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Heat Transfer Enhancement Studies using Nano Fluids in a Wavy Plate Heat Exchanger

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Abstract: ***The Nano fluids have higher values of thermal conductivity than those of the pure liquids and greater potential for heat transfer enhancement. The main aim of the present investigation is to study the heat transfer behaviour of Nano fluids in a heat exchanger with wavy plate. In current studies inlet and wall pressure values, and average Nusselt number values are calculated numerically. And T hermo-physical properties of the Nano fluids (thermal conductivity, density, all the investigations of Nano-fluids are to be carried out in the volume concentrations rangingfrom0%–2.0%and at different Reynolds numbers.***
In this thesis analysis and comparison carried on 2 models, by using cad tool (creo-2.0) models were designed then after imported in to CAE tool (Ansys workbench) to calculate the results for each model with different Reynolds numbers at different percentage of particles.
Keywords: Nusselt number; CFD; Nano fluids; Reynolds number, Heat transfer rate.

I. INTRODUCTION

A Nano fluid is a fluid containing nanometer-sized particles, called Nano particles. These fluids are engineered colloidal suspensions of nano particles in a base fluid. The nano particles used in Nano fluids are typically made of metals, oxides, carbides, or carbon Nano tubes.

Common base fluids include water, water copper and Nano fluids have novel properties that make them potentially useful in many applications in heat transfer, including microelectronics, fuel cells, pharmaceutical processes, and hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger, in grinding, machining and in boiler flue gas temperature reduction. They exhibit enhanced thermal conductivity and the convective heat transfer coefficient compared to the base fluid. Knowledge of the rheological behavior of Nano-fluids is found to be critical in deciding their suitability for convective heat transfer

The spreading of a nano-fluid droplet is enhanced by the solid-like ordering structure of nano particles assembled near the contact line by diffusion, which gives rise to a structural disjoining pressure in the vicinity of the contact line. However, such enhancement is not observed for small droplets with diameter of nanometer scale, because the wetting time scale is much smaller than the diffusion time scale.

In this work, a two-phase mixture approach is utilized to examine the influence of nano additive shape on the fluid flow and heat transfer aspects of γ- AlOOH nano-fluid flowing through a twisted oval tube. The γ-AlOOH (boehmite alumina) nano additives of various shapes (i.e. cylindrical, brick, blade, and platelet) are dispersed in water as the base fluid. The influence of the Reynolds number and nano additive volume fraction on the nusselt number, pressure drop is numerically studied for different nano additive shapes.

It is revealed that, among the considered nano additive shapes, the platelet shape represents the highest heat transfer performance, while the worst performance belongs to the brick shape nano additives. In addition, the findings reveal that for all states, enhancing the Reynolds number intensifies the nusselt number, pressure drop, and of the γ-AlOOH Nano fluid. Moreover, it is found that boosting the nano additive fraction leads to an enhancement in the nusselt number and of the examined nano-fluids. Furthermore, the pressure drop of all the considered nano-fluids enhances with augmenting the Reynolds number

II. GOVERNING EQUATIONS

A. Continuity Equation

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

B. Momentum Equation (Navier-stokes Equation):

1) X-momentum Equation

$$\rho\left(u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}\right)=-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right)$$

2) Y momentum Equation

$$\rho\left(u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}\right)=-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right)$$

3) Z momentum Equation

$$\rho\left(u\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}+w\frac{\partial w}{\partial z}\right)=-\frac{\partial p}{\partial z}+\mu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right)$$

4) Energy Equation

$$\left(u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}+w\frac{\partial T}{\partial z}\right)=\frac{1}{\alpha}\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}\right)$$

