International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print)
Volume No.3 Issue No: Special 1, pp: 21-25 22nd March 2014

Thermal Analysis of Tubular Heat Exchangers Using ANSYS

[1]B.Jayachandriah1, K. Rajasekhar[2]
Professor of Mechanical Engineering and Vice -Principal[1],
[2]srikalahasteeswara institute of technology, Srikalahasti
Corresponding author e-mail:bjcskit2011@gmail.com

Abstract— **Tubular Heat exchangers can be designed for high pressures relative to environment and high-pressure differences between the fluids. Tubular exchangers are used primarily for liquid-to-liquid. An attempt is made in this paper is for the Design of shell and tube heat exchangers by modeling in CATIA V5 by taking the Inner Diameter of shell is 400 mm, length of the shell is 700 mm and Outer diameter of tube is 12.5mm, length of Tube is 800mm and Shell material as Steel 1008, Tube material as Copper and Brass. By using modeling procedure Assembly Shell and Tube with water as medium is done. By using ANSYS software, the thermal analysis of Shell and Tube heat exchangers is carried out by varying the Tube materials. Comparison is made between the Experimental results, ANSYS. With the help of the available numerical results, the design of Shell and Tube heat exchangers can be altered for better efficiency**

Keywords**— Tubular heat exchangers, CATIA V5, ANSYS**.

I. Introduction

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion, and exchange of thermal energy and heat between physical systems. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes.

MODE OF HEAT TRANSFER:

On a microscopic scale, heat conduction occurs as hot, rapidly moving or vibrating atoms and molecules interact with neighboring atoms and molecules, transferring some of their energy (heat) to these neighboring particles. In other words, heat is transferred by conduction when adjacent atoms vibrate against one another, or as electrons move from one atom to another. Convective-, or convection, is the transfer of heat from one place to another by the movement of fluids, a process that is essentially the transfer of heat via transfer. Thermal radiation is electromagnetic radiation generated by the thermal motion of charged particles in matter.

Tubular heat exchangers are widely used, and they are manufacture in many Sizes, flow arrangements, and types. They can accommodate a wide range of operating Pressures and temperatures. The ease of manufacturing and their relatively low cost have Been the principal reason for their wide spread using engineering applications. A Commonly used design, called the shell-and-tube exchanger, consists of round tubes Mounted on a cylindrical shell with their axis parallel to that of shell.

Resat Selbas et al has studied the genetic algorithms (GA) for the optimal design of shell-and-tube heat exchanger by varying the design variables outer tube diameter, tube layout, number of tube passes, outer shell diameter, baffle spacing and baffle cut. G.N. Xie, et al had carried-out an experimental system for investigation on performance of shell-and-tube heat exchangers, and limited experimental data is obtained. The ANN is applied to predict temperature differences and heat transfer rate for heat exchangers. José M. Ponce-Ortega et al has presented an approach based on genetic algorithms for optimum design of shell and tube heat exchanger and for optimization major geometric parameters such as the number of tube-passes, standard internal and external tube diameters, tube layout and pitch, type of head, fluids allocation, number of sealing strips, inlet and outlet baffle spacing, and shell side and tube-side pressure drops were selected.M. M. El-Fawal et al has presented in this paper a computer program for economical design of shell and tube heat exchanger using specified pressure drop is established to minimize the cost of the equipment. Zahid H. Ayub has calculate single-phase shell side heat transfer coefficient in a typical TEMA style single segmental shell and tube heat exchanger. A case study of rating water-to-water exchanger is shown to indicate the result from this method with the more established procedures and softwares available in the market. R. Hosseini et al is presented experimentally obtained the heat transfer coefficient and pressure drop on the shell side of a shell-and-tube heat exchanger for three different types of copper tubes (smooth, corrugated and with micro-fins). Experimental work shows higher Nusselt number and pressure drops with respect to theoretical correlation based on Bell's method.

