RESEARCH ARTICLE OPEN ACCESS

THERMAL HYDRAULIC PERFORMANCES OF WATER BASED NANO FLUIDS IN A MCPFHS: A NUMERICAL APPROACH

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ABSTRACT
Numerical study was applied on the influence of Nano fluids (Al_2O_3-water, Z_nO-water, S_iO_2-water and T_iO_2-water) as a fluid at volumetric concentration has used (c= 4%) in micro circular pin fin heat sink has studied with the assistance of simulations developed victimization commercially accessible procedure fluid dynamics software Fluent fourteen. The comparison of liquid flow and heat transfer characteristics of cooling fluids have been created beneath the similar stipulation and also the range of Reynolds number has used (100-500). The obtained results are illustrated that, Z_nO-water Nano fluid is offers the minimum pressure drop and most heat transfer rate compared to S_iO_2-water and T_iO_2-water Nano fluids. And Al_2O_3-water Nano fluid is offers most heat transfer rate compared to others. It's additionally supported that Al_2O_3-water & T_iO_2-water Nano fluids offer approximate same performance on pressure drop.

Keywords- Thermo hydraulic performance, Micro pin fins, Nano Liquid, Fluent.

I. INTRODUCTION
Last few years' heat management of electronic chips is way centred topic of the many investigators. over the year's investigators are develop several devices for heat management among of them micro circular pin-fin sink is one amongst the extensively used device for cooling of electronics chips, as a result of their high heat transfer, effectiveness, compact size, and high area per unit volume. so as to reinforce the thermo hydraulic performances of MCPFHS, it's essential such a lot of techniques are recommended by the investigation one amongst it, is Nano fluid is employed as a fluid for improve the heat transfer rate. Nano fluid could be a form of fluid containing tiny amount of Nano meter size particle of metal or metal compound is suspended uniformly in a base fluid like oil, water etc. But due to have the metal particles in the fluid, increases the pressure drop which are responsible for more pump work. So pressure drop is also essential aspect for the investigation. Denpong Soodphakdee et al (2001) [1] They have observed that at lower value of pressure drop & pumping power elliptical fins gives best performance and at higher value of pressure drop & pump power round fin work best. Also analysis the staggered arrangement gives better performance than inline arrangement by their CFD simulation of the heat transfer of heat sink with used fin geometry (round, elliptical or square) and plate fin in staggered & inline arrangement. C.J. Ho and Chen (2013) [6] they did trial studied in copper mini channel heat sink using Al2O3- water Nano fluid and determine forced convective heat transfer. They take Reynolds number ranging from 133 to 1515 & they compare the result with the pure water & on the base of inlet & bulk temperature difference they calculate average heat transfer coefficient & after the trial they set up the Nano fluid cooled heat sink gives higher average heat transfer coefficient as compare to pure water. Md. Farahad Ismail et al (2013) [8] they observed that perforated fins gives better effectivity compared to the solid fins and also found that both the cross-section gives same amount of heat dissipation rate but circular fin gives less pressure drop by their numerically investigation on the turbulence heat convection from solid and longitudinally perforated rectangular fin. Ahmadreza Abbasi Baharanchi (2013) (13) He sheds light on the present state of the art tentative exploration started in this field and hosts today's new ideas to resolve the present and forthcoming issues with fast developing devices and power generation technologies that the world is passing after he reviewed on implicit usages of Nano fluid technology in heat transfer enhancement. Mushtak Ismael Hasan (2014) (14)In this paper he has numerically investigated the flow

