Three Zone Model – A case Study

Praveen Kumar

ABSTRACT

In this model the heat money dealer is split into 3 zones and the mass and energy balance equation and Peclet’s law are written for every zone. The accuracy of the models was examined on the idea of real data. Peclet’s law is written for the heat exchange.

Keywords: Heat transfer; Feed water heater; Mathematical Model
INTRODUCTION

The feed water heaters will be divided into 3 zones to effectively recover the heat from the superheated steam. Within the initial zone, which is named the desuperheating zone, the superheated steam cools right down to the saturation state. In the second zone, a compression zone, saturated steam condenses, whereas within the third zone, subcooling zone, saturated water is cooled to below saturation temperature.

The mathematical model (three-zone model)

In this model the heat changer was divided into three zones and each zone the mass and energy balance equation and Peclet’s law is written. As with the single-zone model, with two unknown parameters could be determined for three-zone model. It was assumed the searched values area unit the water temperature at the outlet of the heat changer and the mass flow of steam (looking for a different combination of parameters is additionally possible).

Fig: Three Zones Feed Heater
In this model input parameters are: temperature, pressure and mass flow of water at the body of water to the warmth exchanger, pressure and steam temperature, condensate temperature, average heat transfer coefficients for each zone (kI, kII, kIII) and therefore the heat transfer surface (F).

After the division of the feed heater into three zones an energy balance equation and a heat transfer equation are written for every zone. For the primary zone of the feed heater the following relations can be written.

\[ Q_1 = m_{c1}(i_{c1} - i_{c1}) = m_{h1}(i_{h1} - i_{h2}) \]

Enthalpy at the inlet to the first zone is equal to

\[ i_{hl} = i' = f(p_{h1}) \]

The heat flux transferred

\[ Q_1 = k_1 F_1 \Delta T_{ln1} \]

Logarithmic mean temperature difference

\[ \Delta T_{ln1} = \frac{(T_{hl} - T_{cl}) - (T_{h2} - T_{c1})}{ln \left( \frac{T_{hl} - T_{cl}}{T_{h2} - T_{c1}} \right)} \]

Heat transfer surface area in the first zone can be written as

\[ F_1 = \frac{m_{h1}(i_{h1} - i_{h2})}{k_1 \Delta T_{ln1}} \]

Enthalpy of the outlet water from the first zone can be determined as
Outlet water temperature is a function of pressure and enthalpy

\[ T_{cl} = f(p_{c1}, i_{cl}) \]

For the second zone of the feed water heater the following equations can be written

\[ Q_{II} = m_{c1}(i_{cII} - i_{cl}) = m_{h1}(i_{hII} - i_{hl}) \]

Enthalpy at the inlet to the second zone is equal to

\[ i_{hII} = i' = f(ph1) \]

The heat flux transferred

\[ Q_{II} = k_{II} F_{II} \Delta T_{inII} \]

Logarithmic mean temperature difference

\[ \Delta T_{inII} = \frac{(T_{hII} - T_{cII}) - (T_{hl} - T_{cl})}{\ln\left(\frac{T_{hII} - T_{cII}}{T_{hl} - T_{cl}}\right)} \]

Heat transfer surface area in the second zone can be written as

\[ F_{II} = \frac{m_{h1}(i_{hII} - i_{hl})}{k_{II} \Delta T_{inII}} \]

Enthalpy of the outlet water from the second zone can be determined as

\[ i_{cl} = i_{cl} + \frac{m_{h1}(i_{hII} - i_{hl})}{m_{cl}} \]

Outlet water temperature is a function of pressure and enthalpy

\[ T_{cl} = f(p_{c1}, i_{cl}) \]

For the third zone of the feed water heater the following equations can be written

\[ Q_{III} = m_{c1}(i_{cII} - i_{cIII}) = m_{h1}(i_{hl} - i_{hIII}) \]
Enthalpy of steam is equal to

\[ i_{hl} = f(ph1, T_{hl}) \]

The heat flux transferred

\[ Q_{III} = k_{III}F_{III} \Delta T_{III} \]

Logarithmic mean temperature difference

\[ \Delta T_{III} = \frac{(T_{h1} - T_{c2}) - (T_{hl} - T_{cl})}{\ln \left(\frac{T_{h1} - T_{c2}}{T_{hl} - T_{cl}}\right)} \]

Heat transfer surface area in the third zone can be written as

\[ F_{III} = \frac{m_{h1}(i_{hl} - i_{hll})}{k_{III}\Delta T_{III}} \]

Enthalpy of the outlet water from the heat exchanger can be determined as

\[ i_{c2} = i_{cl} + \frac{m_{h1}(i_{hl} - i_{hll})}{m_{cl}} \]

Outlet water temperature is a function of pressure and enthalpy

\[ T_{c2} = f(p_{c1}, i_{c2}) \]

The total heat transfer surface area of the feed water heater is equal
The block algorithm for a three-zone model with an indication of input and output data

\[ F = F_{I} + F_{II} + F_{III} \]

The block algorithm for a three-zone model with an indication of input and output data

Conclusion

Both the models from part 1 and 2 are simple and, importantly, User friendly. Use of the three-zone model is more recommended as it is greater in accuracy.

References


