Re-Design and Analysis of Helical Fin on Shell & Tube Type Heat Exchanger Tubes

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Abstract— This paper faces the problem of geometric optimisation for fins profile on tube of heat exchanger. In particular the tubes are being analysed under different conditions. The analysis is being performed on a single tube by mounting helical fines on it of different height and pitch within constant thickness. The methodological approach here is chosen as CFD software. The result are optimized by comparing the result after analysis.

Index Terms— Heat Exchanger, Helical Fins, Catia V5, Ansys 14.0, CFD, Efficiency.

I. Introduction

Heat exchangers are specialized devices which accelerate heat transfer and are of great importance in industrial applications. Various types of heat exchangers are used in refineries, chemical industries, food industries, and so forth. Heat load can vary according to their different applications from less than 1 W to more than 1000 kW.

This extensive range of heat load in heat exchangers has caused them to be designed and manufactured in various shapes and sizes. Shell-and-Tube Heat Exchangers (STHXs) are one of the mostly used types of heat exchangers in industry with numerous applications in power plants, oil 0refineries, food industries, and so forth. More than 35–40% of the heat exchangers worldwide are STHX which are simply maintained and upgraded considering their robust geometry construction.

Therefore, it is of great significance to improve their thermal–hydraulic performance and reduce their cost as much as possible. Baffles are important shell-side components of STHXs which conduct the shell-side flow perpendicular to the tubes in addition to supporting the tubes bundle. Most commonly used baffles in STHXs are segmental ones which force the shell-side flow to move along a zigzag pattern and improve heat transfer.

Manuscript revised on April 05, 2020 and published on April 10, 2020

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II. Formulae

a) $NTU = \frac{UA}{Cmin}$

b) $R = \frac{Cmin}{Cmax}$

c) $Ch = \dot{m}h \times Cph$

d) $Cc = \dot{m}c \times Cpc$

e) $\varepsilon = 1 - \frac{e(-NTU(1-R))}{1-Re(-NTU(1-R))}$

f) $\varepsilon = \frac{Cmax(Tco-Tci)}{Cmin(Thi-Tho)}$

g) $\varepsilon = \frac{mh \times ch}{Cmin} \times \frac{T1-T2}{T1-t2}$

III. Units

NTU - Number of Transfer Unit
U- Overall heat transfer coefficient, W/m^2K
A - Area, m^2
C_{min} - Smaller value of m_h and c_h, W/K
C_h – Specific heat of hot fluid, J/kg K
C_c - Specific heat of cold fluid, J/kg K
m_c – Mass flow rate of cold fluid, kg/s
m_h - Mass flow rate of hot fluid, kg/s
T1 – Entry Temperature of hot fluid
T2 - Entry Temperature of hot fluid
t_1 - Entry Temperature of cold fluid
t_2 - Entry Temperature of cold fluid
ε - Effectiveness

IV. Specification

- No of tubes-26
- Length of tubes-1000mm
- Diameter of tubes (inner)-11mm
- Diameter of tubes (outer)-13mm
- No of baffle-8
- Plate thikness-5mm
- Diameter of baffle plate-215mm
- Shell diameter (inner)-220mm
- Shell diameter (outer)-215mm
- Shell thickness-5mm
- End plate diameter-260mm
- Thickness of fin-1mm

doi: 10.32622/ijrat.83202010

- Pitch of fin-10mm, 12mm, 14mm, 16mm, 18mm, 20mm
- Height of fin-2.5mm, 3.5mm, 4.5mm
- Hot fluid inlet temperature – 100^0C
- Cold fluide inlet temperature – 27^0C

