ENTROPY GENERATION ANALYSIS OF A REACTIVE HYDROMAGNETIC FLUID FLOW THROUGH A CHANNEL

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This research investigates the entropy generation analysis of a reactive hydromagnetic fluid flow through a channel with isothermal wall temperature, under various chemical kinetics namely: Sensitized, Arrhenius and Bimolecular kinetics.

The analytical solutions of the nonlinear dimensionless equations governing the fluid flow are obtained using Adomian Decomposition Method (ADM). Effects of all – important flow properties on the fluid flow are presented and discussed.

Keywords: Hydromagnetic flow, Chemical Kinetics, Adomian Decomposition Method (ADM), Isothermal Wall

1. Introduction

In a reacting material undergoing an exothermic reaction, in which reactant consumption is neglected, heat is being produced in accordance with chemical kinetics. That has been of great concern in the study of any reactive hydromagnetic flows, which is important in many engineering applications.

During the last few decades, many insightful studies have been done on reactive hydromagnetic fluid flow [1] – [4]. For example, [1] studied the inherent and thermal stability in a reactive electrically conducting fluid flowing steadily, through a channel with isothermal walls, under the influence of a transversely imposed magnetic field. Also, [2] conducted detailed numerical analysis of unsteady hydromagnetic generalized Couette flow of a reactive third – grade fluid with asymmetric convective cooling.

In addition, [5] pointed out that hydromagnetic reactive flows are often accompanied with heat transfer which is an integral part of natural convection flow and belongs to the class of problems in boundary layer theory. This occurs in various physical phenomena such as fire engineering, combustion modelling, nuclear reactor, heat exchangers, etc.

Meanwhile, extensive research studies in [6] – [8] have been carried out on the properties and importance of fluid flow under Arrhenius kinetics. However, little attention has been given to hydromagnetic fluid flow under other chemical kinetics such as sensitized and bimolecular kinetics.

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Therefore, the aim of this study is to respectively obtain and compare the temperature profiles and entropy generation rate of Sensitized, Arrhenius and Bimolecular kinetics with a numerical exponent (*m*) such that $m \in \{-2, 0, 0.5\}$ and to investigate other effects of all – important flow property on the fluid flow due to its importance in several applications such metallurgical and petro – chemical engineering. The problem is strongly nonlinear involving exponential nonlinearity. Hence, analytical solution shall be obtained using Adomian Decomposition Method (ADM). The rest of the paper is organized as follows: the problem is formulated in section 2; in section 3 the problem is solved together with other properties. Section 4 gives the results while section 5 concludes the research work.

2. Problem Formulation

We considered the steady flow of a reactive, incompressible and electrically conducting fluid; flowing through a channel, between two parallel plates, with isothermal wall temperature, under the influence of a transverse magnetic field strength B_0. When the consumption of the reactant is neglected, the continuity, momentum and energy equations governing the flow in a non dimensionless form can be written as:

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

$$-\frac{d\bar{P}}{d\bar{x}} + \mu \frac{d^2\bar{u}}{d\bar{y}^2} - \sigma_0 B_0^2 \bar{u} = 0 \tag{2}$$

$$k\frac{d^2\bar{T}}{d\bar{y}^2} + \mu\left(\frac{d\bar{u}}{d\bar{y}}\right)^2 + \sigma_0 B_0^2 \bar{u}^2 + QC_0 A\left(\frac{k\bar{T}}{vl}\right)^m e^{-\frac{E}{R\bar{T}}} = 0 \tag{3}$$

with the following boundary conditions

$$\frac{d\bar{u}}{d\bar{y}} = \frac{d\bar{T}}{d\bar{y}} = 0 \text{ on } y = 0 \text{ and } u = 0, T = 0 \text{ on } y = a \tag{4}$$

where the bar on each variable represents the non dimensionless form.

However, the additional chemical kinetics term in the energy equation (3) is due to [9]. Also, in equations (1) – (4), *u* is axial velocity, *v* is normal velocity, *T* represent the fluid temperature, *a* is channel half width, C_o is reactant species initial concentration, *E* is activation energy, *R* is the universal gas constant, *A* is reaction rate constant, *k* thermal conductivity coefficient, μ is fluid viscosity, *Q* is the heat of reaction term, *P* is the modified pressure, *l* is the Planck's number, *v* is the vibration frequency, σ_0 represents electrical conductivity and *m* is a numerical constant such that $m \in \{-2, 0, 0.5\}$. The three values taken by the parameter *m* represent the numerical exponent for Sensitized, Arrhenius and Bimolecular kinetics.

