CFD Investigation of Nano-fluid on Heat Exchanger Rate in Micro Channel Heat Sink

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Abstract:

We explore the impact of Nano liquid on the warmth exchange rate. We likewise examine the impact of volume division of a Nano liquid in the base liquid (like water and ethylene glycol or EG). We additionally research the stature of smaller than expected channel fluid cooling. We locate the viable stature in which they work viable in the wake of expanding this tallness past the viable stature there is no expansion in the warmth exchange so we increment the stature in compelling locale for most extreme warmth exchange. We examination the geometry in Computational Fluid Dynamics programming. We consider the rectangular divert in which Nano liquid are stream with the volume part of 0.8, 1.6, 2.4, 3.2 and 4% in base liquid. These Nano fluid are flow in channel with the five inlet velocity 2, 3, 4, 5 and 6 m/s. In the base paper only two inlet velocities is consider which is 2m/s and 6m/s. We also investigate the result on three inlet velocities which is 3, 4 and 5 m/s and compare the result with two inlet velocities which is 2 and 6m/s. We also investigate the effect of skin fraction by increasing the volume fraction of Nano fluid.
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Keywords: CFD, Nano-Fluid, Channel Heat Sink

I. INTRODUCTION

The performance of heat exchange system can be improved by introducing various heat transfer techniques and reducing the energy consumption. Latter in 1950s, some efforts have been done on the variation in geometry of heat exchanger apparatus using different fin types or various tube inserts or rough surface. Further enhancement in heat transfer is always in demand, as the operational speed of these devices depends on the cooling rate. New technology and advanced fluids with greater potential to improve the flow and thermal characteristics are two options to enhance the heat transfer rate.

In current world, nanotechnology is being used in many applications to provide cleaner, more efficient energy supplies and uses. Many of these applications may not affect energy transmission directly, each has the potential to reduce the need for the electricity, petroleum distillate fuel, or natural gas that would otherwise be moved through energy transmission system. More efficient energy generation and use may decrease the amount of construction, maintenance, repair, and decommissioning activities. Some of nanotechnology integration specific applications are as follows:

• Engine cooling.	• Engine transmission oil.
• In diesel electric generator as jacket water coolant.	• Refrigeration (domestic refrigerator, chillers).
• Boiler exhaust flue gas recovery.	• Heating and cooling of buildings.
• Cooling of electronics.	• Nuclear systems cooling.
• Cooling of welding.	• Solar water heating.
• Nanofluids in transformer cooling oil.	• High-power lasers, microwave tubes.
• Defense.	• Drilling.
• Space.	• Lubrications.

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1.1: Preparation Of Nanofluids

Preparation of nanofluids is the first key step in the experimental studies of nanofluids. Nanofluids are not just the dispersion of solid nanoparticles in the base fluid. The essential requirements that a nanofluid must fulfill are even and stable suspension, negligible agglomeration of particles, no chemical change of the particles or fluid, etc. Nanofluids are produced by dispersing nano-meter sized solid particles into base liquids such as water, ethylene glycol (EG), oil, etc.

1.1.1 Single step process

The single step simultaneously makes and disperses the nanoparticles directly into a base fluid; best for metallic nanofluids. Various methods have been tried to produce different kinds of nanoparticles and nano suspensions. The initial materials tried for nanofluids were oxide particles, primarily because they were easy to produce and chemically stable in solution. Various investigators have produced Al_2O_3 and CuOnano-powder by an inert gas condensation process and found to be 2–200 nm-sized particles.

1.1.2 Two step process

Two-step method is the most widely used method for preparing nanofluids. Nanoparticles, Nano fibers, nanotubes, or other nanomaterials used in this method are first produced as dry powders by chemical or physical methods. Then, the nano-sized powder will be dispersed into a fluid in the second processing step with the help of intensive magnetic force agitation, ultrasonic agitation, high-shear mixing, homogenizing, and ball milling. Two-step method is the most economic method to produce nanofluids in large scale, because nano-powder synthesis techniques have already been scaled up to industrial production levels.

II. LITERATURE REVIEW

2.1 Nano Fluid Research

Lee et al. showed that the suspension of 4.0% with 35 nm CuO particles in ethylene glycol had 20% increment in the thermal conductivity.

