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Design and Analysis of AC Condenser for Improving Efficiency

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ABSTRACT

In systems involving heat transfer, a condenser is a device or unit used to condense a substance from its gaseous to its liquid state, typically by cooling it. In so doing, the latent heat is given up by the substance, and will transfer to the condenser coolant. Condensers are typically heat exchangers which have various designs and come in many sizes ranging from rather small to very large industrial-scale units used in plant processes. Air cooled condensers are used in small units like household refrigerators, deep freezers, water coolers, window air-conditioners, split air-conditioners, small packaged air-conditioners etc. These are used in plants where the cooling load is small and the total quantity of the refrigerant in the refrigeration cycle is small.

In this thesis a design optimization is done by comparing various models of louver fin ac condensers. Heat transfer by convection in air cooled condensers will be studied and improved in this work. The assessment is carried out on an air-cooled finned-tube condenser of a vapor compression cycle for air conditioning system. Modelling is done in CATIA V5 R20

I. INTRODUCTION

An air conditioner (AC) in a room or a car works by collecting hot air from a given space, processing it within itself with the help of a refrigerant and a bunch of coils and then releasing cool air into the same space where the hot air had originally been collected. This is essentially how air conditioners work

The direct methanol fuel cell (DMFC) is a proton-exchange fuel cell, in which methanol is used as the fuel. The advantage of DMFC is to use of methanol, a reasonably stable liquid at environmental conditions. DMFC has developed to portable or small mobile applications where energy and power density are more important than efficiency. Recently, DMFC is finding broader application, because of their low-noise operation, mobility, and nontoxic e. Fuel cells should be effectively cooled for efficiency, and normally exchangers are needed for the anode and cathode sides. However methanol is not compatible with most metals, so the choice of metal is very limited. The heat exchangers are operated by using a fan and motor, so effective cooling is very important in the total fuel cell system. The louver fin and tube heat exchanger is one of the best candidates this application because of their performance, light weight, and low fan power. A large fraction of the total thermal resistance is on the air side of the louver fin heat exchanger. The configurations of the louver and tube greatly affect performance, cost, productivity, weight, etc. Much research has been conducted on the louver fin heat exchanger to improve heat transfer performance and reduce pressure drop. Kays and London (1984), Davenport (1983), Achaichia and Cowell (1988), Sunden and Svantesson (1992), Sahnoun and Webb (1992), Park and Jacobi (2009) and Kang and Jun (2011) presented empirical data and suggested correlations for louver fins. Gupta (2010) reported on the air side drainage and heat transfer performance of louver fin heat exchangers with drainage channels in their flat tubes. The present study considers a multi-tube and louver fin heat exchanger modified from the conventional flat tube or micro channel tube base heat exchanger. Experiments and numerical simulations were conducted for heat exchangers having six kinds of multi-tubes and flat tubes to investigate their performance.

Air conditioner fins:

There are two types of air conditioner fins: condenser fins and evaporator fins. Each performs a similar job of allowing air to flow smoothly through and out of an air conditioner, while each does this in a unique way.

Flat and louvered fin:

The usage of fin-and-tube heat exchangers in water chillers and heat pumps is increasing. Due to the relatively small heat transfer coefficient on the air side, the evaporators and condensers of these devices are relatively large in size. Decreasing their dimensions requires improvements in the heat exchange on the air side which can be achieved by redesigning the fin shape in the heat exchanger. Although many automotive companies and heat exchangers manufacturers have performed a lot of experimental research in fin heat exchangers, very little of the experimental data is publicly available due to its commercial value. However some extensive experimental data for louvered fins was reported by Davenport, Achaichia, Chang and Wang. Expensive and long-term experimental research allows examination of only a restricted number of geometrical shapes. In addition to the experimental study with the increasing processing power of modern computers, numerical fluid flow simulations have recently been widely used in order to improve airside performance of fin heat exchangers. Many papers report an improvement in airside performance by changing the fin geometry. One of the very popular enhancements is the interrupted surface. This is because the interrupted surfaces can provide higher average heat transfer coefficients owing to periodical renewal of the boundary layer development. The most common interrupted surfaces are louvered fins whose performance is analyzed in this paper. Performance can also be improved by intervening on the tube side or changing its shape from circular to oval and arrangements. Fluid flow and heat transfer simulation using CFD tools allow performing cost-effective virtual "numerical experiments". Virtual experiments enable examination a large number of different shapes and evaluate the actual performance or improve it through new design, all within a short timeframe. In fin-and-tube heat exchangers, the fin shape has an important role in the heat exchange. This research began with the premise of isothermal condition on the whole louver fin surface in which case the thermal conductivity of the fin is infinite. This paper is intended to examine the influence of main geometric parameters of the louvered fins on heat exchange and pressure drop in order to improve the overall performance of the louvered fin-and-tube heat exchanger. Calculated data from fluid flow simulations was compared to experimental ones in order to validate the procedure. It is safe to assume that the exact thermal conductivity of the fin will increase result accuracy, the proof of which will be the aim of the next step in this research.

II. Literature Review

1. Aytune, Erek et al (1) observed greater heat transfer and pressure drop values are obtained as the fin height is increased , due to the increased heat transfer surface area .As the tube thickness is decreased, heat transfer is increased whereas pressure drop is decreased. Because heat resistance between water and flue gas is lower for this case.

2. DavidYashar et al (2) presented a comparable evaluation ofR600a (isobutene), R290 (propane), R134a, R22, R410A, and R32 in an optimized finned-tube evaporator. And analyzes the impact of evaporator effects on the system coefficient of performance (COP).

3. Jader R. Barbosa et al (3) observed the heat transfer increase associated with these of interrupted fins has been quantified. A heat transfer rate similar to the baseline configuration (continuous fins) can be achieved with interrupted fins with 33% less fin surface area and an

associated air side pressure drop 15%lower than that obtained in the baseline case.

4. Apu Roy et al (4) said that temperature variation with same velocity of castor oil and water is greatly noticeable. This is due to better thermal properties of castor oil than the water. Better

5. Effectiveness can be achieved by using castor oil as heat transfer fluid whereas water gives the traditional effectiveness.

6. Devendra A. Patel et al (5) observed that: i) Case-I shows calculation for actual readings and case-II shows calculation for simulation when inlet temperature of oil & cooling water are kept unchanged. ii) As the outlet temperature of oils 1 degree less in case-H die values of heat transfer rate, overall heat transfer co-efficient & effectiveness are higher for case-II compared to the case-I. iii) Case-II, III & IV shows the calculation and results for simulation readings. The cooling water Inlet temperature is gradually decreased by 2 degree in each case. iv) as the temperature difference between oil inlet temperature and water inlet temperature, becomes larger, the values of Qmax increases. This is why. The heat transfer rate, overall heat transfer co-efficient and effectiveness is higher in case-in and case-VI compared to case-II.

III. CATIA-Introduction

CATIA which stands for Computer Aided Three Dimensional Interactive Application is CAD software owned and developed by Dassault Systems and marketed worldwide by IBM. It is the world's leading CAD/CAM software for design and manufacturing. CATIA supports multiple stages of product development through conceptualization, design, engineering and manufacturing.

CATIA has a unique ability of modelling a product in the context of its real life behavior. This design software became successful because of its technology which facilitates its customers to innovate a new robust, parametric, feature based model consistently. CATIA provides easy to use solution tailored to the needs of small medium sized enterprises as well as large industrial corporations in all industries, consumer goods, fabrications and assembly, electrical and electronics goods, automotive, aerospace, 24

Shipbuilding and plant design. It is user friendly. Solid and surface modelling can be done easily. As products and experiences continue to increase in complexity, performance and quality targets are becoming more demanding. CATIA answers to that challenge, enabling rapid development of high-quality mechanical products.

