International Journal of Engineering Technology and Applied Science
(ISSN: 2395 3853), Vol. 8 Issue 4 April 2022

A Review on Effect of Different Nanofluids on Thermal Performance in Trapezoidal Corrugated Channel

Nasir Alam
Madhayanchal Professional University, Bhopal, Madhya Pradesh

Brijendra Kumar Yadav
Madhayanchal Professional University, Bhopal, Madhya Pradesh

ABSTRACT

Using corrugated channels is one of the passive heat transfer enhancement techniques in fabrication of heat exchange devices. Designing more effective energy systems is a challenge for researchers and engineers to minimize the consumption of energy in order to improve energy system efficiency. In recent years, many industries have a strong need to achieve higher thermal performance in order to gain high efficiency, reduce the cost and weight, and minimize the size of heat exchangers. Use of corrugated channels can decrease the thermal resistance where its acts to reduce the thermal boundary layer thickness of the heat exchanger surface. Therefore, corrugated surface geometry is one of the numerous appropriate procedures to upgrade the heat transfer in these devices due to the appearance of the secondary flow regions in the trough of the corrugated channel which leads to improve the blending of the fluid and consequently maximize the heat transfer exchange. This paper presents the review of studies done by different researchers on the similar topic.

***Keywords*: Corrugated channels, Nanofluids, Thermal fields, Forced convective flows**

1. INTRODUCTION

The corrugated channel is a common heat exchanger configuration. Such a channel is formed by two corrugated walls placed side by side, the corrugations being perpendicular to the flow direction. The flow impinges on, and is deflected by, the corrugations, thermal boundary-layer growth is interrupted by flow separation, and at sufficiently high Reynolds numbers, streamwise (Goertler) vortices or spanwise vortices may occur. These phenomena influence the temperature field significantly, resulting in sizable heat transfer enhancement in comparison to a parallel-plate channel. However, since the gains in heat transfer are accompanied by increased losses of mechanical energy in the flow, the practical utility of this approach would depend on design constraints such as the pressure drop or pumping power required to sustain the flow.

Designing more effective energy systems is a challenge for researchers and engineers to minimize the consumption of energy in order to improve energy system efficiency. In this respect, improving the heat transfer rate and hence producing more compact heat exchangers which are essential components for many engineering applications such as space, aeronautics, automotive industry, ocean thermal energy conversion technology is a major concern. Corrugations are used in plate heat exchangers to enhance the heat transfer rate and to improve the strength of plates. Complex corrugated channel geometry improves the heat transfer efficiency resulting in higher-pressure losses, especially in turbulent flow regime.

Flow control techniques consist of three main techniques: active flow control technique, passive flow control technique, and compound flow control technique for improving the heat transfer rate. The active flow control technique requires external power input in order to provide heat transfer enhancement. Some examples of active flow techniques include flow oscillation, flow vibration, surface vibration, magnetic field and other similar methods. This example provides better flow mixing and heat transfers enhancement. The passive flow control technique does not need any external power input to improve the heat transfer, but, causes a further pressure drop because of the geometrical changes. Some examples of the passive flow control methods are the use of inserts, additives, rough surface, swirl flow devices, treated surface, extended surfaces and coiled tubes. As seen from examples, reducing the hydraulic diameter of the flow passage improves the rate of heat transfer. Also, in some cases by applying this technique, a secondary flow can be obtained which upgrades the rate heat transfer by mixing fluids between the core flow region with the flow region close to the wall surface. The compound flow control technique involves combinations of the two or more flow control methods for enhancing the heat transfer rate.

2. LITERATURE REVIEW

Ajeel et al. (2019) presented A numerical simulation performed on thermal performance comparison of a corrugated channel with three corrugation profiles. Semicircle, trapezoidal, and house shapes are considered as corrugation profiles for corrugated walls channel using nanoparticles volume fractions of ZnO and Reynolds number ranging from 0 to 0.08 and 10,000–30,000, respectively.