C. Geometry

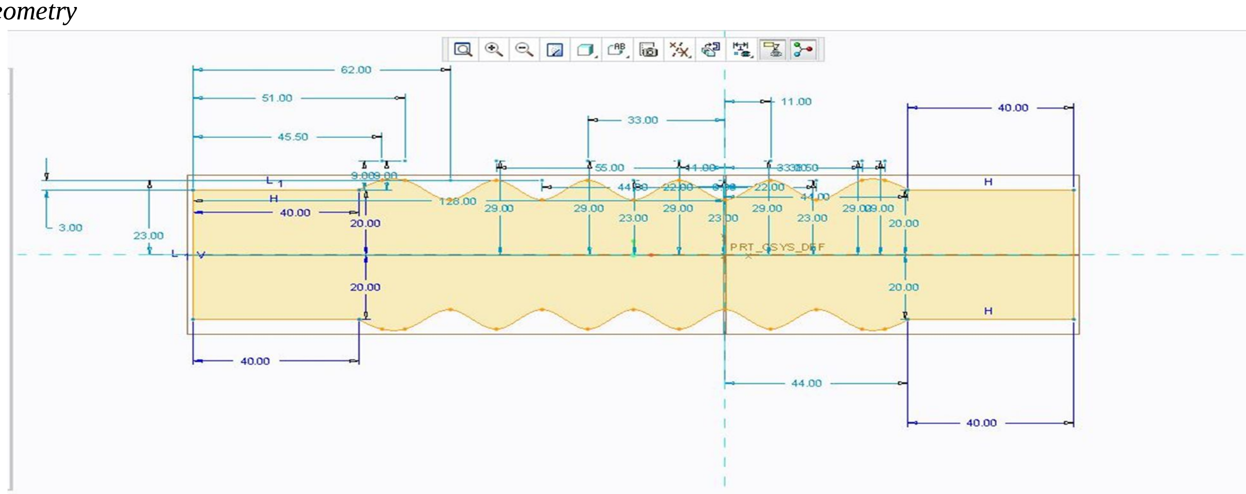
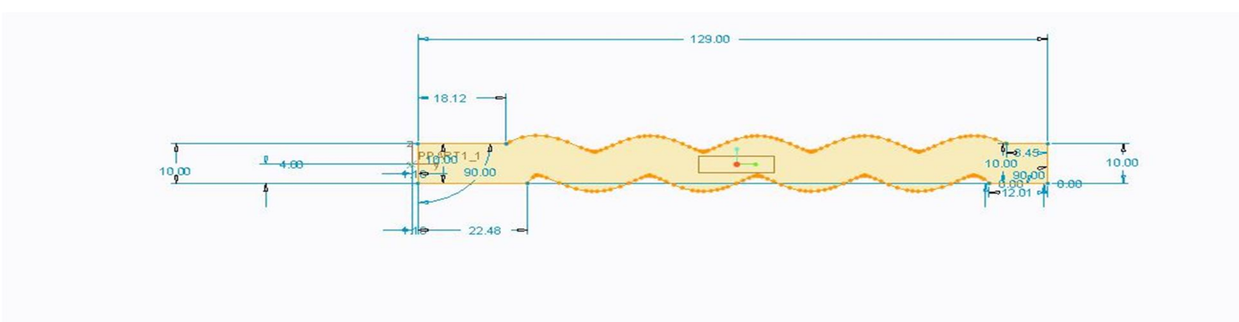


Fig.1. Geometry



In this wave channel 129 mm length of wavy taken. and 10 mm width is taken in this calucation part inlet is taken 0.00801989m.The hydraulic diameter ratio, Dh, is 0.0182 and wavy pitch is 11mm. The effects of these various-shaped on Local Heat Transfer are studied. The computational domain consists of a 129 mm long. smooth section followed by a section of 18.12mm.. The whole computational domain including both long smooth section and wavy section is taken .meshed with more cells near the walls top and near the bottom wall. This fine mesh size will be able to provide good for the distribution of most variables within the duct.

