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Thermal Hydraulic Performances of Water Based Nano Fluids in a MCPFHS – A Review

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ABSRACT

Today various new methods have to be explored for the developments of recent electronic devices for dissipating excessive heat flux for ensure stable and optimum operation. like Micro-channel heat sinks because of their tiny mass and larger volume they have widely used for cooling of high heat flux chips with pin fins with different shapes and different arrangements. So as to more optimize the small heat sink performance, the various kinds of Nano-fluids are used as a cooling agent. The most aim of this work is to review the numerous researches work who tired past to boost heat transfer rate and hydraulic behavior of small pin fins heat sink by either changing its geometry or climate condition and material, spacing between the fins and its configuration with differing kinds of Nano-fluids, additionally with completely different size and concentration of Nano particle.

Keywords-Heat Transfer, Fins, Nano Fluid, Computational Fluid Dynamic.

I. INTRODUCTION

Fins are used as associate extended surface to extend the heat transfer rate in a very large area of engineering applications, and provide a sensible approach while not use of an excessive quantity of primary area for achieving a large heat transfer area. It's normally used for heat management in electrical appliances, cooling of combustion machine, like fins in an exceedingly automobile radiator. Therefore its vital issue to analysis the behavior of the fin in relation to temperature distribution for optimizes the effectiveness. currently the present approach for enhance the heat transfer rate Nano-fluid is employed as a medium, containing nanoparticles (1–100 nm) of metal or metal compound that are uniformly and stably distributed in a base fluid for increase the thermal conductivity of base fluid. So that heat transfer from fin arrays has been studied extensively, both analytically and experimentally.

II. LITERATURE REVIEW

Some of the vital paper associated with CFD analysis of heat transfer rate of fins are reviewed and mentioned here.

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.

T.J. John et al (2010) [2] they Computationally observed the overall performance of a micro pin fin heat sink with single phase liquid flow & different fin geometry (square& circular shaped pin fin). They study the effect of thermal resistance & pressure drop of micro heat sinks when take various factors such as pitch distance in axial & transverse direction, aspect ratio & hydraulic diameter of pin fin & concluded that at Reynolds number 50-500. They found at the

minimumRe (below 300) circular pin fin heat sink gives better performance as compare with square pin fin heat sink and vice versa at high Reynolds number. The figure of merit for both the heat sink increases as the aspect ratio of pin fin is increased.

H.A. Mohammed et al (2010) [3] They have founded that the Nano fluid with 5% volume fraction could not able to enhance the heat transfer & give same result as pure water. So that the presence of nanoparticle could enhance the heat transfer of MCHS. also observed that when volume fraction of nanoparticle increases under the extreme heat flux, both heat transfer coefficient & wall shear stress increase but thermal resistance of MCHS decrease by their numerically investigation on rectangular micro channel heat sink (MCHS) with effect of Al_2O_3-water Nano fluids

H.A. Mohammed et al (2011) [4] they have analyzed the impact of various Nano fluid on triangular micro channel heat sink. Used water as a base fluid and various types of Nano fluid such as Al_2O_3, Ag, Cuo, diamond, SiO_2, TiO_2 as coolants. This study covers the volume fraction 2% 3-D steady, laminar flow with finite volume method. And founded that the diamnd-H_2O & Ag-H_2O attains overall heat transfer enhancement & low pressure drop as compare with pure water.

Guan Qiu Li et al (2012) [5]they did the trial of condensation characteristic inside five micro fin tubes for single phase inflow & select external diameter 5 mm for all tubes & helix angle 180C. They also take following data mass fluxes 200 to 650 kg/ m2s, nominal saturation temperature 320k, inlet & outlet rates0.8 &0.1 independently. The result attained from this trials is tubes 4 has highest condensation heat transfer coefficient & pressure drop penalty and tube 5 has highest enhancement ratio but intermediate heat transfer coefficient.

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 compareto pure water.

