ISSN (e): 2250 – 3005 || Volume, 08 || Issue, 2|| February – 2018 ||
International Journal of Computational Engineering Research (IJCER)

Thermal Analysis of Double Pipe Heat Exchanger with Different Mass Flowrates

B.Ramakrishna[1] , J .Pavan Kumar[2] ,M.Yadi Reddy[3] ,K. Sudheer Kumar[4]
[1,2,3] Assistant professor, Department of Mechanical Engineering, Mahatma Gandhi Institute of Technology, Gandipet, Hyderabad, Telangana- 500075.
[4] Assistant professor, Department of Mechanical Engineering, Vaageswari College of Engineering ,Karimnagar, Telangana -505481
Corresponding author: B.Ramakrishna

Abstract*:*
Heat exchangers are the equipment used in industrial processes to recover heat between two process fluids. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, and natural gas processing. The operating efficiency of these exchangers plays a very key role in the overall running cost of a plant. So the designers are on a trend of developing heat exchangers which are highly efficient, compact, and cost effective. A common problem in industries is to extract maximum heat from a utility stream coming out of a particular process, and to heat a process stream. Therefore the objective of present work involves study of refinery process and apply phenomena of heat transfer for Aluminum as material and with different thickness for thermal design procedure of the double pipe counter flow heat exchanger. The validation of design out comes will be done by simulation in CFD software.
Keywords: Heat exchanger; fouling; Refinery process; Distillation;

Date of Submission: 09-02-2018 Date of acceptance: 26-02-2018

I. INTRODUCTION

A heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. In heat exchangers, there are usually no external heat and work interactions.
Typical applications involve heating or cooling of a fluid stream of concern and evaporation or condensation of single- or multi component fluid streams. In other applications, the objective may be to recover or reject heat, or sterilize, pasteurize, fractionate, distill, concentrate, crystallize, or control a process fluid. In a few heat exchangers, the fluids exchanging heat are in direct contact.
In most heat exchangers, heat transfer between fluids takes place through a separating wall or into and out of a wall in a transient manner. In many heat exchangers, the fluids are separated by a heat transfer surface, and ideally they do not mix or leak. Such exchangers are referred to as direct transfer type, or simply recuperators. In contrast, exchangers in which there is intermittent heat exchange between the hot and cold fluids—via thermal energy storage and release through the exchanger surface or matrix are referred to as indirect transfer type, or simply regenerators. Such exchangers usually have fluid leakage from one fluid stream to the other, due to pressure differences and matrix rotation/valve switching.
Heat transfer in the separating wall of a recuperator generally takes place by conduction. However, in a heat pipe heat exchanger, the heat pipe not only acts as a separating wall, but also facilitates the transfer of heat by condensation, evaporation, and conduction of the working fluid inside the heat pipe. In general, if the fluids are immiscible, the separating wall may be eliminated, and the interface between the fluids replaces a heat transfer surface, as in a direct-contact heat exchanger. The double pipe heat exchanger is shown in fig 1.

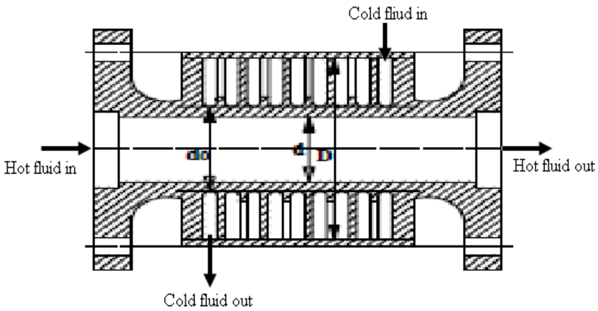


Fig.1 Double pipe heat exchanger

II. FOULING IN HEAT EXCHANGERS

Fouling refers to undesired accumulation of solid material (by-products of the heat transfer processes) on heat exchanger surfaces, which results in additional thermal resistance to heat transfer, thus reducing exchanger performance. The fouling layer also blocks the flow passage/area and increases surface roughness, which either reduces the flow rate in the exchanger or increases the pressure drop or both. The fouling deposits may be loose, such as magnetite particles, or hard and tenacious, such as calcium carbonate scale; other deposits may be sediment, polymers, cooking or corrosion products, inorganic salts, biological growth, and so on.

Fouling in heat exchangers is a very complex phenomena and its negative impact translates into billions of dollars every year worldwide and is being investigated with considerable effort.

