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Effect of aspect ratio of a corrugated cavity filled with porous media on the coefficient of heat transfer

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Abstract

The purpose of this research is to investigate the influence of porous media on the convective heat transfer coefficient and the modified Rayleigh number as a function of the cavity's aspect ratio. This study investigated the free convective 3D flow then heat transmission in a cavity that has a width of 20 cm in width, a depth of 2.7 cm in depth, and varying heights of 20, 25 and 30 cm. The cavity has an anisotropic fluid-filled porous wavy enclosure with steady-state incompressible flow. The bottom surface radiates heat with a steady heat flux. (300, 500, 700, 900, 1100 W/m²), while the top is exposed to the environment at 25 C° (h=25 W/m²) and other walls are adiabatic. Rayleigh's number range (3.13×10^{7} to 2.61×10^{8}), D_a (1.9×10^{-8}), aspect ratio (As=1,1.25,1.5), porosity (ε=0.36), permeability (k=7.593×10^{-10} m²), amplitude (a=1.5 cm). The findings indicate that: 1- Increasing the heat flux on the temperature profile progressively increases the pressure and velocity.2- The highest value for the heat transfer coefficient and modified Rayleigh No. was obtained when the aspect ratio was 1.3-With increasing heat flux, the temperature and modified Rayleigh number rise. 4- The aspect ratio (As=1.5) values produce a high Nusselt number.

Keywords: ANSYS CFX; Numerical simulation; free convection; wavy-wall cavity; porous medium.

الخلاصة: الغرض من هذا البحث هو دراسة تأثير الوسائط المسامية على معامل انتقال الحرارة بالحمل الحراري ورقم رايلي المعدل كدالة لنسبة أبعاد التجويف. فحصت هذه الدراسة التدفق الحر ثلاثي الأبعاد للحمل الحراري ثم انتقال الحرارة في تجويف بعرض 20 سم وعمق 2.7 سم وبارتفاعات متفاوتة 20 و 25 و 30 سم. يحتوي التجويف على غلاف مموج مملوء بالماء ومواد مسامية مع تدفق ثابت غير قابل للضغط. السطح السفلي معرض الى فيض حراري بتدفق ثابت (300 ، 500 ، 700 ، 900 ، 1100 واط / متر مربع) ، بينما يتعرض الجزء العلوي للظروف الجوية عند 25 درجة مئوية (معامل انتقال الحرارة = 25 واط / م 2) والجدران الأخرى ثابتة الحرارة. نطاق عدد رايلي (3.13 * 10^{7} حتى 2.61 * 810^{8}) ، رقم دارسي (1.9 * 10^{-8}) ، نسبة العرض إلى الارتفاع (As = 1،1.25،1.5) ، المسامية (0.36) ، النفاذية (* 7.593 10^{-10}) وعرض الموجة(1.5 سم). تشير النتائج إلى أن: 1- زيادة التدفق الحراري تودي الى زيادة الفرق في درجات الحرارة ويزيد الضغط والسرعة بشكل تدريجي. 2- تم الحصول على أعلى قيمة لمعامل انتقال الحرارة ورقم راليه المعدل عندما كانت نسبة العرض إلى الارتفاع تساوي1. 3 - بزيادة التدفق الحراري يزداد الفرق في درجات الحرارة وارتفاع قيم رقم راليه المعدل .4- تنتج قيم نسبة العرض إلى الارتفاع (As = 1.5) اعلى قيم لرقم نسلت.

1.NTRODUCTION

The heat transform mechanism in the past two decades, researchers have paid considerable attention to heat transfer by natural convection in cavities owing to its rising relevance in engineering and industrial applications. This technique is used in the nuclear reactor cooling, electronic devices, sunlight collectors, air cooling central heating, and geotechnical systems. Cheong (2017) et. al [1] said that natural convection cools a source of heat is an important subject of study since it is used in a variety of industrial and home equipment. A wavy surface was a larger surface area that flat surface for the same length and width and hence allows for more heat transmission during energy exchange Some technical applications, including as solar thermal collectors, dual energy absorption, and cooling of nanoelectronics are only some of the applications, depend on convection in a wavy cavity.

Janagi (2017) et. al [2] Inside a square porous chamber, the heat transfer and spontaneous convection movement of cold water at 4°C were investigated. The hollow's vertical walls were kept at a temperature different from the adiabatic horizontal walls.; particularly, the right-hand wall was kept at 6 °C, whilst the temperature on the opposite wall was sinusoidal dispersion. The impacts of the density reversal parameter, Darcy number, Rayleigh number, and porosity were explored to use the Brinkman-Forchheimer-extended Darcy concept for porous material, and the governing equations were solved using the finite volume method. The results of the study show that when the Darcy number and porosity are raised, the heat transfer rate increases. In addition, as the density inversion parameter increases, the convective heat transfer rate inditially reduces and subsequently increases. Numerical simulations were carried out using The Darcy number is in the range of $10^{-1} \leq \mathrm{Da} \leq 10^{-4}$, the porosity is in the limit of $0.4 \leq \varepsilon \leq 0.8$, and the density stratification parameter is in the range of $0 \leq \mathrm{Tm} \leq 1$ and Ra = 10^{6}. Electronic hardware cooling, heat storage devices, and heat exchangers can all benefit from the results. N. Tokgoz (2017) et. al [3] used numerical and experimental methods to find more about the flow properties and thermal efficiency of different materials duct designs. The entire research was done for Reynolds numbers in the vicinity of $3 * 10^{3} \leq \mathrm{Re} \leq 6 * 10^{3}$. The first goal was to investigate the impacts of aspect ratio, S/H, and Enhancement of flow energy transfer topologies. As a result, three distinct aspect ratios were used to build the corrugated duct geometries: L/H = 0.1, 0.2, and 0.3. In the interest of maximise the aspect ratio, L/H, the thermal efficiency of various geometries was quantitatively analysed. On the direction of the porous channel, the amount of turbulence anxiety increased when the corrugation height was increased, as was expected. The heat transfer rate increased as the aspect ratio, L/H, was raised, peaking at L/H = 0.3, which was the highest length to width ratio.

Habeeb (2017) et. al [4] For steady-state incompressible flow, the non-Darcy flowing model was used to investigate free convective 2D flow after that, transfer of heat in an anisotropic a porous rectangular container filled with fluid and with discriminatingly heated walls. For a range of porosity ($0.4 \leq \varepsilon \leq 0.9$), the consequence of the Darcy No, ($0.0001 \leq \mathrm{Da} \leq 10$), Rayleigh number ($10 \leq \mathrm{Ra} \leq 5000$), and aspect ratio ($0.25 \leq \mathrm{AR} \leq 4$) with and without a moving lower wall were investigated. The lower and upper surfaces of the cavity were insulated, while convective transport across the porous material was enabled by the heated surfaces on the right and left which resulted in thermal stratification and flow circulations. The Darcy number, Rayleigh number, aspect ratio, and porosity were discovered to have a significant impact on the properties of flow and heat transmission mechanisms. Ali Maseer (2017) et. al [5] did a numerical examination regarding laminar free convection heat using ANSYS-CFX R15 program. Transport within a completed curved utilising a porous cavity heat source from below by using models of Darcy-Forchheimer ignoring viscous dissipation. By using water, a saturated silica-sand porous combination. The studied variables included the phase angle, the aspect ratio, and the waving of the container sidewalls in a sinusoidal form. Unless the number of waves per cavity height equals one, the results show that the cavity's walls have a sinusoidal curviness reduces the rate of heat transfer (i.e., N=1). When the wave's amplitude is almost comparable to one, the heat transfer rate within the cavity enhances (amplitude = 0.075). A Abdulkadhim (2018) et. al [6] conducted simulations of numerical data Optimizing heat transfer by free convection in a porous cavity partial heating. Using the finite element method, the governing dimensionless equations were solved. The modified Rayleigh No. ($10 \leq \mathrm{Ra} \leq 10^{3}$), finite wall thickness ($0.02 \leq \mathrm{D} \leq 0.5$), ratio of thermal Conductivity ($0.1 \leq \mathrm{Kr} \leq 10$), and aspect ratio ($0.5 \leq \mathrm{AR} \leq 10$) were employed in the classic Darcy model. The information was provided Flow pattern, temperature profile, and local & average Nusselt numbers. The findings show that as the thickness of wall grows, the transfer of heat by conduction mechanism takes over. Furthermore, raising the aspect ratio increases the stream function while lowering the heat transfer rate.