II. Data Collection & Modelling

Based on the above data, in this paper work has taken steel 1008 material for shell, copper and brass material for tube. Hence these materials have good working properties compared to the other materials such as Silver, Cast Iron, Aluminum etc. CATIA version is a process-centric computer-aided design/computer-assisted manufacturing/computer-aided engineering (CAD/CAM/CAE) system that fully uses next generation object technologies and leading edge industry standards. Seamlessly integrated with Dassault Systemes Product Lifecycle Management (PLM) solutions, it enables users to

International Journal of Engineering Research
Volume No.3 Issue No: Special 1, pp: 21-25
ISSN:2319-6890)(online),2347-5013(print)
22nd March 2014

simulate the entire range of industrial design processes from initial concept to product design, analysis, assembly, and maintenance. The CATIA V5 product line covers mechanical and shape design, styling, product synthesis, equipment and systems engineering, NC manufacturing, analysis and simulation, and industrial plant design.

DIMENSIONS OF MODELLING

Dimensions of shell and tube heat exchangers:

No of tubes	= 44
Length of the tubes	= 800mm
Tube diameter	= 25mm
Tube pitch	= 32mm
Clearance	= Pt – do =32 – 25 =7
Tube layout	= 90
Shell length	= 800mm
Shell diameter	= 135
Thickness	=9mmm

THERMAL PROPERTIES OF STEEL 1008

Thermal Conductivity	45 W m^-1 C^-1
Density	7872 kg m^-3
Specific Heat	481 J kg^-1 C^-1

THERMAL PROPERTIES OF FRESH WATER

Thermal Conductivity	0.604 W m^-1 C^-1
Density	997.4 kg m^-3
Specific Heat	4179 J kg^-1 C^-1

THERMAL PROPERTIES OF BRASS

Thermal Conductivity	111 W m^-1 C^-1
Density	8600 kg m^-3
Specific Heat	162 J kg^-1 C^-1

THERMAL PROPERTIES OF COPPER

Thermal Conductivity	400 W m^-1 C^-1
Density	8933 kg m^-3
Specific Heat	385 J kg^-1 C^-1

III. Modelling Of Tubular Heat Exchanger

Modelling is a pre-processor tool, the modelling of crankshaft are created using the Computer aided three-dimensional interactive application (Catia) V5 software tool. The geometrical module of the crankshaft is created using CATIA V5 software, CATIA is a pre-processor were the solid geometry is created using 2-D drawings, module created in CATIA is exported as IGES file for the next pre-processor for meshing. Meshing can be defined as the process of breaking up a physical domain into smaller sub-domains (elements) in order to facilitate the numerical solution of a partial differential equation.

