

Java Development Program on Parallel and Counter Flow Heat Exchanger

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Abstract — The concept of heat exchangers plays a major role in the refrigeration and air conditioning system. This project discusses about the parallel flow and counter flow heat exchanger using LMTD and NTU effectiveness method. The main objective of this project is to calculate theoretical parameters of heat exchanger like Effectiveness, Area, Inlet and outlet temperatures, Log mean temperature difference (LMTD), Number of Transfer units (NTU), by using concepts of OOPs & java. To calculate this all parameters java program is done on the parallel and counter flow heat exchanger.

Keywords— LMTD, NTU, Java, Parallel flow heat exchanger, Counter flow heat exchanger.

I. INTRODUCTION

A 'heat exchanger' may be defined as an equipment which transfer the energy from a hot fluid to cold fluid, with maximum rate and minimum investment and running cost. In heat exchanger the temperature of each fluid changes as it passes through the exchangers, and hence the temperature of the dividing wall between the fluids also changes along the length of exchanger. In heat exchangers the temperature of each fluid changes as it passes through the exchangers, and hence the temperature of the dividing wall between the fluids also changes along the length of the heat exchanger.

A. Classification of Heat Exchanger

In order to meet the widely varying applications, several types of heat exchanger have been developed which are classified on the basis of nature of heat exchange process, relative direction of fluid motion, design and constructional features, and physical state of fluid. Following two types of heat exchanger which are classified on the basis of relative direction of fluid motion are the area of interest of this Article.

1. Parallel flow heat exchanger

In parallel flow heat exchanger, as the name suggest, the two fluid streams (hot and cold) travel in the same direction. The two streams enter at one end and leave at bother end. It is evident from fig.2 that the temperature difference between the hot and cold fluids goes on decreasing from inlet to outlet. Since this type of heat exchanger needs a large area of heat transfer, therefore, it is rarely used in practice. As the two fluids are separated by a wall, this type of heat exchanger may be called parallel flow recuperator or surface heat exchanger.

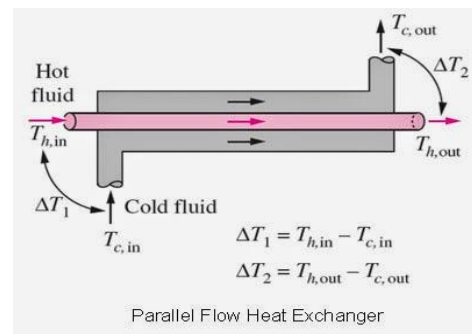


Fig.1 Representation of Parallel Heat Exchanger

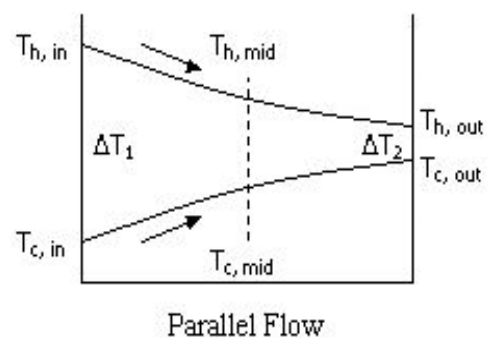


Fig.2 Temperature Distribution of Parallel Flow Heat Exchanger

2. Counter flow heat exchanger

In a counter flow heat exchanger, the two fluids flow in opposite directions. The efficiency of counter flow heat exchanger is higher than parallel flow heat exchanger. Temperatures within the two streams tend to approach one another in a nearly linearly fashion resulting in a much more uniform heating pattern. The maximum temperature difference across the exchanger wall thickness (between the wall surfaces exposed on the hot and cold fluid sides) either at the hot- or cold-fluid end is the lowest, and produce minimum thermal stresses in the wall for an equivalent performance compared to any other flow arrangements.

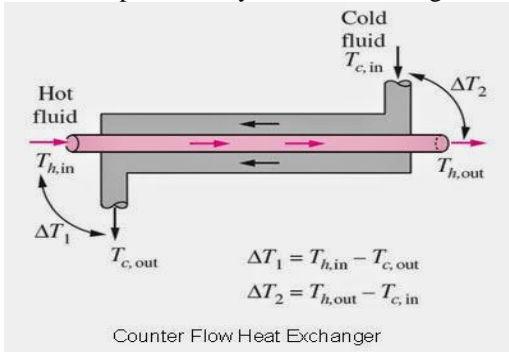


Fig.3 Representation of Counter Flow Heat Exchanger

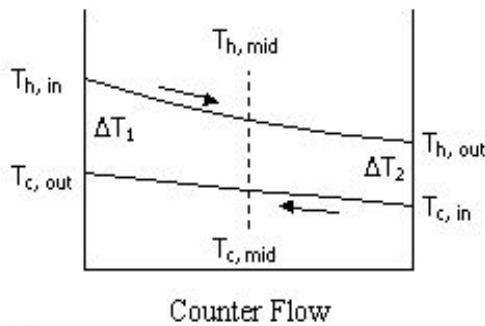


Fig.4 Temperature Distribution of counter Flow Heat Exchanger

3. LMTD & NTU Method

To determine the temperature driving Force for heat transfer in flow system of heat exchanger “Logarithmic mean temperature difference” is used. The LMTD is a logarithmic average of the temperature difference between the hot and cold feeds at each end of the double pipe exchanger. The larger the LMTD, the more heat is transferred. The use of the LMTD arises straightforwardly from the analysis of a heat exchanger with constant flow rate and fluid thermal properties.