D. Meshing

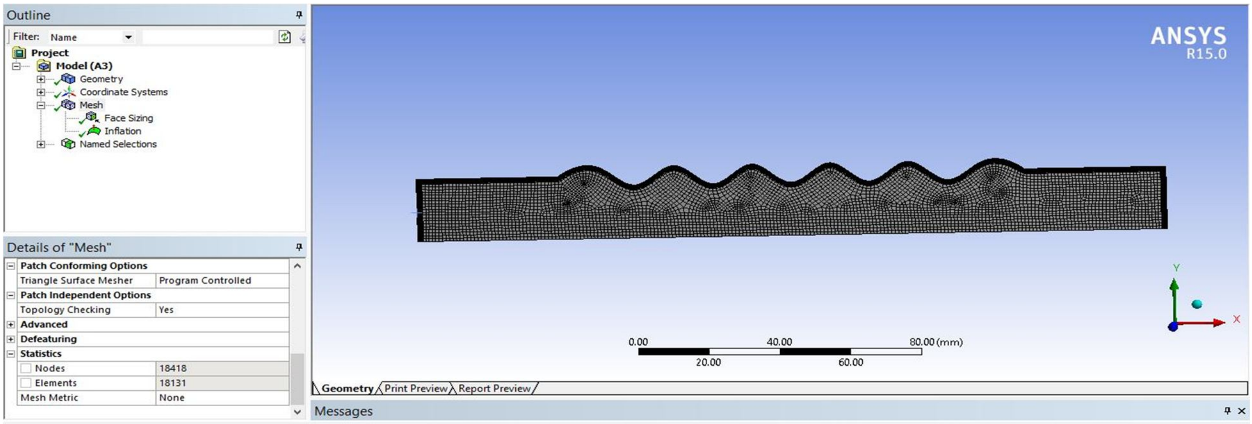
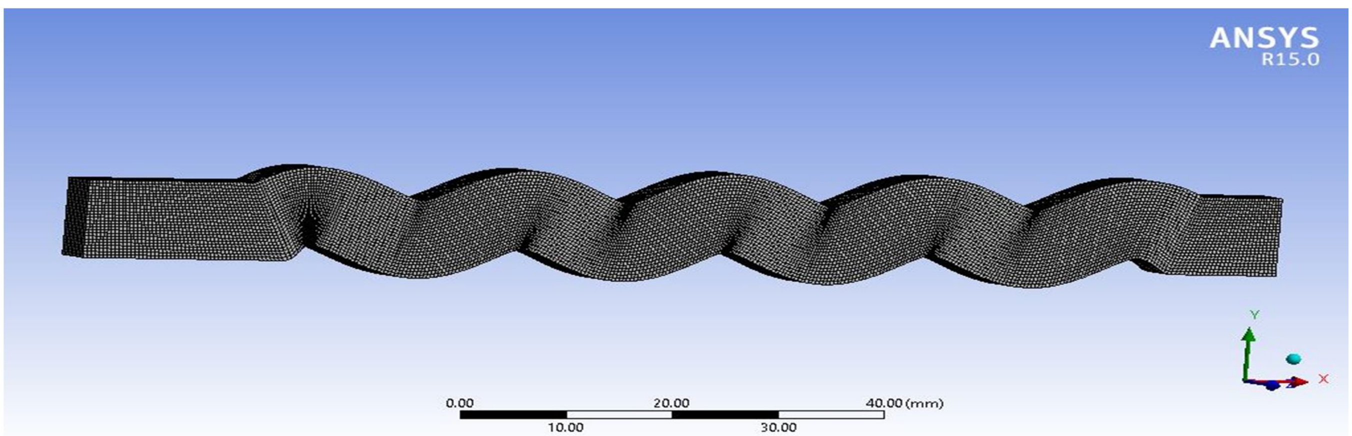
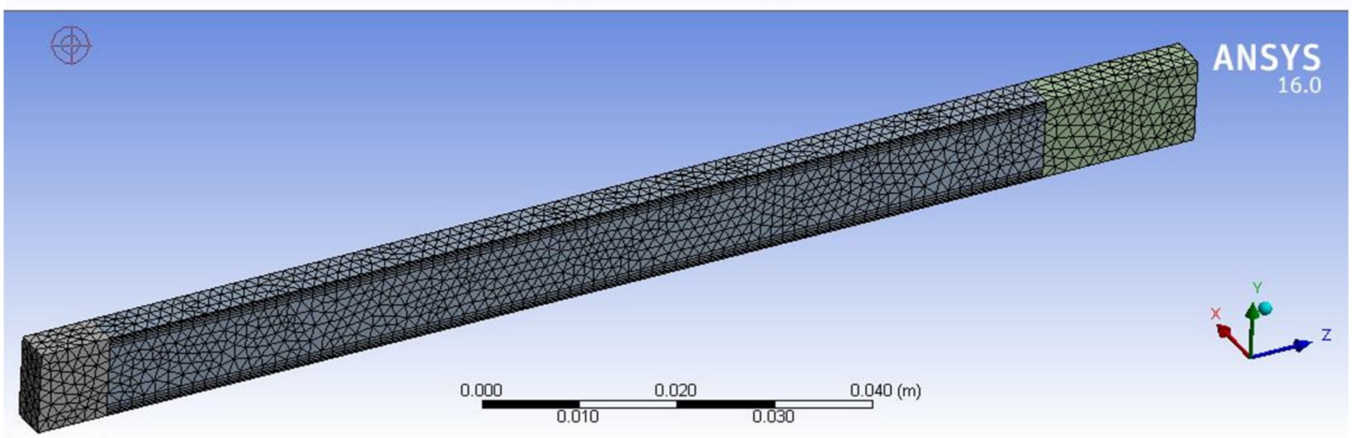


