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Review on performance of Passive Enhancement Techniques in Double Pipe Heat Exchanger

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ABSTRACT: With the growing need for more energy, it is always important to design energy-efficient heat exchangers which intern leads to simpler in design, cheaper in cost and higher heat transfer rate. The Double pipe heat exchanger (DPHE) has the benefit of reduced construction and maintenance cost so that its application has been widely supported in industries like food processing, textile, energy, power, oil refineries, and refrigeration. From the earlier year's studies, it has foreseen that a great amount of passive augmented techniques has been introduced to enhance and optimize double pipe heat exchanger. In this review paper, both experimental and numerical works are considered on the aspects of the augmented approach, working conditions, the percentage of heat transfer enhancement, working fluids and observations for a double pipe heat exchanger which is widely discussed. The current study represents the best of a comprehensive review on passive augmented technique as it's been cited regularly. The paper also signifies the amount or percentage of enhancement in Nusselt number and friction factor from previous studies, believing that the review may offer further insights for the researchers on passive augmented techniques. This paper reviews numerical and experimental works of various investigators on these techniques since 1998 such as fins, inserts, swirl generators, turbulators etc. Lastly, the present review article excludes the previous works on twisted tapes as there are a lot of review papers done on it.

KEYWORDS: Health Care, Delivery System, Rural Health, GIDA, Philippine Health Agenda, Case Study

I. INTRODUCTION

The heat exchangers are devices where the heat is transferred between two flowing fluids out which one is cold and the other one is hot. The heat exchangers are extensively applied in industries like power, processing, oil, air conditioning, and refrigeration. Technically, the challenge before engineers is to design compact, economical and energy efficient heat exchangers. To design a heat exchangers lot of parameters are required to be analyzed like, pressure drop, heat transfer rate, friction coefficient, efficiency, effectiveness, and economic feasibility. In order to design any heat exchanger, the focus will be mainly towards optimization of heat transfer rate with less pressure drop, and this can be achieved by three main methods of heat transfer enhancement techniques 1. Active Methods 2. Passive Methods and 3. Compound Methods. In this paper, numerically and experimentally studied passive heat transfer techniques on DPHE are reviewed.

With respect to passive heat transfer techniques, there will be no external power required to drive the enhancement system and rather the additional power is taken by the main drives with an increase in the pressure drop to drive the entire system. Some of the techniques involved are geometrical modifications, the inclusion of inserts, twisted tapes, strips, extended surfaces, swirl flow devices, treated surface, rough surface, wire coils, fluid additives, and surface tension devices.

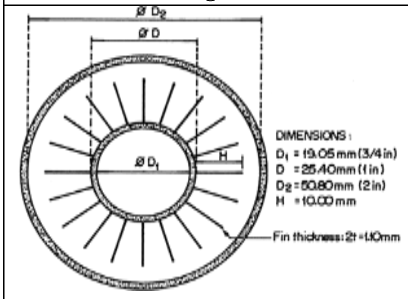
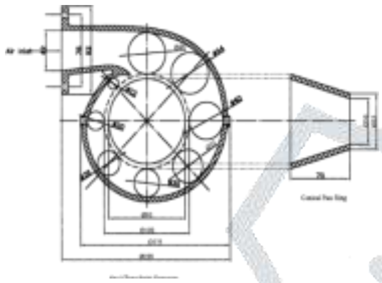
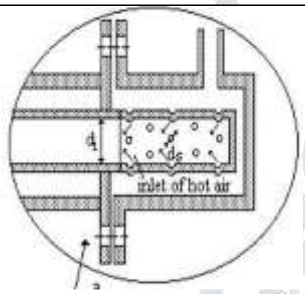
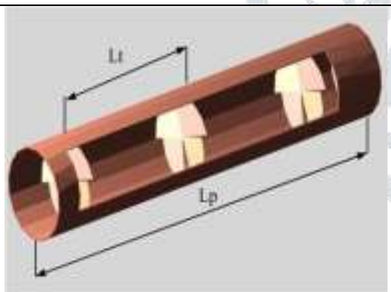
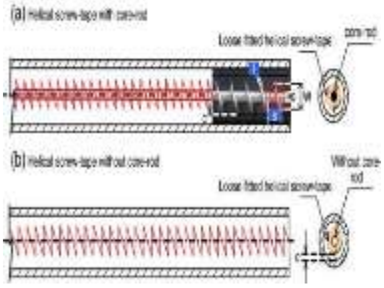
The equipment which is employed with transfer of energy, which one state with another state, with help of utmost heat and lower cost. Examples of heat exchanger is intercooler, pre heater, condenser and steam power plant, condenser, evaporators and R &AC, automobile radiators, milk chiller and several industrial applications. DPHE is one of the least complex kinds of heat exchanger found in mechanical applications. They are known as double- pipe exchange as one of the fluid flows in inner pipe and other fluid flows around the inner pipe through the annulus. They also are known as a pipe in pipe heat exchangers. The DPHE are very well appreciated for their operations in a different range of temperature. It is likewise all around reported that the Double pipe heat exchanger makes a critical commitment to the condenser, economizer, chemical processing, pasteurizing, and digester heating, effluent heat, reheating and preheating. The advantage of DPHEs over small and medium scale industries is their simple design and low-cost maintenance.

