Electric field strength on MHD aluminum alloys (AA7075) nanofluid flow

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Abstract

This work concerns with a numerical study on heat transfer by MHD aluminum alloys nanofluid (AA7075-water) flow over a nonlinear wall for extensible compactness of electric field. The steady governing momentum and energy equations are transformed to similarity equations for certain families of the controlling parameters. The transformed equations of momentum and thermal transport are solved by applying Runge–Kutta Fehlberg method with shooting technique. The three classical form of nanoparticle shapes are registered into report, i.e., sphere, cylinder and lamina and the heat transfer by natural convection of AA7075-water was studied. It is observed that the thermal and diffusive boundary layer thickness of AA7075-water is weaker in the presence of electric field, $E_1 = 0.2$ as compared to $E_1 = 0.0$. In the presence of electric field, temperature and concentration of lamina shape AA7075 particles hit a dominant role on AA7075-water nanofluid flow regime.

Keywords MHD AA7075-water · Wall thickness · Thermal radiation · Similarity solution · Viscous dissipation · Nanoparticle shapes

1 Introduction

Aluminum alloys are composed by melting, sintering (assemble of shaped parts utilizing metal particle that is melt together at exalted temperatures) or mechanical braiding. Durable collegial interruption to nanoparticles in distinct solvents is consistently entitled as “Nanofluids”. In this analysis the distinct attitudes to nanofluids technology are defined with an insistence on utilization in energy organization. Aluminum alloys have been very influential in aerospace manufacturing. In special, the aluminum alloys such as AA7072 and AA7075 are very fruitful in transport utilizations such as marine, aviation and automotive which are also recycled in construction of bicycle equipment, glider rock climbing equipment and aircrafts. An aluminum alloy is a chemical design where new materials are combined with pure aluminum with regard to upgrading its resources, basically to enhance its stability. Alloy desires the complete associating of aluminum with

these other materials although the aluminum is in liquid-molten-form. Superficial Aluminum alloy AA7075 was cultivated over Japanese in 1942, for construction of air frame in Japanese navy [1].

The boundary layer flow of an electrical controlling nanofluid against a stretching sheet has been an alive field of analysis freshly. Nanofluid is a fluid composed by a reliable interruption of micro/nano-sized particles (non-metallic/metallic/nanofibers) with a classic size < 100 nm in a typical base fluid (liquid). One of these advances is the inclusion of small-sized particles to the liquid. This method contributes to raise the thermal conductivity of the base fluid relatively twice and the convective heat transfer achievement. The flow due to stretching boundary has inclusive analysis in the exclusion mechanisms associates in metal and plastic industries. An aluminum alloy is a synthetic configuration where modern materials are combined with ideal aluminum with employing to improve its resources, really to boost its solidity and

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thermal conductivity. Aluminum alloys have been achieving a powerful issue in aerospace forming, [2–4]. Thermophoresis and Brownian motion effects on MHD bioconvection of nanofluid with nonlinear thermal radiation and quartic chemical reaction past an upper horizontal surface of a paraboloid of revolution with variable stream conditions are studied by [5–7].

Magnetohydrodynamic (MHD) nanofluid is an authentic significant in the field of engineering, science and technology. These fluids are more suitable in the optical grating, optical modulators, optical switches, tunable optical fiber filters, stretching of plastic materials, polymer industry and metallurgy. Nanotechnology investigation is repeatedly in the area of energetic scientific event due to an appreciable cast of useful utilizing in optical, medical and electrical fields and the nanoparticles thermal conductivity are more energetic as associated to the ideal fluids, as noticed in practical analysis was organized by [8–10]. The miserable of Lorentz force velocimetry is placed on appraisal of the Lorentz force that develops a convective fluid flow under the issue of an extensible magnetic field. Assigning to Faraday's law, when a metal or convective fluid efforts over a magnetic field, eddy currents expanded there by electromotive energy in zones of controlling magnetic field gradient. Eddy current in its support admits convinced magnetic field assigning to Ampère's law. The affiliation with eddy currents and total magnetic field allotments upgraded to Lorentz force that cracks the velocity and raises the temperature of the flow, [11, 12]. Nonlinearity in the stretching sheet surface system has been consigned to exponential and quadratic (power-law) models, [13, 14].

