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Fvm Analysis for Thermal and Hydraulic Behaviour of Circular Finned Mpfhs by Using Ag-H_20 Nano Fluid

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Abstract
In this exploration the influence of using two types of Nano fluids (Ag-water and Al_20_3-water) as a coolant at volumetric concentration is taken (c= 4%) in micro pin fin heat sink with circular fins in addition to the un-finned micro-channel heat sink is deliberated with the help of commercially available computational fluid dynamics software Fluent 14. The evaluation of flow and heat transfer characteristics of MPFHS and cooling fluids has been made under the similar boundary condition; at the range of Reynolds number used is (100-500). The gotten outcomes is exemplified that, Ag-water Nano fluid is gives the minimum pressure drop and slightly maximum heat transfer rate compared to Al_20_3-water Nano fluid. And circular finned heat sink is dissipating more amount of heat compared to un-finned micro-channel heat sink. But it is also gives the maximum pressure drop due to finned area.
Key words: Nano fluid, MPFHS, Heat Transfer, Pressure drop, CFD

I. INTRODUCTION

Micro-pin-fin heat sink is one of the unique devices for cooling of microelectronic chips, due to their high heat transfer, effectiveness, compact size, and high surface area per unit volume. In order to optimize the performance of MPFHS, it is important to understand the thermal and hydrodynamic characteristics in these devices. So many techniques are suggested by the research one of it, is Nano fluid is used as a coolant for enhance the heat transfer rate. Nano fluid is a fluid contains Nano meter size particle of metal or metal oxide is suspended uniformly in a base fluid such as oil, water etc. For enhance thermal conductivity of the fluidA.A. Alfaryjat et al. (2014) [1] they are numerically examined that Water flow and heat transfer characteristics are affected by the geometrical constraints of the micro-channel heat sink with three different channel shapes hexagonal, circular, and rhombus by Finite volume method. And they founded that the smallest hydraulic diameter of the hexagonal cross-section MCHS has the highest pressure drop and heat transfer coefficient among other shapes and the rhombus cross-section MCHS gives the highest value of the top wall temperature, friction factor and thermal resistance. Mushtaq Ismael Hasan, (2014) [2] he has computationally investigated the micro pin fin heat sink with three fin geometries (square, triangular and circular) same in hydraulic diameter in addition to the un-finned micro channel heat sink, also two types of Nano-fluid (diamond-water and Al_20_3-water) in addition of pure water are used as cooling medium and founded that heat transfer is enhanced by using the Nano-fluid instead pure water as cooling medium. But it leads the pressure drop for all fins shapes also concluded diamond-water Nano fluid is better than Al_20_3-water from heat transfer point of view and circular fins give the higher heat transfer rate compared with other fins also square fins caused higher pressure drop**.** W.H. Azmi et al. (2013) [3]they are determined experimentally the heat transfer coefficients and friction factor with $Si0_2$-water Nano fluid up to 4% particle volume concentration for flow in a circular tube under constant heat flux boundary condition. And they are founded that the pressure drop increases with particle concentration up to 3.0% and decreases thereafter and the $Si0_2$ Nano fluid friction factor decreases with increase in Reynolds number at any concentration. Paisarn Naphon and Lursukd Nakharintr, (2013) [4]they are studied the heat transfer characteristics of $Ti0_2$-water Nano fluids cooling in the mini-rectangular heat sink with three different channel heights. And they found that average heat transfer rates for Nano fluids as a coolant are higher than those for water.H.A. Mohammed et all, (2011) [5]they are studied theimpact of using water as a base fluid with various types of Nano-fluids with volume fraction of 2% as the coolants such as Al_20_3, Ag, Cu0, diamond, $Si0_2$, and $Ti0_2$ on heat transfer and fluid flow characteristics in triangular shaped aluminium micro channel heat sink (MCHS) by finite volume method. And founded that diamond-water Nano fluid has the lowest temperature and the highest heat transfer coefficient, while Al_20_3-water Nano fluid has the highest temperature and the lowest heat transfer coefficient. $Si0_2$–water Nano fluid has the highest pressure drop and wall shear stress while Ag–water Nano fluid has the lowest pressure drop and wall shear stress among other Nano fluid types. And finally concluded that Diamond-water and Ag–water Nano fluids are recommended to achieve overall heat transfer enhancement and low pressure drop respectively compared with pure water. Liu et al. (2011)[6]they did deliberated experimentally the flow and heat transfer in micro square pin fin heat sink with staggered arrangement, using water as coolant, They found that, both the Nusselt number and pressure drop increased with Re and the heat resistance decreased with the pressure drop.Shaeri and Yaghoubi (2009) [7]they did investigated numerically the fluid flow and heat transfer from an array of solid and perforated fins that are mounted on a flat plate with incompressible air as working fluid. And founded that, fins with longitudinal pore, have remarkable heat transfer enhancement in addition to the considerable reduction in weight by comparison with solid fins.