Chandra (2019) et. al [7] did a numerical study of natural convection in a porous container with insulated sidewalls that were both hydrodynamically and thermally anisotropic. Two scenarios were considered: (I) the upper and base walls provide the same heat flux, and (II) the heat flux upon the top-tier wall is negative compared to the support wall's heat flux. The combined mathematical expressions were solved numerically using the SIMPLER technique using a model that is non- Darcy and contains Brinkman with Darcy relations. It was discovered that when the medium's permeability drops, the maximum magnitude of Nu_x increases. Cimpean (2019) et. al [8] studied natural convection inside an inclined square cavity which had a sinusoidal temperature variation on the side walls and a porous fluid-saturated media. The case was solved using a finite difference approach of second-order accuracy, and the dimensional-less governing equations for the mathematical model and boundary bounds were derived. The numerical findings reveal the effect of varying cavity tilt angles, sinusoidal thermal amplitude ratio, and phase deviation. Heat plus fluid movement control variables within the container are considered to be the cavity incline angle and regular thermal boundary constraints. As the inclination angle rises, the average Nusselt number and fluid flow rate increase.

Rao (2020) et. al [9] developed a numerical representation a source of heat trapped in a curvy enclosure cooled by natural convection. The wavy right-side the wall was applied at a constant ambient Tempe, in contrast to the other walls were kept adiabatic. A continuous heat flux with partial source of heat was put on the right wall. The governing non-dimensional equations that characterised the fluid flow were finalised using a numerical technique accurate to the second order. A logarithmic length (0.25≤ ε ≤ 1.0) of the heater is situated on the left of the vertical enclosure, in the centre the effective Rayleigh-Darcy number (10 ≤ Ra ≤10^3) and thus the right vertical wall's waviness, its amplitude is in charge of this (0.05 ≤ a ≤ 0.25), the size of the wave and how many undulations there are (1≤ N ≤5) per unit length. Only one factor influences convection within a wavy cavity filled with a fluid-structure porous medium at high Ra, and when surface roughness increases, substantial inside the cavity there occurs convection. Theeb (2020) et. al [10] studied various width-to-height ratios (aspect ratios) in a two-dimensional numerical method of a porous material-filled enclosure from the bottom, which is constantly exposed to heat flux. The streamlines, average Nusselt numbers, and isotherm lines were calculated, and the free convection in the two-dimensional model was numerically defined using the methodology of finite difference. Rayleigh's number 10^6, the Prandtl number 0.72, and aspect ratios ranging from 1:4 to 4:1 were used. The outcomes revealed that the length to width ratio has a significant impact based on the Nusselt number. Furthermore, Increasing the rate of flow for length to width ratio of 1:4 to 4:1 increases the average Nusselt number. Parvin (2021) et.al [11] studied numerically the flow field and heat transfer characteristics of nanofluids between the domains delimited by a square and a wavy cylinder. The cavity's left and right walls were kept at a constant low temperature while the remaining walls were insulated. The increased temperature of the inner corrugated surface caused the convective processes. The governing equations of the classical rectangular enclosure were transformed into a system of equations valid for concentric cylinders using super elliptic functions. The implicit finite difference approach was used to solve the resulting equations iteratively. Due to a rise in the aspect ratio of the inner cylinder and the Rayleigh number, the streamlines' strength increased dramatically. The average Nusselt number at the internal and external cylinders became stronger as the concentration of nanoparticles increased. When plotted against the volume percentage of the nanofluid, the average Nusselt number throughout the whole Rayleigh number range improved. P. Barman (2021) et.al [12] did a numerical study on the influence in a porous medium, the influence of aspect ratio on free convection, undulating container. In this study, the enclosure was vertically positioned with the right undulating wall remained at a constant low Tempe then a source of heat that is only partially effective inserted in vertical wall on the left, leaving adiabatic the top & bottom walls. The difference of finite approach was used to solve equations of governing that describe Darcy flow. The heat source's cooling effectiveness was found to improve as the aspect ratio increased. Zachi (2021) et. al [13] steady naturally convection in a square container with walls that are 20 cm long and that are filled up with a porous media that has been saturated with the same fluid in both the bottom and higher layers. The conceptual analysis of the transfer of heat accomplishments is carried out under the influence of heating the bottom by constant heat flux (q=150,300,450,600W/m²) for 3 heaters with a size of (0.2,0.14,0.07) m, cooling symmetrically on two sidewalls at a particular temperature, and adiabatic top wall. The highest temperature is attained at modest porosity and rises with a growth in size of heater and a decrease in thickness of porous, with a rise in maximum temperature of around 5%, according to the data. Nusselt number grows with porous layer and with heater height, and Darcy number obviously influences the augmentation of heat transmission at high porosity. Barman (2021) et. al [12] Analyze numerically how aspect ratio affects natural convection in a porous cavity with waves. The cavity is positioned vertically and has a right wavy wall that is kept at a constant low temperature, while the left vertical wall has a partial heat source imbedded in it, maintaining the top and bottom walls at adiabatic temperatures. Rayleigh (Ra = 10, 10^2, 10^3), aspect ratio (AR = 0.2, 0.5, 2.0, 5.0). The increase in aspect ratio improves the heat source's capacity for cooling.

It can be seen from the earlier research and from the report of the authors' understanding that heat transfer occurs in a wavy chamber that is filled with porous medium and heated from the bottom with a steady heat flux. The top is exposed to the environment. The side walls, front and back walls are insulated but have not been reported as of yet. The current work illustrates the influence of aspect ratio (ratio of height to width) on various parameters such as modified Rayleigh number, temperature profile, pressure, and velocity.

2. MATHEMATICAL FORMATION

2.1. Description of model

Consider a wavy similar wall cavity with length, w, and height, H, containing water and porous media. The top of the container is subjected to the environment (h=25W/m²) at T=25 C°, and a constant heat flux is applied from the bottom. All other walls are insulated (front, back and side walls)." **Figure** (1)" Provides a graphical representation of the problem. In order to simplify the case, the following parameters are dependent; laminar flow, steady-state, 3D flow, single-phase flow, incompressible fluid, constant porosity, thermal equilibrium in the immediate vicinity (T_s=T_f), and finally, dissipation of viscous fluid, neglect the effects of radiation.

