Rectangle_Calculations

July 10, 2020

To verify that our calculations were somewhat correct, the HEX was simulated as many rectangular channels running in parallel.

[35]:

```
#!/usr/bin/python3
from math import *
import matplotlib.pyplot as plt
import matplotlib.patches as patches

d2=4.76*0.0254 # (m) inner diameter of the outer tubular housing
d1=4.75*0.0254 # (m) diameter of the inner cold cylinder before
               # cutting any grooves
groove_depth=0.1*0.0254 # m
groove_width=0.06*0.0254 # m
n=ngrooves=124
r=d1/2
w=groove_width
d=groove_depth
mdot=0.004
mu=3.5e-5 # Pa*s
kt=0.104 # W/(m*K)
p_psi=20. # PSI
p=p_psi*6894.76 # Pa
rho=168
Tin=23.4 # (K) inlet temp
Tw=20.7 # (K) temperature of cold wall
Ts=(Tw+Tin)/2 # (K) temperature of film, with which we will exchange heat.
T1=T=Tin
Cp=5841.605609
L=10.*0.0254 # (m) length of tube(s)
```

[37]:

```
Af=w*d # (m^2)
Pf=2*w + 2*d # (m)
Dh=4*Af/Pf # (m)
print('The hydraulic diameter for one rectangular channel is %f m.' %Dh)
#all
Afall=d*(n*w) # (m^2)
#Pfall=2*d + 2*n*w # (m)
Pfall=2*n*d + 2*n*w # (m) # Jeff edited
```

```
Dhall=4*Afall/Pfall # (m)
print('The flow area for all the rectangular channels is %f m^2.' %Afall)
print('The hydraulic diameter for all the rectangular channels is %f m.' %Dhall)
```

```
The hydraulic diameter for one rectangular channel is 0.001905 m.
The flow area for all the rectangular channels is 0.000480 m^2.
The hydraulic diameter for all the rectangular channels is 0.001905 m.
```

The Reynolds Number is found from:

$$Re = \frac{D_h G}{\mu} \tag{1}$$

[38]:
```
#Mass flux
Grect=mdot/Afall
Rerect=Dhall*Grect/mu # should be dimensionless
print('The Reynolds number for the rectangles is %f'%Rerect) #still laminar!
 ↪                                                          #albeit larger
 ↪than                                                         #the cylinder
```

```
The Reynolds number for the rectangles is 453.572336
```

The heat transfer coefficient is found from:

$$hc = \frac{Nu k_t}{D_h} \tag{2}$$

[39]:
```
ba=w/d #dimentionless
print('The b/a is %f.' %ba) # b/c 0.600 I am using C1, C2, from Table 6.2
fRerect=C1=59.94
frect=fRerect/Rerect
print('The friction factor is %f.'%frect)
Nurect=C2=3.205
hcrect=(Nurect*kt)/Dhall # W/(m^2*K)
print('The hc of the rectangles is %f W/(m^2*K)' %hcrect)
```

```
The b/a is 0.600000.
The friction factor is 0.132151.
The hc of the rectangles is 174.971129 W/(m^2*K)
```

The number of transfer units is found from:

$$Ntu = \frac{hcA_w}{\dot{m}C_p} \tag{3}$$

[33]:
```
#Wetted area of duct
#Awrect = 2*(w + d)*L # (m^2)
```

```
Aw_wet=(2*n*w+2*n*d)*L # (m^2) # Jeff edited # entire wetted wall area -- for
 ↪friction losses
Aw_heat=(n*w+2*n*d)*L # (m^2) # Jeff edited # area for heat transfer
print('Wetted area of duct is %f' %Aw_wet)
print('Area for heat transfer is %f' %Aw_heat)
#transfer units
Nturect=(hcrect*Aw_heat)/(mdot*Cp)
print('The transfer units is %f' %Nturect)
```

```
Wetted area of duct is 0.255999
Area for heat transfer is 0.208000
The transfer units is 1.557531
```

The pressure drop is found from:

$$\Delta P = \frac{fLG^2}{2D_h\rho} \tag{4}$$

[40]:
```
#heat transfer
Qrect=mdot*Cp*(T1 - Tw)*(1 - exp(-Nturect)) #W
print('The heat transfer is %f W' %Qrect)
#pressure drop
dprect=(frect*L*Grect**2)/(Dhall*2*rho) #Pa
print('The pressure drop is %f Pa.' %dprect)
```

```
The heat transfer is 49.799219 W
The pressure drop is 3.641740 Pa.
```

[ ]:
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```