The flow of electrically controlling fluids such as liquid metals is efficiently impressed by applied magnetic and electric fields. The issue has significant industrial utilizations in nuclear technology, metallurgy and other fields. The electric conductivity, which regulates the heat transit in an indirect aspect, is one of the well-designed of the transport assets because it is nearly easy to define. It has been well-defined that nanofluid flow, thus convective heat transfer, could be formed if the electrically controlling fluid is exposed to either electric or magnetic or combined fields. Electric conducting energy film nanofluid flow across a wall has been an energetic field of research freshly. This technique commits to advance conductivity of the common fluid about double and the convective heat transfer fulfillment [15–19]. Nanofluid placed magnetohydrodynamic hits a crucial role in technology, science and engineering [20–25]. Synthetic reaction impact is to estimate the reactor fulfillment of flexible stream conditions is investigated by [26–31]. Particle concentration depreciates for energetic Brownian motion although it rises for more dynamic thermophoretic of the nanofluid which rises the

thermal attitude of the fluid [29–32]. A few experimental based articles have been investigated with aspect of hybrid nanofluids, [33–39].

The intent at this effort is delighted by the intimate survey and strong accessible industrial and engineering applications. The instant review introduces such distinct thickness on a nonlinear wall on electric MHD boundary layer AA7075-water flow in biography. This formable thickness nonlinear stretching sheet has energetic message on mechanical, civil, marine, aeronautical structure and designs. Confirmed conditions of the current work are analyzed and authorized graphically to real amplitudes convoluted within it and the prompt attainments are associated with the suitable literature.

2 Mathematical formulation

Investigate a steady electric MHD AA7075-water flow up a non-linear wall with flexible thickness. Wall velocity is designed as $U_w(x) = U_0(x + b)^{(n)}$, and the stretching sheet is appropriated at $y = A_1(x + b)^{(\frac{n-1}{2})}$. The boundary layer equations are refined placed on Ohm's and Maxwell's laws in the existence of Electrical magnetohydrodynamics (EMHD). The incompressible AA7075-water viscous nanofluid with enhanced magnetic field B and electric field E is appropriated into consideration. The flow is in aspect of stretching to a sheet from a crack at two equal and opposite force and thermally radiative. The magnetic and electric zones acknowledge the Ohm's law define $\vec{J} = \sigma(\vec{E} + \vec{V} \times \vec{B})$ where $\vec{J}$ —the Joule current, σ —the electrical conductivity and $\vec{V}$ —the fluid velocity. $E(x)$, $B(x)$ —electric and magnetic strength is normal through the flow, such that the Reynolds number is endorsed small. The assured magnetic field is weaker to the confirmed magnetic field. So the assured magnetic field is insistent on small-scale magnetic Reynolds number. The two-dimensional electrical MHD boundary layer flow equations of an incompressible electric conducting AA7075-water nanofluid are given as [19, 24, 37, 38] (Fig. 1)

$$\frac{\partial v}{\partial y} = -\frac{\partial u}{\partial x} \quad (1)$$

$$u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = -\frac{1}{\rho_{nf}} \frac{\partial P}{\partial x} + \frac{\mu_{nf}}{\rho_{nf}} \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right) - \frac{\sigma_{nf}}{\rho_{nf}} (B_0^2(x)u - E(x)B(x)) \quad (2)$$

$$\rho_{nf} \left(v \frac{\partial v}{\partial y} + u \frac{\partial v}{\partial x} \right) = -\frac{\partial P}{\partial y} + \mu_{nf} \left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} \right) + \sigma_{nf} (E(x)B(x) - B_0^2(x)v) \quad (3)$$

Fig. 1 Physical structure of flow geometry

$$u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} = \frac{k_{nf}}{(\rho c_p)_{nf}} \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right) + \frac{1}{(\rho c_p)_{nf}} \frac{\partial q_r}{\partial y} + \frac{\mu_{nf}}{(\rho c_p)_{nf}} \left(\frac{\partial u}{\partial y} \right)^2 + \frac{\sigma_{nf}}{\rho_{nf}} (uB(x) - E(x))^2 + \tau \left[(D_B)_{nf} \left\{ \frac{\partial \phi}{\partial x} \frac{\partial T}{\partial x} + \frac{\partial \phi}{\partial y} \frac{\partial T}{\partial y} \right\} + \frac{(D_T)_{nf}}{T_\infty} \left\{ \left(\frac{\partial T}{\partial x} \right)^2 + \left(\frac{\partial T}{\partial y} \right)^2 \right\} \right] \quad (4)$$

$$\frac{\partial \phi}{\partial x} + v \frac{\partial \phi}{\partial y} = (D_B)_{nf} \left(\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} \right) + \frac{(D_T)_{nf}}{T_\infty} \left\{ \frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right\} - K^* (\phi - \phi_\infty) \quad (5)$$

$$u(x+b)^{-n} = U_0, v = 0, T = T_w, \phi = \phi_w, y = A_1(x+b)^{\left(\frac{1-n}{2}\right)}; u \rightarrow 0, T \rightarrow T_\infty, \phi \rightarrow \phi_\infty \text{ as } y \rightarrow \infty \quad (6)$$