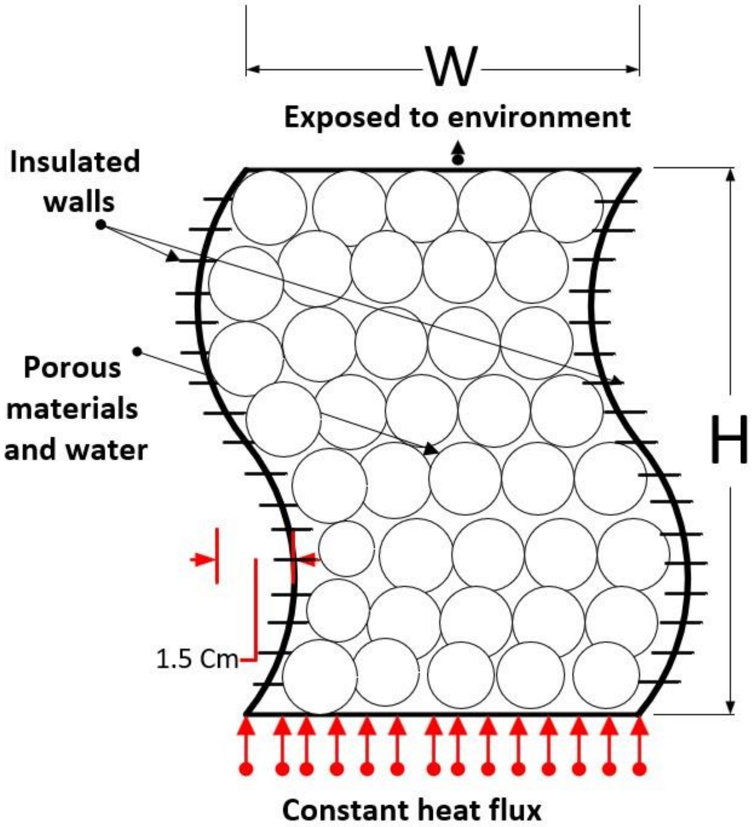


Figure 1 Schematic diagram of the problem.

2.2. Governing equations

The equations of mass, momentum, and energy that govern convection events within the porous medium under the previously stated, preceding assumptions are built as regards, Salman (2022) et.al [14]:

Continuity equation:

The pure fluid conjugation equation is produced by removing the phrase "porosity coefficient" from the continuity equation for a porous medium and a three-dimensional state. The porosity of the medium is represented by the coefficient in the following equation, whose value varies from zero to one

$$\varepsilon \frac{\partial \rho_f}{\partial t} + \nabla\left(\rho_f v\right) = 0 \quad (1)$$

Momentum equation:

The momentum equation, often known as the Darcy law in its simplest form, is obtained through empirical and numerical measurements in the porous media. According to Henry Darcy, who made this claim in 1856, the average fluid velocity in a porous media with a pressure gradient is proportional to the experimental gradient. Additionally, Forchheimer and Dupit produced a more comprehensive equation by simulating the Navier-Stokes equation, which is as follows, Salman (2022) et.al [14]:

$$\rho_f \left[\varepsilon^{-1} \frac{\partial \boldsymbol{v}}{\partial t} + \varepsilon^{-2} (\boldsymbol{v}.\nabla)\boldsymbol{v}\right] = -\nabla P - \frac{\mu}{K} \quad (2)$$

Energy Equation:

In a porous media, the energy equation is often stated on any phase. In the equations, this condition is referred to as local thermal equilibrium; Salman (2022) et.al [14]:

$$\left(\rho C_p\right)_{eff} \frac{\partial T}{\partial t} + \left(\rho C_p\right)_f . v.\nabla T = \nabla.\left(k_{eff} \nabla T_{eff}\right) + \varepsilon \bar{\bar{q}}_{eff} \quad (3)$$

The inclusion of conduction flow, transient term, and a solid energy source in the pure fluid energy equation change the energy of the porous medium such that, Saied (2004) et.al [15]:

$$k_{eff} = \varepsilon k_f + (1-\varepsilon)k_s \quad (4)$$

$$\bar{\bar{q}}_{eff} = \varepsilon \bar{\bar{q}}_f + (1-\varepsilon)\bar{\bar{q}}_s \quad (5)$$

$$(\rho c)_{eff} = \varepsilon(\rho c)_f + (1-\varepsilon)(\rho c)_s \quad (6)$$

$$\alpha_{eff} = \frac{k_{eff}}{(\rho c_p)_f} \quad (7)$$

Here, the fluid phase is selected to be water. The particle diameter from Equation (8) is used to determine the porosity setting, Saied (2004) et.al [15], given by:

$$\varepsilon = 0.3454 + 11.6985(D_p) \quad (8)$$

The magnitude of the permeability parameter in the porosity setting is calculated using Equation (9)[16], given by:

$$K = \frac{D_p^2\ \varepsilon^3}{150\ (1-\varepsilon)^2} \quad (9)$$

Table 1. Water and glass thermo-physical properties at T = 25 °C[17]:

matter	porosity	Permeability (m^2)	Density Kg/m^3	Thermal conductivity (W/m. k)	C_p (J/kg. k)
Water	----------	-------------	997	0.6069	4181.7
Glass	0.36	7.593e^{-10}	2500	1.4	750

2.3. The boundary conditions

The following boundary requirements are described in" **Figure** (2)", which is a detailed representation of the boundary conditions for the case, to simulate a flow in porous media.

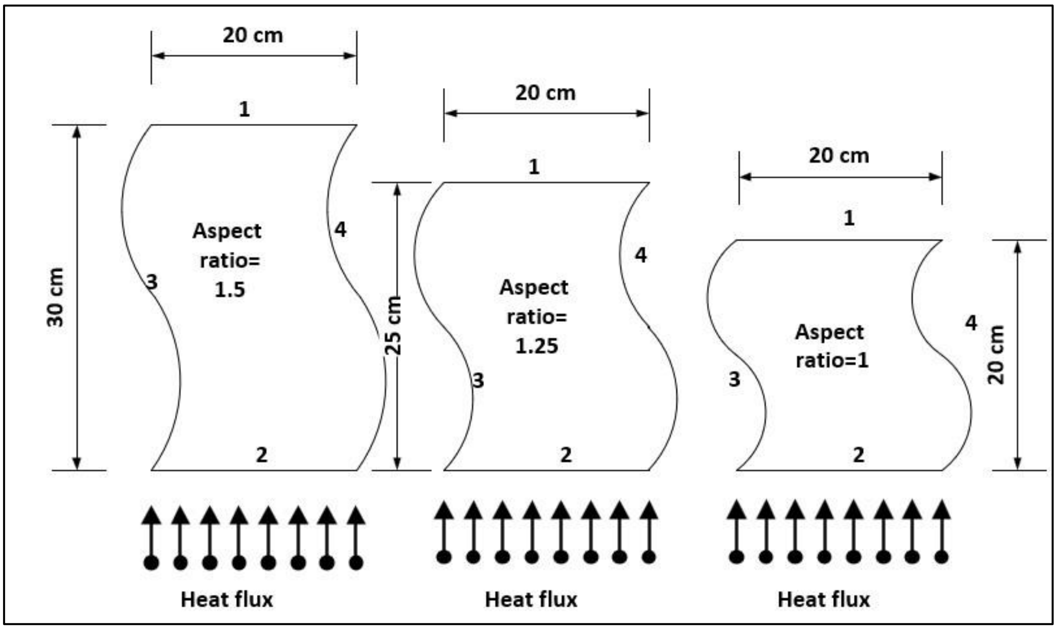


Figure 2 Boundary conditions applied to the model.

Whare: -

1. Exposed to ambient.
2. Subjected to constant heat flux.
3. Insulated wall.
4. Insulated wall.

2.4. Number of Iterations and Convergence

The maximum number needed for the solver to stop is indicated by the iterations number. 15000 were used in this project, as depicted in" **Figure** (3)". Initial completion required 5000 iterations, and if this number is below the appropriate values, more iterations will be given. When the solution satisfies the chosen convergence criteria, the iterations will end. Through the iterative solutions, the scaled residual for the energy, velocities, and continuity equations was observed. "Table 2' provides a list of the convergence values used in this investigation.

Table 2. Convergence values.