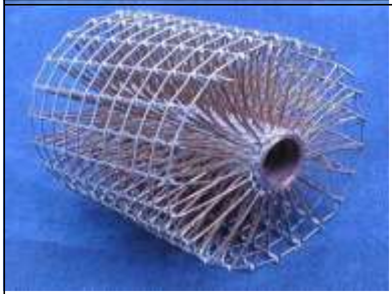
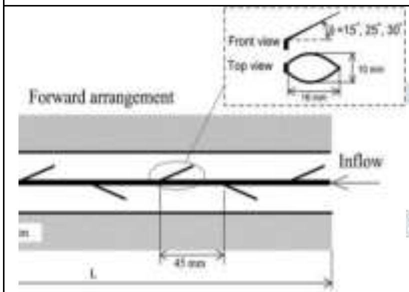
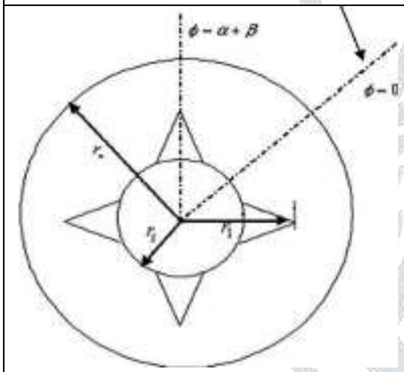
Therefore, we arrived at a conclusion from the past research on DPHE which it ought to be arranged keeping in mind the end goal to overcome the perplexities of picking the most proper techniques for intrigue. To the authors' learning's, so far no review papers are investigated on double pipe heat exchangers concerning to only passive augmented techniques by any of the authors and this reality is also one of the fundamental objectives of this review paper. The investigations extensively bolster that there is an impressive advance toward the development of heat exchangers. As the years progressed, plenty of inquiries about passive enhancement a technique in DPHE has been completed which fall into different classifications.

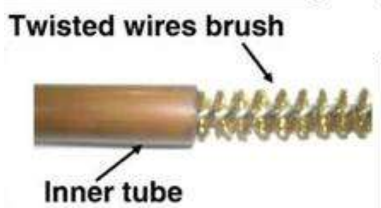
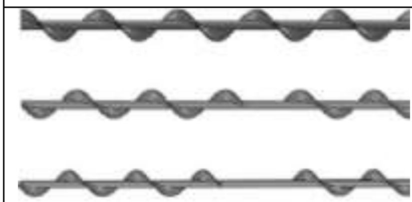
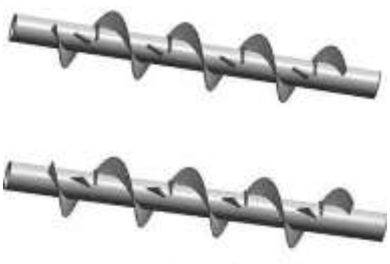
II. LITERATURE REVIEW

