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Performance Analysis of The Hairpin Heat Exchanger Using Different Nano Fluids

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ABSTRACT - An apparatus that moves heat from one fluid to another is a heat exchanger. To avoid mixing, the fluids may be separated by a solid wall, or they may be in direct touchHairpin Exchangers are available in bare tubes, finned tubes, U-tubes, straight tubes (with rod-thru capability), fixed tube sheets, and detachable bundles. They also come in single tubes (Double Pipe) and numerous tubes within a hairpin shell (Multitude). The combination characteristics of nano fluid and base fluid water are calculated in this article. Magnesium Oxide and silver nano particle volume fractions of 0.35, 0.45, 0.55, and 0.65 percent at varied velocities (0.5, 1,1.5, and 2 m/s) were used as nano fluids. The properties of nanofluids are calculated theoretically, and the results are used as inputs for analysisA 3D model of the hair pin heat exchanger with and without twisted tape is made using CREO parametric software. CFD analysis of the hair pin heat exchanger is performed at different nanofluid volume fractions. The pressure drop, Reynolds number, heat transfer coefficient, and Nusselt number are all determined using CFD analysis.

KEYWORDS - Hair pin heat exchanger, CFD study, and finite element analysis.

I. INTRODUCTION

HEAT EXCHANGER DESIGN, INC. a full array of hairpin exchangers is available. These exchangers provide true counter-current flow and are especially suitable for needs involving extreme temperature crossover, high pressure, high temperature, and low to direct surface region.Our Hairpin Exchangers are accessible in single cylinder (Double Pipe) or various cylinders inside a clasp shell (Multitube), exposed tubes, finned tubes, U-tubes, straight cylinders (with pole through capacity), fixed tube sheets and removable group. The area of the surface ranges from one square foot to six thousand square feet (Finned tubes). Capabilities for pressure range from full vacuum to more than 14,000 PSI (restricted by size, material, and configuration condition). Clip Exchangers are made in line with TEMA and ASME rules in design and production. An knowledge of the capital expenditure and power requirements (Running expense) of an intensity exchanger is provided by the pressure drop and region anticipated for a given measure of intensity move. Ordinarily, there is loads of writing and hypotheses to plan an intensity exchanger as per the necessities.

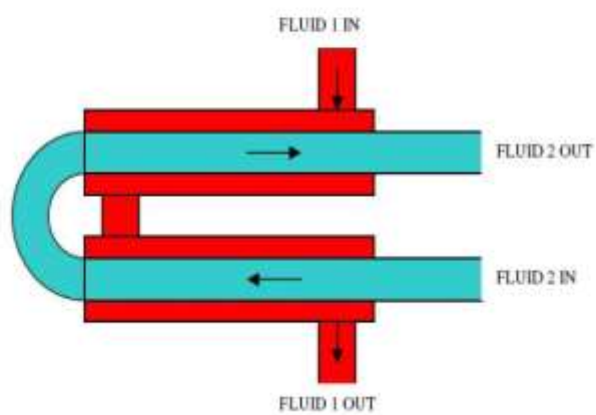

Figure 1: Heat Exchange Block Diagram.