Let $B(x) = B_0(x+b)^{\left(\frac{n-1}{2}\right)}$ —magnetic field factor, σ —electrical conductivity, $E(x) = E_0(x+b)^{\left(\frac{n-1}{2}\right)}$ —electric field factor, c, b, n —constants, u, v —velocity factor, T —nanofluid temperature, α_{nf} —nanofluid thermal diffusivity, ρ_{nf} —nanofluid effective density and $(\rho c_p)_{nf}$ —nanofluid heat capacitance are explained [29] as:

$$\begin{aligned} \rho_{nf} - \zeta \rho_s &= (1 - \zeta) \rho_f, \mu_{nf} \\ &= \frac{\mu_f}{(1 - \zeta)^{2.5}}, (\rho \beta)_{nf} - \zeta (\rho \beta)_s = (1 - \zeta) (\rho \beta)_f, (\rho c_p)_{nf} \\ &= (1 - \zeta) (\rho c_p)_f + \zeta (\rho c_p)_s \\ \frac{\alpha_{nf}}{k_{nf}} &= \frac{1}{(\rho c_p)_{nf}}, \frac{k_{nf}}{k_f} \\ &= \left\{ \frac{(k_s + (l-1)k_f) - (l-1)\zeta(k_f - k_s)}{(k_s + (l-1)k_f) + \zeta(k_f - k_s)} \right\}, \sigma_{nf} - \zeta \sigma_s \\ &= (1 - \zeta) \sigma_f (D_B)_{nf} = (1 - \zeta) (D_B)_f \end{aligned} \quad (7)$$

Maxwell design [40] was cultivated to assign the dynamic thermal or electrical conductivity of liquid–solid suspensions. Let σ_f and σ_s —fluid and nanoparticle electrical conductivity, k_{nf} —nanofluid effective thermal conductivity. Rosseland's dissipation for the radiative heat flux, $q_r = -\frac{4\sigma^* \partial T^4}{3k^* \partial y}$ (Magyari and Pantokratoras [41]), σ^* —Stefan–Boltzmann constant, the thermal field by Taylor's series, $T^4 + 3T_\infty^4 = 4T_\infty^3 T$.

Dynamic similarity transformations is

$$\begin{aligned} \psi &= \sqrt{\frac{2\nu_f U_0 (x+b)^n}{(n+1)(x+b)^{-n}}} f(\eta), \quad \eta = \sqrt{\frac{(n+1)U_0}{2\nu_f (x+b)^{(1-n)}}} y, \\ \theta(\eta) &= \frac{T - T_\infty}{T_w - T_\infty}, \quad \phi(\eta) = \frac{\phi - \phi_\infty}{\phi_w - \phi_\infty}, \\ u(x+b)^{-n} &= U_0 f(\eta), \\ v &= -\sqrt{\frac{(n+1)\nu_f U_0 (x+b)^{(n-1)}}{2}} \left(f(\eta) + \eta \frac{n-1}{n+1} f'(\eta) \right) \end{aligned} \quad (8)$$

Flow function ψ —composed as $u = \frac{\partial \psi}{\partial y}$, $v = -\frac{\partial \psi}{\partial x}$ which sufficiently conduct the Eq. (1). Establish on the Eqs. (7, 8), the Eq. (1) is adequately formed whereas the Eqs. (2) and (6) become as

$$f''' + G.B \left(ff'' - \frac{2n}{n+1} f'^2 \right) + G.A.M(E_1 - f'^2) = 0 \quad (9)$$

$$\begin{aligned} \theta'' + \text{Pr} E_f (f\theta' + (A_1)Nb\theta' \phi' + (A_1)Nt\theta'^2 \\ + \left(\frac{1}{G.E} \right) Ec.f''^2 + \frac{A.M}{E} Ec.(f' - E_1)^2) = 0 \end{aligned} \quad (10)$$

