Experimental Investigation On Natural Convection Heat Transfer Augmentation With Vibration Effect By Using Water-Al_2o_3 Nanofluid

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ABSTRACT: Conventional fluids including water, engine oil, ethylene, ethylene glycol, and transformer oil have a lower thermal conductivity of fluid compared to strong. The nanofluid is used in different applications like commercial, heat exchange, motor car, and biomedical, etc. The nanoparticles and sodium dodecyl sulfate are mixed into a base fluid (water) for distinct volume fractions (0.05%, 0.1%, 0.15%, and 0.2%) and supply diverse heat inputs 30W, 40W, 50W, 60W. The Al_2O_3 nanoparticles are high thermal conductivity then Cuo. The SDS (sodium dodecyl sulfate) mixed with Al_2O_3 nanoparticles are suspension kingdom for a long time without settling at the lowest allocation of the square rectangular prismatic enclosure. The unbalanced motor positioned below the cylindrical surface then its floor is vibrated and its temperature increases. The dimmer stat used to various voltages and frequency 100Hz-190Hz. The fluid at constant in enters gadget then enhancement of heat transfer coefficient increase.

Keyword: Natural convection, Heat transfer, Constant heat flux, Boundary theory layer, Vibration, Frequency.

I. INTRODUCTION

The metallic oxides are Al_2O_3 are nano-sized debris 50-80nm, sodium dodecyl sulfate and base fluid of water blended into glass breaker via the usage of the magnetic stirrer technique in 1 hour without settle within the bottom part of the enclosure but sodium dodecyl sulfate is used to surface is corrosion. The cylindrical floor temperature measured an axial distance of boundary layer thickness because the lowest part of a boundary layer is less will temperature increase and above in advance will temperature decreases that component due to the fact boundary layer thickness is greater. The two strategies used for without vibration impact and with vibration impact on a cylindrical floor. The vibratory motor placed beneath the desk and its accelerometer used to measure the vibrating alerts to the enhancement of warmth transfer fee will increase. Better to its temperature increases with vibration impact.

II. EXPERIMENTAL SETUP

The experimental setup includes a galvanized cylindrical container and inside a rectangular enclosure and it located inside the brass vertical heater. A vibrator (single-phase vibrator) became bolted at the rigid helping body and it's tightly. The outer galvanized iron cylindrical field consists of L*H*D (265mm*350mm*258mm) and its cylinder fixed at each end became carried on brackets installed at the vibrating strip and receiving vibrations via it. The inner aluminium square enclosure includes l*b (120mm*120mm) and t*h (4mm*300mm) respectively.

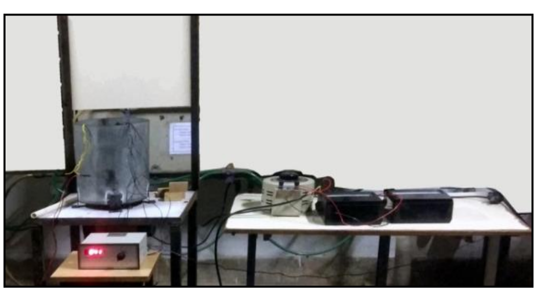

Fig 1: *Experimental setup*

The cylindrical heater road covered with brass fabric consists of D*l (18.5mm*250mm) and its floor located on Eight K-type thermocouples and its each thermocouple distance is 33.3mm. The 6 point temperature indicator connected to the six K-type thermocouples (data received system) and its temperature recorded. A 3 core cable linked vibrator to dimmer stat and its frequency or amplitude tiers growth to decrease. An accelerometer was used to pick out up a vibration sign from the cylinder and transmit the same to a vibration meter that could measure amplitude, pace or acceleration.