Eastman et al. showed that nanofluids consisting of water and 5 vol. % CuO nanoparticles can increase thermal conductivity of approximately 60%. Xuan and Li [7, 8] experimentally studied the convective heat transfer and friction coefficient for the nanofluids in both laminar and turbulent flows. According to these researchers, the flow velocity and volume fraction of nanoparticles affected the heat transfer coefficient.

Das et al. [11] investigated the temperature dependency of thermal conductivity in the nanofluids. It was observed that a 2–4 fold increase in the thermal conductivity of nanofluids can take place over a temperature range of 21–51°C.

Zeinali Heris et al. showed that enhancement in heat transfer efficiency due to particle size reduction in a suspension because heat transfer takes place at the particles surface.

Mirmasoumi et al. numerically studied the convective heat transfer in a fully developed flow for Al_2O_3-water nano-fluid. They applied two-phase mixture model in their simulation. They found that the convective heat transfer coefficient significantly increased by decreasing the nanoparticles mean diameter.

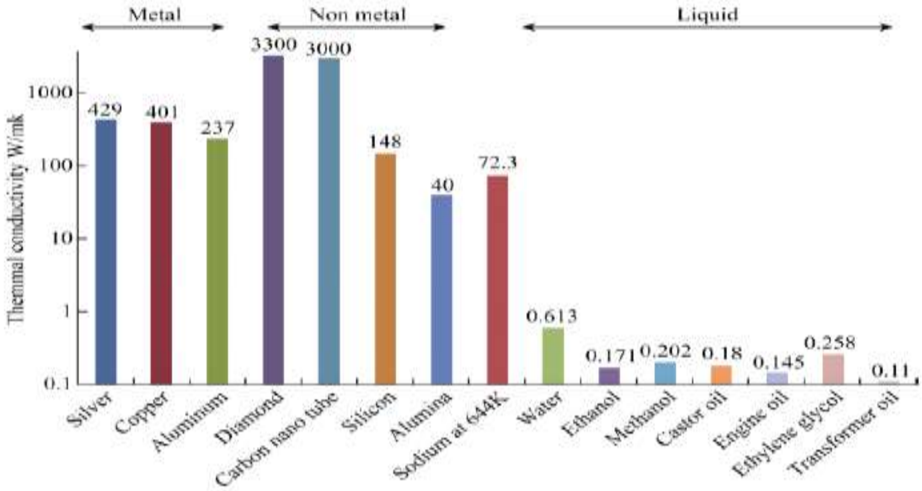
Sharma et al. experimentally studied the convective heat transfer coefficient and pressure drop in the transient region for Al_2O_3-water nanofluid under a constant heat flux. They found that convective heat transfer increased by adding Al_2O_3 nano-particles in water.

Serrano et al. investigate excellent examples of nanometer sized particles and compare them with millimeter and micrometer sized particles. The result shows that heat transfer increase with decrease in particle size i.e. nanometer sized particle have better heat transfer coefficient than millimeter and micrometer sized particle.

V. Bianco et al. numerically investigated nanofluids forced convection in circular tubes. They used Al_2O_3 nanoparticles of size 100 nm dispersed in water. Results have shown that inclusion of nanoparticles increase the heat transfer with respect to that of the base liquid. Heat transfer enhancement was increasing with the concentration of particle volume. The maximum difference detected is 11% for the average heat transfer coefficient.
Rezaee&Tayebi [20] investigate that alumina and copper oxide are the most ordinary and cheap nanoparticles which are used in the applied processes. And in the same year for the first time nanofluid was used as a coolant in automobile (truck) radiator.

S.M. Peyghambarzadeh et al. studied the comparison of the heat transfer performance of pure water and pure EG with their binary mixtures. Different amounts of Al_2O_3 nanoparticle have been added into these base fluids and experimentally determine its effects on the heat transfer performance of the car radiator. Liquid flow rate has been varied in the range of 2 to 6 l per minute and the inlet temperature of fluid has been changed for all the experiments. The experimental result shows that nanofluids enhance heat transfer about 40% compared to their own base fluid.

Demir et al. done a 2D numerical study of a single phase forced convective heat transfer for Al_2O_3 and TiO_2nanofluids in a horizontal counter current double pipe heat exchanger. Result shows that heat transfer increased with the presence of nanoparticles in the base fluid.



