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Influence of Inclined Lorentz Forces on Entropy Generation Analysis for Viscoelastic Fluid over a Stretching Sheet with Nonlinear Thermal Radiation and Heat Source/Sink

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ABSTRACT

In the present study, an analytical investigation on the entropy generation examination for viscoelastic fluid flow involving inclined magnetic field and non-linear thermal radiation aspects with the heat source and sink over a stretching sheet has been done. The boundary layer governing partial differential equations were converted in terms of appropriate similarity transformations to non-linear coupled ODEs. These equations were solved utilizing Kummer's function so as to figure the entropy generation. Impacts of different correlated parameters on the profiles velocity and temperature, also on entropy generation were graphically provided with more information. Based on the results, it was revealed that the existence of radiation and heat source parameters would reduce the entropy production and at the same time aligned magnetic field, Reynolds number, dimensionless group parameter, Hartmann number, Prandtl number, and viscoelastic parameters would produce more entropy. The wall temperature gradient was additionally computed and compared with existing results from the literature review, and demonstrates remarkable agreement.

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1. Introduction

The territory of entropy generation has always attracted huge consideration in a few fields, for example, heat exchangers, electronic cooling, porous media, solar power collectors, turbomachinery, and combustions. Entropy investigation is a framework for specifying the irreversibility of thermodynamic in a few fluid heat transfer and flow forms, which is a result of the second law of thermodynamics. It tries to find out the measure of irreversibility related to genuine procedures. The idea of minimization of entropy generation was proposed by Bejan [1]. Then, a few analysts examined the entropy generation on viscoelastic fluid flows over an extending sheet. The impact of entropy generation examination over a stretching sheet was studied by Aiboud and Saouli [2] for viscoelastic hydromagnetic flow. It was demonstrated that the entropy production is slightly affected by the magnetic parameter. The impact of entropy generation examination for hydromagnetic, mixed convective flow was contemplated by Butt et al. [3]. This expansion in the viscoelastic parameter has changed the entropy generation by a greater amount compared to what happened before. Analysis of the entropy generation test to the hydromagnetic flow of viscoelastic fluid in the presence of heat generation on a stretching surface was done by Baag et al. [4]. Rashidi et al. [5] performed work on entropy generation investigation for the hydromagnetic nonfluid flow on a stretching sheet. A numerical report on entropy production was studied by Lopez et al. [6] with non-linear hydromagnetic thermal radiation in a micro-channel. The impact of entropy generation examination for hydro-

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magnetic-nano-fluid stream over a porous medium was investigated by Shit et al. [7].

The issue of Magneto-hydrodynamic (MHD) fluid flow has been deliberated for its essentialness in the geophysical, extrusion of plastic sheets, aero-dynamics, extrusion of plastic sheets, metallurgy, engineering procedure, for example, in oil enterprises, plasma contemplates, cooling of atomic reactors and MHD power generators. Furthermore, in medical fields, the MHD is pertinent in the magnetic wound, blood pump machinery, transportation of drugs, blood loss saving for the period of surgical treatment. In an inclined magnetic field with non-linear thermal radiation, Hayat et al. [8] accomplished work for nano-fluid flow on a stretching surface, including heat source/sink effects. Abdul Hakeem et al. [9] resolved the boundary layer flow of a Casson fluid on a stretching sheet by means of an inclined magnetic field effect. In recent years, several articles deliberated the influence of an inclined magnetic field on the boundary layer flow issues [10-14].

Even though the significance of viscoelastic fluid cannot be denied due to their applications in plastic manufacturing, extrusion of plastic films, drawing of stretching sheet through quiescent fluid models are meant for slow fluids taking a slight level of elasticity [15]. Over an irregular channel, the performance of the magnetic field on viscoelastic fluid flow was analytically evaluated by Sivaraj and Rushi Kumar [16]. The same researchers studied the production of a viscous-fluid flow on a moving cone and flat plate [17]. Such attempts have still been pointed out to non-Newtonian fluid, with a much smaller number of records for a stretched flow of viscous fluid. Thermal radiation is a key in the plan of countless advanced energy alternatives operating in high-temperature liquids. A numerical inquiry of thermal radiation on the flow of MHD nano-fluid was analyzed by Sheikholeslami et al. [18] through an enclosure. Ganesh Kumar et al. [19], in the existence of the magnetic field, tested the dusty hyperbolic tangent fluid through a stretching sheet. The three-dimensional flow with non-linear thermal radiation influence on a stretched nanofluid was studied by Rakesh Kumar et al. [20] along with a rotating sheet.

Hayat et al. [21] tackled an issue for mixed convective magneto-hydro-dynamic nano-fluids flow past an inclined stretching sheet incorporating its effectiveness for non-linear thermal radiation. Farooq et al. [22] took into account the hydromagnetic stagnation point flow of the viscoelastic nanofluid to typically access the condition of non-linear thermal radiation along with a stretching sheet. Likewise, Ganesh Kumar et al. [23] inspected the viscoelastic nanofluid flow with double-diffusive free convective boundary condition in order to determine the impact of non-linear thermal radiation. Numerous examinations have been completed successfully by the specialists to plot the non-linear thermal radiation in different geometries [24, 25].

