CHAPTER- 6

CONCLUSIONS
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CHAPTER 6

CONCLUSIONS

A search of the pertinent literature revealed that pool boiling studies with nano fluids on vertical surfaces is scarce and also data with nanofluids WO$_3$ is not available in open literature. The problem has been taken up to obtain experimental data on pool boiling heat transfer of two nanofluids on three different surface materials in vertical orientation.

The experimental setup has been devised for data collection in nucleate pool boiling regime. Since available studies on vertical surfaces are very limited the data has been validated with boiling on horizontal surfaces with pure water.

- From the experiments for boiling of pure water on stainless steel, brass and copper vertical surfaces it is recorded that the excess temperature on stainless steel surface is $16^\circ$C lowest, $20^\circ$C for brass and for copper surface is $22^\circ$C highest, accordingly the boiling heat transfer coefficient of stainless steel, which is highest is $92.54$ kW/m$^2$K and for brass is $74.03$ kW/m$^2$K, while it was lowest on copper surface is $67.38$ kW/m$^2$K. These are similar results as on horizontal surfaces. The trends and enhancements are not much deviated from boiling on horizontal surface.
Heat transfer coefficient on stainless steel surface recorded about 37% more than that of copper surface while that on brass surface gave about 10% higher than that of copper surface.

- The experiments on boiling of nanofluıds on copper surface with varying concentrations gave (i) with silica nanofluid the heat transfer enhancement is found gradually increasing with concentration of the silica from about 10% for 0.01g/l concentration to about 37% with 1.0g/l concentration when compared with heat transfer coefficient values for pure water. (ii) With tungsten oxide nanofluids the heat transfer coefficient is found gradually increasing with concentration of tungsten oxide from about 4.63% for 0.01g/l concentration to about 29.25% with 1.0g/l concentration when compared with heat transfer coefficient values for pure water.

- Similarly the boiling of nanofluıds on brass surface with varying concentrations gave (i) with silica nanofluid the heat transfer coefficient enhancement is found gradually increasing with concentration of the silica from about 11.10% for 0.01g/l concentration to about 42.85% with 1.0g/l concentration when compared with heat transfer coefficient values for pure water. (ii) With tungsten oxide nanofluids the heat transfer coefficient is found gradually increasing with concentration of tungsten oxide from about 5.26% for 0.01g/l concentration to about 33.33% with 1.0g/l concentration when compared with heat transfer coefficient values for pure water.
Similarly on stainless steel surface with varying concentrations gave (i) with silica nanofluid the heat transfer enhancement is found gradually increasing with concentration of the silica from about 14.28% for 0.01g/l concentration to about 60% with 1.0g/l concentration when compared with heat transfer coefficient values for pure water. (ii) With tungsten oxide nanofluids the heat transfer coefficient is found from about 6.66% for 0.01g/l concentration to about 45.45% with 1.0g/l concentration when compared with heat transfer coefficient values for pure water.

From experimental data collected for the boiling heat transfer coefficient of nanofluids with different concentrations on three vertical surfaces, it is found that (i) for lower concentrations of silica in the nanofluid the enhancement of heat transfer coefficient on the three surfaces are very low while at higher concentrations the enhancement is appreciable. The enhancement is low on copper surface in line with the findings in the literature while the heat transfer coefficient enhancement gave about 60% on stainless steel for silica concentration of 1.0g/l in the nanofluid. (ii) The values for the brass stand in between those on stainless steel and copper values.

The experimental data for boiling heat transfer coefficient it is found that (ii) for lower concentrations of tungsten oxide nanofluid enhancement of heat transfer on the three surfaces are very low while at higher concentrations the enhancement is appreciable. The enhancement is low on copper surface while the heat transfer
coefficient enhancement gave about 45.45% on stainless steel for tungsten oxide concentration of 1.0g/l in the nanofluid. (ii) The values for the brass stand in between those on stainless steel and copper values.

- The heat transfer coefficient of two nanofluids (i.e. silica and tungsten oxide) compared with different concentrations on three vertical surfaces (i) the heat transfer enhancement is found to be 6.38% with 1.0g/l concentration of silica nanofluid when compared with heat transfer coefficient values for tungsten oxide nanofluid on copper surface, (ii) the same is 7.14% with 1.0g/l concentration of silica nanofluid when compared with heat transfer coefficient values for tungsten oxide nanofluids on brass surface and (iii) on stainless steel surface it is about 10% with 1.0g/l concentration of silica nanofluid when compared with heat transfer coefficient values for tungsten oxide nanofluids.

- From the results it is found that Tungsten oxide based nanofluids gave higher heat transfer coefficients than pure water and also the enhancement is higher for higher concentrations, while they gave lower heat transfer enhancement than that of silica based nanofluids for all concentrations.
Scope for future investigations

The present work is oriented towards pool boiling on vertical cylindrical surface with nanofluids at atmospheric pressure. Yet the nucleate pool boiling with nanofluids is to be well explained. There is need and scope for further research on boiling heat transfer including critical heat flux, dynamics of bubble growth at different pressure conditions with nanofluids.