III. MATERIALS AND MANUFACTURING PROCESS

The selection of materials of construction is a very important aspect to be considered before undertaking the design of heat exchangers. In each individual case the choice of proper material shall be made, bearing in mind the specific requirements normally which is as follows:

- Mechanical resistance i.e. Strength and sufficient toughness at operating temperatures.
- Chemical resistance under operating conditions with regard to corrosive media, concentration, temperature, foreign substances, flow behavior etc. the rate of corrosion must be negligible over a prolonged period of time and the material must be resistant against other corrosion phenomenon.
- No detrimental interference by the material on the process or on the products.
- Easy supply of material with time permitted and in the time required.
- Good workability, lowest possible costs.

IV. REFINERY PROCESS

Every refinery begins with the separation of crude oil into different fractions by distillation. The fractions are further treated to convert them into mixtures of more useful saleable products by various methods such as cracking, reforming, alkylation, polymerization and isomerisation. These mixtures of new compounds are then separated using methods such as fractionation and solvent extraction. Impurities are removed by various methods, e.g. Dehydration, desalting, sulphur removal and hydro treating. Refinery processes as shown in fig 2, have developed in response to changing market demands for certain products. With the advent of the internal combustion engine the main task of refineries became the production of petrol.

Distillation is the first step in the processing of crude oil and it takes place in a tall steel tower called a fractionation column. The inside of the column is divided at intervals by horizontal trays. The column is kept very hot at the bottom (the column is insulated) but as different hydrocarbons boil at different temperatures, the temperature gradually reduces towards the top, so that each tray is a little cooler than the one below.

As the raw crude oil arriving contains quite a bit of water and salt, it is normally sent for salt removing first, in a piece of equipment called a desalter. Upstream the desalter, the crude is mixed with a water stream, typically about 4 - 6% on feed. Intense mixing takes place over a mixing valve and (optionally) as static mixer. The desalter, a large liquid full vessel, uses an electric field to separate the crude from the water droplets.

Fouling in liquids and two-phase flows has a significant detrimental effect on heat transfer with some increase in pressure drop. In contrast, fouling in gases reduces heat transfer somewhat (5%–10% in general) in compact heat exchangers but increases pressure drop significantly (up to several hundred %). Depending on the fluids, operating conditions, and heat exchanger construction, the maximum fouling layer thickness on the heat transfer surface may result in a few hours to a number of years.

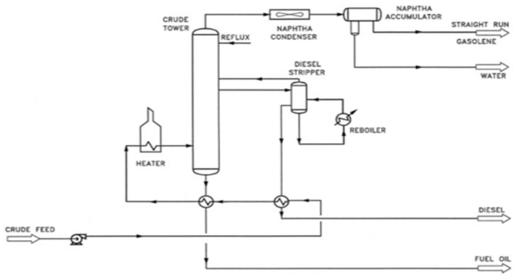


Fig 2. Refinery process

V. DISTILLATION (FRACTIONATION)

Because crude oil is a mixture of hydrocarbons with different boiling temperatures, it can be separated by distillation into groups of hydrocarbons that boil between two specified boiling points. Two types of distillation are performed: atmospheric and vacuum.

Atmospheric distillation

Atmospheric distillation takes place in a distilling column at or near atmospheric pressure. The crude oil is heated to 350 - 400^{o}C and the vapour and liquid are piped into the distilling column. The liquid falls to the bottom and the vapour rises, passing through a series of perforated trays (sieve trays). Heavier hydrocarbons condense more quickly and settle on lower trays and lighter hydrocarbons remain as a vapour longer and condense on higher trays.

Liquid fractions are drawn from the trays and removed. In this way the light gases, methane, ethane, propane and butane pass out the top of the column, petrol is formed in the top trays, kerosene and gas oils in the middle, and fuel oils at the bottom. Residue drawn of the bottom may be burned as fuel, processed into lubricating oils, waxes and bitumen or used as feedstock for cracking units.

Vacuum distillation

To recover additional heavy distillates from this residue, it may be piped to a second distillation column where the process is repeated under vacuum, called vacuum distillation. This allows heavy hydrocarbons with boiling points of 450oC and higher to be separated without them partly cracking into unwanted products such as coke and gas.

The heavy distillates recovered by vacuum distillation can be converted into lubricating oils by a variety of processes. The most common of these is called solvent extraction. In one version of this process the heavy distillate is washed with a liquid which does not dissolve in it but which dissolves (and so extracts) the non-lubricating oil components out of it. Another version uses a liquid which does not dissolve in it but which causes the non-lubricating oil components to precipitate (as an extract) from it. Other processes exist which remove impurities by adsorption onto a highly porous solid or which remove any waxes that may be present by causing them to crystallize and precipitate out.