and heat transfer characteristics in small pin fin conductor with Nano fluid. They used three different fins (square, triangular, circular) in addition to unfinned heat sink. Nano fluids have taken as a cooling fluid instead of pure fluid. here two types of Nano fluid used (diamond-water, Al_2O_3-water) select volumetric concentration in range (1-4)% with boundary condition constant wall temperature and the Reynolds number in range (100-900) and to insure that the flow should be remain in laminar range. The result obtained from the following present work is by increasing volumetric concentration of Nano fluid increase the amount of heat dissipation and increase the pressure drop all fin shaped. In both the Nano fluid diamond-water Nano fluid is superior than Al_2O_3-water nanofluid and carry large amount of heat transfer rate another result shows the circular fin give higher heat transfer rate as compare with other fins and highest pressure drop with square fin. Tehmina Ambreen etal. (2018) (19) They have examined by discrete phase model (DPM) to square, circular and hexagon cross-section with constant fin diameter and height. And founded that under identical flow conditions, the Nano fluid cooled circular fins displayed most efficient thermal performance followed by the hexagon and square fins. While the water cooled square fins depicted lowest heat transfers characteristics. Niranjan Ramendra Singh etal. (2021) (21) They have experimental explored that the square micro-pin fins heat sink for finding the most appropriate pin fin shape for heat removal applications under forced convection. Twenty-five square micro pin fin heat sinks were verified for three different heat load and Reynolds number and founded that the large fin height lower thermal resistance at the cost of large pressure drop. The dimensionless heat transfer coefficient increases with fin height and Reynolds number while it decreases with increasing fin spacing. A. Gonzalez etal. (2021) (22) They have numerically evaluated thermal performances of staggered circular pin microchannel devices at steady and time-dependent flows in the range of $400 < Re < 2000$ with water and ethylene-glycol Nano fluids. And founded that the shear-thinning behaviour of the Nano fluids is the most critical factor in enhancing heat transfer rates due to the promotion of unsteady flows even for low Reynolds number values and a reduction of pressure drop.

Equation use for calculating properties of Nano fluid and velocity of flow

The properties of Nano fluids will be calculated by using the subsequent equations. The thermo physical properties of the Nano fluids have an effect on once using numerous parameterssuch as, the properties of the base fluid, the solid particles, volume concentration of the solid particles and particles shape.

- Thermal conductivity:

$$\frac{K_{nf}}{K_f} = \frac{K_{p+(SH-1)K_f - (SH-1)c\,(K_f - K_p)}}{K_{p+(SH-1)K_f + c\,(K_f - K_p)}} \quad (1)$$

- Viscosity : $\frac{\mu_{nf}}{\mu_f} = 1 + 2.5\,c$ (2)
- Density : $\rho_{nf} = c\rho_p + (1-c)p_f$ (3)
- Specific heat : $C_{p_{nf}} = cC_{p_p} + (1-c)C_{p_f}$ (4)
- $w_i = \frac{R_e\,\mu}{\rho\,d_h}$ (5)
- $d_h = \frac{4a}{p}$ (6)

Where: SH is solid particle shape factor.

$SH = \frac{3}{\Psi}$

Ψ is sphericity that is outlined as the ratio of the surface area of a sphere to the surface area of particles. Sphericity measure how spherical of an object is. For spherical particle SH = 3. K_{nf}, k_f, k_p are thermal conductivity of the Nano fluid, base fluid and solid particles. In this thesis four Nano fluids were used. Water is the base fluid used for all of them and the volume concentration 4% is used.

Designing parameter

Following dimensions are calculated for modeling of the specimens are given in the Table 1.

Table 1 Geometrical parameter

S.no.	Name of the specimens	Geometrical parameter
1	Base plate (heat sink)	Length = 11.5 mm, Width = 6 mm, Thickness = 1mm
2	Circular fins	Diameter = 0.5 mm, Height = 0.5 mm

Material Parameter-The properties of Nano fluids can be calculated by using the following equations. The thermo physical properties of the Nano fluids affect when using various parameters such as, the properties of the base fluid, the solid particles, volume concentration of the solidparticles and particles shape is shown in Table 2.

Table 2 Material parameter

Material	(ρ) (kg/m^3)	(C_p) (J/kg- k)	(K) (W/m-k)	(μ) (kg/m-s)
Pure water (c=0%)	981.3	4189	0.643	0.000598
Al_2O_3 -water (c = 4%)	1082.4	4041.3	0.723	0.000657
Z_nO-water (c = 4%)	1202.048	4042.864	0.7158	0.000657
S_iO_2-water (c=4%)	1362.048	4030.89	0.723	0.000657
TiO_2-water (c = 4%)	1112.048	4048.8	0.7077	0.000657

Where ρ, Cp, K and μ are density, specific heat, thermal conductivity and dynamic viscosity respectively.