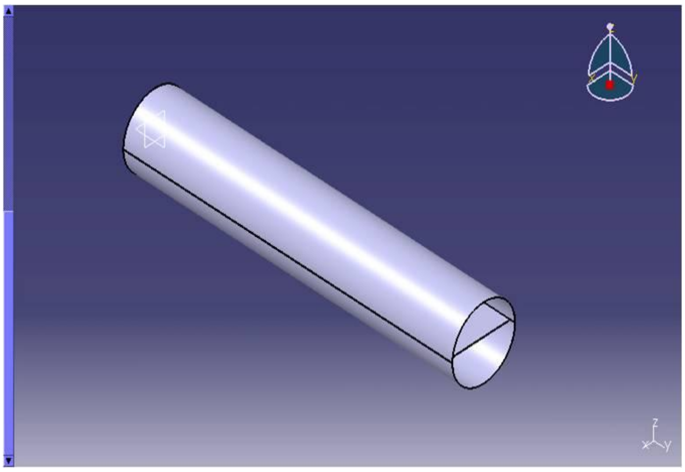


Fig:1 Design of shell and separator

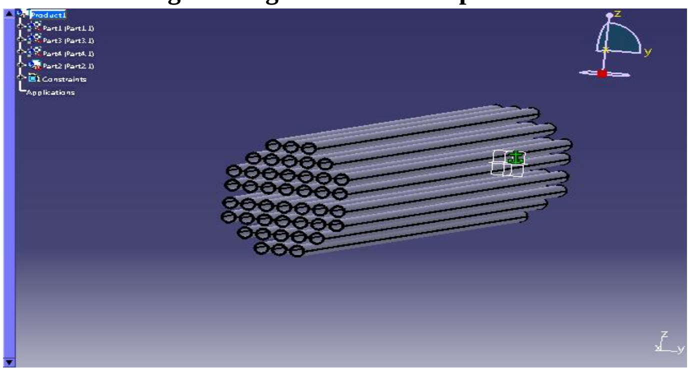


Fig:2 Design of tubes

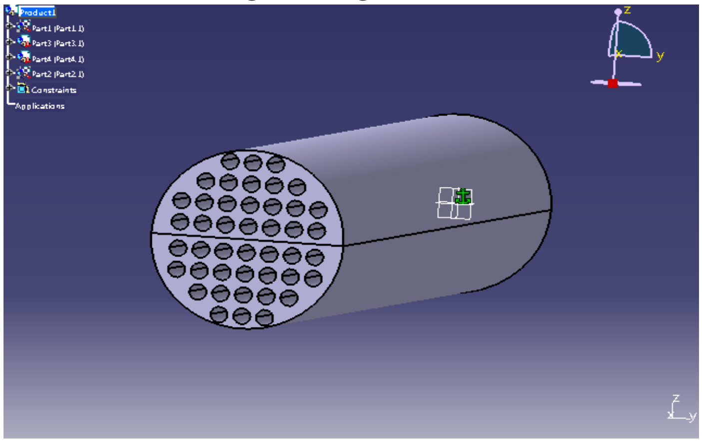


Fig:3Assembled part

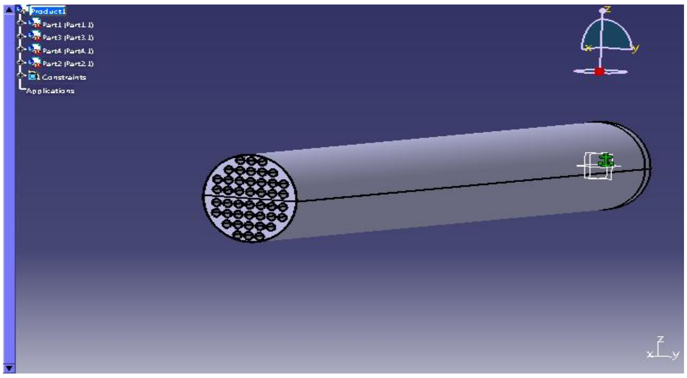


Fig:4 Design of medium

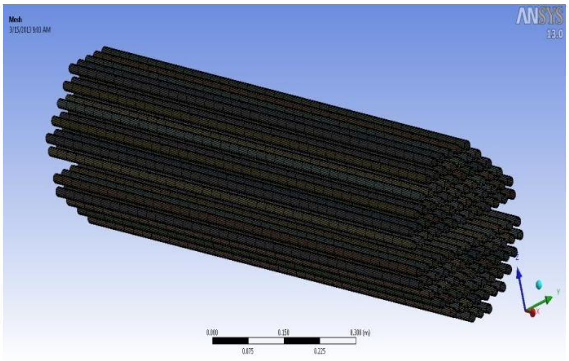


Fig:5 Mesh of tubes

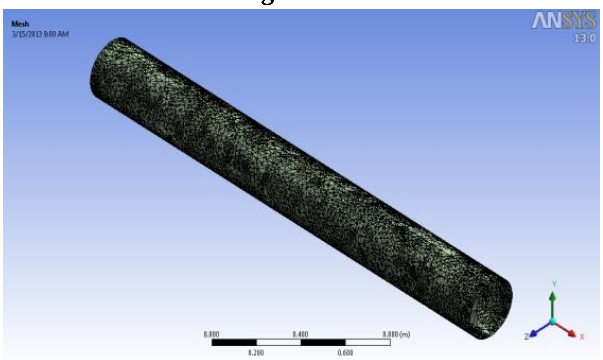


Fig:6 Mesh of shell and separate

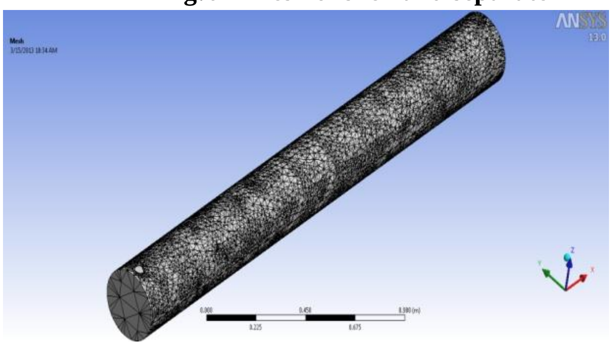


Fig:7 Mesh of fresh water (medium)

