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Design and Development of Solar Water Heater to Enhance Thermal Efficiency

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Abstract: ***This project is about development of a solar water heater with increased thermal efficiency using nanofluids as enhancement medium compared to conventional solar water heater which uses water as the working medium to overcome the inadequate heating of water in the seasons like rainy and winter. In this project Al_2O_3-H2O nanofluid is used as working medium, where Al_2O_3 is used as nanoparticle and water is used as base fluid. A nanofluid is a fluid containing nanometer sized particles, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. It also includes analysis at various concentrations of Al_2O_3 to determine the performance of the solar water heater.***
Keywords: Al_2O_3, nanoparticles, nanofluids, thermal efficiency.

I. INTRODUCTION

There is a major problem of energy crisis which is faced by all over the world. In order to control this energy crisis problem many researches are performed using renewable energy sources like using solar energy instead of electrical and fuel energy. Because solar energy is free of cost and environmentally friendly. In this perspective different solar water heaters are designed to use solar energy for heating of water, which is used for domestic and industrial purposes. Solar water heater largely depends on transmittance, absorption and conduction of solar and the conductivity of the working fluid. Sunlight based vitality is one of the cleaner types of sustainable power source assets. The regular sun oriented gatherer is a settled innovation, which has different applications, for example, water warming, space warming and cooling. Nonetheless, the warm productivity of these authorities is restricted by the assimilation properties of the working liquid, which is extremely poor for commonplace traditional sunlight based level plate gatherer. As of late utilization of Nano liquids, which is fundamentally fluid nanoparticles colloidal scattering as a working liquid has been found to upgrade sun based level plate gatherer warm proficiency most extreme by 30 percent. Prerequisite of vitality is expanding step by step since total populace is additionally expanding. Vitality can be sort of inexhaustible or non-sustainable. Sustainable is the type of vitality that can be reused and are effectively accessible in nature like sun powered vitality, geothermal vitality, wind vitality, tidal vitality and so forth non-sustainable power source goes under the sort of vitality which is gotten from non-renewable energy source as like coal, oil and other subparts. The non-sustainable power source supplies are getting depleted with constant use. So to finish this necessity there is just a single excellent way that is to utilization of sun based vitality in immediate or backhanded manner. Sun based vitality is most regular vitality, which gives enormous measure of intensity. The wellspring of sun powered vitality is sun watts are the vitality which strike on earth surface. Sun gives us 35 thousand times more force than we really need. In any case, of complete sun based vitality arriving at the world's surface just 7 to 8% is being used. Vitality originates from sun as electromagnetic wave which has frequency in the middle of 0.2 to 0.4 micrometers. Sun based radiation can partition one is immediate radiation and other is diffuse radiation. Sunlight based vitality is utilized in different fields like Heating and cooling of private structure, sun oriented water warming, sun based drying of farming and animal items, Salt creation by vanishing of seawater, sun based cookers, and sun powered motors for water siphoning, Solar Refrigeration, Solar electric force age and sun based photograph voltaic cells. Solar energy is considered nowadays as one of the most important sources of clean, free and renewable energy with minimum environmental effects. After industrial revolution (1970s) energy consumption increased sharply, so threat of energy shortages led scientists to find new sources of energy.

II. EXPERIMENTAL TEST SET UP AND DESIGN

The nanofluid is placed in the riser tube and is circulated with the help of a pump and the flow of nanofluid is controlled with the help of a flow control valve. The solar panel when exposed to the sunlight, it gets heated up, this also causes heating up of the nanofluid. And these heated nanofluid is passed to the heat exchanger, there will be heat exchange between nanofluid pipes to water, resulting in heating up of water.