II. LITERATURE REVIEW

In mechanical method, pipe-in-pipe warmth exchangers are used to increase the temperature between the fluids in the strategy. The [1] plan and experimental analysis of these devices are displayed. After the project was finished, a direct-in-pipe heat exchanger with a tube that is imbalanced and has a sharp section was developed. The sharp edges have been identified as semi-spherical shapes that were created in an overlapping manner with 50mm spacing. The equilibriums had actually been provided on the interior of the chamber to increase the amount of bloodless[2] water. The number of sharp edges increased to 18, with its peak at 10 mm and thickness at 1.6 mm. For a heat exchanger without balances and with sharp[3] edges, preliminary work has been completed. The test was conducted to determine the maximum warm, bloodless fluid flow rates. The limit that each glow exchanger fills in an approach is where they are all arranged in wards.[3] Although the crucial times for warmth flow and the burden drop in a two-channel heat exchanger are available, using these circumstances to support the association is difficult. Based on the findings of the[4] CFD study, logical association of the exchanger has been supported at this time. Currently, the CFD test is based on the standard ok-illustration format.[5] When a predetermined flow speed of the approach circulation is to be treated for a given narrows to outlet temperature, the strategy of the problem produces the best checks of inward pipe distance across, outdoor channel broadness, and application movement price for use for a two-channel heat exchanger of a given appropriate period. Warm analysis of a double pipe heat exchanger with conversion. The materials-based CFD [5] heat exchanger is a device used to exchange the glow-essentiality between the two fluids through which the working efficiency is increased. These Efficiencies anticipate significant employment for low-cost Operations within th[5]e way of undertakings. The two fluids' temperatures will fluctuate as they pass through the glow exchanger. [6]This paper's primary objective is to control the display speed of a two-channel heat exchanger by altering the materials that utilise glow commitment from steam waste recovery in medical office processes.[7] CATIA and GAMBIT are used to organise double channel heat exchangers. ANSYS is utilised to conduct the CFD exam. With three distinct types of, convincing results are gained. This balance was purposefully[8] created to be in an upward position inside of an uneven, diagonal partition with opposing sides. The final component was embraced over the pipe, with the decreasing edges submerged up to semi-indirect[9] within the channel. Cold fluid enters to one stop and exits to another as hot fluid enters to one stop.[10] Within the pipe, the heated liquid is moving erratically. Due to the increased contact surface, this flow is increasing the sufficient warmth move rating.[11] Learn about the warm convective temperature circulation that occurs through conduction at the channel with balances.[12] This method is specifically designed to create a warm flow area, switch the circulating channel, and shorten the cooling time with reduced size. The design is uncertain at this time by usage, thus general appraisal is made.

III. MODELING AND ANALYSIS

The term "computer supported design" (CAD) refers to the use of computer workstations or frameworks to assist in the development, modification, or construction of a product. Computer programmes that aid in planning are used to build organisational skills, work on setup concepts, as well as create correspondences through documentation and data sets for collection. Computer-assisted planning yield is always provided as electronic data for printing, machining, or other assembling projects. CADD is another term that is used to refer to computer-aided design and drafting. Three-layered interactive computer-aided application is abbreviated as CATIA. It is one of the important three-D programmes used by relationships in unique businesses ranging from flight, car, and customer issues. CATIA is a multi-stage 3-D design programme(see figure 1-9).

A. Dimensions of Designed Double Tube Hair-Pin Heat Exchanger

Outer pipe specification Inner tube specification
Copper tube of U bends
I.D. of shell= 19.05 mm
I.D. of tube = 8.4 mm
Copper tube of U bends
I.D. of shell= 19.05 mm
I.D. of tube = 8.4 mm
O.D. of shell = 22 mm O.D. of tube = 9.5 mm
Center to center distance is taken
Wall thickness= 0.55 mm
1.5 - 1.8 times of outer dia. of shell.
Thermal conductivity of wall= 385 w/m2K
Length of each G.I. pipe =
22.86cm
Effective length of copper tube through which heat transfer could take place=45cm
Total length of the copper tube = straight part
(51cm) + U-shaped bend part (9cm) =60cm

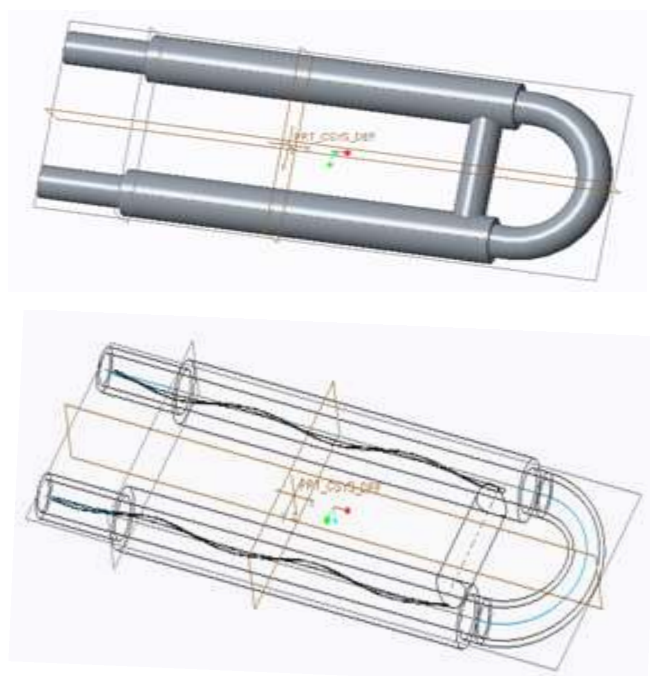

Figure 2: 3D model of hair pin heat exchanger

During the planning stage, FEM/FEA aids in assessing jumbled structures in a framework. With the aid of PCs and FEA, the model's strength and layout may be increased, which justifies the expenditure of the inquiry. The plan of the designs that were built quite a while ago has been noticeably expanded by FEA.

