Abstract
In the present computational study, the inclined angle effect of unsteady heat and mass transfer flow through salt water in an ocean was studied. The governing equations together with continuity, momentum, salinity and temperature were developed using the boundary layer approximation. Cartesian coordinate system was introduced to interpret the physical model where x-axis chosen along the direction of salt water flow and y-axis is inclined to x-axis. Two angle of inclination was considered such as 90° and 120°. The time dependent governing equations under the initial and boundary conditions were transformed into the dimensionless form. A numerical solution approach so-called explicit finite difference method (EFDM) was employed to solve the obtained dimensionless equations. Different physical parameter was found in the model such as Prandtl number, Modified Prandtl number, Grashof number, Heat source parameter and Soret number. A stability and convergence analysis was developed in this study to describe the aspects of the finite difference scheme and this analysis is significant due to accuracy of the EFDM approach. The convergence criteria were observed to be in terms of dimensionless parameter as \( P_r \geq 0.0128 \) and \( P_\alpha \geq 0.016 \). The distributions of the temperature and salinity profiles of salt water flow over different time steps were investigated for the effect of different dimensionless parameters and shown graphically.

Keywords
Inclined angle, heat and mass Transfer, Finite difference method

1. INTRODUCTION

In recent years, boundary layer simultaneous heat and mass transfer flow has received a lot of attention and used in various science and engineering problems due to several industrial applications such as heat removal in nuclear reactors, geothermal and oil recovery, heat exchangers, drying processes, building construction, solar collectors, etc. This study also finds applications in food processing, metallurgical processes for example drawing of continuous filaments, tinning of copper wires, wet-bulb thermometer, polymer solution, cooling processes etc. Moreover, the combined heat and mass transfer phenomenon is observed to be in our daily life in the formation of fog. Salt water flow in an ocean is a new invented area of boundary layer phenomena which has also a lot of applications in practical life. Within a few hundred miles of the ocean, many peoples were living and the salt water flow influences in their everyday lifespan. It is very important to mention that, the oceans can absorb and release large amounts of heat. Moreover, ocean plays a dominant role in the climate change in many different time scales [1, 2]. In recent times, ocean flows observed to be quite measurable [3]. The theoretical developments were also found in the previous literature describing large scale circulation [4]. Blumberg and Mellor [5-10] have developed mathematical models and investigated physical behavior of an ocean. Tal Ezer [11] described the significance of ocean circulation. However, the momentum, energy and mass (salinity) transfer through the boundary layer ocean water flow has not received due attention though these physical properties are significant.

Therefore, it was thought desirable to investigate the heat and mass transfer flow through salt water in an ocean. In this study, a mathematical model on boundary layer time dependent salt water flow was studied to recognize more information in this specific area of heat and mass transfer. This numerical study investigates the transient heat and mass transfer flow through salt water in an ocean by inclined angle. Explicit finite difference method has been used to solve the unsteady boundary layer model with different time steps. For detail description of the explicit finite difference method, reader can refer to the recent published literatures [12-15].

2. MATHEMATICAL MODEL OF FLOW

![Figure 1 Physical model and coordinate system.](image.png)
To establish a physical configuration, a two-dimensional Cartesian co-ordinate system was introduced. Where X-axis was considered along the boundary plate which is the direction of salt water flow. And the Y axis considered to be inclined with the X-axis. Here α is the angle of inclination between X and Y. Two values of α such as 90° and 120° are considered in this study. Initially the temperature of both plate and fluid are considered to be same, \( T(T_c) \) and water salinity level \( S(S_c) \) is also equal everywhere. The fluid velocity \( (U_0) \) was also considered uniform. Instantaneously at time \( t > 0 \), the temperature of the plate and spices salinity changes to \( T(T_0) \) and \( S(S_0) \) respectively, which are these after maintained constant. Here \( T_c, S_c \) are the temperature and spices salinity at the wall and \( T_0, S_0 \) are the temperature and salinity of the spices far away from the plate respectively. The physical configuration and coordinate system is provided in the Fig.1.

