A Review on Simulation of Heat Transfer Enhancement in Corrugated Channel By Numerical Investigation

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Abstract -In the current work, a numerical exploration is made on the flow characteristics and improvement of heat transfer in 2D channel with wavy wall covering a broad range of Reynolds numbers. For enhanced understanding, the numerical analysis is carried out by considering three different wall-geometry (triangular, sinusoidal, and trapezoidal corrugated wall). The outcomes are examined by drawing graph of the wall-Nusselt number along the channel length by varying the operating parameters like Reynolds number, amplitude of geometry, heat flux. The flow characteristics (such as pressure, temperature, velocity) deviation down the channel are also being examined to encapsulate the hydrodynamics. The two modes of boundary conditions employed are constant heat flux and constant wall temperature at the channel-wall, at the inlet velocity is completely stated, and atmospheric pressure is specified at outlet. The fluid used for the simulation is water. It is perceived that with the increase in the geometry amplitude and Reynolds number there is significant enhancement in heat transfer. It is obtained from the analysis that the heat transfer rate is maximum with triangular channel and the pressure drop is minimum with triangular channel.

Keywords-Heat transfer enhancement, corrugated wall, Wall-Nusselt number, trapezoidal, sinusoidal, triangular.

I. INTRODUCTION

Heat transfer augmentation with nominal pressure drop by any heat exchanging devices is extremely important phenomena within the thermal engineering. It has a bunch of application in Heat exchangers, method industries, Evaporators, Condenser, Thermal power plants, Air-conditioning systems etc. Overheating is the major problem associated with any power plants that triggers the failure of the system and the efficiency of the system is also reduced due to loss of heat in various forms. To overcome this problem effective cooling is required for which a heat exchanger is employed. A heat exchanger is a device that transfer heat from hot fluid to the cold fluid with maximum rate and minimum investment. Employing heat exchanger also improve the efficiency of the system for super-heater, feed hot-water heater, condenser, air pre-heater used in power plant is used to increase the efficiency of the system. The two major parameters associated with heat exchanger are heat transfer rateand the pressure drop across it (if it is high then additional power would need to pump the fluid). In a heat exchanger device heat transfer takes place mainly due to convection and from newton's law of cooling for convection heat transfer depend on surface area exposed and difference of wall temperature and fluid temperature. Since temperature difference can be varied only to certain limit, other ways to improve the heat transfer rate is by either varying heat transfer coefficient or to vary the area exposed in such a way that it has minimum pressure drop across it. A number of the ways to improve the warmth transfer rate are given below.

a) Active method: This method is based on the forced convection that is an external devices like blowers, pumps, fan etc. are used to agitate the fluid. Due to which convective heat transfer coefficient increases.

b) Passive method: This technique based on the surface treatment method without aid of any external power device. Various surface treatment like: imposing surface roughness on the wall, use of baffles or fins, changing the shape of the wall of pipe/channel (corrugated wall), etc are used.

c) Compound Method: This method is the amalgamation of the two methods discussed above.

This work is solely based upon passive method.

II. LITERATURE REVIEW

1. Hamza et al**.** has done experimental study on the results of operational parameters on stratified forced convection. He thought of V-corrugated channel with air as an operating fluid for this experiment. For this experiment associate constant heat flux condition is applied to the upper wall of the V- furrowed channel and the lower one was insulated. The assorted variable parameter taken are Reynolds number, temperature of air, painter variety the angle of tilt of the V-corrugated channel. And therefore the result of those parameters on the Nusselt numbers were evaluated by varying these parameters in respective ranges.

2. Islamoglu et al. performed experiment to judge the friction factor and convective heat transfer coefficients of furrowed channel in a plate heat exchanger during which operating fluid used are air. He performed the experiment

for 2 totally different heights of furrowed channel and single tilt angle of V- furrowed channel for different value of Reynolds number. The results displays that there's a vast increment in each the Nusselt variety and the pressure drop with the heights of the wave.

3. Paisarndid experiment to review the heat transfer characteristics and pressure drop of the streamline flow through the triangular formed furrowed channel. He performed the experiment for various angle of 20°, 40°, and 60° whereas the peak being constant at 12.5 mm. He maintains a continuing heat flux through the channel and varied the Reynolds numbers within the range of 500 to 1400. And created associate observation that for higher worth of Reynolds numbers and the tilt angle, the rate of heat transfer is higher on the expense of pressure drop.

4. Pethkool et al. performed associate experiment on helical furrowed tube and examined the convective heat transfer with flow. He collected the result for various pitch to diameter ratio and Reynolds numbers and observed a rise within the convective heat transfer of 1.23 to 2.32 times than that of sleek pipe, reckoning on the rib height of the helical tube. Friction factor conjointly will increase within the range of 1.46 to 1.93 times of the sleek tube.

