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Cfd and Thermal Analysis of Micro Fin Tubes to Optimize the Heat Transfer Rate Using Different Coolants

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ABSTRACT

In this thesis, analytical investigations are performed to determine boiling characteristics in micro-fin tubes for different refrigerants R32, R404a, R410A and R600. The performance of the micro fin tubes is determined bychanging fin heights 5mm and 4mm.

3D models of the tubes are done in 3D modelling software Catia. CFD and Thermal analysis is performed on the tube to determine the heat transfer coefficients, pressure drop and heat transfer rates. Thermal analysis is performed for different materials Aluminium alloy, Copper alloy and Titanium alloy.

Analysis is done in Ansys 14.5.

INTRODUCTION

Conventional resources of energy are depleting at an alarming rate that makes future sustainable development of energy use terribly tough. As a result, more emphasis has been placed on the development of different heat transfer surfaces and devices. Heat transfer augmentation techniques are usually classified into 3 classes namely: active techniques, passive techniques and compound techniques. Passive heat transfer techniques (ex: tube inserts) don't need any direct input of external power. Therefore several researchers' most popular passive heat transfer improvement techniques for their simplicity and applicability for several applications. Tube inserts present some benefits over different enhancement techniques, like they may be installed in existing smooth tube that exchanger, and that they maintain the mechanical strength of the smooth tube. Their installation is easy and price is low. It comparatively easy to do for cleanup operations too.

The process of increasing the performance of a heat transfer system is referred as the heat transfer enhancement technique.In recent years, the high price of energy and material has resulted in an increased effort aimed toward manufacturing additional efficient heat exchange equipment.The major challenge in planning a heat transfer is to manufacture the equipment compact and achieve a high heat transfer rate utilizing minimum pumping power. The topic of heat transfer growth in heat exchanger is serious interest within the style of effective and economical heat exchanger. Augmentation techniques increase convective heat transfer by reducing thermal resistance in a heat exchanger. A decrease in heat transfer surface area, size, and therefore weight of heat exchanger for a given heat duty and pressure drop. The heat transfer is enhanced by the subsequent totally different augmentation techniques. They're classified as (i) Passive Techniques (ii) Active Techniques (iii) Compound Techniques

The various heat transfer enhancement techniques is classified broadly as passive and active techniques. Passive techniques don't need direct input of external power, like active techniques. They typically use surface or geometrical modifications to the flow channel, or incorporate an insert, material, or extra device. Apart from extended surfaces, that increase the effective heat transfer surface area, these passive schemes promote higher heat transfer coefficients by disturbing the present flow behavior. This, however, is among a rise within the pressure drop. In the case of active techniques, the addition of external power primarily facilitates the specified flow modification and improvement within the rate of heat transfer. The employment of 2 or a lot of techniques (passive and/or active) in conjunction constitutes compound augmentation techniques.

The effectiveness of any of those methods is dependent addicted to the mode of heat transfer (single-phase free or forced convection, pool boiling, forced convection boiling or condensation, and convective mass transfer), and type and process application of the heat exchanger.

LITERATURE SURVEY

The paper is written by G.B. Jiang[1], The refrigerants tested were R32, R134a, R404a and R600A whereas vapour quality ranges from 0.1 to 0.9, mass flux 50, 250, 450 Kg m^2/sec and heat flux of 5, 12.5, 20 kW/ m^2 . The saturation temperature is 5^0C. For the smooth tube, the common heat transfer coefficients of R134a, R404a and R600A are110.9%, 78.0% and 125.2% of these of R22 in check conditions resp. For the micro-fin tube, the common heat transfer coefficients of R32, R134a, R404a and R600a are 1.86, 1.80, 1.69 and 1.78 times more than those of the smooth tube. The pressure drop of R32, R404a and R600a for the smooth tube is same to each other whereas the pressure drop of R134a is 17 times higher. The avg. pressure drop of R22, R134a, R407C and R410A for the micro-fin tube is 1.42, 1.30, 1.45 and 1.40 times higher in comparison with smooth one. Considering the impact of heat transfer improvement and pressure drop augment, the efficiency index g1 that values the thermo-hydraulic performance at identical flow rate of R32, R134a, R404aand R600a within the micro-fin tube used is 1.31, 1.38, 1.17 and 1.27 resp. compared with the smooth tube.