Introducing the following dimensionless variables into equations (1) – (4)

$$y=\frac{\bar{y}}{a},\ x=\frac{\bar{x}}{a},\ u=\frac{\bar{u}}{U},\ v=\frac{\bar{v}}{U},\ T=\frac{E\left(\bar{T}-T_0\right)}{RT_0^2},\ P=\frac{a\bar{P}}{\mu U},\ \delta=\frac{RT_0}{E},$$

$$G=-\frac{dP}{dx},\ Br=\frac{E\mu U^2}{kRT_0^2},\ Ha^2=\frac{\sigma B_0^2 a^2}{\mu},\ \lambda=\frac{QEAa^2C_0}{kRT_0^2}\left(\frac{kT_0}{vl}\right)^m e^{-\frac{E}{RT_0}} \quad (5)$$

and obtain the following dimensionless governing equations:

$$\frac{du}{dx}+\frac{dv}{dy}=0 \quad (6)$$

$$G+\frac{d^2u}{dy^2}-Ha^2u=0 \quad (7)$$

$$\frac{d^2T}{dy^2}+\lambda(1+\delta T)^m e^{\frac{T}{1+\delta T}}+Br\left(\left(\frac{du}{dy}\right)^2+Ha^2u^2\right)=0 \quad (8)$$

satisfying the following boundary conditions.

$$\frac{du}{dy}=\frac{dT}{dy}=0 \text{ on } y=0 \text{ and } u=0, T=0 \text{ on } y=1 \quad (9)$$

where G is constant axial pressure gradient, Ha represents Hartmann number, Br is Brinkman number, λ is Frank – Kamenettski parameter and δ is the activation energy parameter.

3. Method of solution

Solving (7) with the appropriate boundary conditions, one obtains

$$u(y)=\frac{G}{Ha^2}\left(1-\frac{Cosh\,(Ha\,y)}{Cosh\,(Ha)}\right). \quad (10)$$

(a) Case 1: when *m* = – 2 (Sensitized Kinetics)

Substituting (10) and making $m=-2$ in equation (8), we have:

$$\frac{d^2T}{dy^2}+\lambda(1+\delta T)^{-2}e^{\frac{T}{1+\delta T}}+\frac{BrG^2}{Ha^2}\left(\frac{Cosh(2Hay)}{Cosh^2Ha}-\frac{2Cosh(Hay)}{CoshHa}+1\right)=0$$

(11)

Hence,

$$T(y)=B-\lambda\int_0^y\left(\int_0^y\frac{e^{\frac{T}{1+\delta T}}}{(1+\delta T)^2}dy\right)dy-\frac{BrG^2}{Ha^2}\int_0^y\left(\int_0^y\left(\frac{\frac{Cosh(2Hay)}{Cosh^2Ha}-}{\frac{2Cosh(Hay)}{CoshHa}+1}\right)dy\right)dy \quad (12)$$

Where $B=T(0)$ and is to be determined using the boundary conditions (9).
We now introduce a series solution of the form

$$T(y)=\sum_{n=0}^{\infty}T_n(y) \quad (13)$$

Substituting (13) in (12), we get

$$T(y)=B-\lambda\int_0^y\left(\int_0^y\frac{e^{\frac{\sum_{n=0}^{\infty}T_n(y)}{1+\delta\sum_{n=0}^{\infty}T_n(y)}}}{(1+\delta\sum_{n=0}^{\infty}T_n(y))^2}dy\right)dy-\frac{BrG^2}{Ha^2}\int_0^y\left(\int_0^y\left(\frac{\frac{Cosh(2Hay)}{Cosh^2Ha}-}{\frac{2Cosh(Hay)}{CoshHa}+1}\right)dy\right)dy \quad (14)$$