V. FIGURES

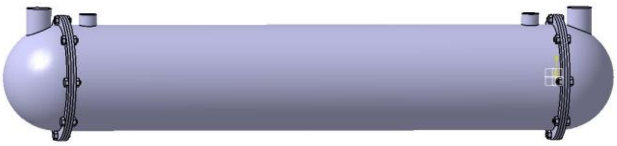

Fig1 : Shell and Tube Heat Exchanger

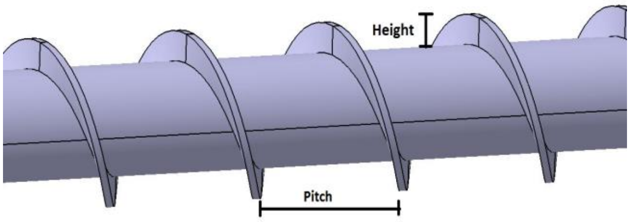

Fig2 : Helical Fins on Tube

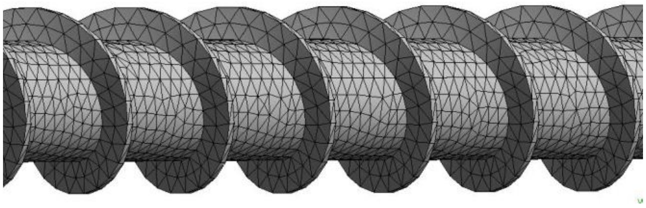

Fig3 : Example of Mesh

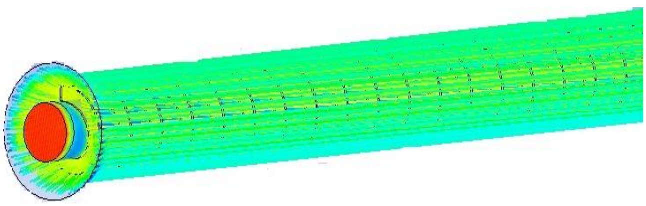

Fig4 : Streamline

VI. SOLUTION IN CFD

For Fin Height 2.5

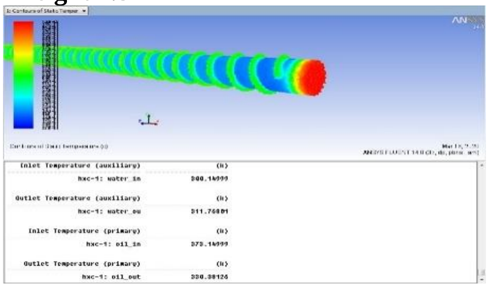

Fig 5: Height 2.5 Pitch 10

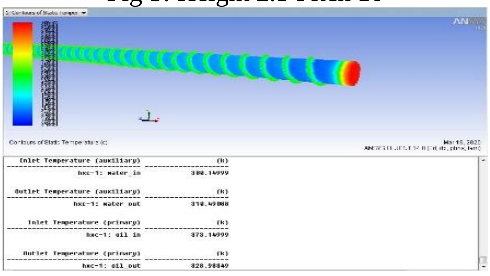

Fig 6: Height 2.5 Pitch 12

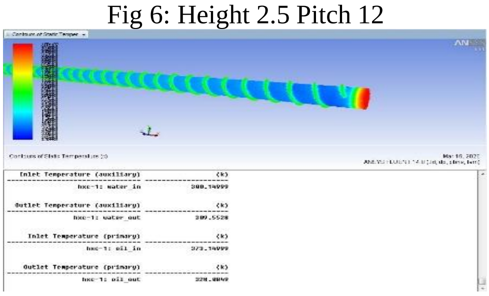

Fig 7: Height 2.5 Pitch 14

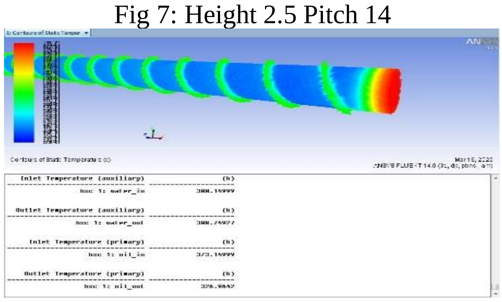

Fig 8: Height 2.5 Pitch 16

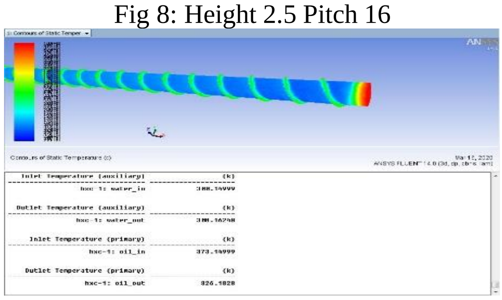

Fig 9: Height 2.5 Pitch 16

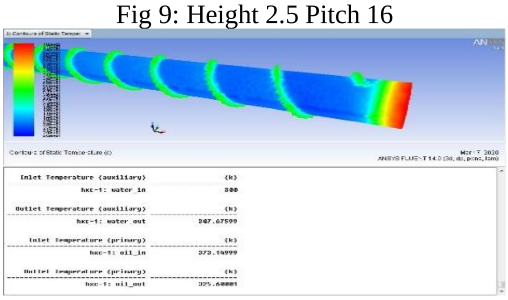

Fig 10: Height 2.5 Pitch 20

doi: 10.32622/ijrat.83202010

For Fin Height 3.5

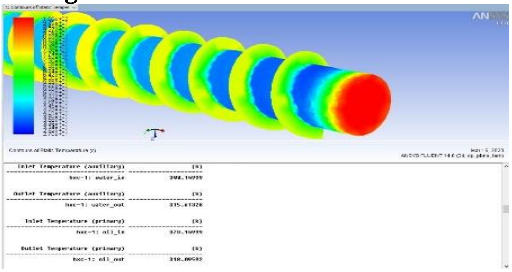

Fig 11: Height 3.5 Pitch 10

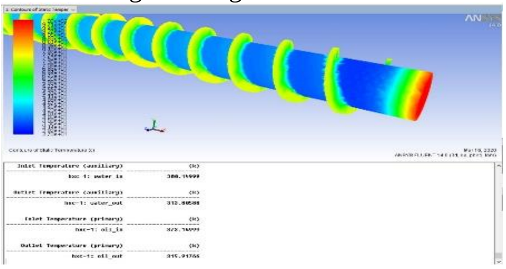

Fig 12: Height 3.5 Pitch 12

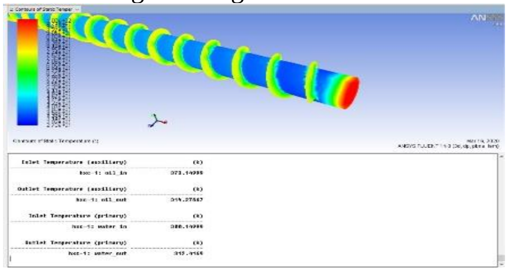

Fig 13: Height 3.5 Pitch 14

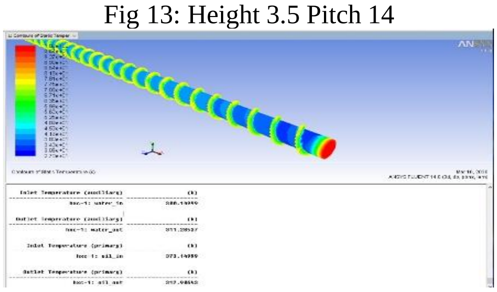

Fig 14: Height 3.5 Pitch

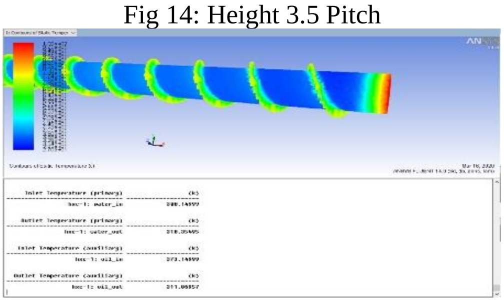

Fig 15: Height 3.5 Pitch 18

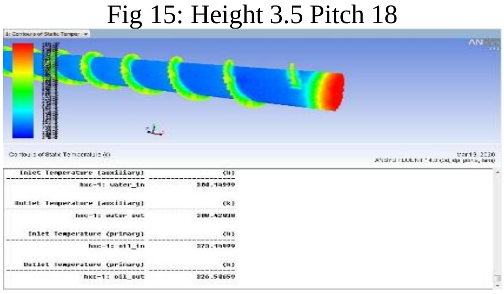

Fig 16: Height 3.5 Pitch 20

For Fin Height 4.5

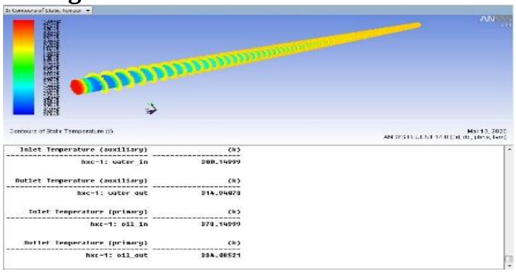

Fig 17: Height 4.5 Pitch 10

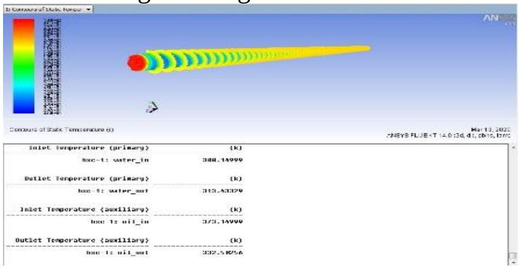

Fig 18: Height 4.5 Pitch 12

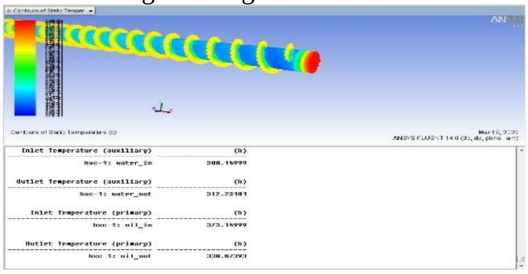

Fig 19: Height 4.5 Pitch 14