Nobody has ever considered the stretching sheet problem with the effects of blending inclined magnetic field and non-linear thermal radiation on entropy generation of the viscoelastic fluid (to the greatest extent of the authors' data). Remembering this, in the present examination, we have broken down for the viscoelastic fluid, the impacts of the inclined magnetic field on entropy generation over a stretching sheet together with non-direct thermal radiation and uniform heat source/sink analytically. The emerging profiles were utilized to process the entropy generation. The outcomes were also examined using graphical outlines and tables.

2. Mathematical formulation and solution

We analyzed two-dimensional steady, boundary layer flow of viscoelastic fluid on a stretching sheet coinciding with a plane y equal to zero, and the flow is confined to y greater than zero. The inclined magnetic field of strength B_0 is applied along the y-direction, with a sensitive angle γ. If magnetic field acts as the transverse magnetic field at the angle $\gamma = 90^0$, under the usual boundary layer hypothesis, the continuity, momentum, and energy equations for the flow of viscoelastic fluid would be as [2, 8].

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \tag{1}$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\nu\frac{\partial^2 u}{\partial y^2}-k_0\left(\begin{matrix} u\dfrac{\partial^3 u}{\partial x\,\partial y^2}+v\dfrac{\partial^3 u}{\partial y^3} \\ -\dfrac{\partial u}{\partial y}\dfrac{\partial^2 u}{\partial x\,\partial y}+\dfrac{\partial u}{\partial x}\dfrac{\partial^2 u}{\partial y^2}\end{matrix}\right) -\frac{\sigma B_0^2}{\rho}u\sin^2\gamma \tag{2}$$

$$\rho C_p\left(u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}\right)=k\frac{\partial^2 T}{\partial y^2}+q(T-T_\infty)-\frac{\partial q_r}{\partial y} \tag{3}$$

where $k_0=\frac{-\alpha_1}{\rho}$ is the viscoelastic parameter, q_r is the radiative heat flux, and q is the rate of volumetric heat source/sink.

The boundary conditions for the velocity field are of the form:

$$y=0,\quad u=u_p=\lambda x,\quad v=0$$

$$y\to\infty,\quad u=0,\quad \frac{\partial u}{\partial y}=0 \tag{4}$$

Using Rosseland approximation for radiation (see Hayat et al. [8]):

$$q_r=-\frac{4\sigma^*}{3k^*}\frac{\partial T^4}{\partial y} \tag{5}$$

Disregarding the higher order terms T^4, the assumed neglected temperature difference about T_∞ in the flow could be expanded utilizing Taylor's series as:

$$T^4\cong 4T_\infty^3 T-3T_\infty^4 \tag{6}$$

and

$$\frac{\partial q_r}{\partial y} = -\frac{16\sigma^* T_\infty^3}{3k^*}\frac{\partial^2 T}{\partial y^2} \tag{7}$$

After substituting Eq. (7) into Eq. (3):

$$\rho C_p\left(u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y}\right) = k\frac{\partial^2 T}{\partial y^2} + q(T - T_\infty) + \frac{16\sigma^* T_\infty^3}{3k^*}\frac{\partial^2 T}{\partial y^2} \tag{8}$$

Using dimensionless stream ψ(x,y) such that

$$u = \frac{\partial \psi}{\partial y} \text{ and } v = -\frac{\partial \psi}{\partial x} \tag{9}$$

2.1. Solution of flow field

Introducing the similarity transformations [2]

$$\eta = y\sqrt{\frac{\lambda}{\nu}}, \qquad \psi(x,y) = x\sqrt{\nu\lambda}f(\eta) \tag{10}$$

Then, the momentum Eq.(2) becomes:

$$f'^2 - ff' = f''' - k1\left(2f'f''' - ff'''' - f''^2\right) - Mnf'\sin^2\gamma \tag{11}$$

where $Mn = \frac{\sigma B_0^2}{a\rho_f}$ is the magnetic parameter and $k1 = \frac{\lambda k_0}{\nu}$ is the viscoelastic parameter.

The boundary conditions of Eq. (11) are:

$$f(0) = 0, f'(0) = 1, f'(\infty) = 0, f''(\infty) = 0 \tag{12}$$

An analytic solution of Eq. (11) satisfying the boundary conditions (12) as [Abdul Hakeem et al.[9]] could be obtained as:

$$f(\eta) = \frac{1 - e^{-\alpha\eta}}{\alpha} \tag{13}$$

Substituting Eq. (13) into Eq. (11) and using Eq. (12), the velocity components take the form:

$$u = \lambda x f'(\eta), \qquad v = -\sqrt{\nu\lambda}f(\eta) \tag{14}$$

where

$$\alpha = \sqrt{\frac{1 + Mn\sin^2\gamma}{1 - k1}} \tag{15}$$

2.2. Solutions for the thermal transport

Which are relevant as:

$$y = 0, \qquad T = T_p = A\left(\frac{x}{l}\right)^r + T_\infty$$

$$T \to \infty, \qquad T = T_\infty \tag{16}$$

Describing dimensionless temperature as

$$\theta(\eta) = \frac{T - T_\infty}{T_p - T_\infty} \tag{17}$$

using Eq. (14) and Eq. (17), in Eq. (8) the result would be:

$$\frac{\theta''(\eta)}{Pr}\left(1 + \frac{4Rd}{3}\{1 + (\theta_w - 1)\theta\}^3\right) + \frac{4Rd}{3}\{1 + (\theta_w - 1)\theta\}^2 \times (\theta_w - 1)\theta'^2 + f(\eta)\theta'(\eta) - (rf'(\eta) - \beta)\theta(\eta) = 0 \tag{18}$$

and the corresponding boundary conditions of Eq. (16) takes the form

$$\theta(0) = 1 \quad \text{and} \quad \theta(\infty) = 0 \tag{19}$$

where $Pr = \frac{\mu C_p}{k}$ the Prandtl number, $\beta = \frac{q\upsilon}{\rho C_p}$ the heat/sink parameter, $\theta_w = \frac{T_w}{T_\infty}$ is the temperature ratio parameter and $Rd = \frac{4\sigma^* T_\infty^4}{kk^*}$ is the thermal radiation parameter.

When $\theta_w = 1.0$, the non-linear radiation captures linearity. We are able to give the exact solution of Eq. (18), the energy equation with the aid of Confluent hypergeometric function [31]

Introducing the new variable,

$$\xi = \frac{Pr}{\alpha^2}\left(\frac{3}{3 + 4Rd}\right)e^{-\alpha\eta} \tag{20}$$

and inserting Eq. (20) into Eq. (18):

$$\xi\theta''(\xi) + \left(1 - \frac{Pr}{\alpha^2}\left(\frac{3}{3 + 4Rd}\right) + \xi\right)\theta'(\xi) - \left(r - \frac{Pr\beta}{\alpha^2\xi}\left(\frac{3 + 4Rd}{3}\right)\right)\theta(\xi) = 0 \tag{21}$$

and Eq. (19) would be transformed to:

$$\theta\left(\frac{Pr}{\alpha^2}\left(\frac{3}{3 + 4Rd}\right)\right) = 1 \quad \text{and} \quad \theta(0) = 0 \tag{22}$$

The solution of Eq. (21) in terms of η is written as [2]:

$$\theta(\eta) = e^{-\alpha(a_0+b_0)\eta}\frac{M\left[a_0+b_0-r\ 2b_0+1,\ -\frac{Pr}{\alpha^2}\left(\frac{3}{3+4Rd}\right)e^{-\alpha\eta}\right]}{M\left[a_0+b_0-r, 2b_0+1,\ -\frac{Pr}{\alpha^2}\left(\frac{3}{3+4Rd}\right)\right]} \tag{23}$$

Where $a_0 = \frac{Pr}{\alpha^2}\left(\frac{3}{3+4Rd}\right)$, $b_0 = \frac{\sqrt{Pr^2\left(\frac{3}{3+4Rd}\right)^2 - 4Pr\beta\alpha^2\left(\frac{3}{3+4Rd}\right)}}{2\alpha^2}$, and $M\left[a_0 + b_0 - r, 2b_0 + 1, -\frac{Pr}{\alpha^2}\left(\frac{3}{3+4Rd}\right)e^{-\alpha\eta}\right]$ is the Kummer's function.

The non-dimensional wall temperature gradient derived from Eq. (23) would be:

$$\theta'(0) = -\alpha(a_0 + b_0) + \frac{Pr}{\alpha}\left(\frac{3}{3+4Rd}\right)\frac{a_0+b_0-r}{1+2b_0}\frac{M\left[a_0+b_0-r+1, 2b_0+2, -\frac{Pr}{\alpha^2}\left(\frac{3}{3+4Rd}\right)\right]}{M\left[a_0+b_0-r, 2b_0+1, -\frac{Pr}{\alpha^2}\left(\frac{3}{3+4Rd}\right)\right]} \tag{24}$$

3. Entropy generation analysis

According to Woods [32] and Arpaci [33], the dimensional form of entropy generation is given by [2].

$$S_G = \frac{k}{T_\infty^2}\left[\left(\frac{\partial T}{\partial x}\right)^2 + \left(1 + \frac{16\sigma^* T_\infty^3}{3kk^*}\right)\left(\frac{\partial T}{\partial y}\right)^2\right] + \frac{\mu}{T_\infty}\left(\frac{\partial u}{\partial y}\right)^2 + \frac{\sigma B_0^2}{T_\infty}u^2\sin^2\gamma \tag{25}$$

