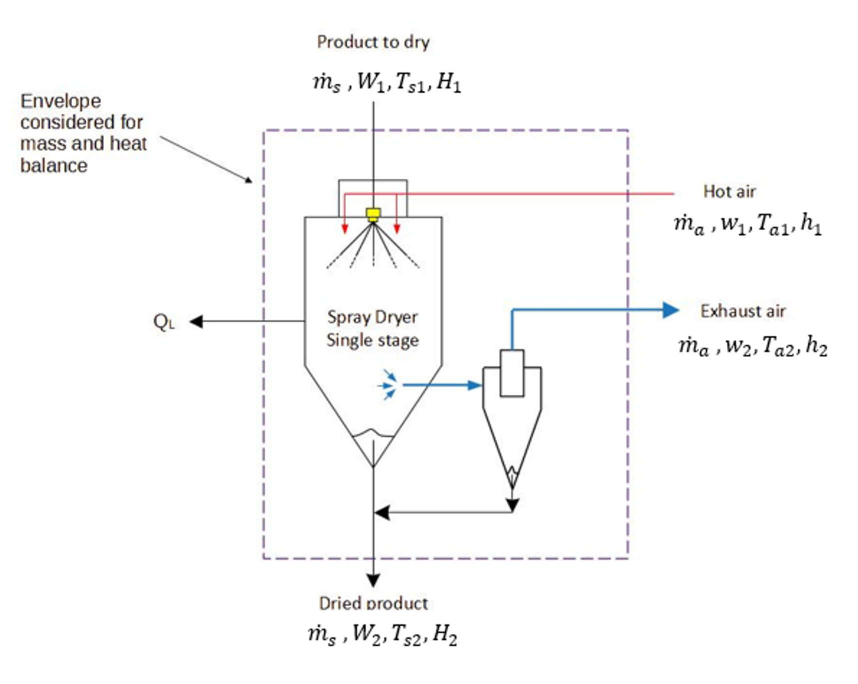
Spray Dryer Input-Output Model



Mass Balance

$$\dot{m}_a\,\omega_1 + \dot{m}_s\,W_1 = \dot{m}_a\,\omega_2 + \dot{m}_s\,W_2$$

$\dot{m}_a$ = mass flow rate of air

$\dot{m}_s$ = mass flow rate of solid at the feed

ω_1 = absolute humidity of air at the inlet

W_1 = feed moisture content at the inlet

ω_2 = absolute humidity of air at the outlet

W_2 = feed moisture content at the outlet

```
In[7]:= Qmilk = 1900 / 3600; (* Mass Flow Rate of Feed Concentrate kg/s*)

In[15]:= Gdry = 20 ; (* Mass flow rate of dry air*)

In[8]:= fat = 4.76 / 100;  (* Fat ratio of milk *)

In[9]:= Qfat = Qmilk * fat (* Mass flow rate of fat*)

Out[9]= 0.0251222

In[10]:= Ql = Qmilk - Qfat  (* Mass flow rate of liquid water *)

Out[10]=
        0.502656
```

In[11]:=
```
Win = Ql / Qfat (*Moisture content at the inlet kg water/kg dry solid*)
```
Out[11]=
```
20.0084
```

In[12]:=
```
Wout = 0.005; (*Moisture content at the outlet kg water/kg dry solid*)
```

In[13]:=
```
w1 = 0; (* Absulete humidity of air at the inlet kg water/kg dry air*)
```

In[16]:=
```
w2 = (Gdry * w1 + Qfat * Win - Qfat * Wout) / Gdry
  (* Calculate outlet absolute humidity kg water/kg dry air*)
```
Out[16]=
```
0.0251265
```

Heat Balance

$$\dot{m}_a h_1 + \dot{m}_s H_1 = \dot{m}_a h_2 + \dot{m}_s H_2 + Q_L$$

$\dot{m}_a$ = mass flow rate of air

$\dot{m}_s$ = mass flow rate of feed

h_1 = specific enthalpy of air at the inlet

H_1 = feed concentrate specific enthalpy at the inlet

h_2 = specific enthalpy of air at the outlet

H_2 = feed concentrate specific enthalpy at the outlet

Q_L = heat losses from chamber

In[17]:=
```
CpG = 1.046;  (* Specific Heat of air kj/kgK*)
CpL = 4.184; (* Specific Heat of water liquid kj/kgK*)
dHev = 2259.360 ; (*Latent heat of vaporization  kj/kg*)
```

In[20]:=
```
QLoss = 0; (*Heat Loss*)
```

In[21]:=
```
Ts1 = 303; (* Temperature of solid at inlet K*)
```

In[22]:=
```
Ts2 = 315;  (* Temperature of solid at outlet K*)
```

In[23]:=
```
Ta1 = 403; (* Temperature of air at outlet K*)
```

In[24]:=
```
h1 = CpG * (Ta1) + dHev * w1 (* Enthalpy of air at inlet kj/kg*)
```
Out[24]=
```
421.538
```

In[25]:=
```
H1 = CpL * (Ts1) (* Enthalpy of liquid water at inlet kj/kg*)
```
Out[25]=
```
1267.75
```

In[26]:=
```
H2 = CpL * (Ts2) (* Enthalpy of liquid water at outlet kj/kg*)
```
Out[26]=
```
1317.96
```

In[27]:=
```
h2 = CpG * (Ta2) + dHev * w2 (* Enthalpy of air at outlet kj/kg*)
```
Out[27]=
```
56.7698 + 1.046 Ta2
```

In[28]:=
```
eqn1 = h2 == (Gdry * h1 + Qfat * H1 - Qfat * H2) / Gdry  (* Heat balance Equaiton*)
```

Out[28]=
```
56.7698 + 1.046 Ta2 == 421.475
```

In[29]:=
```
Solve[eqn1, Ta2] (*Calculate temperature of air at the outlet *)
```

Out[29]=
```
{{Ta2 → 348.666}}
```