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REALTIME DOUBLE PIPE HEAT EXCHANGER LAB EXPERIMENT SIMULATOR

CL398, GENERAL LEARNING OF CHEMICAL ENGINEERING RESEARCH PROJECT - I

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ABSTRACT

In scientific and engineering disciplines, researchers and engineers are most likely to discover solutions to diverse mathematical expressions, in order to solve many real life problems. Heat Exchanger is a device used intensively for heat transfer form fluid. Thus all various type of heat exchanger .Our concentration is on double pipe type heat exchanger .We will design the heat exchanger. This research deals with the application of a 2D real-time temperature variance simulation for the double pipe heat exchanger. This helps us to overcome certain questions, such as whether this can be safely achieved with an tough experimental system and heavy-cost equipment. Many universities do not have too much resources for heavy-cost infrastructure and this is a concern for budding students. I will illustrate in this project the solution to one such problem that occurs in today.

KEYWORDS

Optimization, Realtime Simulation, Heat transfer, Double Pipe Heat Exchanger, OLE for Process Control (OPC) server, MATLAB, Dymola Application

1 INTRODUCTION

A heat exchanger is a system used to transfer heat between two or more fluids. Heat exchangers are used in both cooling and heating processes.The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. Double pipe heat exchangers are the simplest exchangers used in industries. On one hand, these heat exchangers are cheap for both design and maintenance, making them a good choice for small industries. On the other hand, their low efficiency coupled with the high space occupied in large scales, has led modern industries to use more efficient heat exchangers like shell and tube or plate. However, since double pipe heat exchangers are simple, they are used to teach heat exchanger design basics to students as the fundamental rules for all heat exchangers are the same.

1. When the other fluid flows into the annular gap between two tubes, one fluid flows through the smaller pipe. The flow may be a current flow or parallel flow in a double pipe heat exchanger.
2. **Parallel flow**, where at the same point, the hot and cold liquids join, flow in the same direction and exit at the same end.
3. **Counter flow**, where at opposite ends, hot and cold fluids join, flow in the opposite direction and exit at opposite ends.

Applications used to build this project include:

1. **Dymola - Dassault Systèmeső**: Dymola is a commercial modeling and simulation environment based on the open Modelica modeling language. Large and complex systems are composed of component models; mathematical equations describe the dynamic behavior of the system.
2. **MATLAB - MathWorks**: MATLABő combines a desktop environment tuned for iterative analysis and design processes with a programming language that expresses matrix and array mathematics directly.

On the DYMOLA programme, a model was written and the MATLAB Interface was developed to plot the realtime simulation of that file.

2 IMPLEMENTED ATTRIBUTES

I have implemented the objectives that were given. They are listed as below:

- Write a Double Pipe Heat Exchanger Model in Dymola.
- Create a Realtime Simulation Model File using OPC Server.
- Connection between the OPC Server and the MATLAB GUI Application.
- Take varying inputs from the user using MATLAB GUI Application.
- Analyse, Plot and simulate the model using MATLAB GUI Application.
- Let user do realtime changes to the experimental setup

THEORY

2.1 DETERMINE HEAT LOAD

Obtain flowrate (W), inlet, outlet temperatures and fouling factor for both hot and cold stream. Calculate physical properties like density (), viscosity (), specific heat (Cp) and thermal conductivity (k) at mean temperature. Determine heat load by energy balances on two streams.

$$Q = m_H.Cp_H(T_HotIn - T_HotOut)$$

$$Q = m_C.CpC(t_ColdOut - t_ColdIn)$$

$$where,$$

m_H , m_C: Mass flow rate of Hot and Cold Stream

Cp_H , Cp_C: Specific Heat of Hot and Cold Stream

$T_{\text{Hot in}}$, $T_{\text{Hout out}}$: Inlet and outlet temperature of Hot Stream

$t_{\text{Cold in}}$, $t_{\text{Cold out}}$: Inlet and outlet temperature of Cold Stream

2.2 CALCULATE LOGARITHMIC MEAN TEMPERATURE DIFFERENCE (LMTD)

$$LMTD = \frac{(\delta T_1 - \delta T_2)}{ln(\delta T_1/\delta T_2)}$$

2.3 FOR COUNTER-CURRENT FLOW

$$\delta T_1 = T_{\text{Hot In}} - t_{\text{Cold out}}$$

$$\delta T_2 = T_{\text{Hot Out}} - t_{\text{Cold In}}$$

2.4 FOR CO-CURRENT FLOW

$$\delta T_1 = T_Hot_In - t_Cold_In$$

$$\delta T_2 = T_Hot_Out - t_Cold_Out$$

2.5 Formulation

$$F_{\text{Cold In}} = F_{\text{Cold}_{Out}}$$

$$F_{\text{Hot}_{In = F_{Hot_{Out}}}}$$

$$Unsteady/SteadyStateTempProfile$$

$$V_C Cp \frac{dT_{Co}}{dt} = F_{C,i} Cp(T_{C,i} - T_{C,o}) - UA(_i -_o ln(\frac{i}{\delta T_o}))$$

$$V_h Cp \frac{dT_{ho}}{dt} = F_{h,i} Cp(T_{h,i} - T_{h,o}) - UA(_i -_o ln(\frac{\delta T_i}{o}))$$