Eq. (25) undeniably indicates the three sources in bringing about a result of entropy generation. The leading term on the right-hand side of Eq. (25) is the entropy generation caused by heat transfer covering a finite temperature difference; the following term takes place owing to viscous dissipation and is named as the local entropy generation, while the third term stands for the local entropy generation owed to the consequence of the magnetic field. To be particular, this dimensionless number is the proportion of SG, the local volumetric entropy generation rate to SG0, the characteristic entropy generation rate. SG0, the characteristic entropy generation rate under a prescribed boundary condition is:

$$(S_G)_0 = \frac{k(\Delta T)^2}{l^2 T_\infty^2} \tag{26}$$

Entropy generation number is:

$$N_s = \frac{S_G}{(S_G)_0} \tag{27}$$

Using Eqs. (13), (23) and (25), the entropy generation number is given by:

$$N_s = \frac{r^2}{X^2}\theta^2(\eta) + \left(\frac{3}{3+4Rd}\right)Re_l\theta'^2(\eta) + Re_l\frac{Br}{\Omega}f''^2(\eta) + \frac{BrHa^2}{\Omega}f'^2(\eta)\sin^2\gamma \tag{28}$$

where Re_l, the Reynolds number and Br, the Brinkman number could be obtained from:

$$Re_l = \frac{u_l l}{\upsilon},\quad Br = \frac{\mu u_p^2}{k\Delta T},\quad \Omega = \frac{\Delta T}{T_\infty}, Ha = B_0 l\sqrt{\frac{\sigma}{\mu}} \tag{29}$$

4. Results and discussion

The major intention of this section is to highlight the outcome of distinct parameters on longitudinal and transverse velocities, temperature, and entropy generation profiles. The numerical outcomes for the wall temperature gradient compared with some previously done works on Newtonian fluids were set down in Tables 1 and 2, which established the correctness of the present work.

4.1. Flow characteristics

The impact of changing the estimations of the viscoelastic parameter on $f(\eta)$& $f'(\eta)$ are displayed in Fig. 2. It is perceptible that elevating values of viscoelastic parameter slow down the fluid velocity. The impact of magnetic and the inclined angle on the longitudinal and transverse velocities are clarified in Figs. 3 and 4, respectively. Because of improved magnetic field parameter, well known Lorentz force enriches, with which the velocity of the fluid becomes smaller. It is prominent that the increase in the inclination angle is to diminish the flow velocity.

4.2. Thermal characteristics

The $\theta(\eta)$ and the thermal boundary layer were improved with an expansion in the viscoelastic parameter, which is obvious from Fig. 5. The behavior of magnetic and aligned angle parameters is disclosed in Figs. 6 and 7. It reveals that in the heat transfer process, the thermal boundary layer would be enhanced with the influence of the aligned magnetic field.

Fig. 8 depicts the typical profile of temperature for Prandtl number. The thickness of the thermal boundary layer grows smaller when the magnitude of the Prandtl number is enlarged. The variations of temperature profile, along with different values of thermal radiation parameter, are plotted in Fig. 9. It is noticeable that the augmentation in the radiation parameter upturns the temperature profile; this is caused by the release of heat energy to the flow, which helps to increase the thermal boundary layer. The change in the temperature profile with respect to the heat source/sink parameter is depicted in Fig. 10. It is quite interesting that increasing the variation of temperature distribution would enhance the thermal boundary layer thickness when heat source parameter (β >0) diminishes while the reverse for heat sink parameter (β <0) situation were observed.

4.3 Entropy generation analysis

The viscoelastic parameter has a fascinating part in the entropy generation. Attributable to this, it is displayed in Fig. 11 that the occurrence of viscoelastic parameter delivers more entropy in fluid flow. The impact of varying magnetic and inclination angle parameters on entropy generation could be seen in Figs. 12 and 13, separately. It seems that both these parameters would improve the N_S. Fig. 14 speaks to the impact of distinct Prandtl number values on N_S; it could be concluded that a higher estimation of Prandtl number produces higher entropy in the fluid stream. In Fig. 15, the N_S is plotted against the radiation parameter. Obviously, the N_S close to the surface diminishes with an enhancement in the thermal radiation parameter past the sheet.

The impact of modified estimations of the heat source/sink parameter on entropy generation is introduced in Fig. 16. It is witnessed that the entropy production reduces for heat source parameter (β>0) and in the meantime, it enhances for heat sink parameter (β <0). Figs. 17, 18 and 19, help to explain the influence of Reynolds number, dimensionless group parameter, and Hartmann number on NS. It could be declared that all these parameters produce more entropy in the fluid flow.

Table 3 is intended to reveal the insight into the values of the -θ’(0). The wall temperature gradient diminishes because of increment in the viscoelastic, magnetic, heat source, and radiation parameters, yet it increments within sight of Prandtl number. It is likewise commented that the existence of the inclination angle has no effect on the wall temperature gradient of the viscoelastic fluid.

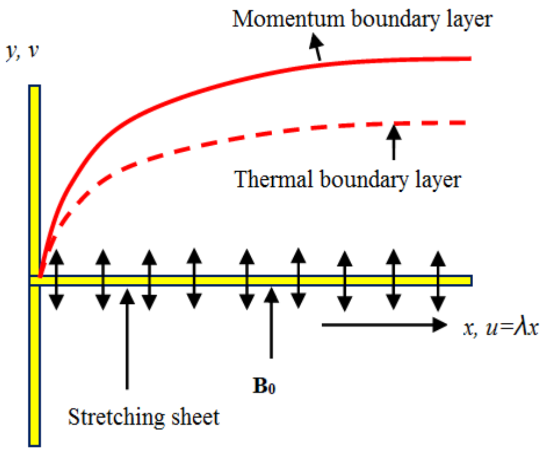

Figure 1.A sketch of the physical model.