B. CFD

A branch of liquid mechanics called computational liquid elements—often abbreviated as CFD—uses mathematical techniques and simulations to address and investigate problems involving liquid streams(see table 1).

Calculations to Analyze Nano Fluid Properties Using Variable Volume Fractions Nano Fluid Calculations: Nano Fluid Properties

Table 1: Nano Fluid Properties from Theoretical Calculations

FLUID	Volume fraction	Thermal conductivity (w/m-k)	Specific heat (J/kg-k)	Density (kg/m^3)
MAGNESIUM OXIDE	0.35	2.8234	1711.2	2001.3
	0.45	3.0993	1831.14	2160.01
	0.55	3.2123	1976.12	2300.21
	0.65	3.5341	2078.34	2450.45
SILVER	0.35	3.0923	612.23	5192.37
	0.45	3.2587	682.001	5274.01
	0.55	3.4212	750.12	5356.89
	0.65	3.7561	823.45	5498.79

IV. RESULTS AND DISCUSSION

A. CFD Analysis of Hair Pin Heat Exchanger Imported Model

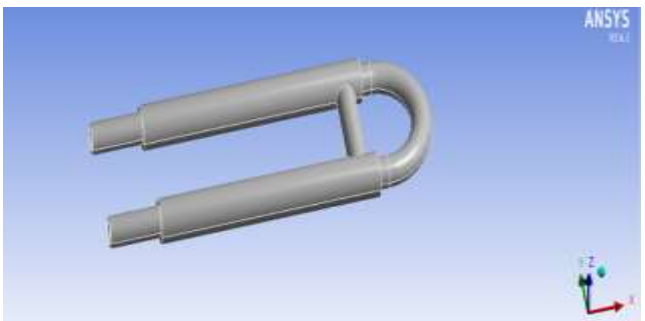

Figure 3: 3D software model

Figure 4: Meshed model

The version is planned using CATIA, and occasionally it is imported into ANSYS for meshing and testing. Temperature dispersion and stress profile are computed using CFD analysis. The liquid ring is divided into two related volumes for lattice. Then, 360 spans are coincided with all of the thickness edges. It makes use of a tetrahedral structural network. The total number of hubs and additives in this case is 6576 and 3344, respectively.

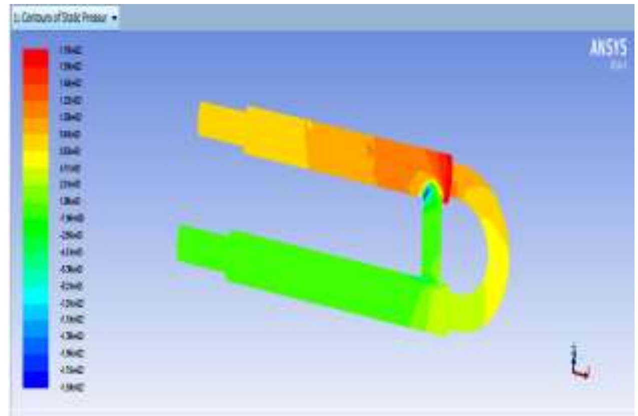

Figure 5: Static Pressure

According to the counter plot shown in figure 5, the applied strain at the gulf causes the highest strain drops at the cylinder's channel and the least tension beyond the cylinder. 1.75e+02 Pa is the highest strain, and 2.51e+01 Pa is the lowest tension.