3 PROGRAMMING

Below is our model file for realtime simulation for Dymola.

DOUBLEPIPE.mo

```
model DOUBLEPIPE
  parameter Real Fci(unit = "kg/h")=250 "Feed cold in/out";
  parameter Real Fhi(unit = "kg/h")=70 "Feed hot in/out";
  parameter Real Tci(unit = "K")=80 "Temp cold in";
  parameter Real Thi(unit = "K")=215 "Temp hot in";
  parameter Real U(unit = "kg/Km^2s^2")=2000 "Heat transfer
    coefficient";
  parameter Real Area(unit = "m^2")=200 "Area";
  parameter Real Volume(unit = "m^3")=5 "Volume";
  parameter Real Density(unit = "kg/m^3")=10 "Density";
  parameter Real Cp(unit = "Jkg^-1K-1")=150 "Specific Heat";

  Real Tco,Tho;
initial equation
    Tco = Tci+1;
    Tho = Thi-1;
equation
  der(Tco)=if Tho-Tco <= 0 then 0 else (Fci*Cp*Density*(Tci-Tco)+U*
    Area*((Thi-Tco)-(Tho-Tci))/log((Thi-Tci)/(Tho-Tco)))/(Volume*Cp*
    Density);
  der(Tho)=if Tho-Tco <= 0 then 0 else (Fhi*Cp*Density*(Thi-Tho)-U*
    Area*((Thi-Tco)-(Tho-Tci))/log((Thi-Tci)/(Tho-Tco)))/(Volume*Cp*
    Density);

end DOUBLEPIPE;
```

Listing 1: DYMOLA MODEL FILE

Script.m

```
hostInfo = opcserverinfo('localhost');
da = opcda('localhost','Dymosim.OPCServer.1');
connect(da);
pause(2);
fprintf("CONNECTED\n");
grp=addgroup(da,'Demo');
grp2=addgroup(da,'Demo2');

Initialize=additem(grp2,{'SimControl.Initialize'});
Run=additem(grp2,{'SimControl.Run'});
Status=additem(grp2,{'SimControl.Status'});
Stop=additem(grp2,{'SimControl.Stop'});
Pause=additem(grp2,{'SimControl.Pause'});

write(Initialize,1);
pause(2);

itmIDs={'ModelVariables.Tco'};
Tco=additem(grp,itmIDs);
area=additem(grp,{'ModelVariables.Area'});
volume=additem(grp,{'ModelVariables.Volume'});
density=additem(grp,{'ModelVariables.Density'});
cp=additem(grp,{'ModelVariables.Cp'});
Fci=additem(grp,{'ModelVariables.Fci'});
Fhi=additem(grp,{'ModelVariables.Fhi'});
Tci=additem(grp,{'ModelVariables.Tci'});
Thi=additem(grp,{'ModelVariables.Thi'});
Tho=additem(grp,{'ModelVariables.Tho'});

write(Run,1);
fprintf("STARTED LOGGING\n");

t=0:0.01:9999;
figure
hold on;
flag=true;
i=0;
t(1)=0;
while(flag)
    i=i+1;
    Tco_val(1,i)=read(Tco,'device').Value;
    Tho_val(1,i)=read(Tho,'device').Value;
    plot(t(1:i),Tco_val(1:i),'b');
    plot(t(1:i),Tho_val(1:i),'r');
    legend('Tco','Tho')
    pause(0.01);
end
```

Listing 2: MATLAB FILE

WORKING

1. After the creation of *Double-Pipe Heat Exchanger* Dymola model file and Matlab GUI application, when we hit *Simulate button* in Dymola, this creates *dymosim.exe* file. Dymola also generates the *dsin.txt* file that contains the initial or default values given to the model.

