CFD ANALYSIS OF SHELL AND TUBE HEAT EXCHANGER

APROJECTREPORT
Submitted by

R.HARIHARAN (821716114311)
M.MAHESWARAN (821716114314)
M.SRINIVASAN (821716114327)
T.AAGASH (821716114702)

In partial fulfillment for the award of the degree
of
BACHELOR OF ENGINEERING
In
MECHANICAL ENGINEERING

SIR I SSAC NEWTON COLLEGE OF ENGINEERING AND TECHNOLOGY,PAPPAKOVIL,NAGAPATTINAM-611102

ANNAUNIVERSITY::CHENNAI600025 APRIL2020

BONAFIDECERTIFICATE

ABSTRACT

Inpresentdayshellandtubeheatexchangeristhemostcommontypeheatexchangerwidelyuse inoilrefineryandotherlargechemicalprocess,becauseitsuitshighpressureapplication.The processinsolvingsimulationconsistsofmodelingandmeshingthebasicgeometryofshelland tubeheatexchangerusingCFDpackageANSYS13.0.Theobjectiveoftheprojectisdesignof shellandtubeheatexchangerwithhelicalbaffleandstudytheflowandtemperature fieldinsidetheshellusingANSYSsoftwaretools.Theheatexchangercontains7tubesand600 mmlengthshelldiameter90mm.Thehelixangleofhelicalbaffle

willbevariedfrom0^0to20^0.Insimulationwillshowhowthepressurevaryinshelldueto differenthelixangleandflowrate.Theflowpatternintheshellsideoftheheatexchanger withcontinuoushelicalbaffleswasforcedtoberotationalandhelicalduetothegeometryofthe continuoushelicalbaffles,whichresultsinasignificantincreaseinheattransfercoefficientper unitpressuredropintheheatexchanger.

CONTENTS Pageno.

ListOfFigures

ListofTables	Pag no
	27

ListofTables e

Nomenclature

L	Heatexchangerlength
Di	Shellinnerdiameter,
do	Tubeouterdiameter
Nt	Numberoftubes,
Nb	Numberofbaffles.
B	Centralbafflespacing,
Θ	Baffleinclinationangle
Bc	Bafflecut

Chapter1

Introduction

Edit with WPS Office

1.INTRODUCTION

Heatexchangersareoneofthemostlyusedequipmentintheprocessindustries.Heatexchangers areusedtotransferheatbetweentwoprocessstreams.Onecanrealizetheirusagethatany processwhichinvolvecooling,heating,condensation,boilingorevaporationwillrequireaheat exchangerforthesepurpose.Processfluids,usuallyareheatedorcooledbeforetheprocessor undergoaphasechange.Differentheatexchangersarenamedaccordingtotheirapplication. Forexample,heatexchangersbeingusedtocondenseareknownascondensers,similarlyheat exchangerforboilingpurposesarecalledboilers.Performance andefficiencyofheat exchangersaremeasuredthroughtheamountofheattransferusingleastareaofheattransfer andpressuredrop.Amorebetterpresentationofitsefficiencyisdonebycalculatingoverallheat transfercoefficient.Pressuredropandarearequiredforacertainamountofheattransfer, providesaninsightaboutthecapitalcostandpowerrequirements(Runningcost)ofaheat exchanger.Usually,thereislotsofliteratureandtheoriestodesignaheatexchangeraccording totherequirements.

Heatexchangersareoftwotypes:-

- Wherebothmediabetweenwhichheatisexchangedareindirectcontactwitheach otheris Directcontact the at exchanger,
- Wherebothmediaareseparatedbyawallthroughwhichheatistransferredsothat theynevermix,Indirectcontactheatexchanger.

Atypicalheatexchanger,usuallyforhigherpressureapplicationsupto552bars,istheshell andtubeheatexchanger.Shellandtubetypeheatexchanger,indirectcontacttypeheat exchanger.Itconsistsofaseriesoftubes,throughwhichoneofthefluidsruns.Theshellisthe containerfortheshellfluid.Generally,itiscylindricalinshapewithacircularcrosssection, althoughshellsofdifferentshapeareusedinspecificapplications.Forthisparticularstudy shellisconsidered,whichisgenerallyaonepassshell.Ashellisthemostcommonlyuseddue toitslowcostandsimplicity,andhasthehighestlog-meantemperature-difference(LMTD) correctionfactor.Althoughthetubesmayhavesingleormultiplepasses,thereisonepassonthe shellside,whiletheotherfluidflowswithintheshelloverthetubestobeheatedorcooled.The tubesideandshellsidefluidsareseparatedbyatubesheet.

Bafflesareusedtosupportthetubesforstructuralrigidity,preventingtubevibrationand saggingandtodivertttheflowacrossthebundletoobtainahigherheattransfercoefficient. Bafflespacing(B)isthecentrelinedistancebetweentwoadjacentbaffles,Baffleisprovidedwith acut(B_c)whichisexpressedasthepercentageofthesegmentheighttoshellinsidediameter.Bafflecut canvarybetween15%and45%oftheshellinsidediameter.Inthepresentstudy36%bafflecut(B_c)is considered.Ingeneral,conventionalshellandtubeheatexchangersresultinhighshell-sidepressure dropandformationofrecirculationzonesnearthebaffles.Mostoftheresearchesnowadayarecarried onhelicalbaffles,whichgivebetterperformancethensinglesegmentalbafflesbuttheyinvolvehigh manufacturingcost,installationcostandmaintenancecost.Theeffectivenessandcostaretwoimportant parametersinheatexchangerdesign.So,Inordertoimprovethethermalperformanceatareasonable costoftheShellandtubeheatexchanger,bafflesinthepresentstudyareprovidedwithsomeinclination inordertomaintainareasonablepressuredropacrosstheexchanger.

Thecomplexitywithexperimentaltechniquesinvolvesquantitativedescriptionofflowphenomena usingmeasurementsdealingwithonequantityatatimeforalimitedrangeofproblemandoperating conditions.ComputationalFluidDynamicsisnowanestablishedindustrialdesigntool,offeringobvious advantages.Inthisstudy,afull360°CFDmodelofshellandtubeheatexchangerisconsidered.By modellingthegeometryasaccuratelyaspossible,theflowstructureandthetemperaturedistribution insidetheshellareobtained.

1.1OBJECTIVE:

Themainobjectiveofthisprojectisdesigningandsimulationofshellandtubeheat exchangerwithhelicalbaffleusingAnsystools.

Chapter2

LiteratureReview

2.LITERATUREREVIEW

2.1Introduction

Thepurposeofthischapteristoprovidealiteraturereviewofpastresearcheffortsuchas journalsorarticlesrelatedtoshellandtubeheatexchangerandcomputationalfluiddynamics (CFD)analysiswhetherontwodimensionandthreedimensionmodelling.Moreover,reviewof otherrelevantresearchstudiesaremadetoprovidemoreinformationinordertounderstand moreonthisresearch.

2.2PurposeofUseofHelicalBaffle:

Anewtypeofbaffle,calledthehelicalbaffle,providesfurtherimprovement.Thistypeof bafflewasfirstdevelopedbyLutchaandNemcansky.Theyinvestigatedtheflowfieldpatterns producedbysuchhelicalbafflegeometrywithdifferenthelixangles.Theyfoundthattheseflow patternswereveryclosetotheplugflowcondition,whichwasexpectedtoreduceshell-side pressuredropandtoimproveheattransferperformance.Stehliketal.comparedheattransfer andpressuredropcorrectionfactorsforaheatexchangerwithanoptimizedsegmentalbaffle basedontheBell–Delawaremethod,withthoseforaheatexchangerwithhelicalbaffles.Kralet al.discussedtheperformanceofheatexchangerswithhelicalbafflesbasedontestresultsof variousbafflesgeometries.OneofthemostimportantGeometricfactorsoftheSTHXHBisthehelix angle.Recentlyacomprehensivecomparisonbetweenthetestdataofshell-sideheattransfer coefficientversusshell-sidepressuredropwasprovidedforfivehelicalbafflesandone segmentalbafflemeasuredforoil-waterheatexchanger.Itisfoundthatbasedontheheat transferper unitshell-sidefluidpumpingpowerorunitshell-sidefluidpressureddrop,thecaseof40^{0}helix anglebehavesthebest.Theflowpatternintheshellsideoftheheatexchangerwithcontinuous helicalbaffleswasforcedtoberotationalandhelicalduetothegeometryofthecontinuous helicalbaffles,whichresultsinasignificantincreaseinheattransfercoefficientperunitpressure dropintheheatexchanger.Properlydesignedcontinuoushelicalbafflescanreducefoulinginthe shellsideandpreventtheflow-inducedvibrationaswell.TheperformanceoftheproposedSTHXs wasstudiedexperimentallyinthiswork.Theuseofcontinuoushelicalbafflesresultsinnearly 10%increaseinheattransfercoefficientcomparedwiththatofconventionalsegmentalbaffles forthesameshell-sidepressuredrop.Basedontheexperimentaldata,thenondimensional correlationsforheattransfercoefficientandpressure dropweredevelopedfortheproposedcontinuoushelicalbaffleheatexchangerswithdifferent shellconfigurations,whichmightbeusefulforindustrialapplicationsandfurtherstudyof continuoushelicalbaffleheatexchangers.

2.3ComputationalFluidDynamics (CFD):

CFDisasophisticatedcomputationally-baseddesignandanalysistechnique.CFD softwaregivesyouthepowertosimulateflowsofgasesandliquids,heatandmasstransfer, movingbodies,multiphasephysics,chemicalreaction,fluid-structureinteractionandacoustics throughcomputermodelling.Thissoftwarecanalsobuildavirtualprototypeofthesystemor devicebeforecanbeapplytoreal-worldphysicsandchemistrytothemodel,andthesoftware willprovidewithimagesanddata,whichpredicttheperformanceofthatdesign.

