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Design, Fabrication and Performance of Twisted Tube Heat Exchanger

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Abstract: Heat exchangers are very much essential industrial as well as domestic equipment usedeveryday. The fundamental basis for this statistic is shell and tube technology is a cost effective, proven solution for a wide variety of heat transfer requirements. There are various limitations with technology which include inefficient usage of shell side pressure drop, dead or low flow zones around the baffles where fouling and corrosion can occur, and flow induced tube vibration, which can ultimately result in equipment failure.

This paper presents a recent innovation and development of a latest heat exchanger technology, known as Twisted Tube Technology, which has been able to overcome the limitations of conventional technology. This technology provides solution to almost all mentioned problems and provide good overall heat transfer coefficients through tube side enhancements. This paper primarily focuses on thermal analysis on twisted tube Heat exchangers.

Keywords: Heat exchangers, Twisted tube technology, conventional technology, thermal analysis

I. INTRODUCTION

Heat Exchangers, one of the common equipment used for heating process fluids either by direct or indirect means. However the efficiency of the existing heat exchangers is poor and no longer high when used for longer time. In order to enhance the rate of heat transfer and efficiency twisted tube heat exchangers play a vital role. Heat exchangers are generally characterized by the compactness factor in m2/m3 (=/m) and it is generally accepted that values greater than 700/m characterize the compactness of the equipment. Although shell and tube heat exchangers can have a compactness factor, compact heat exchangers are often referred as non tubular devices.[1]

In order to augment heat transfer and to increase thermal performance of the heat exchangers heat transfer enhancement techniques are widely used. These techniques are classified in two groups, active and passive techniques. For active techniques heat transfer rate is improved by supplying extra energy to the system while in passive techniques the purpose is solved without use of any extra energy. The passive techniques include surface area extension (extended surfaces: fins), rough surfaces, inserts, turbulators also called swirl flow devices and coated surfaces.[2]

This paper describes an advance shell and tube heat exchanger with twisted tube which always enhances surface area provided due to twisting and corrugations. Recent advances in the range of design and operational reliability and flexibility have made twisted tube heat exchangers attractive in various industries, including offshore applications, pharma, dairy industries and in the field of petroleum processing industries. Taking into the size and surface area of contact, these heat exchangers can be cost effective in a wider range of applications than the traditional type of heat exchangers employed in process industries.

A. Twisted Tube Heat Exchanger

In twisted tube heat exchanger corrugated surface heat exchangers and extended surface heat exchangers have greater advantages when compared with conventional type of heaters. A twisted tube is a passive heat transfer enhancement device, generally classified in a swirl type flow device category. Swirl flow devices consist of a greater variety of geometrical flow arrangements in order to produce a stable form of forced vortex fluid motion in confined flows. This device facilitates fluid agitation and mixing of heat patterns induced by swirl flow.

The main advantages are mainly they do not require extra attention during assembly, maintenance, inspection and cleaning when intermediate viscous fluids are used.

This devices consists of helically twisted double radius oval tubes,welded their round ends to tube sheets. This device design is similar to structure of Human DNA which is double helical in patterns and extended all along the length and finally ends with DNA strands. The tubes contact one another at their wider sides, six times over the length of one twist pitch which makes the unit practically vibration free. The purely longitudinal shell side flow in twisted tube bundles thereby has an ability to provide high surface area (and density), low pressure drop, good heat transfer rates and coefficients.[3]

B. Enhancement Technique for Heat Transfer

Convective heat transfer is always achieved of expense of fluid flow and there by, pressure drop. But at the same time higher the pressure drop, the operating cast will be higher.Therefore it is important to minimize pressure drop for a given heat transfer coefficient. So that the overall cost of heat exchanger, which is sum of operating cast and fixed cast, is low.

The key to enhanced heat transfer is higher turbulence, which is not produced by increase in the fluid velocity but by improvement in basic pattern. Increased turbulent leads to not only enhanced heat transfer, but reduced fouling as well.

Heat transfer enhancement is one of the fastest growing areas of heat transfer technology. The technologies are classified into active and passive techniques depending on how the heat transfer performance is improved. A twisted tube is a typical passive method that uses a specific geometry to induce swirl on the tube side flow. The twisted tube heat exchanger has a bundle of uniquely formed tubes. Swirl flow in tube create turbulence to improve heat transfer, by helping the turbulent flow gives a high heat transfer rate.

II. METHODOLOGY OF TWISTED TUBE HEAT EXCHANGER

$Q= F_t*U*A*\Delta T_{lm}$ (1)

$D_h=d_{max}*d_{min}/\{3(d_{max}+d_{min})[(3d_{max}+d_{min})(d_{max}+3d_{min})]0.5$(2)

Nu=-hdh/k

Re=ρ*v*dh/μ

$Pr = C_p*\mu/k$

$Fr = S^2/ d_{max}*d_h$(3)

Tube side coefficient : $Nu = 0.21 * Re0.8Pr0.4*[1+3.74(s/d_{max} – 1] (Twt/Tbt)^n$ (4)

Shell side co efficient : $Nu = 0.521* Re^{0.8} * Pr^{0.4} *(Twt/Tbs)^{-0.55}$ (5)

Overall heat Transfer coefficient: U =(1/hi+L/kc+Rf + 1/ho) (6)

Total Pressure drop $\Delta P_{Total}=\Delta P_{Entrance}+ \Delta P_{Core}+ \Delta P_{Exit}$(7)

Tube side friction coefficient: $f_D= 0.92 * (s / dh)^{-0.55} * Re^{-0.18}$ (8)

Shell side friction coefficient :$f_D= 10.5\ Fr^{-1.6181 + 2.263logFr}$ (9)

Core pressure drop $\Delta P_{Core}= f_D*L / 2dh\rho v^2$

Nusselt number = f(Re, Pr, Fr)

Darcy Friction Factor = f(Re, Fr)

III. RESULT

Twisted tube heat exchanger are compact and more efficient than conventional shell and tube heat exchangers the cost of fabrication and work during the fabrication is tedious work so it affect on the fabrication costing. This type of heat exchanger is more expensive than a conventional shell and tube heat exchanger but their payback time is quite short. Evaluating both twisted tube and shell and tube heat exchanger under the same operating conditions. The heat transformer coefficient is normally assumed as a basic measure of efficiency.