2.2 Nano Fluid as Lubricant

Hernández Battez et al. studied the friction behavior of a NiCrBSi coating lubricated by CuO nanoparticle suspension (nano-lubricant or nanofluid) in a polyalphaolefin (PAO_6). CuO nanoparticles were separately dispersed in range from 0.5 and 2.0 wt. % in PAO_6. Tests were made under loads of 165 and 214 N, sliding speed of 0.5 m/s and a total distance of 1800 m. This study led to the conclusion that all nano-lubricants tested exhibited reduction in friction compared to the base oil.

Mu-Jung Kao et al evaluate the role of spherical titanium oxide nanoparticles in reducing friction between two pieces of cast iron. The friction between two pieces of cast iron was determined at 30–130 ºC using home-made titanium nano-oil on a friction test bench. Spherical titanium nanoparticles were submerged in oil providing rolling characteristics in the two-iron friction test. The results show that the friction coefficient obtained using nano-oil is always lower than that obtained using normal oil. The nanoparticles provide a rolling function, surface repair and have more viscosity as a lubricant.

Ehsan-o-llahEttefaghi et al. studied the effect of multi-walled carbon nanotubes (MWCNTs) on some of the properties of engine oils when used with them in different concentration. The effective functionality of engine oils like viscosity, pour point, flash point and thermal conductivity were also studied. The results concluded that with respect to the base oil, 0.1 wt. % of nano-lubricants improve thermal conductivity and flash point about 13.2% and 6.7%, respectively.

III. RESEARCH METHODOLOGY

In this thesis there are 2 type of Nano fluidsand there five varying Nano fluid volume fraction (0.8, 01.6, 2.4, 3.2 and 4 percent) were used. And TiO^2 and SiC Nano fluid and water at 35^0c were used.

Governing equations:
Continuity Equation:

$$\nabla.(\rho_{nf}.V_m) = 0 \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Momentum Equation:

$$\nabla.(\rho_{nf}.V_m.V_M) = -\nabla p + \nabla.(\mu_{nf}.\nabla V_m) \ldots\ldots\ldots 2$$

Energy Equation:

$$\nabla.(\rho_{nf}.C.V_m.T) = \nabla.(k_{nf}.\nabla T) \ldots\ldots\ldots 3$$

$$\vec{V} = 0(@walls) \ldots\ldots\ldots\ldots 4$$

$$\vec{V} = V_m(@inlet) \ldots\ldots\ldots\ldots 5$$

P= atmospheric pressure (@outlet)………………………6

$$-k_{nf}.\nabla T = q''(@bottom\ of\ mini\ channel) \ldots\ldots\ldots 7$$

$$-k_{nf}.\nabla T = 0\ (@top\ of\ mini\ channel) \ldots\ldots\ldots 8$$

In this research I have taken 3 dimensional computational fluid dynamics is modeled bases on the single phase fluid system. The geometry made for the same is done on the preprocessor which is available under the design modeler of ANSYS package.

3.1 The Fluent Window Has Five Pre-Loaded Software Which Are In Following Order

1. Design modeler
2. Mesh software
3. Setup
4. Solution
5. Results.

The cross section of the outline done on ICEM CFD work bundle is improved by expanding the work components on the gulf, warm source and the outlet. This prompts showing signs of improvement comes about. The season of examination is likewise expanded as the quantity of work components is expanded.

The mesh generation of the DS TYPE configuration is shown below. The mesh is constructed using the ANSYS ICEM CFD software. The meshing of the geometry is done using the sizing tab where the relevance center is increased from course to medium. In 3D channel has been meshed in three cases 100x10x10, 160x10x10 and 200x10x10.

The underlying size seed is set to dynamic get together and traverse point focus is characterized as fine as a matter of course .The base size of the work is of course put to 3.5245e-006 m and the greatest face size to 3.5245e-004 naturally. The base edge length of the work is as a matter of course 8.8136e-004 m.

In the expansion tab the swelling alternative is set to smooth progress .The change proportion is 0.272 .The greatest layers is settled to 2 as a matter of course. The development rate is 1.2 .The expansion calculation is set to pre and in cutting edge choice is no. The get together cross section tab has technique set to none. In the fix acclimating choice the triangle surface mesher is default put to program controlled. In cutting edge alternative of the work shape checking is put to CFD. The component mid side hubs is dropped. The inflexible body limit is put to dimensionally lessen. The work transforming is impaired as a matter of course. In the defeaturing tab, utilize sheet thickness for squeeze is default (3.172e-006 m).The create squeeze on invigorate is put to no. Sheet Loop on Removal is no .Automatic work construct defeaturing is put to with respect to. The defeaturing resistance is default (1.7622e-006 m.).