Computationalfluiddynamics(CFD)isusefulinawidevarietyofapplicationsand useinindustry.CFDisoneofthebranchesoffluidmechanicsthatusesnumericalmethodsand algorithmcanbeusedtosolveandanalyseproblemsthatinvolvefluidflowsandalsosimulate theflowoverapiping,vehicleormachinery.Computersareusedtoperformthemillionsof calculationsrequiredtosimulatetheinteractionoffluidsandgaseswiththecomplexsurfaces usedinengineering.Moreaccuratecodesthatcanaccuratelyandquicklysimulateeven complexscenariossuchassupersonicandturbulentflowsareongoingresearch.Onwardsthe aerospaceindustryhasintegratedCFDtechniquesintothedesign,R&

Dandmanufactureofaircraftandjetengines.Morerecentlythemethodshavebeenappliedto thedesignofinternalcombustionengine,combustionchambersofgasturbineandfurnacesalso fluidflowsandheattransferinheatexchanger(Figure1).Furthermore,motorvehicle manufacturesnowroutinelypredictdragforces,underbonnetairflowsandsurroundingcar environmentwithCFD.IncreasinglyCFDisbecomingavitalcomponentin thedesignofindustrialproductsandprocesses.

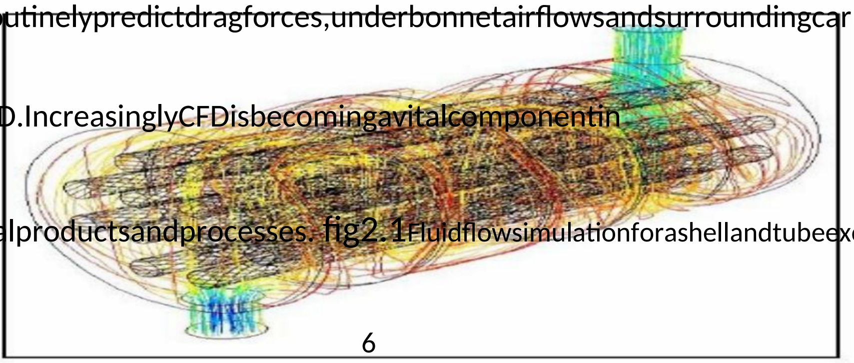

fig2.1Fluidflowsimulationforashellandtubeexchanger.

6

2.4APPLICATIONOFCFD:

CFDnotjustspansonchemicalindustry,butawiderangeofindustrialandnonindustrial applicationareaswhichisinbelow:

- Aerodynamicsofaircraftandvehicle.
- CombustioninICenginesandgasturbineinpowerplant.
- Loadsonoffshorestructureinmarineengineering.
- Bloodflowsthrougharteriesandveininbiomedicalengineering.
- Weatherpredictioninmeteorology.
- Flowinsiderotatingpassagesanddiffusersinturbo-machinery.
- Externalandinternalenvironmentofbuildingslikewindloadingandheatingor
- Ventilationsystem.
- Mixingandseparationorpolymermoldingsinchemicalprocessengineering.
- Distributionofpollutantsandeffluentinenvironmentalengineering.

2.5ANSYS:

Ansysisthefiniteelementanalysiscodewidelyuseincomputeraidedengineering(CAE)field. ANSYSsoftwarehelpustoconstructcomputermodelsofstructure,machine,componentsor system,applyoperatingloadsandotherdesigncriteria,studyphysicalresponsesuchasstress leveltemperaturedistribution,pressureetc.

InAnsysfollowingBasicstepisfollowed:

- Duringpreprocessingthegeometryoftheproblemisdefined.Volumeoccupiedbyfluid isdividedintodiscretecells(themesh).Themeshmaybeuniformornonuniform.The physicalmodellingisdefined.Boundryconditionisdefined.Thisinvolvesspecifyingthe fluidbehaviouroftheproblem.Fortransientproblemboundryconditionarealsodefined.
- Thesimulationisstartedandtheequationaresolvediterativelyassteadystateor transient.
- Finallyapostprocedureisusedfortheanalysisandvisualisationoftheresulting problem.

Chapter3

COMPUTATIONALMODELFORHEATEXCHANGER

3.COMPUTATIONALMODELFORHEAT EXCHANGER

3.1ProblemDescription:

Designofshellandtubeheatexchangerwithhelicalbaffleusing CFD.To studythetemperatureandpressureinsidethetubewithdifferentmassflow rate.

3.2ComputationalModel:

ThecomputationalmodelofanexperimentaltestedShellandTubeHeatExchanger(STHX) with10helixangleisshowninfig.2,andthegeometryparametersarelistedinTable1.Ascanbe seenfromFig2,thesimulatedSTHXhassixcyclesofbafflesintheshellsidedirectionwithtotal numberoftube7.Thewholecomputationdomainisboundedbytheinnersideoftheshelland everythingintheshellcontainedinthedomain.Theinletandoutletofthedomainareconnected withthecorrespondingtubes.

Tosimplifynumericalsimulation,somebasiccharacteristicsoftheprocessfollowing assumptionaremade:

1. Theshellsidefluidisconstantthermalproperties
2. Thefluidflowandheattransferprocessesareturbulentandinsteadystate
3. Theleakflowsbetweentubeandbaffleandthatbetweenbafflesandshellareneglected
4. Thenaturalconvectioninducedbythefluiddensityvariationisneglected
5. Thetubewalltemperaturekeptconstantinthewholeshellside
6. Theheatexchangeriswellinsulatedhencetheheatlosstotheenvironmentistotally neglected.

3.3Navier-StokesEquation:

ItisnamedafterClaude-LouisNavierandGabrielStokes,Hedescribedthemotionoffluid substances.ItsalsoafundamentalequationbeingusedbyANSYSandeveninthepresentproject work.Theseequationarisefromapplyingsecondlawofnewtontofluidmotion,togetherwiththe assumptionthatthefluidstressissumofadiffusingviscousterm,plusapressureterm.The derivationoftheNavierStokesequationbeginswithanapplicationofsecondlawofnewtoni.e conservationofmomentum.Inaninertialframeofreference,the generalformoftheequationsoffluidmotionis:-

$$\partial_x u + \partial_y v = 0, \tag{1}$$

$$\begin{aligned}\partial_t u + u\partial_x u + v\partial_y u = -\partial_x p + \frac{1}{\mathrm{Re}}\big[&\partial_x(\mu\partial_x u) + \partial_y(\mu\partial_y u) \\ &+ \partial_x\mu\partial_x u + \partial_y\mu\partial_x v\big],\end{aligned} \tag{2}$$

$$\begin{aligned}\partial_t v + u\partial_x v + v\partial_y v = -\partial_y p + \frac{1}{\mathrm{Re}}\big[&\partial_x(\mu\partial_x v) + \partial_y(\mu\partial_y v) \\ &+ \partial_y\mu\partial_y v + \partial_x\mu\partial_y u\big],\end{aligned} \tag{3}$$

$$\partial_t T + u\partial_x T + v\partial_y T = -\frac{1}{\mathrm{Re}\,\mathrm{Pr}}\big[\partial_x(\kappa\partial_x T) + \partial_y(\kappa\partial_y T)\big], \tag{4}$$

ThisNavierStokesEquationsloveineverymessshellandthesimulationshowstheresult.

3.4GeometryandMesh:

ThemodelisdesignedaccordingtoTEMA(TubularExchangerManufacturers Association)StandardsGaddis(2007).

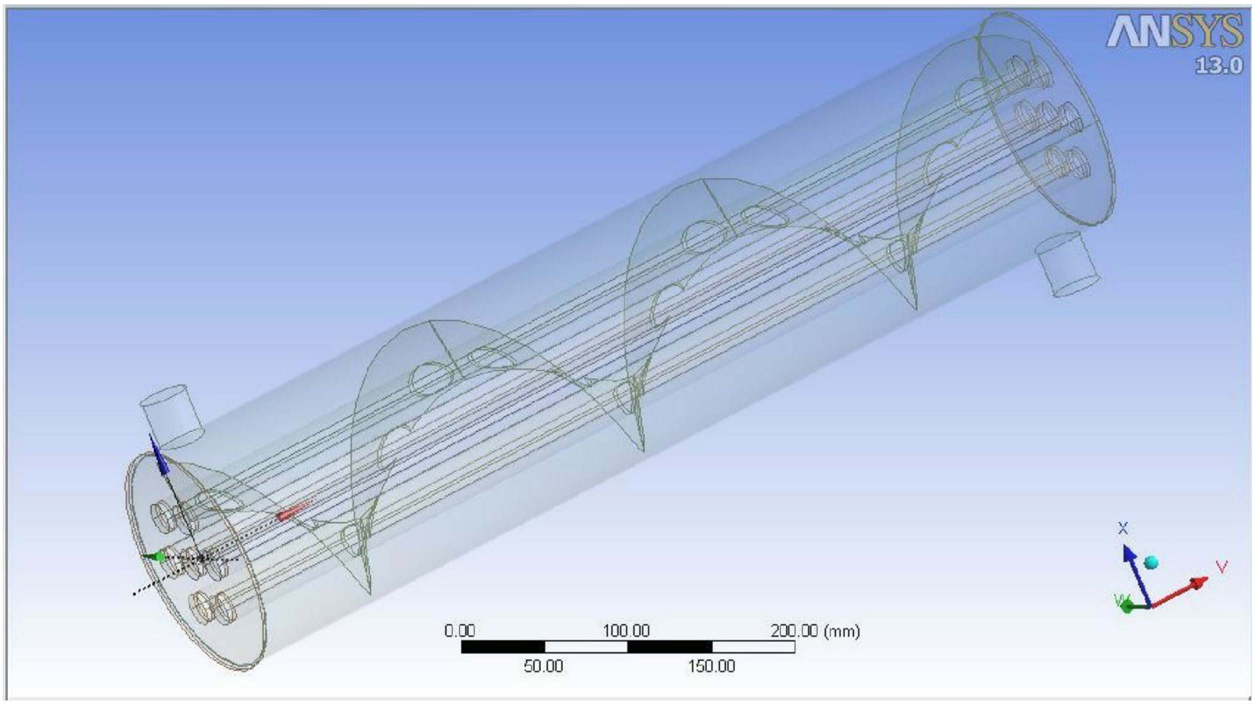

Fig3.1Isometricviewofarrangementofbafflesandtubesofshellandtubeheatexchanger withbaffleinclination.