The Number of Transfer Units (NTU) Method is used to calculate the rate of heat transfer in heat exchangers (especially counter current exchangers) when there is insufficient information to calculate the Log-Mean Temperature Difference (LMTD). In heat exchanger analysis, if the fluid inlet and outlet temperatures are specified or can be determined by simple energy balance, the LMTD method can be used; but when these temperatures are not available The NTU or The Effectiveness method is used. It is a dimensionless parameter.

II. LITERATURE SURVEY

Prabhat [1] studied on a performance evaluation of counter flow heat exchanger considering for low temp application. He found those Counter flow heat exchangers are commonly used in cryogenic systems because of their high effectiveness. They observed that losses such longitudinal conduction through wall, heat in leak from surrounding, flow mal distribution etc. They extended their study to understand quantitative effect of heat in leak and axial conduction parameters on degradation of heat exchanger performance for 300-80k and 80-20k temperature range.

Christian [2] has discussed about experimental Investigation on the Effect of Fluid Flow Rate on the Performance of a Parallel Flow Heat Exchanger. Physical characteristics and thermal performance of a real heat exchanger were studied in this work. Also the convective heat transfer coefficient increases with both Reynolds and Nusselt numbers, which increases the overall heat transfer coefficient.

Akshay Kumar Magadum [3] has discussed about Review of Experimental analysis of parallel and counter flow heat exchanger. In this paper, we have discussed about various literature review of various paper and we are now going to calculate LMTD by varying flow rate and temperature of hot water and cold fluid.