IV. Analysis

Analytical Analysis:

General formula for calculating heat transfer:

The heat release from the shell and tube heat exchangers was obtained by multiplying over all heat transfer co-efficient, Area of tubes and difference of temperatures.

$$Q = UA\theta_m$$

Where, A = area of tub, U = Overall heat transfer coefficient

Area of the tubes $A = \pi d_0 L$

where, do = out side diameter of tubes

L = length of the tubes.

LMTD method:

$$\theta_m = \frac{(t_{h1} - t_{c1}) - (t_{h2} - t_{c2})}{ln\left(\frac{t_{h1} - t_{c1}}{t_{h2} - t_{c2}}\right)}$$

Where,

Th1=hot water inlet

T_{h2}=hot water outlet

T_{c1}=cold water inlet

T_{c2}=cold water outlet

For copper:

Heat release : $Q=UA\theta_m$

Overall heat transfer coefficient,U :

$$\frac{1}{U} = \frac{1}{h_i} + \frac{1}{h_o}$$

1/u =1/0.604 + 1/400

1/u =1.658

U=0.603 w/m^{2}k

Area of tubes

$A=\pi d_o L$,A=3.14×0.0025×0.7=0.05494 m^2

LMTD method : θ_m=((60-30)-(43.648-37.963))/ln((60-30)/(43.648-37.963))

θ_m=33.7 k

Heat release,

$Q=UA\theta_m$= 0.6033×0.05495×33.7 = 11.17 w

For brass:

heat release : $Q=UA\theta_m$

Overall heat transfer coefficient, U : U=0.938 w/m^{2}k

Area of tubes

$A=\pi d_o L$

A=3.14×0.0025×0.7=0.05494 m^2

LMTD method

$$\theta_m = \frac{(t_{h1} - t_{c1}) - (t_{h2} - t_{c2})}{ln\left(\frac{t_{h1} - t_{c1}}{t_{h2} - t_{c2}}\right)}$$

θ_m=((60-30)-(43.93-37.78))/ln((60-30)/(43.93-37.78)) = 27 k

Heat release: $Q=UA\theta_m$=0.938×0.05495×30 = 8.34 w

V. Finite element analysis

The Finite Element Analysis (FEA) method, originally introduced by Turner at 1956, is a powerful computational

International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print)
Volume No.3 Issue No: Special 1, pp: 21-25 22nd March 2014

technique for approximate solutions to a variety of "real world" engineering problems having complex domains subjected to general boundary conditions A steady-state thermal analysis determines the temperature distribution and other thermal quantities under steady-state loading conditions. A steady state loading condition is a situation where heat storage effects varying over a period of time can be ignored.A transient thermal analysis determines the temperature distribution and other thermal quantities under conditions that vary over a period of time.

INTRODUCTION TO 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 designed size) called elements. The software implements equations that govern the behavior these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results can be presented in tabulated or graphical forms. This type of analysis is typically used for the design and optimization of a system for too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

5.0 RESULTS :Temperature distribution of steel 1008 and copper materials of shell and tube heat exchangers

Steel 1008 and copper temperature distribution

Temperature distribution of steel 1008 and brass materials of shell and tube heat exchanger