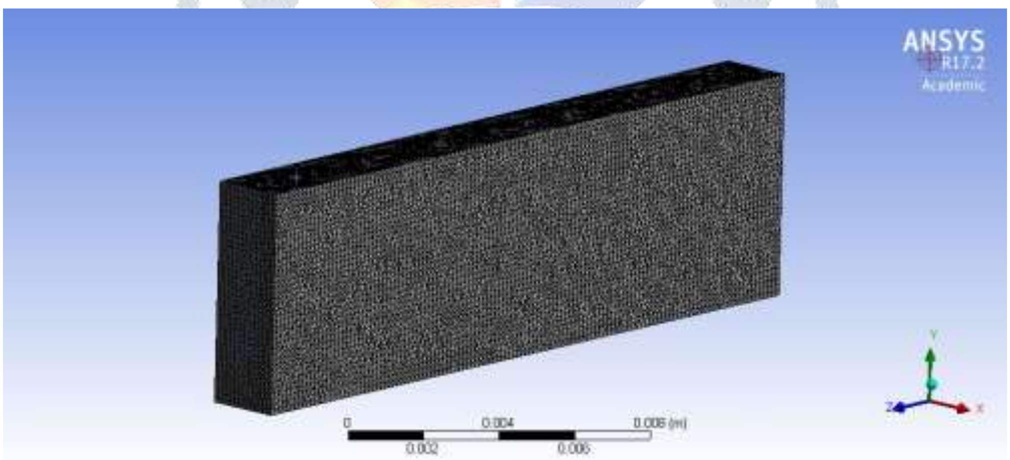


Figure 3.1: Meshing Model of mini channel

IV RESULTS AND DISCUSSION

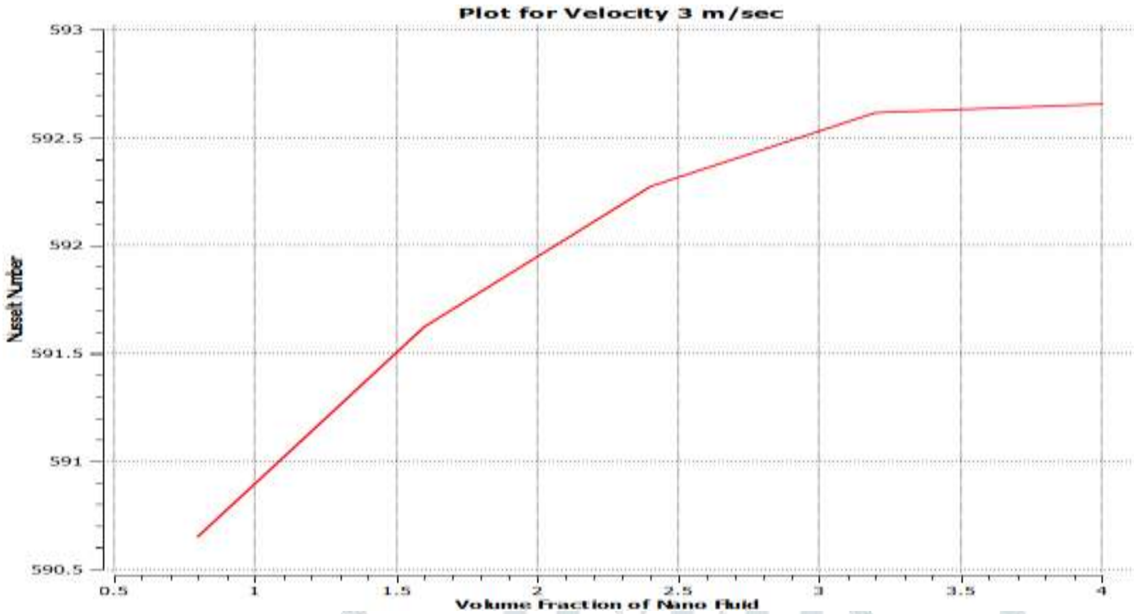


Figure 4.1: Effect of volume fraction of nanoparticles on the nusselt number at inlet velocities of 3 m/s. (For titanium)

