1 System Diagram

The Process Floe Diagram of the system, with all the relevant inputs, outputs and disturbances are displayed in Figure **??**.

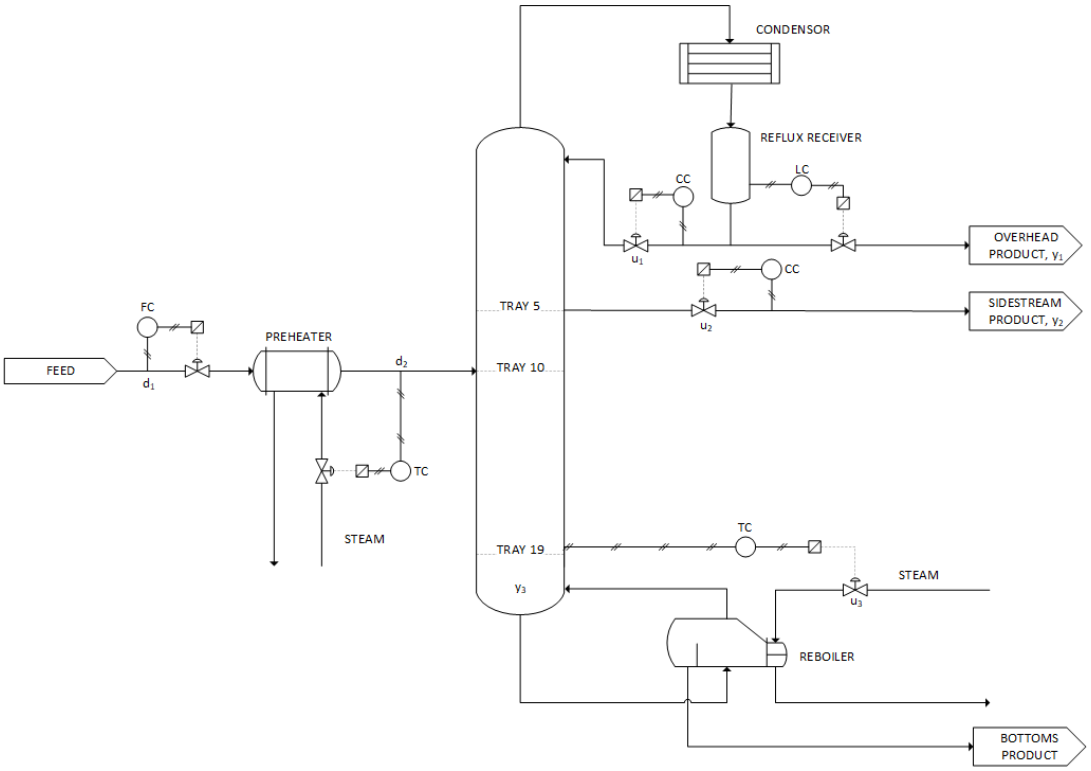

Figure 1: Process flow diagram of the system

2 System Description

3 System Variables

Table 1: Summary of all the model variables.

Input Variables			
Variable	Description	Steady State Value	Units
u_1	Reflux flow rate	0.18	gpm
u_2	Side stream product flow rate	0.046	gpm
u_3	Reboiler steam pressure	20	psi
Output Variables			
Variable	Description	Steady State Value	Units
y_1	Overhead ethanol mole fraction	0.7	-
y_2	Side stream ethanol mole fraction	0.52	-
y_3	Tray #19 temperature	92	°C
Disturbance Variables			
Variable	Description	Steady State Value	Units
d_1	Feed flow rate	0.8	gpm
d_2	Feed temperature	78	°C

4 System Model

The model takes the form of a commonly employed linear model for a MIMO system,

$$\mathbf{y}(s) = \mathbf{G}(s)\mathbf{u}(s) + \mathbf{G}_d(s)\mathbf{d}(s) \tag{1}$$

where

$$\mathbf{G}(s) = \begin{bmatrix} G_{11} & G_{12} & G_{13} \\ G_{21} & G_{22} & G_{23} \\ G_{31} & G_{32} & G_{33} \end{bmatrix} = \begin{bmatrix} \frac{0.66e^{-2.6s}}{6.7s+1} & \frac{-0.61e^{-3.5s}}{8.64s+1} & \frac{-0.0049e^{-s}}{9.06s+1} \\ \frac{1.11e^{-6.5s}}{3.25s+1} & \frac{-2.36e^{-3s}}{5.0s+1} & \frac{-0.012e^{-1.2s}}{7.09s+1} \\ \frac{-34.68e^{-9.2s}}{8.15s+1} & \frac{46.2e^{-9.4s}}{10.9s+1} & \frac{0.87(11.61s+1)e^{-s}}{(3.89s+1)(18.8s+1)} \end{bmatrix} \tag{2}$$

and

$$\mathbf{G}_d(s) = \begin{bmatrix} G_{d11} & G_{d12} \\ G_{d21} & G_{d22} \\ G_{d31} & G_{d32} \end{bmatrix} = \begin{bmatrix} \frac{0.14e^{-12s}}{6.2s+1} & \frac{-0.0011(26.32s+1)e^{-2.66s}}{(7.85s+1)(4.63s+1)} \\ \frac{0.53e^{-10.5s}}{6.9s+1} & \frac{-0.0032(19.62s+1)e^{-3.44s}}{(7.29s+1)(8.94s+1)} \\ \frac{-11.54e^{-0.6s}}{7.01s+1} & \frac{0.32e^{-2.6s}}{7.76s+1} \end{bmatrix} \tag{3}$$