II. OBJECTIVE OF THE THESIS

The present study approaches to examine the influences of Nano fluids on thermo hydraulic characteristic of micro circular pin fin heat sink withdifferentNano fluids (Al_2O_3-water, Z_nO-water,S_iO_2-water and T_iO_2-water) at 4% volumetric concentration at similar boundary condition and the range Reynolds number is 100 to 500 for further optimization of its performance.

III. METHODOLOGY

Modelling

The 3D geometric model of circular pin fin array is created by using design modular software. Following Figure showing the 3D geometry model consisting the 50 fin array staggered assembly having constant spacing S_x =S_y = 0.5 mm between each other attached from a base plate maintained uniform heat input. A fluid domain has to be builtfor examine thebehaviour of Nano fluid& heat flow from the fin, because the area of attention is the outside of fin, which is the interface between the Nano fluidand fin surface. Thus, the fluid domain consists of Nano fluid. The height of fluid domain is taken as 0.5 mm which is shown in fig. 1. Aluminium is used as material for the base plate and fins.

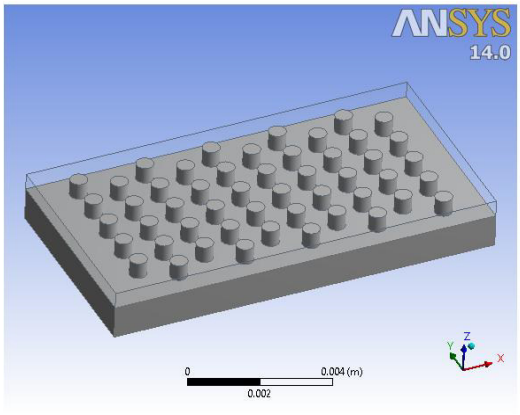


Fig. 1 Isometric view of micro circular pin fin heat sink

Meshing

Meshing of the specimen is generated by meshing software of Ansys, which play the important role in simulation.For the specimen programmable controlled meshing is generated with growth rate, relevance and span angle centre is kept fine which is shown in fig. 2.

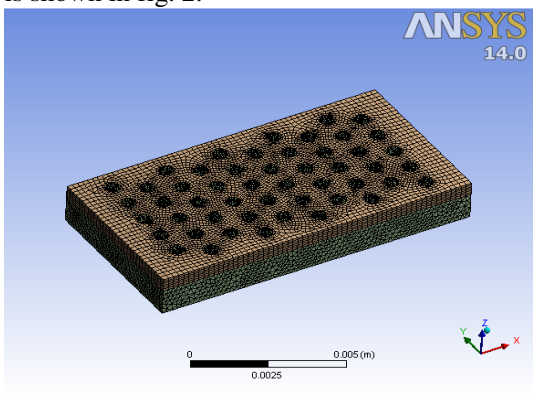


Fig. 2 Meshing of circular-finned heat sink

Simulation

To analyse the thermal performance and other characteristics of differentNano fluids with Circular-finned heat sink, after meshing of the all the specimen, output file has been created and further it was imported in fluent solver, where all the boundary condition has defined for simulation. In this study one open field has been generated for fluid flow.

(a) Flow analysis-Here domain properties and boundary condition are defined. The realizable laminar model was applied to all the simulations because of its numerical constancy for examination of fluid flow. Energy model is also used for analysis of heat flow. Viscosity and density of fluid is considered to be constant i.e. the Nano fluid is Newtonian and incompressible.

(b) Boundary conditions-The two types of boundary condition are defined at inlet and outlet, at normal atmospheric working condition.