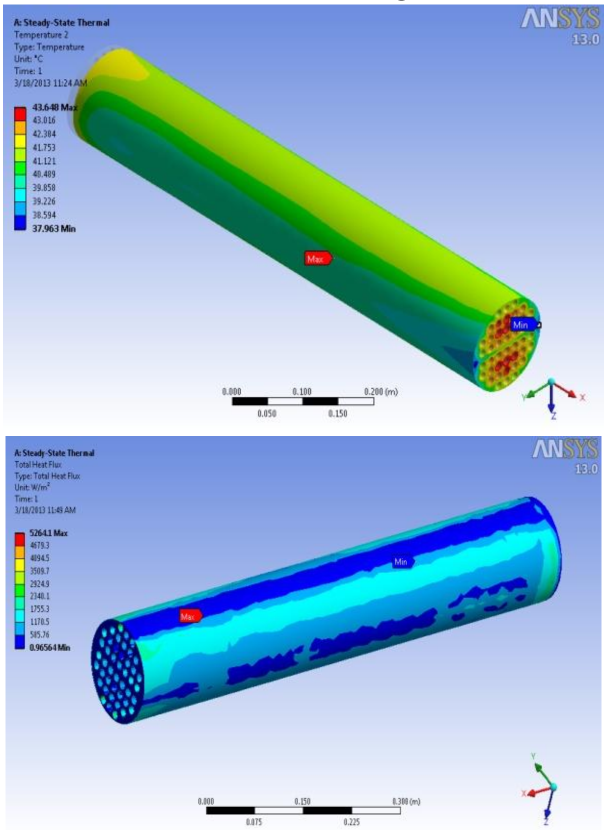


Fig:8 Steel 1008 and Brass temperature distribution

Heat flux for steel 1008 and brass materials of shell and tube heat exchangers

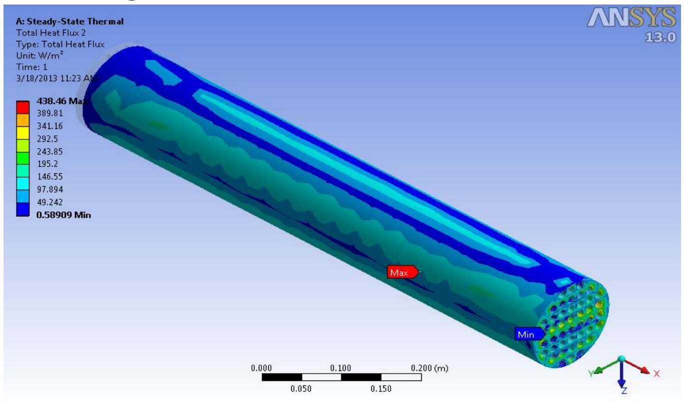
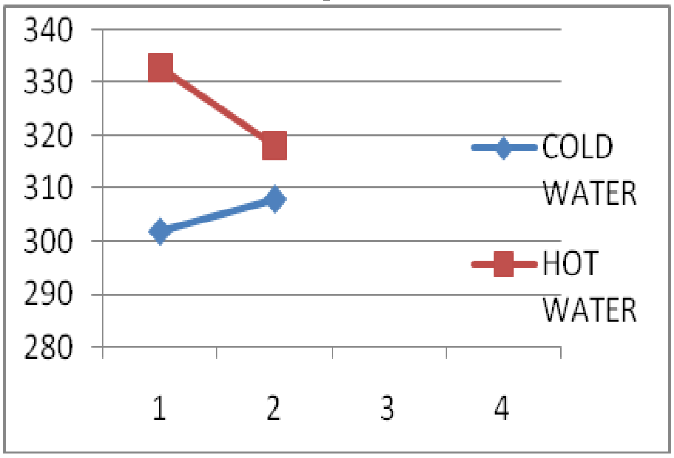


Fig:9 Heat flux for steel 1008 and copper

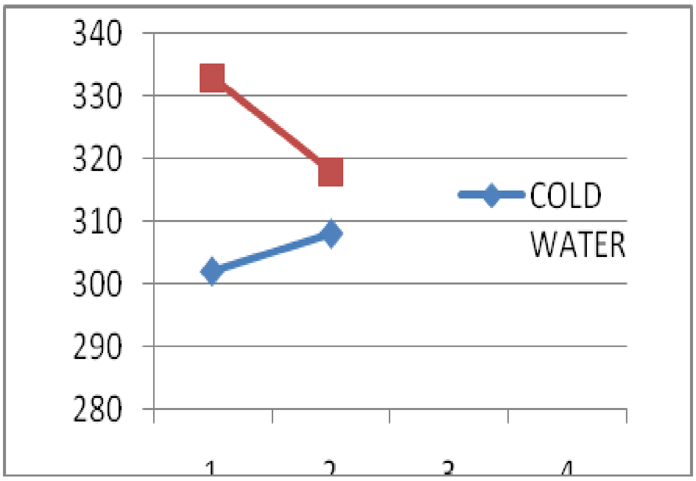
Tabular column of results

Temperatures	Copper	Brass
	Hot Water cold water	Analytical Hot water cold water
Max. temp	333k 310k	333k 333k 308k
Min. temp	316k 303k	312k 310k 303k

min and max temperatures of material



International Journal of Engineering Research
Volume No.3 Issue No: Special 1, pp: 21-25
ISSN:2319-6890)(online),2347-5013(print)
22nd March 2014