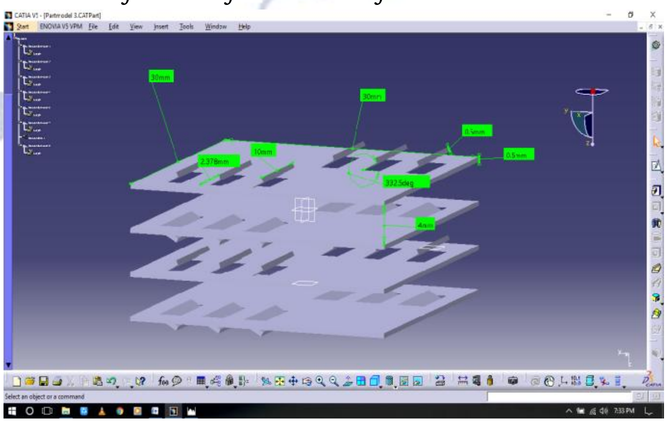
ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behavior of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyses by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

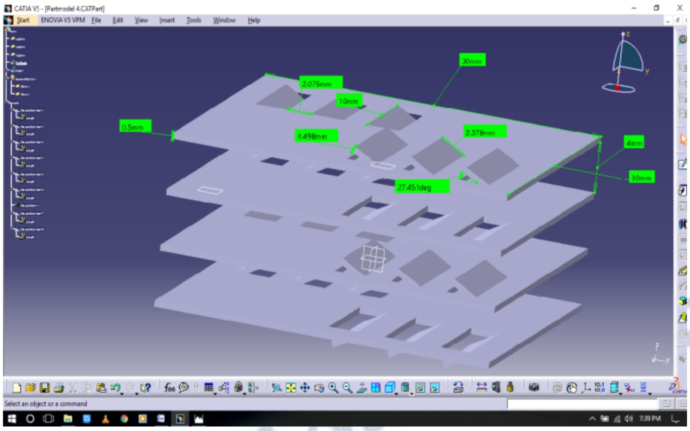
ANSYS is the standard FEA teaching tool within the Mechanical Engineering Department at many colleges. ANSYS is also used in Civil and Electrical Engineering, as well as the Physics and Chemistry departments.

ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping. With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effect of a design on the whole behavior of the product, be it electromagnetic, thermal, mechanical etc.

3d view of louver fin model 3 from CATIA



3d view of louver fin model 4 from CATIA



CFD analysis of copper louver fins model 3 at wind speed 14.722m/s

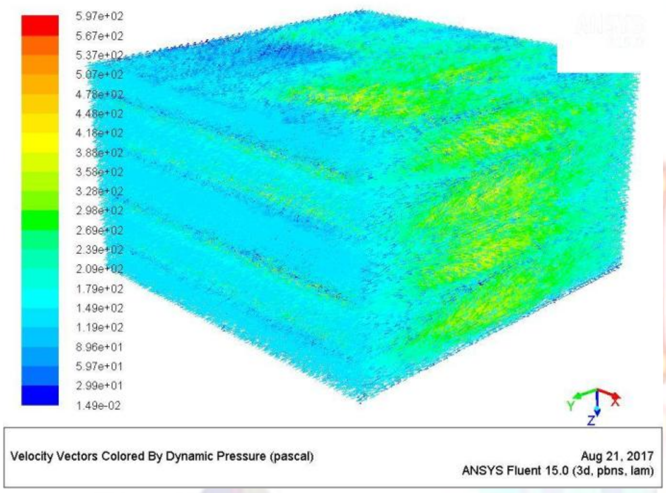


Fig: (pictorial graph representing dynamic pressure in copper louver fin at wind speed 14.722m/s)