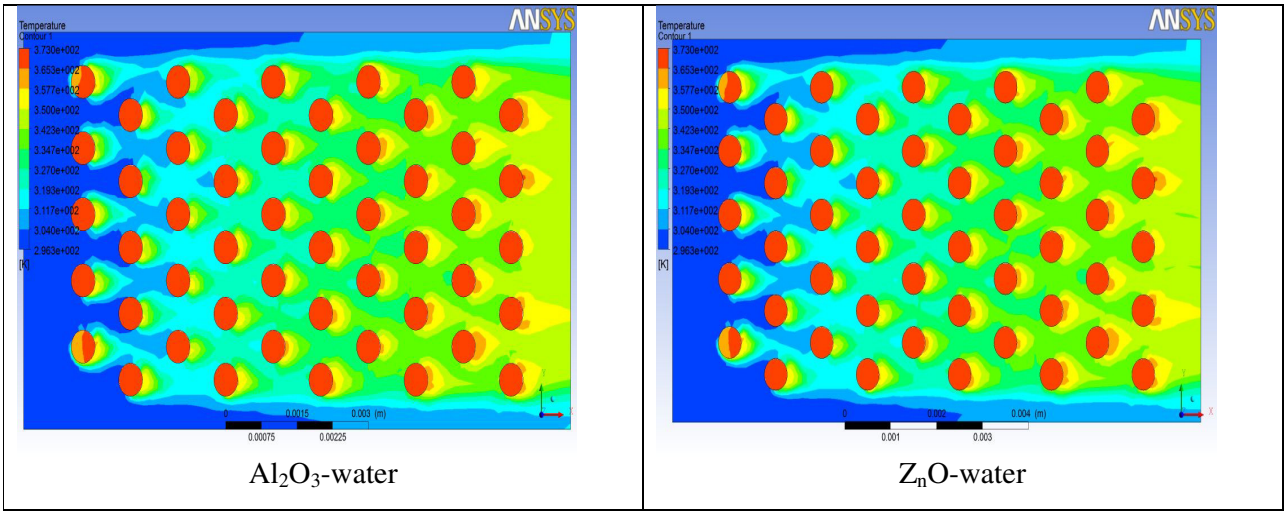
Inlet boundary- At the entrance the finite values of velocity and temperature was used at the lower surface of the heat sink with boundary condition at constant wall temperature is used (T = 373 K) and velocity is w = w_{in}, u = v = 0 which is calculated by equation (5).

Outlet boundary- At the outlet the flow assumed to be fully developed hence gauge pressure is taken zero at outlet.

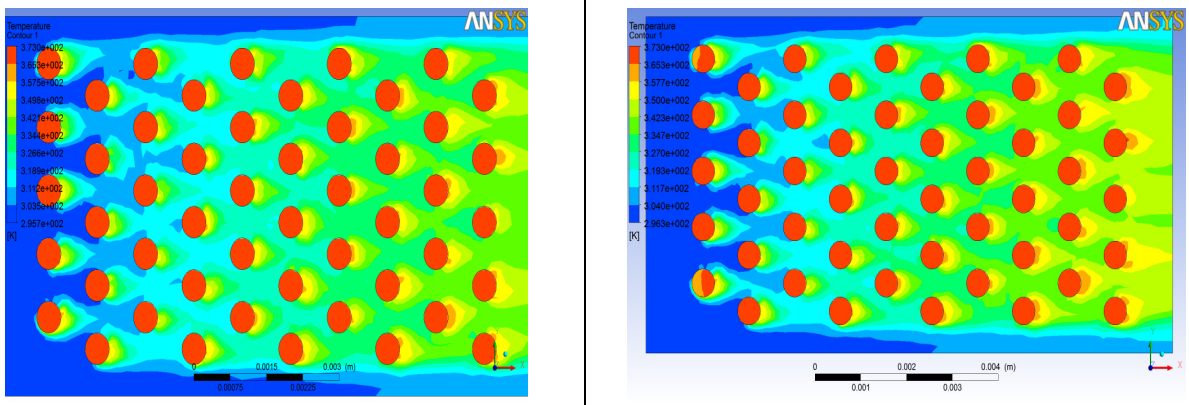
IV. Result & Discussion

Solver solves the given problem and creates a result file, which has been analysed in CFD-Post. Here temperature contour pattern and velocity contour pattern etc. has been analysed. The values of heat transfer rate and pressure are predicted at different surfaces.

