Impacts of electric field quality on MHD Carreau AA7075 – water nanofluid flow

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ABSTRACT
In this report, the electric field strength impact on MHD Carreau AA7075 – water nanofluid flows is controlled by a stretching sheet with formable thickness. The three simple models of nanoparticle shapes are enrolled into a pattern, i.e. sphere \((m = 3.0)\), cylinder \((m = 6.3698)\) and lamina \((m = 16.1576)\). The powerful partial differential equations (PDEs) are reconstructed into ordinary differential equations (ODEs) by performing persistent conformity design and it is polluted numerically by executing the Cash and Carp method, MAPLE 18 and Matlab. It is interesting to note that the rate of heat transfer of sphere-shaped nanoparticles in AA7075 – water nanofluid flow is more energetic than all the other shapes in the flow regime.

Nomenclature

| Symbol | Description |
|--------|-------------|
| \(u, v\) | Velocity components along \(x, y\) axes \((m s^{-1})\) |
| \(\psi\) | Stream function |
| \(f'\) | Dimensionless velocity |
| \(m\) | Nonlinear stretching parameter |
| \(c\) | Stretching/shrinking parameter \((> 0\) for enhancing sheet and \(< 0\) for shortening sheet) |
| \(l\) | Nanoparticle shape |
| \(S\) | Suction/injection parameter |
| \(Re_x^2\) | Reynolds number |
| \(Ec\) | Eckert number |
| \(Pr\) | Prandtl number |
| \(C_f\) | Skin friction coefficient |
| \(B\) | External magnetic force |
| \(q_r\) | Thermal radiative heat flux |
| \(k_f\) | Thermal conductivity of the fluid \((W m^{-1} K^{-1})\) |
| \(T\) | Local temperature of the fluid \((K)\) |
| \(T_\infty\) | Free stream temperature \((K)\) |
| \(U_s\) | Stretching/shrinking sheet velocity |
| \(\eta\) | Similarity variable |
| \(g\) | Acceleration due to gravity \((m s^{-2})\) |
| \(b\) | Constant |
| \(M\) | Dimensionless magnetic strength |
| \(N_r\) | Thermal radiation parameter |
| \(R_i\) | Richardson number (Buoyancy parameter) |
| \(Nu_x\) | Nusselt number |
| \(Pr_{ eff}\) | Effective Prandtl number |
| \(Gr\) | Thermal Grashof number |
| \(B_o\) | Magnetic field strength |
| \(k_s\) | Thermal conductivity solid \((W m^{-1} K^{-1})\) |
| \(k_{nf}\) | Thermal conductivity fluid \((W m^{-1} K^{-1})\) |
| \(T_w\) | Temperature of the fluid at the wall \((K)\) |

|希腊符号 | Description |
|--------|-------------|
| \(\delta\) | Heat Source/Sink parameter |
| \(\alpha_f\) | Thermal diffusivity of the fluid \((m^2 s^{-1})\) |
| \(\alpha_{nf}\) | Thermal diffusivity of the nanofluid \((m^2 s^{-1})\) |
| \(\beta_f\) | Coefficient of thermal expansion of the fluid \((K^{-1})\) |
| \(\rho_f\) | Density of the fluid friction \((kg m^{-3})\) |
| \(\rho_{nf}\) | Density of the nanofluid \((kg m^{-3})\) |
| \(\nu_f\) | Kinematic viscosity of the fluid \((m^2 s^{-1})\) |
| \(\mu_f\) | Dynamic viscosity of the fluid \((Ns m^{-2})\) |
| \(\sigma\) | Electrical conductivity \((sm^{-1})\) |
| \(\sigma_f\) | Electrical conductivity of the fluid \((sm^{-1})\) |
| \(\sigma^*\) | Stefan–Boltzmann constant |
| \((\rho C_p)_{nf}\) | Heat capacitance of the nanofluid \((J m^{-3} K^{-1})\) |
| \((\rho C_p)_{s}\) | Heat capacitance of the solid \((J m^{-3} K^{-1})\) |
| \(\theta\) | Non-dimensional temperature |
| \(\alpha\) | Thermal diffusivity coefficient \((m^2 s^{-1})\) |
| \(\alpha_s\) | Thermal diffusivity of the solid \((m^2 s^{-1})\) |
| \(\beta\) | Thermal expansion coefficient \((K^{-1})\) |
| \(\beta_s\) | Coefficient of thermal expansion of the solid \((K^{-1})\) |
| \(\rho_s\) | Density of the solid friction \((kg m^{-3})\) |
| \(\nu\) | Kinematic viscosity \((m^2 s^{-1})\) |
| \(m^2 s^{-1}\) | Dynamic viscosity \((Ns m^{-2})\) |
| \(\mu_{nf}\) | Dynamic viscosity of the fluid \((Ns m^{-2})\) |
| \(\sigma_s\) | Electrical conductivity of the solid \((sm^{-1})\) |
| \(\sigma_{nf}\) | Electrical conductivity of the fluid \((sm^{-1})\) |
| \(\zeta\) | Specific heat at constant pressure \((J m^{-3} K^{-1})\) |
| \((\rho C_p)_{nf}\) | Heat capacitance of the fluid \((J m^{-3} K^{-1})\) |