Under the boundary layer approximation, the governing equation for the unsteady heat and mass transfer flow through salt water in an ocean by inclined angle can be expressed as follows:

**The continuity equation**
\[
\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0
\]

**The momentum equation**
\[
\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = \frac{-1}{\rho} \frac{\partial p}{\partial x} + \nu \left( \frac{\partial^2 u}{\partial y^2} \right)
\]

**The salinity equation**
\[
\frac{\partial s}{\partial x} + \frac{\partial v}{\partial y} = \frac{K}{\rho} \frac{\partial s}{\partial y} + \frac{F_s}{\rho} \frac{\partial^2 T}{\partial y^2} + \frac{Q_s}{\rho C_p}
\]

**The temperature equation**
\[
\frac{\partial T}{\partial x} + \frac{\partial v}{\partial y} = \frac{1}{\rho \alpha \theta} \frac{\partial^2 T}{\partial y^2} + \frac{Q_v}{\rho C_p}
\]

The initial and boundary conditions are
\[
t \leq 0, \quad u = 0, \quad v = 0, \quad T = T_c, \quad S = S_c \quad \text{everywhere}
\]
\[
t > 0, \quad u = 0, \quad v = 0, \quad T = T_0, \quad S = S_0 \quad \text{at } x = 0
\]
\[
u = U_0, \quad v = 0, \quad T = T_0, \quad S = S_0 \quad \text{at } y \to \infty
\]
\[
u = U_0, \quad v = 0, \quad T = T_0, \quad S = S_0 \quad \text{at } y = \infty
\]

where \( \nu \) is the kinematic viscosity, \( \kappa \) is the thermal conductivity for salinity, \( \alpha \) is the thermal conductivity for temperature, \( F_s \) is the molecular diffusion, \( C_p \) is the specific heat at constant pressure and \( U_0 \) is the uniform fluid velocity.

### 3 MATHEMATICAL FORMULATION

Since the governing equations including the initial and boundary conditions will solve based on an explicit finite difference method. Therefore, it is required the governing equations to be a dimensionless form. For this purpose, we introduced following dimensionless variables:
\[
X = \frac{x}{U_0}, \quad Y = \frac{y}{U_0}, \quad \nu = \frac{\nu}{U_0}, \quad \kappa = \frac{\kappa}{U_0^2}, \quad \frac{\partial T}{\partial x} = \frac{\partial^2 T}{\partial y^2}
\]
\[
\bar{T} = \frac{T - T_c}{T - T_c} \quad \text{and} \quad \bar{S} = \frac{S - S_c}{S - S_c}, \quad Q_v = (T - T_c) Q_v
\]

After using the above dimensionless quantity, the governing equations /1/ to /5/ transformed to the following manner:

\[
\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0
\]

\[
\frac{\partial U}{\partial x} + \frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = \frac{1}{\nu} \left( \frac{\partial^2 U}{\partial y^2} \right)
\]

\[
\frac{\partial S}{\partial x} + \frac{\partial V}{\partial y} = \frac{K}{\rho} \frac{\partial S}{\partial y} + \frac{F_s}{\rho} \frac{\partial^2 T}{\partial y^2} + \frac{Q_s}{\rho C_p}
\]

\[
\frac{\partial T}{\partial x} + \frac{\partial V}{\partial y} = \frac{1}{\alpha \rho \theta} \left( \frac{\partial^2 T}{\partial y^2} \right) + \frac{Q_v}{\rho C_p}
\]

And the non-dimensional boundary conditions are;
\[
t \leq 0, \quad U = 0, \quad V = 0, \quad \bar{T} = 0, \quad \bar{S} = 0 \quad \text{everywhere}
\]
\[
t > 0, \quad U = 0, \quad V = 0, \quad \bar{T} = 0, \quad \bar{S} = 0 \quad \text{at } X = 0
\]
\[
u = U_0, \quad v = 0, \quad T = 1, \quad S = 1 \quad \text{at } Y = 0
\]
\[
u = U_0, \quad v = 0, \quad T = T_0, \quad S = S_0 \quad \text{as } Y = \infty
\]

Where,
\[
P_r = \frac{\rho \alpha C_p}{K}, \quad \text{is the Prandtl number},
\]
\[
P_r = \frac{\rho \alpha C_p}{K}, \quad \text{is the Modified Prandtl number},
\]
\[
G = \frac{g \beta \theta (T - T_c)}{U_0^2}, \quad \text{is the Grashof number},
\]
\[
\bar{\sigma} = \frac{Q_v}{U_0^2 \rho \bar{C}_p}, \quad \text{is the Heat source parameter and}
\]
\[
\bar{S} = \frac{F_s}{(T - T_c)} \left( \frac{T_c - T_c}{T_c - T_c} \right), \quad \text{is the Soret number.}
\]

The symbol, \( \gamma \), denotes the acceleration due to gravity force, \( \beta \) is the volumetric thermal expansion coefficient and \( \beta \) is the volumetric thermal expansion coefficient due to salinity.