(a) Temperature Distribution of Circular Heat Sink with Different Nano Fluid with Reynolds Number(Re=100)



Al_2O_3-water | Z_nO-water

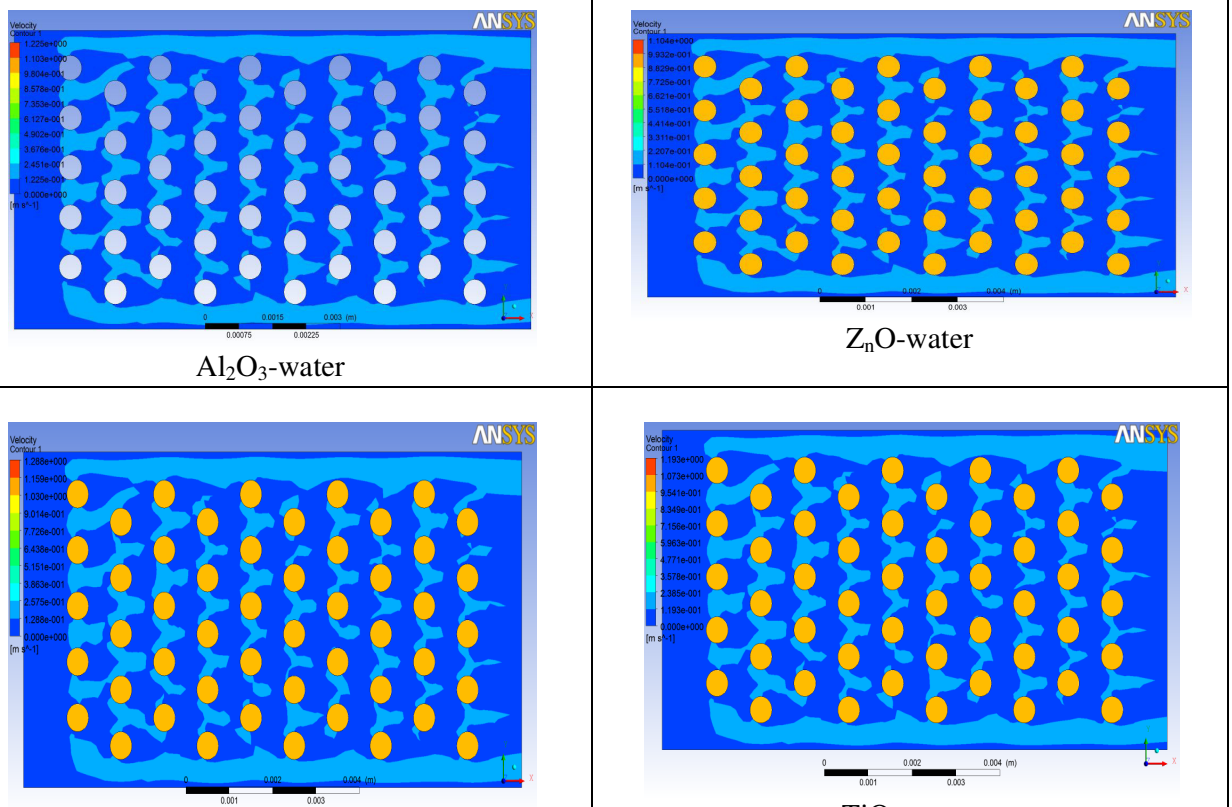


S_iO_2-water TiO_2-water

Fig. 3 Temp. Contour of circularpin fins HS with different Nano fluid at Re=100

Fig. 3 shows the temperature contour on z = 0.0002165 m at longitudinal (x-y) plan for heat sink with circular fins with different Nano-fluid (Al_2O_3-water, Z_nO-water, S_iO_2-water, TiO_2-water) with volumetric concentration (c=4%) at Re=100 respectively. It is inferred from the figure that the fins are provide better mixing for attained the higher temperature. Also at low Reynolds number due to low velocity Nano fluid gives the more time for heat transfer.

