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Original Research

NUMERICAL INVESTIGATION OF FORCED CONVECTION HEAT TRANSFER ON INLINE CYLINDERS IMMERSED IN A POROUS MEDIA

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Abstract: In the present study, forced convection heat transfer on eight inline cylinders immersed in a 10 × 10 × 30 cm packed bed of porous medium is numerically explored with a range of Reynolds numbers from 1100 to 2250. The airflow passes through eight cylinders with an inline arrangement, each having a diameter of 15 mm and a length of 10 cm, immersed in a horizontal porous channel at a constant heat flux of 2000W/m^2. The commercial program ANSYS Fluent R.19 simulates the changes in pressure drop and temperature distribution by changing the Reynolds number and porosity. The dimensions of each porous pack are 10x10 cm in cross-section, 5 cm in length, and 5 cm in spacing from the next porous pack. The porosity values are (0.4001, 0.39112, and 0.3822). The general shape of all temperature contours shows that the high porosity near the cylinder wall enhances heat transfer from the heated cylinder surface. After that, the air temperature gradually decreases when going away from the cylinder surface. It can also be seen that the pressure drop decreases as particle diameter increases.

Keywords: *Heat transfer; porous media beds; cylinders immersed; inline arrangement*

1. Introduction

Cross-flow across a bank of circular cylinders is necessary for tubular heat exchangers. [1] Heat Exchangers, chemical reactors, and heat pipes benefit from porous materials with high thermal conductivity. Porous media are used for drying, nuclear reactors, storing solar energy, building materials, and insulating materials [2]. Partially filled channels often have porous layers or blocks. Inline and staggered heat exchangers with many cylinders are widespread [3]. Many scholars have mathematically studied optimizing heat transmission from packed cylinders using a porous material. Few numerical studies of heat transfer and fluid flow in packed circular cylinders in porous media exist. Layeghi and Borujerdi [4] used the finite volume element to analyze convective heat transmission around a submerged cylinder for Peclet numbers less than 40. The Nusselt number increased as porosity declined, and the pressure drop increased as Permeability decreased. Heat transfer and fluid flow research employ the Darcy model. A.l Eleiwi [5] experimentally and numerically examined forced convection heat transport around a cylinder immersed in 4-, 8- and 12-mm porous glass spheres. A 13 mm copper cylinder heating model. Momentum and energy equations are solved within a Peclet range (1<P<e10). In tests and theory, the Peclet number enhances average heat transfer. Al-Sumaily and Thompson [6] investigated non-equilibrium local temperatures that affect forced convection heat transfer from a cylinder submerged in porous particles. It

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considered non-Darcian phenomena and thermal dispersion. The Biot number (0.01-0.100) and solid-to-fluid thermal conductivity ratio were researched to understand how they affected heat transfer rates and hydrodynamic friction (0.01 to 1000). Research on temperature responses was undertaken over an extensive Reynolds number range (1 to 250). The use of porous particles minimized wakes and increased heat transmission.

Habeeb et al. [7] compared free and forced convection in a porous glass cube (30x30x30 cm), where the porous plastic balls have a diameter of (11.7 mm). This investigation used a range of Reynolds numbers from (17.45<Re< 22.13) with uniform heat flux at the lower wall of the cube. The results show that adding glass balls improved heat transfer compared to clear cubic.

Thompson and Al-Sumaily [8] simulated the effect of adding a porous medium on the forced convection of a horizontal cylinder in a pulsating flow with constant heat flux. The porous channel employed Darcy-Brinkmann-Forchheimer momentum and two-equation energy models, while the empty channel used Navier-Stokes equations. As the Reynolds number grows, the result shows stable and unsteady wakes form as the Reynolds number grows in an empty channel. Simulations of porous-medium-filled channels revealed stable flow without protracted wakes.

Adnan [9] conducted numerical and experimental research on forced convection from a porous plate with constant heat flux. It numerically examined heat flow and temperature profile at Reynolds number Re (24118, 44545, 739832, and 82208) using Ansys fluent. The result shows that porous medium fluid temperature lowers from a heated wall as the Reynolds number and heat flow increase. Al-Sumaily [10] studied spacing between cylinders, Reynolds number, and porous media thermal conductivity around four heated cylinders in inline and staggered arrangement numerically. The effect of cylinder Centre distance (SP = 1.5 and 3.0) on local and average heat transfer was studied for three solid/fluid thermal conductivity ratios (1.72, 57.5, and 248) and varied Reynolds numbers (1 to 250). The result shows that Nusselt numbers rise as Reynolds increases, and heat transfer from cylinder arrangement in Staggered was better than inline. Thermal conductivity ratios do not affect SP Nusselt number averages.

Fadhl [11] Experimental and numerical examination of forced convection in a rectangular duct (10*12*100 cm) heated at 0.2 to 0.54 kW/m2 with porous plastic spheres (4 cm). Reynolds number and heat flux both increased as the Nusselt number did in both sites. Reynolds's range (6913-11433). Koundinya et al. [12] studied fluid flow and heat in a porous medium from air alumina numerically. Parametric investigations include thermal conductivity, pressure drop, velocity, and temperature distribution. The result shows that porous alumina material enhances heat transfer compared to an empty channel.

Sayehvand et al. [13] used numerically forced convection to study two tandem circular cylinders in spherical aluminum particles. The flow and heat transfer are impacted by the horizontal distance between the tandem circular cylinders. Porous material increases pressure drop and heat absorption compared to an empty channel.

Amatachaya and Krittacom [14] examined the heat exchanger's efficiency and the porous burner's temperature profile. Volumetric premixed-gas velocity and equivalent ratio boost temperature, according to experiments. A glass-ball-packed duct was tested for forced convection heat transfer experiments with Re (1094) and a heat flux of 2455W/m2. It also tested the heater shapes: square, triangle, and circular. A circle shape has a higher Nusselt number than squares and triangles as well porous cylinders helped heat convection.

Alvandifar, et al. [17] studied inline and staggered tube bundles with three porous rows with used the first and second thermodynamic concepts. Isotropic metal foam with a porosity of 0.9726 fills the tubes. Adding a porous tube increases the Nu number and pressure drop. Staggered porous tube bundles were more thermally efficient and produced less entropy than the inline arrangement.