No	Residual	Convergence value
1	Continuity	10^{-4}
2	Energy	10^{-6}
3	Momentum	10^{-6}
4	Velocities	10^{-5}
5	Permeability K	10^{-5}
6	Porosity ε	10^{-4}

The solver control is configured by selecting the number of iterations, the convergence criteria are setup as RMS for residual type, and the values (1e-4) for the residual target are suitable to comprehend the flow field, as shown in" **Figure** (3)".

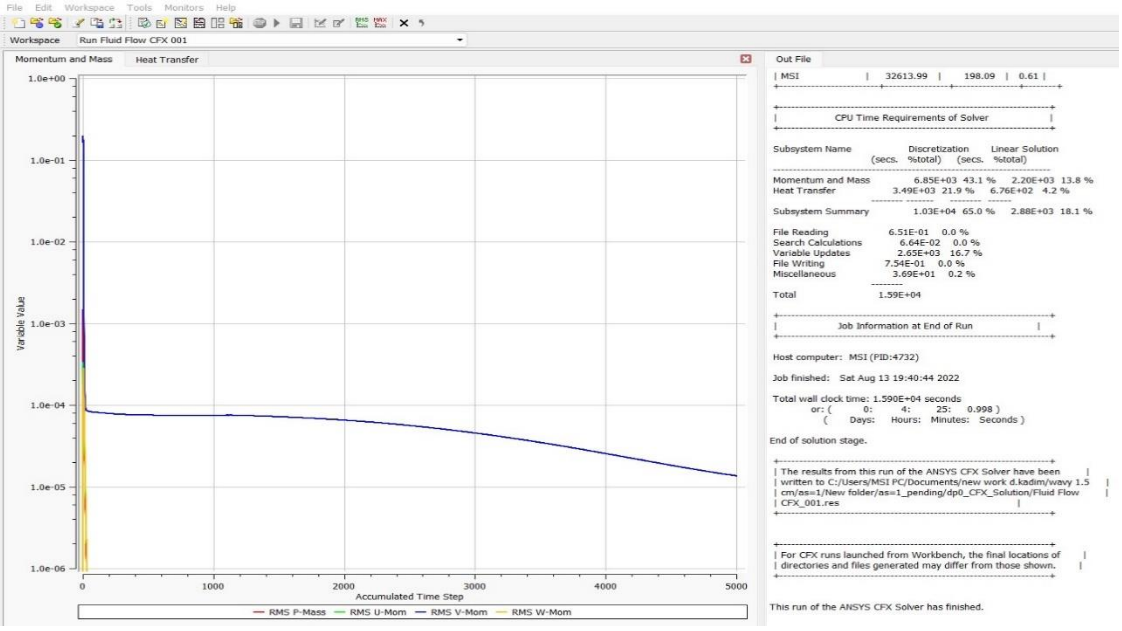


Figure 3 Residual toward achieving convergence.

3. NUMERICAL METHOD, VALIDATION AND GRID CHECK

A numerical study of the flow field and temperature distribution in three dimensions is performed utilising a ANSYS 2020 R2 program under CFX-solver manager. This program is one of the most widely used in the world for analysing flow and heat in a variety of complex configurations. The governing equations are solved based on the model's finite volume to evaluate the numerical results of a computational fluid dynamics model. The mass, momentum, and energy equations are among the governing equations, which are determined using various models. To validate the numerical analytic approach utilized in this research are acceptable, the outcomes are contrasted to a published experimental research study by M. Sadeq (2020) et.al [18] that studied the same problem. As demonstrated in." **Figure** (4)", equivalent results are obtained, thus providing validation for the numerical aspect of the present investigation. The dimensions of the cavity I use in me are 20 cm x 20 cm x 2.7 cm and the cavity amplitude is 3 cm. Heat flux from bottom (589, 800, 1111, 1555.5, 2074 w/m^2), top exposed to ambient (h=10 W/m^2, T=300 K) and other walls are insulated. The porous media is used glass (1 mm) with constant porosity (0.36) and permeability ($7.593 \times 10^{10}\ m^2$).

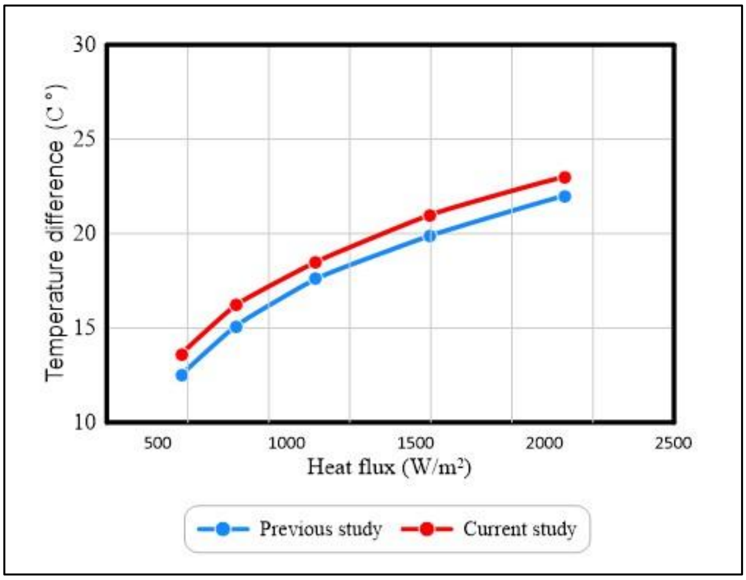


Figure 4 validation with the previous study.

“Table 3’ shows the grid dependency by changing the mesh size (4cm, 2 cm, 1 cm, 0.5 cm, 0.125 cm) to calculate the temperature difference.

Table 3. Grid dependency.

NO	Size(cm)	Element	Nodes	Temperature Difference(k)
1	4	434	919	20.6
2	2	1821	3330	18.2
3	1	9978	16491	20
4	0.5	65370	99657	20.1
5	0.125	420347	609482	20.1

Owing to the working circumstances and measuring devices used throughout the experimental investigation, the comparison revealed an accurate value and excellent agreement between them, with a little discrepancy due to the work environment and measuring devices used during an experimental test, such as the air temperature was not set to 300 degrees Kelvin, and the power was interrupted during the process. At the heat flux (250 W/m²), the temperature difference was calculated and compared with the calculated value from the practical work to determine the error rate as shown in “Table 4’.

Table 4. Comparison between previous experimental studies and the numerical result depends on the temperature difference.

Porous material	Wavy cavity with amplitude (3cm)	
	Experimental	Numerical
Glass 1mm	12.9	14

The mesh is created in volume within the model's geometry. It is used for the discrete time solution of the energy and the three-dimensional governing equation. The mesh stage's goal is to break down the geometric domain into little shapes. The mesh is built up of node points, which are derived from cell volumes and are sometimes referred to as elements. A tetrahedral mesh is utilized for a three-dimensional mesh because it is preferred in complicated geometry. The (tetrahedral) method has been used with a 0.5 cm element size, resulting in (65370) elements and (99657) nodes for the wavy shape container when As=1; “Table 5’ shows mesh information, and” **Figure** (5)”. goes to show the grid used throughout the simulation model.