Table3.1Geometricdimensionsofshellandtubeheatexchanger

Heatexchangerlength,L	600mm
Shellinnerdiameter,Di	90mm

Tubeouterdiameter,do	20mm
TubebundlegeometryandpitchTriangular	30mm
Numberoftubes,Nt	7
Numberofbaffles.Nb	6
Centralbafflespacing,B	86mm
Baffleinclinationangle,θ	0to40^0

3.5.GridGeneration

Thethree-dimensionalmodelisthendiscretizedinICEMCFD.Inordertocapturebooththe thermalandvelocityboundarylayerstheentiremodelisdiscretizedusinghexahedralmesh elementswhichareaccurateandinvolvelesscomputationeffort.Finecontrolonthe hexahedralmeshnearthewallsurfaceallowscapturingtheboundarylayergradient accurately.TheentiregeometryisdividedintothreefluiddomainsFluid_Inlet,Fluid_Shell andFluid_OutletandsixsoliddomainsnamelySolid_Baffle1toSolid_Baffle6forsixbaffles respectively.

Theheatexchangerisdiscretizedintosolidandfluiddomainsinordertohavebetter controloverthenumberofnodes.Thefluidmeshismadefinerthensolidmeshfor simulatingconjugateheattransferphenomenon.ThethreefluiddomainsareasshowninFig.

2.Thefirstcellheightinthefluiddomainfromthetubesurfaceismaintainedat100micronsto capturethevelocityandthermalboundarylayers.Thediscretisedmodelischeckedforquality andisfoundtohaveaminimumangleof18°andmindeterminantof

4.12.Oncethemeshesarecheckedforfreeoferrorsandminimumrequiredqualityitis exportedtoANSYS

CFXpre-processor.

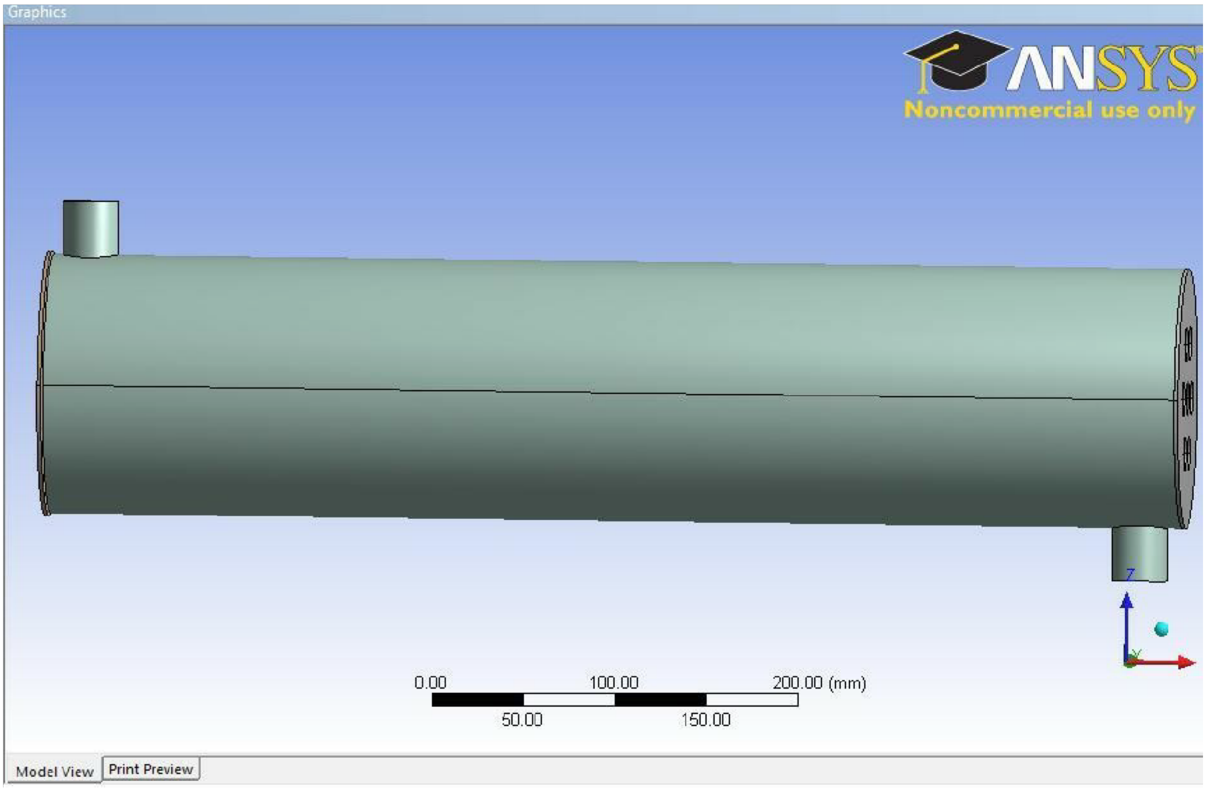

Fig3.2completemodelofshellandtubeheatexchanger

3.6Meshing:

Initiallyarelativelycoarsermeshisgeneratedwith1.8Millioncells.Thismeshcontainsmixed cells(TetraandHexahedralcells)havingbothtriangularandquadrilateralfacesatthe boundaries.Careistakentousestructuredcells(Hexahedral)asmuchaspossible,forthis reasonthegeometryisdividedintoseveralpartsforusingautomaticmethodsavailableinthe ANSYSmeshingclient.Itismeanttoreducenumericaldiffusionasmuchaspossibleby structuringthemeshinawellmanner,particularlynearthewallregion.Lateron,forthemesh independentmodel,afinemeshisgeneratedwith5.65Millioncells.Forthisfinemesh,the edgesandregionsofhightemperatureandpressuregradientsarefinelymeshed.

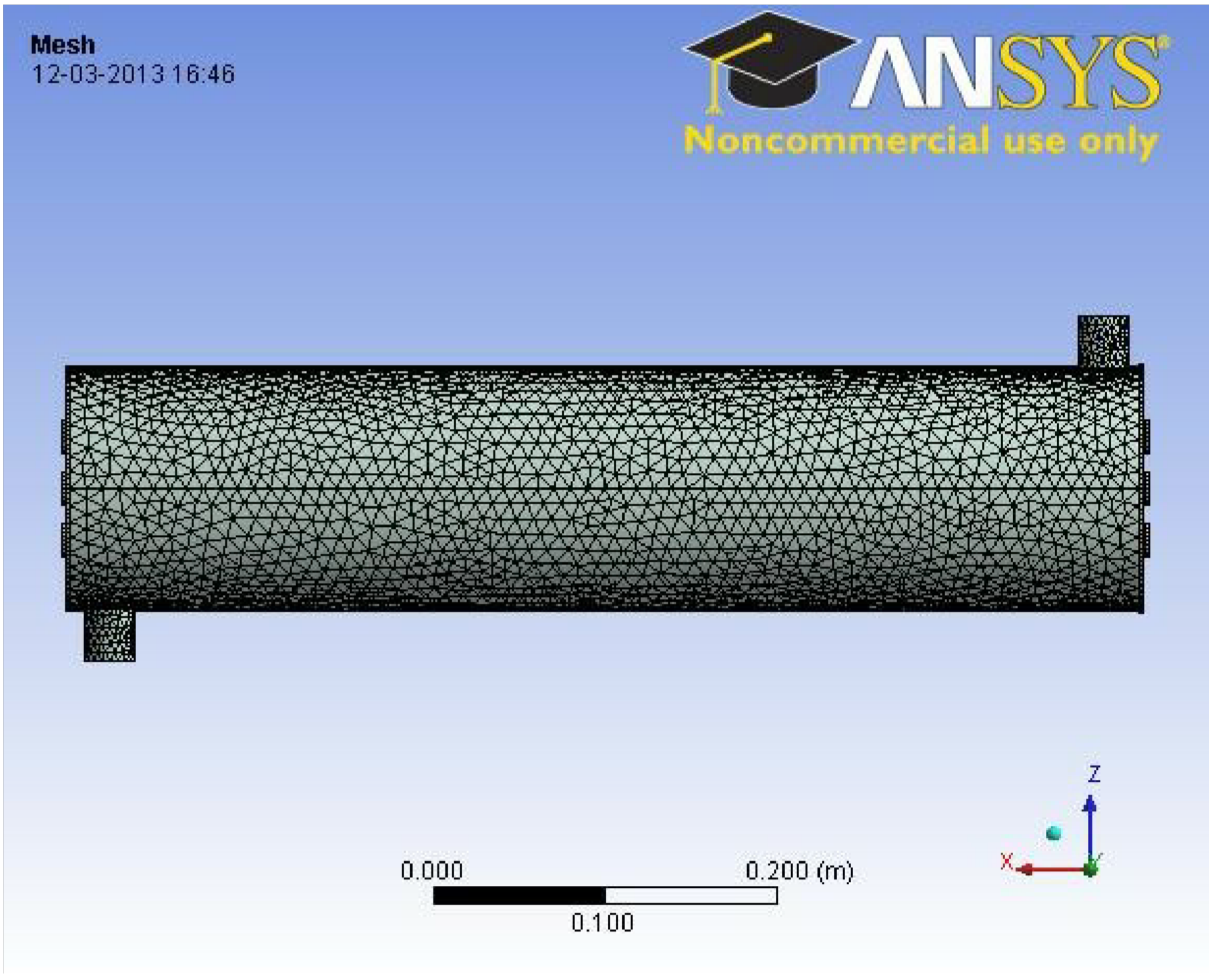

Fig3.3Meshingdiagramofshellandtubeheatexchanger

3.7ProblemSetup

SimulationwascarriedoutinANSYS® FLUENT® v13.IntheFluentsolverPressureBased typewasselected,absolutevelocityformationandsteadytimewasselectedforthesimulation.In themodeloptionenergycalculationwasonandtheviscouswassetasstandardk-e,standard wallfunction(k-epsilon2eqn).