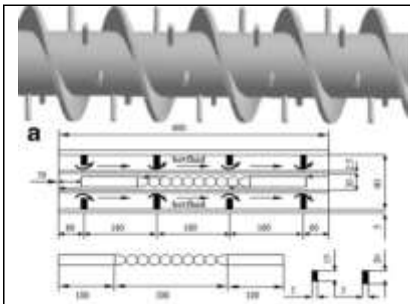
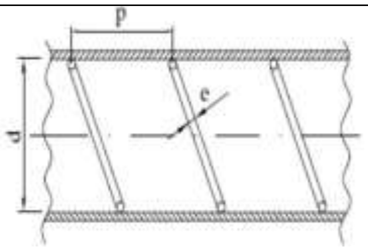
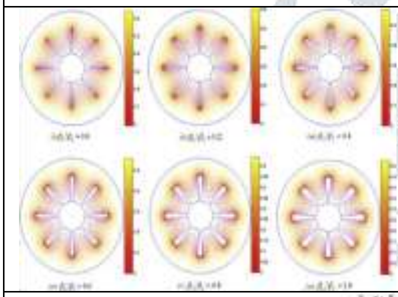
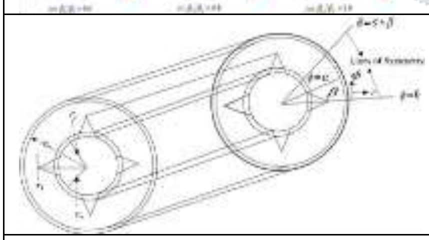
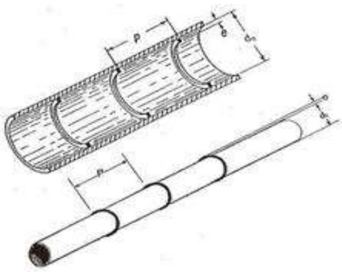
Some of previous experimental works conducted with tape twisted inserts was given below.

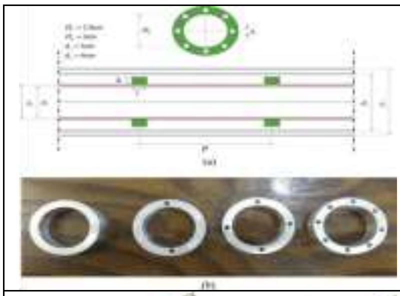
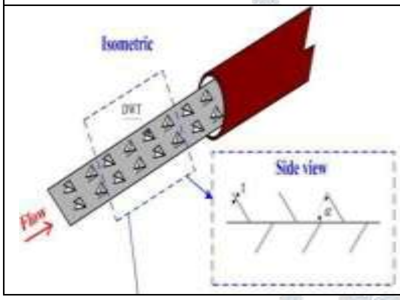
TABLE 1. AUGMENTED TECHNIQUES OF DHPE

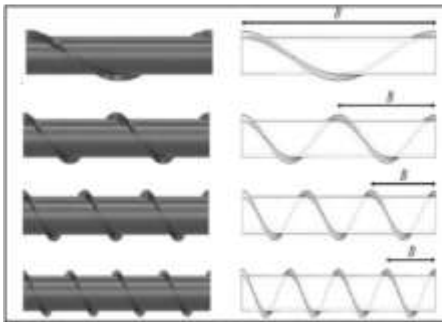
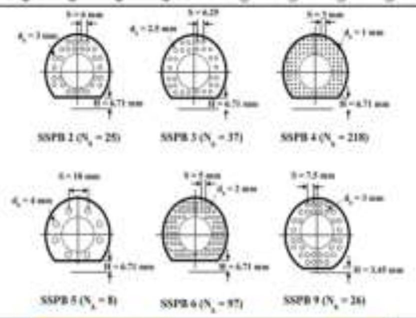
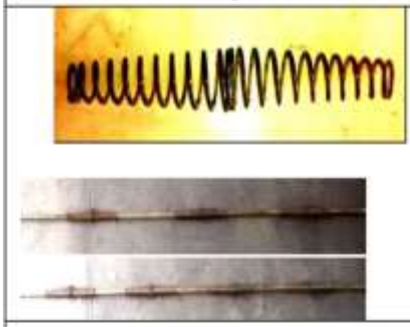
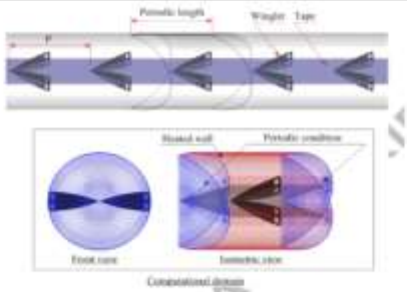
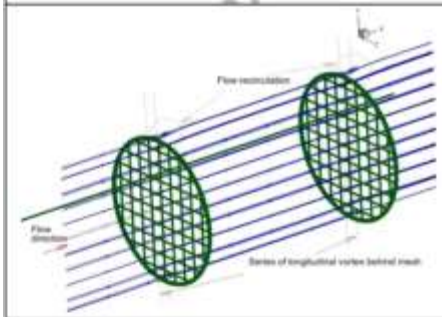
Configuration	Name	Reference
	Continuous longitudinal rectangular fins	[1]
	Snail entrance	[2]
	Swirl elements	[3], [4]
	Propeller-type turbulator	[5]
	Helical screw-tape with/without core-rod inserts	[6]