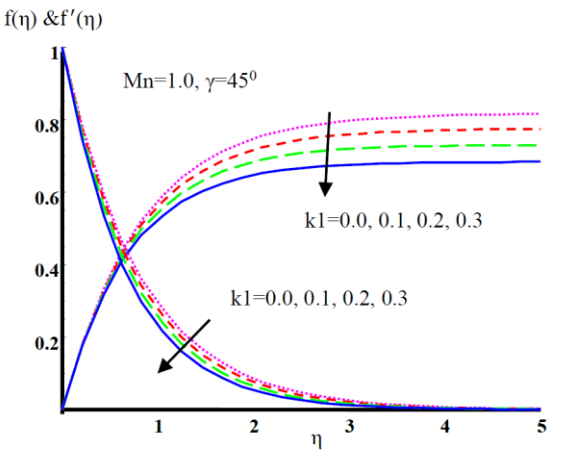

Figure 2. f(η) and f′(η) via variation of k1.

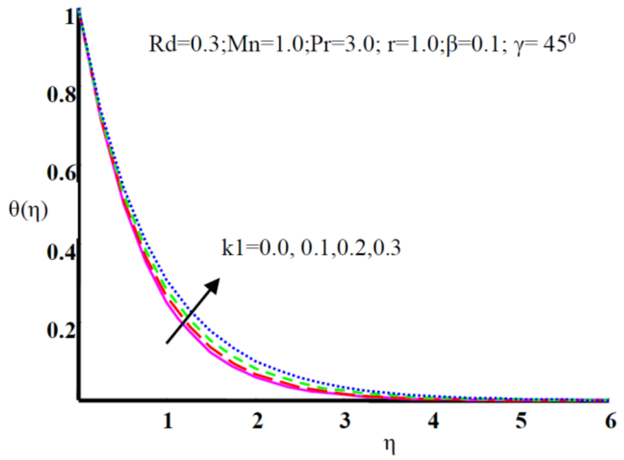

Figure 5. θ(η) variation via k1

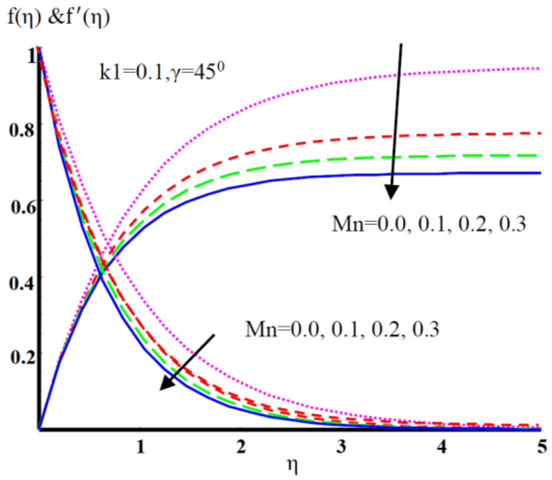

Figure 3. f(η) and f′(η) via variation of Mn.

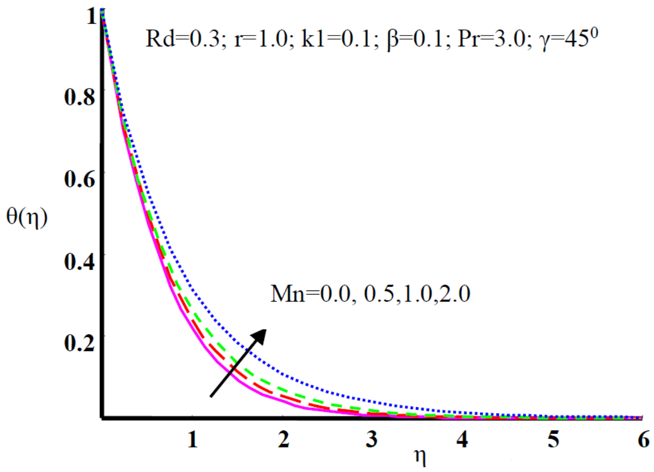

Figure 6. θ(η) variation via Mn

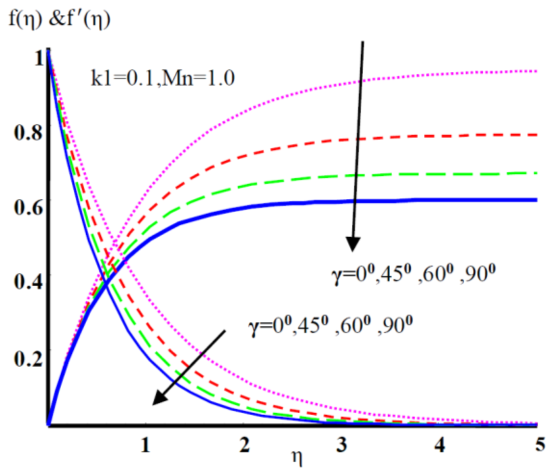

Figure 4. f(η) and f′(η) via variation of γ .