R. Ricci and S. Montelpare (2006) [8] they did investigated experimentally the pin fin heat sink with fins in different shapes (circular, square, triangular and rhomboidal) arranged in-line with constant heat flux boundary condition and evaluated the convective heat transfer coefficient, i.e. the Nusselt number, of short pin fins cooled by means of water in forced convection. They found that, the triangular geometry is on an average the best with respect to the others.

Material Used for Investigation

Generally there are two types of Nano-fluid is used silver-water and alumina-water as a coolant for micro pin fin heat sink. And aluminium (Al) is used as a material for MPFHS having thermal conductivity (K=202.4 w/m-k).the thermo physical properties of both Nano fluid is given in the table.

S.No.	Ag-water	Al_20_3-water
Specific heat (J/kg-k)	4030.89	4052
Thermal conductivity (w/m-k)	0.723	0.719
Density (kg/m^3)	1362.048	1086
Kinematic viscosity (kg/m-s)	0.000657	0.000657

Objective of the Work

From the literature survey it is observed that different researcher uses different types of fin shapes, different types of Nano fluid is used as a coolant for micro pin fin heat sink and analyzed the effect of different parameters like length, height, spacing, shapes and Nano fluid as a coolant on heat transfer rate. Here we used silver-water Nano fluid as a coolant and compare its thermal & hydraulic performance with the alumina-water Nano fluid.

- Computational fluid dynamics analysis of un-finned micro-channel heat sink with similar boundary condition as taken in literature in reference [2] for reliability of presented model.
- CFD analysis of circular finned MPFHS and un-finned MCHS with Ag-water and Al_20_3-water at c=4% Nano fluid at Reynolds number ranging from 100 to 500 are conducted and the results (pressure drop and heat transfer rate) are compared with respect to each other.

II. METHEDOLOGY

Ansys Fluent 14 software is used for Computational fluid dynamic analysis. Laminar force convection is the mechanism for heat transfer. Radiation heat loss is not considered. NX-7.5 is used to create geometry of model. And meshing capabilities within ANSYS Workbench is done. The 3D geometric model of MPFHS is created. Figure 1 is showing the 3D geometry model which is created in NX -7.5 consisting with the 50 circular micro pin fin array in staggered configuration with the fluid domain. The geometry for un-finned cases is created as like shown below but the fins are detached.