	Spined pipe	[7]
	Pin fin heat exchanger	[8]
	Louvered strip inserts	[9]
	Triangular fins outside of inner pipe	[10]

	Twisted wires brush inserts	[11]
	Helical screw-tape inserts	[12]
	Helical fins with vortex generators	[13]

	Helical fins with and pin fin	[14]&[15]
	Coil wire insert	[16]
	Triangular, rectangular and parabolic curved finned inserts	[17]
	Inserting agitator improves	[18]
	Doubly enhanced tube	[19]
	Variable fin-tip thickness insert	[20]
	Triangular finned inserts	[21]
	Repeated ribs inner and outer surfaces	[22]

	Perforated circular ring turbulators	[23]
	Discontinuous helical turbulators	[24]
	Circular and Square helical ring	[25]
	Delta-wing tape vortex generator	[26]

	Continuous helical baffles	[27]
	Segmental perforated baffle	[28]
	Divergent convergent spring turbulators	[29]
	Inner pipe with triangular fins	[30],[31]
	Curved-winglet tapes	[32]
	Compound circular ring–metal wire net inserts	[33]

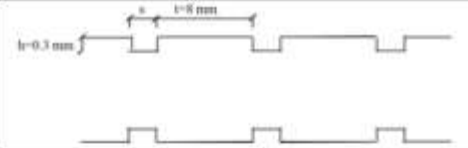
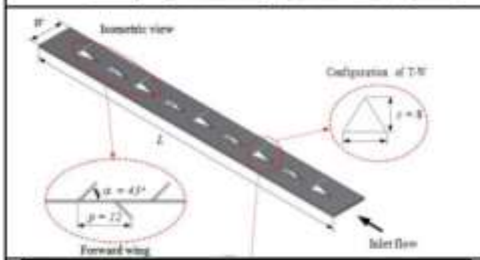
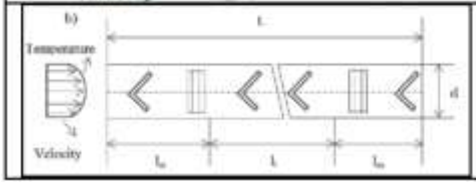
	Grooved double pipe heat exchanger	[34]
	Double-sided delta-wing tape inserts	[35]
	Angle plate inserts	[36]

