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Performance evaluation of Nano fluids for Radiator effectiveness

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Abstract

Newly emerging technologies due to their compactness are not being effectively served by the conventional heat transfer fluids. To serve these emerging technologies, Nano fluids are found to be best alternatives to the general heat transfer fluids. The heat transfer enhancement for many industrial applications by adding small Nano particles to liquids is efficient topic topics in the last few years. In this research work, experimental study of effective thermal conductivity of Zinc oxide based Nano fluids is to be presented. The concentration added is in of total volume fraction as 0.5, 1.0, 1.5, 2.0, and 2.5 %. Thermal conductivity of Nano fluids is to be experimentally measured, with the Nano particles volume concentration variation. The experimental results are to be validated through literature. This work is for Engine cooling system application where as we apply these effects on to all parallel applications. Further radiator effectiveness is to be study based on time of operation and temperature variation in radiator at that time; and finally, suggestion of good Nano particle % based on radiator effectiveness is to be done.
Keywords: *Radiator Effectiveness, Nano fluid, efficiency improvement techniques.*

1. Introduction

The execution of the motor cooling framework has dependably been obliged by the inactive way of the framework and it is have to give the required warmth dismissal capacity at high power conditions. This prompts impressive misfortunes in the cooling framework at part-stack conditions where vehicles work often. An arrangement of outline and working elements from cutting edge motor cooling frameworks is investigated and assessed for their capability to give enhanced motor insurance while enhancing fuel effectiveness and discharges yield. Although these elements show noteworthy potential to enhance motor execution, their maximum capacity is constrained by the need to adjust between fulfilling the motor cooling necessity under all working encompassing conditions and the framework viability, as with any ordinary motor cooling framework. The reconciliation of split cooling and exactness cooling with controllable components has been recognized as the most encouraging arrangement of ideas to be received in an advanced motor cooling framework. We realize that if there should be an occurrence of Internal Combustion motors, ignition of air and fuel happens inside the motor chamber and hot gasses are created. The temperature of gasses is to be around 2300-2500°C. at this high temperature and this may come about into consuming of oil film between moving parts and may come about into welding of the parts. Along these lines, this temperature must be decreased to around 150-200°C at which the motor is to work generally effectively. Cooling excessively is not attractive since it limits the warm productivity. Subsequently, the question of cooling framework is to keep up the motor running at its most productive working temp. the motor is very wasteful when it is frosty and in this manner the cooling framework is composed such that it counteracts cooling when the motor is beginning up and till it accomplishes most extreme proficient working temp, then it begins cooling.

A. Problem statement

The proposed project focuses on a system development where in total heat load on the radiator is studied along with effectiveness improvement based on coolant improvement. Engine coolant which is water + EG was tested with different combinations of ZnO for better radiator effectiveness.

B. Objectives of the Project

1. to develop set up for carrying out experimentation on radiator to improve effectiveness using nano fluids.
2. performance effectiveness of nanomaterials for different % concentration.
3. to select best concentration of Nano fluids.

C. Methodology

a] Theoretical Work:
1. Literature review of various configurations of radiator, Nanoparticles, Enhancement effects of nanoparticles and its applications.
2. Design of experimental set up with necessary instrumentation.

b] Experimental Work:
1. Experimentation with and without adding *nanoparticles.*
2. Testing of thermal performance on the % of nanoparticles added into the base fluid at different concentrations.

3. Testing of radiator effectiveness based on operation time at different Nano concentrations.

2. Nano Fluids

Today like never, ultrahigh-execution cooling assumes an imperative part in the improvement of vitality productive warmth exchange liquids which are required in numerous enterprises and business applications. Customary liquids, for example, water, motor oil and ethylene glycol are ordinarily utilized as warmth exchange liquids however these ordinary coolants are inalienably poor warmth exchange liquids. Albeit different methods are connected to improve the warmth exchange, the low warmth exchange execution of these regular liquids discourages the execution upgrade and the smallness of warmth exchangers.