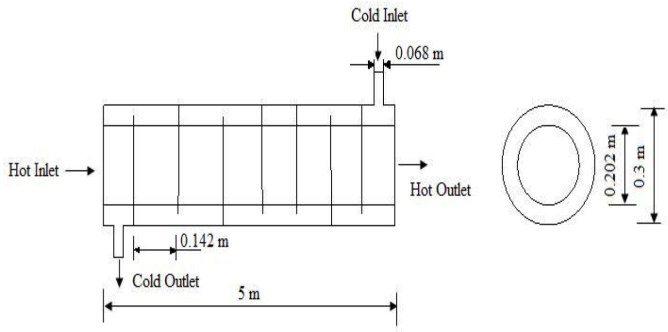
VI. PROBLEM DESCRIPTION

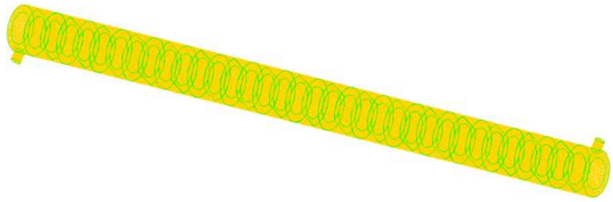
The present work is based on industrial requirement. In the petroleum refinery after distillation different grade of oil comes out at different high temperature which comes in to a pump and supplied at required level. The heat recovered from high temperature hydrocarbons is utilized to increase the temperature of crude oil up to required limit. The heat exchanger data, temperature of hydrocarbon and required temperature rise of crude oil were Chosen.

VII. OBJECTIVE

The objective of present work is based on design and thermal analysis of double pipe counter flow heat exchanger. The inner pipe is a in which hot hydrocarbon flows and in outer annulus cold crude oil passes from opposite direction. The heat recovery from hot fluid is used to increase the temperature of cold fluid. Design was carried out based on the outlet temperature requirement of the cold fluid. With the help of computation fluid dynamics the study and unsteady simulation carried out for designed heat exchanger and based on the simulation results thermal analysis carried out.

VIII. MODEL DEVELOPMENT OF HEAT EXCHANGER





IX. DESIGN PARAMETERS

Shell side

- Type of fluid: crude oil.
- Inlet temperature =313k
- Outlet temperature =553k.
- Mass flow rate=0.320kg/s.
- Diameter of shell=0.3m.

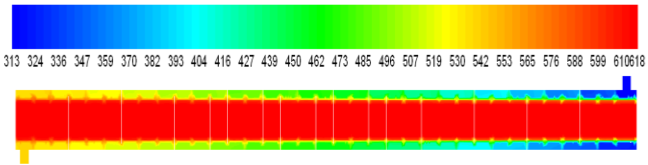
Tube side

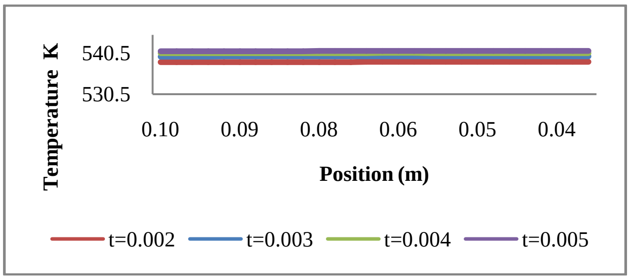
- Type of fluid: diesel oil.
- Inlet temperature =618k
- Outlet temperature =?.
- Mass flow rate=145.6kg/s.
- Specific gravity=0.874
- Tube inside diameter =0.2027m.
- Tube outside diameter=0.2191m

X. RESULTS AND DISCUSSIONS

. The present work involves the Numerical analysis of the heat exchanger with aluminum material with varying fin thickness and by changing the mass flow rates for cold fluid. Initially the simulation is carried out with mass flow rate 0.320 kg/s and shifted to 0.220 and 0.120 kg/s. The analysis carried out aluminum material for different thickness range of 0.002m to 0.005m in the interval of 0.001m are and the simulations and results are discussed. These simulations are done as an attempt for analysis of heat transfer and flow phenomena in the shell side and tube side. The steady state and unsteady simulations are done with inlet conditions using turbulence model. The domain in the present study is quite a complex 3-D geometry, so it is quite diligent to present the flow physics in the whole domain for discussions. The 2-D planes are taken in the geometry for the discussions. The plane and line along with the whole geometry and the coordinate axes are shown in Fig 5.1. The Plane and line are taken along the length of the heat exchanger in the X-Y planes of constant Z-coordinate. Plane is taken in the centre of tubular section and a line is at 0.220m from an outlet of the section.