Chakkingal, et al. [18] studied analytical and numerical methods for a porous tube's flow and heat transfer. A homogeneous/heterogeneous porous material and homogenous heat flow were considered. The result showed that the Nusselt number in heterogeneous porous media was higher than in homogeneous porous media. Darcy and Brinkman's equations depict constant incompressible viscous fluid flow through a porous medium.

Aamer and Hameed. [19] Studied the convection heat transfer inside a channel packed with porous glass material experimentally. The dimension of the iron test section was (0.2x0.2x0.4 m3) loaded with 5mm glass balls. The test portion uses a 0.015m-diameter, 0.2m-long copper cylinder heater. Throughout the test, the cylinder's surface temperature distribution was consistent. The result displays that the Nusselt number rises with the Reynolds number increases.

Yasir. et al. [20] investigated the Forced convective heat transport in an experimental setting using a horizontal tube filled with porous particles made of steel and plastic. Steel and mixed porous media increase Nusselt numbers as Reynolds increases. Rasheed [21] studied forced convection about a triangle cylinder with a 0.015-m-diameter with a Reynolds number range (1089–1422) submerged in porous media involving (polypropylene, glass, and alumina) particles. The result showed that high particle thermal conductivity increased polypropylene, glass, and alumina's heat transfer coefficients by 2.28, 3.85, and 4.9. Mahdi [22] investigated experimentally and numerically triangular channel heat transport. The Reynolds numbers range (3165–10910) was employed with saturated glass spheres heated symmetrically (1300 W/m2). Two sizes of spherical glass fill the test channel. The results showed that the test section pressure difference rises as air velocity increases and declines as glass sphere size increases. The temperature distribution of the channel surface decreases with an increase in glass sphere size.

The current work explores the fluid flow and heat transfer across cylinders immersed in a horizontal two-packed bed of spherical particles of porous media (silica gel and molecular sieve). The working fluid is air at three velocities (0.187, 0.24, and 0.35) m/s, and the cylinders are heated at a constant rate (2000 W/m2).

2. Numerical Investigation

2.1 The Physical Model

As can be seen in Fig. 1, the current study examined the fluid flow and heat transfer from cylindrical tubes submerged with inline arrangements in a horizontal porous medium-packed bed filled with spherical particles (silica gel and molecular sieve). A viscous, incompressible, and laminar forced convective flow passes over four cylindrical tubes immersed in a horizontal porous packed bed with inline arrangements, as illustrated in Fig.1. The cylinders are continuously heated, and the incoming external flow cools them to 25°C. The cylinders are heated at a constant rate (2000 W/m2), and the working fluid is air at three different speeds (0.187, 0.24, and 0.35) m/s. Table 1 shows the Permeability, porosity, diameter, and effective thermal conduction of the porous media used in this study. It can be to calculate the properties of porous materials (silica gel and molecular sieve) by using the following equations:

- Porosity: can be calculated from the equation below [24]

$$\varepsilon 1 = 0.3454 + 11.6985\ (ds) \quad (1)$$

$$\varepsilon 2 = 0.3754 + 4.744\ (ds) \quad (2)$$

$$\varepsilon 3 = 0.37206 + 10.395\ (ds) \quad (3)$$

$$\boldsymbol{\varepsilon_{average}} = \frac{\boldsymbol{\varepsilon 1 + \varepsilon 2 + \varepsilon 3}}{\mathbf{3}} \quad (4)$$

- The capacity of a medium to permit the passage of fluids is known as permeability [25].

$$\mathbf{K} = \frac{\boldsymbol{ds^2\ \varepsilon^3}}{\mathbf{170\ (1-\varepsilon)^2}} \quad (5)$$

ds = porous particles diameter in mm

K= Permeability in (m2)

- Effective thermal conduction [25].

$$keff = \mathcal{E}\, kF + (1 - \mathcal{E})\, k\mathrm{a} \quad (6)$$

k_{eff} = Effective thermal conduction in w/m2.c

k_S= Thermal conductivity of the porous (balls) in w/m2.c

ka = Thermal conductivity of air in w/m2.c

Table1. Porous media porosity and thermal characteristics

Material	**Ds(mm)**	**K (m^2)**	Keff **($w/m^2.c$)**	**Porosity**
Silica gel	4mm	$1.8984x10^{-8}$	0.84992	0.4001
	2mm	$3.9007x10^{-9}$	0.87453	0.3822
Molecular Sieve 13X	3mm	$2.47576x10^{-8}$	0.16425	0.39112
	2mm	$3.9007x10^{-9}$	0.166283	0.3822

As illustrated in Fig. 2, the channel's inlet portion, entrance section, test section, and output section make up the physical mode. The air duct has a square cross-section with a length of (240) cm and a square cross-section (of 10×10) cm. The test portion's length is 30 cm, and its cross-sectional dimensions are 10 x 10 cm. The porous channel's geometrical structure is shown in Fig. 3 and consists of two porous packed beds, and each packed has a cross-section (10× 10) cm and a length of (5) cm. There is a (5) cm gap between each permeable block. The distances are (7.5) cm before the fluid flows into and out of the physical realm. The air flows through four cylinder banks with inline arrangements in a horizontal porous channel, each with a diameter of 15 mm and a length of 10 cm. The difference between the top and bottom of the cylinder is its transverse pitch, while its front and back are separated by its longitudinal pitch. With inline layouts, the longitudinal pitch is regarded as equivalent to the transverse pitch (15 mm).