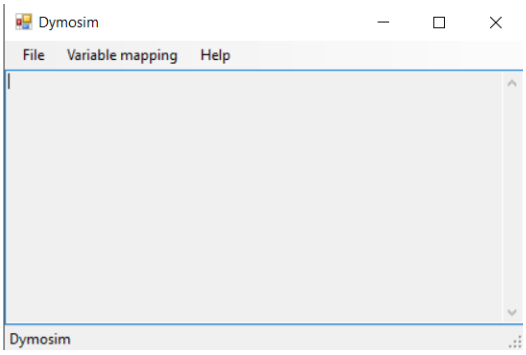


Fig 1: DYMOSIM APPLICATION

2. Now we will open our MATLAB application to perform experiment

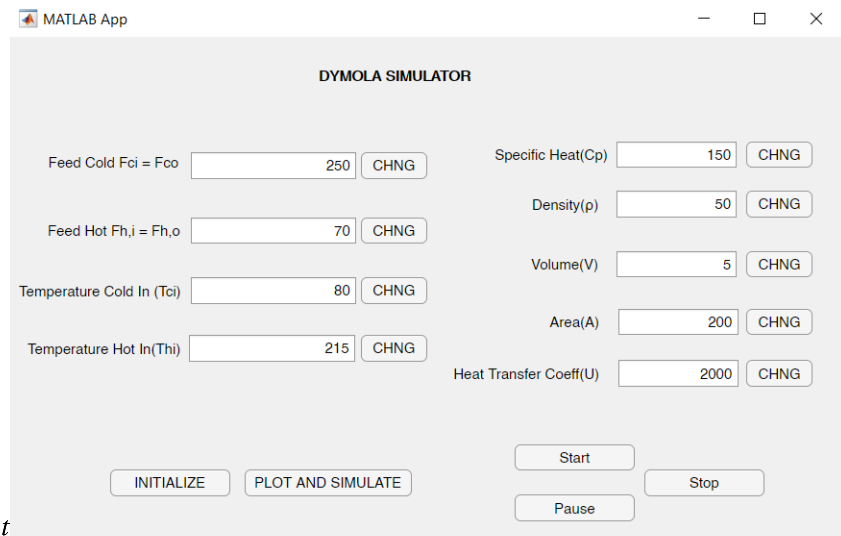


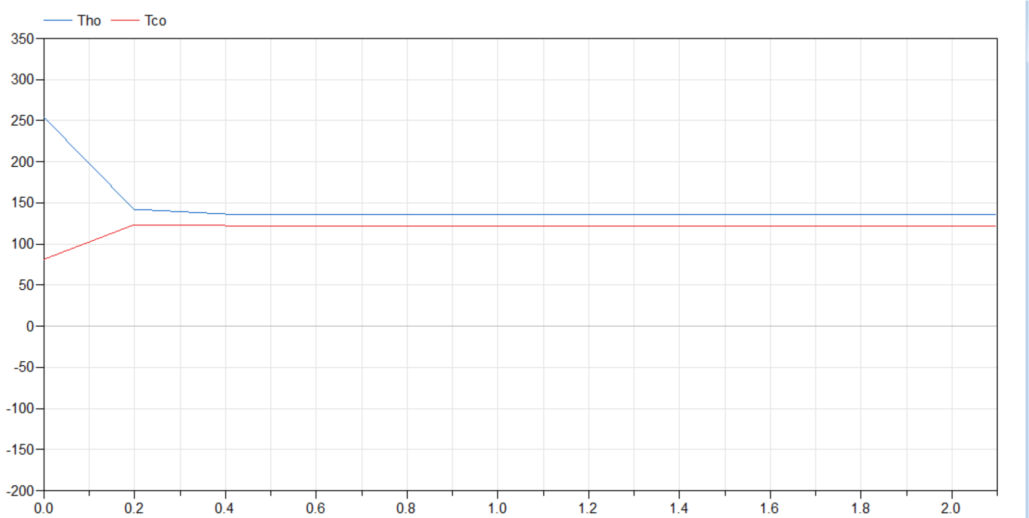
Fig 2: MATLAB GUI APPLICATION

3. *Initialize Button* :in MATLAB GUI searches for a open OPC server and connects to it, after that it writes all the values given to GUI to Dymosim and give command to initialize the dymosim file.

4. On clicking the *Plot and simulate button* it reads live data generated from dymola in background and it generates plot for that in MATLAB.

RESULT

Finally created a simple MATLAB GUI application, using this GUI interface user can easily simulate double pipe heat exchanger model without thinking of complex codes and heavy cost equipments. All this will work at the background, Matlab will send the user's data to OPC server of Dymola and fetch result and finally plot that in Matlab figure in realtime.
This is how the plot looks like when we hit plot and simulate button in MATLAB GUI application run.



We are thinking to file a patent for this. This can help people to easily simulate lab experiments which may cost hefty infrastructure and bills for conducting of a experiment.

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