The paper is written by S. Wellsandt[2]An experimental investigation of in-tube evaporation of R134a has been done for a four m long herringbone micro fin tube with an outer diameter of 9.53 mm. Measured local heat transfer coefficients and pressure losses are reported for evaporation temperatures between K0.7 and 10.1 8C and mass flow rates between 162 and 366 Kg mK2 s K1. Results from this work are compared to experimental results from literature, in addition as expected values from some helical and herringbone micro fin correlations. Variations in heat transfer mechanisms between helical and herringbone micro fin tubes are mentioned, as heat transfer coefficients within the herringbone tube tend to peak at lower vapour qualities compared to helical micro fins. Correlations developed for helical micro fin tubes typically predict experimental values inside G30% for vapour qualities below 50%. However, at higher qualities none of the correlations areable to early of the peak of heat transfer coefficients.

The paper is written by S. Mukul Ray [3]Review of Nucleate Pool Boiling Heat Transfer utilizing Refrigerant, The pool boiling method happens within the shell side of flooded evaporators and air mass refrigerants are projected for industry applications. Improvement of heat transfer rate depends on totally different design of heating surface, type of refrigerant and in operation parameters like heating surface roughness, surface orientation, in operating pressure & temperature. Refrigerant plays an important role within the study of nucleate pool boiling heat transfer. Varied inferences are drawn based the prevailing parameters by totally different researchers for improvement of heat transfer rate. An in depth study has been applied utilizing different refrigerants on different surfaces to investigate the optimum value of heat transfer coefficients (HTC). The method can be additionally investigated utilizing heat transfer improvement particles like nanofluids and modification of the heating. The pool boiling process happens within the shell side of flooded evaporators and low pressure refrigerants are projected for industry applications. Improvement of heat transfer rate depends on totally different design of heating surface, design of refrigerant and operating parameters like heating surface roughness, surface orientation, operating pressure & temperature. Refrigerant plays an important role within the study of nucleate pool boiling heat transfer. Varied inferences are drawn supported the prevailing parameters by totally different researchers for improvement of heat transfer rate.

The paper is written by Wei-Juan Wang[4]Generalized neural network correlation for flow boiling heat transfer of R22 and its different refrigerants within horizontal smooth tubes, the proper prediction of refrigerant boiling heat transfer performance is vital for the design of evaporators. A generalized neural network correlation for boiling heat transfer coefficient of R22 and its different refrigerants R134a, R407C and R410A within horizontal smooth tubes has been developed. Four types of dimensionless parameter groups from existing generalized correlations are selected because the input of neural network, whereas the Nusselt number employed as the output. Three-layer perceptron is utilized because the universal approximator to create the connection between the input and output parameters. The neuron number of hidden layer is set by the performance of model accuracy and also the customary sensitivity analysis. The experimental data of the four refrigerants in open literatures are used for correlation.

The paper is written by KookjeongSeo[5]An experimental study on convective boiling of R-22 and R-410A in Horizontal smooth and micro-fin tubes, Evaporation heat transfer coefficients and pressure drops were measured for smooth and micro-fin tubes with R-22 and R-410A. Heat transfer measurements were performed for three.0 m long horizontal tubes with nominal outside diameters of nine.52 and 7.0 millimetre over an evaporating temperature range of −15 to 5°C, a mass flux range of sixty eight to 211 kg/m2s, and a heat flux vary of five to fifteen kW/m2. It had been determined that the heat transfer coefficient is magnified with mass flux. Evaporation heat transfer coefficients of R-22 and R-410A magnified because the evaporating temperature decreased at a lower heat flux. Generally, R-410A showed the higher heat transfer coefficients than R-22 within the range of Low Mass flux, high heat flux and high evaporating temperature. Pressure drop magnified with a decrease of evaporating temperature and an increase of mass flux.

Pressure drop of R-22 was higher that of R-410A at identical mass flux.

The Paper is Written ByAhmetSelimDalkiliç[6]presents an experimental comparison of the laminar film condensation heat transfer coefficients of R134a in vertical smooth and micro-fin tubes having inner diameters of 7mm and lengths of five hundred mm. Condensation experiments were performed at a mass flux of twenty nine kilogram m-2 s -1 . The pressures were between 0.8 and 0.9 MPa. The original smooth tube heat transfer model was changed by awell known friction factor to account for the heat transfer increment effects attributable to the presence of micro-fins on the interior wall surface throughout circular flow regime conditions. Modifications of the local heat transfer coefficient, and condensation rate on the tube length throughout downward condensation film were determined, considering the effects of the temperature distinction between the saturation temperature and therefore the inner wall temperature of the test tubes, and therefore the condensation temperature on these items. The results show that the surface shear stress is found to own significance for the laminar condensation heat transfer of R134a underneath the given conditions attributable to its higher predictive performance than the classical answer neglecting the interfacial shear stress impact.