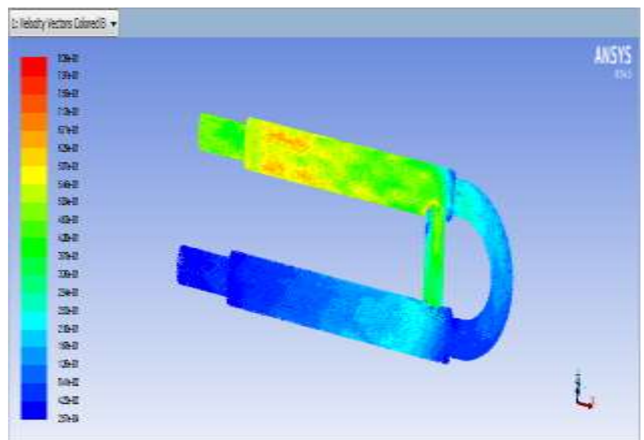

Figure 6: Velocity

According to the counter shown in figure 6, the applied speed at the channel causes the greatest velocity at the cylinder's outlet and the least velocity at the cylinder's inlet. 8.36e+01 m/s is the fastest speed, and 2.51e-04 m/s is the slowest speed.

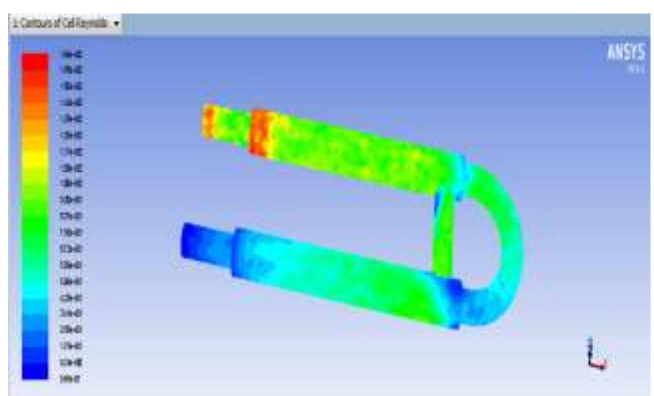

Figure 7: Re Number and its bay has the lowest Re given the applied speed at the channel

According to the counter plot shown in figure 7, the cylinder's outlet has the highest Re Number and its bay has the lowest Re given the applied speed at the channel. Re ranges from the most extreme 1.66e+02 to the least, 9.22e+01.

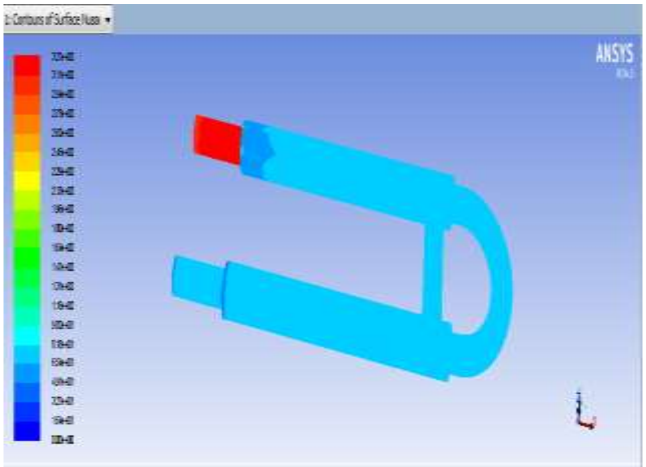

Figure 8: The largest and smallest Nusselt numbers

According to the counter plot shown in figure 8, the applied speed at the channel results in the highest Nusselt Number at the cylinder's outlet and the lowest Nusselt Number at the cylinder's delta. The largest and smallest Nusselt numbers are 3.27e+02 and 1.16 e+01 respectively.

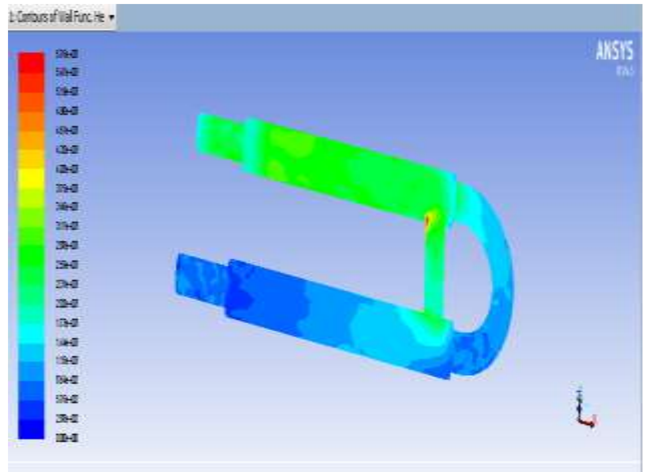

Figure 9: Heat transfer coefficient

According to the counter plot shown in figure 9, in view of the applied speed at bay, the largest heat transfer coefficient occurs at the cylinder's outlet and the least heat transfer coefficient occurs at the cylinder's delta.
2.76 e+02 and 6.67 e+03, respectively, are the largest and smallest heat move coefficients.