We let the nonlinear term be represented by

$$\sum_{n=0}^{\infty}C_n(y)=\frac{e^{\frac{\sum_{n=0}^{\infty}T_n(y)}{1+\delta\sum_{n=0}^{\infty}T_n(y)}}}{(1+\delta\sum_{n=0}^{\infty}T_n(y))^2} \quad (15)$$

such that

$$T(y)=B-\lambda\int_0^y\left(\int_0^y\sum_{n=0}^{\infty}C_n(y)dy\right)dy-\frac{BrG^2}{Ha^2}\int_0^y\left(\int_0^y\left(\frac{\frac{Cosh(2Hay)}{Cosh^2Ha}-}{\frac{2Cosh(Hay)}{CoshHa}+1}\right)dy\right)dy \quad (16)$$

The few Adomian polynomials of (15) are given as follows:

$$C_0=\frac{\mathrm{e}^{\frac{T_0(y)}{1+\delta T_0(y)}}}{(1+\delta T_0(y))^2} \quad (17)$$

$$C_1=\frac{\mathrm{e}^{\frac{T_0(y)}{1+\delta T_0(y)}}(1-2\delta-2\delta^2T_0(y))T_1(y)}{(1+\delta T_0(y))^4} \quad (18)$$

$$C_2 = \frac{e^{\frac{T_0(y)}{1+\delta T_0(y)}}}{2(1+\delta T_0(y))^6}\begin{bmatrix}\left(1-6\delta+6\delta^2+6\delta^2(-1+2\delta)T_0(y)+6\delta^4 T_0(y)^2\right)T_1(y)^2 \\ -2(1+\delta T_0(y))^2(-1+2\delta+2\delta^2 T_0(y))T_2(y)\end{bmatrix} \tag{19}$$

Then, the zeroth component of (16) can be written following the new modification in [7], [10] and [11] as follows:

$$T_0(y) = 0 \tag{20}$$

$$T_1(y) = B - \lambda\int_0^y\left(\int_0^y C_0(y)dy\right)dy - \frac{BrG^2}{Ha^2}\int_0^y\left(\int_0^y\left(\frac{Cosh(2Hay)}{Cosh^2 Ha} - \frac{2Cosh(Hay)}{CoshHa}+1\right)dy\right)dy \tag{21}$$

and

$$T_{n+1}(y) = -\lambda\int_0^y\left(\int_0^y C_n(y)dy\right)dy \tag{22}$$

Hence

$$T_S(y) = -\frac{y^2\lambda}{2} - \frac{BrG^2}{2Ha^2}\left(y^2 + \frac{1}{Ha^2}\begin{pmatrix}Sech[Ha](4-4Cosh[Hay]+ \\ Sech[Ha]Sinh[Hay]^2)\end{pmatrix}\right)$$
$$+\frac{1}{1+\frac{1}{2}(-1+2\delta)\lambda}\begin{pmatrix}\frac{\lambda}{2}+\frac{1}{24}(-1+2\delta)\lambda^2 \\ +\frac{BrG^2}{24Ha^6}\begin{pmatrix}(-1+2\delta)\lambda(Ha^4+24(2+Ha^2 \\ -2Cosh[Ha])Sech[Ha]+ \\ Sech[Ha]^2(-3Ha^2+3Sinh[Ha]^2))\end{pmatrix}+ \\ \frac{BrG^2}{2Ha^2}\left(1+\frac{1}{Ha^2}\begin{pmatrix}Sech[Ha](4-4Cosh[Ha]) \\ +Sinh[Ha]Tanh[Ha])\end{pmatrix}\right)\end{pmatrix} \tag{23}$$

(b) Case 2: when *m* = 0 (Arrhenius Kinetics)

In a similar way, substituting (10) and making m = 0 in (8), we have

$$\frac{d^2T}{dy^2} + \lambda e^{\frac{T}{1+\delta T}} + \frac{BrG^2}{Ha^2}\left(\frac{Cosh(2Hay)}{Cosh^2 Ha} - \frac{2Cosh(Hay)}{CoshHa}+1\right) = 0 \tag{24}$$

$$T(y) = D - \lambda\int_0^y\left(\int_0^y e^{\frac{T}{1+\delta T}}dy\right)dy - \frac{BrG^2}{Ha^2}\int_0^y\left(\int_0^y\left(\frac{Cosh(2Hay)}{Cosh^2 Ha} - \frac{2Cosh(Hay)}{CoshHa}+1\right)dy\right)dy \tag{25}$$

where $D = T(0)$ and is to be determined using the boundary conditions (9).