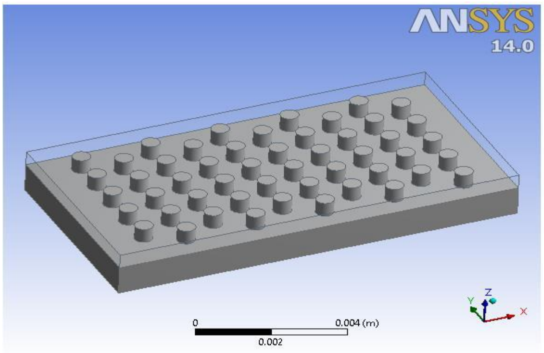

Fig. 1: schematic of circular finned MPFHS

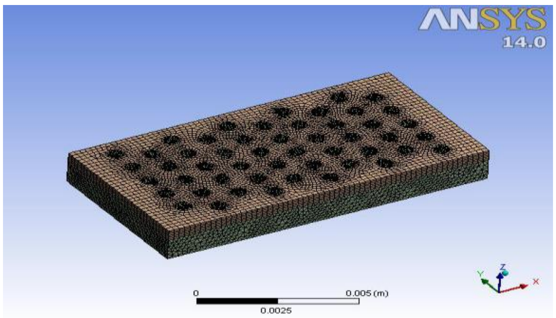

Fig. 2: Meshing of circular finned MPFHS

After making the geometry, import it into ANSYS workbench for the discretization. Precision of the CFD examination depends on the quality of mesh. Mesh generation includes the application of elements and nodes on existing geometry. Programmable controlled method is used for generate the mesh of geometry. Edge sizing is done for avoid the overlapping of elements, negative element not generated. After discretization the mesh file is imported into the fluent solver where all the boundaries condition is assigned for the calculation. Here the fin surface and base are held at a constant thermal boundary condition. Interfacing of mesh is prepared in which fluid wall is interface with the fin wall. At inlet the value of inlet velocity which is calculated based on Reynolds number is assigned and at outlet boundaries is allotted as pressure outlet where Nano fluid is leaves the channel at the ambient temperature. Here the ambient pressure is used as stagnation boundary condition. The static pressure is assumed equal to the pressure of surrounding atmosphere. Examination and evaluation of the results is referred to as post processing after calculation where contours of temperature and velocity at various surfaces are viewed with respect to different Reynolds number. Also heat transfer rate and pressure drop are analyzed in every cases.

III. RESULT

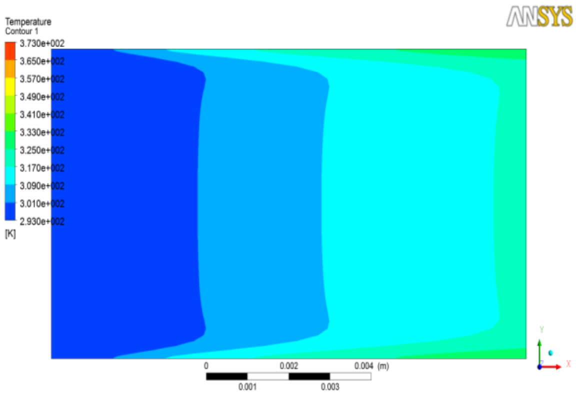

Fig. 3: Static temperature contour of un-finned MPFHS (at Re=100).

Fig 3 is showing the temperature distribution of un-finned MCHS on (x-y) plan at z=0.0002165 with Ag-water Nano fluid. From the fig it is illustrated that the temperature of Nano fluid is maximize along the direction of flow.

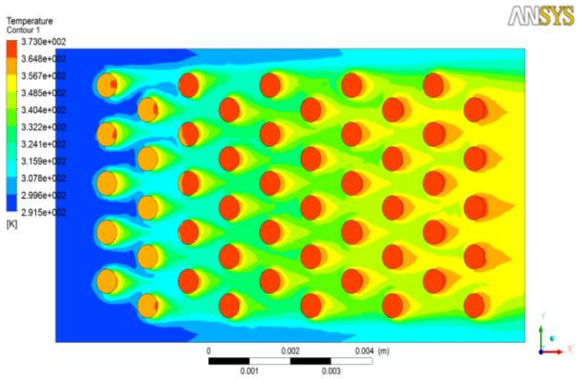

Fig 4: Static temperature contour of circular-finned MPFHS (at Re=100).