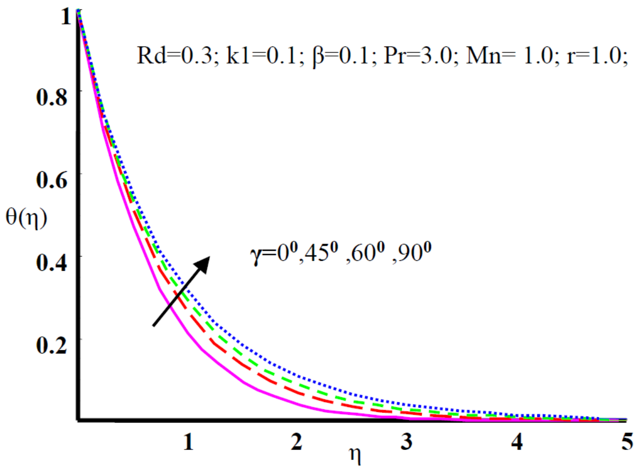

Figure 7. θ(η) variation via γ .

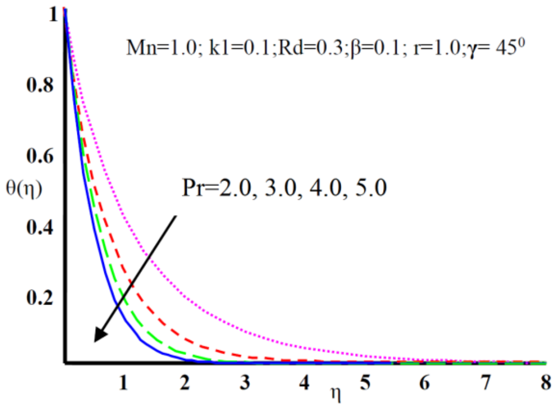

Figure 8. θ(η) variation via Pr .

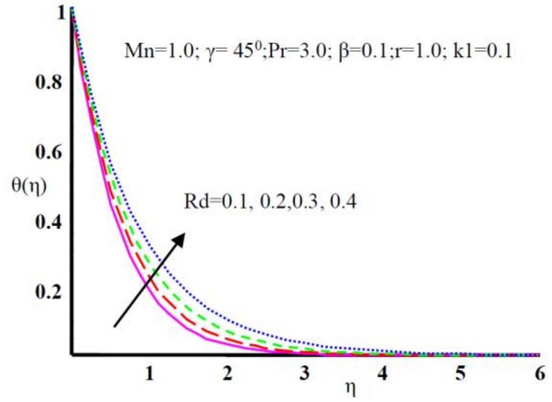

Figure 9. θ(η) variation via Rd.

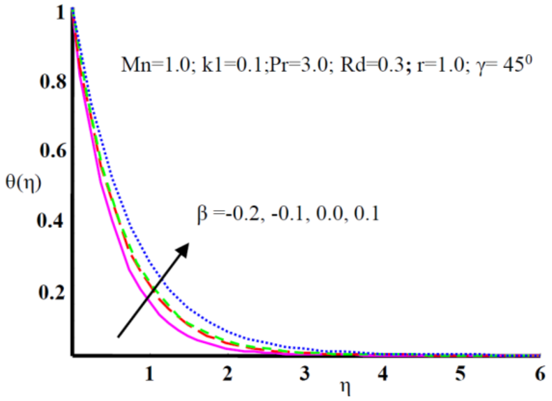

Figure 10. θ(η) variation via β .

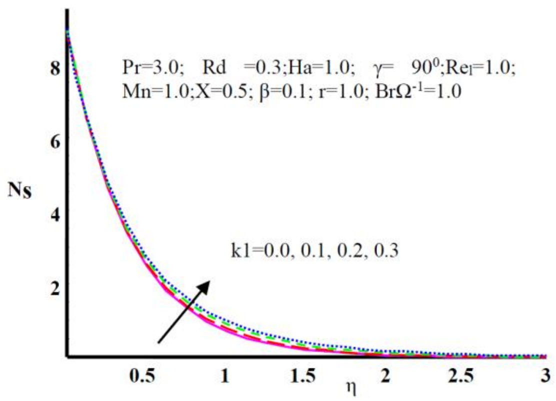

Figure 11. Ns variation via k1

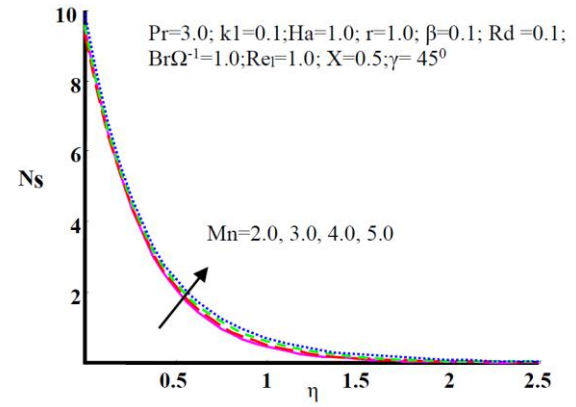

Figure 12. Ns variation via Mn.