$$\phi'' + (A_1) \cdot \left(\frac{1}{(A_1)} \frac{Nt}{Nb} \theta'' + Lef\theta' - Le\gamma\phi \right) = 0 \quad (11)$$

with boundary conditions

$$\begin{aligned} f(0) &= \alpha \frac{(1-n)}{(1+n)}, f'(0) = 1, \theta(0) = 1, \phi(0) = 1; \\ f'(\infty) &= 1, \theta(\infty) = 0, \phi(\infty) = 0 \end{aligned} \quad (12)$$

$$\begin{aligned}
\frac{K_{nf}}{(k_s + (e-1)(k_f))} &= 1 + \frac{(1-e)\zeta(k_f - (k_s))}{(k_s + (e-1)(k_f))}, \\
K_f &= (k_s + (e-1)(k_f) - \zeta(k_f - (k_s)), \\
B &= \left(1 - \zeta + \zeta \frac{\rho_s}{\rho_f}\right), \quad T = \frac{K_{nf}}{K_f}, \\
E &= \left(1 - \zeta + \zeta \frac{\rho_s(cp)_s}{\rho_f(cp)_f}\right), \\
E &= \left(1 - \zeta + \zeta \frac{\rho_s(cp)_s}{\rho_f(cp)_f}\right), \\
A &= \left[\frac{3 \left(\frac{\sigma_s}{\sigma_f} - 1\right) \zeta}{\left(\frac{\sigma_s}{\sigma_f} + 2\right) - \left(\frac{\sigma_s}{\sigma_f} - 1\right) \zeta} + 1 \right], \\
G &= (1 - \zeta)^{2.5}, \quad A1 = \frac{1}{1 - \zeta}
\end{aligned} \quad (13)$$

$Pr_f = \frac{Pr}{\left(\frac{k_{nf}}{k_f} + \frac{4}{3}Ra\right)}$ —effective Prandtl number, $M = \frac{2\sigma_f B_0^2}{c((n+1)\rho_f)}$
 —magnetic parameter, $\gamma = \frac{2k^*(x+b)^{(1-n)}}{U_0(n+1)}$ —chemical reaction
 parameter, $Ri = \frac{Gr}{Re_x^2}$ —Richardson number, $Gr = \frac{g\beta(T_w - T_\infty)x^3}{\nu_f^2}$
 —local Grashof number, $E_1 = \frac{E_0(x+b)^{-n}}{B_0 U_0}$ —the electric param-
 eter, $Ec = \frac{U_w^2}{(c_p)_f(T_w - T_\infty)}$ —the Eckert number, $Ra = -\frac{4\sigma^* T_\infty^3}{k_f k^*}$
 the radiation–conduction parameter, $N_b = \frac{(\rho C)_s(D_B)_f(\phi_w - \phi_\infty)}{(\rho C)_f \nu_f}$
 —Brownian motion and $N_t = \frac{(\rho C)_s(D_T)_f(T_w - T_\infty)}{(\rho C)_f \nu_f T_\infty}$ —thermopho-
 resis parameter. As well as the physical assets of engineer-
 ing impacts of materials assisting utilizations are

$$\begin{aligned}
Re_x^{\frac{1}{2}} C_f &= \sqrt{\frac{n+1}{2}} \frac{f''(0)}{(1-\zeta)^{2.5}}, \\
Re_x^{-\frac{1}{2}} Nu_x &= -\sqrt{\frac{n+1}{2}} \left(\frac{k_{nf}}{k_f} + \frac{4}{3}N \right) \\
\theta'(0), Sh_x Re_x^{-\frac{1}{2}} &= -\sqrt{\frac{n+1}{2}} \frac{\phi'(0)}{(1-\zeta)}
\end{aligned} \quad (14)$$

It is a fundamental law of thermodynamics that the Nusselt and Shear wood number can be negative, since it is defined as the dimensionless temperature and

Table 1 Thermal and physical asserts of fluid and particles

Thermophysical properties	H ₂ O	AA7075
ρ	997.1	2810
c_p	4179	960
k	0.6129	173
σ	0.05	26.77×10^6

concentration gradient at the wall. The slope may be negative or positive, depending on the direction of heat flux. The skin friction coefficient based on the wall sheat stress magnitude has to be positive.