COPPER
BRASS
HOT=333,316
HOT=333,318
COLD=303,310
COLD=303,308

Comparison of copper and brass

Validation : Experimental results has taken from the reference paper and it is compared with the ANSYS results. Graphs are plotted for inlet and out let temperature.

Materials	Exp Results	Ansys Results
Copper	14.17	15.63
Brass	11.34	12.98

Table 1.1

DISCUSSIONS:

Thus the ANSYS Results is calculated for copper and brass materials. The heat released from copper material is 15.63w and that from brass is 12.98 w which is less when compared with the copper. Whereas available literature Experimental Results are 14.17w for copper and11.34w for Brass. Therefore ,range of variation is within 10% .Hence Results are validated. The temperature distribution profile of whole assembly in the sectional front view .From the figure it is seen that the maximum and minimum temperature for copper is from 316 K to 310 K and for brass is 318 and 308 which is simulated from the ANSYS Workbench result. Hence, it is observed that copper gives better heat transfer rate compared with that of brass.

VI. Conclusion & Future Work

After performing all the analysis work for shell & tube heat exchangers the following observation had been done. From the study of the result as mentioned in table 1 , after performing the calculation the fluid water for bass output temperature is 310 °k which is nearer to the value mentioned in output temperature of ansys.As we change the tube material from the brass to the copper, temperature difference between output temperature of copper & brass had been varied.

Analysis has been done by varying the tube materials and it is found that copper material gives the better heat transfer rates than the brass material.

1. Rate of heat transfer can be improved by varying the tube diameter, length and no of tubes.
2. By changing the pitch lay out rate of heat transfer can be improved.
3. By changing the temperature of tubes and medium rate of heat transfer can be improved.
4. By changing the materials of tubes heat transfer rate can be improved.

REFERENCES

i. Wilfried Roetzel and ChakkritNa Ranong,. 1999, "Consideration of maldistribution in heat exchangers using the hyperbolic dispersion model" Chemical Engineering and Processing 38, pp. 675-681.

ii. Sahoo, R.K., and Wilfried Roetzel., 2002, "Hyperbolic axial dispersion model for heat exchangers" International Journal of Heat and Mass Transfer 45, pp 1261-1270.

iii. Wilfried Roetzel , Chakkrit Na Ranong., 2000 "axial dispersion model for heat exchangers" Heat and Technology vol. 18.

iv. Yimin Xuan, and Wilfried Roetzel., "Stationary and dynamic simulation of multipass shell and tube heat exchangers with the dispersion model for both fluids" Int. J. Heat Mass Transfer. Vol. 36, No. 17,4221A231,

v. Danckwerts, P.V., 1953, Continuous flow systems Distribution of Residence times Chemical Engineering science genie chimique Vol. 2.

vi. Lalot, S., P. Florent, Langc, S.K., Bergles, A.E., 1999, "Flow maldistribution in heat exchangers "Applied Thermal Engineering 19, pp 847-863.

vii. Prabhakara Rao Bobbili, Bengt Sunden, and. Das, S.K., 2006, "An experimental investigation of the port flow maldistribution in small and large plate package heat exchangers Applied Thermal Engineering 26, pp 1919-1926.

viii. Zakro Stevanovic, Gradimir, Ilić., Nenad Radojković, Mića Vukić, Velimir Stefanović, Goran Vučković., 2001, "Design of shell and tube heat exchangers by using CFD technique- part one: thermo hydraulic calculation" Facta Universities Series: Mechanical Engineering Vol.1, No 8, pp. 1091 – 1105

ix. Wilfried roetzel and Das, S.K., 1995 "Hyperbolic axial dispersion model: concept and its application to a plate heat exchanger" Int..J. Heat Mass Transfer. Vol. 38, No. 16, pp.3062-3076.