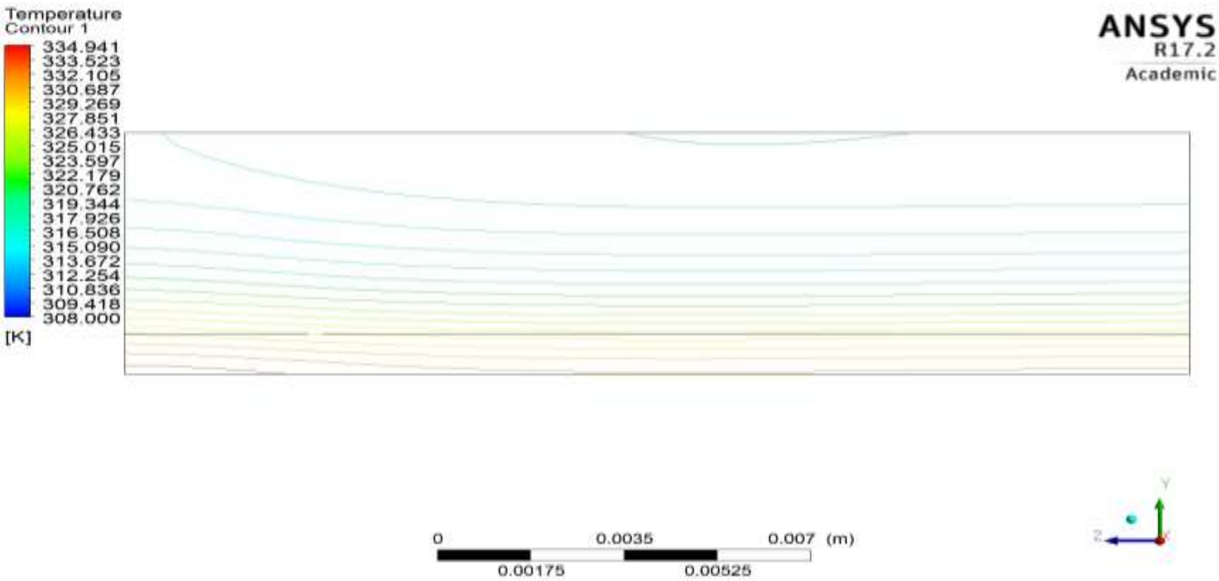


Figure 4.2: Temperature contour with 0.8% volume fraction of nanoparticle

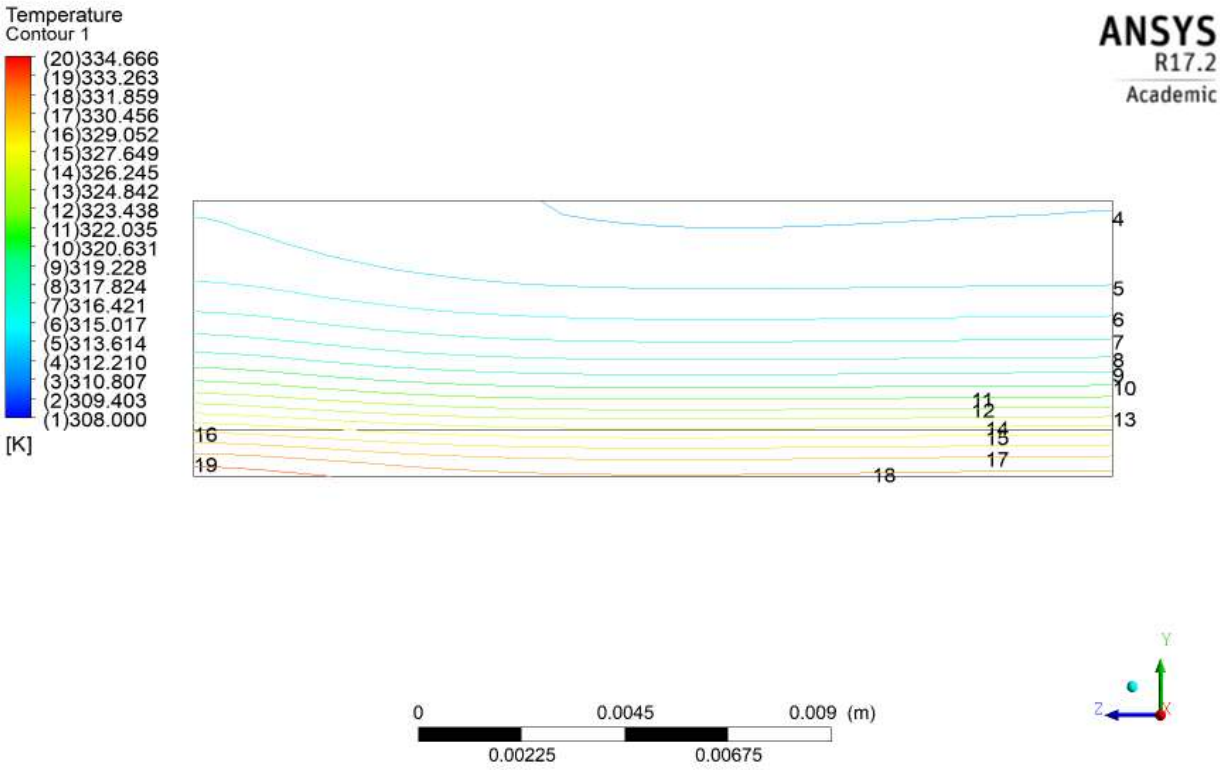


Figure 4.3: Temperature contour with 1.6% volume fraction of nanoparticle

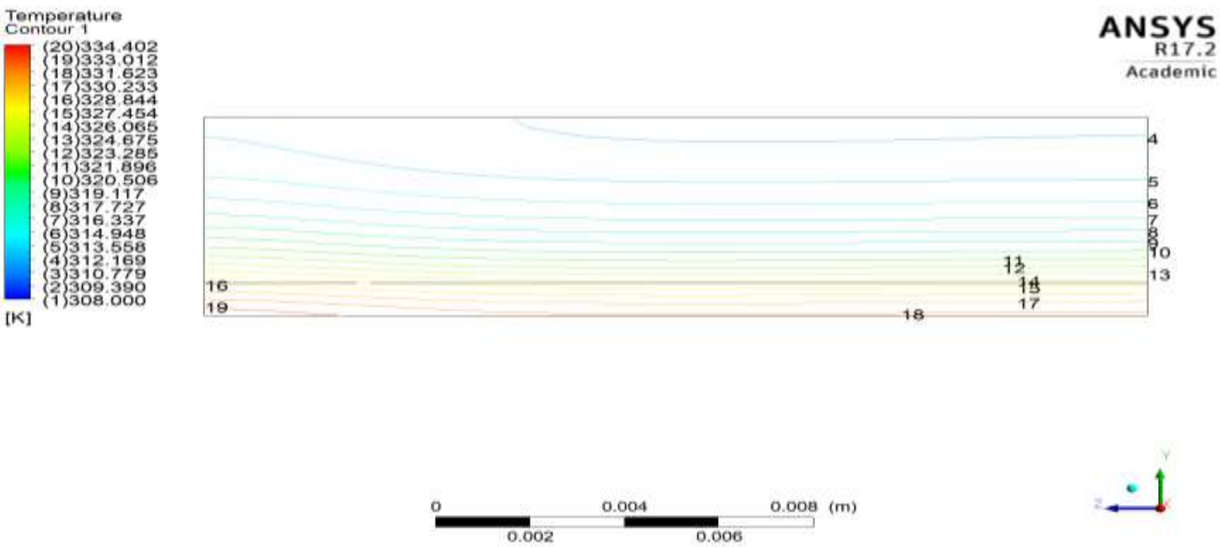


Figure4.4: Temperature contour with 2.4% volume fraction of nanoparticle

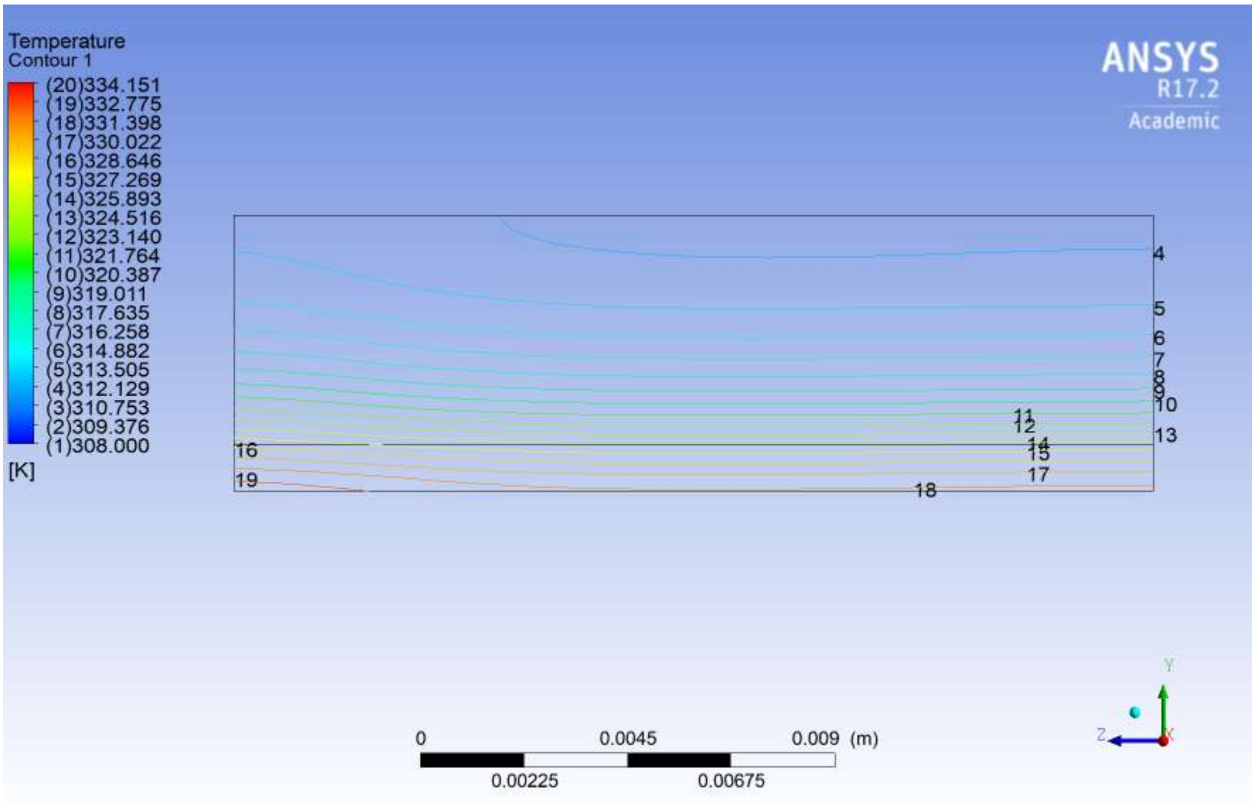


Figure 4.5: Temperature contour with 3.2 % volume fraction of nanoparticle

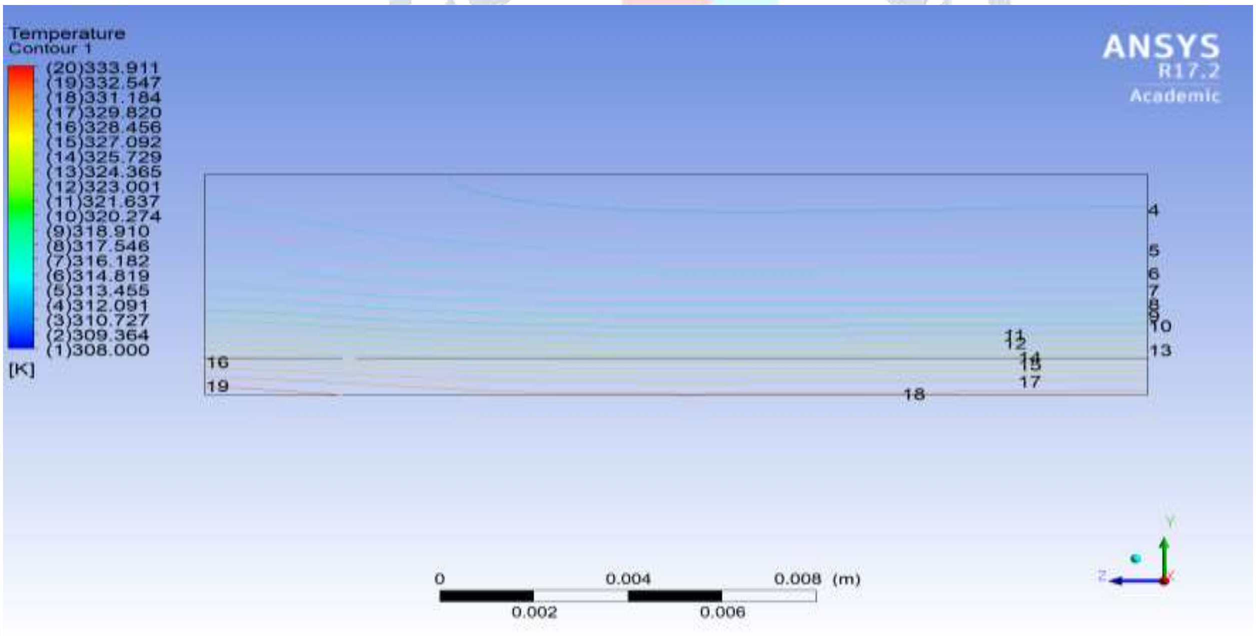


Figure 4.6: Temperature contour with 4 % volume fraction of nanoparticle

V. CONCLUSION

Study researched the execution of Titanium nanofluid with the working base of water. It reproduces a state of IC cooling for the hardware gear considering 100 KW warm transition at the base of the surface. We had researched our work for the diverse estimations of the speed and rate sythesis of nano liquid. Following are the concluded summary:

1. With the increase in percentage of volume heat transfer rate is increasing as value of the Nusselt Number increasing