TABLE 2
EXPERIMENTAL WORKS OF PASSIVE AUGMENTED TECHNIQUES OF DHPE

Authors	Working fluid	Construction	Conditions	observation
braga & saboya [1]	air/water	Continuous longitudinal rectangular fins	10000≤Re≤50000, unifrom temperature with 20 no.fins	The comparison between with and without inclusionof fins was studied and inclusion of longitudinal fins has a significant effect over friction and heat transfer parameters
A. Durmus [2]	air/water	Snail entrance	2500≤Re≤10000 and 20000≤Re≤100000 for hot water and cold air	For a swirling angle of 45° the maximum augmentation of 120% was achieved in the case of the counterflow heat exchanger
E.K.Akpinar [3]	air/water	Swirl generators	8500≤Re≤17500 3mm to 9mm hole diameter with 3 to 5 holes	Swirl elements at the entrance of the heat exchanger was found to be much effective with 130%
E.K.Akpinar [4]	air/water	Helical wires	6500≤Re≤13000 Pitch of 9mm to 21mm	During experimentation the heat transfer was maximized with increasing helical number and decreasing pitch. The .final augmentation achieved was 2.64 times and 2.74 times of nusselt number and friction factor respectively.
Irfan Kurtbas [5]	air	Propeller type turbulators	10000≤Re≤30000 Blade angles (θ) of 10^0, 20^0 and 40^0	By introduction of propeller turbulators the efficiency of heat exchanger was enhanced from 18% to 72%
Smith Eiamsa-ard [6]	water	Helical screw-tape	2000≤Re≤12000	Optimization of the Nusselt number in by with
		with/without core-rod inserts		core rod was 230% and without core rod was 340%
Balikowski [7]	Water/PCM	Spined type inserts	2000≤Re≤6000	In comparison with a spined and smooth heat exchanger,

				the spined heat exchanger was quick responsive for change in temperature and flow rates.
Sahiti [8]	air/water	Pin fin inserts	5000≤Re≤32000	The investigation proved that short flow length will produce smaller entropy over larger flow length
Smith Eiamsa-ard[9]	water	Louvered strip inserts	6000≤Re≤42,000	NU increases from 284% to 413% and 263% to 233% for forward and backward arrangement
Syed [10]	air	Triangular fins	5000≤Re≤15000	The heat transfer increased to 4 times of that of normal with the introduction of fins
Naphon [11]	water	Twisted wires brush inserts	6000≤Re≤20000	Brush inserts will create small swirls and turbulence in the flow which final lead to enhancement of overall performance of heat exchanger.
Ibrahim [12]	water	Helical screw-tape inserts	5700≤Re≤13100	Nusselt number optimizes with the increase in Reynolds number and reduction in twist ratio and spacer length
Zhang [13]	Air/steam	Helical fins with vortex generators	6500≤Re≤21000	The combined effect of helical fins and vortex generators resulted in an increase of heat exchanger efficiency of 42–43%
Jianhua [14]	water	Helical fins and pin fins	200≤Re≤8494	Two vortices of fluid are created near the wall and at the wall boundary
Choudhari [16]	water	Coil wire insert	4000≤Re≤13000	The Nusselt number was increased to 1.58, 1.41 and 1.31 times with CU, Al and SS materials
Mohanty [15]	water	The protrusion and twisted tape	2300≤Re≤4300	The nusselt number increased was optimized from 13.125 to 16.13% in comparison with the plain case
Sheikholeslami [18]	water	Inserting agitator	3800≤Re≤5400	Incorporation of agitator resulted greater performance of the heat exchanger when compared to smooth one.
Shiva Kumar [17]	water	Triangular, rectangular and parabolic fins	3000≤Re≤20000	rectangular fins showed the highest effectiveness of 21% and 11.5%. Parabolic fins showed 38% and 65% reduced pressure drop compare.