3 Results and discussions

In this scheme, nanoparticle shapes (sphere, cylinder and lamina) on MHD AA7075-water flow up a nonlinear devoted stretching from the cause of electric field in thermal radiation have been analyzed numerically. The system for Eqs. (9)–(11) are not be recognized exactly and algorithmic realization acceptable to the boundary conditions (12) are approved the very appreciable conducting software Maple 18. This software networks a fourth or fifth order Runge–Kutta Fehlberg technique with shooting

Fig. 2 Comparison of different Pr with Fig. 7 of Daniel et al. [43]

Table 2 Comparison of $-f''(0)$ when $E1 = M = 0$

Parameter	Fang et al. [42]	Daniel et al. [43]	Present result	Error
$n, \alpha = 0.25$				
10.0	1.1433	1.143316	1.143308	8.1E–06
9.0	1.1404	1.140388	1.140372	3.2E–06
7.0	1.1323	1.132281	1.132268	1.3E–06
5.0	1.1186	1.118587	1.118575	1.2E–06
3.0	1.0905	1.090490	1.090479	1.1E–06
1.0	1.0000	1.000001	1.000000	1.0E–06

Fig. 3 Temperature and concentration profiles for Magnetic field

system as persistent to execute the boundary value problems numerically proceeding the classification model. The Prandtl number range of the nanofluid is assumed as $6.2 \leq Pr \leq 10.4$.

3.1 Affirmation

Analytical formation is to observe the pattern and realistic events raised the classic issue and confirm the numerical scheme. The numerical application is highly to decode confusion, physically or geometrically. We admit absolutely algorithm control numerical software automatically to appreciable engrossment. In the exploration system, most of the investigator doesn't constitute numerical pattern to investigate the problem fasts from enhancement construction. But we ought to transit in mind that all the

software, precisely system has been accepting the analytical fulfillment lately. Analytical structures are employed to initial problem. However, the numerical schemes are excited for empirical aggregation (Table 1).

It is accepted of the Fig. 2 and Table 2, theoretical perception of $\theta(\eta)$ and $-f''(0)$ for noticeable values of the parameter are associated with Fig. 7 and Table 1 of Daniel et al. [43] respectively.

3.2 Magnetic effects on temperature and concentration profiles, Fig. 3

In the presence of electric field $E_1 = 0.5$, it is observed that the temperature and concentration of AA7075-water nanofluid decrease with increase of magnetic strength. In the presence of $E_1 = 0.0$, it is seen that the temperature

Fig. 4 Temperature and concentration profiles for thermal radiation

and concentration of AA7075-water increase with increase of magnetic strength. In the presence of electric field, thermal and diffusive boundary layer thickness of lamina shape particles on AA7075-water is stronger as compared to other shapes in the flow regime. This is due to the evidence that the magnetic lines of forces move over the plate and the fluid which is decreased by the viscous force, obtains an effort from the magnetic field strength which prevents the viscous effects. Hence the temperature and concentration of the AA7075-water decelerate as the parameter M increases in the presence of electric field, Fig. 3.

3.3 Thermal radiation energy effects on temperature and concentration profiles, Fig. 4

In the presence of electric field, it is predicted that the temperature and concentration of AA7075-water nano-fluid increase with increase of thermal radiation energy strength. In the presence of electric field, thermal and diffusive boundary layer stiffness of lamina shape particles on AA7075-water is more significant as compared to other shapes in the flow regime because of low level thermal conductivity of base fluid (water), Table 1. The increase in thermal radiation energy aids the commute of heat energy from the flow region and so the fluid temperature decelerates. A decelerate in the ranges of forgiven and

Fig. 5 Temperature and concentration for non-linear wall strength

aids a reduce in the Rosseland radiation absorptivity. Since divergence of the radiative heat flux enhances, decelerates which in turn roots to enhance the rate of radiative heat transfer to the AA7075-water and hence the nanofluid temperature and concentration increase. This means that the thermal boundary layer decelerates and more uniform temperature and concentration distribution across the boundary layer.

3.4 Non-linear wall strength on temperature and concentration profiles, Fig. 5

In the presence of $E1 = 0.0$ and $E1 = 0.2$, it is noticed that the temperature and concentration of AA7075-water nanofluid enhance with increase of non-linear wall strength. In the existence of electric field, thermal and diffusive boundary layer stiffness of lamina shape particles

on AA7075-water is higher as compared to other shapes in the flow regime.