Fig.2. Mesh





The geometry is meshed by keeping the relevance to 100 and by selecting a size function to Proximity and curvature. In sizing relevance centre is kept as fine. Moreover in sizing Max face size is kept to1.0 mm and Max face size and Max text size is kept to 500.0 mm.

E. Boundary Conditions

The working fluid in all cases is different percentages of water- copper is used those are 0% copper, 0.5% copper ,1% copper , 1.5%copper, 2% copper is used. The inlet temperature of fluids is considered to be 293 K. The Different Reynolds number is 100, 400, 700. at the inlet. the velocity is given as inlet. The top and bottom wall given temperature is 303k and left and right walls are adiabatic .

III. RESULTS AND DISCUSSION

3 d wavy contours water-copper

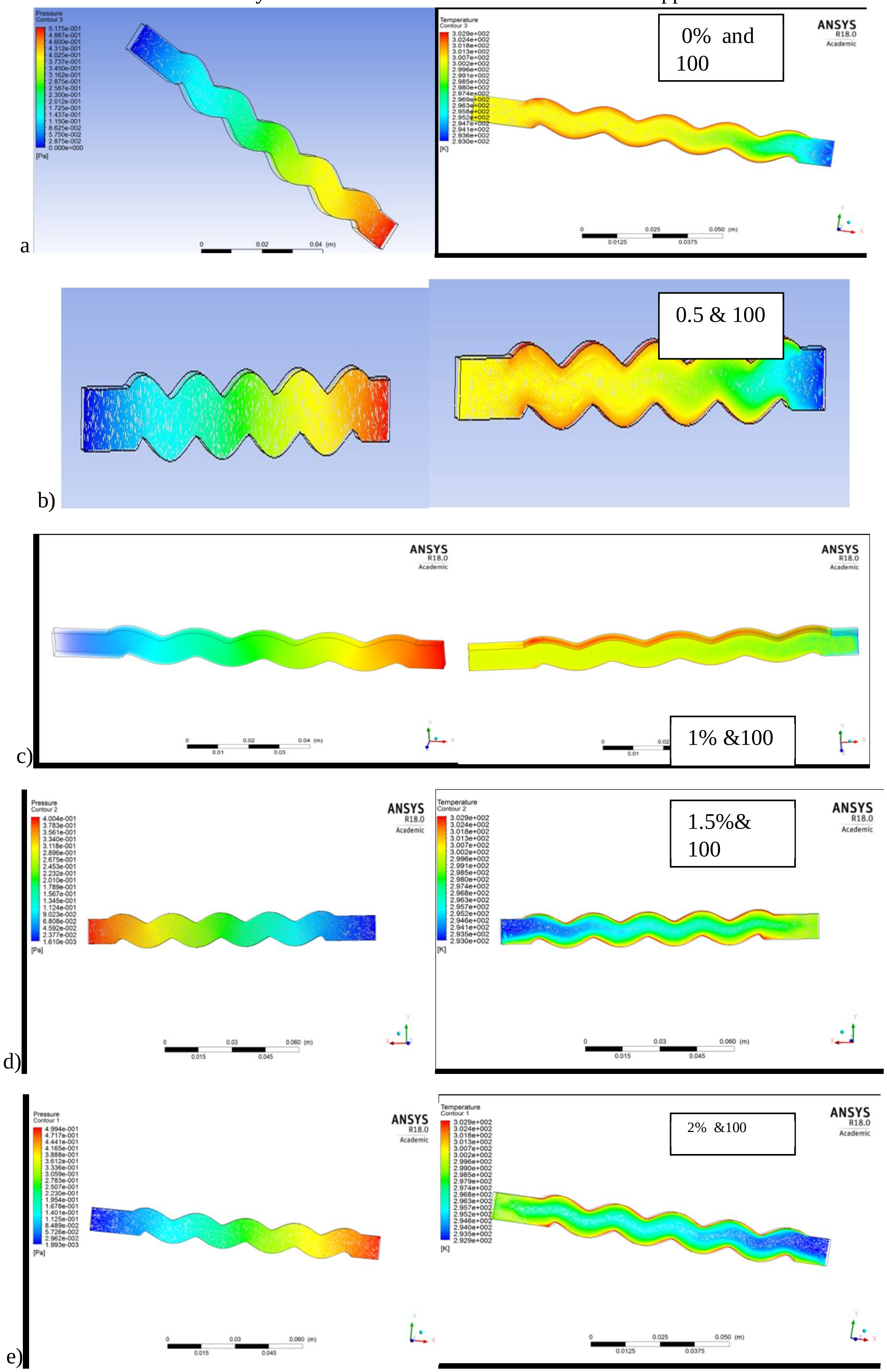


Fig.3.contures of pressure and temperature (a) 0 % 100 (b)0.5 % 100 (c) 1% 100 (d) 1.5 % 100 (e) 2%100

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A. Rectangular Duct Of Contours