Paisarn Naphon and Lursukd Nakharintr (2013) [7] they are examined heat transfer characteristic in the mini rectangular heat sink with the use of two Nano fluid mixture TiO_2& water. The TiO_2Nano fluid used as working fluid & deionized water as base fluid. In this analysis the method used is deionized water cooling method in heat sink with three different channel heights. they found the average heat transfer rates is high for Nano fluid as a coolant are more than for 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.

Hardik D. Rathod et al (2013) [9] they have performed a studied on the effect of different variables on the transfer of four stroke SI engine through fins. To study the various research papers related to fins and effect on heat transfer coefficient by changing cross-section, climate condition and material etc. The extended surface (fin) are generally used to increase heat transfer rate by increase the heat transfer area. This study is very useful to understand the batter geometry and material for the fins and for batter engine cooling.

Amol B. Dhumne et al (2013) [10] they observe experimentally heat transfer improvement and pressure drop in a rectangular channel over a flat surface equipped with cylindrical perforated pin fins. The trial covers the Reynolds number 13500- 42000, the clearance ratio 0,0.33, & 1, the inter fin spacing ratio1.208,1.524,1.944 &3.417. correlation equation developed using Nussult number and Reynolds number for the heat transfer, friction factor & improvement efficiency. The above trial shows the use of cylindrical perforated pin fins gives better heat transfer improvement as compare to solid cylindrical fins enhance efficiency vary and depending on the clearance ratio inter fin spacing ratio. For better

thermal performance they suggested lower clearance ratio, inter fin spacing ratio & lower Reynold number.

Haleh Shafeie et al (2013) [11] they have examined laminar forced convection in water cooled heat sink. Two pin finned microchannel heat sink(MCHSs) and pin fin heat sink(PFHSs) are studied. The distribution patterns of the fabricated pin fins are both oblique and staggered. The Naiver – stokes and energy equation are answered to find hydraulic and heat transfer performance of the heat sink and compare the heat junking fluxes in both the MCHSs and PFHSs with different height in equal pumping power. After the complete study they set up for same pumping power heat removal of MCHSs gives better performance PFHSs at medium and high pumping power and PFHSs gives slightly better performance than MCHSs for small pumping power.

W.H. Azmi et al (2013) [12] They are determined experimentally the heat transfer coefficient and friction factor using of SiO2nanofluid flow in a circular tube under constant heat flux boundary condition in the turbulent region and take particle volumetric concentration up to 4, Reynold number in the range 5000- 27000 at a bulk temperature 300Cand they determined the pressure drop increase with particle concentration up to 3 and drop later and SiO2nanofluid friction factor drop with increase in Reynold at any concentration.

AhmadrezaAbbasiBaharanchi (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) They numerically studied the heat transfer and flow characteristics in micro pin fin heat sink with Nano fluid with square, triangular, circular fins in addition to un finned heat sink with two types of Nano fluid used (diamond-water, Al2O3- water) elect volumetric concentration in range (1- 4) with boundary condition constant wall temperature and the Reynolds number in range (100- 900) and to ensure that the flow should be remain in laminar range. The result attained from the following present work is by raising 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 better than Al2O3- water Nano fluid and carry large amount of heat transfer rate another result shows the circular fin give better heat transfer rate as compare with other fins and highest pressure drop with square fin

Alfaryjatetal. (2014) (15) They have numerically investigated the water flow and heat transfer characteristics with three different channel shapes (hexagonal, circular and rhombus). In this study covers the Reynold number value in the range of 100 ¬ – 1000 and maintained heat flux is 500 KW/ M2. finite volume system used to solve the governing equation and figures of exclusive attributes and they set up the lowest hydraulic periphery of the hexagonal cross-section MCHS. The best channel shape for the pressure drop and heat transfer coefficient and highest value of temperature, friction factor, and thermal resistance are set up with the use of rhombus cross-section MCHS.