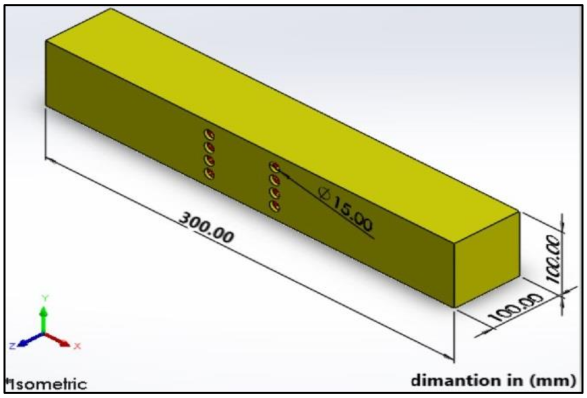

Figure 1. The test section of the present model

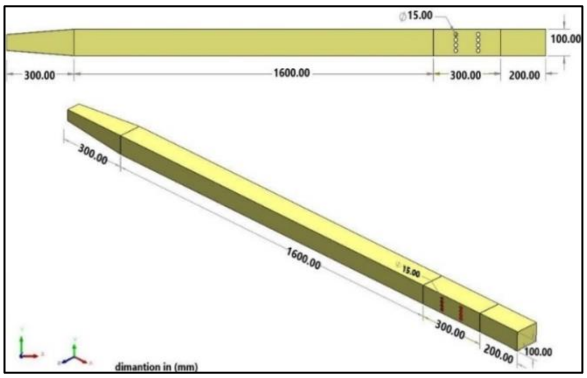

Figure 2. Physical mode

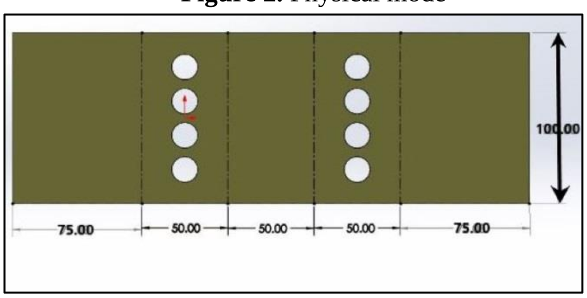

Figure 3. The geometrical of the porous channel

2.2 The Mesh Generation

In the present work, different mesh sizes were used using the multizone method for the porous channel and the tetrahedrons method for two porous packed beds. The (x, y, z) orientation computational grid for the geometric layout of Porous channels is shown in Fig. 4 .
In this research, the meshes of the proposed geometry for two porous blocks with cylindrical tubes submerged in a horizontal porous packed bed in inline patterns are investigated, as illustrated in Fig. 5.

For the present case, an average of (3120337) elements and (741109) nodes are used after several attempts, as shown in Fig. 6. This study used 1000 iterations, but the convergence happened at iteration 1000.

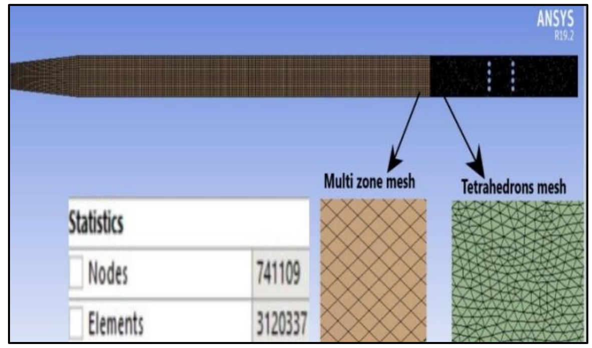

Figure4. Mesh generation of porous channel

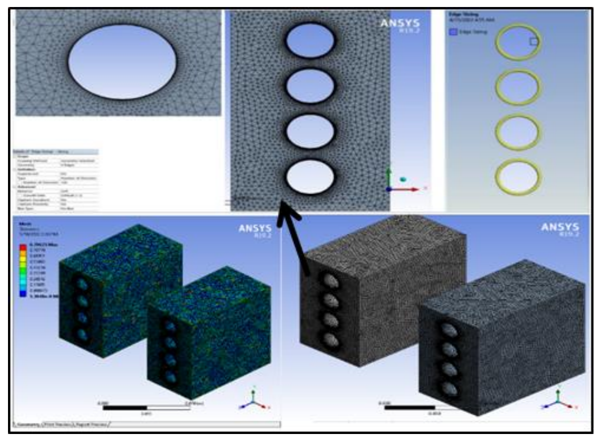

Figure 5. The mesh of porous packed bed

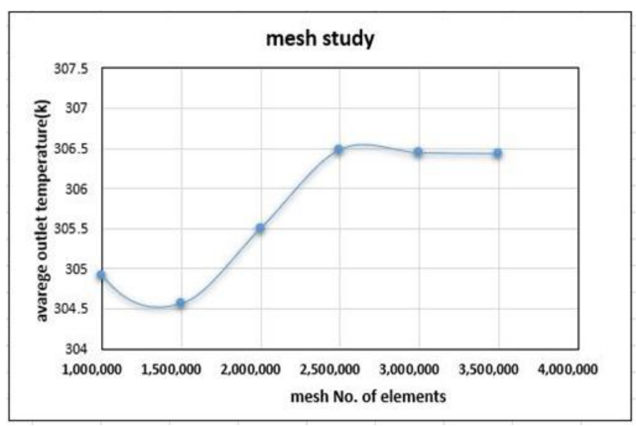

Figure 6. The mesh independence

2.3 The Governing Equations

Before starting to analyze cases, it is a good idea to state the governing equations' assumptions:

- Steady-state.
- Incompressible fluid
- Newtonian flow.
- Laminar flow
- The Reynolds number rag ($1100 \leq Re \leq 2250$)
- Three dimensions.
- Constant heat flux

The conservation of mass, momentum, and energy equations, as well as the governing differential equations of fluid flow and heat transmission, have been illustrated. The computational fluid dynamic (CFD) gives the best model to be made experimentally without needing costly prototypes. Through the use of computational fluid analysis (CFD), the temperature profiles are determined in this work. Every equation was shown using a Cartesian coordinate system.

2.3.1 Conservation of mass

This research used the three-dimensional Navier-Stokes governing equations for an incompressible fluid.

For the fluid domain, the mass continuity equation is [14]:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0 \qquad (7)$$

2.3.2 Momentum Conservation

Newton's second law is the foundation for the other fundamental set of equations that govern fluid flow (the conservation of momentum). Darcy-equilibrium equations or full instantaneous equations for an incompressible fluid are the names of the equations [23]:

The x-momentum equations

$$\frac{1}{\varepsilon^2}\left[u\,\frac{\partial u}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial w}{\partial z}\right]-\frac{1}{\rho f}\frac{\partial p}{\partial x}+\frac{1}{\varepsilon^2}\ \mathrm{veff}\ \left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right)-\frac{vf}{ka}+\frac{\varepsilon C}{\sqrt{ka}}\left|\vec{V}\right| \qquad (8)$$

The y- momentum equations:

$$\frac{1}{\varepsilon^2}\left[u\,\frac{\partial u}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial w}{\partial z}\right]=-\frac{1}{\rho f}\frac{\partial p}{\partial y}+\frac{1}{\varepsilon^2}\mathrm{veff}\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right)-\left[\frac{vf}{ka}+\frac{\varepsilon C}{\sqrt{ka}}\left|\vec{V}\right|\right]v \qquad (9)$$

The z-momentum equations:

$$\frac{1}{\varepsilon^2}\left[u\,\frac{\partial u}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial w}{\partial z}\right]=\frac{1}{\rho f}\frac{\partial p}{\partial z}+\frac{1}{\varepsilon^2}veff\ \left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right)-\left[\frac{vf}{ka}+\frac{\varepsilon C}{\sqrt{ka}}\left|\vec{V}\right|\ \right] \qquad (10)$$

Where:

$\left|\vec{V}\right|$: Dimensionless absolute velocity.

