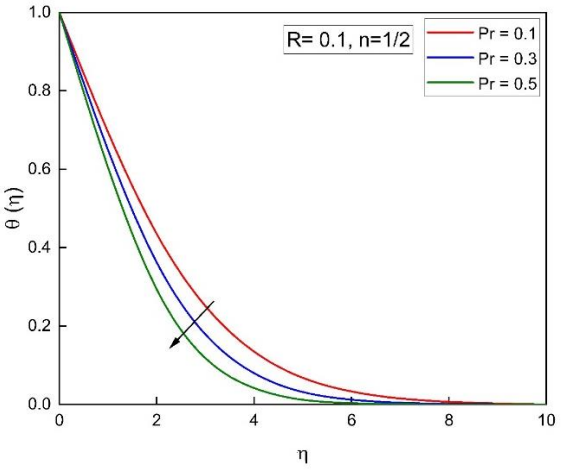

Figure 3: Repercussion of *Pr* in thermal profile

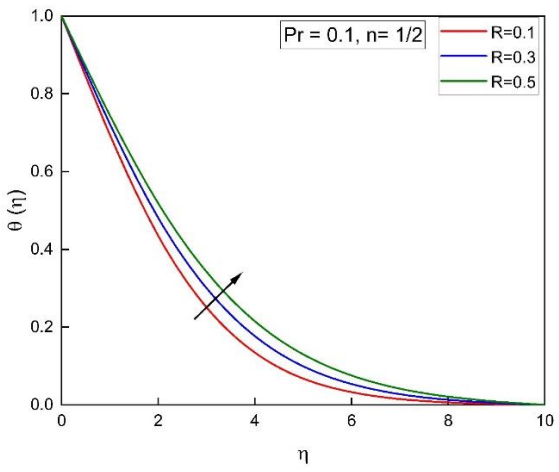

Figure 4: Repercussion of R in thermal profile

2. RESULTS AND HIGHLIGHTS OF IMPORTANT POINTS

In this current work, a new set of similarity transformations has been derived in which the nondimensional similarity variable η is a consequence of all independent variable which are exist in the formulation and is dimensionless too. Furthermore, the stretching velocity is also of appropriate dimension (m/s). Homotopy perturbation Sumudu transformation method and Runge-Kutta Fehlberg 4-5th technique and HPSTM are used to solve the transformed equations analytically and numerically respectively. The solution obtained with the aid of new set of similarity transformations depends on various parameters such as Prandtl number and radiation parameter on the thermal profile is investigated. It is found that the lack of selection of similarity transformation leads to much error in the solution.

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