CFD ANALYSIS OF BOILING HEAT TRANSFER IN MICRO-FIN TUBES

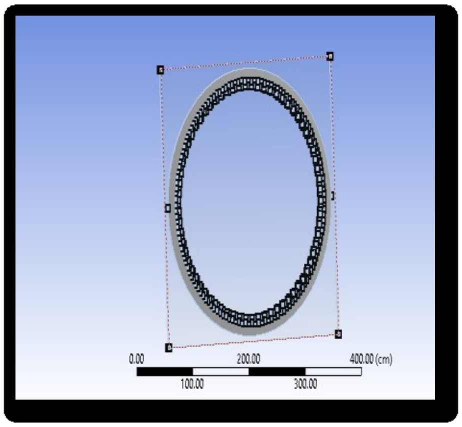

Fig: imported geometry

SPECIFYING BOUNDARIES FOR INLET AND OUTLET

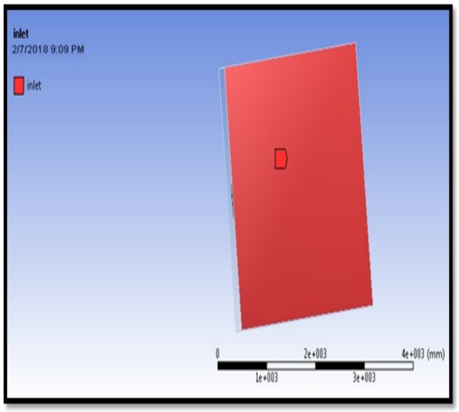

Fig: inlet

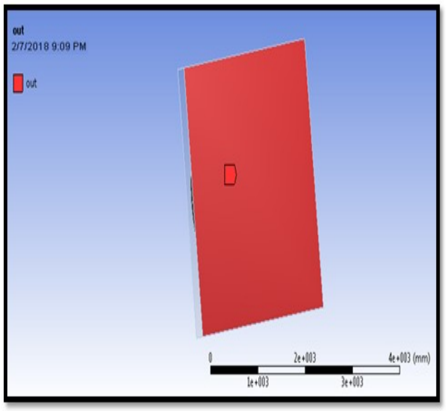

Fig: outlet

THERMAL ANALYSIS

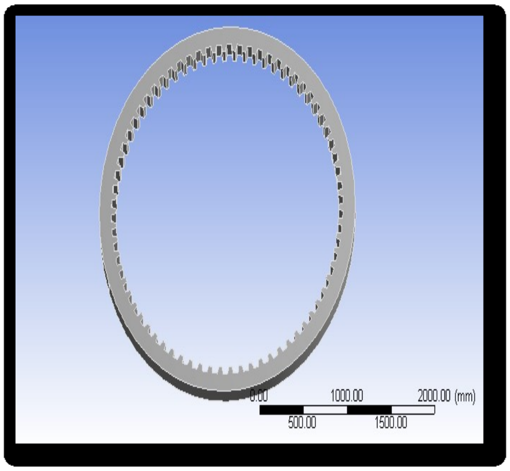

Fig - Imported model

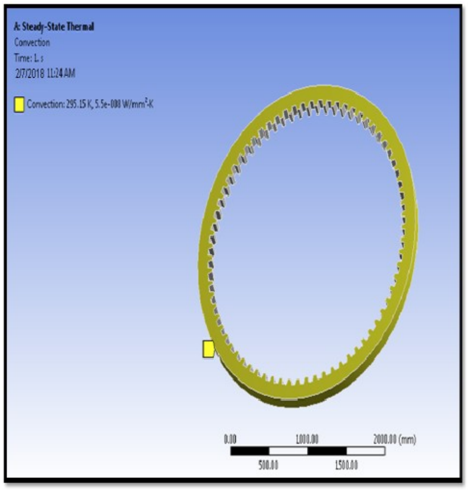

Fig – Convection applied on the outer surface

RESULTS TABLE

FIN HEIGHT – 5mm

	R32	R134A	R404A	R600
Pressure(Pa)	1.180e+005	1.199e+005	1.143E+005	1.139e+005
Velocity(m/s)	8.855e+000	7.294e+000	8.002e+000	1.232e+001
Heat transfer coefficient(W/m^2 K)	5.50e-02	3.58e-02	4.22e-02	3.95e-02
Total heat transfer rate (W)	9439.9105	2999.992	4839.9592	8399.9148