Incellzonefluidwater-liquidwasselected.Water-liquidandcupper,aluminumwasselectedas materialsforsimulation.Boundaryconditionwasselectedforinlet,outlet.Ininletandoutlet1kg/s velocityandtemperaturewassetat353k.Acrosseachtube0.05kg/svelocityand300k temperaturewasset.Massflowwasselectedineachinlet.InreferenceValueAreasetas1m^2 ,Density998kg/m^3,enthalpy229485j/kg,length1m,temperature353k,Velocity1.44085m/s ,Rationofspecificheat1.4wasconsidered.

3.8SolutionInitialization:

PressureVelocitycouplingselectedasSIMPLEC.Skewnesscorrectionwassetatzero.In SpatialDiscretizationzoneGradientwassetasLeastsquarecellbased,Pressurewasstandard, MomentumwasFirstorderUpwind,TurbulentKineticenergywassetasFirstorderUpwind, EnergywasalsosetasFirstorderUpwind.InSolutioncontrol,Pressurewas0.7,Density1,Body force1,Momentum0.2,turbulentkineticandturbulentdissipationratewassetat1,energyand turbulentViscositywas1.Solutioninitializationwasstandardmethodandsolutionwasinitialize frominletwith300ktemperature.

Chapter4

Results

4Results

UndertheAboveboundaryconditionandsolutioninitializeconditionsimulationwasset for1000iteration.

4.1ConvergenceOfSimulation:

TheconvergenceofSimulationisrequiredtogettheparametersoftheshellandtubeheat exchangerinoutlet.Italsogivesaccuratevalueofparametersfortherequirementofheattransfer rate.Continuity,X-velocity,Y-velocity,Z-velocity,energy,k,epsilionarethepartofscaled residualwhichhavetoconvergeinaspecificregion.Forthecontinuity,X-velocity,Y-velocity,Zvelocity,k,epsilionshouldbelessthan10^{-4}andtheenergyshouldbelessthan10^{-7}.Iftheseall valuesinsamemannerthensolutionwillbeconverged.

0^0Baffleinclination

ForZerodegreebaffleinclinationsolutionwasconvergedat170^{th}iteration.Thefollowingfigure showstheresidualplotfortheaboveiterations:

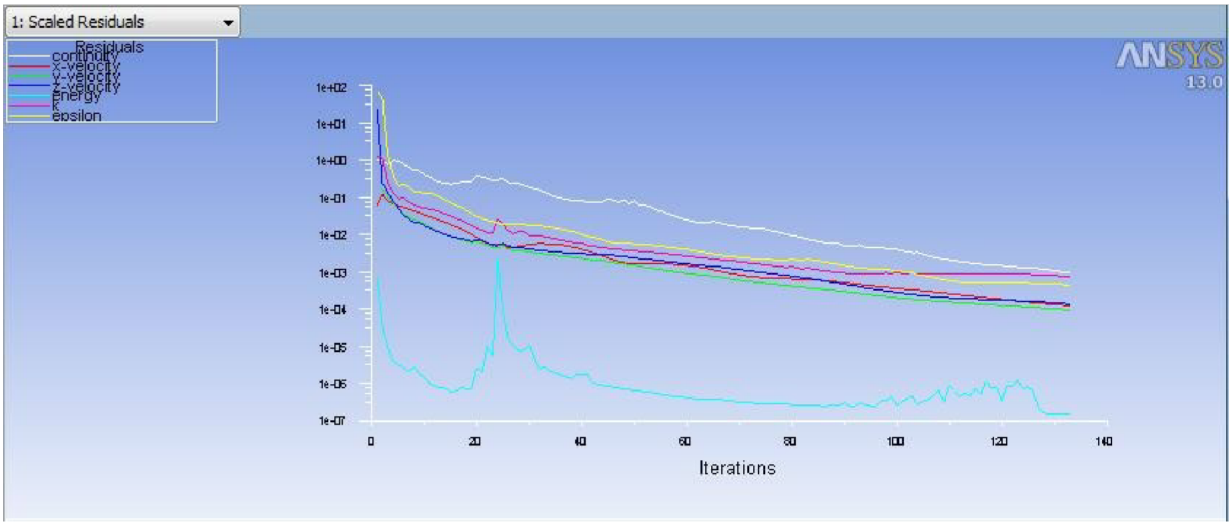

Figure4.11-ForConversion0^0Baffleinclinationafter170^{th}iteration

10^0Baffleinclination:

Simulationof10^{0}Baffleinclinationisconvergedat133thiteration.Thefollowingfigure showstheresidualplot:

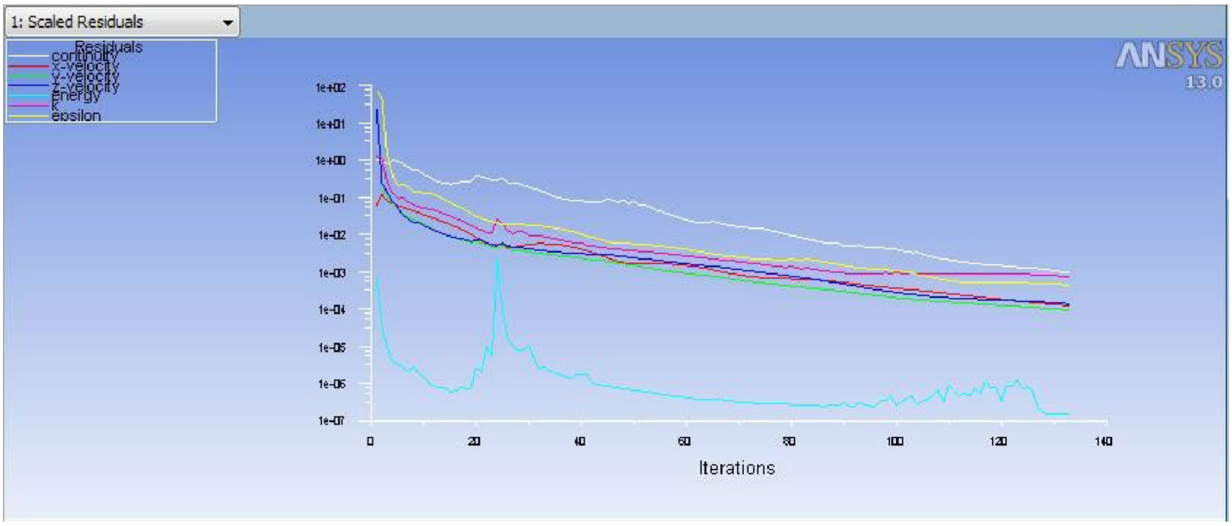

Figure4.12Convergesimulationof10^{0}baffleinclinationat133thiteration.20^0

Baffleinclination:
Simulationof20^{0}baffleinclinationisconvergedat138thiteration.Thefollowingfigureshowsthe residualplot:

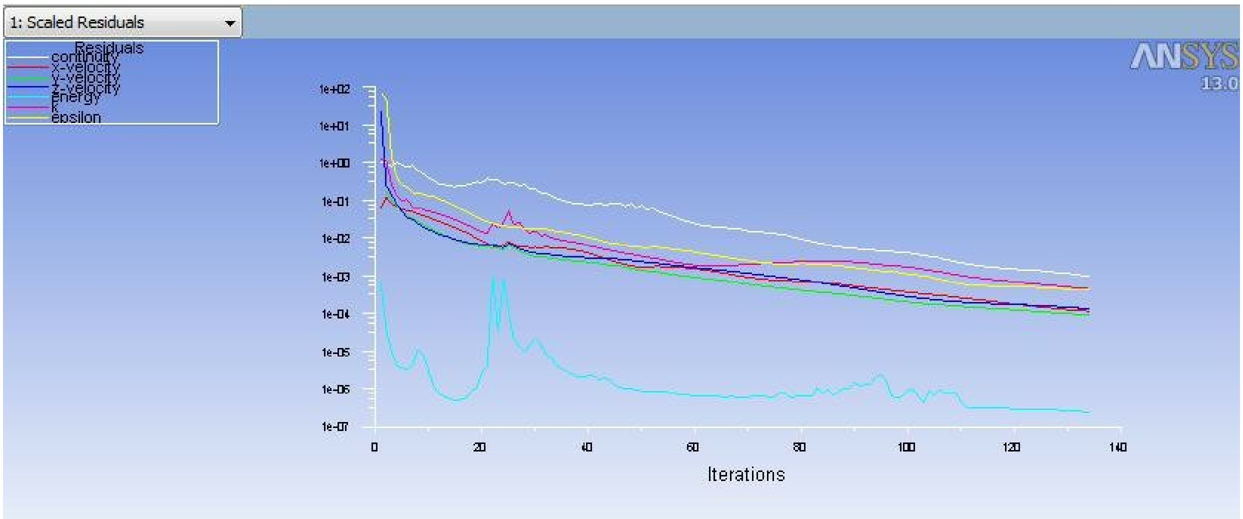

Figure4.13Convergenceof20^{0}baffleinclinationat138thiteration

4.2VariationofTemperature:

ThetemperatureContoursplotsacrossthecrosssectionatdifferentinclinationofbafflealongthe lengthofheatexchangerwillgiveanideaoftheflowindetail.Threedifferentplotsof temperatureprofilearetakenincomparisonwiththebaffleinclinationat0^0,10^0,20^0.