(b) Velocity Distribution of Circular Pin Fin Heat Sink with Different Nano Fluid with Reynolds Number(Re=100)



Al_2O_3-water Z_nO-water

S_iO_2-water TiO_2-water

Fig. 4 Velocity Contour of circular pin fins HS with different Nano fluid at (Re=100)

Fig 4, shows the velocity profile on z = 0.0002165 m at longitudinal (x-y) planfor micro heat sink with circularpin fin heat sinkwith different Nano-fluid (Al_2O_3-water, Z_nO-water, S_iO_2-water, TiO_2-water) with volumetric concentration (c=4%) at Re=100 respectively. From the figure it can be observed that, velocity increases at side of wall along the flow.

(a) Validation of Result of Presented Model with Reference [1] For Heat Transfer Rate and Pressure Drop.

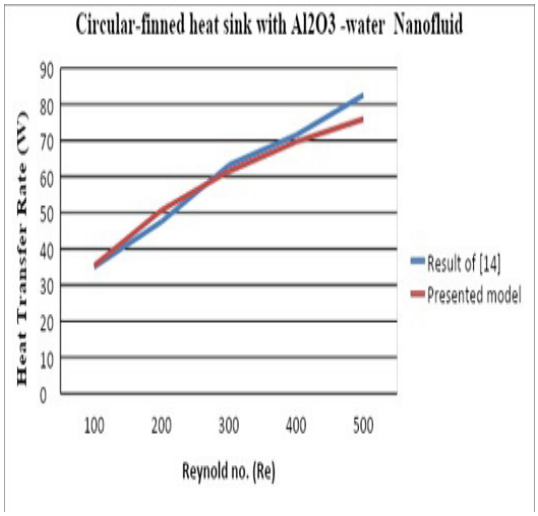


Fig 5 Comparison of heat transfer rate between the result of [14] and presented model.

Fig 5 shows the comparison between result of presented numerical model and the data of [14] forheat transfer rate and pressure dropof circular - finned heat with Al_2O_3-water Nano-fluid respectively. From these two figures it can be seen that, the valueof present model and data of [14] is very near to close. The slightly difference in both the parameter (heat transfer rate and pressure drop) due to the difference in mesh and solving control method. Therefore, the present numerical model is reliable and can be used to study the effect of Nano-fluid and geometry of fins.

(a) Graphical representation of comparison of heat transfer rate with Nano-fluids for Circular Finned heat sink.

Fig 4.11 Shows the comparison of heat transfer rate with Reynolds number with circular-finned heat sink for different Nano fluids (Al_2O_3-water, Z_nO-water, S_iO_2-water, T_iO_2-water) respectively.

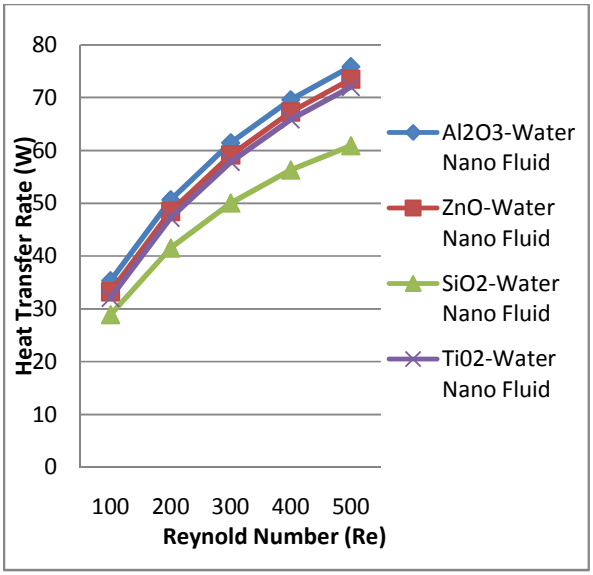


Fig 4.11 Comparison of Re of difference Nano-fluids with heat transfer rate

From the figure it has been observed that Al_2O_3-water Nano-fluid gives the higher heat transfer rate compared to other Nano-fluids due to having the higher thermal conductivity. It has been also observed that the Z_nO-water & T_iO_2-water Nano fluids give the approximate same heat transfer rate. And it has also notice that the higher Reynolds number gives the higher heat transfer rate.