III. JAVA PROGRAM ON PARALLEL FLOW AND COUNTER FLOW HEAT EXCHANGER

```
package heatexchanger;
import java.util.*;
```

```
class Lmtd1
{
    public double
    qh,qc,t1,t2,l,b,c,A,cph,cpc,mh,mc,thi,tho,tci,tco,u;
    Lmtd1()
    {
        Scanner input =new Scanner (System.in);
        int pc = 0,ans=3;
        System.out.println (" cp of hot fluid (J/kgk) =");
        cph= input.nextDouble();
        System.out.println(" cp of cold fluid(J/Kgk) =");
        cpc= input.nextDouble();
        System.out.println(" overall heat transfer
        coefficient(W/m^2°k)=");
        u= input.nextDouble();
        System.out.println(" mass of hot fluid in kg/sec=");
        mh= input.nextDouble();
        System.out.println(" mass of cold fluid in kg/sec=");
        mc= input.nextDouble();
        System.out.println(" Temperature of hot fluid at inlet Thi in
        °c=");
        thi= input.nextDouble();
        System.out.println(" Temperature of hot fluid at outlet Tho
        in °c=");
        tho= input.nextDouble();
        System.out.println(" Temperature of cold fluid at inlet Tci in
        °c=");
        tci= input.nextDouble();
        System.out.println(" Temperature of cold fluid at outlet Tco
        in °c=");
```

```
tco= input.nextDouble();

qh=mh*cph*(thi-tho);
System.out.println(" heat generated (qh=qc=q) in WATT ="
+qh);
    while(ans==3)
    {
System.out.println(" calculation of change in temperature at
inlet & outlet as follows");
System.out.println(" 1: for parallel flow press 1,2: for
counter flow press 2");
        pc=input.nextInt();
        switch(pc)
        {
            case 1:
                t1=thi-tci;
System.out.println(" change in inlet temperature t1 in °C =
"+t1);
                t2=tho-tco;
System.out.println(" change in outlet temperature t2 in °C=
"+t2);
                l=(t2-t1);
                b=Math.log(t2/t1);
                c=(1/b);
System.out.println(" log mean temperature difference is in
°C="+c);
                A=qh/(u*c);
System.out.println(" area of heat exchanger is in m^2 =
"+A);
                break;
            case 2:
                t1=thi-tco;
System.out.println(" change in inlet temperature t1 in °C=
"+t1);
                t2=tho-tci;
System.out.println(" change in outlet temperature t2 in °C=
"+t2);
                l=(t2-t1);
                b=Math.log(t2/t1);
                c=(1/b);
System.out.println(" log mean temperature difference is in
°C="+c);
                A=qh/(u*c);
System.out.println(" area of heat exchanger is in m^2 =
"+A);
                break;
        }
System.out.println(" if you want to calculate for another
type press 3,otherwise press any key ");
        ans=input.nextInt();
        if(ans!=3)
        {
            break;
        }
    }
}
}
}
public class Ntu
{
    public static void main(String args[])
    {
```

```
        double
ch,cc,cmin,n,c,cmax,e,d,f,g,h,tho,tco,i;
        Scanner output =new Scanner
(System.in);
        int nc = 0; int ans=3;
        Lmtd1 l=new Lmtd1();
System.out.println("cp of hot fluid (J/kgk) =");
System.out.println(l.cph);
System.out.println(" cp of cold fluid(J/Kgk) =");
System.out.println(l.cpc);
System.out.println(" mass of hot fluid in kg/sec=");
System.out.println(l.mh);
System.out.println(" mass of cold fluid in kg/sec=");
System.out.println(l.mc);
System.out.println(" Temperature of hot fluid at inlet Thi in
°C=");
System.out.println(l.thi);
System.out.println(" Temperature of cold fluid at inlet Tci in
°C=");
System.out.println(l.tci);
System.out.println(" Area of heat exchanger in m^2=");
System.out.println(l.A);
        ch=l.mh*l.cph;
System.out.println("capacity of hot fluid in W/°C"+ch);
        cc=l.mc*l.cpc;
System.out.println("capacity of cold fluid in W/°C"+cc);
        if(ch>cc)
        {
            cmin=cc;
            cmax=ch;
System.out.println(" c min="+cmin);
        }
        else
        {
            cmin=ch;
            cmax=cc;
System.out.println("c min="+cmin);
        }
        c=cmin/cmax;
System.out.println("Overall Capacity Ratio is "+c);
        n=(l.u*l.A)/cmin;
System.out.println("Number Of Transfer Unit (NTU)="+n);
        while(ans==3)
        {
System.out.println(" 1: for parallel flow press 1,2: for
counter flow press 2");
            nc=output.nextInt();
            switch(nc)
            {
                case 1:
                    d=(-n*(1+c));
                    g=Math.pow(2.17,d);
                    f=(1+c);
                    h=(1-g);
                    e=(h/f);
System.out.println("effectiveness of parallel flow heat
exchanger"+e);
                    tho=l.thi-e*cmin*(l.thi-l.tci)/ch;
System.out.println("the outlet temperature of hot fluid in
°C= "+tho);
```

```
tco=l.tci+e*cmin*(l.thi-l.tci)/cc;  
System.out.println("the outlet temperature of cold fluid in  
°C= "+tco);  
break;  
case 2:  
d=(-n*(1-c));  
g=Math.pow(2.17,d);  
h=(1-g);  
i=(c*g);  
f=(1-i);  
e=(h/f);  
System.out.println("effectiveness of counter flow heat  
exchanger"+e);  
tho=l.thi-e*cmin*(l.thi-l.tci)/ch;  
System.out.println("the outlet temperature of hot fluid in  
°C= "+tho);  
tco=l.tci+e*cmin*(l.thi-l.tci)/cc;  
System.out.println("the outlet temperature of cold fluid in  
°C= "+tco);  
break;  
}  
System.out.println(" if you want to calculate for  
another type press 3,otherwise press any key ");  
ans=output.nextInt();  
if(ans!=3)  
{  
break;}}}}
```