$veff$: Effective kinematic Viscosity.

C : Constant.

2.3.3 Energy Conservation

In a non-dimensional formation, the governing equation for energy is defined as

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}+w\frac{\partial T}{\partial z}=\frac{k_{eff}}{(\rho C_P)f}\left(\frac{\partial^2 T}{\partial x^2}\right)+\left(\frac{\partial^2 T}{\partial y^2}\right)+\left(\frac{\partial^2 T}{\partial z^2}\right) \qquad \ldots.(5)$$

U, v, and w are the velocities in the x, y, and z directions. T is the temperature and also is the fluid density.

2.4 Boundary Conditions

Boundary conditions are applied at the inlet when the fluid enters the duct at a constant velocity and temperature. With the pressure outlet at the outlet, the flow can be presumed to be fully developed.

The air temperature at the domain inlet is 298K, and the domain's outer surface acts as a thermal insulator. The inflated walls of the cylinders immersed in porous media are kept adiabatic, and the heat flux is kept constant (q = 2000 W/m^2).

The entrance air velocity to the test channel is in the range of (0.187 to 0.35) m/s, and boundary conditions were considered in this analysis.

Boundary conditions are present at the inlet:

$T = T_{in}$=298K, u = v =0

Boundary conditions are present at the outlet:

$P = P_{out}$, u = v = 0, $\frac{\partial T}{\partial z} = 0$

Boundary conditions at the walls are:

u = v = w = 0, $\frac{\partial T}{\partial x} = \frac{\partial T}{\partial y} = 0$

Boundary conditions at the heat flux surface are:

u = v = w = 0, $q = -k_s \frac{\partial T}{\partial y}$

When porous media was present, a porous zone was chosen, with porosity values of (Ɛ = 0.41798), (Ɛ = 0.40011), (Ɛ = 0.39112), and (Ɛ = 0.3822), respectively. This study's proposed geometry and flow direction are depicted in Fig.7. The solution becomes convergent when the residuals are less than 10^{-6}, as illustrated in Fig.8.

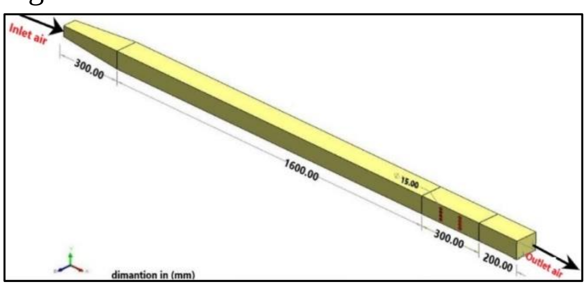

Figure7. Flow direction and shape in the present study

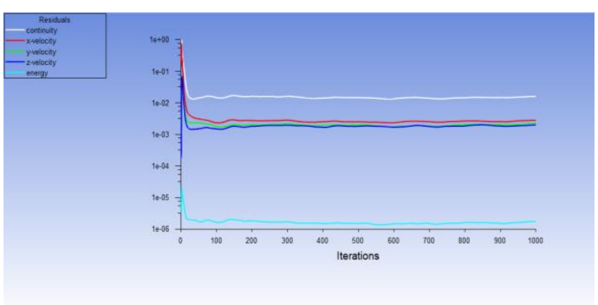

Figure8. The solution residuals

3. Numerical Results and Discussion

The primary purpose of this study is to determine how porous materials affect convective heat transfer from circular cylinders in inline form. Two types of porous media (silica gel and molecular sieve) are investigated using numerical ANSYS FLUENT version 19.2 software. The temperature contours, velocity vector, and pressure drop are obtained at Reynolds numbers (1100 to 2250) and heat flux 2000 W/m2.

Figures (9-10) and (11-12) show the effect of the changing diameter on the temperature distribution contour for silica gel from (2mm to 4 mm) and molecular sieve from (2mm to 3mm). It can be noted from the figures that the temperature distribution contour increases with decreases in particle diameter due to the amount of heat that particles in contact with the cylinder transmit to it. Smaller particles increase the number of contact points between cylindrical and porous particles.

Fig.9, Fig.10, Fig.11, and Fig.12 illustrate the influence of various airflow velocities (0.187, 0.24, and 0.35) on the temperature distribution contour for silica gel (2 and 4 mm) and molecular sieve (2 and 3 mm), respectively. Both types of materials (silica gel and molecular sieve) experience more pronounced temperature gradients as the fluid velocity rises because the temperature rises more quickly in the direction of flow and the isotherm lines move closer to the cylinder surfaces.

Fig.13, Fig.14, Fig.15, Fig.16, and Fig.17 display fluid velocity vectors for inline cylinder arrangements with different airflow velocity values (0.187, 0.24, and 0.35) m/s for silica gel and molecular sieve with different diameters. This figure illustrates that increasing the velocity from 0.187 m/s to 0.35 m/s increases the mass flow rate, causing a significant heat transfer between the cylinder surface and the air. The airflow is forced to move from the packed bed region to the outer regions when the inflow velocity increases from 0.187 to 0.35 m/s, increasing the heat transfer rate by thinning the boundary layer around the cylinders.

Fig.18, Fig.19, Fig.20, and Fig.21 show pressure losses for inline cylinder arrangement with different air velocity values (0.187, 0.24, and 0.35) m/s for the silica gel and molecular sieve with different diameters.