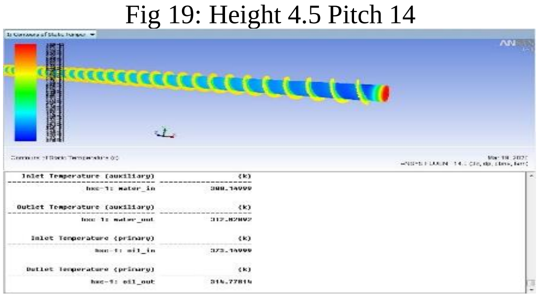

Fig 20: Height 4.5 Pitch 16

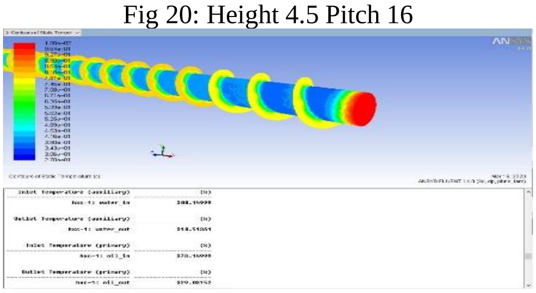

Fig 21: Height 4.5 Pitch 18

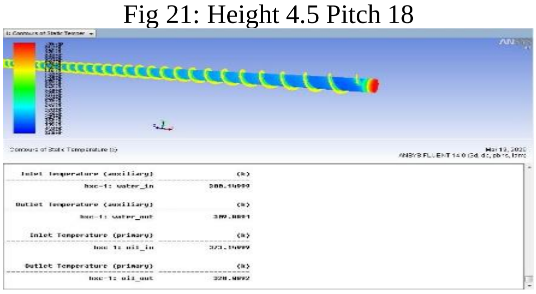

Fig 22: Height 4.5 Pitch 20

doi: 10.32622/ijrat.83202010

VII. RESULT TABLE FOR TEMPRATURE DIFFERENCE

For Fin Height 2.5

Pitch (mm)	Inlet Temperature (K)	Outlet Temperature (K)	Temperature Difference (^{0}C)
10	373.1499	330.38126	42.76864
12	373.1499	328.98349	44.16641
14	373.1499	328.0849	45.065
16	373.1499	326.9642	46.1857
18	373.1499	326.1828	46.9671
20	373.1499	325.60001	47.54989

For Fin Height 3.5

Pitch (mm)	Inlet Temperature (K)	Outlet Temperature (K)	Temperature Difference (^{0}C)
10	373.1499	318.09592	55.05398
12	373.1499	315.91766	57.23224
14	373.1499	312.4169	60.733
16	373.1499	312.90643	60.24347
18	373.1499	311.8695	61.28033
20	373.1499	326.50659	46.64331

For Fin Height 4.5

Pitch (mm)	Inlet Temperature (K)	Outlet Temperature (K)	Temperature Difference (^{0}C)
10	373.1499	334.08521	39.06469
12	373.1499	332.50256	40.64734
14	373.1499	330.8739	42.27597
16	373.1499	314.77814	58.37136
18	373.1499	329.0135	44.11836
20	373.1499	328.0892	45.0607

VIII. CONCLUSION

According to the results of the analysis performed in CFD on Ansys 14.0, we concluded that the helical fins of pitch 3.5mm and length 18mm gives the maximum temperature drop.

We insert the hot fluid at 100^{0}C and cold water at 27^{0}C. We get a drop of 61.280033^{0}C which is 83.95% drop.