Table 2: Without twisted tape

Fluid	Inlet velocity (m/s)	Pressure (pa)	Velocity (m/s)	Re	Friction Factor	Nu	Heat transfer coefficient (w/m^2-k)
Water	**0.5**	1.78e+02	0.83	1.66e+02	3.02	3.27e+02	5.76e+03
	1	5.35e+02	1.62	2.74e+02	12.74	3.46e+02	1.03e+04
	1.5	1.05e+03	2.40	4.66e+02	1.73e+01	3.52e+02	1.44e+04
	2	1.81e+03	3.22	7.64e+02	2.90e+01	3.55e+02	1.81e+04

Table 3: With twisted tape

Fluid	Inlet velocity (m/s)	Pressure (pa)	Velocity (m/s)	Re	Friction Factor	Nu	Heat transfer coefficient (w/m^2-k)
Water	**0.5**	1.96e+02	0.831	1.70e+02	4.12	3.37e+02	6.76e+03
	1	5.75e+02	1.623	2.79e+02	13.54	3.56e+02	1.11e+04
	1.5	1.15e+03	2.401	4.96e+02	1.79e+01	3.62e+02	1.53e+04
	2	1.92e+03	3.222	7.84e+02	3.12e+01	3.65e+02	1.88e+04

B. Fluid –Magnesium Oxide

Table 4: Without twisted tape

Fluid	Inlet velocity (m/s)	Pressure (pa)	Velocity (m/s)	Re	Friction Factor	Nu	Htc (w/m²-k)
MgO (0.35)	0.5	3.50e+02	0.831	1.49e+02	6.93	7.31e+01	1.24e+04
	1	1.003e+03	1.612	1.84e+02	2.09e+01	7.48e+01	2.18e+04
	1.5	2.16e+03	2.389	2.72e+02	3.92e+01	7.64e+01	2.98e+04
	2	3.58e+03	3.16	3.88e+02	6.18e+01	7.69e+01	3.73e+04
MgO (0.45)	0.5	3.61e+03	0.8312	1.52e+02	7.33	6.74e+01	1.44e+04
	1	1.34e+03	1.61	1.92e+02	2.17e+01	6.86e+01	2.45e+04
	1.5	2.31e+03	2.37	2.93e+02	4.11e+01	7.02e+01	3.43e+04
	2	4.36e+03	3.21	4.64e+02	6.67e+01	7.07e+01	4.31e+04
MgO (0.55)	0.5	3.68e+03	0.8291	1.55e+02	7.62	6.53e+01	1.59e+04
	1	3.68e+02	1.61	2.05e+02	.26e+01	6.63e+01	2.80e+04
	1.5	1.23e+03	2.39	3.25e+02	4.30e+01	6.76e+01	3.81e+04
	2	4.36e+03	3.19	4.90e+02	6.93e+01	6.79e+01	4.78e+04
MgO (0.65)	0.5	4.38e+02	0.8312	1.57e+02	7.93	5.98e+01	1.82e+04
	1	1.50e+03	1.61	2.2e+02	2.34e+01	6.09e+01	3.15e+04
	1.5	2.60e+03	2.391	3.55e+02	4.49e+01	6.18e+01	4.34e+04
	2	511e+03	3.19	5.38e+02	7.31e+01	6.26e+01	4.98e+04