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Solid phase

Subscripts
f Fluid Phase
nf Nanofluid
∞ Condition at freestream
s Solid phase
w Condition at the wall

1. Introduction

Nanofluids have attracted much attention of researchers due to their industrial applications such as transportations, ethylene glycol, microelectronic, utilization of solar energy power generation, rubber sheet and manufacture of plate. Aluminium alloys are composed by melting, sintering (assembly of shaped parts utilizing metal particle that is melt together at exalted temperatures) or mechanical braiding. Aluminium alloys have been very influential in aerospace manufacturing. Especially, the aluminium alloys, such as AA7072 and AA7075, are very fruitful in transport utilization, such as marine, aviation and automotive, which are also recycled in the construction of bicycle equipment, glider rock climbing equipment and aircrafts.

Electric field quality on metallic nanofluid stream expects a huge activity on fluid mechanical structure field. The least mind-boggling summarized Newtonian liquid is the power law constitutive association. The power law consistency design has the confinement that it can’t acceptably predict the consistency for little or particularly colossal shear rates. Considering such detainment of the force law model, particularly for low and exceptionally high shear rates, we consider another thickness model from the class of outlined Newtonian liquids, to express the Carreau rheological design. This design beats the impediments of the force law design perceived above and shows up, evidently, to extend progressively wide insistence made in arranging and inventive frameworks. Aluminium and its blends have been the tip-top material of relationship for the plane business all around the huge bulk of its record. Indeed, even today, when titanium and orchestrates are considered for use, 70% of business common airplane airframes are constructed from aluminium compounds, and without aluminium common aviation would not be monetarily usable. Al-Zn-Mg-Cu alloys (7075 series aluminium alloys) are fascinating more and more for applications in high-tech zones such as defence, aerospace, sport goods and automotive, due to the distinguished aspects, particularly the immense strength-to-weight ratio and corrosion resistance. Anyway, when utilized in design of sheets, their defined feasibility at room temperature instants a major protest and ranges their actual utilize [1,2].

While aluminium composites have a conductivity averaging 62% of the Universal Annealed Copper Standard (UACS), as a result of their thickness, they can import more than twice as much power as an indistinguishable load of copper. An aluminium amalgam is a material model where new materials are joined to form unadulterated aluminium to overhaul its assets, fundamentally to upgrade its steadiness. Aluminium compound (AA7075) was created by Japanese association in 1943, for bit of air diagram in Japanese maritime power [3]. A7075 is a limited instance of warmth comparable aluminium combination with 98% of Al and 1% of Zn with the customary Si, Fe and Cu. Thus, AA 7075 commits 90% Al, 5 – 6%Zn, 2 – 3% Mg, 1 – 2%Cu with the preventive such as Si, Fe and Mn. The nanoparticles thermal conductivity are logically vivacious as identified with the standard fluids, as declared in exploratory and theoretical assessments created by [4,5]. AA7075 – nanofluids have intrigued a lot of retention of analysts because of their mechanical applications, for example, ethylene glycol, microelectronic, transportation utilization of sun-oriented vitality power proliferation, elastic sheet and assembling of plate [6,7].

Nanofluids have attracted much attention of researchers due to their industrial applications such as transportations, ethylene glycol, microelectronic, utilization of solar energy power generation, rubber sheet and manufacture of plate. Aluminium alloys are composed by melting, sintering (assembly of shaped parts utilizing metal particle that is melt together at exalted temperatures) or mechanical braiding. Aluminium alloys have been very influential in aerospace manufacturing. Aluminium alloys, such as AA7072 and AA7075, are very useful in transport such as marine, aviation and automotive which are also recycled in the construction of bicycle equipment, glider rock climbing equipment and aircrafts. Magnetohydrodynamic (MHD) nanofluid is authentically significant in the field of engineering, science and technology.