As can be seen in the figures, the pressure loss rises as air velocity increases and the porous particle's diameters decrease due to the increased air opposition caused by particles within the test section. Porous particles in the test section change the fluid regime considerably by making the streamlines, pressure gradient, and pressure contours more uniform.

Solid particles in porous media change the fluid regime considerably by making the streamlines, pressure gradient, and pressure contours more uniform. Behind the second cylinder and between the two cylinders, there is no wake. When air flows consistently and slowly along the channel, the heat from the wall cylinders and solid particles is best absorbed. Furthermore, absorbed heat from solid particles quickly travels to air particles in the porous packed bed due to the interaction of air and solid particles.

Fig.22 shows that at a constant heat flow rate, the temperatures along the horizontal axis of the circular cylinders increase as the particle diameter rises because air resistance rises, slowing airflow around the cylinders and increasing the temperature on the surface. That is shown in both materials. Temperatures of molecular sieve and silica gel differed by 2.8% at Re (1197).

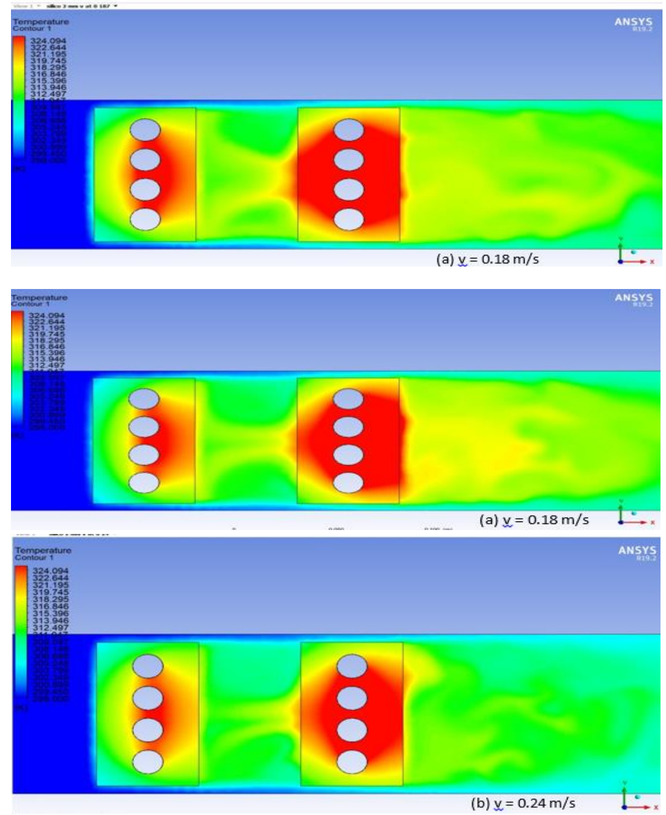

Figure 9. Temperature contours of the silica gel with a 2mm diameter

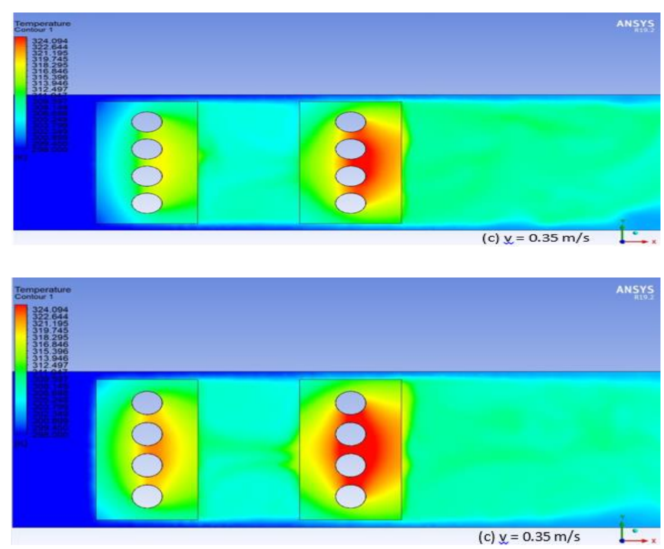

Figure10. Temperature contours of the silica gel with 4mm diameter.