### 4 STABILITY AND CONVERGENCE ANALYSIS

Since an explicit finite difference procedure is being used, the analysis will remain incomplete unless we discuss the stability and convergence of the finite difference scheme. For the constant mesh sizes, the stability criteria of the scheme established as follows:

The continuity equation will be ignored, since \( \Delta \tau \) does not appear into it. The general term of the Fourier expansion for \( \bar{U}, \bar{S}, \bar{T} \) and \( \bar{T} \) at a arbitrary time \( t = 0 \) is \( \bar{e}^{i \alpha \bar{x}} \frac{\partial Y}{\partial \bar{y}} \), apart from a constant, where \( \alpha = \sqrt{-1} \). At a time \( t = \tau \), these terms become:
\[
\bar{U} = \psi(\tau) e^{i \alpha \bar{x} \frac{\partial Y}{\partial \bar{y}}}
\]
\[
\bar{S} = \phi(\tau) e^{i \alpha \bar{x} \frac{\partial Y}{\partial \bar{y}}}
\]
\[
\bar{T} = \theta(\tau) e^{i \alpha \bar{x} \frac{\partial Y}{\partial \bar{y}}}
\]

and after a certain time-step the above terms will be:
\[
\bar{U} = \psi(\tau) e^{i \alpha \bar{x} \frac{\partial Y}{\partial \bar{y}}}
\]
\[
\bar{S} = \phi(\tau) e^{i \alpha \bar{x} \frac{\partial Y}{\partial \bar{y}}}
\]
\[
\bar{T} = \theta(\tau) e^{i \alpha \bar{x} \frac{\partial Y}{\partial \bar{y}}}
\]

We obtain the following equations upon simplification of equation /7/ to /9/,
\( \psi'(\tau) - \psi(\tau) + U \frac{\psi(\tau)(1-e^{-\alpha \Delta t})}{\Delta t} + V \frac{\psi(\tau)(e^{\beta \Delta t} - 1)}{\Delta Y} \)

\( = G, \theta'(\tau) \sin \alpha + 2 \psi(\tau) \left( \cos \beta \Delta Y - 1 \right) \)

\( \phi'(\tau) - \phi(\tau) + U \frac{\phi(\tau)(1-e^{-\alpha \Delta t})}{\Delta t} + V \frac{\phi(\tau)(e^{\beta \Delta t} - 1)}{\Delta Y} \)

\( = 1 \left[ 2 \phi(\tau) \left( \cos \beta \Delta Y - 1 \right) + S, \right. \)

\( \theta'(\tau) - \theta(\tau) + U \frac{\theta(\tau)(1-e^{-\alpha \Delta t})}{\Delta t} + V \frac{\theta(\tau)(e^{\beta \Delta t} - 1)}{\Delta Y} \)

\( = 1 \left[ 2 \theta(\tau) \left( \cos \beta \Delta Y - 1 \right) + \theta(\tau) \alpha \right] \)

Equations /14/ to /16/ can be written in the following form:

\( \psi' = \alpha \psi + B \psi \theta \)

\( \phi' = \phi \theta + F \phi \theta \)

\( \theta' = G \theta \)

where,

\( A = 1 - U \frac{\Delta \tau}{\Delta X} \left( 1-e^{-\alpha \Delta t} \right) - V \frac{\Delta \tau}{\Delta Y} \left( e^{\beta \Delta t} - 1 \right) \)

\( + 2 \frac{\Delta \tau}{\Delta Y} \left( \cos \beta \Delta Y - 1 \right) \)

\( E = 1 - U \frac{\Delta \tau}{\Delta X} \left( 1-e^{-\alpha \Delta t} \right) - V \frac{\Delta \tau}{\Delta Y} \left( e^{\beta \Delta t} - 1 \right) \)

\( + 1 \frac{2 \Delta \tau}{P_r (\Delta Y)} \left( \cos \beta \Delta Y - 1 \right) \)

\( F = S, \frac{2 \Delta \tau}{P_r (\Delta Y)} \left( \cos \beta \Delta Y - 1 \right) \)

\( G = 1 + \alpha - U \frac{\Delta \tau}{\Delta X} \left( 1-e^{-\alpha \Delta t} \right) - V \frac{\Delta \tau}{\Delta Y} \left( e^{\beta \Delta t} - 1 \right) \)