Yagnavalkya [19]	Water/Ethylene Glycol	Doubly enhanced tube	400≤Re≤39500	The overall heat transfer coefficients of the turbulent flow regime were optimized to 116%.
Syed [20]	Water	Variable fin-tip thickness		Fin-tip thickness variation has resulted in enhancement of the convection heat transfer coefficient significantly
Sheikholeslami [23]	Air/Water	Perforated circular-ring turbulators	6000≤Re≤12000	The nusselt number optimization can be achieved with increase in number of perforated hole and Reynolds number, and decrease with the increase in pitch ratio
Sheikholeslami [24]	Air/Water	Discontinuous helical turbulators	6000≤Re≤12000	With the increase in open air ratio the heat transfer coefficient increases resulting in an increased nusselt number
Sheikholeslami [25]	Air/Water	Perforated helical ring and helical fin	4000≤Re≤14000	Perforated helical fin with rectangular cross-section was found to be more promising than Perforated helical fin with a round cross section
Skullong [26]	Air	Delta-wing tape (DWT)	4200≤Re≤25500	The maximum thermal factor resulted by delta wing tape was 1.49 with an optimization of 505% in nusselt number
Anas [27] Salem [28]	Water Water	Continuous helical baffle Segmental perforated baffle	Re≤6000 1380≤Re≤570 0	The inclusion of baffles in tube resulted in optimization of heattransfer The inclusion of segmental perforated baffles in tube resulted in better recirculation, swirl, and greater turbulence
Kushal [29]	Water	Divergent-convergent spring turbulator	9000≤Re≤14000	The nusselt number overthe plain tube enhanced to 26.76 %, while frictionfactor gives rise around
Hameed [30], [31]	Air/Water	Triangular fins	10000≤Re≤23000	Triangular fins show the splitting of the boundary layer of the flow near thewall and the fins
Skullong [32]	Air	Curved-winglet tapes	4150≤Re≤25400	The nusselt number over the plain tube enhanced to 3.34–4.76 times, while friction factor gives rise around 13 – 49.5 times.
Amit Bartwal [33]	Air	Circular ring–metal wire net inserts	5000≤Re≤40000	The enhancement of Nuover plain tube is in the range of 226% -354%

Sunu [34]	Water	Grooved double pipe heat exchanger	31981≤Re≤43610	The LMTD in 1 mm groove space increased about 0.04% to 1.8% compared to those of 2 mm groove space
Wijayanta [35]	Water	Double-sided delta-wing tape inserts	5300≤Re≤14500	The average Nusselt number was enhanced to 177% with a twist ratio of 0.63 relative to that for the
Thejaraju [36]	Air	Angle plate inserts	6000≤Re≤18000	The Nu is augmented byaround 2.43 to 3.83 times of the smooth pipe in forward arrangement and 3.27 to 4.62 times in backward arrangement.

III. CONCLUSION

In the present paper, an effort has been made to report useful passive methods which are utilized so in order to enhance the heat transfer performance other than twisted tape augmentation. The thermal conductivity of the material plays a significant role in enhancement ratio, entropy production rates increases with the increase in the pin-fin length, the geometric parameters of the fins strongly influence on the performance parameters, fins in vertical position resulted in generation of two vortices of fluid at the center and near the wall. of helical fin and delta winglet vortex generator has greater influence in turbulence than other vortex generator, fin with rectangular profile showed marginal improvement over triangular and concave parabolic profiles in terms of heat transfer characteristics and Variation in the thickness of fin-tip resulted to influence the performance of convection heat transfer coefficient.