Ajeel et al. (2019) presented heat transfer and flow characteristics of the symmetry semicircle-corrugated channel with (SiO_2) - water nanofluid numerically over Reynolds number ranges of 10,000–30,000. The influence of geometrical parameters including height-to-width ratio (h/W) and pitch-to-length ratio (p/L) on the thermal and hydraulic characteristics are evaluated. A numerical simulation covering nanofluid with SiO_2 volume fractions of 0–8.0% was carried out by employing the finite volume method for discretization of the governing equations.

Ajeel et al. (2019) presented A numerical comparison of the thermal performance of different shapes of corrugated channels as well as straight channels in a turbulent flow of ZnO–water nanofluid under constant heat flux.

Shirzad et al. (2019) presented the effect of using different nanofluid as a coolant fluid on the thermal performance of Pillow plate heat exchanger (PPHE). The objective of present study is using a new heat transfer enhancement method in PPHE by utilizing nanofluid instead of pure fluid as a heat transfer medium.

Ajeel et al. (2019) presented heat transfer and flow characteristics of the symmetry trapezoidal-corrugated channel with silicon dioxide (SiO_2) - water as nanofluid performed numerically over Reynolds number ranges of 10,000–30,000. The influence of geometrical parameters including height-to-width ratio (h/W) and pitch-to-length ratio (p/L) on the thermal and hydraulic characteristics are evaluated.

Ajeel et al. (2019) presented the forced convective turbulent flow of SiO_2-water nanofluid through different corrugated channels studied numerically and experimentally. All studies are performed for the straight channel (SC) and different two corrugated channels, namely semicircle corrugated channel (SCC) and trapezoidal corrugated channel (TCC) over Reynolds number ranges of 10000–30000.

Ajeel et al. (2019) presented the employment of alumina oxide (Al_2O_3) in water nanofluid for heat transfer enhancement with corrugation is performed numerically and experimentally over Reynolds number ranges of 10,000–30,000. Three corrugated channels, semicircle (SCC), trapezoidal (TCC), and straight (SC) are fabricated and tested with nanofluid Al_2O_3 volume fractions of 0%, 1%, and 2%.

Tokgöz et al. (2018) presented Heat transfer enhancement in channel flow is investigated by using corrugated duct in lieu of smooth duct. In this regard, periodic different cavities are applied on the duct walls using the same aspect ratios. The values of the Reynolds numbers are in the range of $10{,}000 \leq Re \leq 20{,}000$.

Ajeel et al. (2018) presented the effects of four different types of nanofluids which are Al2O3, CuO, SiO2 and ZnO–water under constant heat flux condition (10kw/m2). The governing equations of continuity, momentum and energy are solved using finite volume method (FVM). The study was carried out at 8% volume fraction of nanoparticles with 20nm particle diameters.

Ajeel et al. (2018) presented The performance of a trapezoidal-corrugated channel with four different kinds of nanofluids (ZnO, Al2O3, CuO, and SiO2), with four various nanoparticle volume fractions of 2%, 4%, 6% and 8% using water as base fluid.

Hosseinnezhad et al. (2018) presented the turbulent flow of water/Al2O3 nanofluid in a tubular heat exchanger with two twisted-tape numerically investigated in the three-dimensional coordinate. This numerical simulation has been done by using FVM, and all of the equations have been discretized by second-order upwind method.

Ajeel et al. (2018) presented numerical investigation of Thermal and hydraulic characteristics of turbulent nanofluid flow in a semicircle zigzag corrugated channel by implementing the finite volume method (FVM) to describe the governing equations.

Ma et al. (2018) presented numerical investigation of the laminar forced convection heat transfer of nanofluid through a bent channel. The lattice Boltzmann method was used for solving the governing equations in the domain. The effect of different parameters such as Reynolds number ($50 \leq Re \leq 150$), vertical passage ratio ($2.0 \leq M \leq 4.0$), and nanoparticle solid volume fractions (Φ = 0, 0.01, 0.03, 0.05) are analyzed in terms of streamlines, isotherms, and local Nusselt numbers.

Sadripour et al. (2018) presented numerical investigation of A forced convection flow and heat transfer of a water-based nanofluid with SiO_2 particles with different volume fractions and nanoparticle diameters in corrugated ducts with different shapes.