Volume fraction % = $(\frac{mn}{\rho n})/(\frac{mn}{\rho n}+\frac{mf}{\rho f})$

Density of nano-fluid $\rho nf = \phi\rho p + (1-\phi)\ \rho f$ Specific heat $Cp_{nf} = (1-\phi)(\rho C_p)_f + \phi(\rho C_p)_p$

Dynamic viscosity $\mu nf = \mu f(1+2.5\,\phi$

Thermal conductivity

$$K_{nf} = \frac{K_p+2K_f+2(K_p-2K_f)\,\phi}{K_p+2K_f-(K_p-2\,K_f)\,\phi} \cdot K_f$$

Rayleigh number $Ra_L = Gr.\ Pr = g\beta l^3\Delta T/v^{2.}\ \mu c_{p\,/k}$

Nusselt number $Nu = 0.287\ (Ra_L)^{0.287}$

III. EXPERIMENTAL WORK

Two-step techniques are employed to produce the alumina nanofluid. Alpha-Al_2O_3 nanoparticles (99.5% Virtue) had been obtaining from nano labs, India and the producer stated that the purchased alumina particles with not unusual length 50-80nm had been having a specific floor area15-20 m^2/g, bulk density of 3.95-4.1 g/cm^3. Al_2O_3 nanoparticles have been diffuse into the demineralised liquid inside the needed bulk comparable to the volume fraction of nanofluid and executed to the magnetic stirring, ultrasonication. The quantity of the nanoparticles delivered to the bottom fluid for making nanofluid through the use of under Eq. And show underneath the TEM pictures.

Volume fraction % = $(\frac{mn}{\rho n})/(\frac{mn}{\rho n}+\frac{mf}{\rho f})$

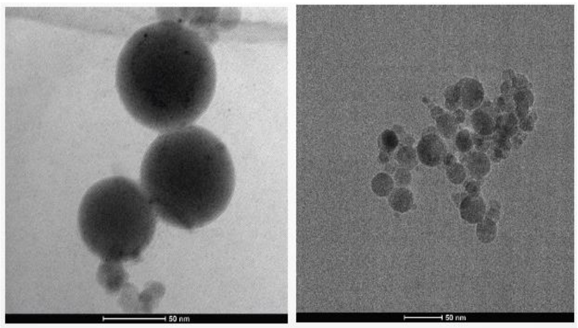

Fig 2: *Transmission electron micrographs*

The experimental method may be divided into

1. Natural convection without vibration 2. Natural convection with vibration

The natural convection without vibration in electrical enter is given to the heater in the cylinder. The water entered into the cylinder floor reaches to examine kingdom circumstance. The thermocouples located on the heater surface and it's connected to the information acquired a device. The two successive readings of thermocouples were the identical, output readings are recorded. The convection with vibration in an electrical heater became given a random input. The demon stat turned into the first set to power-on position and varying to energy-load function, therefore beginning the vibration of the cylinder. The dynamo frequency was adjusted to the favoured degree. The accelerometer is used to measure the frequencies which had been established at the bracket carrying the cylinder. After the regular-kingdom become reached, the temperature distinction, frequency, peak to peak values of amplitude, voltage, modern-day electrical energy, and the ambient temperature was recorded top to the bottom component.

IV. RESULT AND DISCUSSIONS:

Analysis to perform at distinct heat inputs through adjusting the voltage switch with the use of diverse Heat inputs specified to the cylinder is 30W, 40W, 50W and 60W. The outside temperatures of the brass vertical cylinder are systematic with using thermocouples within the axial course for nanofluid medium accelerated for any warmness input, due to excessive neighborhood warmness switch coefficients going on at the bottom vicinity of the cylinder and pinnacle portion of the cylinder at temperature decreases because relies upon on perimeter layer thickness. The thermo physical properties plot of the evaluation fluid is estimated on the film heat, that's the same old outside heat of the cylinder and the bulkhead of the fluid and is supplied in the equation. The bulk circumstance of the fluid medium is estimated via the usage of a natural convective without or with a vibration impact.