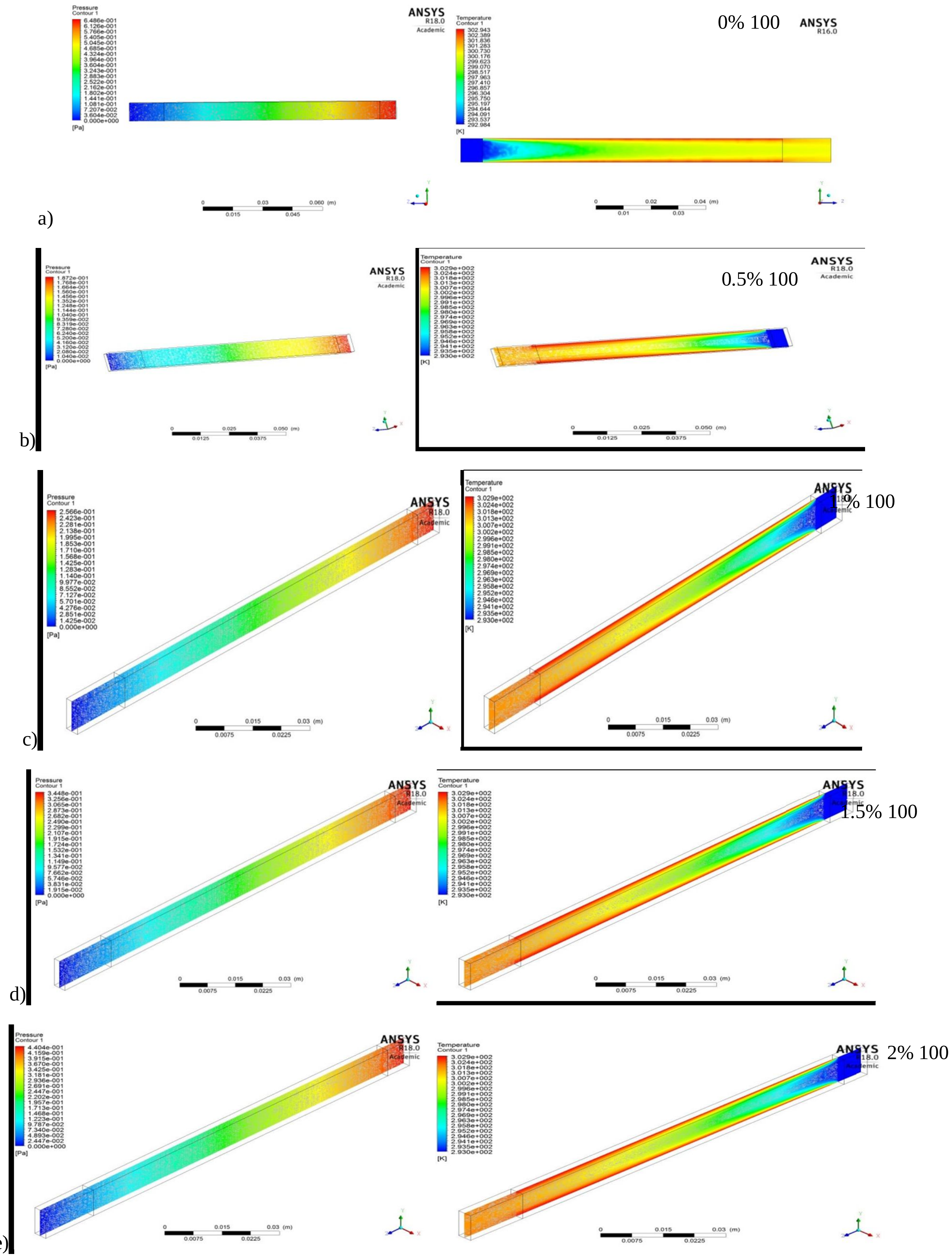

Figure 4. pressure and temperature contours (a) 0 % 100 (b) 0.5% 100 (c) 1% 100 (d) 1.5 % 100 (e) 2% 100

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B. 2 D Wavy Velocity Counters