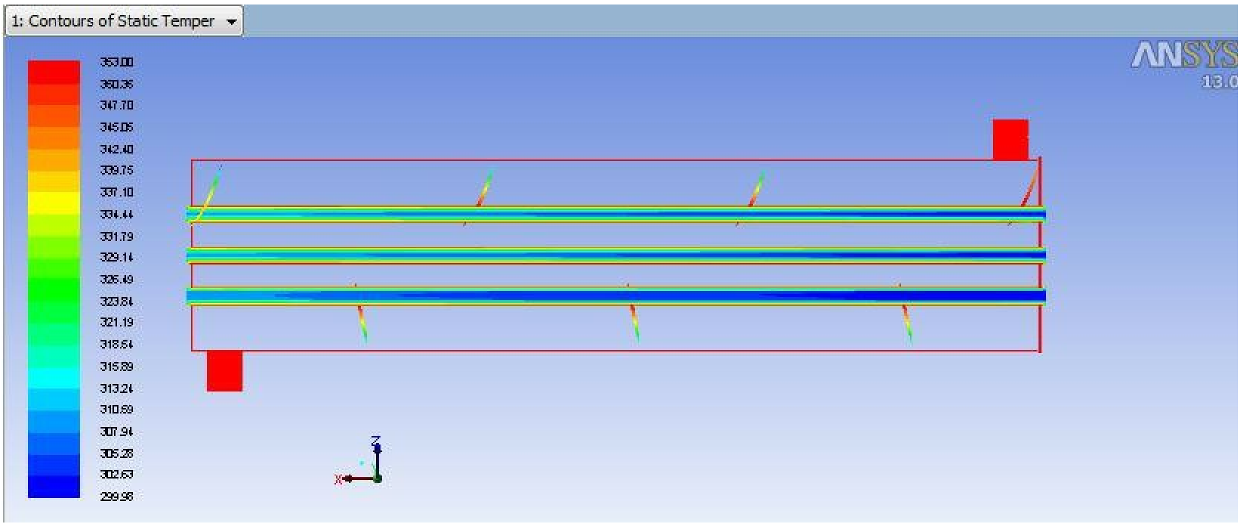

Figure4.21TemperatureDistributionacrossthetubeandshell.

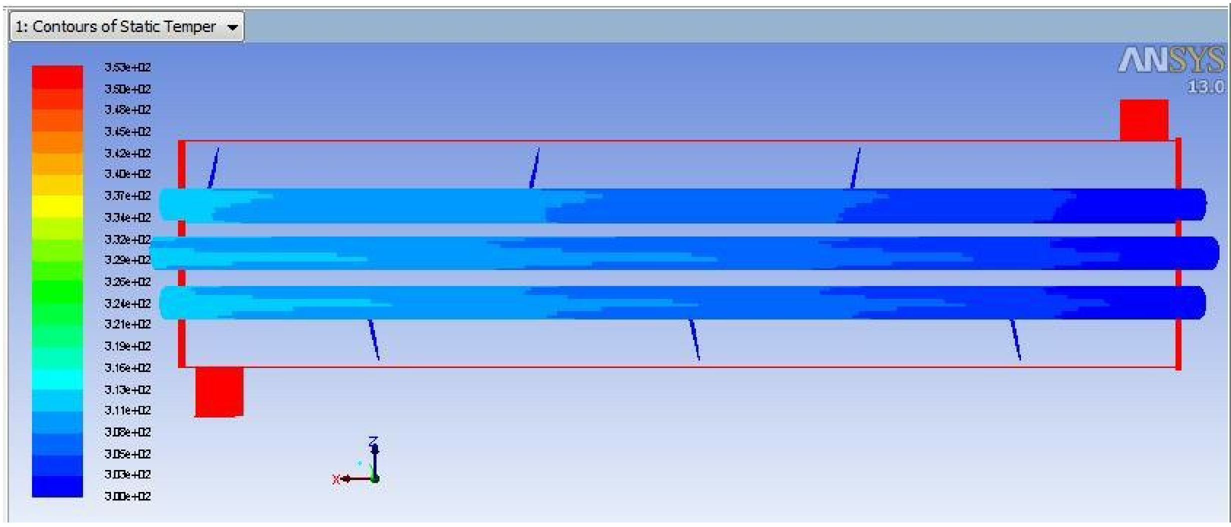

Figure4.22TemperatureDistributionfor10^0baffleinclination

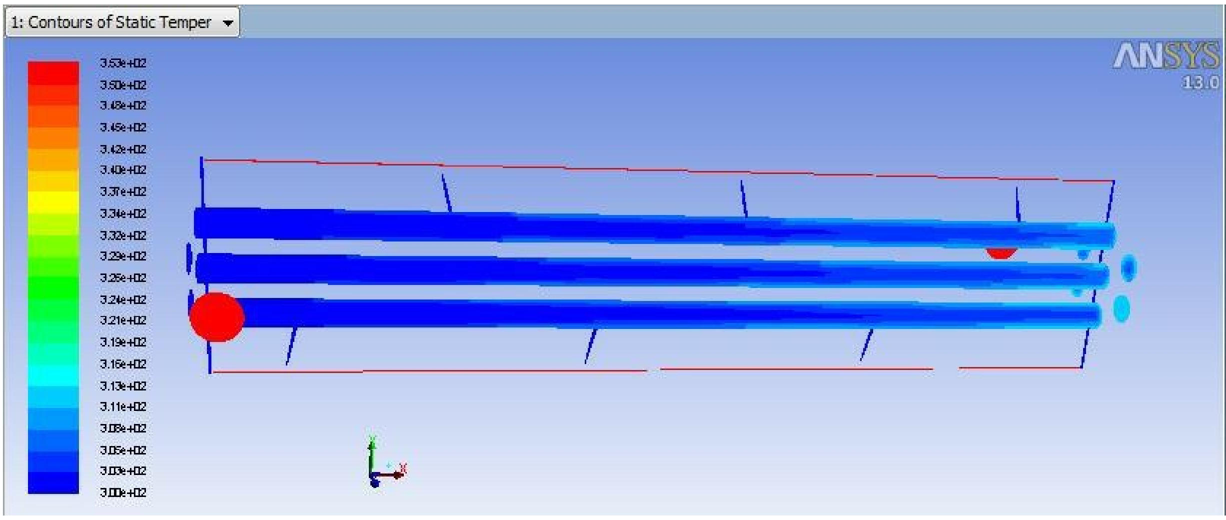

Figure4.23TemperatureDistributionof20^{0}baffleinclination

Temperatureofthehotwaterinshellandtubeheatexchangeratinletwas353kandinoutletit became347k.Incaseofcoldwaterinlettemperaturewas300kandtheoutletbecame313k.

TubeoutletTemperatureDistributionwasgivenbelow:
Exchanger

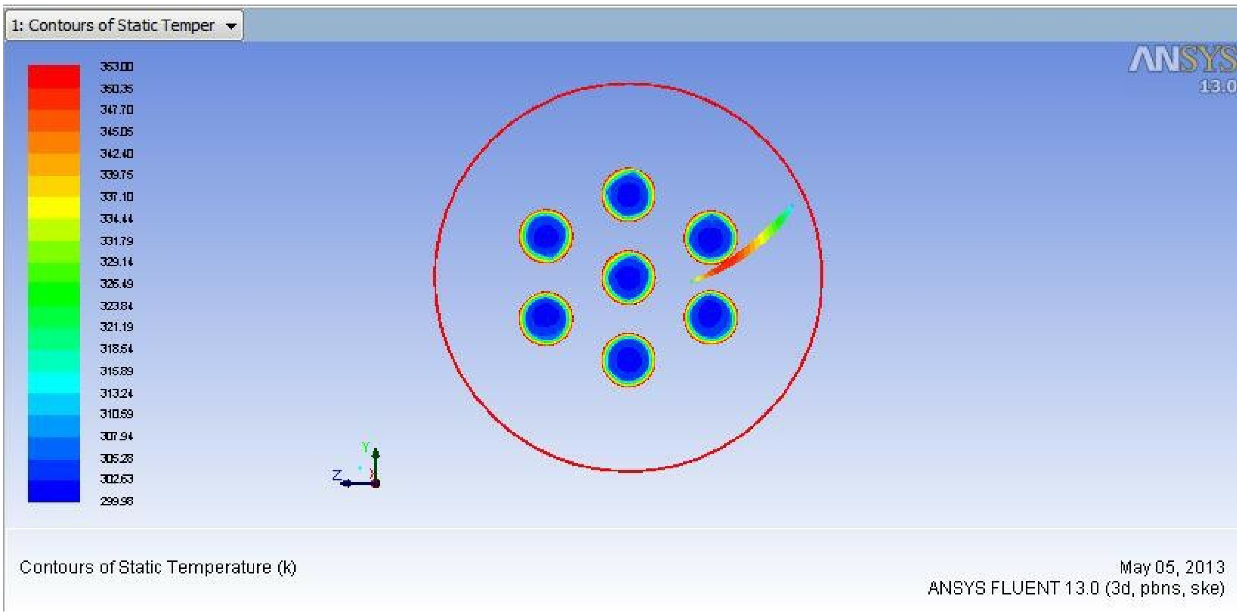

Figure4.24TemperatureDistributionacrossTubeoutletin0^{0}baffleinclination

4.3VariationOfVelocity:

Velocityprofileisexaminedtounderstandtheflowdistributionacrossthecrosssectionatdifferent positionsinheatexchanger.BelowinFigure(12)(13)(14)isthevelocityprofileofShellandTube HeatexchangeratdifferentBaffleinclination.Itshouldbekeptinmindthattheheatexchangeris modeledconsideringtheplanesymmetry.Thevelocityprofileatinletissameforallthree inclinationofbaffleanglei.e1.44086m/s.Outletvelocityvarytubetohelicalbaffleand turbulenceoccurintheshellregion.