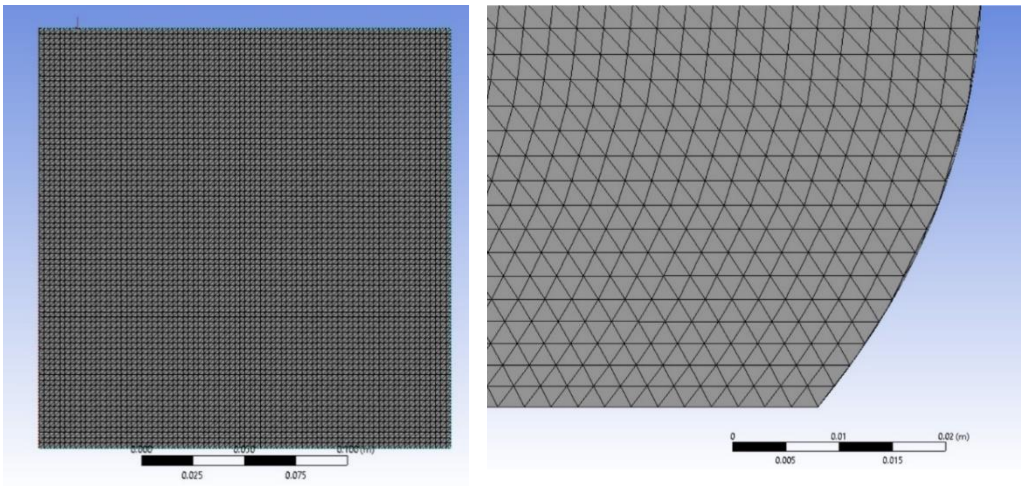


Figure 5 Tetrahedral grid for the two forms with focused zoon.

Table 5. Mesh details.

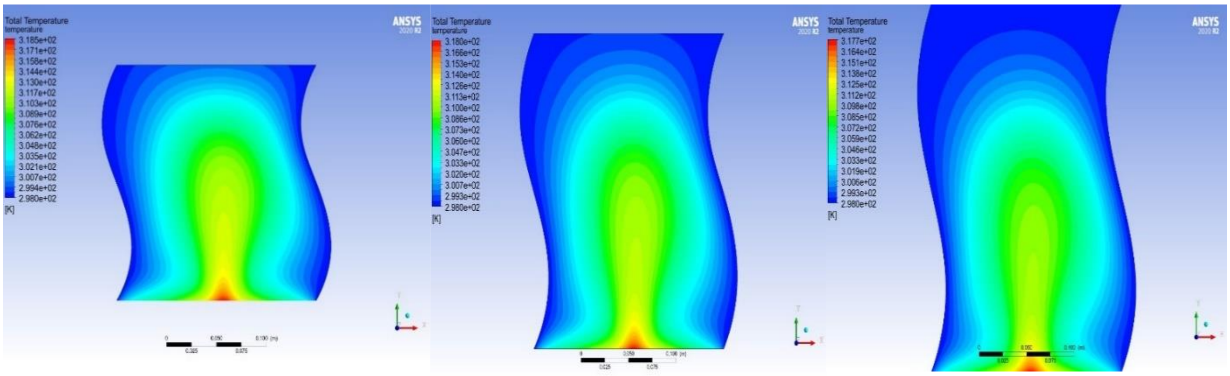
Zone	Type mesh	Transition ratio	Aspect ratio	Volume quality	Growth rate	Max. cell size (mm)
Similar wall cavity (As=1)	tetrahedral	0.77	1.8	0.83	1.2	5

4. RESULT AND DISCUSSION

The natural convection of a hollow cavity filled with porous media saturated with the same fluid as the enclosure was explored. The physical properties of water and glass balls diameters (1 mm) demonstrates are "Table 1'. The 2 vertical wavy walls are symmetrical and adiabatically insulated with an amplitude of 1.5 cm, the bottom wall is heated via a constant heat flux of 300, 500, 700, 900 and 1100 W/m^2, and the top wall is exposed to the environment with h=25W/m^2 and T=298 K[19]. A cavity with three different heights, namely 20, 25 and 30 cm, and a porosity of 0.36 and permeability $7.593 \times 10^{10}\ m^2$ was studied. The modified Rayleigh number, aspect ratio, pressure, temperature, and velocity were the parameters that were investigated. This section evaluates and displays the impact of different factors on thermal and hydraulic properties.

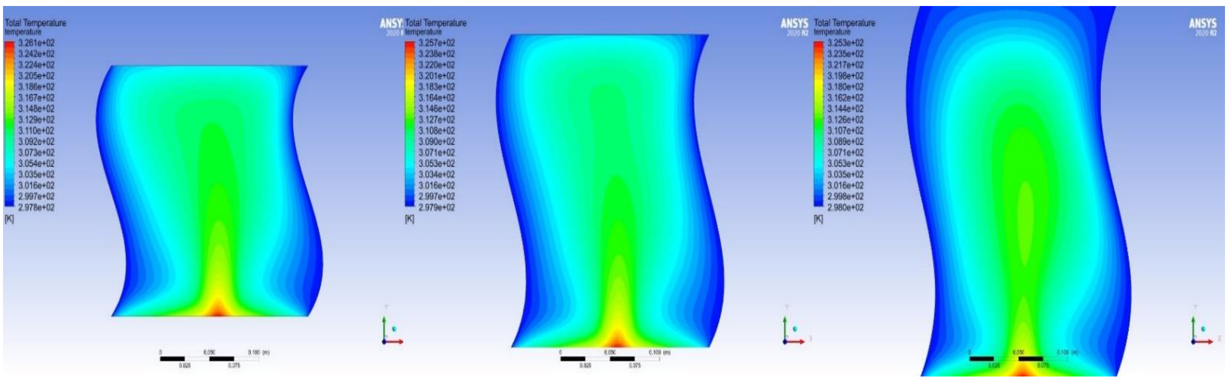
4.1. Effect of aspect ratio on the temperature difference

As the length-to-width ratio increases, the temperatures decrease because of (i) the increase in the distance that the fluid takes to reach the upper surface and (ii) the increase in thermal resistance, as shown in" **Figures** (6 to 10)".



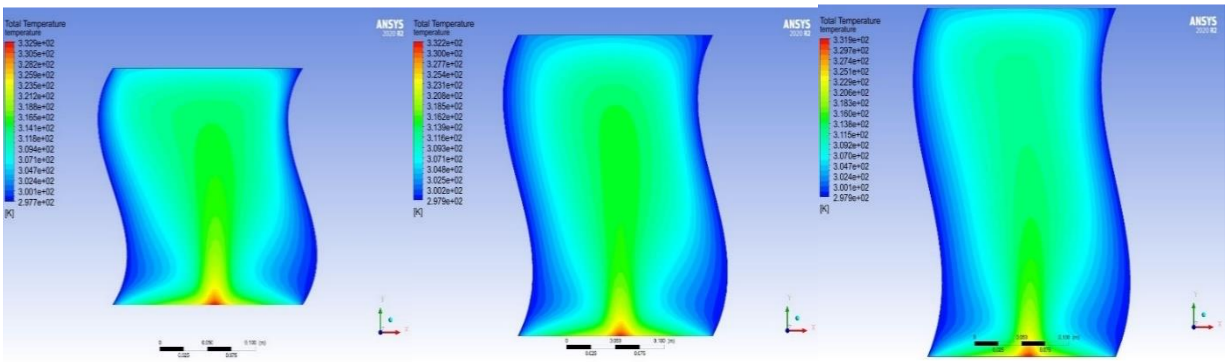
As=1 As=1.25 As=1.5

Figure 6 As and ΔT(℃)when q is 300 W/m².