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 [8,9]. The miserable of Lorentz force velocimetry is placed on appraisement of the Lorentz force that develops a convective fluid flow under the issue of an extensible magnetic field. According to Faraday’s law, when a metal or convective fluid acts upon a magnetic field, eddy currents are expanded thereby producing electromotive energy in zones of controlling magnetic field gradient. Eddy current admits convinced magnetic field according to Ampère’s law. The affiliation with eddy currents and total magnetic field allotments are upgraded to Lorentz force that cracks the velocity and raises the temperature of the flow [10]. Nonlinearity in the stretching sheet surface system has been consigned to exponential and quadratic (power-law) models [11].
The flow of electrically controlling fluids, such as liquid metals, is efficiently used by applying in magnetic and electric fields. This has significant industrial utilisations 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 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. Electrically conducting energy film nanofluid flow across a wall has been an energetic field of research recently. This technique commits to advance conductivity of the common fluid on double and convective heat transfer fulfillment [12,13]. Nanofluid placed MHD in a crucial role in technology, science and engineering [14,15].

At the present situation, watch out for the contact on particle shapes on radiated MHD water-based aluminium compound nanoparticles (AA7075) stream past a nonlinear uneven expanding sheet in the area of warmth source/sink and thick dispersal. Neighbourhood balance change is resolved to update PDEs into ODEs and after some time the numerical delayed consequence of the intrigue is created by using R.K. Fehlberg procedure with firing framework. Exploratory work has studied that the particle structure significantly influences warmth and mass trade of nanofluids. In the progressed certify, nobody has quickened to do the two-dimensional Carreau nanofluid (AA7075 – water) preceding a widening layer with adaptable thickness [16–19]. A comprehensive amalgamation of the Maxwell model was proposed by Hamilton and Crosser [20] that fuses a formable permitted shape factor of nanoparticles. The numerical model is nonlinear when combined with standard differential conditions, which is unwound by utilizing shooting strategy. Structures for adaptable physical systems are conceded and analysed in the component. It is additionally predicted that the lamina particles in the AA7075 – water aluminium amalgams acknowledge a typical movement on warmth and mass exchange as separated and the various shapes in the stream system.

### Table 1. Thermophysical resources of the fluid and nanoparticles.

|                | $\rho$ (kg/m$^3$) | $c_p$ (J/kgK) | $k$ (W/mK) | $\sigma$ ($\Omega^{-1}\text{m}^{-1}$) |
|----------------|-------------------|---------------|------------|-------------------------------------|
| Pure water     | 997.1             | 4179          | 0.613      | 5.5                                 |
| AA7075         | 2810              | 173           | 26.77      | 1.67                                |

Figure 1. Physical configuration of AA7075 – water nanofluid system.

Figure 2. Comparison of temperature profiles with Figure 7 of Mair Khan et al. [22].
2. Mathematical analysis

Right now, guard a scientific plan to examine Carreau AA7075 – water nanofluid stream because of a non-linear extending sheet with extensible thickness. The sheet is made using the speed $U \equiv U_0(x + b)^m$, where $U_0$ is the source speed. $y = B(x + b)^{(1-m)/2}$ is the width of the layer and $b$ is the non-dimensional consistent and $m$ is the force law record. We survey that the model must be satisfied uniquely for $m \neq 1$, considering the reality that for $m = 1$, the issue diminishes to the level sheet. The adaptable attractive field quality $B_0(x)$ is forced vertical to the surface. In light of the above-indicated conditions, the Carreau AA7075 – water design is accounted as

$$\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} = 0, \quad (1)$$

$$u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = \frac{\mu_{nf}}{\rho_{nf}} \left( \frac{\partial^2 u}{\partial y^2} + \frac{3(n-1)}{2} \Gamma^2 \left( \frac{\partial u}{\partial y} \right)^2 \right) \frac{\partial^2 u}{\partial y^2} - \frac{\sigma_{nf}}{\rho_{nf}} (E(x)B(x) - B_0^2(x)u), \quad (2)$$

$$u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} = \frac{k_{nf}}{(\rho c_p)_{nf}} \left( \frac{\partial^2 T}{\partial y^2} \right) - \frac{1}{(\rho c_p)_{nf}} \frac{\partial q_r}{\partial y}$$