We let the nonlinear term be represented by

$$\sum_{n=0}^{\infty} E_n(y) = e^{\frac{\sum_{n=0}^{\infty} T_n}{1+\delta \sum_{n=0}^{\infty} T_n}} \tag{26}$$

such that

$$T(y) = D - \lambda \int_0^y \left(\int_0^y \sum_{n=0}^{\infty} E_n(y) dy \right) dy - \frac{BrG^2}{Ha^2} \int_0^y \left(\int_0^y \left(\frac{Cosh(2Hay)}{Cosh^2 Ha} - \frac{2Cosh(Hay)}{CoshHa} + 1 \right) dy \right) dy \tag{27}$$

The few Adomian polynomials of (26) are given as follows:

$$\mathrm{E}_0 = \mathrm{e}^{\frac{T_0(y)}{1+\delta T_0(y)}} \tag{28}$$

$$\mathrm{E}_1 = \frac{\mathrm{e}^{\frac{T_0(y)}{1+\delta T_0(y)}} T_1(y)}{(1+\delta T_0(y))^2} \tag{29}$$

$$\mathrm{E}_2 = \frac{\mathrm{e}^{\frac{T_0(y)}{1+\delta T_0(y)}} ((1-2\delta-2\delta^2 T_0(y))T_1(y)^2 + 2(1+\delta T_0(y))^2 T_2(y))}{2(1+\delta T_0(y))^4} \tag{30}$$

In a similar way as in case 1, we have,

$$T_0(y) = 0 \tag{31}$$

$$T_1(y) = D - \lambda \int_0^y \left(\int_0^y E_0(y) dy \right) dy - \frac{BrG^2}{Ha^2} \int_0^y \left(\int_0^y \left(\frac{Cosh(2Hay)}{Cosh^2 Ha} - \frac{2Cosh(Hay)}{CoshHa} + 1 \right) dy \right) dy \tag{32}$$

$$T_{n+1}(y) = -\lambda \int_0^y \left(\int_0^y E_n(y) dy \right) dy \tag{33}$$

Hence,

$$T_A(y) = -\frac{y^2 \lambda}{2} - \frac{BrG^2}{2Ha^2} \left(y^2 + \frac{1}{Ha^2} \left(\begin{array}{l} Sech[Ha](4 - 4Cosh[Hay] \\ +Sech[Ha]Sinh[Hay]^2) \end{array} \right) \right) \tag{34}$$

(c) Case 3: when *m* = 0.5 (Bimolecular Kinetics)

In a similar way, substituting (10) and making m = 0.5 in (8), we have

$$\frac{d^2T}{dy^2} + \lambda \sqrt{(1+\delta T)} e^{\frac{T}{1+\delta T}} + \frac{BrG^2}{Ha^2} \left(\frac{Cosh(2Hay)}{Cosh^2 Ha} - \frac{2Cosh(Hay)}{CoshHa} + 1 \right) = 0 \tag{35}$$

Also,

$$T(y) = F - \lambda\int_0^y\left(\int_0^y \sqrt{(1+\delta T)}e^{\frac{T}{1+\delta T}}dy\right)dy - \frac{BrG^2}{Ha^2}\int_0^y\left(\int_0^y\left(\frac{Cosh(2Hay)}{Cosh^2 Ha} - \frac{2Cosh(Hay)}{CoshHa} + 1\right)dy\right)dy \tag{36}$$

Where $F = T(0)$ and is to be determined using the boundary conditions (9).
We let the nonlinear term be represented by

$$\sum_{n=0}^{\infty} H_n(y) = \sqrt{(1+\delta\sum_{n=0}^{\infty} T_n)e^{\frac{\sum_{n=0}^{\infty} T_n}{1+\delta\sum_{n=0}^{\infty} T_n}}} \tag{37}$$

such that

$$T(y) = F - \lambda\int_0^y\left(\int_0^y \sum_{n=0}^{\infty} H_n(y)dy\right)dy - \frac{BrG^2}{Ha^2}\int_0^y\left(\int_0^y\left(\frac{Cosh(2Hay)}{Cosh^2 Ha} - \frac{2Cosh(Hay)}{CoshHa} + 1\right)dy\right)dy \tag{38}$$