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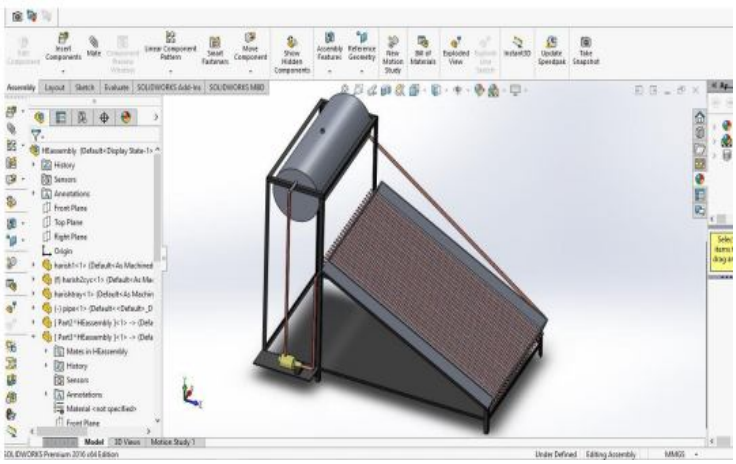


Fig: 1 Design of Solar water Heater

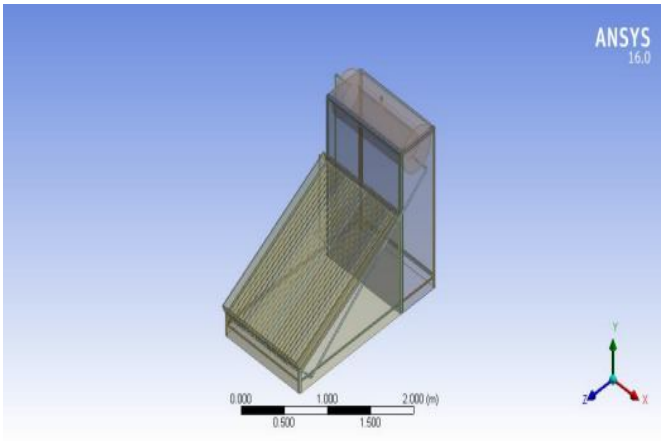


Fig: 2 Analysis of Solar water Heater

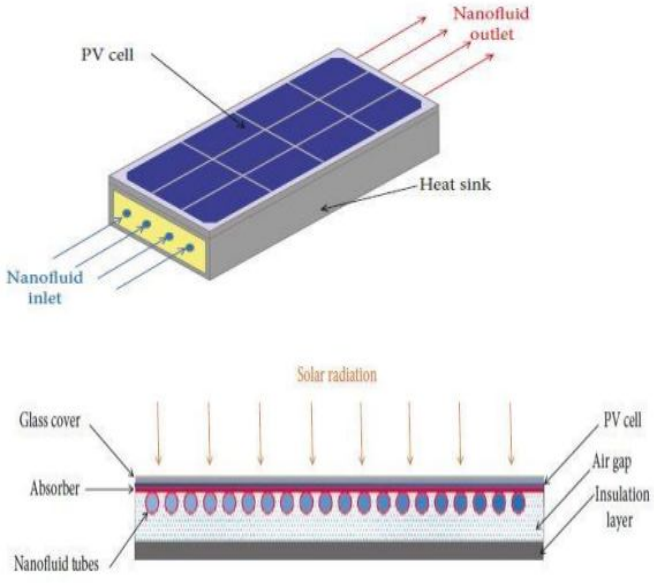
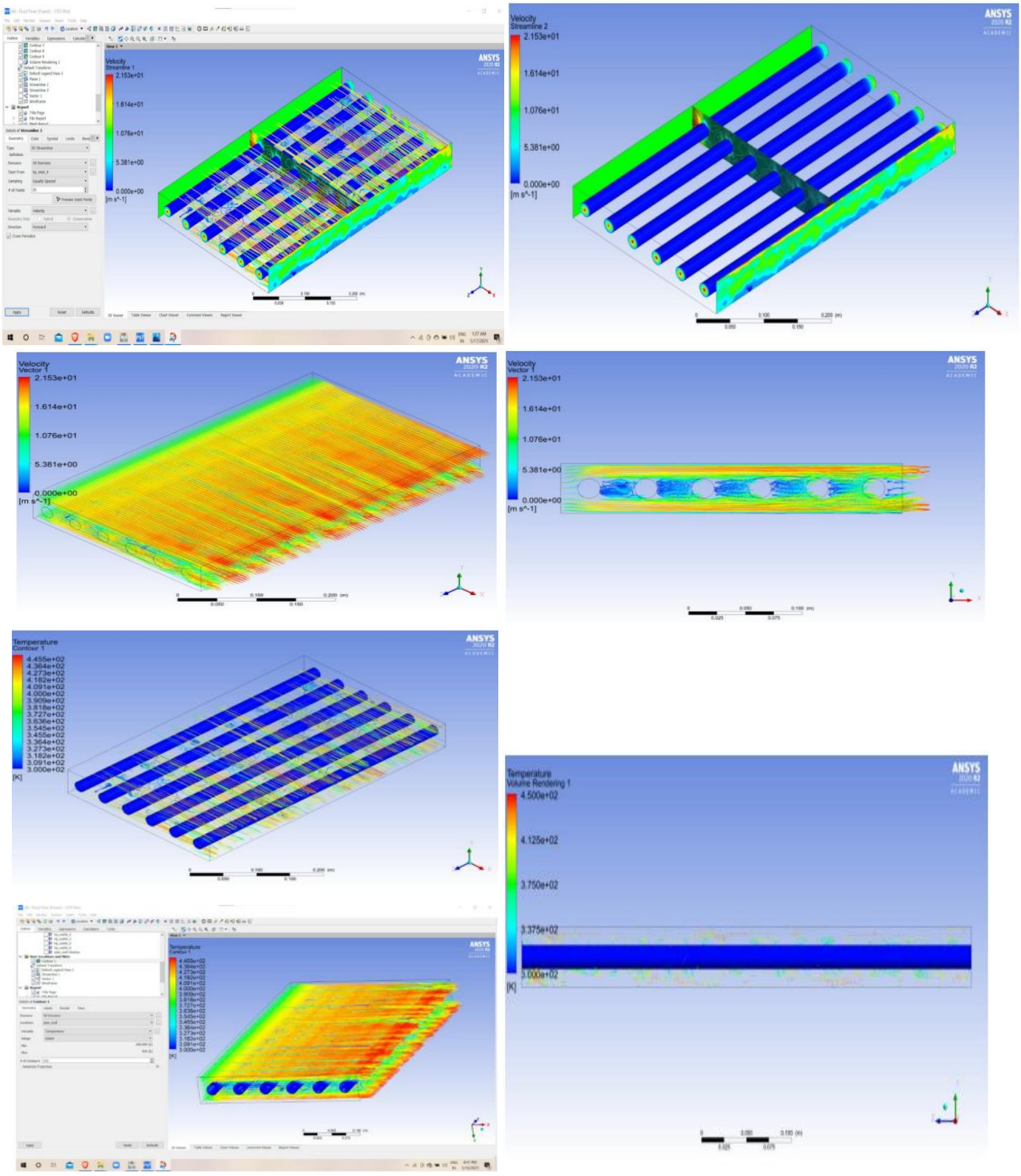


Fig: Schematic diagram of the PV/T System working on nano fluids.

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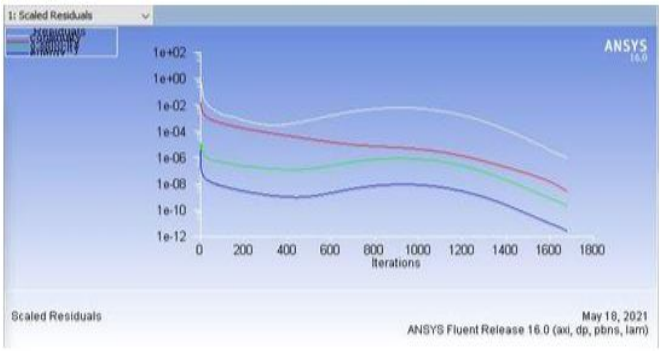
III. ANALYSIS METHODOLOGY FOR NANOFLUIDS



IV. RESULTS AND DISCUSSION

A. Comparison Between Al2O3 and CuO Nanofluids.

For Al2O3 at 4% concentration.



At 4% concentration of Al2O3 and a Heat flux of 5000 w/m2 , it is observed that the outlet temperature of nanofluid is 305.6 K.