Fig 4 is showing the temperature distribution of circular-finned MPFHS on (x-y) plan at z=0.002165 with Ag-water Nano fluid. From the fig it is illustrated more heat is achieved by the Nano- fluid compared to un-finned MCHS due to provide the larger surface area.

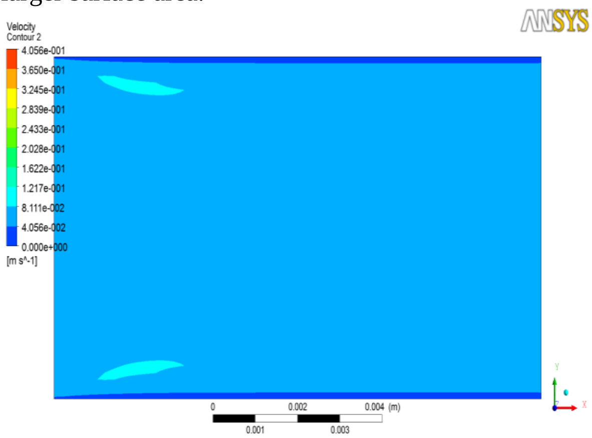

Fig. 5: Velocity contour of Un-finned MPFHS (at Re=100).

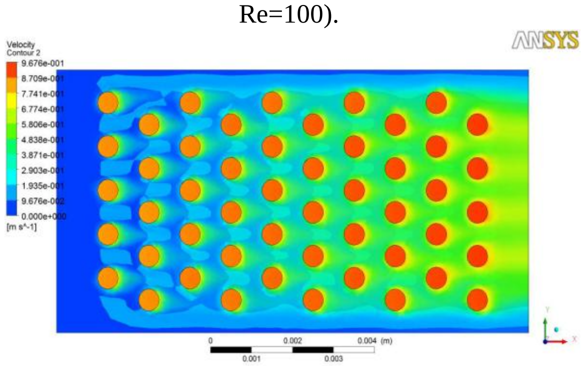

Fig. 6: Velocity contour of circular-finned MPFHS (at Re=100).

Fig. 5 & 6 showing the velocity contour of un-finned and circular finned MCHS on (x-y) plan at z=0.0002165 with Ag-water Nano fluid. From the figures it is examined that circular-finned heat sink is create good mixing of Nano-fluid by which more heat is transferred compared to Un-finned micro channel heat sink. But it is also increased the pressure drop due to the finned area.

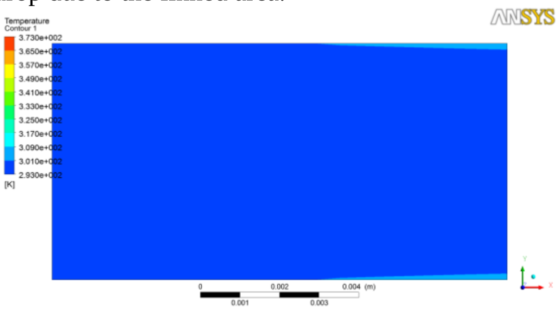

Fig. 7: Static temperature contour of un-finned MPFHS (at Re=500).

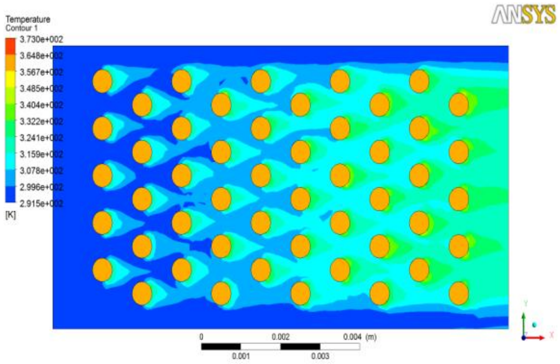

Fig. 8: Static temperature contour of circular-finned MPFHS (at Re=500).