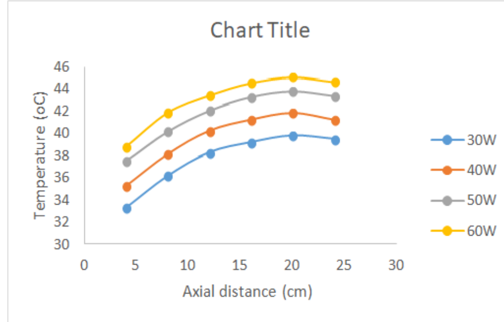

Fig-3: *Surface temperature of the vertical cylinder along axial distance for without vibrations in the nanofluid.*

The experimentation was conducted on various heat inputs are 30W, 40W, 50W & 60W by adjusting the voltage supply with the use of variation. An area temperature of the cylindrical brass prismatic container in axial direction for base fluid (water) + Al_2O_3 nanoparticle is called nanofluid. The brass cylindrical area temperature increases in axial direction because depends on boundary layer thickness. The resident heat transfer coefficient increases below the portion of the container. The average area temperature of the film temperature and bath temperature is recycled to estimate the film temperature.

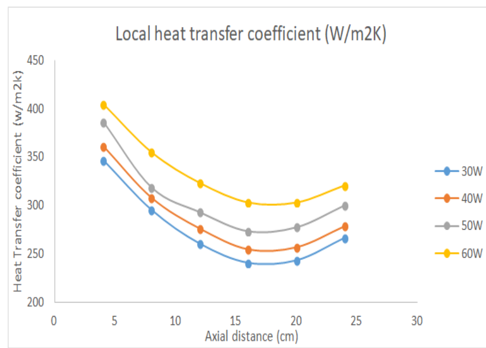

Fig-4: *Variation of heat transfer coefficient with axial distance various heat input*

It is recognized that the resident heat transfer coefficient increases in the lower allocate of the cylinder and it decreases above ahead. Because perimeter layer thickness is small in the lower allocate of the cylinder then the local heat transfer rate increases. Otherwise, the thickness of the perimeter layer is more than its local heat transfer coefficient decrease.

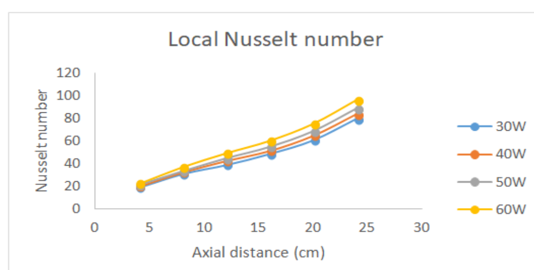

Fig-5: *Variance of the local Nusselt number with axial distance in various heats input*

It is recognized that the resident nusselt number increases to the axial direction for various heat inputs in water + Al_2O_3 in a fluid medium. The thermal properties of the fluid measure to the film temperature of the fluid and its boundary layer thickness increases in the lower allocation to the above allocation of the cylinder. The variation of temperature along radial direction when the water + Al_2O_3 its fluid medium respectively.

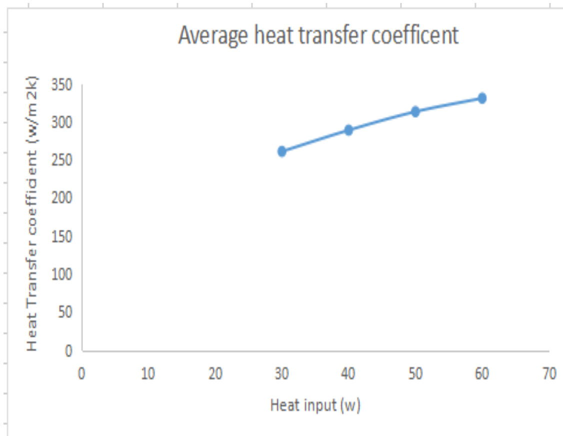

Fig-6: *Variation of heat transfer coefficient with heat input*

It is observed that different heat inputs 30W, 40W, 50W and 60W with average heat transfer coefficient increases by the lower allocation to the above allocation of the cylinder with linearly.