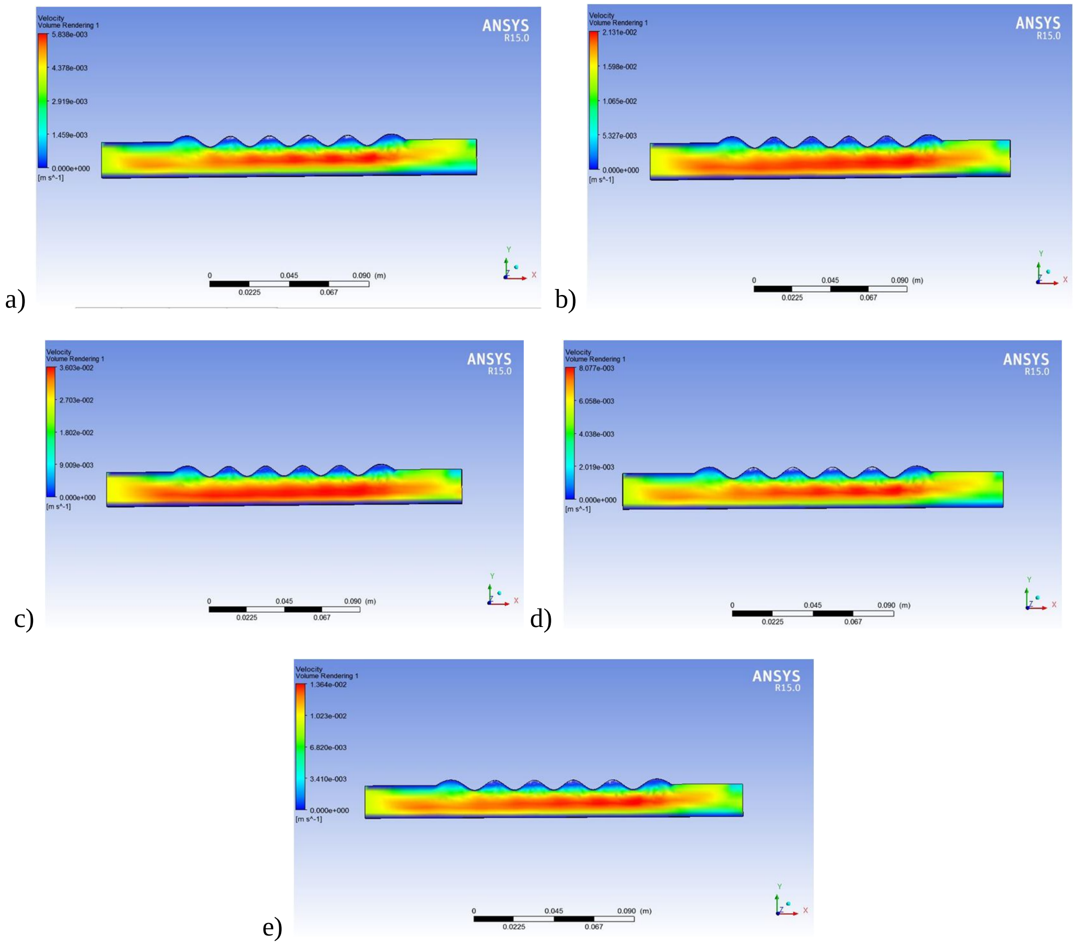
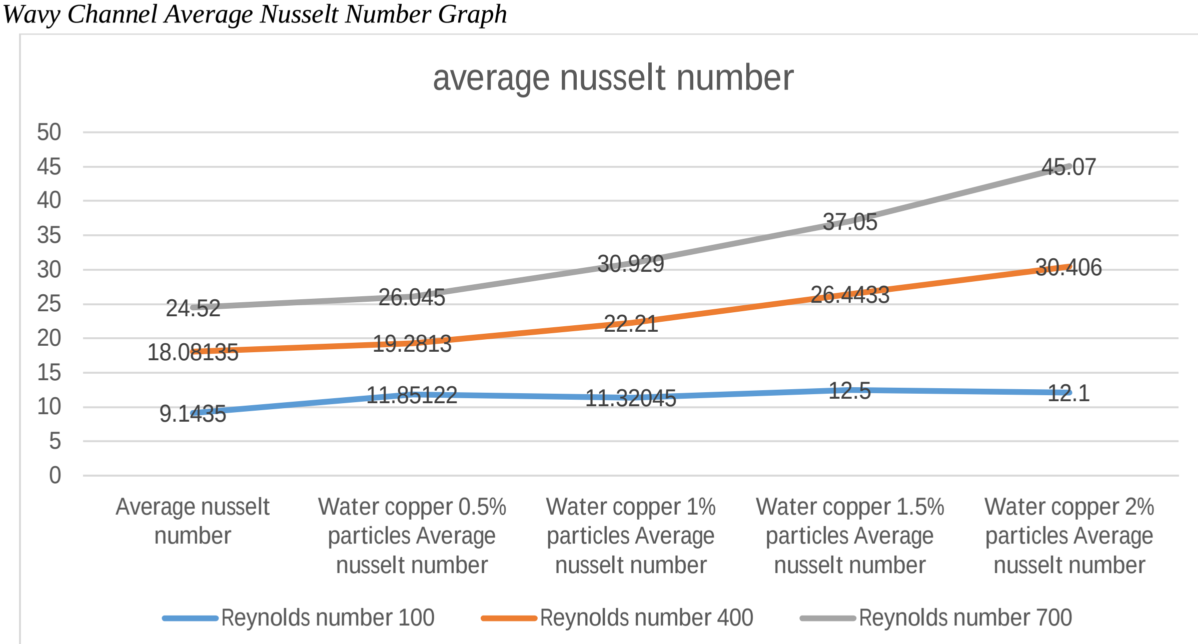


Fig.5. Velocity contours of (a) 0% 100 (b) 0.5 % 100 (c) 1% 100 (d) 1.5% 100 (e) 2% 100

C. 2 D Wavy Channel Average Nusselt Number Graph



Average Nusselt number by Numerical vs. Reynolds number.

