d2-hex-calcs

July 10, 2020

UCN LD2 Calculations

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May 19/20

[22]:
```
#!/usr/bin/python3
from math import *
import matplotlib.pyplot as plt
import matplotlib.patches as patches
```

[23]:
```
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

print('d 2 is %f.' %d2)
print(' and d 1 is %f' %d1)

fig,ax=plt.subplots()

ax.set_xlim([-d2/2,d2/2])
ax.set_ylim([-d2/2,d2/2])

# outer housing
circle1=plt.Circle((0,0),d2/2,color='r',fill=False)
ax.add_artist(circle1)

groove_depth=0.1*0.0254 # m
groove_width=0.06*0.0254 # m
n=ngrooves=124

print('goove depth %f' %groove_depth)
print('goove width %f' %groove_width)

# shorter names
r=d1/2
w=groove_width
d=groove_depth
```

```
for groove in range(ngrooves):
    theta=360./ngrooves
    center_angle=groove*theta

    alpha=center_angle*pi/180
    x=r*cos(alpha)
    y=r*sin(alpha)

    dalpha=asin(w/2/r)

    xsl=r*cos(alpha+dalpha)
    ysl=r*sin(alpha+dalpha)
    xel=xsl-d*cos(alpha)
    yel=ysl-d*sin(alpha)

    xsr=r*cos(alpha-dalpha)
    ysr=r*sin(alpha-dalpha)
    xer=xsr-d*cos(alpha)
    yer=ysr-d*sin(alpha)

    # draw line at edge of each groove
    line=plt.plot([xsl,xel],[ysl,yel],color='black')
    line=plt.plot([xsr,xer],[ysr,yer],color='black')
    # and bottom of groove
    line=plt.plot([xel,xer],[yel,yer],color='black')

    alpha_deg=alpha*180/pi
    dalpha_deg=dalpha*180/pi
    arc=patches.
 ↪Arc((0,0),2*r,2*r,0,alpha_deg+dalpha_deg,alpha_deg+theta-dalpha_deg)
    ax.add_patch(arc)

# Calculation of perimeter of all those grooves
pgroove=2*d+w # inner "U" of a groove
parc=(theta-2*dalpha_deg)*pi/180*r # outer arc length between two grooves
perimeter=ngrooves*(pgroove+parc)

print('The length of the inner U of a groove is %f m'%pgroove)
print('The length of an arc between two grooves is %f m'%parc)
print('The length around all those fins and grooves is %f m'%perimeter)

print()

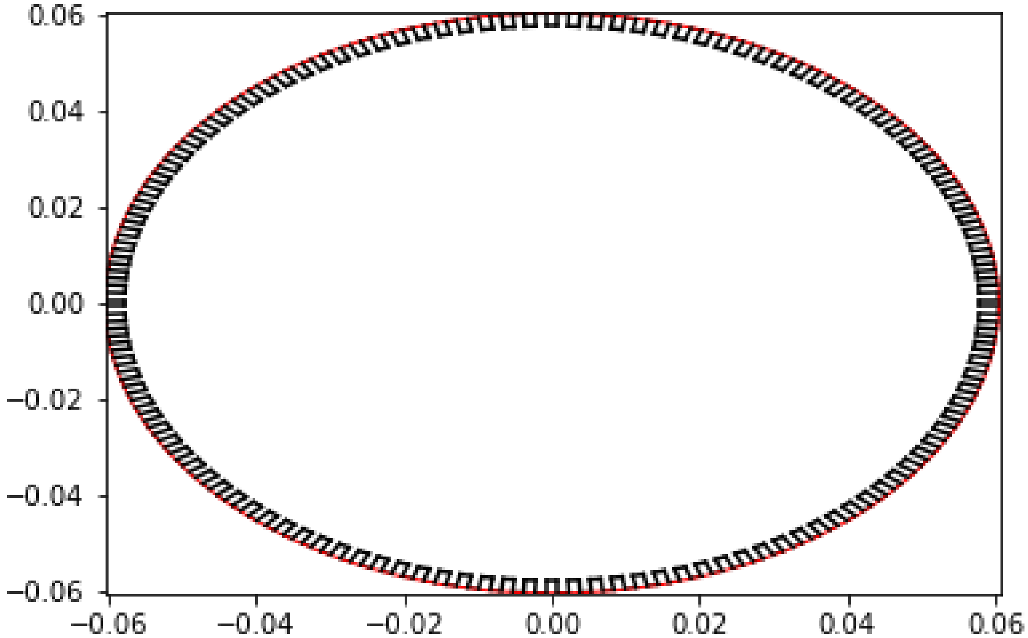
# Calculation of area for flow
annulus=pi*(d2**2-d1**2)/4
agroove=d*w # area of one groove # approximately
aeps=((2*dalpha)/(2*pi))*pi*r**2-2*0.5*(w/2)*(r*cos(dalpha)) # area
```

```
                                                                    # between
                                                                    # the arc
                                                                    # and the
                                                                    # area of
                                                                    # the
                                                                    # groove
                                                                    # on the
                                                                    # previous
                                                                    # line
agroove_total=agroove+aeps
agrooves=agroove_total*ngrooves
area=annulus+agrooves


print('Area of annular region between cylinders %f m^2'%annulus)
print('Additional area cut out by each groove %f m^2'%(agroove+aeps))
print('Area of all the grooves %f m^2'%agrooves)
print('Total flow area %f m^2'%area)
print()
```

```
d 2 is 0.120904.
 and d 1 is 0.120650
goove depth 0.002540
goove width 0.001524
The length of the inner U of a groove is 0.006604 m
The length of an arc between two grooves is 0.001533 m
The length around all those fins and grooves is 1.008948 m

Area of annular region between cylinders 0.000048 m^2
Additional area cut out by each groove 0.000004 m^2
Area of all the grooves 0.000481 m^2
Total flow area 0.000529 m^2
```