IV. REFERENCES

[1] Braga and Saboya, ―Turbulent heat transfer, pressure drop and fin efficiency in annular regions with continuous longitudinal rectangular fins,‖ Exp. Therm. Fluid Sci., vol. 20, no. 2, pp. 55–65, 1999.
[2] A. Durmus, ―Investigation of heat transfer and pressure drop in a concentric heat exchanger with snail entrance,‖ Appl. Therm. Eng., vol. 22, pp. 321–332, 2002.
[3] E. K. Akpinar, ―Heat transfer enhancements in a concentric double pipe exchanger equipped with swirl elements,‖ Int. Commun. Heat Mass Transf. 31(6) 857-868, vol. 31, no. 6, pp. 857–868, 2004.
[4] E. K. Akpinar, ―Evaluation of heat transfer and exergy loss in a concentric double pipe exchanger equipped with helical wires,‖ Energy Convers. Manag., vol. 31, no. 6, pp. 857–868, 2006.
[5] İ. Kurtbaş, A. Durmuş, H. Eren, and E. Turgut, ―Effect of propeller type swirl generators on the entropy generation and efficiency of heat exchangers,‖ Int. J. Therm. Sci., vol. 46, no. 3, pp. 300–307, Mar. 2007.
[6] S. Eiamsa-ard and P. Promvonge, ―Heat transfer characteristics in a tube fitted with helical screw-tape with/without core-rod inserts,‖ Int. Commun. Heat Mass Transf., vol. 34, no. 2, pp. 176–185, 2007.
[7] J. R. Balikowski and J. C. Mollendorf, ―Performance of Phase Change Materials in a Horizontal Annulus of a Double-Pipe Heat Exchanger in a Water-Circulating Loop,‖ J. Heat Transfer, vol. 129, no. 3, p. 265, 2007.
[8] N. Sahiti, F. Krasniqi, X. Fejzullahu, J. Bunjaku, and A. Muriqi, ―Entropy generation minimization of a double- pipe pin fin heat exchanger,‖ Appl. Therm. Eng., vol. 28, no. 17–18, pp. 2337–2344, 2008.
[9] S. Eiamsa-ard, S. Pethkool, C. Thianpong, and P. Promvonge, ―Turbulent flow heat transfer and pressure loss in a double pipe heat exchanger with louvered strip inserts,‖ Int. Commun. Heat Mass Transf., vol. 35, no. 2, pp. 120–129, 2008.
[10] K. S. Syed, M. Ishaq, and M. Bakhsh, ―Laminar convection in the annulus of a double-pipe with triangular fins,‖ Comput. Fluids, vol. 44, no. 1, pp. 43–55, 2011.
[11] P. Naphon and T. Suchana, ―Heat transfer enhancement and pressure drop of the horizontal concentric tube with twisted wires brush inserts,‖ Int. Commun. Heat Mass Transf., vol. 38, no. 2, pp. 236–241, 2011.
[12] E. Z. Ibrahim, ―Augmentation of laminar flow and heat transfer in flat tubes by means of helical screw-tape inserts,‖ Energy Convers. Manag., vol. 52, no. 1, pp. 250– 257, 2011.
[13] L. Zhang, H. Guo, J. Wu, and W. Du, ―Compound heat transfer enhancement for shell side of double-pipe heat exchanger by helical fins and vortex generators,‖ Heat Mass Transf. und Stoffuebertragung, vol. 48, no. 7, pp. 1113–1124, 2012.
[14] L. Zhang, W. Du, J. Wu, Y. Li, and Y. Xing, ―Fluid flow characteristics for shell side of double-pipe heat exchanger with helical fins and pin fins,‖ Exp. Therm. Fluid Sci., vol. 36, pp. 30–43, 2012.
[15] R. L. Mohanty, S. Bashyam, and D. Das, ―Numerical analysis of double pipe heat exchanger using heat transfer augmentation techniques,‖ Int. J. Plast. Technol., vol. 18, no. 3, pp. 337–348, 2014.
[16] P. S. S. Choudhari and P. T. S. G, ―Experimental Studies on Effect of Coil Wire Insert On Heat Transfer Enhancement and Friction Factor of Double Pipe Heat Exchanger,‖ Int. J. Comput. Eng. Res., vol. 3, pp. 32–39, 2013.
[17] S. Kumar, K. V. Karanth, and K. Murthy, ―Numerical study of heat transfer in a finned double pipe heat exchanger,‖ World J. Model. Simul., vol. 11, no. 1, pp. 43– 54, 2015.
[18] M. Sheikholeslami, M. Hatami, M. Jafaryar, F. Farkhadnia,
D. D. Ganji, and M. Gorji-Bandpy, ―Thermal management of double-pipe air to water heat exchanger,‖ Energy Build., vol. 88, pp. 361–366, 2015.