The few Adomian polynomials of (37) are given as follows:

$$H_0 = \mathrm{e}^{\frac{T_0(y)}{1+\delta T_0(y)}}\sqrt{1+\delta T_0(y)} \tag{39}$$

$$H_1 = \frac{\mathrm{e}^{\frac{T_0(y)}{1+\delta T_0(y)}}(2+\delta+\delta^2 T_0(y))T_1(y)}{2(1+\delta T_0(y))^{3/2}} \tag{40}$$

$$H_2 = \frac{\mathrm{e}^{\frac{T_0(y)}{1+\delta T_0(y)}}}{8(1+\delta T_0(y))^{7/2}}\begin{pmatrix} -(-4+4\delta+\delta^2+2\delta^2(2+\delta)T_0(y)+\delta^4 T_0(y)^2)T_1(y)^2 \\ +4(1+\delta T_0(y))^2(2+\delta+\delta^2 T_0(y))T_2(y) \end{pmatrix}$$

Similarly,

$$T_0(y) = 0 \tag{41}$$

$$T_1(y) = F - \lambda\int_0^y\left(\int_0^y H_0(y)dy\right)dy - \frac{BrG^2}{Ha^2}\int_0^y\left(\int_0^y\left(\begin{array}{c}\frac{Cosh(2Hay)}{Cosh^2 Ha} \\ -\frac{2Cosh(Hay)}{CoshHa} + 1\end{array}\right)dy\right)dy \tag{42}$$

$$T_{n+1}(y) = -\lambda\int_0^y\left(\int_0^y H_n(y)dy\right)dy \tag{43}$$

Therefore, we have

$$T_B(y) = -\frac{y^2\lambda}{2} - \frac{BrG^2}{2Ha^2}\left(y^2 + \frac{1}{Ha^2}\left(Sech[Ha]\begin{pmatrix}4-4Cosh[Hay]\\ +Sech[Ha]Sinh[Hay]^2\end{pmatrix}\right)\right)$$
$$+\frac{1}{1-\frac{1}{4}(2+\delta)\lambda}\left[\begin{array}{l}\frac{\lambda}{2} - \frac{1}{48}(2+\delta)\lambda^2 - \frac{1}{48Ha^6}\begin{pmatrix}BrG^2(2+\delta)\lambda(Ha^4+\\ 24(2+Ha^2-2Cosh[Ha])Sech[Ha]+\\ Sech[Ha]^2(-3Ha^2+3Sinh[Ha]^2))\end{pmatrix}\\ +\frac{BrG^2}{2Ha^2}\left(1+\frac{1}{Ha^2}\begin{pmatrix}Sech[Ha](4-4Cosh[Ha]\\ +Sinh[Ha]Tanh[Ha])\end{pmatrix}\right)\end{array}\right] \tag{44}$$

Equations (23), (34) and (44) are the respective solutions for temperature under Sensitized, Arrhenius and Bimolecular Kinetics.

3.2. Entropy Generation Analysis

Inherent irreversibility in a channel flow arises due to exchange of energy and momentum within the fluid and the solid boundaries. The entropy production is due to heat transfer and the combined effects of fluid friction and Joules dissipation. Following [12], the general equation for the entropy generation per unit volume in the presence of a magnetic field is given by:

$$S^m = \frac{k}{T_0^2}\left(\frac{d\overline{T}}{d\overline{y}}\right)^2 + \frac{\mu}{T_0}\left(\frac{d\overline{u}}{d\overline{y}}\right)^2 + \frac{\sigma B_0^2 \overline{u}^2}{T_0} \tag{45}$$

The first term in (45) is the irreversibility due to heat transfer, the second term is the entropy generation due to viscous dissipation and the third term is the local entropy generation due to the effect of the magnetic field.

We express the entropy generation number in dimensionless form using the existing non – dimensional variables and parameter in (5) as:

$$N_s = \frac{S^m a^2 E^2}{kR^2T_0^2} = \left(\frac{dT}{dy}\right)^2 + \frac{Br}{\Omega}\left[\left(\frac{du}{dy}\right)^2 + Ha^2u^2\right]. \tag{46}$$

The first term, $\left(\frac{dT}{dy}\right)^2$ is assigned N_1 which is the irreversibility due to heat transfer and the second term, $\frac{Br}{\Omega}\left[\left(\frac{du}{dy}\right)^2 + Ha^2u^2\right]$ referred to as N_2 is the entropy generation due to the combined effects of viscous dissipation and magnetic field where $\Omega = RT_0/E$ is the wall temperature parameter.