Parsaiemehr et al. (2018) presented numerical investigation of the turbulent flow and heat transfer of Water/Al2O3 nanofluid inside a rectangular channel. The main purpose of present study is investigating the effect of attack angle of inclined rectangular rib, Reynolds number and volume fraction of nanoparticles on heat transfer enhancement.

Khoshvaght-Aliabadi et al. (2018) presented numerical investigation of The forced convective turbulent flow of Al_2O_3-water nanofluid through the offset-strip channel. The mixture model is applied to model the Al_2O_3-water nanofluid flow.

Ajeel et al. (2017) presented the recent development of heat transfer enhancement through facing step and corrugated channels. Numerical simulation findings of the convective heat transfer with and without nanofluids have been investigated.

The experimental trials to augment heat transfer in the facing step and corrugated channels by using conventional fluids and nanofluidsare reported.

Khoshvaght-Aliabadi et al. (2017) presented Evaluation of Thermal and hydraulic performances of two types of fin, namely plate and plate-pin, in water-cooled corrugated miniature heat sinks (MHSs) having triangular, trapezoidal, and sinusoidal shapes. In fact, the plate-pin fins are designed and constructed based on the plate fins.

Selimefendigil et al. (2017) presented Numerical study of jet impingement cooling of a corrugated surface with water–SiO2 nanofluid of different nanoparticle shapes. The bottom wall is corrugated and kept at constant surface temperature, while the jet emerges from a rectangular slot with cold uniform temperature.

Sadripour et al. (2017) presented Numerical study of the effects of corrugated absorber plate and using aerosol-carbon black nanofluid on heat transfer and turbulent flow in solar collectors with double application and air heating collectors,. The two dimensional continuity, momentum and energy equation were solved by finite volume and SIMPLE algorithm. In the present investigation all the simulations were done for two different angles of tilt of collector according to horizon, that these angles were the optimum ones for the period of six months setting.

Selimefendigil et al. (2017) presented numerical examination of laminar forced convection of pulsating nanofluid flow over a backward-facing step with a corrugated bottom wall by using finite volume method. Part of the bottom wall downstream of the step was corrugated and kept at constant temperature. Effects of Reynolds number, length and height of the surface corrugation wave, nanoparticle volume fraction, amplitude and frequency of flow pulsation on the fluid flow and heat transfer were numerically investigated.

Hassanzadeh et al. (2017) presented effects of periodic corrugations in rectangular ducts on the thermal-hydraulic behaviors of nanofluids. The applied corrugations were rectangular cavities with a constant cavity length. In this regard, three various dimensionless cavity shaped corrugation widths such as S/H = 0.1, 0.2, and 0.3 were investigated.

Akdag et al. (2017) presented numerical investigation of the heat transfer characteristics of CuO-water-based nanofluids in a trapezoidal-corrugated channel under pulsating inlet flow conditions. A comparison is presented between the heat transfer coefficients for nanofluids under steady flow conditions and the existing results. The use of nanoparticles under the pulsating flow conditions increases the heat transfer rate compared with the steady flow case. The obtained results are given as a function of dimensionless parameters.

Rashidi et al. (2016) presented numerical investigation of mixed convection heat transfer of nano-fluid flow in vertical channel with sinusoidal walls under magnetic field effect. The heat transfer and hydrodynamic characteristics have been examined. This study has performed for $500 \leq Re \leq 1000$, $5\times104 \leq Gr \leq 1\times106$, three amplitude sine wave (0.1, 0.2 and 0.3) and three values of Hartman numbers (0, 5 and 10).

3. CONCLUSION

The enhancement of convection heat transfer is a very interesting topic for different kinds of industrial and engineering applications and can be improved passively by changing the flow geometry and boundary conditions or by enhancing the thermophysical properties of the fluid. Depending on the mentioned literature, it can be inferred that the forced convective heat transfer in a trapezoidal -corrugated channel with symmetry and zigzag configurations and using nanofluids has never been reported. Additionally, most of the past studies examined a 2D turbulent convective heat transfer. Accordingly, this lack of knowledge represents the prime motivation behind conducting the current research.

4. REFERENCES

[1] https://energyeducation.ca/encyclopedia/Forced_convection

[2] Ajeel, Raheem K., WS-IW Salim, and Khalid Hasnan. "Thermal performance comparison of various corrugated channels using nanofluid: Numerical study." Alexandria Engineering Journal 58, no. 1 (2019): 75-87.