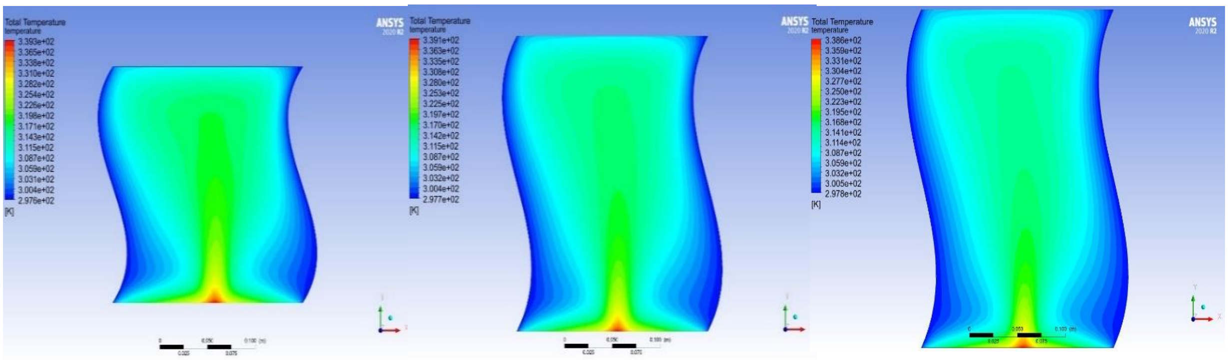
As=1 As=1.25 As=1.5

Figure 7 As and ΔT(℃)when q is 500 W/m².



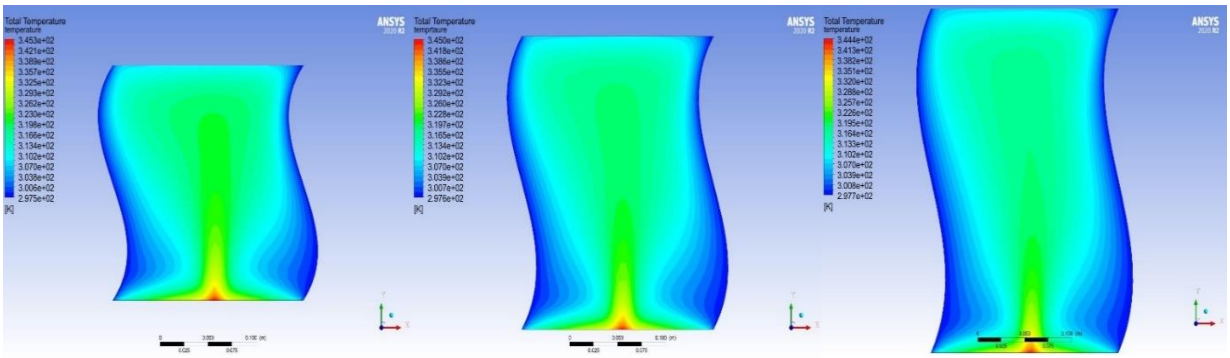
As=1 As=1.25 As=1.5

Figure 8 As and ΔT(°C)when q is 700 W/m².



As=1 As=1.25 As=1.5

Figure 9 As and ΔT(°C)when q is 900 W/m².



As=1 As=1.25 As=1.5

Figure 10 As and ΔT(°C)when q is 1100 W/m².

4.2. Effect of aspect ratio on velocity distribution

The velocity distributions are shown in" **Figures** (11 to 15)". The sharp edge depicts the core of the cells where the fluid is flowing around, while the edge around the container signifies the container's die flow region. Close-to-nil velocity was found in the hollow at the top and bottom of the container, while a turbulent flow distribution is seen in the container's centre. Small eddies are shown emerging along the diagonal to join in the centre and build a massive vortex. As the length-to-width ratio increases, the speed decreases owing to increased resistance.

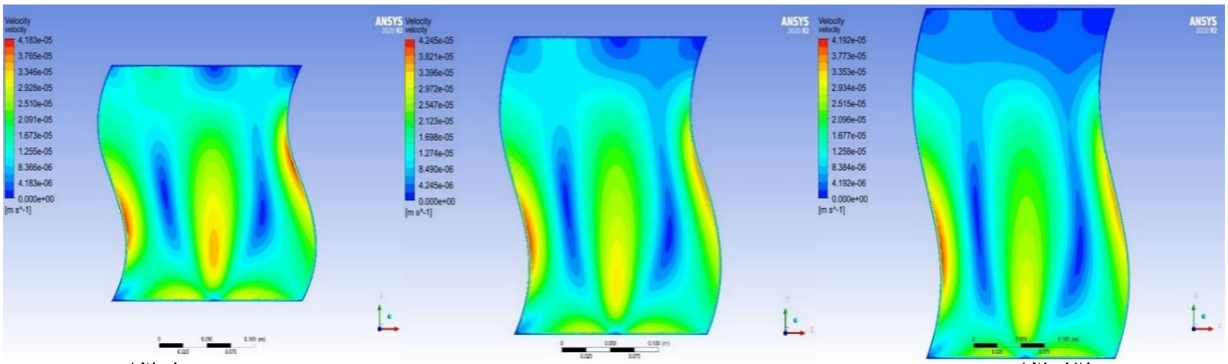


Figure 11 Velocity(m/s) with different in As when q is 300W/m².

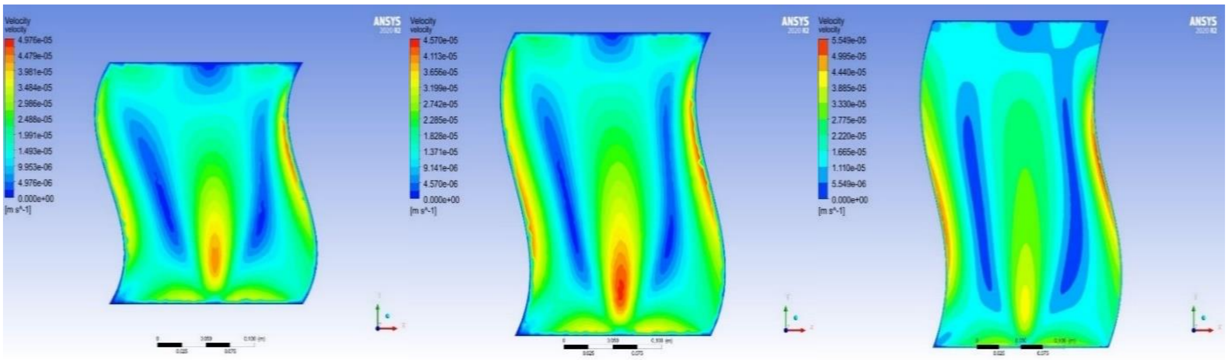
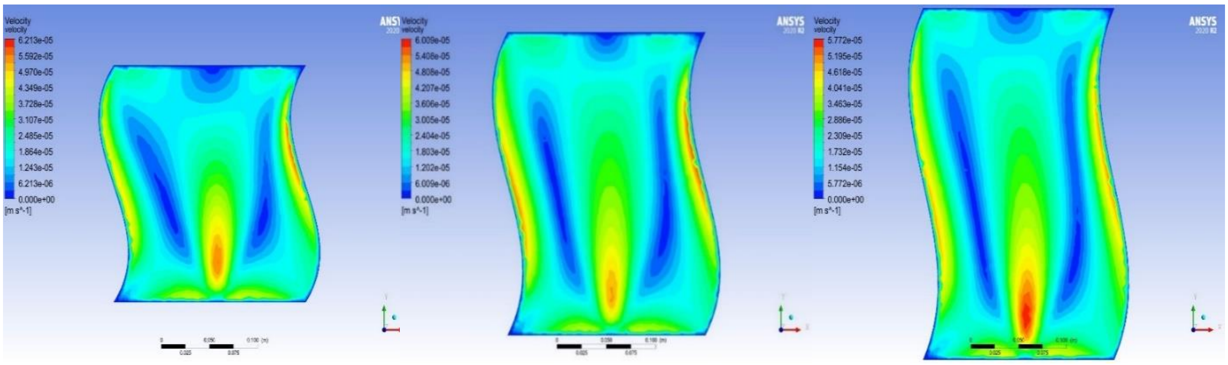
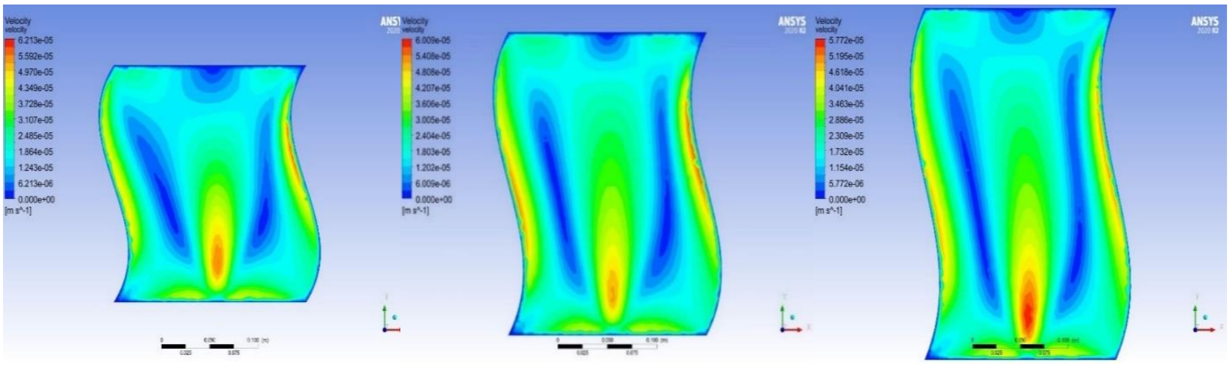