\( + 1 \frac{2 \Delta \tau}{P_r (\Delta Y)} \left( \cos \beta \Delta Y - 1 \right) \)

From equations /17/ to /19/ we obtain:

\( \psi' \psi + B \psi \theta \)

where

\( A_i = A, \)

\( B_i = G \Delta \tau \Delta t \sin \alpha \)

The equations /20/ to /19/ become:

\( \psi' = \alpha \psi + B \psi \theta \)

\( \phi' = \phi \theta + F \phi \theta \)

\( \theta' = G \theta \)

And these above mentioned equations can be expressed in the following matrix notation:

\[ \begin{bmatrix} \psi \\ \phi \\ \theta \end{bmatrix} = \begin{bmatrix} A_i & B_i & 0 \\ 0 & F & E \\ 0 & G & 0 \end{bmatrix} \begin{bmatrix} \psi \\ \phi \\ \theta \end{bmatrix} \]

where, \( \eta = T \eta \).

For obtaining the stability condition we have to determine eigenvalues of the amplification matrix \( T \) but the procedure is very difficult as it is a third order square matrix and all the elements of \( T \) are different. Under this consideration we have \( A_i = A, \) \( B_i = B, \) and the amplification matrix becomes:

\[ T = \begin{bmatrix} A & B & 0 \\ 0 & F & E \\ 0 & G & 0 \end{bmatrix} \]

After simplification of the matrix \( T \), eigenvalues are obtained as, \( \lambda = A, \lambda_i = G, \lambda_i = E \).

For stability, each eigenvalue \( \lambda_i, \lambda_2, \lambda_3 \) must not exceed unity in modulus. Hence the stability condition is \( |A| \leq 1, |G| \leq 1, |E| \leq 1 \) and, for all \( \alpha, \beta \).

Now we assume that \( U \) is everywhere positive and \( V \) is everywhere negative. Thus, \( E = 1 - a \theta - \frac{2c}{P_r} \theta + ae^{-\alpha \Delta t} + be^{\beta \Delta t} + 2c \cos \beta \Delta Y \)

where \( a = U \frac{\Delta \tau}{\Delta X}, b = V \frac{\Delta \tau}{\Delta Y} \) and \( c = \frac{\Delta \tau}{\Delta Y} \iota \)

The coefficients \( a, b \) and \( c \) are all real and non-negative. We can demonstrate that the maximum modulus of \( E \) occurs when \( \alpha \Delta X = m \pi \) and \( \beta \Delta Y = n \pi \), where \( m \) and \( n \) are integers and hence \( G \) is real. The value of \( |E| \) is greater when both \( m \) and \( n \) are odd integers. Therefore, \( E \) can be expressed as follows:

\[ E = 1 - a + \frac{2c}{P_r} = 1 - 2 \left[ a + b + \frac{2c}{P_r} \right] \]

To satisfy the first condition \( |E| \leq 1 \) where the most negative allowable value is \( E = -1 \). Therefore, the first stability condition is, \( 2 \left[ a + b + \frac{2c}{P_r} \right] \leq 2 \), therefore,

\[ \frac{U \Delta \tau}{\Delta X} + \left| V \right| \frac{\Delta \tau}{\Delta Y} \frac{1}{P_r (\Delta Y)} \leq 1 \]

Likewise, the second condition \( |G| \leq 1 \) requires that

\[ \frac{U \Delta \tau}{\Delta X} + \left| V \right| \frac{\Delta \tau}{\Delta Y} \frac{1}{P_r (\Delta Y)} \leq 1 \frac{\alpha}{2} \]

Hence the stability conditions of the present study are developed and given below:

\[ \frac{U \Delta \tau}{\Delta X} + \left| V \right| \frac{\Delta \tau}{\Delta Y} \frac{1}{P_r (\Delta Y)} \leq 1 \]

\[ \frac{U \Delta \tau}{\Delta X} + \left| V \right| \frac{\Delta \tau}{\Delta Y} \frac{1}{P_r (\Delta Y)} \leq 1 \frac{\alpha}{2} \]

Since from the initial condition, \( U = V = 0 \) at \( \tau = 0 \) so the equations /24/ and /25/ gives \( P_r \geq 0.0128 \) and \( P_r \geq 0.016 \) respectively. Hence the convergence criteria of the computational approach are \( P_r \geq 0.0128 \) and \( P_r \geq 0.016 \).