[3] Ajeel, Raheem K., WS-IW Salim, and Khalid Hasnan. "Design characteristics of symmetrical semicircle-corrugated channel on heat transfer enhancement with nanofluid." International Journal of Mechanical Sciences 151 (2019): 236-250.

[4] Ajeel, Raheem K., WS-IW Salim, and Khalid Hasnan. "Comparative study of the thermal performance of corrugated channels using ZnO–water nanofluid." Journal of Thermophysics and Heat Transfer 33, no. 2 (2019): 508-516.

[5] Shirzad, Mojtaba, Seyed Soheil Mousavi Ajarostaghi, Mojtaba Aghajani Delavar, and Kurosh Sedighi. "Improve the thermal performance of the pillow plate heat exchanger by using nanofluid: numerical simulation." Advanced Powder

Technology 30, no. 7 (2019): 1356-1365.

[6] Ajeel, Raheem K., WS-IW Salim, and Khalid Hasnan. "Influences of geometrical parameters on the heat transfer characteristics through symmetry trapezoidal-corrugated channel using SiO2-water nanofluid." International Communications in Heat and Mass Transfer 101 (2019): 1-9.

[7] Ajeel, Raheem K., WS-I. Salim, K. Sopian, M. Z. Yusoff, Khalid Hasnan, Adnan Ibrahim, and Ali HA Al-Waeli. "Turbulent convective heat transfer of silica oxide nanofluid through corrugated channels: An experimental and numerical study." International Journal of Heat and Mass Transfer 145 (2019): 118806.

[8] Ajeel, Raheem K., WS-IW Salim, and Khalid Hasnan. "Experimental and numerical investigations of convection heat transfer in corrugated channels using alumina nanofluid under a turbulent flow regime." Chemical Engineering Research and Design 148 (2019): 202-217.
Tokgöz, Nehir, E. Alıç, Önder Kaşka, and M. M. Aksot. "The numerical study of heat transfer enhancement using AL2O3.

[9] Ajeel, Raheem Kadhim, W. I. Salim, and Khalid Hasnan. "Impacts of corrugation profiles on the flow and heat transfer characteristics in trapezoidal corrugated channel using nanofluids." Journal of Advanced Research in Fluid Mechanics and Thermal Sciences 49, no. 2 (2018): 170-179.

[10] Ajeel, Raheem K., WS-IW Salim, and Khalid Hasnan. "Thermal and hydraulic characteristics of turbulent nanofluids flow in trapezoidal-corrugated channel: Symmetry and zigzag shaped." Case studies in thermal engineering 12 (2018): 620-635.

[11] Hosseinnezhad, Rahim, Omid Ali Akbari, Hamid Hassanzadeh Afrouzi, Mohit Biglarian, Ali Koveiti, and Davood Toghraie. "Numerical study of turbulent nanofluid heat transfer in a tubular heat exchanger with twin twisted-tape inserts." Journal of Thermal Analysis and Calorimetry 132, no. 1 (2018): 741-759.

[12] Ajeel, Raheem K., Wan SW Salim, and Khalid Hasnan. "Numerical investigations of flow and heat transfer enhancement in a semicircle zigzag corrugated channel using nanofluids." Journal homepage: http://iieta. org/Journals/IJHT 36, no. 4 (2018): 1292-1303.

[13] Ma, Yuan, Rasul Mohebbi, M. M. Rashidi, and Zhigang Yang. "Study of nanofluid forced convection heat transfer in a bent channel by means of lattice Boltzmann method." Physics of Fluids 30, no. 3 (2018): 032001.

[14] Sadripour, S. "Investigation of Flow Characteristics And Heat Transfer Enhancement in a Nanofluid Flow in a Corrugated Duct." Journal of Applied Mechanics and Technical Physics 59, no. 6 (2018): 1049-1057.

[15] Parsaiemehr, Mohammad, Farzad Pourfattah, Omid Ali Akbari, Davood Toghraie, and Ghanbarali Sheikhzadeh. "Turbulent flow and heat transfer of Water/Al2O3 nanofluid inside a rectangular ribbed channel." Physica E: Low-Dimensional Systems and Nanostructures 96 (2018): 73-84.