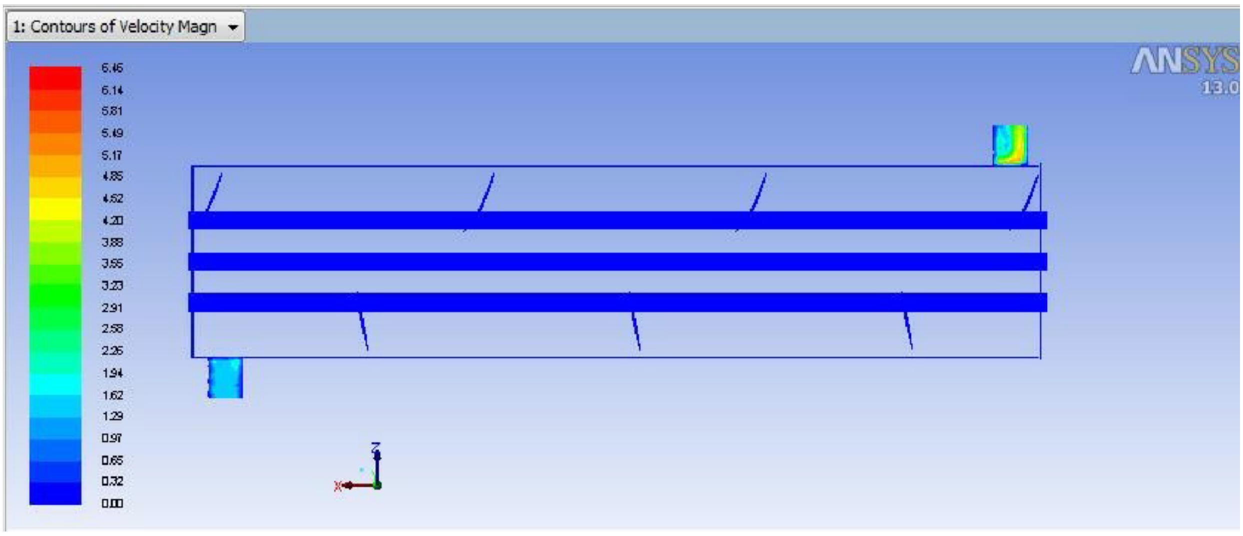

Figure4.31Velocityprofileacrosstheshellat0^{0}baffleinclination.

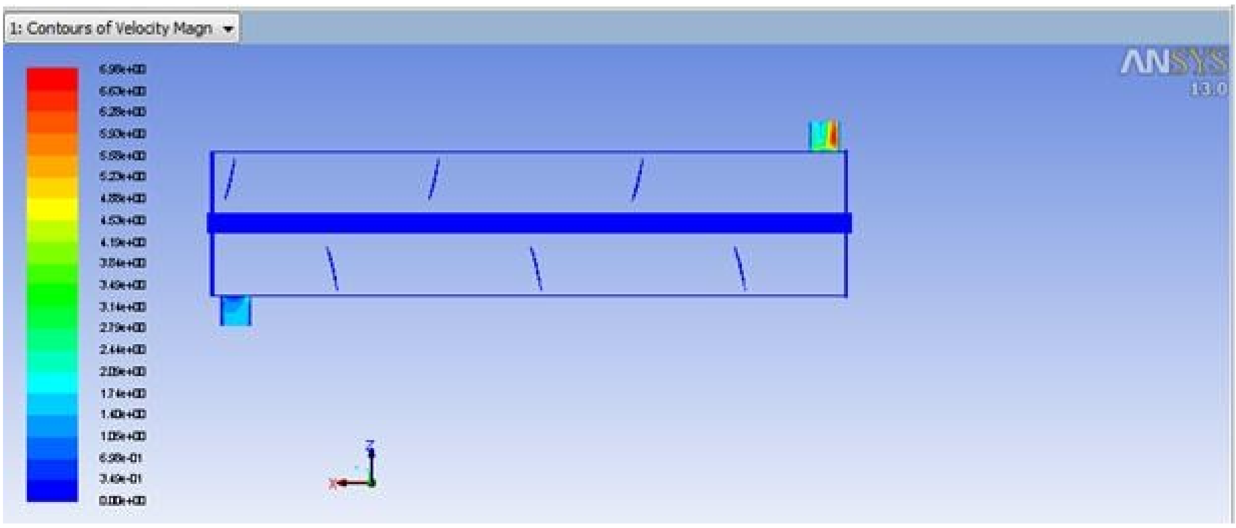

Figure4.32Velocityprofileacrosstheshellat10^{0}baffleinclination.

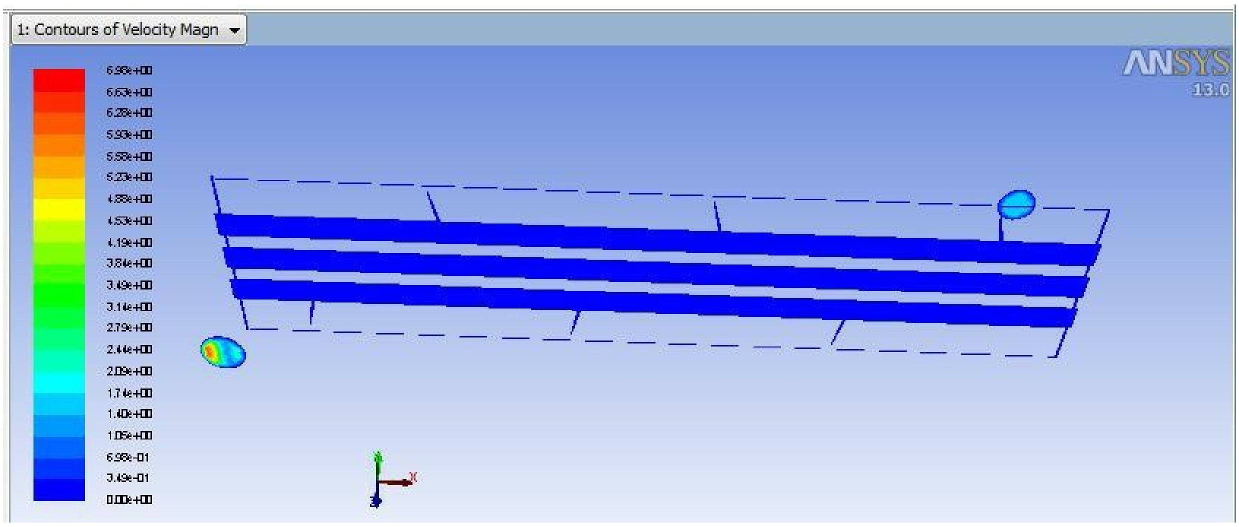

Figure4.33Velocityprofileacrosstheshellat20^{0}baffleinclination.

4.4VariationOfPressure:

PressureDistributionacrosstheshellandtubeheatexchangerisgivenbelowinFig.(14)(15)(16).WiththeincreaseinBaffleinclinationanglepressuredropinsidetheshellisdecrease. Pressurevarylargelyfrominlettooutlet.Thecontoursofstaticpressureisshowninallthe figuretogiveadetailidea.

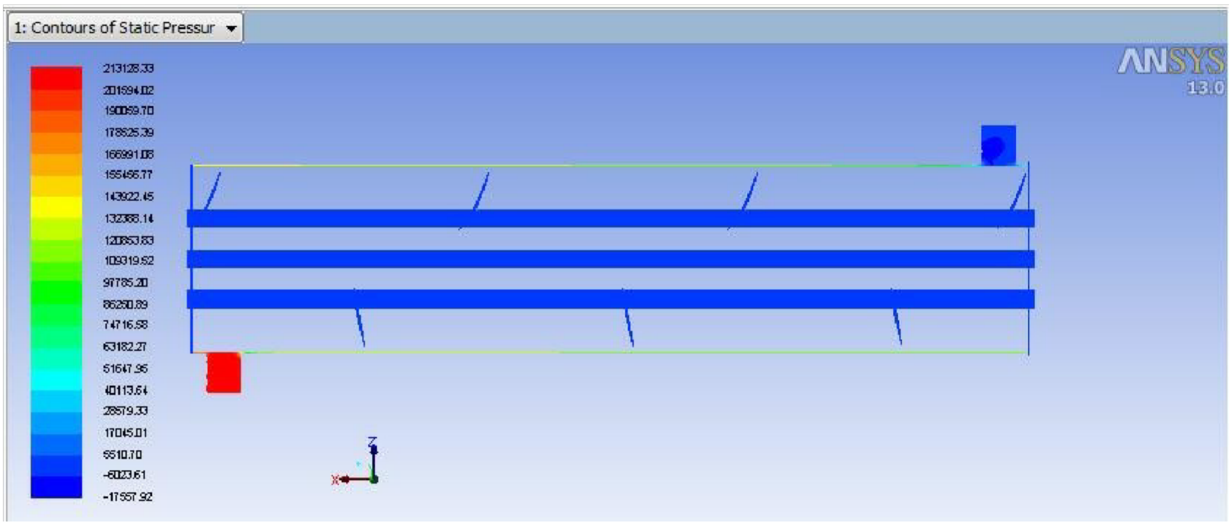

Figure4.41PressureDistributionacrosstheshellat0^{0}baffleinclination.