Figure 3. Magnetic effects on temperature profiles with different electric fields.
\[ v(x + B(x + b)) \frac{1-m}{\tau} = 0, \quad T(x + B(x + b)) \frac{1-m}{\tau} = T_w, \]

\[ C(x + B(x + b)) \frac{1-m}{\tau} = C_w; \]

\[ u(x, \infty) \to 0, \quad T \to T_\infty, \quad C \to C_\infty \text{ as } \gamma \to \infty \quad (5) \]

Let \( B(x) = B_0(x + b)^{(1-m)/2} \) - the attractive field factor, \( \sigma \) is the electric conductivity, \( E(x) = E_0(x + b)^{(1-m)/2} \) - the electrical field factor, \( u, v \) - speed issue on the \( x \)-axis and \( y \)-axis headings individually, \( C_w \) - the grouping of the fluid close to the divider, \( C_\infty \) - the surrounding convergence of the nanofluid, \( T \) - fluid temperature, \( C \) - fluid focus, \( \rho_{nf} \) - fluid compelling thickness, \( \alpha_{nf} \) - nanofluid warm diffusivity, \( \mu_{nf} \) - factor of fluid energetic consistency and \( (\rho c_p)_{nf} \) - nanofluid heat capacitance which are characterized as shown in Figure 4.
(Figure 1):

\[ \rho_{nf} = (1 - \zeta)\rho_f + \zeta\rho_s \]
\[ \mu_{nf} = \frac{\mu_f}{(1 - \zeta)} \]
\[ (\rho\beta)_{nf} = (1 - \zeta)(\rho\beta)_f + \zeta(\rho\beta)_s \]
\[ \alpha_{nf} = (1 - \zeta)\alpha_f + \zeta\alpha_s \]
\[ (\rho c_p)_{nf} = (1 - \zeta)(\rho c_p)_f + \zeta(\rho c_p)_s \]
\[ (D_T)_{nf} = (1 - \zeta)(D_T)_f \]
\[ (D_B)_{nf} = (1 - \zeta)(D_B)_f \]

Maxwell structure [20] was created to give out the dynamic warm or electric conductivity of liquid solid suspensions. \( \sigma_f \) and \( \sigma_s \) are ground fluid and particle electric conductivity, \( k_f \) and \( k_s \) are base fluid and particle warm conductivity, respectively, \( \zeta \) is the particle volume part, \( \rho_f \) and \( \rho_s \) are base fluid and nanoparticle thickness, respectively, \( \mu_f \) is the dynamic consistency of the ground fluid and \( k_{nf} \) is the nanofluid effective warm conductivity. Rosseland’s scattering for the radiative warmth movement, \( q_r = -\frac{4\sigma^\ast T^4}{k^\ast} \) (Magyari and Pantokratoras [21]), \( k^\ast \) is the Rosseland mean ingestion coefficient. \( \sigma^\ast \) is the Stephen-Boltzmann reliable framework. Satisfied with the investigation, it is related to characterize the executing similitude changes:

\[ \psi = \left[ \frac{2\nu_f U_0(x + b)^{m-1}}{m + 1} \right]^{\frac{1}{2}} f(\eta), \]
\[ \eta = \left[ \frac{(m + 1)U_0(x + b)^{(m-1)}}{2\nu_f} \right]^{\frac{1}{2}} y, \]
\[ \theta(\eta) = \frac{T - T_{\infty}}{T_w - T_{\infty}}, \quad \varphi(\eta) = \frac{C - C_{\infty}}{C_w - C_{\infty}}, \]

\( \nu_f \) is the kinematic depth of the liquid and the flow work \( \psi \) is the constructed as \( u = \frac{\partial \psi}{\partial \eta}, v = \frac{\partial \psi}{\partial \eta} \) which sufficiently goes to Equ. (1). Rely upon Equations (6) and (7), the condition (1) is decently affected, while the conditions (2) and (4) salaries delegate

\[ F'''' \left( 1 + \left( \frac{3(n - 1)}{2} W^2 (F''')^2 \right) \right) \]

Table 2. Comparison of rate of heat transfer, \( -\theta'(0) \) with different \( Pr \).