FIN HEIGHT – 3mm

	R32	R134A	R404A	R600
Pressure(Pa)	1.209e+005	1.220e+005	1.215e+005	1.211e+005
Velocity(m/s)	1.113e+001	9.512e+000	1.026e+001	1.559e+001
Heat transfer coefficient(w/m^2 K)	8.90e-02	6.45e-02	6.98e-02	8.76e-02

Total heat transfer rate (W)	3136.0473	2320.0535	2640.0086	2335.8784

THERMAL ANALYSIS

FIN HEIGHT – 5mm

R32

	ALUMINUM ALLOY	COPPER ALLOY	TITANIUM ALLOY
TEMPERATURE(℃)	121.14	121.12	121.27
HEAT FLUX (W/mm^2)	3.1873e-5	3.1876e-5	3.1857e-5

Table – Thermal analysis results of micro-fin tubes at 5mm height of R32

The table presents the values of temperature distribution and heat flux obtained from thermal analysis for micro-fin tubes at 5 mm fin height when R32 is used.

FIN HEIGHT – 3mm

R32

	ALUMINUM ALLOY	COPPER ALLOY	TITANIUM ALLOY
TEMPERATURE(℃)	121.16	121.12	121.38
HEAT FLUX (W/mm^2)	6.9203e-5	6.9214e-5	6.9137e-5

Table – Thermal analysis results of micro-fin tubes at 3mm height of R32

The table presents the values of temperature distribution and heat flux obtained from thermal analysis for micro-fin tubes at 3 mm fin height when R32 is used.

R134A

	ALUMINUM ALLOY	COPPER ALLOY	TITANIUM ALLOY
TEMPERATURE(℃)	121.15	121.12	121.31
HEAT FLUX (W/mm^2)	5.0156e-5	5.0162e-5	5.0121e-5

Table – Thermal analysis results of micro-fin tubes of R134A

The table presents the values of temperature distribution and heat flux obtained from thermal analysis for micro-fin tubes at 3 mm fin height when R134A is used.

R404A

	ALUMINUM ALLOY	**COPPER ALLOY**	**TITANIUM ALLOY**
TEMPERATURE(℃)	121.15	121.12	121.32
HEAT FLUX (W/mm^2)	5.4277e-5	5.4284e-5	5.4236e-5

Table – Thermal analysis results of micro-fin tubes of R404A

The table presents the values of temperature distribution and heat flux obtained from thermal analysis for micro-fin tubes at 3 mm fin height when R404A is used.

R600

	ALUMINUM ALLOY	**COPPER ALLOY**	**TITANIUM ALLOY**
TEMPERATURE(℃)	121.16	121.12	121.38
HEAT FLUX (W/mm^2)	6.8115e-5	6.8126e-5	6.8051e-5

Table – Thermal analysis results of micro-fin tubes of R600

The table presents the values of temperature distribution and heat flux obtained from thermal analysis for micro-fin tubes at 3 mm fin height when R600 is used.

CONCLUSION

In this thesis, analytical investigations are performed to determine boiling characteristics in micro-fin tubes for different refrigerants R32, R134a, R404A and R600. The performance of the micro fin tubes is determined bychanging fin heights 5mm and 3mm.

CFD is performed on the tube to determine the heat transfer coefficients, pressure drop and heat transfer rates.

By observing the results, the heat transfer coefficient for fin height 3mm is more for all refrigerants when compared with that of 5mm fin height. The heat transfer rate for fin height 5mm is more for all refrigerants when compared with that of 5mm fin height.

Comparing the results between fluids, the heat transfer coefficient and heat transfer rate are more when R32 is used.

Thermal analysis is performed for different materials Aluminum alloy, Copper alloy and Titanium alloy. It is performed for fin height 5mm with only R32 refrigerant and for fin height 3mm with all refrigerants.

By observing the results, the heat flux for fin height 3mm with R32 refrigerant is more for all materials when compared with that of 5mm fin height. The heat flux is more when Copper alloy is used.

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