A. The concept of Nano fluids

The idea of Nano liquids is created at Argonne National research facility (Choi, 1995) is straightforwardly identified with patterns in scaling down and nanotechnology. Late audits of research projects on nanotechnology in the U. S., China, Europe, and Japan demonstrate that nanotechnology is to be a developing and energizing innovation of the 21st century and that colleges, national labs, independent companies, and vast multinational organizations have officially settled nanotechnology inquire about gatherings or interdisciplinary focuses that attention on nanotechnology. It is assessed that nanotechnology is at a comparable level of advancement as PC/data innovation was in the 1950s. Solids have requests of-extent higher warm conductivities than those of regular warmth exchange liquids for instance, the warm conductivity of copper at room temperature is around 3000 times more prominent than that of motor oil. Along these lines, strong particles in liquids are relied upon to improve the warm conductivities of liquids. Indeed, various hypothetical and exploratory investigations of the viable warm conductivity of scatterings that contain strong particles have been directed since Maxwell's hypothetical work was distributed over 100 years back. Be that as it may, every one of the reviews on warm conductivity of suspensions have been restricted to millimeter or micrometer estimated particles. The real issue with these particles is their quick settling in liquids. As of late, nanotechnology has empowered the generation of Nanoparticles with normal sizes underneath 50 nm. Nanoparticles at this scale have remarkable properties. Applying this rising nanotechnology to build up warm vitality designing, Argonne built up the idea of Nano liquids, another and creative class of warmth exchange liquids that are built by suspending nanoparticles in ordinary warmth exchange liquids.

B. Synthesis process of nanofluids

The examples utilized as a part of this proposition work are the different sorts of nanofluids. Arrangement of nanofluids is the principal enter venture in exploratory reviews with nanofluids. Extensively nanofluids are by and large arranged by two strategies which are (a) One stage technique and (b) Two stage strategy. These techniques are depicted underneath. In nanofluids there is a fluids medium in which particles are scattered these are normally called the warmth exchange liquids.

1. One-stage Method: As the name proposes this is a one pot combination handle in which at the same time makes and scatters nanoparticles straightforwardly into base liquid. This is best to synthesize metallic nanofluids. Couple of techniques exist for the arrangement of nanofluids through a one stage handle. These strategies incorporate the warm decay of an organometallic antecedent within the sight of a stabilizer, concoction lessening, and polyol combination. The polyol strategy is a standout amongst the most surely understood pathways to respectable metal nanoparticles. In the polyol procedure, a metal antecedent is broken up in a fluid polyol (for the most part ethylene glycol), after which the trial conditions are acclimated to accomplish the diminishment of the metallic forerunner by the polyol, trailed by nuclear metal nucleation and metal molecule development. The immediate dissipation. Strategy was created by Choi et al. It comprises of a barrel containing a liquid which is pivoted. Amidst the chamber, a source material is vaporized. The vapor gathers once it meets the cooled fluid. The disadvantages of this method notwithstanding, are that the utilization of low vapor weight fluids are fundamental and just restricted amounts be delivered. Different single-stride compound combination methods likewise be utilized to create nanofluids. For instance, Burst and collaborators built up a system for delivering metallic nanoparticles in different solvents by the lessening of metal salts to create colloidal suspensions for an extensive variety of uses, including investigations of warm transport. Superb control of size and extremely limit measure appropriations be acquired by utilizing such techniques. A submerged circular segment nanoparticle blend framework (SANSS) was produced to get ready CuO nanoparticles scattered consistently in a dielectric fluid (deionized water). The technique effectively created a stable nanofluid. On a basic level, an unadulterated copper pole is submerged in a dielectric fluid in a vacuum chamber. A reasonable electric power source is utilized to deliver a circular segment between 6000 - 12000 °C which dissolves and vaporizes the metal pole in the district where the curve is produced. In the meantime, the deionized water is additionally vaporized by the curve. The vaporized metal experiences nucleation, development and buildup bringing about nanoparticles scattered in belittled water. Nanofluids containing CuO particles of size 49.1 ± 38.9 nm were gotten.