Figure 12 Velocity(m/s) with different in As when q is 500W/m².



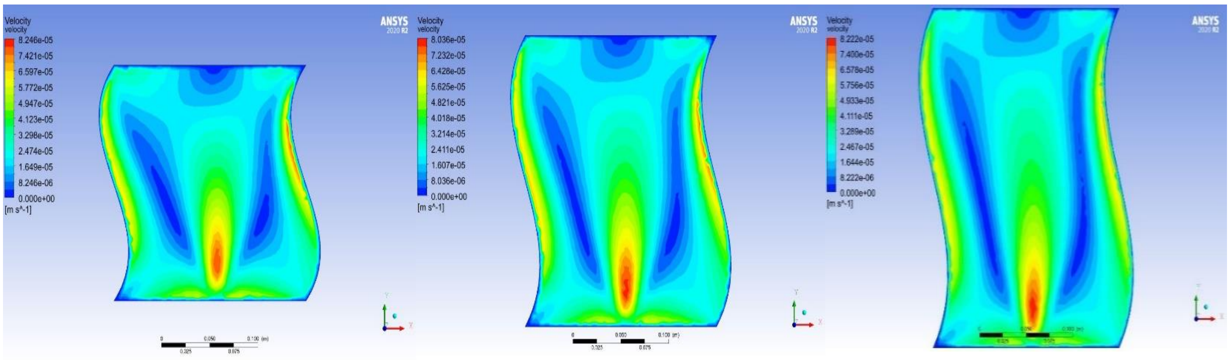
As=1 As=1.25 As=1.5

Figure 13 Velocity(m/s) with different in As when q is 700W/m².



As=1 As=1.25 As=1.5

Figure 14 Velocity(m/s) with different in As when q is 900W/m².

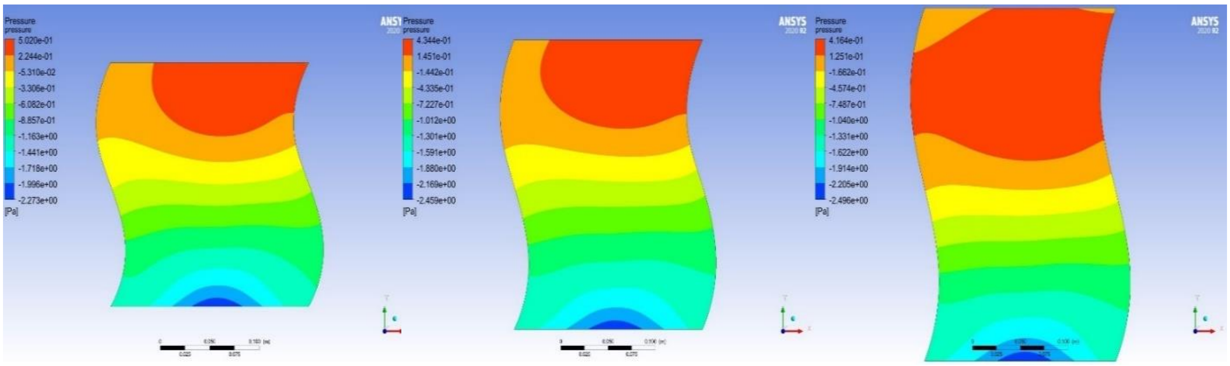


As=1 As=1.25 As=1.5

Figure 15 Velocity(m/s) with different in As when q is 1100W/m².

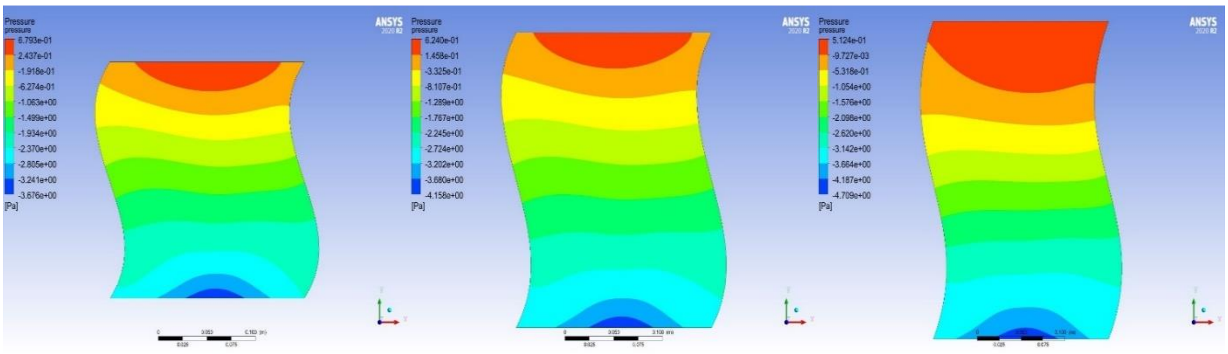
4.3. Effect of aspect ratio on pressure

From.” **Figures** (16 to 20)”, the effects of the length to width ratio on pressure can be seen. That is, when the aspect ratio is increased, the pressure decreases. This is because the size of the cavity increases with an increase in aspect ratio, resulting in both an increase in the distance traveled by the fluid and contact area and thus a decrease in pressure.



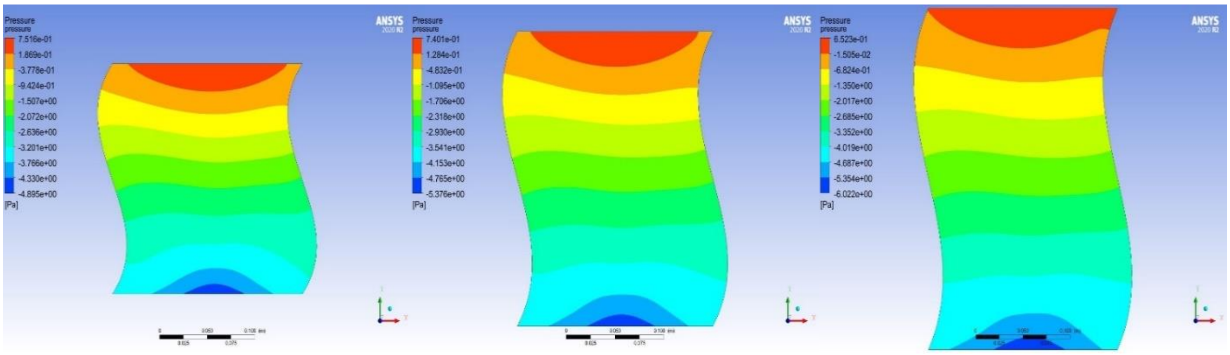
As=1 As=1.25 As=1.5

Figure 16 Pressure (pa) with different in As when q is 300W/m².