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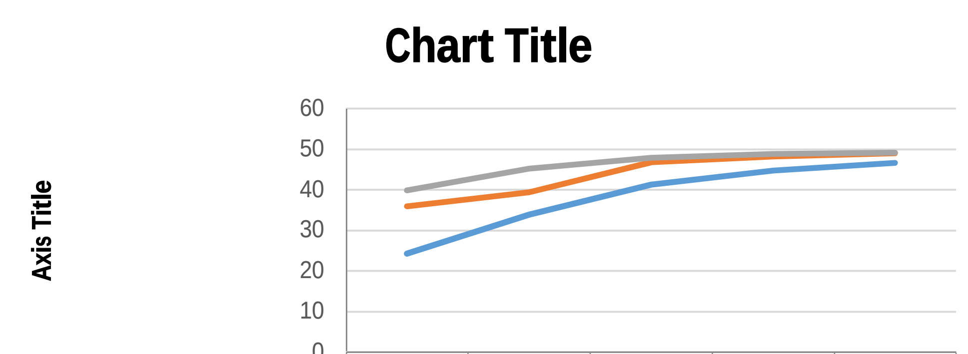
The average Nusselt number of 2d wave , 3d wave, Rectangular duct of different Reynolds (0%, 0.5%, 1%, 1.5%, 2%) here calculated nusslent number for different Reynolds number in this thesis we are calculated nusslent number for 2 d wave and 3d wave and rectangular duct also. In this second order taken and wise variation of augmentation Nusselt number indicates the two-dimensionality in the flow field. The heat transfer coefficient distribution seems to be axisymmetric, and no conclusive outcome can be inferred about the effect of change in percentage of Reynolds number on the average Nusselt number, once inlet flow conditions were laminar.

In the present work rectangular duct and 2d wave and 3d wavy channel with different percentage Reynolds number and the effects wavy channel on heat transfer and fluid flow characteristics have been investigated for all the cases at the different Reynolds number 100, 400,700. The effect of wavy channel configurations on local heat transfer characteristics has been assessed by examining the enhancement in surface heat transfer and with respect to that in smooth surface (i.e., average Nusselt number,).

D. 3 D wavy Channel Average Nusselt Number



	Average nusselt number	0.5% particles Average nusselt number	1% particles Average nusselt number	1.5% particles Average nusselt number	2% particles Average nusselt number
Reynolds number 100	24.2854	33.927	41.28	44.83	46.732
Reynolds number 400	35.99	39.36	46.752	48.26	48.999
Reynolds number 700	39.86	45.24	47.899	48.91	49.2357

Average Nusselt number by Numerical vs. Reynolds number..

First, the effectiveness of wavy channel configurations on mixing/heat transfer enhancement has been studied by investigating the surface- and span wise-averaged heat transfer distribution and the overall heat transfer rate the presence of wavy. In this investigation, an attempt has been made to analyze the basic heat transfer parameters and the laminar together in the immediate vicinity as well as in far downstream region of the wavy , under a variety of flow and geometrical conditions. Furthermore, the role of laminar flow structure on the detailed surface .

In this thesis 3d wavy channel average nusselt number is increasing as comparing to 2d wavy channel

IV. CONCLUSION

In this thesis heat exchanger with 2d geometry , wavy channel 3d models and rectangular duct were designed and analysis results of different Reynolds number with different percentage mixture of particles from 0% to 2%. Here Reynolds numbers were consider as 100,400,700.

Here cad tool creo 2.0 were used to design objects and cae tool Ansys workbench were used to analyze the models. Here average nusselt number, inlet pressure values were calculated and compared with required tables and graphs.

From the results heat transfer rate was increased while increasing the Reynolds number for Rectangular duct & 3d wavy channel. And 3d wavy channel has got higher average nusselt number than 2d geometry in each case.

Finally thesis can be conclude by adding Nano fluid with different percentages of particles can increases the heat transfer rate of the objects.

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