| Pr       | \( \text{Mabood et al. [23]} \) | \( \text{Mair Khan et al. [22]} \) | Present result | Absolute Error |
|----------|-------------------------------|-------------------------------|----------------|----------------|
| 0.07     | 0.0665                        | 0.0645                        | 0.0666752      | 0.0001752      |
| 0.70     | 0.4539                        | 0.4554                        | 0.4559876      | 0.000587       |
| 7.00     | 1.8954                        | 1.8929                        | 1.8928759      | 0.000241       |
| 70.0     | 6.4622                        | 6.4598                        | 6.4597568      | 0.000043       |

Figure 5. Wall thickness strength on temperature profiles with different electric fields.
\[ G.B \left( \frac{2m}{m+1}F^2 - FF' \right) + G.A.M(E_1 - F^2) = 0, \] (8)

\[ \theta'' + Pr.E.(F\theta' + (A1)Nb\theta' + (A1)Nt\theta'^2 + \lambda \theta) = 0, \] (9)

\[ \psi'' + (A1). \left( \frac{1}{(A1) Nb} \theta'' + LeF\theta' - Le\gamma \theta' \right) = 0, \] (10)

with frontier situations are

\[ F(\alpha) = \alpha \frac{1 - m}{1 + m}, \quad F'(\alpha) = 1, \quad \theta(\alpha) = 1, \quad \psi(\alpha) = 1; \]

\[ F'(\infty) = 0, \quad \theta(\infty) = 0, \quad \psi(\infty) = 0, \] (11)

\[ K_{nf} = (k_s + (e - 1)k_f) - (e - 1)\zeta (k_f - (k_s)), \]

\[ K_f = (k_s + (e - 1)k_f) - \zeta (k_f - (k_s)), \]

\[ B = \left( 1 - \zeta + \frac{\rho_s}{\rho_f} \right), \quad T = \frac{K_{nf}}{K_f}, \]

\[ E = \left( 1 - \zeta + \frac{\rho_s (CP_s)}{\rho_f (CP_f)} \right), \]

\[ A = \left( 1 + \frac{3 \left( \frac{\alpha}{m} - 1 \right) \zeta}{\left( \frac{\alpha}{m} + 2 \right) - \left( \frac{\alpha}{m} - 1 \right) \zeta} \right), \]

\[ G = (1 - \zeta)^{2.5}, \quad A1 = \frac{1}{1 - \zeta} \] (12)

\[ \alpha = B\sqrt{(U_0(m + 1))/2\nu_f} \] is the related wall viscosity and \( \eta = B\sqrt{(U_0(m + 1))/2\nu_f} \) is the reliant plate surface. If we utilize the alterations \( f(\alpha) = f(\eta - \alpha), \theta(\alpha) = \theta(\eta - \alpha) = \theta(\eta), \) and \( \psi(\alpha) = \psi(\eta - \alpha) = \psi(\eta), \) Equs. (8)–(10) get the following

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**Figure 6.** Thermophoresis impacts on temperature profiles with different electric fields.


\[
f''\left(1 + \frac{3(n-1)}{2} W^2 (f'')^2\right) \\
+ GB \left(\frac{2m}{m+1} f^2 - f''\right) + GA (ME_1 - Mf'^2) = 0,
\]

(13)

\[
\theta'' + Pr f.E (f\theta' + (A1)Nb\theta'\psi' + (A1)Nt\theta'^2 + \lambda \theta) = 0,
\]

(14)

\[
\varphi'' + (A1) \left(\frac{1}{(A1)Nt} \theta'' + Le f\theta' - Le f\varphi\right) = 0,
\]

(15)

with frontier environments are

\[
f(\alpha) = \frac{1 - m}{1 + m}, \quad f'(\alpha) = 1, \quad \theta(\alpha) = 1, \quad \varphi(\alpha) = 1;
\]

\[
f'(\infty) = 0, \quad \theta(\infty) = 0, \quad \varphi(\infty) = 0,
\]

(16)

where dimensionless and constants parameters are defined as

\[
M = \frac{2\sigma_f B_0^2}{U_0(m+1)(x+b)^{m-1} \rho_f},
\]

\[
W = (m+1) \frac{U_0^2 (x+b)^{3m-1}}{2\nu k} \Gamma^2,
\]

\[
Pr_f = \frac{Pr}{\left(\frac{\lambda}{\nu} + \frac{3}{2} R\right)}.
\]