Best temperature drop in 2.5mm pitch category is 47.54989^{0}C at 2.5mm pitch and 20mm height which is 65.14% drop and best temperature drop in 4.5mm pitch category is 58.37136^{0}C at 4.5mm pitch and 16mm height which is 79.96% drop.

Therefor at 3.5mm pitch and 18mm height helical fin we get 18.81% extra drop in temperature than 2.5mm pitch and 3.99% extra drop in temperature than 4.5mm pitch fins.

ACKNOWLEDGMENT

We would like to thank to our honourable Project guide Prof. Rahul A. Lekurwale under whose necessary guidance we have completed our project successfully. Without his unending help, encouragement and motivation this would not have been possible.

Dedication and perseverance when supported by inspiration and guidance leads to success. For us the inspiration and guidance was given by our project guide Prof. Rahul A. Lekurwale who was accessible for us to obviate the darkness of our problem with light and his knowledge of the relevant subject enriched by his hands on experienced in the field of technology. We truly sense it was privilege for us, to

doi: 10.32622/ijrat.83202010

have them as our guide. We fill highly honoured working under them.

We are thankful to Prof. Rupesh G. Telrandhe (HOD, Mechanical Engineering) for his support and for providing us all the necessary facilities.

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doi: 10.32622/ijrat.83202010

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