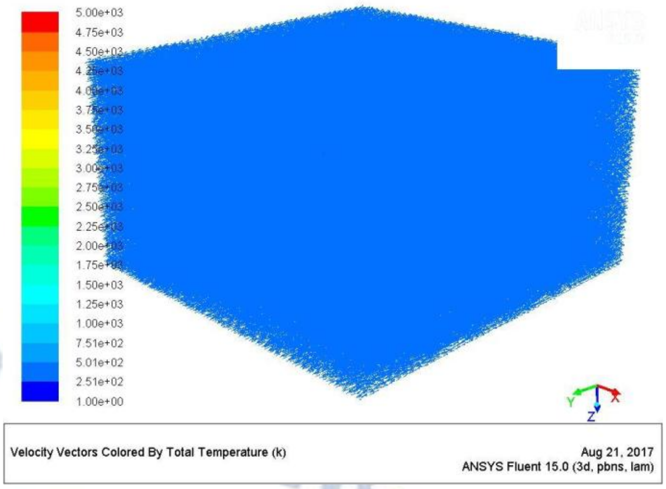


Fig: (pictorial graph representing total temperature in copper louver fin at wind speed 14.722m/s)

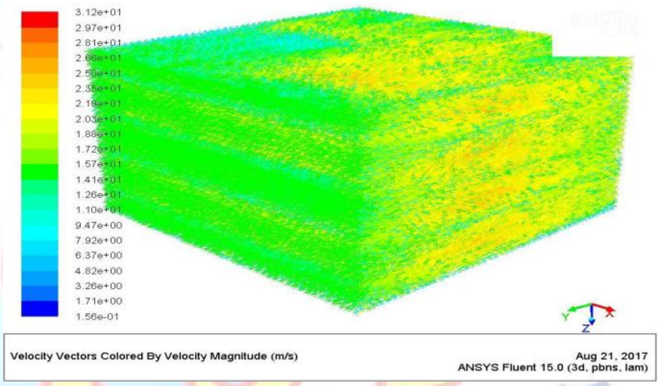
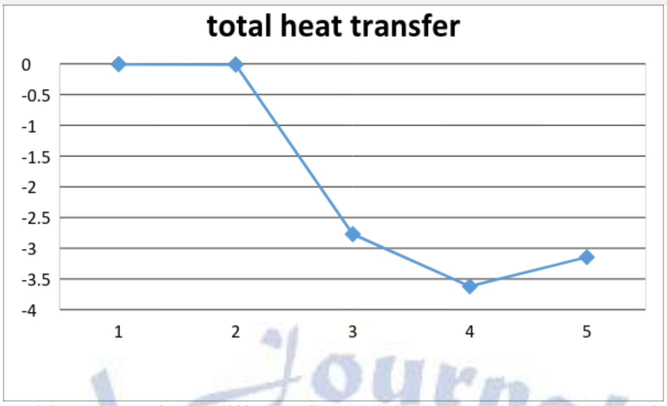


Fig: 4(pictorial graph representing velocity magnitude in copper louver fin at wind speed 14.722m/s)

CFD analysis of different fin models made with copper at wind speed 14.722m/s

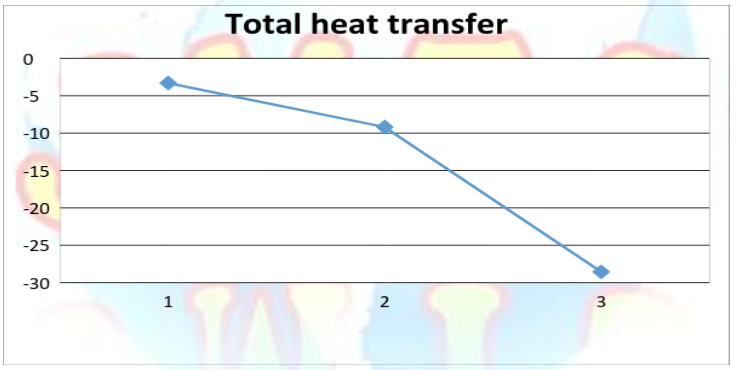
	Dynamic pressure		Total temperature		Velocity magnitude		Total Heat Transfer Rate
	min	max	min	max	min	max	
1.2	5.29E-01	4.17E+02	3.03E+02	3.03E+02	9.29E-01	2.61E+01	0.006438269
2.2	2.26E-01	1.11E+03	3.00E+02	3.03E+02	6.07E-01	4.26E+01	0.012663231
3.2	1.30E-01	1.04E+04	1.00E+00	1.38E+03	4.61E-01	1.30E+02	5.7700426
4.2	1.49E-02	5.97E+02	1.00E+00	5.00E+03	1.56E-01	3.12E+01	3.620034
5.2	5.18E-02	1.84E+03	1.15E+02	5.00E+03	2.91E-01	5.48E+01	-314.49537