2. With the increase in velocity rate of heat transfer also increasing.
3. Because as we increase velocity or percentage composition of nano particle, required value for the work input will increase.

Therefore, we should select the working condition and liquid properties in the reference of work input. Since as we increment speed or rate arrangement of nano molecule, required an incentive for the work information will increment.

REFERENCES

1. Xuan Y.M., Li Q., "Heat transfer enhancement of nanofluids", International Journal of Heat Fluid Flow (21), pp. 58–64 (2000).
2. YiminXuan and Qiang Li, "Investigation on Convective Heat Transfer and Flow Features of Nanofluids", Journal of Heat Transfer 125(1), pp. 151-155 (2003).
3. Choi S.U.S., Zhang Z.G., Yu W., Lockwood F.E., Grulke E.A., "Anomalous thermal conductivity enhancement in nanotube suspensions", Applied Physics Letter 79(14), pp. 2252–2254 (2001).
4. Khanafer K., Vafai K., Lightstone M., "Buoyancy-driven heat transfer enhancement in a two-dimensional enclosure utilizing nanofluids", International Journal of Heat Mass Transfer 46(19), pp. 3639–3653 (2003).
5. Das S.K., Putra N., Theisen P., Roetzel W., "Temperature dependence of thermal conductivity enhancement for nanofluid", Journal of Heat Transfer 125, pp. 567–574 (2003).
6. Abu-Nada E., "Effects of variable viscosity and thermal conductivity of Al_2O_3–water nanofluid on heat transfer enhancement in natural convection". International Journal of Heat Fluid Flow 30, pp. 679–690 (2009).
7. Sharma K.V., SyamSundar L., Sarma P.K., "Estimation of heat transfer coefficient and friction factor in the transition flow with low volume concentration of Al_2O_3nanofluid flowing in a circular tube and with twisted tape insert". International Communication of Heat Mass Transfer 36, pp. 503–507 (2009).
8. Serrano E., Rus G., Martínez J.G., "Nanotechnology for sustainable energy", Renewable Sustained Energy Rev 13, pp. 2373–2384 (2009)