Figure 7. Brownian motion impacts on temperature profiles with different electric fields.
\[ \gamma = \frac{2K}{U_0(m+1)(x+b)^m}, \quad Pr = \frac{(\mu c_p)_{r'}}{k_f}, \]

\[ Re_x = \frac{xU_0(x)}{v_f}, \quad E_1 = \frac{E_0}{B_0U_0(x+b)^m}, \]

\[ N_b = \left(\frac{\rho c_p}{(D_b)r}(C_w - C_{\infty})\right), \quad N_f = \left(\frac{\rho c_p}{(D_f)r}\right), \quad Le = \frac{v_f}{(D_b)r}, \]

\[ R = -\frac{4\sigma^* T_3^2}{k_fk^2}, \quad \lambda = \frac{Q_0x}{(\rho c_p)_{r'}U_r}. \]

Additionally, the physical assets of designing shots of resources encouraging usage are the neighbourhood skin grinding coefficient \( C_f \), Nusselt number \( Nu_x \) and Sherwood number \( Sh_x \) can be exactly as

\[ Re_x^{\frac{1}{2}} C_f = \frac{1}{(1-\zeta)^{2.5}} \left(\frac{m+1}{2}\right) \frac{1}{2} f''(0), \]

\[ Re_x^{\frac{1}{2}} Nu_x = -\left(\frac{k_n}{k_f} + \frac{4}{3} R \left(\frac{m+1}{2}\right)^{\frac{1}{2}} \right) \theta'(0), \]

\[ Sh_xRe_x^{\frac{1}{2}} = -\left(\frac{1}{(1-\zeta)^{2}} \left(\frac{m+1}{2}\right) \right) \psi'(0) \quad (17) \]

Figure 8. Chemical reaction on temperature profiles with different electric fields.
3. Results and discussions

Right now, particle shapes of MHD water-based AA7075 nanofluid flow over a nonlinear one-sided extension for electrical field in thermal radiation have been investigated numerically. The system for Equs. (13) – (15) can’t be awarded logically and numerical confirmations adequate to the threshold conditions (16) are affirmed controlling the truly noticeable programming Maple 18. This product organizes an altered R.K Fehlberg strategy with shooting method (Cash and Carp) as stubborn to sanction the limit esteem issues numerically running the assignment structure. The highly important advance of this technique is to pick the appropriate limited surmised estimations of $\eta_{\infty}$. The arrangement is rehashed until the accompanying estimations of $f''(0)$, $\theta'(0)$ and $\varphi'(0)$ and vary simply after the wanted huge digits. Cash and Carp method gives outcomes over numerous different techniques since it has truncation blunder of request 5. The Prandtl number quality of AA7075 – water is fixed as $6.2 \leq Pr \leq 10.4$. The numerical advancement is established in the accomplishment of the dimensionless speed, temperature and convergence of the water-based AA7075 particles.

3.1. Affirmation

Analytical formation to observe the pattern and realistic events raised the classic issue and confirms the numerical scheme. The numerical application is high to decode confusion, physically or geometrically. We

Figure 9. Heat generation on temperature profiles with different electric fields.
admit absolutely algorithm control numerical software automatically to appreciable engrossment. In the exploration system, most of the investigators do not constitute a numerical pattern to investigate the problem quickly from enhancement construction. But we ought to keep in mind that all the software, precisely the system, has been accepting the analytical fulfilment lately. Analytical structures are employed for initial problems. However, the numerical schemes are excited for empirical aggregation (Table 1).

In the absence of vitality condition, to accommodate the essentialness of our mathematical outcomes, the current effort is related to the performance of accurate outcome in the writing. The heat describes distinct estimations of thermal radiation, $R$ relates to the attainable accurate arrangement (Figure 7) of Mair Khan et al. [22], as depicted in Figure 2. It is spotted that the concurrence with the hypothetical yield of heat outline is appropriate.

In the presence of electric field, $E_1 = 0.0, 0.2$, it is seen that the temperature of AA7075 - water nanofluid increase, whereas $E_1 = 10.0$, it is predicted that the temperature of AA7075 - water decreases with increase of magnetic strength. In the presence of electric field, thermal and diffusive boundary layer thickness of cylinder shape particles on AA7075 - water is more significant as correlated to other shapes in the flow region because of Lorenz force, Figure 3. In the case of $E_1 = 0.0, 0.2$ and 10.0, it is predicted that the temperature of AA7075 - water nanofluid

Figure 10. Nanoparticle volume part on temperature and focus profiles with various electric fields.
enhances with the rise of thermal radiation energy strength. For \( E_1 = 0.2 \), thermal boundary layer stiffness of sphere shape particles on AA7075 – water is monotonically stronger than other shapes in the flow regime because of the low-level thermal conductivity of base fluid (water), Table 1. The increase in thermal radiation energy aids in the commutation of heat energy from the flow region and so the fluid temperature accelerates, Figure 4 (Table 2).