Table 5:. With twisted tape

Fluid	Inlet velocity (m/s)	Pressure (pa)	Velocity (m/s)	Re	Friction Factor	Nu	Heat transfer coefficient (w/m²-k)
MgO (0.35)	0.5	3.56e+02	0.832	1.53e+02	7.04	7.38e+01	1.30e+04
	1	1.05e+03	1.614	1.92e+02	2.19e+01	7.57e+01	2.27e+04
	1.5	2.18e+03	2.390	2.84e+02	4.12e+01	7.72e+01	3.11e+04
	2	3.72e+03	3.162	3.95e+02	6.26e+01	7.81e+01	3.94e+04
MgO (0.45)	0.5	3.72e+03	0.8314	1.65e+02	7.42	6.82e+01	1.65e+04
	1	1.44e+03	1.615	1.96e+02	2.26e+01	6.93e+01	2.55e+04
	1.5	2.54e+03	2.373	2.99e+02	4.24e+01	7.12e+01	3.51e+04
	2	4.44e+03	3.214	4.75e+02	6.78e+01	7.17e+01	4.49e+04
MgO (0.55)	0.5	3.76e+03	0.8294	1.65e+02	7.72	6.63e+01	1.67e+04
	1	3.82e+02	1.615	2.15e+02	2.41e+01	6.73e+01	2.89+04
	1.5	1.36e+03	2.392	3.33e+02	4.45e+01	6.79e+01	3.88e+04
	2	4.51e+03	3.191	4.92e+02	7.12e+01	6.85e+01	4.89e+04
MgO (0.65)	0.5	4.42e+02	0.8315	1.64e+02	8.012	6.07e+01	1.96e+04
	1	1.62e+03	1.616	2.49e+02	2.54e+01	6.17e+01	3.26e+04
	1.5	2.73e+03	2.395	3.68e+02	4.65e+01	6.27e+01	4.43e+04
	2	5.21e+03	3.192	5.45e+02	7.51e+01	6.37e+01	5.12e+04

C. Fluid –Silver Nano Fluid

Table 6: Without twisted tape

Fluid	Inlet velocity (m/s)	Pressure (pa)	Velocity (m/s)	Re	Friction Factor	Nu	Heat transfer coefficient (w/m²-k)
Ag (0.35)	0.5	7.84e+02	0.831	2.42e+02	1.28e+01	6.86e+01	1.84e+04
	1	2.71e+03	1.63	6.14e+02	3.94e+01	7.01e+01	2.96e+04
	1.5	5.54e+03	2.41	1.32e+03	7.91e+01	7.06e+01	3.87e+04
	2	9.4e+03	3.21	2.7e+03	1.27e+02	7.10e+01	4.68e+04
Ag (0.45)	0.5	7.95e+02	0.834	2.48e+02	1.30e+01	6.6e+01	2.01e+04
	1	2.73e+03	1.632	6.28e+02	4.03e+01	6.77e+01	3.22e+04
	1.5	5.55+03	2.412	1.45e+03	8.11e+01	6.89e+01	4.05e+04
	2	9.45e+03	3.25	2.82e+03	1.45e+02	7.01e+01	4.95e+04
Ag (0.55)	0.5	8.01e+03	0.837	2.58e+02	1.32e+01	6.27e+01	2.19e+04
	1	2.83e+02	1.619	6.47e+02	4.09e+01	6.41e+01	3.52+04
	1.5	5.65e+03	2.431	1.59e+03	8.13e+01	6.56e+01	4.55e+04
	2	9.49e+03	3.251	2.96e+03	1.321e+02	6.96e+01	5.12e+04
Ag (0.65)	0.5	8.48e+02	0.837	2.63e+02	1.33e+01	5.83e+01	2.42e+04
	1	2.91e+03	1.619	6.72e+02	4.10e+01	5.90e+01	3.91e+04
	1.5	5.69e+03	2.431	1.63e+03	8.14e+01	5.96e+01	4.95e+04
	2	9.51e+03	3.271	3.12e+03	1.42e+02	6.09e+01	5.88e+04