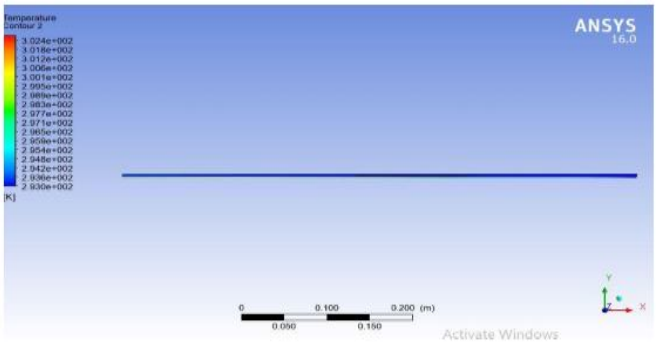


Image of pipe wall at inlet and outlet.

FOR Al203-4%

Iteration	Continuity	X-Velocity	Y-Velocity	Energy
364	3.0733e-04	5.6466e-05	1.3266e-07	1.1078e-09
370	3.0880e-04	5.4479e-05	1.3161e-07	1.0862e-09
400	3.5070e-04	4.5618e-05	1.2804e-07	1.006e-09
450	5.1187e-04	3.4112e-05	1.2913e-07	9.6391e-09
600	1.6891e-03	1.4879e-05	2.6390e-07	2.1236e-09
700	3.4557e-03	9.7363e-06	5.0321e-07	4.3386e-09
750	4.4650e-03	8.3880e-06	6.4631e-07	5.8165e-09
900	6.7355e-03	6.1944e-06	9.3731e-07	9.2734e-09
1050	5.0130e-03	3.7994e-06	7.0517e-07	7.4770e-09
1300	6.0939e-04	5.6850e-07	8.9221e-08	1.0126e-09
1500	2.5684e-05	6.1165e-08	4.5258e-09	5.2051e-11
1600	4.1032e-06	1.4617e-08	8.8889e-10	1.0154e-11
1678	1.0223e-06	2.8882e-09	2.1020e-10	2.4139e-12

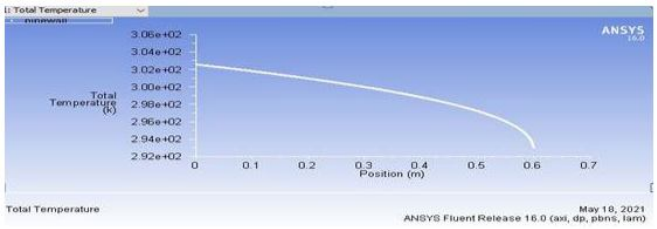
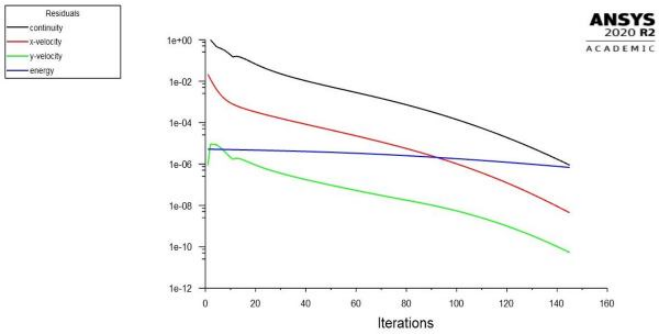


Image of pipe wall temperature

For CuO at 4% concentration



Iteration	Continuity	X-Velocity	Y-Velocity	Energy	Time/itera
1	0.0000e+00	2.1434e-02	8.6925e-07	5.1346e-06	1:23:19/4999
2	1.0000e+00	1.2536e-02	9.1045e-06	5.1321e-06	1:06:38/4998
10	1.8649e-01	8.9222e-04	2.0711e-06	4.9602e-06	0:39:48/4990
50	5.3381e-03	4.3861e-05	9.4798e-08	3.6910e-06	0:18:01/4990
100	1.4116e-04	1.0250e-06	5.4482e-09	1.8030e-06	0:28:11/4900
144	1.0128e-06	5.1019e-09	6.0755e-11	7.0087e-07	0:30:49/4856
145	8.8482e-07	4.4090e-09	5.3031e-11	6.8380e-07	0:24:39/4855