5. Yin et al.investigated numerically the flow and also the convective heat transfer characteristics of curving furrowed channel by varying the phase angle between the higher and lower furrowed wall. He meted out the simulation for constant wall temperature condition at the wall and periodic condition at recess of the channel for different Reynolds numbers. The results shows that by increasing the phase angle, The shear stress, friction factor and the average Nusselt number decreases linearly. It absolutely was concluded within the paper that higher overall performance is extracted by the channel having part shift angle of 0o and 90o. The best result was obtained by the channel having part shift angle of 0o.

6. Ozbolat, V. et al. coherently describes the heat transfer improvement and flow characteristics in two-dimensional furrowed (sinusoidal and square) channel. During this work the comparison has been created between completely different shapes of furrowed geometries with different Reynolds numbers and different wall temperatures boundary conditions. This work additionally provides completely different rate and temperature contours for various conditions. This work also compare the Nusselt number variation among the straight, curving and square furrowed channel and eventually they reported that curving furrowed channel provides higher results than different two shapes.

7. Pehlivan et al. performed experiment by taking three differing kinds triangular furrowed surfaces. Two completely different channel height was taken and angle of tilt was varied. The experiment was performed for the various Reynolds numbers keeping the heat flux constant. This paper conclude that converging-diverging furrowed channel has comparatively higher result than that of furrowed channel having same phase angle and straight channel.

8. Jafari et al. numerically studied the pulsating flow with forced convection through curving furrowed channel and its effects on the convective heat transfer. The results were obtained by varying the frequency of the pulsating flow for different Reynolds numbers. The results showed the linear relationship between the oscillatory rate amplitude and convective heat transfer rate.

9. Benzenine et al. numerically studied the channel with transverse waved baffles for the turbulent flow. During this paper the inclination angle of baffles was varied and its effects on the skin friction were studied. The results showed that by incorporating the baffles with 15o inclination angle improve the pressure loss by 9.91% compare to the straight baffles.

10. Mohammed et al. meted out the numerical analysis on furrowed channel employed in the plate heat exchangers to analyse the convective heat transfer of this forced flow. The simulation was performed by varying the tilt angle, amplitude and Reynolds number. Finally from the results the optimum specification of the channel forbetter convective heat transfer, pressure drop and compactness has been found that are height of wavy channel 2.5 mm, 60o angle of tilt, and 17.5 millimeter height of channel.

11. Ahmed et al. performed the numerical investigation on Nano fluid of water and Cu-O with completely different volume fractions and Reynolds numbers for straight, triangular, curving and quadrangle furrowed channel. From the result it had been all over that for higher volume fraction and Reynolds number higher is the heat transfer rate and the pressure drop and vice-versa. This paper additionally conclude that for same operating parameters the heat transfer rate for the quadrangle furrowed channel was higher than alternative channel.

12. Maryam et al. performed the big eddy simulation on turbulent flow. Additionally detected convective heat transfer for half furrowed channel. The amplitude of furrowed channel and Reynolds number has been modified. The special result from this paper got was the reattachment and separation regions are strongly affected from the amplitude of channel. More precisely the attachment region is more affected from the amplitude than that of the separation region. Additionally the thermal boundary layer is thickest at the separation region and it's thinnest at the reattachment region in order that the convective heat transfer is most at reattachment region and lowest at the separation region.

13. Umavathi, J. C. et al. numerically studied the mixed convective flow of two viscous fluid that are immiscible within the vertical furrowed channel. The simulation had been performed by them by varying the parameters like viscosity ratio, Grashof variety, thermal conductivity ratio, width ratio, frequency of the flow. The results of this parameter on the temperature, shear stress, speed and the Nusselt variety were also been studied.

III. CONCLUSION

The Numerical simulation is performed on the sinusoidal, trapezoidal and the triangular corrugated channel with water as working fluid using Ansys fluent-16. At the wall, boundary condition are taken as constant wall heat flux or constant wall temperature with no slip and no penetration boundary condition. The simulations cover a wide range of the Reynolds numbers, heat fluxes and wall temperatures. At the inlet, velocity is specified by using the user defined function. For each of the geometry profiles, its amplitude has been varied as 1.75 mm, 3.50 mm and 7.00 mm. From the present study some important findings have been observed which are given below.

- Heat transfer enhancement is maximum for triangular corrugated channel followed by trapezoidal and triangular channel for laminar flow.
- In case of turbulent flow, the triangular corrugated channel shows the better heat transfer rate than others two corrugated channel.
- Pressure loss is maximum in case of trapezoidal corrugated channel followed by sinusoidal and triangular channel for laminar flow.
- For higher Reynolds number the surface-Nusselt number is higher.
- On increasing the amplitude of wavy wall, the Nusselt number increases.
- For laminar flow, it is observed that the problem is not converged when Re and channel amplitude exceeds certain value.
- With increment of Re, outlet temperature decreases.
- For laminar flow, reduction in the centre line velocity is minimum in trapezoidal corrugated channel.

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