2. Two-stage Method: In this procedure as the name recommend there are two distinct strides are included. In the initial step nanoparticles are integrated and in the second step are broken down and scattered in some fluid medium. This strategy is generally connected for oxide nanofluids, nanoparticles are delivered by dissipation and latent gas buildup handling, and afterward scattered (blended, including

mechanical tumult and sonification) in base liquid. Two-stage technique is the most broadly utilized strategy for planning nanofluids. Nanoparticles, nanofibers, nanotubes or other nonmaterial utilized as a part of this technique are first created as dry powders by compound or physical strategies. At that point, the Nano-sized powder is to be scattered into a liquid in the second preparing venture with the assistance of concentrated attractive compel fomentation, ultrasonic unsettling, high-shear blending, homogenizing and ball processing. Two-stage strategy is the most monetary technique to deliver nanofluids in substantial scale, because Nano powder amalgamation procedures have as of now been scaled up to modern creation levels. Because of the high surface territory and surface action, nanoparticles tend to total. The critical system to upgrade the soundness of nanoparticles in liquids is the utilization of surfactants. Be that as it may, the usefulness of the surfactants under high temperature is additionally a major concern, particularly for high temperature applications. Because of the trouble in get ready stable nanofluids by two-stage strategy, a few propelled strategies are created to deliver nanofluids, including one-stage technique. In the accompanying part, we is to present one-stage strategy in detail. When contrasted with the single-stride strategy, the two-stage method functions admirably for oxide nanoparticles, while it is less fruitful with metallic particles. Aside from the utilization of ultrasonic gear, some different systems, for example, control of pH or expansion of surface dynamic specialists are likewise used to accomplish solidness of the suspension of the nanofluids against sedimentation. These strategies change the surface properties of the suspended particles and subsequently stifle the propensity to frame molecule groups. It ought to be noticed that the choice of surfactants ought to depend principally on the properties of the arrangements and particles.

C. Thermal Conductivity of Nanofluid

The warmth exchange resistance of a streaming liquid is frequently spoken to by a Nusselt number, which considers the liquid warm conductivity straightforwardly and normally in a roundabout way too through the Prandtl number. Consequently, a first evaluation of the warmth exchange capability of a nanofluid is to consider its warm conductivity. To date, more research has been distributed here than in some other identified with nanofluids for warmth exchange purposes. In analyzing the building writing, for each situation, the warm conductivity upgrade proportion has been figured from the data given in the specialized papers. The warm conductivity improvement proportion, or just the "upgrade," is characterized as the proportion of the warm conductivity of the nanofluid to the warm conductivity of the base liquid. For consistency in this review, the expression "improvement" alludes to the upgrade proportion seeing any parameter, for example, warm conductivity, warm exchange coefficient, and Nusselt number.

$K_{eff}^* = \frac{K_p^*(1+2\emptyset)+2(1-\emptyset)}{K_p^*(1-\emptyset)+(2+\emptyset)}$ $K_{eff}^* = \frac{K_e}{K_m}$ $K_p^* = \frac{K_p}{K_m}$

Where,

ϕ = Volume fraction of the solid inclusion.
k =Thermal conductivity
Ke = thermal conductivity of mixed phase
Kp = thermal conductivity of the particle
Km = thermal conductivity of the medium

3. Experimental setup

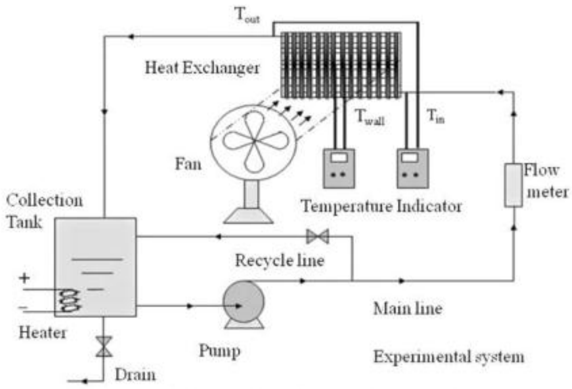

Figure 1: Layout Experimental Setup

Figure 2: Experimental Setup

4. Result and discussion

Table 1. Reading from the testing at different % addition of Nano particles

Sr no.	% Nano Particles	T_{in} (°C)	T_{out} (°C)	T_S (°C)
1	0.5	71	52	61.5
2	1.0	68	48.5	58.25
3	1.5	66.5	46.5	56.5
4	2.0	66.1	46	56.05