[19] R. Raj, N. Shankar Lakshman, and Y. Mukkamala, ―Single phase flow heat transfer and pressure drop measurements in doubly enhanced tubes,‖ Int. J. Therm. Sci., vol. 88, pp. 215–227, 2015.
[20] K. S. Syed, M. Ishaq, Z. Iqbal, and A. Hassan, ―Numerical study of an innovative design of a finned double-pipe heat exchanger with variable fin-tip thickness,‖ Energy Convers. Manag., vol. 98, pp. 69–80, 2015.
[21] Z. Iqbal, K. S. Syed, and M. Ishaq, ―Fin design for conjugate heat transfer optimization in double pipe,‖ Int. J. Therm. Sci., vol. 94, pp. 242–258, 2015.
[22] L. N. A.-H. Hussain H. Al-Kayiem, ―Performance Enhancement of Double Pipe Heat Exchangers by Enforced Turbulence on Single,‖ no. July, 2015.
[23] M. Sheikholeslami, M. Gorji-Bandpy, and D. D. Ganji,―Experimental study on turbulent flow and heat transfer in an air to water heat exchanger using perforated circular-ring,‖ Exp. Therm. Fluid Sci., vol. 70, pp. 185–195, 2016.
[24] M. Sheikholeslami and D. D. Ganji, ―Heat transfer enhancement in an air to water heat exchanger with discontinuous helical turbulators; experimental and numerical studies,‖ Energy, vol. 116, no. 1, pp. 341–352, Dec. 2016.
[25] M. Sheikholeslami and D. Domiri Ganji, ―Turbulent heat transfer enhancement in an air-to-water heat exchanger,‖ Proc. Inst. Mech. Eng. Part E J. Process Mech. Eng., vol. 231, no. 6, pp. 1235–1248, 2016.
[26] S. Skullong, P. Promvonge, N. Jayranaiwachira, and C. Thianpong, ―Experimental and numerical heat transfer investigation in a tubular heat exchanger with delta-wing tape inserts,‖ Chem. Eng. Process. Process Intensif., vol. 109, pp. 164–177, 2016.
[27] A. El Maakoul, A. Laknizi, S. Saadeddine, A. Ben Abdellah, M. Meziane, and M. El Metoui, ―Numerical design and investigation of heat transfer enhancement and performance for an annulus with continuous helical baffles in a double-pipe heat exchanger,‖ Energy Convers. Manag., vol. 133, pp. 76–86, 2017.
[28] M. R. Salem, M. K. Althafeeri, K. M. Elshazly, M. G. Higazy, and M. F. Abdrabbo, ―Experimental investigation on the thermal performance of a double pipe heat exchanger with segmental perforated baffles,‖ Int. J. Therm. Sci., vol. 122, pp. 39–52, 2017.
[29] K. Kamboj, G. Singh, R. Sharma, D. Panchal, and J. Hira, ―Heat transfer augmentation in double pipe heat exchanger using mechanical turbulators,‖ Heat Mass Transf. und Stoffuebertragung, vol. 53, no. 2, pp. 553–567, 2017.
[30] V. M. Hameed and M. A. Hussein, ―Effect of new type of enhancement on inside and outside surface of the tube side in single pass heat exchanger,‖ Appl. Therm. Eng., vol. 122, pp. 484–491, 2017.
[31] B. M. E. M. Vinous M. Hameed, ―Turbulent flow heat transfer and pressure loss in a double pipe heat exchanger with triangular fins,‖ Int. J. ENERGY Environ., vol. 7, no. 2, pp. 149–158, 2016.
[32] S. Skullong, P. Promvonge, C. Thianpong, N. Jayranaiwachira, and M. Pimsarn, ―Thermal performance of heat exchanger tube inserted with curved-winglet tapes,‖ Appl. Therm. Eng., vol. 129, pp. 1197–1211, 2018.
[33] A. Bartwal, A. Gautam, M. Kumar, C. K. Mangrulkar, and S. Chamoli, ―Thermal performance intensification of a circular heat exchanger tube integrated with compound circular ring–metal wire net inserts,‖ Chem. Eng. Process. Process Intensif., vol. 124, pp. 50–70, 2018.
[34] P. W. Sunu, I. M. Arsawan, D. S. Anakottapary, I. D. M. C. Santosa, and I. K. A. Yasa, ―Experimental Studies on Grooved Double Pipe Heat Exchanger with Different Groove Space,‖ J. Phys. Conf. Ser., vol. 953, no. 1, 2018.
[35] A. T. Wijayanta, I. Yaningsih, M. Aziz, T. Miyazaki, and S. Koyama, ―Double-sided delta-wing tape inserts to enhance convective heat transfer and fluid flow characteristics of a double-pipe heat exchanger,‖ Appl. Therm. Eng., vol. 145, pp. 27–37, 2018.
[36] R. Thejaraju, R. Bedi, S. P. Joseph, and E. Paul, ―Numerical study of thermal performance in a circular pipe using angle plate inserts directed in horizontal and vertical direction,‖ JP J. Heat Mass Transf., vol. 15, no. 4, pp. 791– 811, 2018.