A) Material Aluminum





Graph 2. Temperature variation across Outlet for varying Fin thickness.

Summary of CFD analysis results

Mass flow rates 0.320kg/s

Sr no	Thickness of fin (m)	Temp. (k)	Pressure (Pascal)	Vel(m/s)	Heat transfer (W)
1	0.002	538.39	37.7	0.14	176473.69
2	0.003	539.76	38	0.14	177524.04
3	0.004	540.55	38	0.14	178145.21
4	0.005	541.07	38	0.14	178549.9

Table 1. Variation of properties with different thickness of aluminium

Mass flow rates 0.120kg/s

Sr no	Thickness of fin (m)	Temp. (k)	Pressure (Pascal)	Vel(m/s)	Heat transfer (W)
1	0.002	604.47	37.65	0.14	88704
2	0.003	605.12	38	0.14	88896
3	0.004	605.59	38	0.14	89088
4	0.005	605.96	38	0.14	89232

Table 2. Variation of properties with different thickness of aluminium

XI. CONCLUSIONS

Based on the analysis the following important conclusions are conclude that

- The temperature of the cold fluid at the outlet of the heat exchanger increases with increase the fin thickness.
- There is very minor changes occur in the pressure and velocity profile with increase of fin thickness as well as change of material that is pressure and velocity doesn't get much affected by thickness of fin and material of fin.
- The simulated outlet temperature is 543k which is very near to design outlet temperature 553k. there is less than 3% variation occurs than design value**.**

REFERENCES

[1]. A.Behzadmehr, N. Galanis and A. Laneville, Low Reynolds number mixed convection in ertical tubes with uniform wall heat flux, International Journal of Heat and Mass Transfer **46** (2003), pp. 4823–4833.

[2]. A. E. Bergles and W. J. Marner Augmentation of Highly Viscous Laminar Heat Transfer Inside Tubes with Constant Wall Temperature, Experimental Thermal and Fluid Science 1989; 2:252-267.

[3]. A.E. Saad, A.E. Sayed, E.A. Mohamed, M.S. Mohamed, Experimental study of turbulent flow inside a circular tube with longitudinal interrupted fins in the streamwise direction, Experimental Thermal Fluid Science 15 (1) (1997) 1–15.

[4]. Alam, P.S. Ghoshdastidar, A study of heat transfer effectiveness of circular tubes with internal longitudinal fins having tapered lateral profiles, International Journal of Heat and Mass Transfer 45 (6) (2002) 1371–1376.

[5]. Bergles, A. E., and Joshi, S. D., Augmentation Techniques for Low Reynolds Number In-Tube Flow, in Low Reynolds Number Flow Heat Exchangers, S. Kakac, R. K. Shah, and A. E. Bergles, Eds. Hemisphere, Washington, D.C., pp. 695-720, 1983.

[6]. B.Yu, J.H. Nie, Q.W. Wang, W.Q. Tao, Experimental study on the pressure drop and heat transfer characteristics of tubes with internal wave-like longitudinal fins, Heat Mass Transfer 35 (1999) 65–73.

[7]. C.P.Kothandaraman.S.Subramanyan. Heat and Mass transfer Data book New age international publisher sixth edition.

[8]. C.R. Friedrich, S.W. Kang, Micro heat exchangers fabricated by diamond machining, Precision Engineering 16 (1994) 56–59.

[9]. D.A. Olson, Heat transfer in thin, compact heat exchangers with circular, rectangular, or pin-fin flow passages, ASME Journal of Heat Transfer 114 (1992), pp. 373–382.

[10]. Ebru Kavak Akpinar Evaluation of heat transfer and exergy loss in a concentric double pipe exchanger equipped with helical wires. Energy Conversion and Management 47 (2006). 3473- 3486.

[11]. e. r. g. eckert, r. j. goldstein, w. e. ibele, s. v. patankar, t. w. simon, n. a. decker, s. l. girshick, p. j. strykowski, k. k. tamma, a. bar-cohen, j. v. r. heberlein and d. l. hofeldt Heat transfer-a review of 1990 literature Int.J Heat Mass Trans. Vol. 34, No. 12, pp. 2931-3010, 1991.
[12]. Edited by Chang S. Hsu Exxon Mobil Research and Engineering Company Baton Rouge, Louisiana, And Paul R. Robinson PQ Optimization Services Katy, Texas, USA Practical Advances in Petroleum Processing Volume 2.

B.Ramakrishna " Thermal Analysis of Double Pipe Heat Exchanger with Different Mass Flowrates" International Journal of Computational Engineering Research (IJCER), vol. 08, no. 02, 2018, pp. 50-55.