Table 2. Result for Different percentage of Nano Fluid

Sr no	% Nano Particles	Mass Fraction	Ø	μ_{nf}	ρ_{nf}	$C_{p\text{-}nf}$
1	0.5	0.004975	0.000891107	0.000803269	1004.104438	4.162587065
2	1.0	0.009901	0.001780627	0.000808684	1008.201567	4.146336634
3	1.5	0.014778	0.002668564	0.000814244	1012.291407	4.130246305
4	2.0	0.019608	0.003554924	0.000819949	1016.373978	4.114313725

Table 3. Result for Different percentage of Nano Fluid

Sr no	% Nano Particles	K_{nf}	Re	h	Q
1	0.5	0.576196633	5000.091	639.2657	7059.002
2	1.0	0.577701208	4986.8749	762.3828	7245.928
3	1.5	0.579205726	4972.9117	785.3149	7432.912
4	2.0	0.580710186	4958.2286	799.3597	7471.271

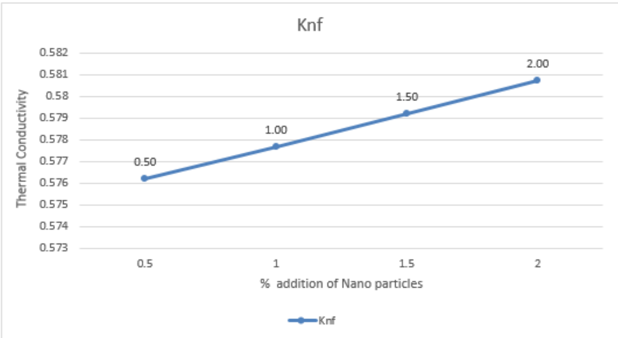

Figure 3: % Addition of +- Nano particles Vs Thermal Conductivity

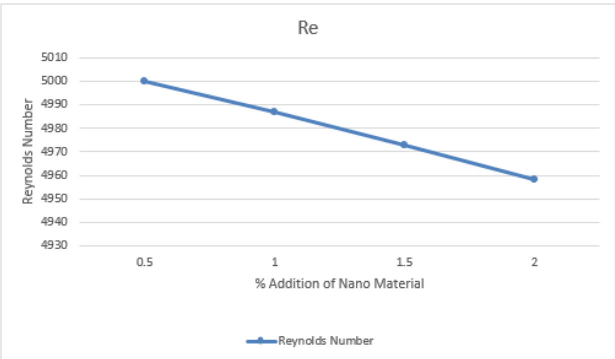

Figure 4: % Addition of Nano particles Vs Reynolds Number

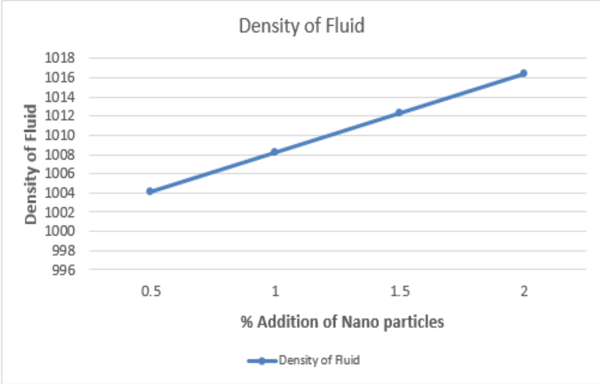

Figure 5: % Addition of Nano particles Vs Density of Fluid

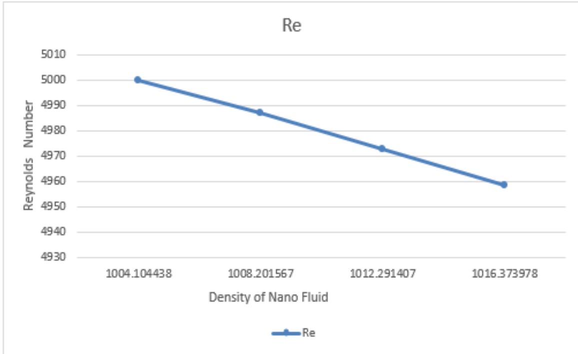

Figure 6: Density of Nano Fluids Vs Reynolds Number

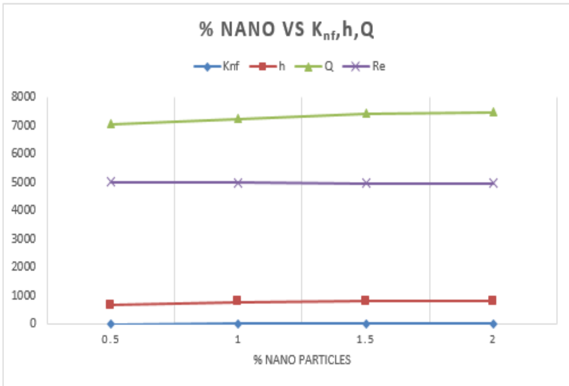

Figure 7: % of Nano Fluids Vs Knf, h, Q

From above results :

K increases as % concentration increases.

Re slightly decreases as % concentration increases.

Density increases % concentration increases.

Re decreases with density increment.

Specific heat decreases as % Concentration increases.

A. Effectiveness Of Radiator For Conventional And Nano Fluid %

Experimental Testing

Here,

T = Tank Fluid Temperature, oC

Tin = Radiator In Temperature, oC