Sr. Number	Component/ Property	Shell and Tube	Twisted tube
1	No. of tubes	14	10
2	Tubeside heat transfer coefficient	2721.5	2813.7
3	Shell side heat transfer coefficient	3514	5675.26
4	Overall heat transfer coefficient	892.31	1672.24

$$\text{Efficiency} = \frac{1672.24-892.31}{1672.24} * 100$$

= 46.6%

IV. CONCLUSION

From the above experimental study, it can be concluded that twisted tube heat exchange by greater advantages than conventional shell and tube heat exchanger. Twisted tube heat exchanger uses fewer tubes, less shell diameter and give more heat transfer for the same mass flow of fluid.

Nomenclature

d_h- hydraulic diameter. S –Twisted pitchin tube bundle, F_r - dimensionless swirl number17. T_{ws}, Tbs = Temperature of wall and bulk flow on shell side. T_{wt}, T_{bt} = Temperature of wall and bulk flow on tube side. F_d-Darcy friction factor. $\Delta \boldsymbol{T}_{lm}$= logarithmic temperature difference. F_t = correction factor for log mean temperature difference.

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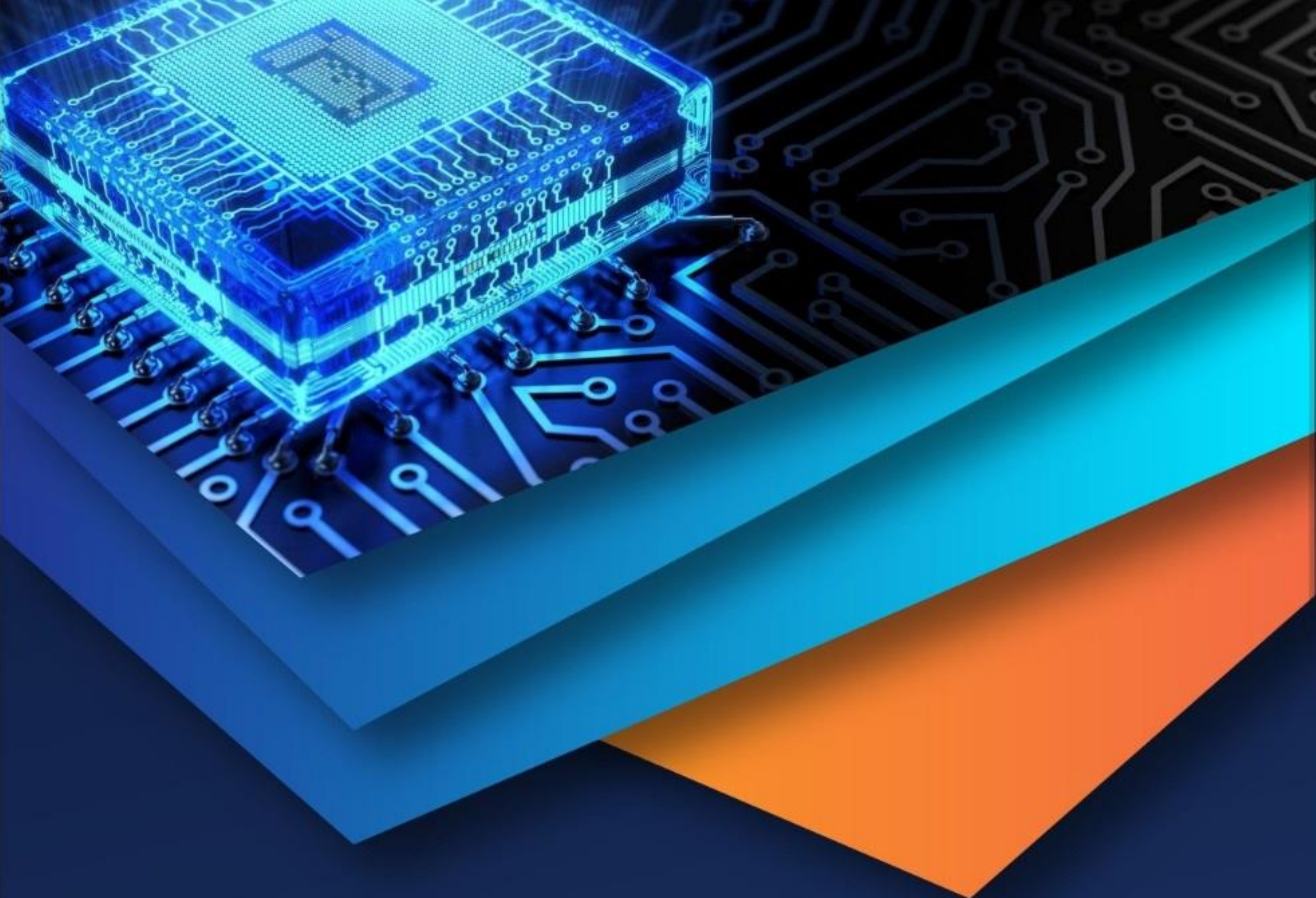

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