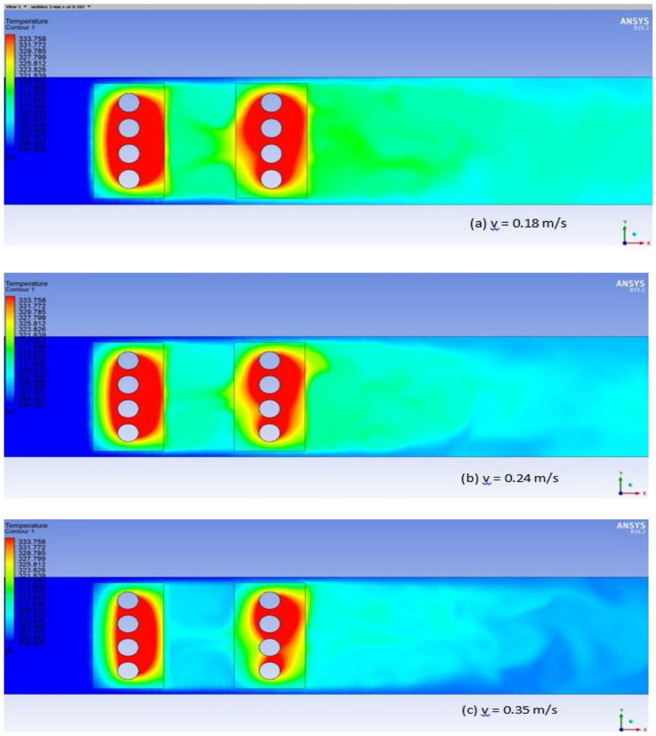

Figure11. Temperature contour of the molecular sieve with a 2mm diameter

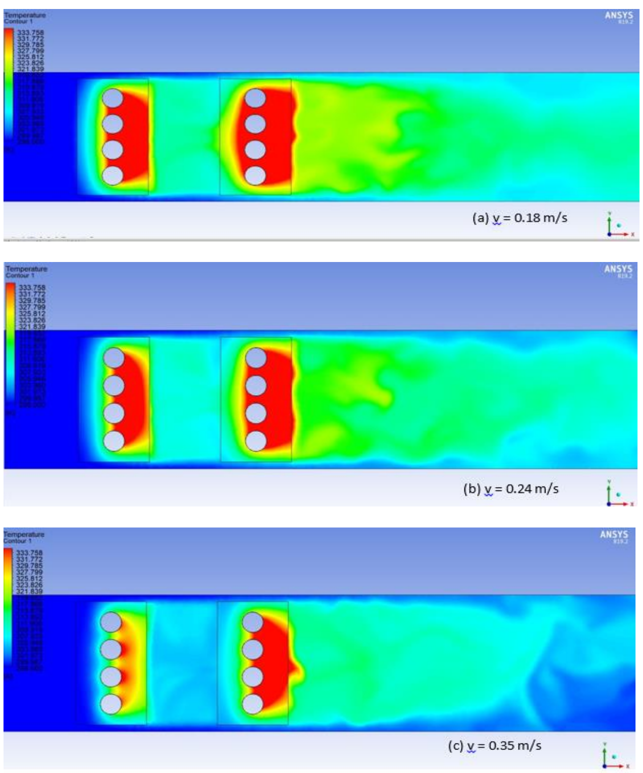

Figure12. Temperature contour of the molecular sieve with 3mm diameter

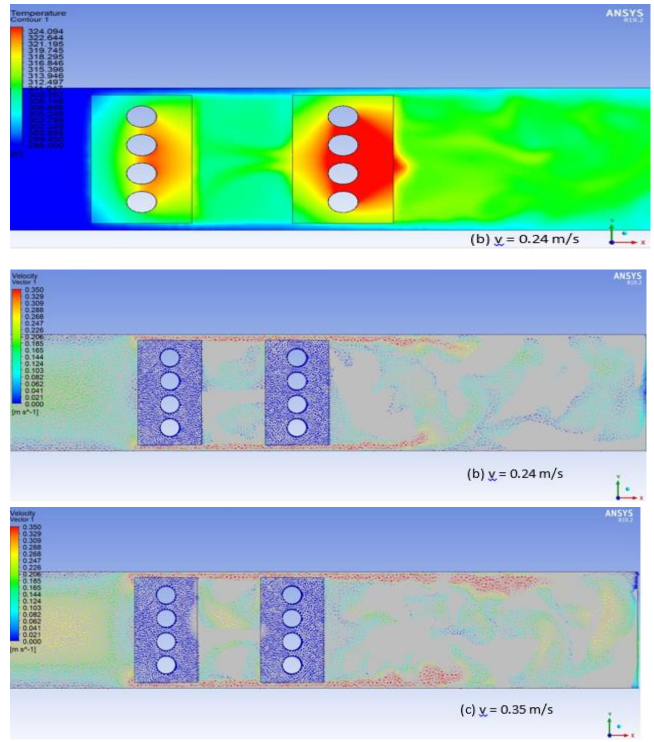

Figure13. Velocity vector of the silica gel with 2mm diameter.

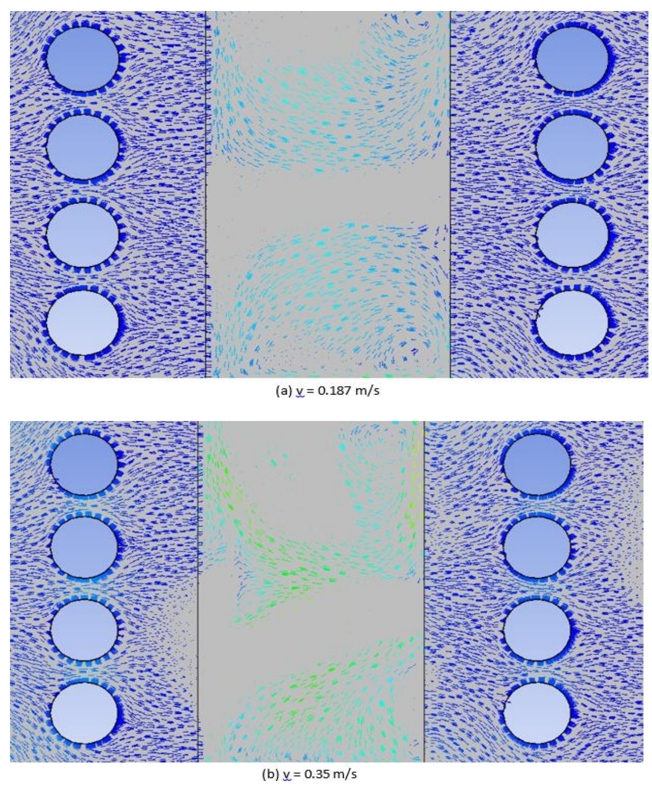

Figure14. Velocity vector for two packs of the silica gel with a 2mm diameter.