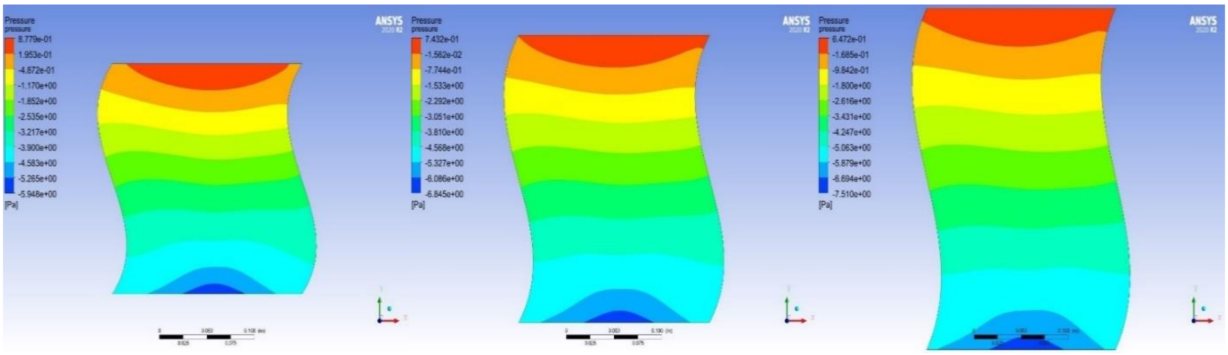
As=1 As=1.25 As=1.5

Figure 17 Pressure (pa) with different in As when q is 500W/m².



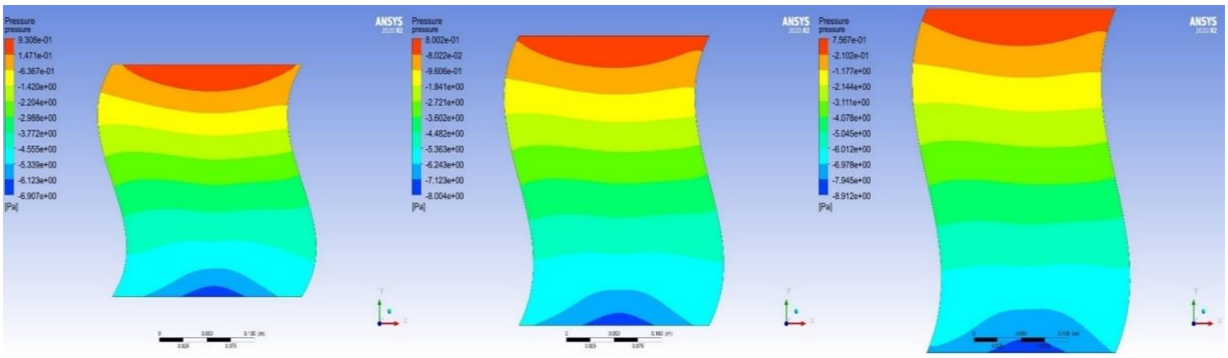
As=1 As=1.25 As=1.5

Figure 18 Pressure (pa) with different in As when q is 700W/m².



As=1 As=1.25 As=1.5

Figure 19 Pressure (pa) with different in As when q is 900W/m².



As=1 As=1.25 As=1.5

Figure 20 Pressure (pa) with different in As when q is 1100W/m².

4.4. Modified Rayleigh number as a function of heat flow

For all the models, the link between the rate of thermal flow and the rate of thermal flux imposed on an enclosure filled up with a saturated and porous material and the modified Rayleigh number was determined based on the hydraulic diameter. Rayleigh-Darcy number appears to increase as the thermal flux increases, reaching a highest value when As= 1. From." **Figure** (21)", it can be seen that the values of the Rayleigh-Darcy number decrease as the ratio of the length of the cavity to its width increases linearly.

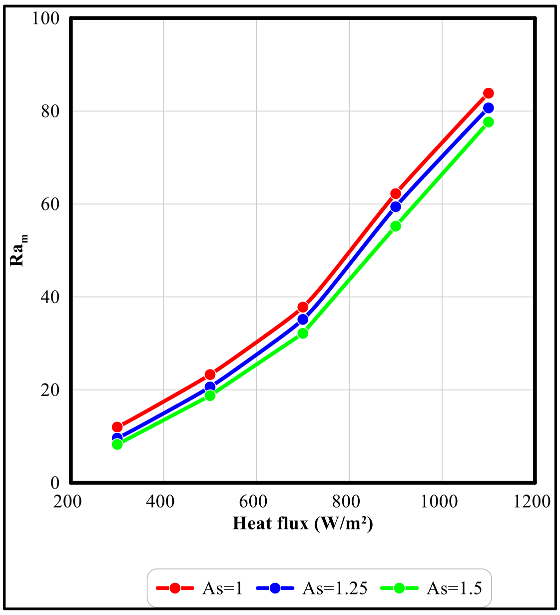


Figure 21 Effect of heat flux on Ra_m.

5. CONCLUSION

The present numerical work investigates the natural convection inside wavy cavity which has a top wall was exposed to air, bottom surface subjected to constant heat flux, front wall, back wall and side walls are assumed to be adiabatic and constant temperature. Here, the working fluid considered is water and porous media is glass with diameter 1mm. The aim of this study is to investigate the influence of aspect ratio on heat transfer phenomenon. The findings of this study may be summarized as follows:

- The temperature and modified Rayleigh number increase with increasing heat flux.
- The modified Rayleigh number dropped with an increase in aspect ratio.
- when aspect ratio increases, the pressure fell steadily.
- The velocity drops as the aspect ratio increases, where velocity when As = 1 is higher than when As = 1.5 by 13%.
- As the ratio of the container length to its width grows, the difference in temperature decreases where temperature when As = 1 is higher than when As = 1.5 by 3%, and thus the transfer of heat coefficient decreases. The best case is when As=1.

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Nomenclature		**unit**
AR	Aspect ratio = L/H	-----------
a	Amplitude	cm
Cp	Specific heat	J.Kg^{-1}.K^{-1}
D	finite wall thickness	-----------
D_p	Porous material diameter	mm
H	Characteristic length	cm
h	Coefficient of heat transfer	Wm^{-2}
K	Permeability	m^2
K_{eff}	Effective thermal conductivity	W$m^{-1}K^{-1}$
K_r	Ratio of thermal Conductivity	-------
L	Enclosure height	cm
p	Pressure	Pa
N	Number of waves per height	---------
q	Heat flux	Wm^{-2}
T	Temperature	K
T_m	Density stratification parameter	-------------
W	Enclosure width	cm
3D	Three dimensional	---------
Greek symbols		
β	Bulk coefficient	K^{-1}
ρ	Density	Kg m^{-3}
ε	Porosity	------
ϑ	Kinematic viscosity	m^2s^{-1}
α	Thermal diffusivity coefficient	m^2s^{-1}
Non-dimensional Numbers		
Da	Darcy numbers	--------
Gr	Grashof number	--------
Nu	Nusselt number	--------
Nu_x	Local Nusselt number	--------
Pr	Prandtl number	--------
Ra	Rayleigh number	--------
Ra_m	Modified Rayleigh number	--------
Re	Reynold number	--------
subscripts		
f	Fluid	
s	Solid	
eff	Effective	