Fig. 7 & 8 showing the temperature counter of on longitudinal plan (x-y) at z=0.0002165of Un-finned and circular finned MCHS with Al_2O_3-water Nano fluid respectively from both the figure it is illustrated that circular finned heat sink is performed better in heat transfer point of view compared to Un-finned heat sink.

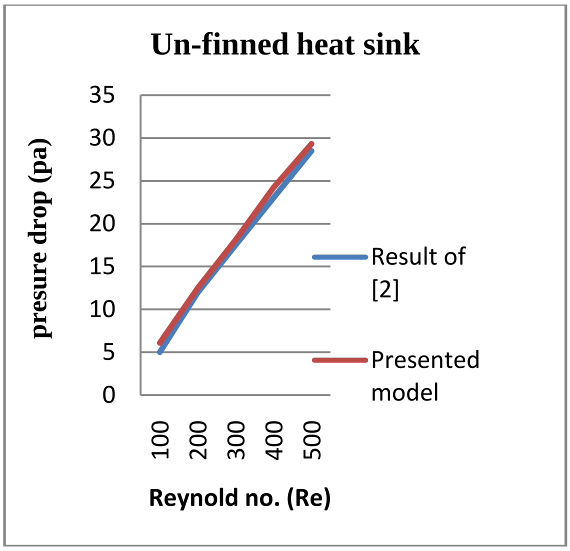

Fig. 9: Comparison of pressure drop between the presented model and result of [2].

Fig. 9 is showing the variation of pressure drop with respect to Reynolds number for Un-finned heat sink with alumina –water Nano fluid of presented model and obtained result by reference [2]. From the above fig it is examined that the value of presented model is so near to close with the result of [2] a slightly difference in result due to discretization method. So the presented model is reliable for further study.

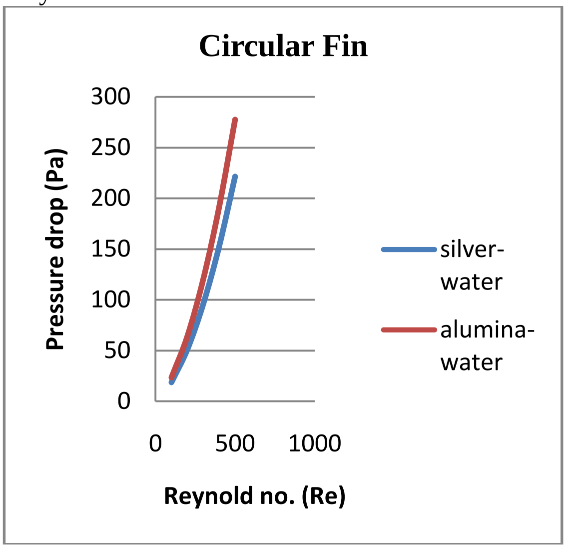

Fig.10: Variation of pressure drop with Re with different Nano-fluid for Circular-finned heat sink.

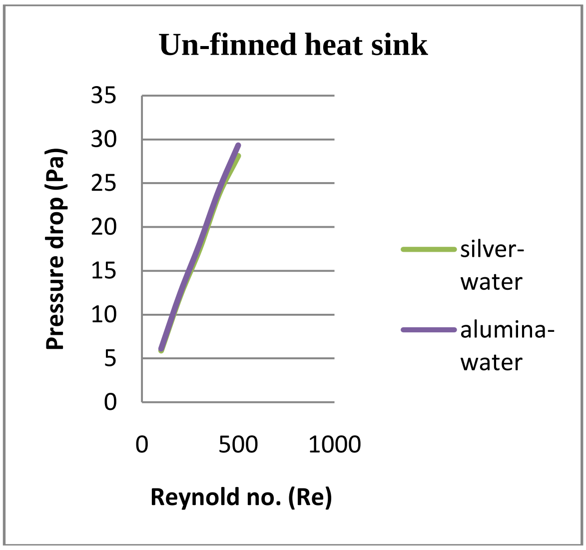

Fig.11: Variation of pressure drop with Re with different Nano-fluid for Un-finned heat sink.