Graph representing total heat transfer in different fin models made with copper at wind speed 14.722m/s

CFD analysis of Aluminum louver fin model 3 at different wind speeds

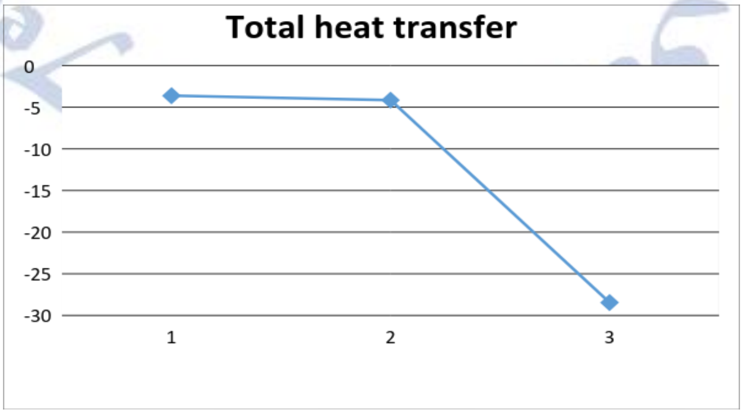
	Dynamic pressure		Total temperature		Velocity magnitude		Total Heat Transfer Rate
	min	max	min	max	min	max	
4.1	5.73E-03	5.98E+02	1.00E+00	5.00E+03	9.68E-02	3.12E+01	-3.3067626
4.1.1	2.67E-02	1.15E+03	1.00E+00	5.00E+03	2.09E-01	4.33E+01	9.1916538
4.2.1	1.18E-01	1.89E+03	1.00E+00	5.00E+03	4.38E-01	5.56E+01	28.560657



Graph representing total heat transfer louver in fin models 3 at different wind speeds

CFD analysis of Copper louver fin model 3 at different wind speeds

	Dynamic pressure		Total temperature		Velocity magnitude		Total Heat Transfer Rate
	min	max	min	max	min	max	
4.2	1.40E-02	5.97E+02	1.00E+00	5.00E+03	1.56E-01	3.12E+01	3.620034
4.1.2	2.80E-02	1.15E+03	1.00E+00	5.00E+03	2.14E-01	4.34E+01	-4.1489474
4.2.2	25.455198		26.455198		27.455198		28.455198



Graph representing total heat transfer in louver fin models 3 at different wind speeds

IV. CONCLUSION

In this thesis we studied the performance of several louver fin arrangements at different wind speeds and these models are compared with each other and basic flat fin model, for observing the pattern in results the results are discussed below,

1. Introduction of louver fins into ac condenser fins raised the heat transfer rate noticeably (-0.006438269 W to -0.012663231 W in copper fins and -0.006486245 W to -0.090278625 W in aluminum fins

2. This increase in heat transfer rate is much more pronounceable in case 4 done with louver mode 3 an average variation of 3 W is noticed in both copper and aluminum fins

3. An average variation of 3.3 Watt heat transfer is observed between the best model (model 4) and basic model (model 1)

4. Second best model is model 3 with a variation of 2.9 Watt with basic model

5. Improvement in heat transfer rate is achieved by creating turbulent flow by introducing louver fins

6. Not much variation is observed between aluminum fins and copper fins

A similar trend is followed at higher wind speeds but an exponential increase in heat transfer is noticed.