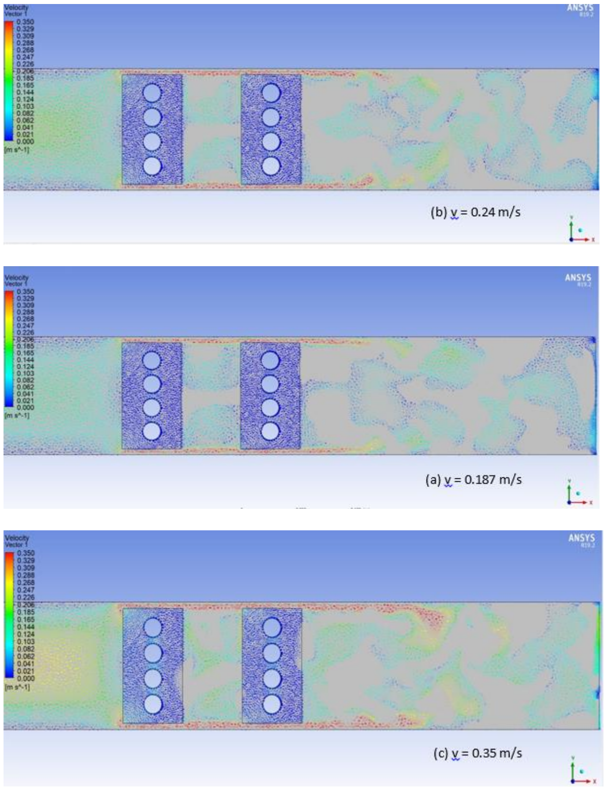

Figure15. Velocity vector of the silica gel with 4mm diameter

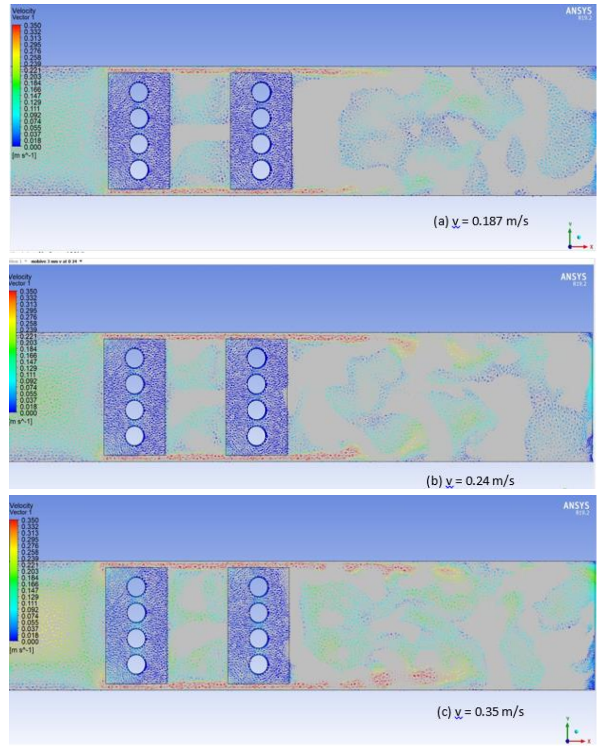

Figure17. Velocity vector of the molecular sieve with 3mm diameter

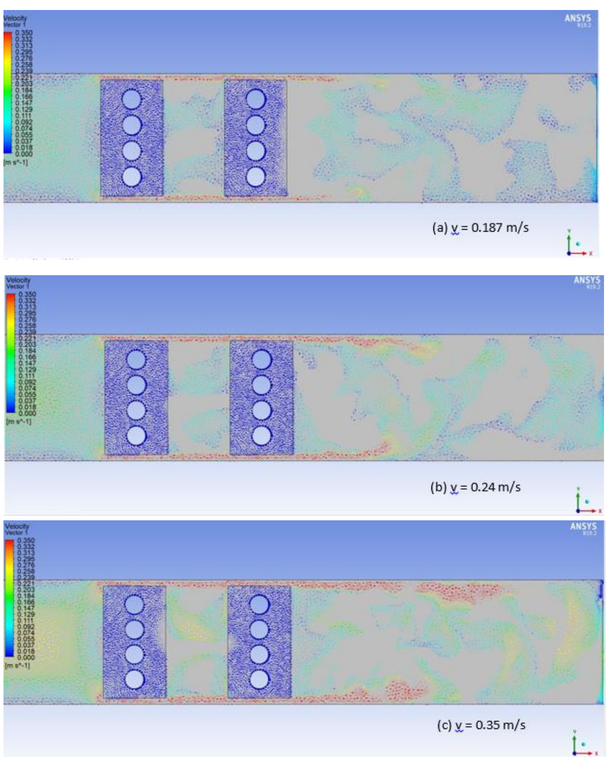

Figure 16. The velocity vector of the molecular sieve with a 2mm diameter

Figure18. Pressure drop of the silica gel: a- 2mm diameter.

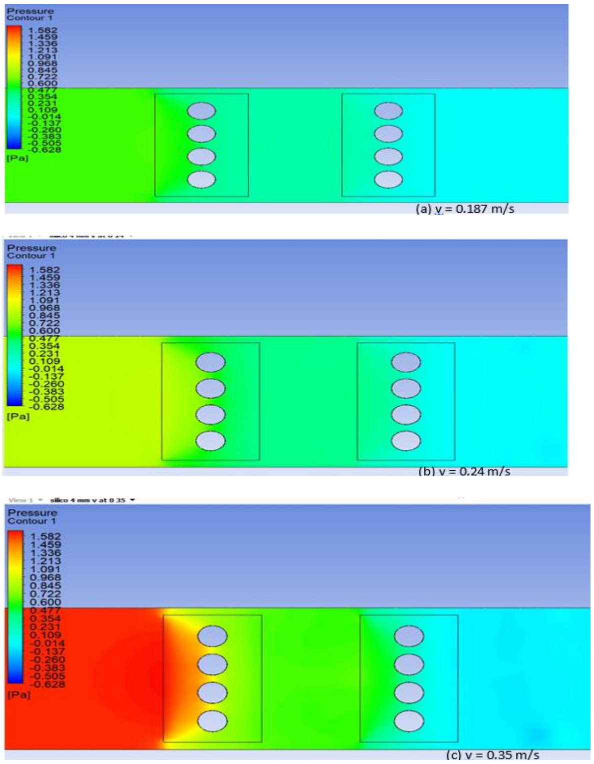

Figure19. Pressure drop of the silica gel with 4mm diameter.

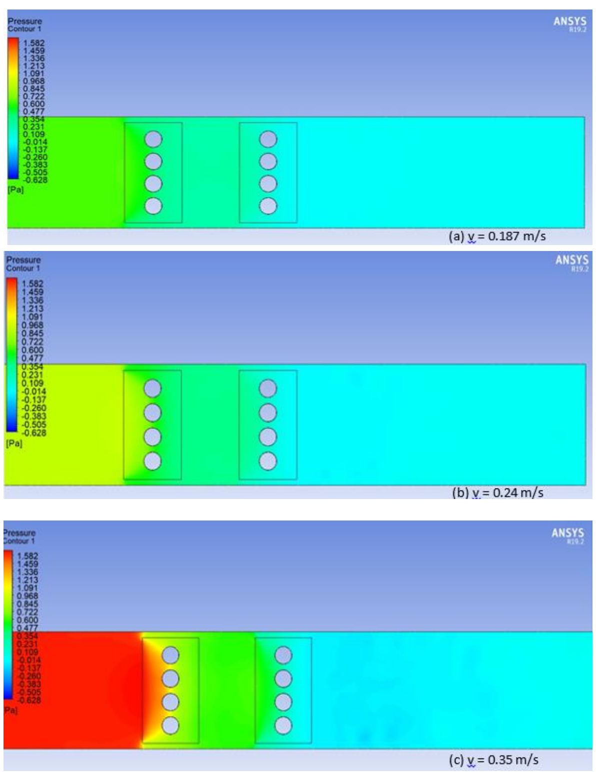

Figure20. Pressure drop of the molecular sieve with 2mm diameter.