Average of fact values

Static temperature	(K)
Inlet	293 K
Outlet	304.6 K

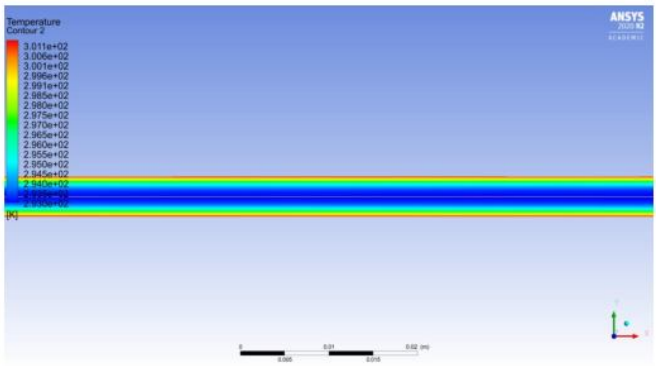


Image of pipe wall at outlet.

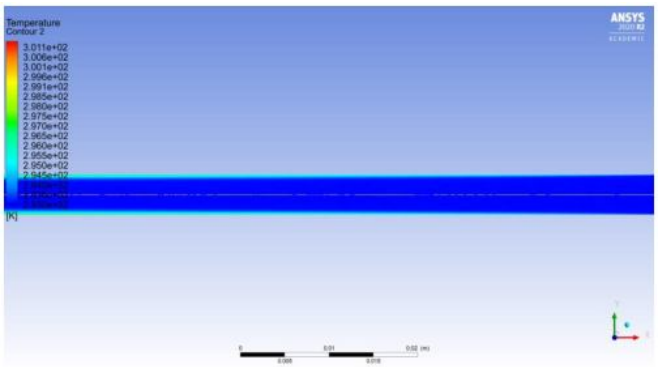


Image of pipe wall at outlet.

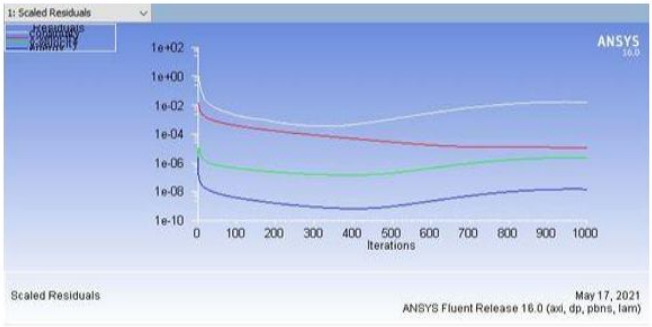
At 4% concentration of CuO and a Heat flux of 5000 w/m2, it is observed that the outlet temperature of nanofluid is 304.6 K. Hence, Al2O3 nanofluid have better thermal efficiency enhancement rate when compared to Cuo nanofluid.

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B. Analysis of Al2O3 Nano Fluid at Various Concentrations

As per the Ansys methodology mentioned above, we have performed analysis at various concentrations of nanofluid and compared the results. We found that, as the concentration of the nanofluid increases, the heat transfer coefficient first increases. When the concentration exceeds the critical value, the heat transfer coefficient decreases due to deposition of nanoparticles on the heating surface.

C. For Conventional solar Water Heater

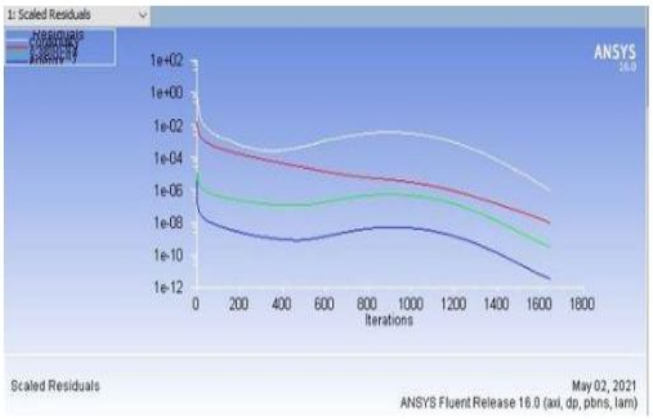


The inlet temperature is taken as 293 Kelvin and the outlet temperature is observed as 301.02 Kelvin.