We defined $\phi = \frac{N_2}{N_1}$ (47)

as the irreversibility distribution ratio. Relation (47) shows that heat transfer dominates when $0 \le \phi < 1$ and fluid friction dominates when $\phi > 1$. This is used to determine the contribution of heat transfer in many engineering designs.

As an alternative to irreversibility parameter, the Bejan number (Be) is defined as

$$Be = \frac{N_1}{N_s} = \frac{1}{1+\phi} \quad where \quad 0 \le Be \le 1. \tag{48}$$

4. Discussion of results

In this section, we compare the temperature profiles and entropy generation rates for various chemical kinetics and the effects of all – important flow properties were discussed.

Table 1 shows that the heat transfer dominates at both the upper and lower regions of the plate surfaces as $0 \le \phi < 1$ and that the fluid friction dominates at the core region of the flow where $\phi > 1$. Also, the Bejan numbers lie between 0 and 1 for various chemical kinetics.

Table 1: Computation of the Entropy Analysis for Various Chemical Kinetics.

$Ha = 1, G = 1, \lambda = 0.1, \delta = 0.1\ Br = 0.1, Br\,\Omega^{-1} = 0.1$										
	$N_1 = \left(\frac{dT}{dy}\right)^2$			$N_2 = \frac{Br}{\Omega}\left[\left(\frac{du}{dy}\right) + Ha^2\right]$	$\Phi = \frac{N_2}{N_1}$			$Be = \frac{1}{1+\Phi}$		
Y	N_{1S}	N_{1A}	N_{1B}		Φ_S	Φ_A	Φ_B	Be_S	Be_A	Be_B
-1	0.1200	0.1214	0.1218	0.0580026	0.4835	0.4777	0.4762	0.6741	0.6767	0.6774
-0.75	0.0456	0.0464	0.0466	0.0309902	0.6802	0.6685	0.6655	0.5951	0.5993	0.6004
-0.5	0.0160	0.0164	0.0165	0.0186529	1.1631	1.1382	1.1320	0.4623	0.4677	0.4690
-0.25	0.0036	0.0037	0.0037	0.0136751	3.8263	3.7352	3.7126	0.2072	0.2112	0.2122
0	0	0	0	0.0123866	∞	∞	∞	0	0	0
0.25	0.0036	0.0037	0.0037	0.0136751	3.8263	3.7352	3.7126	0.2072	0.2112	0.2122
0.5	0.0160	0.0164	0.0165	0.0186529	1.1631	1.1382	1.1320	0.4623	0.4677	0.4690
0.75	0.0456	0.0464	0.0466	0.0309902	0.6802	0.6685	0.6655	0.5951	0.5993	0.6004
1	0.1200	0.1214	0.1218	0.0580026	0.4835	0.4777	0.4762	0.6741	0.6767	0.6774

In Fig. 1, the maximum temperature increases as the numerical exponents (m) increases from – 2 to 0.5. It is generally noticed that the fluid temperature is zero at both the upper and lower stationary surfaces of the channel while the maximum temperature occurred at the central line of the channel.

The result in Fig. 2 showed that the fluid temperature increases as the magnetic intensity (Ha) decreases; this is due to the presence of magnetic forces which have retarding effects on the fluid flow. The reverse is the case in Figs. 3 and 4 where an increase in the values of Brinkman number (Br) and Frank – Kamenettski parameter (λ) give a rise in the temperature profiles which is due to the initial concentration of the reactant.