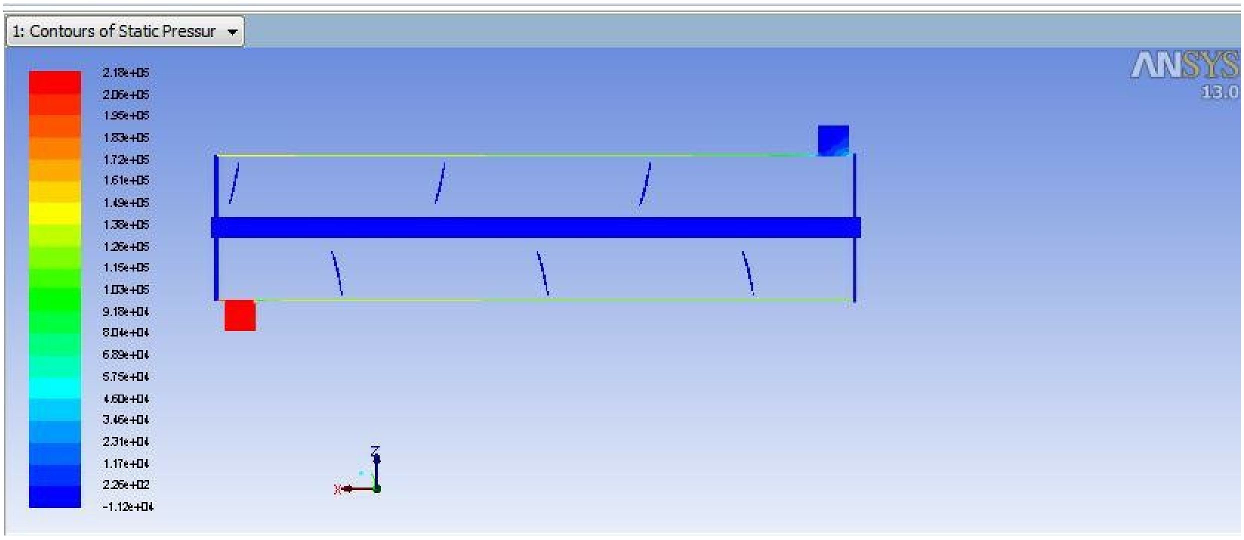

Figure4.42PressureDistributionacrosstheshellat10^{o}baffleinclination

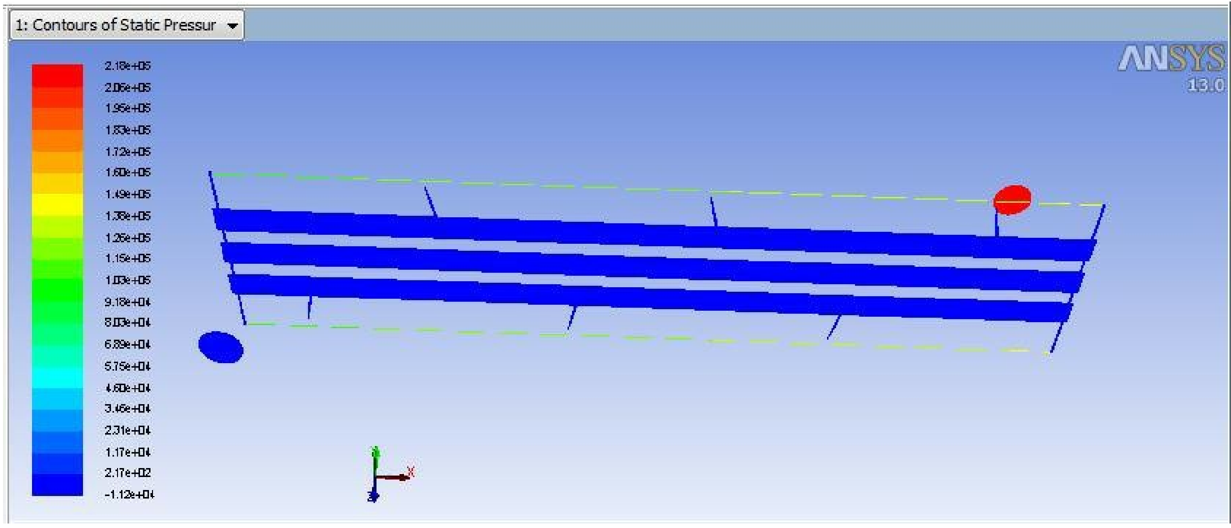

Figure4.43PressureDistributionacrosstheshellat20^{o}baffleinclination.

Table4.1fortheOutletTemperatureoftheShellsideAndTubeSide

BaffleInclinationAngle (Degree)	OutletTemperatureOf Shellside	OutletTemperatureOfTube side
0	346	317
10	347.5	319
20	349	320

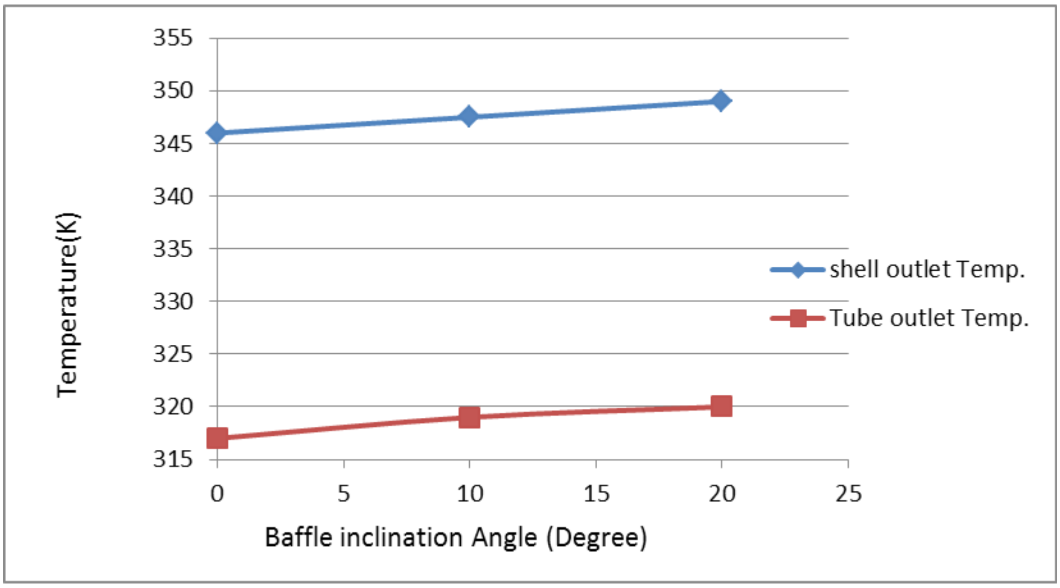

Figure4.44PlotofBaffleinclinationanglevsOutletTemperatureofshellandtubeside

Ithasbeenfoundthatthereismucheffectofoutlettemperatureofshellsidewithincreasingthe baffleinclinationanglefrom0^{0}to20^{0}.

Table4.2forthePressureDropinsideShell

BaffleInclinationAngle(Degree)	PressureDropInsideShell (kPA)
0	230.992
10	229.015
20	228.943

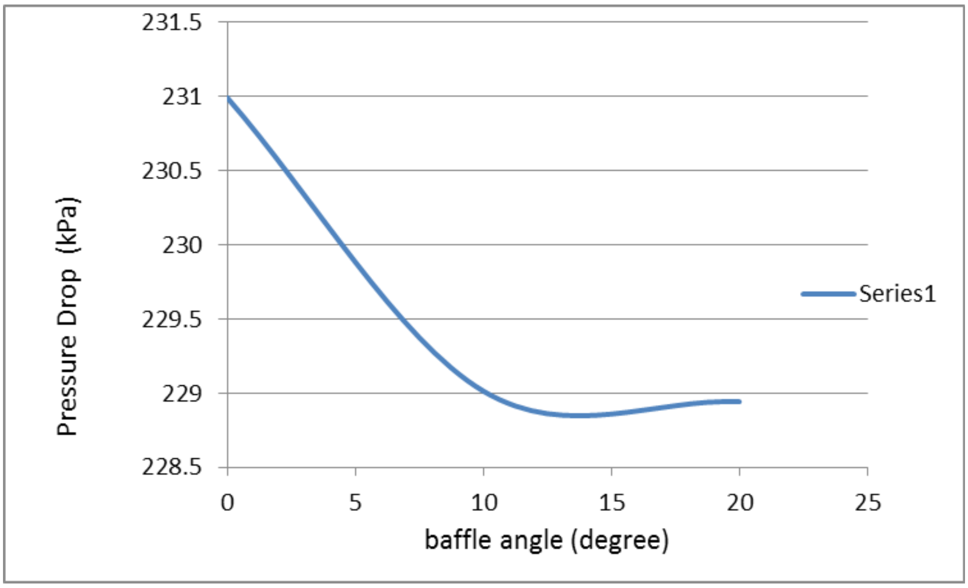

Figure4.45PlotofBaffleanglevsPressureDrop

Theshell-sidepressuredropisdecreasedwithincreaseinbaffleinclinationanglei.e.,asthe inclinationangleisincreasedfrom0°to20°.Thepressuredropisdecreasedby4%,forheat exchangerwith10°baffleinclinationangleandby16%forheatexchangerwith20°baffle inclinationcomparedto0°baffleinclinationheatexchangerasshowninfig.18.Henceitcanbe observedwithincreasingbaffleinclinationpressuredropdecreases,sothatitaffectinheattransfer ratewhichisincreased.