5 NUMERICAL SOLUTIONS
In order to solve a non-dimensional system by the explicit finite difference method, it is required to set a set of finite difference equations. For this, a rectangular region of the flow field is chosen and the region is divided into a grid of lines parallel to X and Y axes, where X-axis is taken along the plate and Y-axis is inclined to the plate. Here we consider that the plate of height \( X_{\text{max}} = 100 \) i.e. \( X \) varies from 0 to 25 and assumed \( Y_{\text{max}} = 25 \) as corresponding to \( Y \rightarrow \infty \). \( Y \) varies from 0 to 25. There are \( m(n = 100) \) grid spacing in the X and Y directions respectively as shown in Fig. 2. It is assumed that \( \Delta X \), \( \Delta Y \) are constant mesh sizes along X and Y directions respectively and taken as follows, \( \Delta X = 1(0 \leq X \leq 100) \) and \( \Delta Y = 0.2(0 \leq Y \leq 25) \) with the smaller time-step, \( \Delta t = 0.001 \).

Let \( U_j^*, V_j^*, \bar{T} \) and \( \bar{S} \) denote the values of \( U \), \( V \), \( \bar{T} \) and \( \bar{S} \) at the end of a time-step respectively. Using the explicit finite difference approximation, we obtain the following appropriate set of finite difference equations:

\[
\frac{U_{i,j}^* - U_{i,j}^{n-1}}{\Delta t} + \frac{V_{i,j}^* - V_{i,j}^{n-1}}{\Delta Y} = 0
\]

\[
\frac{U_{i,j}^* - U_{i,j}^{n-1}}{\Delta t} + \frac{U_{i,j}^* - U_{i,j+1}^*}{\Delta X} + \frac{V_{i,j}^* - V_{i,j}^{n-1}}{\Delta Y} = \frac{G_{TS} \sin \alpha}{X} \frac{(\Delta Y)^2}{\alpha}
\]

\[
\frac{S_{i,j}^* - S_{i,j}^{n-1}}{\Delta t} + \frac{U_{i,j}^* - U_{i,j+1}^*}{\Delta X} + \frac{V_{i,j}^* - V_{i,j}^{n-1}}{\Delta Y} = \frac{P_{\alpha}}{(\Delta Y)^2} \left[ S_{i,j}^{n-1} - 2S_{i,j} - S_{i,j}^{n-1} + 2S_{i,j-1} \right]
\]

\[
\frac{T_{i,j}^* - T_{i,j-1}^*}{\Delta t} + \frac{U_{i,j}^* - U_{i,j+1}^*}{\Delta X} + \frac{T_{i,j}^* - T_{i,j}^{n-1}}{\Delta Y} = \frac{1}{P_c} \left[ \frac{2T_{i,j-1} - T_{i,j} - T_{i,j}}{(\Delta Y)^2} \right]
\]

with initial and boundary conditions

\[
U_{0,j}^* = 0, V_{i,j}^* = 0, T_{i,j}^* = 0, S_{i,j}^* = 0
\]

6 RESULTS AND DISCUSSION

In order to discuss the physical phenomena of the mathematical model, the numerical values of the non-dimensional velocity \( \bar{U} \), temperature \( \bar{T} \) and salinity \( \bar{S} \) with the boundary layer equations have been computed for the corresponding values of dimensionless parameter such as, Prandtl number \( \bar{P}_C \), modified Prandtl number \( \bar{P}_S \), Grashof number \( \bar{G}_T \), heat source parameter \( \bar{a} \) and Soret number \( \bar{S}_C \) together with the inclined angle 90° and 120°.

To obtain a steady-state solution, the computer simulation has been carried out up to dimensionless time \( \tau = 80 \). The computational result exhibits insignificant variations up to the range of dimensionless time, \( \tau = 60 \) to \( \tau = 80 \). Therefore, the solutions time, \( \tau = 80 \) is assumed to be steady-state. Hence the distribution of the velocity, salinity and temperature profiles are drawn for \( \tau = 10, 40, 60, 80 \).

The effects of different numerical values of heat source parameter \( \bar{a} = 0.5, 0.6, 0.7, 0.8, 1.0 \) on the salinity, temperature and velocity profiles are exhibited in Figs. 3a-3c for the corresponding values dimensionless parameter \( P_c = 0.50, P_s = 1.0, G_s = 4.0, S_c = 1.0 \) where the angle of inclination was 90°. For the increasing parameter effect of heat source \( \bar{a} \), the transient salinity profiles were observed to be reduced through the boundary layer whereas transient temperature and velocity profiles were increased.