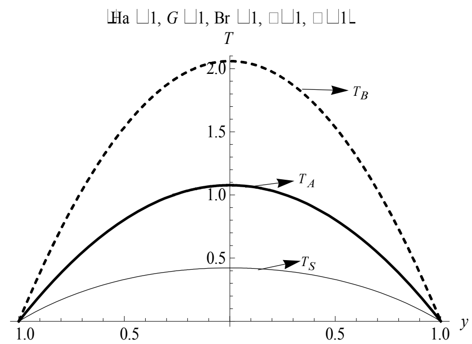

Fig. 1: Comparison of Temperature Profiles for Various Kinetics

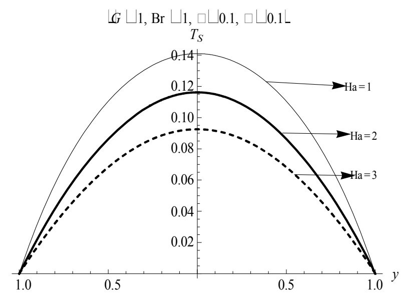

Fig. 2: Effects of Hartmann Number for Various Kinetics

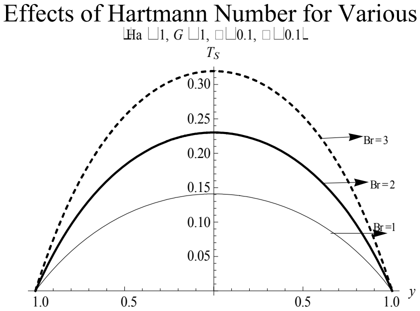

Fig. 3: Effects of Brinkman number for various kinetics.

The effect of entropy generation rate is shown in Fig. 5. On a general note, the entropy generation rate is at minimum around the core region of the channel and rises to its maximum values at the plate surfaces. This is clearly observed in

Fig. 5 where an increase in the numerical exponents (m) gives an increase in the entropy generation rate.

Fig. 6 displays the Bejan number versus the channel width. It is clearly observed that the heat transfer irreversibility dominates at both the upper and lower plate surfaces while the fluid friction irreversibility dominates around the central line of the channel.

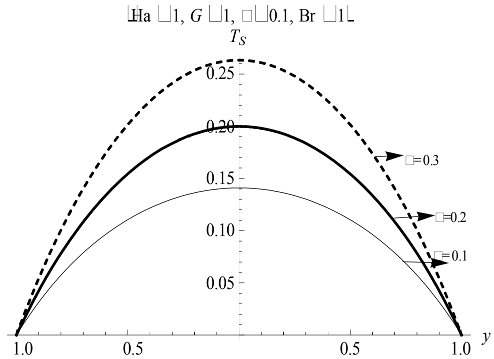

Fig. 4: Effects of Frank – Kamenettski Parameter for Various Kinetics.

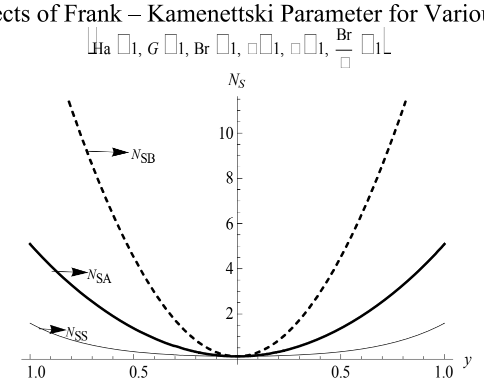

Fig. 5: Entropy Generation Rates for Various Kinetics

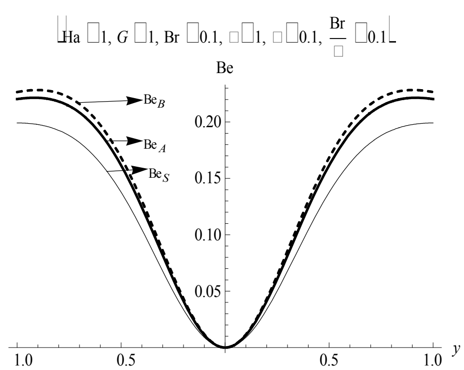

Fig. 6: Bejan number for various kinetics

5. Conclusion

A review of the diverse roles of entropy and the second law analysis in computational thermo fluids has been investigated for Sensitized, Arrhenius and Bimolecular kinetics. The result shows that the temperature increases as the numerical exponents $m \in \{-2, 0, 0.5\}$ increases respectively. Also, the entropy generation rate is at minimum around the core region of the channel and rises to its maximum values at the plate surfaces and that an increase in the numerical exponents (m) gives an increase in the entropy generation rate.

Our results will also be of interest to lubrication companies in improving the efficiency and effectiveness of hydromagnetic lubricants used in engineering systems as mentioned in [1] using appropriate chemical kinetics.

R E F E R E N C E S

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