9. Bianco V., Chiacchio F., Manca O., Nardini S., "Numerical investigation of nanofluids forced convection in circular tubes", Applied Thermal Engineering 29, pp. 3632–3642 (2009).
10. Rezaee F.K., Tayebi A., "Energy destruction of forced convective (EG + Al_2O_3) nanofluid through a duct with constant wall temperature in contrast to (Ethylene Glycol) fluid", Journal of Applied Science 10(13), pp. 1279–1285 (2010).
11. Shafahi M., Bianco V., Vafai K., Manca O., "Thermal performance of flat-shaped heat pipes using nanofluids", International Journal of Heat and Mass Transfer 53, pp. 1438–1445 (2010).
12. Zeng S.T., Lin C. and Huang K., Acta. Mechanica. 179, pp. 11 (2005).
13. Yang Y., Zhang Z.G., Grulke E.A., Anderson W.B., Wu G., "Heat transfer properties of nanoparticle-in-fluid dispersions (nanofluids) in laminar flow", International Journal of Heat Mass Transfer 48, pp. 1107-1116 (2005).
14. Maiga S.B., Palm S.J., Nguyan C.T., Roy G., Galanis N., "Heat transfer enhancement using nanofluids in forced convection flows", International journal of heat fluid flow 26, pp. 530-546 (2005).