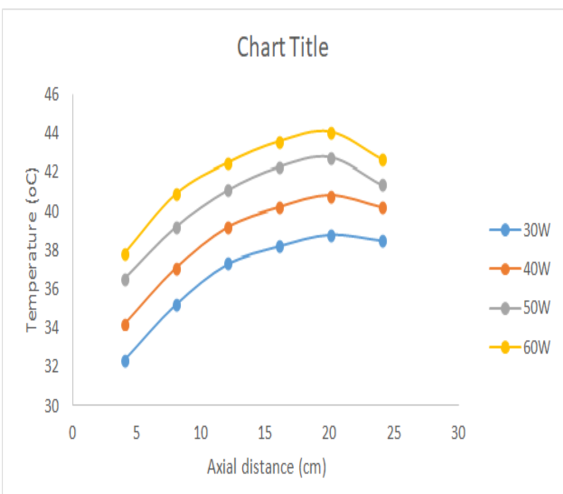

Fig-7: *Surface temperature of the vertical cylinder along axial distance for with vibrations in the base fluid.*

It is observed that the area of the temperature is increased at the lower and it is decreased at the above of the cylinder with vibration effect. As the boundary thickness is small in the lower allocation of the axial direction, the temperature will be increased and as it goes ahead to the above allocation of the cylinder. The vibration reaction on the surface of the fluid temperature increases to better than it's with vibration.

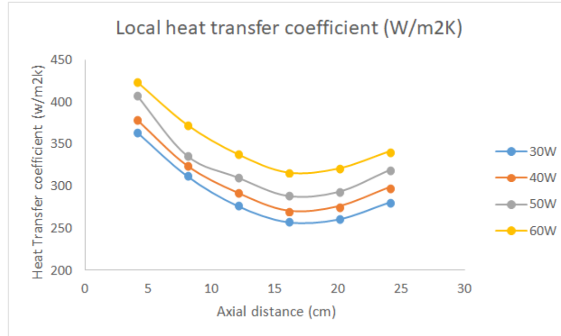

Fig-8*: Variation of heat transfer coefficient with axial distance various heat input with vibration effect*

It is understood that the resident heat transfer coefficient is increased at the lower and it is slightly decreased at the above of the allocation. As the boundary thickness is small in the bottom allocation of the axial direction, the resident heat transfer coefficient will be higher and as it goes ahead to the above allocation of the cylinder, otherwise, the thickness of the boundary layer is more than its resident heat transfer coefficient decrease. The Better to its vibration effect of the fluid than the lower allocation of the cylinder the resident heat transfer coefficient increases.

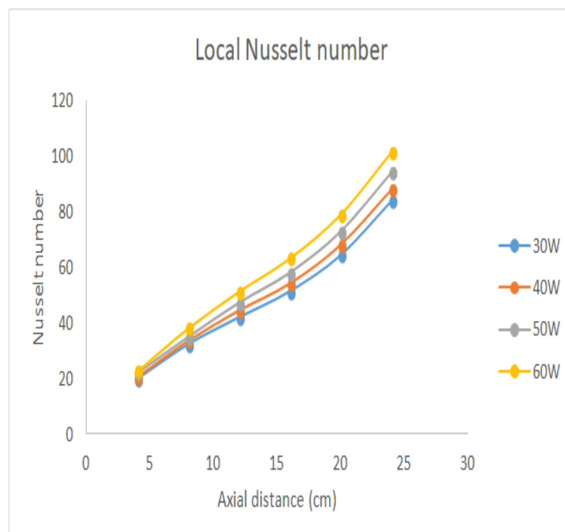

Fig-9*: Variance of local Nusselt number with axial distance various heat input*

It is recognized that the resident nusselt number increases to the axial direction for various heat inputs in water + Al_2O_3 in a fluid medium. The thermal properties of the fluid measure to the film temperature of the fluid and its boundary layer thickness increases in the lower allocation to the above portion of the cylinder. The variation of temperature along radial way when the water + Al_2O_3 its fluid medium respectively. The vibration effect of the area temperature increases the lower allocation of the cylinder better than it's without vibration effect.

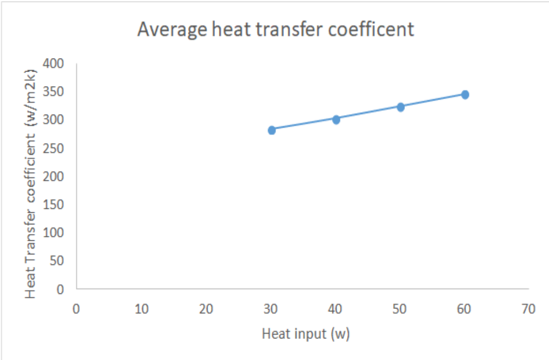

***Fig-10**: Variance of the local Nusselt number with axial distance with various heat input*

It is observed that vibration effect at the floor is given to various heat inputs 30W, 40W, 50W, and 60W with common heat switch coefficient will increase with the aid of the lower component to the pinnacle element with linearly.