Table:7 With twisted tape

Fluid	Inlet velocity (m/s)	Pressure (pa)	Velocity (m/s)	Re	Friction Factor	Nu	Heat transfer coefficient (w/m²-k)
Ag (0.35)	0.5	7.89e+02	0.836	3.42e+02	1.32e+01	6.76e+01	1.94e+04
	1	2.76e+03	1.634	7.24e+02	4.12e+01	6.85e+01	3.42e+04
	1.5	5.59e+03	2.414	1.52e+03	8.12e+01	7.0e+01	3.95e+04
	2	9.47e+03	3.216	2.82e+03	1.44e+02	7.06e+01	4.78e+04
Ag (0.45)	0.5	8.12e+02	0.837	2.48e+02	1.39e+01	6.56e+01	2.11e+04
	1	2.84e+03	1.636	6.38e+02	4.13e+01	6.61e+01	3.34e+04
	1.5	5.59+03	2.415	1.65e+03	8.19e+01	6.72e+01	4.45e+04
	2	9.55e+03	3.252	2.92e+03	1.56e+02	6.89e+01	5.12e+04
Ag (0.55)	0.5	8.11e+03	0.838	2.68e+02	1.39e+01	6.21e+01	2.43e+04
	1	2.93e+02	1.642	6.57e+02	4.19e+01	6.36e+01	3.68+04
	1.5	5.75e+03	2.424	1.67e+03	8.23e+01	6.51e+01	4.78e+04
	2	9.55e+03	3.258	3.15e+03	1.328e+02	6.90e+01	5.54e+04
Ag (0.65)	0.5	8.55e+02	0.839	2.84e+02	1.39e+01	5.67e+01	2.78e+04
	1	3.12e+03	1.621	6.88e+02	4.19e+01	5.74e+01	4.45e+04
	1.5	5.76e+03	2.439	1.74e+03	8.14e+01	5.79e+01	5.7e+04
	2	9.66e+03	3.261	3.38e+03	1.42e+02	5.83e+01	6.12e+04

D. Comparison between Inlet velocities Vs pressure

Here we compare the Intel velocities and pressure and shown in figure 10 to 12.