In the presence of \( E_1 = 0.0, 0.2 \) and 10.0, it is identified that the temperature of AA7075 – water nanofluid increase with the rise of non-linear wall strength. In the presence of electric field, \( e_1 = 0.2 \), thermal boundary layer stiffness of sphere-shaped particles on AA7075 – water is more efficient than other shapes in the flow regime, Figure 5. In the presence electric field, \( E_1 = 0.0, 0.2 \) and 10.0, it is shown that the temperature of AA7075 – water accelerates with the increase of chemical reaction, thermophoretic particle deposition and Brownian motion of the nanoparticles. For \( E_1 = 0.2 \), the thermal boundary layer thickness of sphere-shaped particles of AA7075 – water is more powerful than other shapes because of the combined effect of Brownian and thermophoretic particle deposition strength in the presence of kinematic viscosity of AA7075 – water, Figures 6–8. Brownian and thermophoretic reaction strength replays an impact on temperature distribution as the reaction rewards effective against destructive attitude regardless of the inexistent/resident of electric field.

![Figure 11. Streamline diagrams on warmth and mass exchange on electric field quality.](image-url)
In the presence of electric field, $E_1 = 0.0, 0.2$, it is seen that the temperature of AA7075 – water nanofluid increases, whereas for $E_1 = 10.0$, it is predicted that the temperature of AA7075 – water decreases with the increase of heat generation strength. In the presence of electric field $E_1 = 0.2$, thermal boundary layer thickness of sphere-shaped particles on AA7075 – water is more efficient than other shapes in the flow region because of the combined effect of specific heat and kinematic viscosity of AA7075 – water nanofluid, Figure 9. In the presence of electric field $E_1 = 0.0, 0.2$ and 10.0, it is found that the temperature of AA7075 – water nanofluid flow increases with the increase of nanoparticle volume fraction, whereas the temperature distribution of sphere-shaped particles in AA7075 – water in $E_1 = 0.2$ hits a dominant role as compared to other shapes in the flow regime with increasing $\zeta$, Figure 10.

It is interesting to observe that the rate of heat transfer of all shapes AA7075 – water nanofluid flow decreases/increases with the increase of nanoparticle volume fraction/strength of electric field, whereas the rate of mass transfer of all shape AA7075 – water nanofluid flow increases/decreases with the increase of nanoparticle volume fraction/strength of electric field, Table 3. From 3-D figures, it is noted that the rate of heat and mass transfer of sphere-shaped AA7075 – water nanofluid flow attains its maximum value with the rise of electric strength and nanoparticle volume fraction, Figure 11.

4. Conclusions

Electric field strength on MHD Carreau AA7075 – water convective nanofluid flow through a non-linear extending sheet is presented using the Cash and Carp technique, MAPLE 18. Effects of magnetic strength, thermal radiation energy, thermophoretic particle deposition, Brownian motion, 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 boundary layer thickness of sphere-shaped AA7075 – water, $E_1 = 0.2$ is more significant than $E_1 = 0.0, 10.0$ because of the combined effects of electric and magnetic strength on AA7075 – water nanofluid flow. In the presence of electric field, it is interesting to note from the 3D graph that the rate of heat and mass transfer of sphere-shaped AA7075 – water nanofluid flows attain its maximum value with the rise of electric field strength and nanoparticle volume fraction. The high strength of electric field produced not only forces on the nanoparticle shapes but also on the fluid medium used for suspension and conductivity and the electric field is responsible for the motive force to enhance thermal behaviour in the flow regime, see 3D graph.

It is recommended that the electric strength is validated from potential efficiency or electric kinetic energy because of the Green forces which address the nanofluid from the magnetic field. This attachment to force improves fabricates of the thermal boundary layer and also the temperature contours are encouraged to enhance the magnetic strength. The distinguished viewpoint on sphere-shaped particles of the water-based aluminium alloys (AA7075) show an amazing role in thermal energy field.

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