Navin Raja Kuppusamyetal. (2014) (16) They've conducted numerical analysis for study the hydraulic and thermal attributes of Nano fluids in a triangular grooved microchannel heat sink. And founded that the influence of the geometrical parameters similar as the angle (50 – 100,), depth (10 – 25 lm) and pitch (400 – 550 lm) of the groove on the thermal performance of TGMCHS. And further observed that the effects of different nanoparticle types (Al2O3, CuO, SiO2, ZnO), volume fraction (Ø = 0.01 – Ø = 0.04), particle diameter (25 – 80 nm) and base fluid (water, ethylene glycol, machine oil) at different Reynolds numbersthe thermal performance of TGMCHS had significant increment with the increment of angle and depth of the groove accompanied with an optimum groove pitch. It's also detected that the TGMCHS thermal performance of using Al2O3 – H2O (Ø = 0.04, dnp = 25 nm) is better compared to the simple MCHS using water.

Anuj Kumar Sharma etal. (2016) (17) They've reviewed many research paper on rheological behavior of Nano fluids and set up that particle shape, its concentration, shear rate range, surfactant and magnetic field significantly affect the rheological

behavior of any Nano fluid. It has been also observed that Nano fluids containing spherical nanoparticles are more likely to exhibit Newtonian behavior and those containing nanotubes show non-Newtonian flow behavior. Furthermore, Nano fluids show Newtonian behavior at low shear rate values while behave as non-Newtonian fluid at high shear rate values.

Wei Wanetal. (2016) (18) They have studied square, circular, diamond and streamline staggered micro pin fins, with using deionized water as coolant. And observed that the square micro pin fins presented the best boiling heat transfer, followed by circular and streamline ones. The diamond micro pin fins performed worst in boiling heat transfer and suffered severe two-phase flow instabilities at moderate to high heat fluxes, whereas they introduced the smallest pressure drop. The streamline micro pin fins presented the largest two-phase pressure drop.

Tehmina Ambreenetal. (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.

Abdullah A etal. (2019) (20) They have investigated the hydrothermal and entropy generation characteristics of a non-Newtonian Nano fluid containing CuO nanoparticles in an offset strip-fin microchannel heat sink (MCHS). The base fluid is solution of 0.5 wt% Carboxymethyl Cellulose (CMC) in water. And reveal that the enhancing the Reynolds number improves the performance of MCHS by boosting the convective heat transfer coefficient of the working fluid which favorably reduces the CPU surface temperature and thermal entropy generation rate and importantly leads to the temperature uniformity of the CPU surface. Also observed that the minimum total entropy generation rate of the Nano fluid is 2.7% less than the base fluid.

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 behavior 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.

III. CONCLUSION

This is observed from the literature survey that thermal management is veryessential parameter for cooling the equipment, stationary engines and plenty of engineering application, for the economical operating and additionally avoid the heating drawback, therefore we tend to wants the enhanced styles of fins that is employed as associate extended surface and providing the massive heat transfer expanse with minimum material and most heat transfer rate. however, as a result of several issue like material, fluid rate, cross section, climate condition, thermo-physical properties of operating fluid have an effect on the heat transfer rate of fins, the most dominant variable typically offered to designer is geometry of fin array. And choice of operating fluid as a coolant. Numerousnovel techniques are suggested by researchers like using different shapes of pin fin with different arrangements with different Nano fluids so as to boost small heat sink performance. Nano fluid could be a reasonably fluid containing tiny amount of Nano-sized particles (usually less than 100 nm) of metal and metal oxide that are uniformly and stably suspended in base liquid for enhance the thermal physical phenomenon.There are number of researches in literature created to review the small pin fin sink with completely different fins profiles and configurations and to

review the hydraulic and thermal performances of Nano fluids. And founded that:-

• Nano fluids offer the higher performance in heat transfer as compared to the standard fluid.

• Staggered arrangement of fins offer the best result compared to different configuration.

• Diamond-water Nano fluids is usually suggested to attain overall heat transfer enhancement compared with pure water.

• Circular pin fins offers the higher thermal performance compared to different normal geometry.

• Square pin fins offers the high pressure drop compared to different commonplace geometry.

• Large fin height lower thermal resistance at the cost of large pressure drop.

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