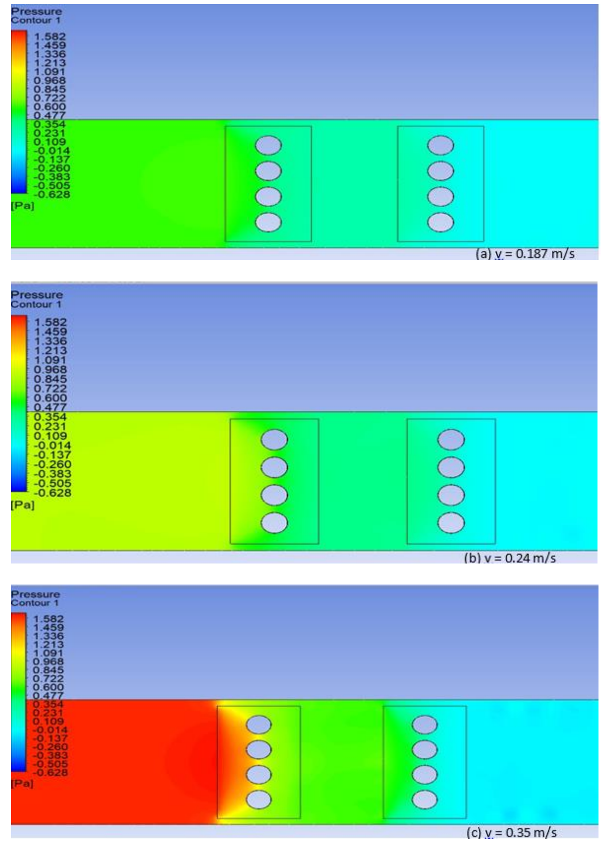

Figure 21. Pressure drop of the molecular sieve with a 3mm diameter

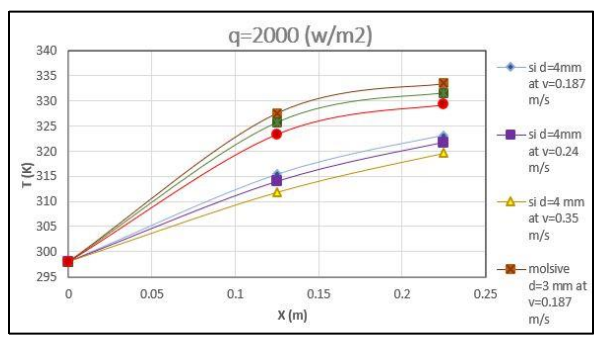

Figure 22. The temperature distribution along the X-axis

4. Comparison

The temperature distribution during the test portion was compared with that of another researcher [21]. As shown in Fig.23. The present study shows similar behavior to Ref [21]; the amount of temperature distribution grows with the length of the horizontal axis parallel to the flow. Furthermore, the temperature distribution decreases as air velocity increases.

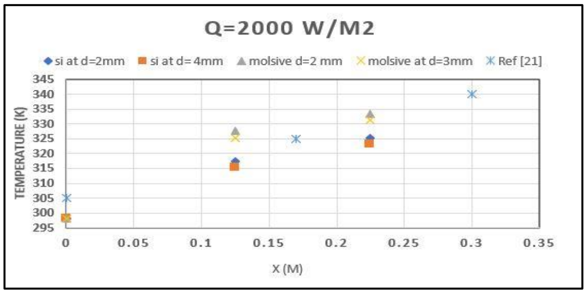

Figure23. Comparison of the validation results of Ref [21] and the present study

5. Contribution Statement

Various types of porous media, such as (glass, aluminum, copper, alumina, and steel). Theoretical and experimental studies have been conducted on improving heat transfer using porous media. A recent study utilized new materials such as silica gel and molecular sieves.

6. Conclusions

The effects of porous materials on conductive and convective heat transfer in fluid and solid phases in two inline cylinder designs are examined in this study. Eight circular cylinders that are implanted in two horizontal baked beds with variable porosities are being studied statistically for fluid flow and forced convection heat transfer. In the porous channel, Reynolds numbers of 1100–2250 and heat flux of 2000 W/m^2 are attained in the porous channel and two porous baked beds for silica gel and molecular sieve. In the current investigation, the fluid flow pressure drops considerably when the diameter of solid particles increases. According to the current analysis, as velocity rises, fluid temperature rises more quickly in the direction of flow, and when isotherm lines approach cylinder surfaces, temperature gradients rise. The fluid thermal boundary layer surrounding the cylinders is thick in the cases with velocity (0.187 m/s). Porous material improved heat transfer from cylinder surfaces to air. Thermal conductivity of silica gel more than molecular sieve so that, silica gel gives enhanced heat transmission than molecular sieve. Increasing the air velocity from 0.187 m/s to 0.35 m/s increased heat transmission.

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Nomenclature

A	Surface area of test section,	mm^2
A_c	cross section of duct,	mm^2
c	Constant	---
ds	porous particles diameter,	mm
ka	Thermal conductivity of air,	W/m. K
$keff$	Effective thermal conduction,	W/m. K
ks	Thermal conductivity of the porous (balls),	W/m. K
p	pressure drop,	Pa
$\dot{Q}$	Heat load,	W
q	Heat flux,	w/m^2
T	Temperature,	°C
u	velocity of air, in the x directions,	m/s
$\lvert\vec{V}\rvert$	Dimensionless absolute velocity,	---
V	velocity of air, in the y directions,	m/s
$veff$	Effective kinematic Viscosity,	m^2/s
w	velocity of air, in the z directions,	m/s
ρ_f	fluid density,	Kg/m^3
ε	porosity,	---

Conflict of interest

There are no competing interests that would prevent the publication of this paper, as confirmed by the authors.

Author Contribution Statement

Author Dhamyaa S. Khudhur proposed the study problem and supervised the work's outcomes. Author Enas Khudhair conducted the research, carried out the computations, verified the analytical procedures, and contributed to the final document of the manuscript. Both authors discussed the findings.

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