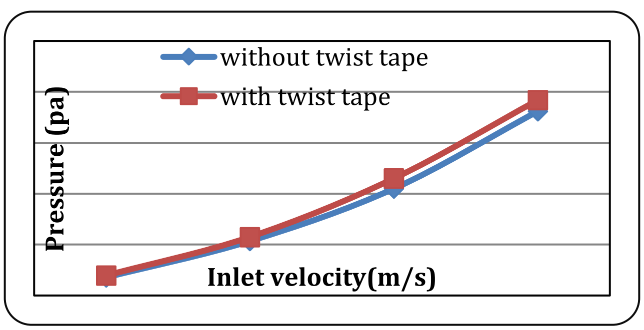

Figure 10: Inlet velocities Vs Heat transfer coefficient

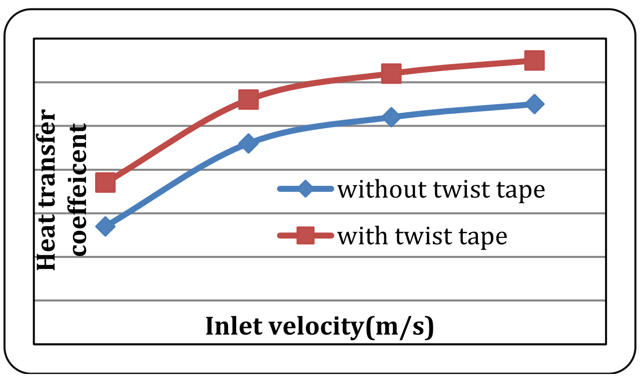

Figure 11: Inlet velocities Vs Friction factor

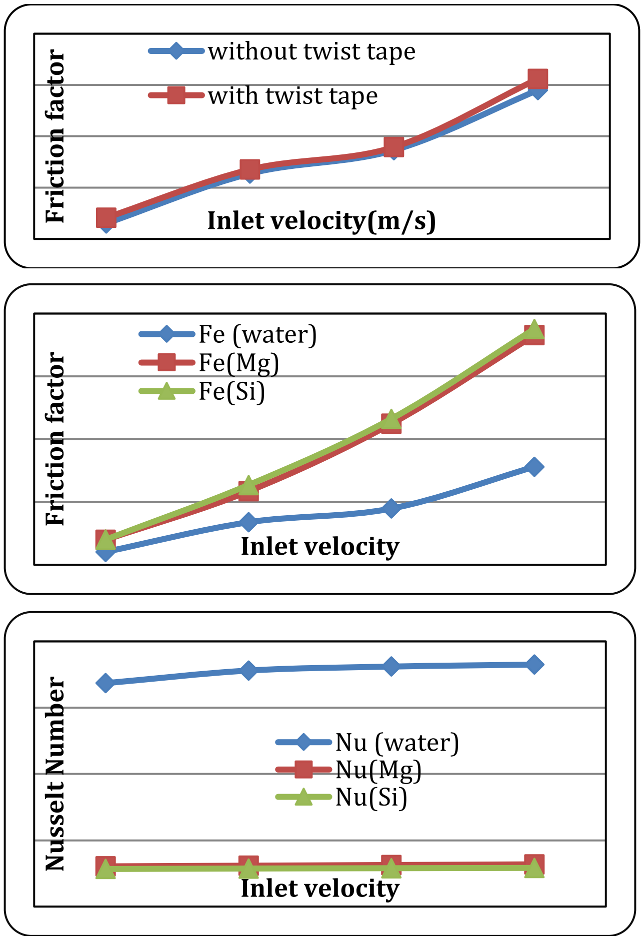

Figure 12: Comparison graphs

V. CONCLUSION

This study examines the qualities of a nanoliquid mixture with water as the foundation liquid. Magnesium oxide and silver nanomolecules in volumes of 0.35, 0.45, 0.55, and 0.65% are the nanoliquids, moving at different speeds of 0.5, 1, 1.5, and 2 m/s. The properties of nano fluid are determined by fictitious computations, and those qualities are then used as contributions for analysis.

In CREO parametric programming, a 3D model of the hair clip heat exchanger with and without bent tape is completed. The Barrette heat exchanger's CFD analysis has been completed in several micro liquid volume regions. The strain drop, Reynolds number, heat transfer coefficient, and Nusselt number are determined using CFD analysis.By noticing the CFD investigation results the rising the speeds builds the grinding variable and intensity move coefficient values.

By looking at the CFD test results, it can be shown that the bent tape model and silver nanomolecule (0.65%) have grating elements and intensity move coefficients that are more valuable. In this manner, it is extremely possible to conclude that the silver nano liquid (0.5%) is the superior liquid for the barrette heat exchanger with twisted tape model (see table table 2 to 7).

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

[1] A.O. Adelaja, S. J. Ojolo and M. G. Sobamowo, "PC Aided Analysis of Thermal and Mechanical Design of Shell and Tube Heat Exchangers", Advanced Materials Vol. 367 (2012) pp 731-737 © (2012) Trans Tech Publications, Switzerland.

[2] Yusuf Ali Kara, Ozbilen Guraras, "A PC program for structuring of Shell and cylinder heat exchanger", Applied Thermal Engineering 24(2004) 1797–1805

[3] Rajagapal THUNDIL KARUPPA RAJ and Srikanth GANNE, "Shell side numerical investigation of a shell and cylinder heat exchanger considering the impacts of perplex tendency edge on liquid stream", Thundil Karuppa Raj, R., et al: Shell Side Numerical Analysis of a Shell and Tube Heat Exchanger, THERMAL SCIENCE: Year 2012, Vol. 16, No. 4, pp. 1165-1174.

[4] S. Noie Baghban, M. Moghiman and E. Salehi, " Thermal investigation of shell-side progression of shell-and cylinder heat exchanger utilizing trial and hypothetical strategies" (Received: October 1, 1998 - Accepted in Revised Form: June 3, 1999).

[5] A. GopiChand, Prof. A.V.N.L. Sharma, G. Vijay Kumar, A. Srividya, "Warm examination of shell and cylinder heat exchanger utilizing mat lab and floefd software", Volume: 1 Issue: 3 276 – 281, ISSN: 2319 – 1163.

[6] Hari Haran, Ravindra Reddy and Sreehari, "Warm Analysis of Shell and Tube Heat Exchanger Using C and ANSYS", International Journal of Computer Trends and Technology (IJCTT) – volume 4 Issue 7–July 2013.

[7] Donald Q.Kern. 1965. Procedure Heat move (23rdprinting 1986). McGraw-Hill companies. ISBN 0-07-Y85353-3.

[8] Richard C. Byrne Secretary. 1968. Cylindrical Exchanger Manufacturers Association, INC. (eighth Edition). 25 North Broadway Tarrytown, New York 10591.

[9] R.H Perry. 1984. Perry's Chemical Engineer's Handbook (sixth Edition Ed.). McGraw-Hill. ISBN 0-07-049479-7.

[10] Ender Ozden, Ilker Tari, Shell Side CFD Analysis of A Small Shell And Tube Heat Exchanger, Middle East Technical University, 2010.