IV. RESULTS

```
WALCHAND INSTITUTE OF TECHNOLOGY SOLAPUR  
JAVA PROGRAM ON HEAT EXCHANGER  
TANMAY SAHUJI  
PRASAD SURYAWANSHI  
GUIDED BY: P.G CHITTE  
cp of hot fluid (J/kgk) =  
3.76E3  
cp of cold fluid(J/Kgk) =  
4.18E3  
overall heat transfer coefficient(W/m^2°k)=  
580  
mass of hot fluid in kg/sec=  
15.28  
mass of cold fluid in kg/sec=  
11.11  
Temperature of hot fluid at inlet Thi in °c=  
66  
Temperature of hot fluid at outlet Tho in °c=  
40  
Temperature of cold fluid at inlet Tci in °c=  
5  
Temperature of cold fluid at outlet Tco in °c=  
37.16  
heat generated (qh=qc=q) in WATT = 1493772.7999999998  
1: for parallel flow press 1,2: for counter flow press 2  
1  
change in inlet temperature t1 in °c = 61.0  
change in outlet temperature t2 in °c= 2.8400000000000034  
log mean temperature difference is in °C= 18.962724543290015  
area of heat exchanger is in m^2 = 135.8175265873869
```

```

1: for parallel flow press 1,2: for counter flow press 2

1
effectiveness of parallel flow heat exchanger= 0.4188168773096978
the outlet temperature of hot fluid in °C= 45.34937734710752
the outlet temperature of cold fluid in °C= 30.547829515891568

if you want to calculate for another type press 3,otherwise press any key

3

1: for parallel flow press 1,2: for counter flow press 2

2
effectiveness of counter flow heat exchanger= 0.4579841531809454
the outlet temperature of hot fluid in °C= 43.418154709771485
the outlet temperature of cold fluid in °C= 32.93703334403767

if you want to calculate for another type press 3,otherwise press any key
    
```

```

3

1: for parallel flow press 1,2: for counter flow press 2

2
change in inlet temperature t1 in °c= 28.840000000000003
change in outlet temperature t2 in °c= 35.0
log mean temperature difference is in °C = 31.820688507273566
area of heat exchanger is in m^2 = 80.93697734537973

if you want to calculate for another type press 3,otherwise press any key

6
NTU METHOD STARTS
cp of hot fluid (J/kgk)=
3760.0
cp of cold fluid(J/Kgk)=
4180.0
mass of hot fluid in kg/sec=
15.28
mass of cold fluid in kg/sec=
11.11
Temperature of hot fluid at inlet Thi in °C=
66.0
Temperature of cold fluid at inlet Tci in °C=
5.0
Area of heat exchanger in m^2=
80.93697734537973
capacity of hot fluid in W/°C = 57452.799999999996
capacity of cold fluid in W/°C= 46439.799999999996
cmin= 46439.799999999996
Overall Capacity Ratio is= 0.80831221454829
Number Of Transfer Unit (NTU)= 1.0108451556707876
    
```

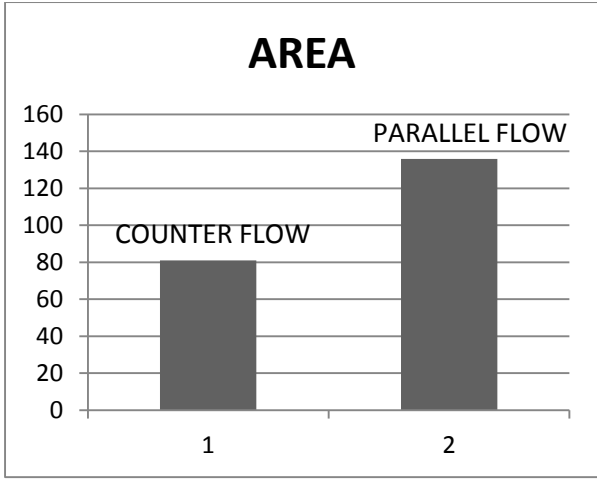


Fig.5 Area Required for Counter flow and Parallel Flow Heat Exchanger.

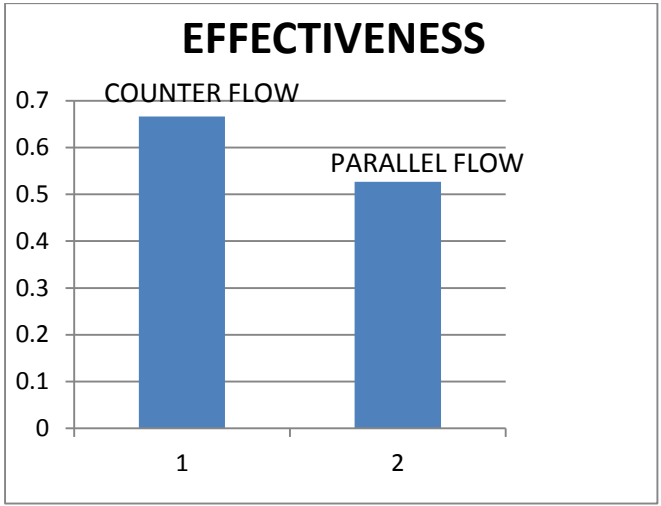


Fig.6 Effectiveness of Parallel and Counter Flow Heat Exchanger

In results all input values are given by user so any type of problems can be solved. From graph 5 and 6 it is observed that the area required for counter flow heat exchanger is less as compared to parallel flow heat exchanger. it also observed that the effectiveness of counter flow heat exchanger is greater than parallel flow heat exchanger.

V. CONCLUSION

At the end of this project we came to conclusion that:

1. The area required for counter flow heat exchanger is less than parallel flow heat exchanger.
2. Because of the counter flow the effectiveness of counter flow heat exchanger is greater than parallel flow heat exchanger inspite of counter flow heat exchanger having less area compared to parallel flow. Because of grater effectiveness of counter flow the efficiency is also greater than parallel flow heat exchanger.
3. Concepts of OOP's helps us to calculate variety of problems of mechanical components like calculation of problems of heat exchanger, design calculation of Pressure vessel, gear etc.

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