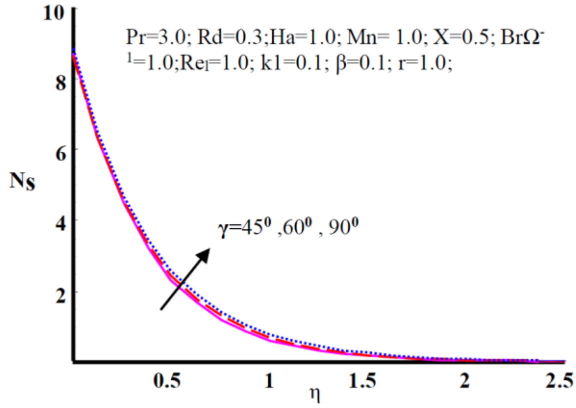

Figure 13. Ns variation via γ

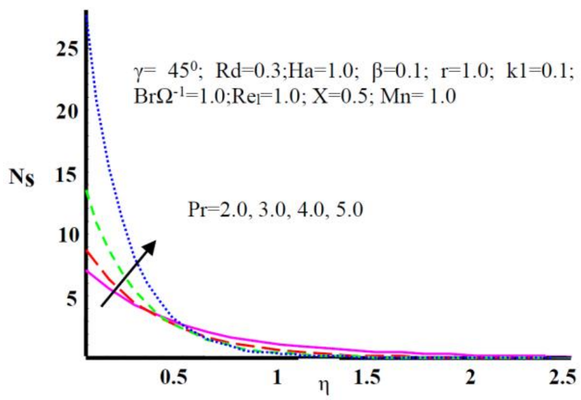

Figure 14. Ns variation via Pr

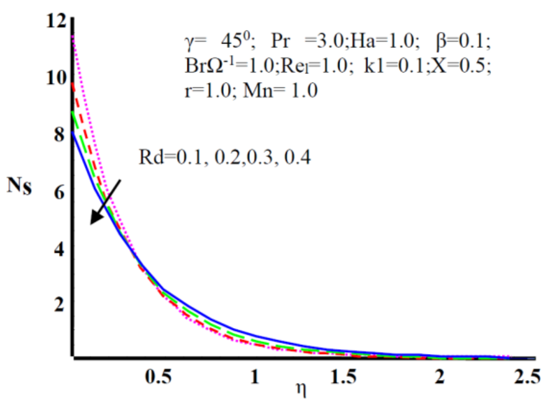

Figure 15. Ns variation via Rd.

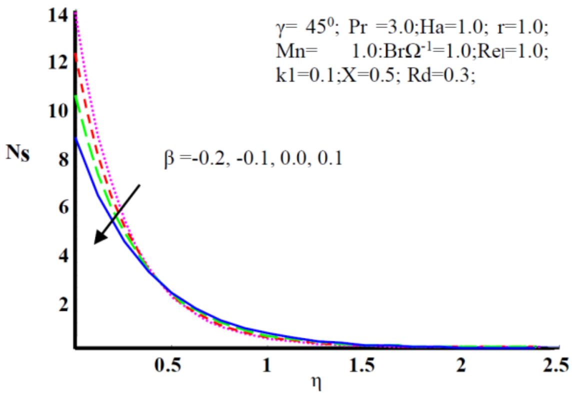

Figure 16. Ns variation via β.

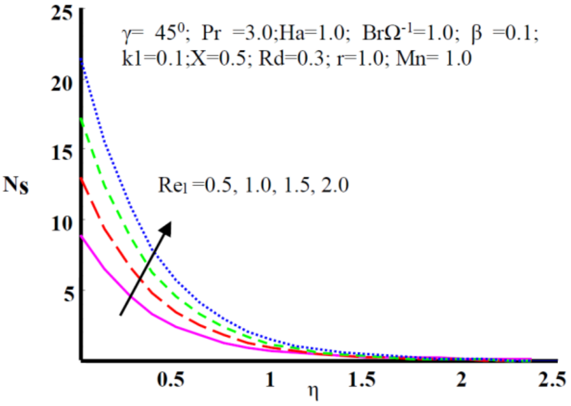

Figure 17. Ns variation via Rel.

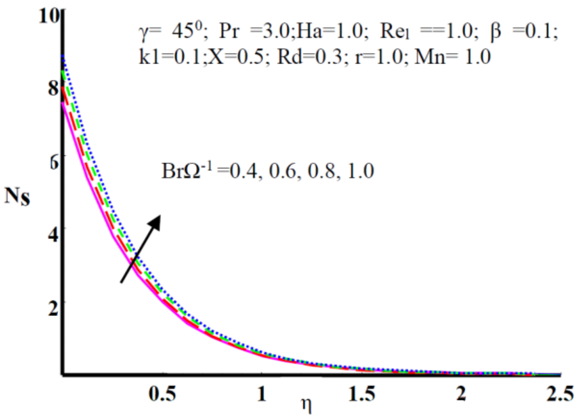

Figure 18. Ns variation via BrΩ-1.