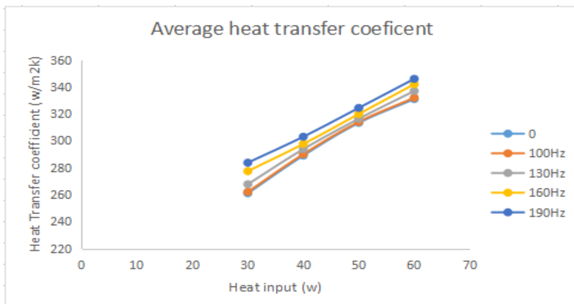

***Fig-11**: Variation of Average heat transfer coefficient with heat input*

It is observed that different heat inputs 30W, 40W, 50W and 60W with average heat transfer coefficient increases by the lower allocation to the above allocation of the cylinder with linearly in a base fluid medium. This graph observed to compare with or without vibration in the lower allocation to increases linearly in the above allocation. The vibrating frequency increases 100Hz, 130Hz, 160Hz, and 190Hz and it's better to improve the heat transfer rate then compare to the without vibration effect.

Uncertainty analysis

Uncertainty and error analysis is a process which takes the errors associated in each and every measuring quantity to figure out the uncertainty of the whole experiment. For example, the error associated in measuring length and breadth leads to error in calculating the cross sectional area. For the present experiment, all the temperatures produce the measured values from thermocouples. Thermocouples are having a resolution of 0.1 ^{o}C. These quantities are used to determine the uncertainties connected to the experiment. To obtain the uncertainty of the experiment from the accuracy of the individual instruments, the following mathematical formula eq.6.1 is used.

$$[\varepsilon(F)]^2 = \left[\frac{\partial F}{\partial x_1}\varepsilon(x_1)\right]^2 + \left[\frac{\partial F}{\partial x_2}\varepsilon(x_2)\right]^2 + \cdots + \left[\frac{\partial F}{\partial x_i}\varepsilon(x_i)\right]^2$$

Where F and ε are calculated quantity and uncertainty or absolute error respectively and x_1, x_2.....x_i is the measured parameters or variables.

In the present experiment, the main source for uncertainty is the error due to measurement of temperature, heat transfer rate and physical dimensions of vertical brass rod. As the heat transfer evaluate is Q= hA (ΔT), heat transfer coefficient is

h=Q/ A (ΔT)

$$[\varepsilon(h)] = \sqrt{\left[\frac{\partial h}{\partial Q}\varepsilon(Q)\right]^2 + \left[\frac{\partial h}{\partial A}\varepsilon(A)\right]^2 + \left[\frac{\partial h}{\partial_{\Delta T}}\varepsilon(\Delta T)\right]^2}$$

$$[\varepsilon(h)] = \sqrt{\left[\frac{1}{A\Delta T}\varepsilon(Q)\right]^2 + \left[\frac{-Q}{A^2\Delta T}\varepsilon(A)\right]^2 + \left[\frac{-Q}{A\Delta T^2}\varepsilon(\Delta T)\right]^2}$$

V. CONCLUSION

1. The impact of vibration upon the cylindrical brass floor the heat switch charge increases with high frequency or amplitude and its small diameter.
2. The axial distance of the boundary layer bottom place to the top vicinity increases barely.
3. The herbal convection of cylindrical surface decreases with increases within the temperature version.
4. The vibration Reynolds variety has riches consequences on the warmth switch from the cylinder. The loose convection term (Gr. Pr) has a bad impact on the vibration heat switch.
5. The Study approximately this test cylindrical diameter decreases with vibration frequency will increase and substantially will increase temperature distinction.
6. The vibration effect on natural convective warmth switch is more desirable by water at 60w heat enter has the heat transfer coefficient is expanded 321.334 w/m2k to 341.419 w/m2k.

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