D. Temperatures with Varying Concentrations.

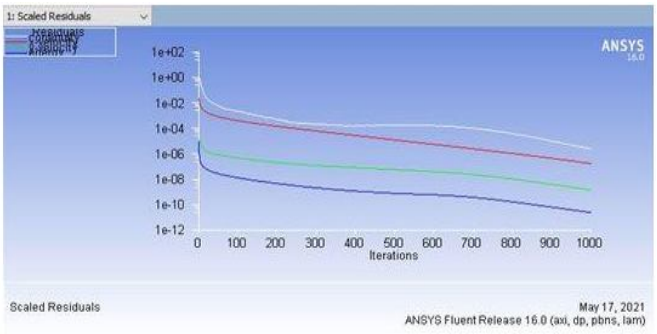
For Nanofluid-phi-1:

For 1% increase in the concentration of Nano fluid.



The inlet temperature is taken as 293Kelvin and the outlet temperature is observed as 303.2 Kelvin.

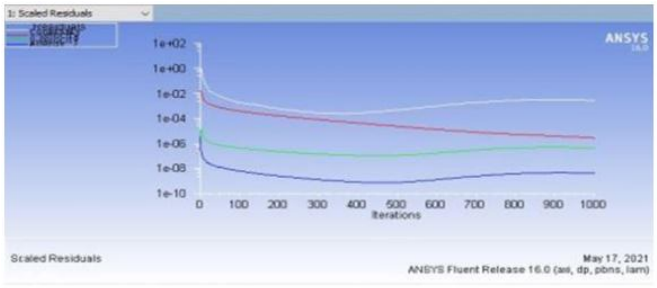
For 3% increase in the concentration of Nano Fluid.



The inlet temperature is taken as 293 Kelvin and the outlet temperature is observed as 306.4 Kelvin.

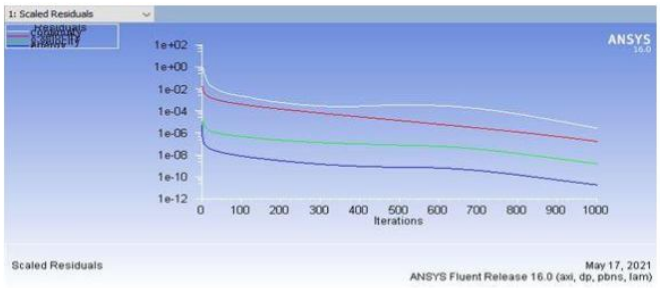
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For 4% increase in the concentration of Nano fluids.



The inlet Temperature is taken as 293 Kelvin and the outlet temperature is observed as 305.6 Kelvin.

For 5% increase in the concentration of Nano Fluid.



Inlet temperature is taken as 293 Kelvin and outlet temperature is observed as 304.6Kelvin.
It is observed form the above that after 3% concentration of the nano fluid, the outlet temperature is gradually decreasing.

E. Properties of Nanofluids

Al_2O_3:

MATERIAL	P(Density) Kg/ m³	Cp J/Kg-K	k W/m.K	μ Kg/m.s
Al_2O_3	3600	765	36	-
Al_2O_3-water c = 1%	1007.4	4154.7	0.661	0.000612
Al_2O_3-water c = 2%	1033.6	4120.5	0.68	0.000627
Al_2O_3-water c = 3%	1059.8	4086.2	0.699	0.000642
Al_2O_3-water c = 4%	1086	4052	0.719	0.000657
Al_2O_3-water c = 5%	1112.2	4017.8	0.739	0.000672

CuO:

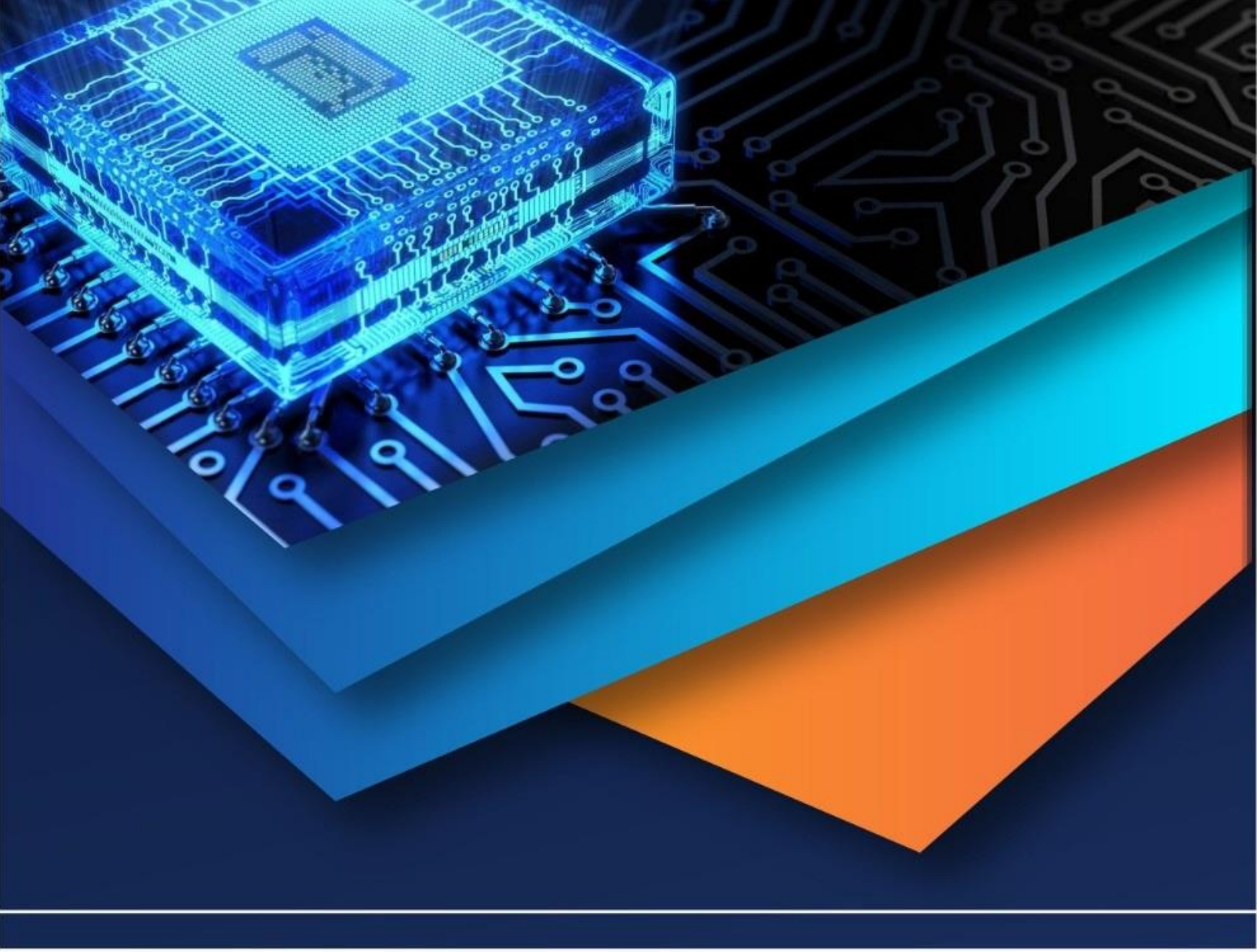
MATERIAL	P(Density) Kg/ m³	Cp J/Kg-K	k W/m.K	μ Kg/m.s
Copper (Cu)	8930	383.1	386	-
Cu-water c = 1%	1061	4150.9	0.662	0.000612
Cu-water c = 2%	1140.7	4112.8	0.682	0.000627
Cu-water c = 3%	1220.4	4074.8	0.702	0.000642
Cu-water c = 4%	1300.2	4036.7	0.723	0.000657
Cu-water c = 5%	1378	3998	0.744	0.000672

V. CONCLUSION

It is observed that the overall efficiency of solar water heater is enhanced. Al2O3 nanofluid has better thermal enhancement rate compared to other nanofluids like CuO. Al2O3 nanofluid has critical point at 3% concentration. As the concentration of nanofluid increases, the heat transfer coefficient first increases. When the concentration exceeds the critical value, the heat transfer coefficient decreases. Sufficient hot water can be available even in the seasons like rainy and winter. This can be used for both commercial and domestic purposes. This provides faster rate of heating water, and saves time compared to conventional solar water heater.

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