However, for the inclined angle 120° the effects of heat source parameter \( \bar{a} = 0.5, 0.6, 0.7, 0.8, 1.0 \) on the salinity, temperature and velocity profiles are displayed in Figs. 3d-3f for the corresponding values \( P_c = 0.50, P_s = 1.0, G_s = 4.0, S_c = 1.0 \). It can be determined that the transient salinity profiles are decreases whereas transient temperature and velocity profiles found to be increases due to increase in heat source parameter \( \bar{a} \).
Figure 3. Heat source parameter \( \alpha \) effects on transient, (a) Salinity profile with the angle 90°, (b) Temperature profile with the angle 90°, (c) Velocity profile with the angle 90°, (d) Salinity profile with the angle 120°, (e) Temperature profile with the angle 120° and (f) Velocity profile with the angle 120°.

The effects of Grashof number \( (G_r = 5, 10, 15, 20, 25) \) on the salinity, temperature and velocity profiles are shown in Figs. 4a-4c for the corresponding values of physical parameters such as \( \mu = 0.125, \rho = 10, \alpha = 1.0, \beta = 0.80 \) and angle of inclination = 90°. As a result, transient salinity profiles was observed to be decreases whereas transient temperature and velocity profile found increases for increasing Grashof number \( (G_r) \).

For the inclined angle 120°, the effects of Grashof number \( (G_r = 5, 10, 15, 20, 25) \) on the salinity, temperature and velocity profiles are exhibited in Figs. 4d-4f for \( \mu = 0.125, \rho = 10, \alpha = 1.0, \beta = 0.80 \). It was examined that as Grashof number \( (G_r) \) increases the transient salinity profiles decreases whereas transient temperature and velocity profile increases.
Figure 4. Graushof number \((G_r)\) parameter effects on transient, (a) Salinity profile with the angle 90°, (b) Temperature profile with the angle 90°, (c) Velocity profile with the angle 90°, (d) Salinity profile with the angle 120°, (e) Temperature profile with the angle 120° and (f) Velocity profile with the angle 120°.

The effects of Prandtl number \((P_r = 0.71, 0.90, 3.0, 4.0, 7.0)\) on the salinity, temperature and velocity profiles are depicted in Figs. 5a-5c for different values of dimensionless parameter as \(P_r = 0.71, G_r = 4.0, S_r = 1.0, \alpha = 0.50\) and inclined angle 90°. It can be seen that transient salinity profiles were increases whereas transient temperature and velocity profile found to be decreases for the rising effect of Prandtl number \((P_r)\).

For the inclined angle 120° the effects of Prandtl number \((P_r = 0.71, 0.90, 3.0, 4.0, 7.0)\) on the salinity, temperature and velocity profiles are displayed in Figs. 5d-5f whereas \(P_r = 1.0, G_r = 4.0, S_r = 1.0, \alpha = 0.50\). It was observed that the transient salinity profiles are increases while transient temperature and velocity profile found to be decreases for increasing the dimensionless Prandtl number \((P_r)\).
7 CONCLUSIONS

A numerical investigation has been carried out for the transient heat and mass transfer salt water flow through an ocean with the effect of inclined angle. A well-known explicit finite difference method (EFDM) was employed in this study to solve a set of dimensionless coupled governing equations. Since EFDM was introduced therefore a stability and convergence analysis has been carried out to estimate the threshold value of dimensionless physical parameters. The concluding remarks for the present numerical study are specified below:

1. Transient salinity profiles were observed to decreases due to rising value of the heat source parameter. This behavior perceived for both of the angle of inclination (90° and 120°).
2. For the increasing effect of the dimensionless parameter Grashof number (Gr), the salinity profiles (for both 90° and 120° inclined angles) were found to be reduced through the boundary layer.
3. Transient salinity profile was observed to be increases due to increase in Prandtl number (Pr) with an inclined angle 90° whereas a reverse behavior was detected for inclined angle 120°.

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Nomenclature

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
<th>Unit</th>
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<tbody>
<tr>
<td>x, y</td>
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<tr>
<td>u, v</td>
<td>Velocity components</td>
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<td>u</td>
<td>Kinematic viscosity</td>
<td>m² s⁻²</td>
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<tr>
<td>τ</td>
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<td>X, Y</td>
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