Table4.3forVelocityinsideShell

BaffleInclinationAngle(Degree)	Velocityinsideshell(m/sec)
0	4.2
10	5.8
20	6.2

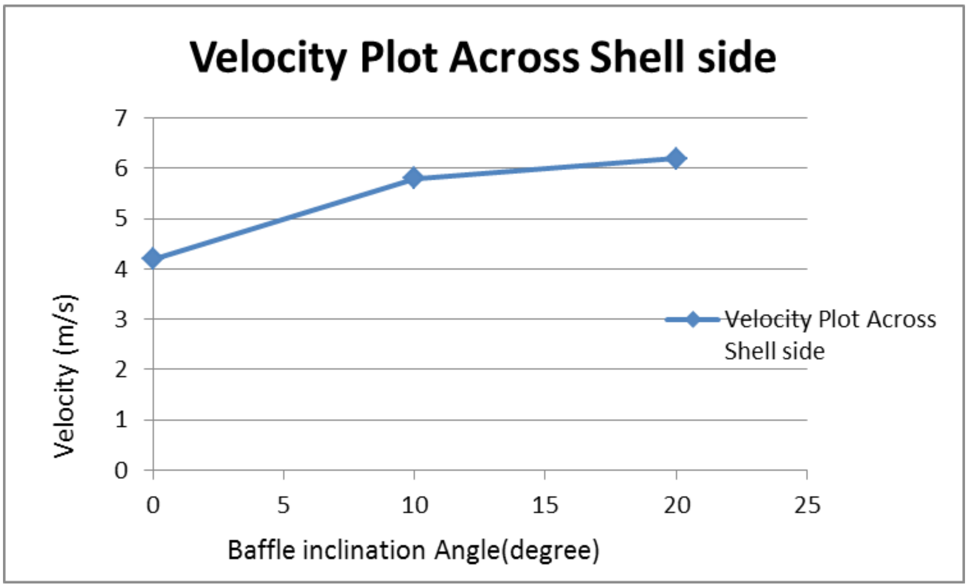

Figure4.46PlotofVelocityprofileinsideshell

Theoutletvelocityisincreasingwithincreaseinbaffleinclination.Sothatmorewillbeheat transferratewithincreasingvelocity.

4.5HeatTransferRate

$$Q=m*C_p*\Delta T$$

m=massflowrate C_p=SpeificHeatofWater

ΔT=TemperatureDifferenceBetweenTubeSide

Table4.4forHeatTransferRateAcrossTubeside

BaffleInclinationAngle (Degree)	HeatTransferRateAcrossTubeside (w/m^2)
0	3557.7
10	3972.9
20	4182

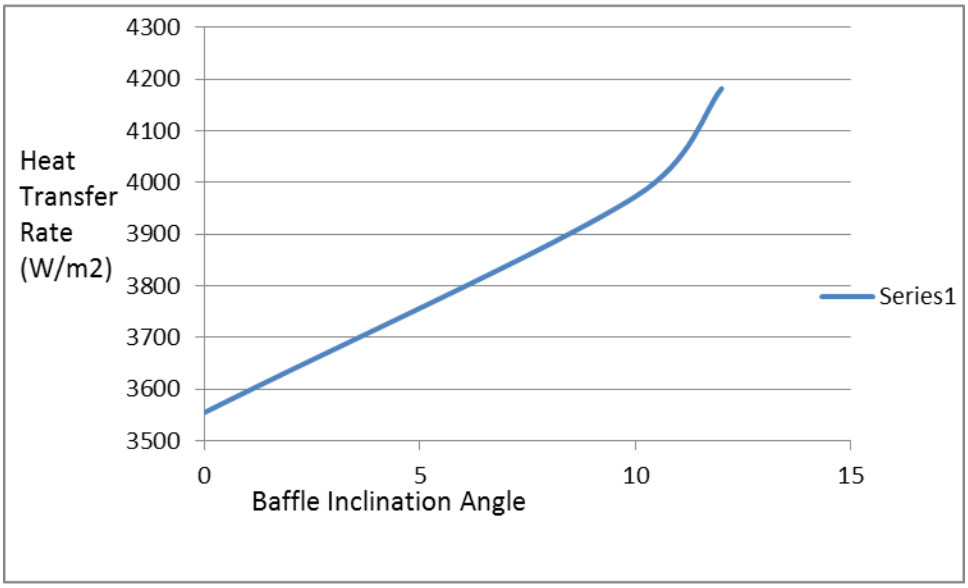

Figure4.47HeatTransferRateAlongTubeside

Theheattransferrateiscalculatedfromaboveformulaefromwhichheattransferrateiscalculated acrossshellside.ThePlotshowingthewithincreasingbaffleinclinationheattransfer rateincrease.Forbetterheattransferratehelicalbaffleisusedandtheresultingisshownin figure20.

Table4.5fortheOverallCalculatedvalueinShellandTubeheatexchangerinthis simulation.

Baffle inclination(in Degree)	Shell Outlet Temperature	Tube Outlet Temperature	Pressure Drop	HeatTransfer Rate(Q) (inW/m^2)	Outlet Velocity(m /s)
0o	346	317	230.992	3554.7	4.2
10^0	347.5	319	229.015	3972.9	5.8
20^0	349	320	228.943	4182	6.2

Theshellsideofasmallshell-and-tubeheatexchangerismodeledwithsufficientdetailto resolvetheflowandtemperaturefields.

Thepressuredropdecreaseswithincreaseinbaffleinclination.

The heat transfer rate is very slow in this model so that it affect the outlet temperature of the shell and tube side.

Chapter 5

Conclusions

5Conclusions

Theheattransferandflowdistributionisdiscussedindetailandproposedmodeliscompared Withincreasingbaffleinclinationangle.Themodelpredictstheheattransferandpressuredrop withanaverageerrorof20%.Thusthemodelcanbeimproved.Theassumptionworkedwellin thisgeometryandmeshingexpecttheoutletandinletregionwhererapidmixingandchangein flowdirectiontakesplace.Thusimprovementisexpectedifthehelicalbaffleusedinthemodel shouldhavecompletecontactwiththesurfaceoftheshell,itwillhelpinmoreturbulenceacross shellsideandtheheattransferratewillincrease.Ifdifferentflowrateistaken,itmightbehelpto getbetterheattransferandtogetbettertemperaturedifferencebetweeninletandoutlet.Moreover themodelhasprovidedthereliableresultsbyconsideringthestandardk-eandstandardwall functionmodel,butthismodeloverpredictstheturbulenceinregionswithlargenormalstrain. ThusthismodelcanalsobeimprovedbyusingNusseltnumberandReynoldsstressmodel,but withhighercomputationaltheory.Furthermoretheenhancewallfunctionarenotuseinthis project,buttheycanbeveryuseful.Theheattransferrateispoorbecausemostofthefluidpasses withouttheinteractionwithbaffles.Thusthedesigncanbemodifiedforbetterheattransferintwo wayseitherthedecreasingtheshelldiameter,sothatitwillbeapropercontactwiththehelical baffleorbyincreasingthebafflesothatbaffleswillbepropercontactwiththeshell.Itisbecause theheattransferareaisnotutilizedefficiently.Thusthedesigncanfurtherbeimprovedby creatingcross-flowregionsinsuchawaythatflowdoesn’tremainparalleltothetubes.Itwill allowtheoutershellfluidtohavecontactwiththeinnershellfluid,thusheattransferratewill increase.

Chapter6

Reference

6References

1.Emerson,W.H.,“Shell-sidepressuredropandheattransferwithturbulentflowin segmentallybaffledshell-tubeheatexchangers”,Int.J.HeatMassTransfer6(1963),pp. 649–66.

2.Haseler,L.E.,Wadeker,V.V.,Clarke,R.H.,(1992),"FlowDistributionEffectinaPlate andFrameHeatExchanger",IChemESymposiumSeries,No.129,pp.361-367.

3.Diaper,A.D.andHesler,L.E.,(1990),"CrossflowPressureDropandFlowDistributions withinaTubeBundleUsingComputationalFluidDynamic",Proc.9thProc.9thHeat TransferConf.,Israel,pp.235-240.

4.Jian-FeiZhang,Ya-LingHe,Wen-QuanTao,“3dnumericalsimulationofshellandtube heatexchangerwithmiddle-overlappedhelicalbaffle”,ajournal,Schoolofenergyand powerengineering,china.

5.Li,H.,Kottke,“Effectofbafflespacingonpressuredropandlocalheattransferinshell andtubeheatexchangersforstaggeredtubearrangement”,sourcebookonInt.J.Heat MassTransfer41(1998),10,pp.1303–1311.

6.Thirumarimurugan,M.,Kannadasan,T.,Ramasamy,E.,PerformanceAnalysisofShell andTubeHeatExchangerUsingMiscibleSystem,AmericanJournalofAppliedSciences 5(2008),pp.548-552.

7.UsmanUrEhman,G¨oteborg,Sweden2011,Master’sThesis2011:09on“HeatTransfer OptimizationofShell-and-Tube&HeatExchangerthroughCFD”.

8.ProfessorSunilkumarShinde,MustansirHatimPancha/InternationalJournalof EngineeringResearchandApplications(IJERA),”ComparativeThermalperformanceof shellandtubeheatExchangerwithcontinuoushelicalbaffleusing“,Vol.2,Issue4,JulyAugust2012.

9.KHAIRUNHASMADIOTHMAN,"CFDsimulationofheattransferinshellandtubeheat exchnager",AthesissubmittedinfulfillmentfortheawardoftheDegreeofBachelorin chemicalEngineering(GasTechnology),April2009.