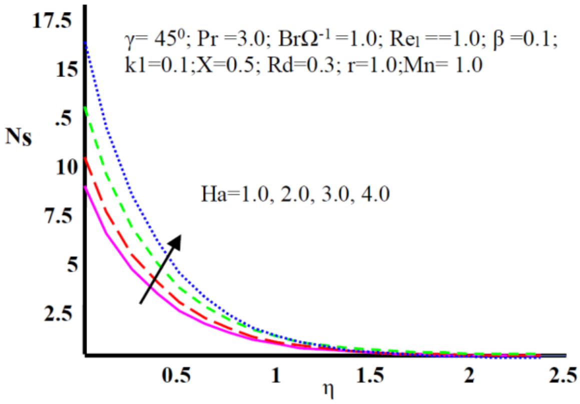

Figure 19. Ns variation via Ha.

5. Conclusion

In the present investigation, the impact of entropy generation examination for viscoelastic fluid on a stretching sheet within the presence of non-linear thermal radiation, inclined magnetic field, and heat source/sink have been evaluated. It was discovered that with the expansion in the estimation of the viscoelastic parameter, inclined magnetic field lessens the fluid velocity, and in the meantime, the temperature is upgraded with increment in the values of viscoelastic parameter, inclined magnetic field, non-linear thermal radiation, and heat source parameters and a backward design could be seen for augmented Prandtl number. It was also discovered that the decline in the entropy generation is higher for radiation and heat source parameter but improving the estimation of the viscoelastic parameter inclined magnetic field, Prandtl number, Reynolds number, dimensionless group parameter, and Hartmann number delivered more entropy in the fluid stream.

Table 1. Values of -θ’(0) for various values of r ,Pr with Mn=Rd =k1= γ= β =0.

r	Pr	Gupta and Gupta [26]	Grubka and Bobba [27]	Ali [28]	Eldahab and Aziz [29]	Abel and Mahesha [30]	Present study
0	0.72	-	0.4631	0.45255	0.45445	0.46314	0.46314
	1.00	0.5820	0.5820	0.59988	0.58201	0.58197	0.58197
	10.0	-	2.3080	2.29589	2.30801	2.30800	2.30800
2	0.72	-	1.0885	-	-	1.08852	1.08852
	1.00	-	1.3333	-	-	1.33333	1.33333
	10.0	-	4.7969	-	-	4.79687	4.79687

Table 2. Values -θ’(0) for various values of r ,Pr and k1 with Mn=Rd =k1= γ= β =0.

r	Pr	k1									
		0.0		0.01		0.1		0.2		0.5	
		Abel and Mahesh a [30]	Present study	Abel and Mahesh a [30]	Present study	Abel and Mahesh a [30]	Present study	Abel and Mahesh a [30]	Present study	Abel and Mahesh a [30]	Present study
-2	1.0	1.0	1.0	0.99498	0.99498	0.94868	0.94868	0.89443	0.89443	0.70710	0.70710
	3.0	3.0	3.0	2.98496	2.98496	2.84605	2.84605	2.68328	2.68328	2.12132	2.12132
	10	10.0	10.0	9.94987	9.94987	9.48683	9.48683	8.94427	8.94427	7.07107	7.07107
0	1.0	0.58197	0.58197	0.58093	0.58093	0.57083	0.57083	0.55786	0.55786	0.50125	0.50125
	3.0	1.16525	1.16525	1.16414	1.16414	1.15341	1.15341	1.13944	1.13944	1.07521	1.07521
	10	2.30800	2.30800	2.30691	2.30691	2.29622	2.29622	2.28229	2.28229	2.21756	2.21756
1	1.0	1.0	1.0	0.99867	0.99867	0.98571	0.98571	0.96886	0.96886	0.89215	0.89215
	3.0	1.92368	1.92368	1.92239	1.92239	1.90976	1.90976	1.89324	1.89324	1.81591	1.81591
	10	3.72067	3.72067	3.71942	3.71942	3.70724	3.70724	3.69132	3.69132	3.61699	3.61699
2	1.0	1.33333	1.33333	1.33192	1.33192	1.31810	1.31810	1.30001	1.30001	1.21577	1.21577
	3.0	2.50973	2.50973	2.50839	2.50839	2.49534	2.49534	2.47824	2.47824	2.39780	2.39780
	10	4.79687	4.79687	4.79559	4.79559	4.78306	4.78306	4.76669	4.76669	4.69021	4.69021

Table 3. Values of -θ’(0) for different values of Pr, r, Mn, Rd, k1, γand β .

k1	Pr	Mn	γ	β	Rd	r	-θ’(0)
0.0	3.0	1.0	450	0.1	0.3	1.0	1.27052
0.1							1.23579
0.2							1.18823
0.1	3.0	1.0	450	0.1	0.3	1.0	1.23579
	4.0						1.52545
	5.0						1.77151
0.1	3.0	0.0	450	0.1	0.3	1.0	1.40771
		0.5					1.32108
		1.0					1.23579
0.1	3.0	1.0	00	0.1	0.3	1.0	1.23579
			450				1.23579
			900				1.23579
0.1	3.0	1.0	450	-0.2	0.3	1.0	1.76617
				-0.1			1.62310
				0.1			1.23579
0.1	3.0	1.0	450	0.1	0.1	1.0	1.52838
					0.2		1.38027
					0.3		1.23579

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