3.5 Nanoparticle volume fraction on temperature and concentration profiles, Fig. 6

In the presence of $E1 = 0.0$ and $E1 = 0.2$, the temperature and concentration of AA7075-water accelerate as nanoparticle volume fraction strength enlarges. It is noted that the thermal and diffusive boundary layer thickness of lamina shape particles on AA7075-water flow is powerful as correlated to other shapes in the flow regime. This is as a result of AA7075 has immense thermal conductivity and its inclusion to the water enhances the thermal conductivity for the nanofluid, so the stiffness of the thermal boundary layer raises. It is also noticed that with rising the volume fraction of the nanoparticles, the thermal

Fig. 6 Temperature and concentration nanoparticle volume fraction

boundary layer is enhanced. This admits with the physical attitude of nanoparticles. This information predicts that the cause of nanofluids will be implication in the cooling and heating movements.

3.6 Thermophoresis particle deposition on temperature and concentration profiles, Fig. 7

Thermophoresis is a phenomenon noticed in mixtures of mobile nanoparticles where the various particle types display different responses to the force of a temperature gradient, Abdel-Wahed et al. [44]. Justify this phenomenon appears in this study through the thermophoresis parameter Nt such that increasing this parameter leads

to increasing of boundary layer temperature and nanoparticle concentration as shown in Fig. 7. Both $E1 = 0.0$ and $E1 = 0.5$, it is shown that the temperature and concentration on AA7075-water accelerate with increase of thermophoresis particle deposition. Thermal and diffusive boundary layer thickness of lamina shaped particles of AA7075-water in the presence of electric field, $E1 = 0.5$ is more efficient as associated with $E1 = 0.0$. This is due to the combined effect of Brownian and thermophoresis diffusion coefficient strength in the presence of kinematic viscosity of AA7075-water.

Fig. 7 Thermophoresis on temperature and concentration with or without electrical field

Table 3 Nanoparticle volume fraction and shape on $f''(0)$, $-\theta'(0)$ and $-\phi'(0)$ with or without electric field ($E1=0.2$) in the presence of AA7075-water

ζ	$f''(0)$	$-\theta'(0)$	$-\phi'(0)$	AA7075 shapes
0.05	-1.572663	0.521300	2.408874	Sphere shape
0.1	-1.511998	0.460948	2.534099	
0.2	-1.361190	0.360827	2.817025	
0.05	-1.572663	0.474963	2.423611	Cylindrical shape
0.1	-1.511998	0.390063	2.555679	
0.2	-1.361190	0.276281	2.839970	
0.05	-1.572663	0.383708	2.450521	Lamina shape
0.1	-1.511998	0.281016	2.584528	
0.2	-1.361190	0.226861	2.838250	

3.7 Nanoparticle volume fraction on skin friction, rate of heat and mass transfer, Table 3

In the presence of $E1=0.2$, heat/mass transfer rate of AA7075-water decreases/increases with increase of ζ . The rate of heat/mass transfer of sphere/cylindrical shaped nanoparticles on AA7075-water is stronger at ($\zeta = 0.05, -\theta'(0) = 0.521300 / (\zeta = 0.2, -\phi'(0) = 2.839970$) whereas the heat/mass transfer rate of lamina shaped nanoparticles on AA7075-water at ($\zeta = 0.2, -\theta'(0) = 0.226861 / (\zeta = 0.05, -\phi'(\eta) = 2.450521$) is weaker as related to other particle shapes in the flow regime with increase of ζ .

4 Conclusion

Impact of electric field strength on AA7075–water convective flow through a non-linear stretching wall is presented using Runge–Kutta Fehlberg method with shooting technique, MAPLE 18. Effects of magnetic strength, thermal radiation energy, thermophoresis particle deposition, particle shapes and volume fraction on AA7075–water nanofluid behaviour are taken into account in the subsistence of electric field. It is interesting to note that the thermal and diffusive thermal boundary layer thickness of lamina shaped AA7075–water, $E_1 = 0.2$ is more significant as compared to $E_1 = 0.0$ because of the combined effects of electric and magnetic strength with increase of all parameters strength. In the presence of electric field, it is noted that the temperature and concentration of AA7075–water increase with increase of all parameters strength while it decreases with rise of magnetic strength. Heat/mass transfer rate of sphere/cylindrical shaped particles on AA7075–water is stronger whereas the lamina shaped particles on AA7075–water is weaker as related to other shapes with rise of nanoparticle volume fraction.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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