Fig. 10 & 11 showing the variation of pressure drop with Reynolds number with different Nano fluid, from both the figures it has been seen that silver water Nano fluid is gives the minimum pressure drop compared to alumina water Nano fluid due to higher dense particle. It has been also illustrated that circular finned heat is gives the higher pressure drop compared to un-finned heat sink.

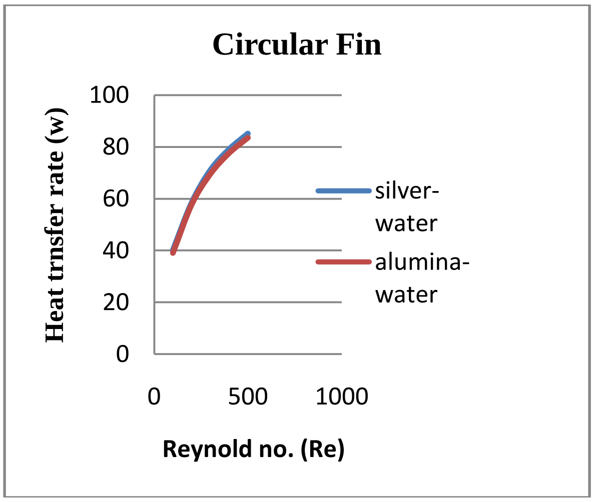

Fig.12: Variation of heat transfer rate with Re with different Nano-fluid for Circular-finned heat sink

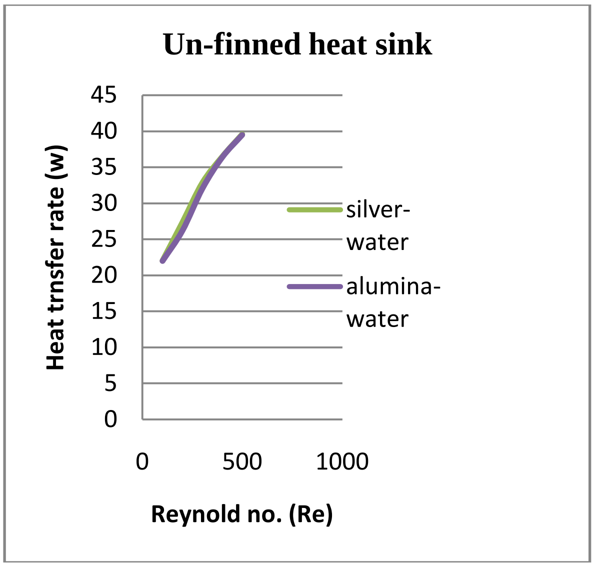

Fig. 13: Variation of heat transfer rate with Re with different Nano-fluid for Un-finned heat sink.

Fig 12 & 13 are showing the variation of heat transfer rate with different Reynolds number with different Nano fluid for circular and un-finned heat sink respectively. From the both the figures it is observed that silver-water Nano fluid is gives slightly maximum heat transfer rate compared to alumina-water Nano fluid. It is also seen that circular finned heat sink is perform better as compared to un-finned heat sink due to provide maximum heat transfer surface area.

IV. CONCLUSION

Following points are worth noting from the present investigation work.

- It is revealed that Ag-water Nano-fluid gives low pressure drop compared to alumina Nano-fluid because it contain higher dense particle by which pump work is minimized.
- Ag-water Nano-fluid gives slightly maximum heat transfer rate compared to Al_20_3-water Nano-fluid due to having higher thermal conductivity.
- Circular finned heat sink performs better in heat transfer but it gives the maximum pressure drop compared to un-finned heat sink.
- The performance of finned heat sink and Nano-fluid can be analysed effectively by commercially available CFD software, Fluent 14 in specific.

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