(b) Graphical representation ofcomparison of pressure drop with Nano-fluids for Circular - Finned heat sink.

Fig 4.12 Shows the comparison of heat transfer rate with Reynolds number with circular-finned heat sink for different Nano fluids (Al_2O_3-water, Z_nO-water, S_iO_2-water, T_iO_2-water) respectively.

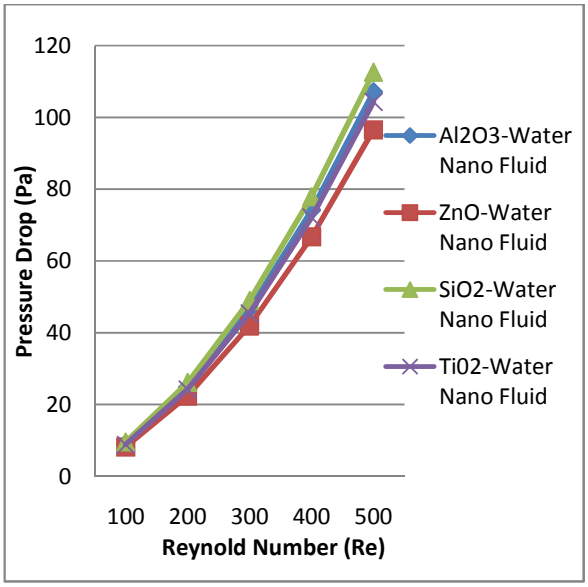


Fig 4.12 Comparison of pressure drop with Re of different Nano-fluids

From the fig it has been illustrated that the Z_nO-water Nanofluid offers the minimum pressure drop and also Al_2O_3-water &T_iO_2-water Nano fluids give approximate same pressure drop.

V. CONCLUSION & FUTURE SCOPE

Conclusion

Following facts are worth observing from the present exploration on numerical analysis for performance characteristics of different Nano fluids of circular finned-heat sink.

- At same precondition after Al_2O_3-water Nano fluid, Z_nO-water Nano fluid performs higher in heat transfer purpose of compared to others.
- Al_2O_3-water Nano-fluid provides most heat transfer rate compared to alternative Nano-fluid because of having higher thermal conductivity.It is additionally revealed that Z_nO-water Nano-fluid provides low pressure drop compared to alternative Nano-fluids as a result of it contain higher dense particle by that pump work is decreased.
- The performance of finned heat sink and Nano-fluid will be analyzed effectively by commercially accessible CFD computer code, Fluent fourteen in specific.

Suggestions for the Future Scope

In the current study and on the premise of literature review, it absolutely was assumed that the speed of heat transfer can increase by considering the employment of fins and Nano-fluid as an agent. Clear of the procedure analysis it absolutely was understood that the speed of heat transfer is magnified by using the Nano-fluid however the pressure drop is additionally will increase that is vital parameter for pump work. The procedure analysis didn't indicate of any explicit form of fins which might provide most heat transfer.

It was solely our presumption of considering only the ordinarily offered shapes like square, triangular, circular and diamond. though this fact-finding study reveals that the Al_2O_3-water performs higher in heat transfer and once this Z_nO –water Nano fluid provides the simplest heat transfer rate conjointly it provides minimum pressure drop compare to others. In all probability there would be alternative shapes of fins and differing kinds of Nano-fluid that the speed of heat transfer would be most and pressure drop would be minimum. Current study conjointly helped to find the performance of Nano-fluid. In future study an analogous thorough investigation is also performed for optimized the result with relevance concentration of Nano-fluid, spacing between the fins and using totally different kind of Nano-fluid and form of fins.

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