[16] Khoshvaght-Aliabadi, Morteza, and Majid Salami. "Turbulent flow of Al2O3-water nanofluid through plate-fin heat exchanger (PFHE) with offset-strip channels." Thermal Science and Engineering Progress 6 (2018): 164-176.

[17] Ajeel, R. K., and W. S. I. W. Salim. "A CFD study on turbulent forced convection flow of Al 2 O 3-water nanofluid in semi-circular corrugated channel." MS&E 243, no. 1 (2017): 012020.

[18] Khoshvaght-Aliabadi, M., S. M. Hassani, and Seyed Hossein Mazloumi. "Comparison of hydrothermal performance between plate fins and plate-pin fins subject to nanofluid-cooled corrugated miniature heat sinks." Microelectronics Reliability 70 (2017): 84-96.

[19] Selimefendigil, Fatih, and Hakan F. Öztop. "Effects of nanoparticle shape on slot-jet impingement cooling of a corrugated surface with nanofluids." Journal of Thermal Science and Engineering Applications 9, no. 2 (2017).

[20] Sadripour, Soroush, Mohammad Adibi, and Ghanbar Ali Sheikhzadeh. "Two different viewpoints about using aerosol-carbon nanofluid in corrugated solar collectors: Thermal-hydraulic performance, and heating performance." Global Journal of Research In Engineering (2017).

[21] Selimefendigil, Fatih, and Hakan F. Öztop. "Forced convection and thermal predictions of pulsating nanofluid flow over a backward facing step with a corrugated bottom wall." International Journal of Heat and Mass Transfer 110 (2017): 231-247.

[22] Hassanzadeh, R., and N. Tokgoz. "Thermal-hydraulic characteristics of nanofluid flow in corrugated ducts." Journal of Engineering Thermophysics 26, no. 4 (2017): 498-513.

[23] Akdag, Unal, Selma Akcay, and Dogan Demiral. "Heat transfer enhancement with nanofluids under laminar pulsating flow in a trapezoidal-corrugated channel." Progress in Computational Fluid Dynamics, an International Journal 17, no. 5 (2017): 302-312.

[24] Khoshvaght-Aliabadi, Morteza, and Mohammad Sahamiyan. "Performance of nanofluid flow in corrugated minichannels heat sink (CMCHS)." Energy conversion and management 108 (2016): 297-308.

[25] Rashidi, Mohammad Mehdi, Mohammad Nasiri, Marzieh Khezerloo, and Najib Laraqi. "Numerical investigation of magnetic field effect on mixed convection heat transfer of nanofluid in a channel with sinusoidal walls." Journal of Magnetism and Magnetic Materials 401 (2016): 159-168.

[26] Abed, Azher M., M. A. Alghoul, K. Sopian, H. A. Mohammed, and Ali Najah Al-Shamani. "Design characteristics of corrugated trapezoidal plate heat exchangers using nanofluids." Chemical Engineering and Processing: Process Intensification 87 (2015): 88-103.

[27] Ahmed, M. A., Mohd Zamri Yusoff, Khai Ching Ng, and N. H. Shuaib. "Numerical and experimental investigations on the heat transfer enhancement in corrugated channels using SiO2–water nanofluid." Case Studies in Thermal Engineering 6 (2015): 77-92.

[28] Ahmed, M. A., Mohd Zamri Yusoff, Khai Ching Ng, and N. H. Shuaib. "Numerical investigations on the turbulent forced convection of nanofluids flow in a triangular-corrugated channel." Case Studies in Thermal Engineering 6 (2015): 212-225.

[29] Jafari, Mohammad, Mousa Farhadi, and Kourosh Sedighi. "Convection heat transfer of SWCNT-nanofluid in a corrugated channel under pulsating velocity profile." International Communications in Heat and Mass Transfer 67 (2015): 137-146.

[30] Navaei, A. S., H. A. Mohammed, K. M. Munisamy, Hooman Yarmand, and Samira Gharehkhani. "Heat transfer enhancement of turbulent nanofluid flow over various types of internally corrugated channels." Powder technology 286 (2015): 332-341.