Tout = Radiator Out Temperature, oC

ΔT = Temperature difference along Radiator, oC

Time = Minutes

Table 4 : Readings for Water

Sr. No.	Time	T	T_{in}	T_{out}	ΔT
1	0	80	73	67	6
2	3.48	75	68	63	5
3	8.55	70	65	59	6
4	14.1	65	61	56	5
5	21.2	60	58	54	4
6	29.44	55	55	52	3
7	42.19	50	50	48	2

Table 5: Reading for 0.5 % Nano particle concentration

Sr. No.	Time	T	T_{in}	T_{out}	ΔT
1	0	80	54	46	8
2	1.38	75	54	44	10
3	4.37	70	52	43	9
4	8.33	65	49	41	8
5	13.3	60	47	39	8
6	19.36	55	44	38	6
7	28.46	50	41	37	4

Table 6: Readings for 1.0 % Nano particle concentration

Sr. No.	Time	T	T_{in}	T_{out}	ΔT
1	0	80	59	47	12
2	2.15	75	54	43	11
3	4.44	70	53	42	11
4	8.04	65	50	40	10
5	12.26	60	47	39	8
6	18.13	55	44	38	6
7	26.17	50	43	37	6

Table 7: Readings for 1.5 % Nano particle concentration

Sr. No.	Time	T	T_{in}	T_{out}	ΔT
1	0	80	58	47	11
2	1.57	75	54	44	10
3	4.25	70	51	43	8
4	7.5	65	49	41	8
5	12.26	60	46	40	6
6	18.24	55	43	38	5
7	26.54	50	40	37	3

Table 8: Reading for 2.0 % Nano particle concentration

Sr. No.	Time, Min	T	T_{in}	T_{out}	ΔT
1	0	80	55	46	9
2	1.51	75	52	43	9
3	4.08	70	50	42	8
4	7.16	65	48	41	7
5	11.26	60	45	40	5
6	16.44	55	43	38	5
7	24.04	50	40	37	3

From the results below there is significant time difference between water cooling and Nano cooling system. For example, for 2.0% Nano its 42.01%-time reduction than water. Also, a reading suggests that time requirement gets reduced as Nano concentration % increases.

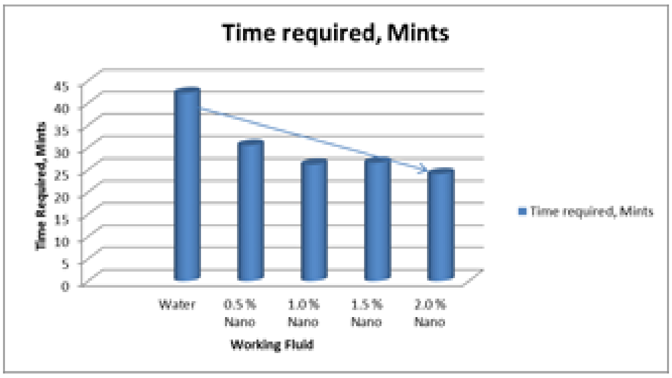

Figure 8: Time required for various working fluids to cool the fluid

Effectiveness of Radiator:

Effectiveness = ((Tin-Tout))/((Tin-Tc))

Tc = Room Temperature

Table 9: Readings at 5 mints of operation

5 Mints				
	Tin	T out	Tc	Effectiveness
Water	67.1	61.8	32	0.176007866
0.5 % Nano	52.07	43.03	32	0.450423518
1 % Nano	52.53	41.69	32	0.431507793
1.5 % Nano	50.54	42.54	32	0.528149946
2 % Nano	49.4	41.7	32	0.442528736

Table 10: Readings at 12.5 mints of operation

12.5 Mints				
	Tin	T out	Tc	Effectiveness
Water	62.51	57.14	32	0.176007866
0.5 % Nano	47.29	40.87	32	0.419882276
1 % Nano	47.18	39.06	32	0.434914361
1.5 % Nano	46.16	40.05	32	0.53497175
2 % Nano	44.71	39.71	32	0.393391031

Table 11: Readings at 20 mints of operation

	20 Mints			
	Tin	T out	Tc	Effectiveness
Water	58.51	54.34	32	0.157299132
0.5 % Nano	44.33	39.16	32	0.429302514
1 % Nano	43.77	37.77	32	0.442077060
1.5 % Nano	42.36	37.78	32	0.509784942
2 % Nano	41.59	37.53	32	0.423357664

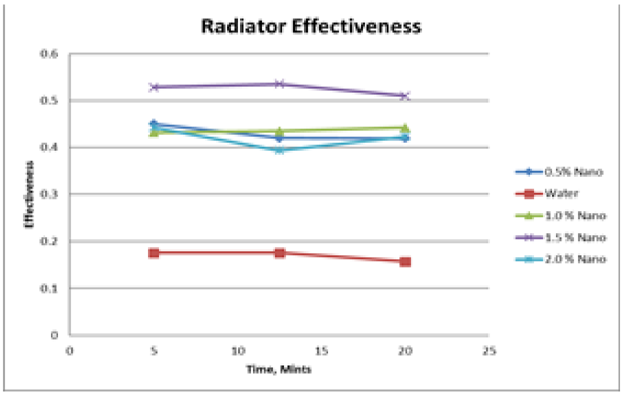

Figure 9: Radiator effectiveness at different working fluids

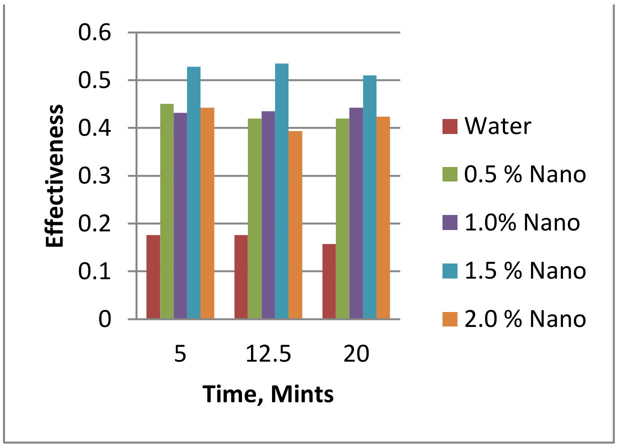

Figure 10: Radiator effectiveness at different working fluids in chart

From the above results, we see that the effectiveness of radiator is on higher side at starting time and goes on decreasing as temperature decreases. 1.5 % Nano particle addition shows higher effectiveness than other concentrations.

CONCLUSION

1. Reynolds Number slightly decreases as % concentration increases.
2. Density increases % concentration increases.
3. Reynolds Number decreases with density increment.
4. Specific heat decreases as % Concentration increases.
5. From the results, we see that the effectiveness of radiator is on higher side for Nano fluids and it goes on decreasing as temperature decreases; i.e. at low temperatures radiator effectiveness is higher.
6. 1.5 % Nano particle shows higher effectiveness ie. 0.509784942 for 20 minutes.

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