They hydraulic diameter was found by:

$$D_h = \frac{4A}{P} \tag{1}$$

[24]:
```
a=area # (m^2) area for fluid flow
p=perimeter+pi*d2 # (m) perimeter of flow region
dh=4*a/p # (m) hydraulic diameter
print('The flow area is %f m^2, A.'%a)
print('The flow perimeter is %f m, P.'%p)
print('The hydraulic diameter %f m, Dh.'%dh)
L=10.*0.0254 # (m) length of tube(s)
Aw=perimeter*L
print('The length of tubes is %f m, L.'%L)
print('The area of cold wall is %f m^2, Aw'%Aw)
```

```
The flow area is 0.000529 m^2, A.
The flow perimeter is 1.388779 m, P.
The hydraulic diameter 0.001523 m, Dh.

The length of tubes is 0.254000 m, L.
The area of cold wall is 0.256273 m^2, Aw
```

G is found from:

$$G = \frac{\dot{m}}{A} \tag{2}$$

[25]:
```
mdot=0.004 # (kg/s) mass flow rate
G=mdot/a # (kg/(m^2*s)) mass flow rate per unit area
print('G is %f kg/(m^2*s)'%G)
```

```
G is 7.564393 kg/(m^2*s)
```

The Reynolds Number is found from:

$$Re = \frac{D_h G}{\mu} \tag{3}$$

[26]:
```
mu=3.5e-5 # Pa*s
Re=dh*G/mu # should be dimensionless
print('The Reynolds number is %f'%Re)
```

```
The Reynolds number is 329.168843
```

The Prandelt Number is found from:

$$Pr = \frac{\mu C_p}{k_t} \tag{4}$$

[27]:
```
# thermal conductivity
kt=0.104 # W/(m*K)
p_psi=20. # PSI
p=p_psi*6894.76 # Pa
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.
T=Tin
Cp=5841.605609
Pr=(mu*Cp)/(kt)
print('The Prandtl Number is %f.'%Pr)
```

```
The Prandtl Number is 1.965925.
```

The Colburn factor is found from:

$$jh = 0.023 Re^{-0.2} B1 \tag{5}$$

[28]:
```
B1=1.174*((3.7e-5)/(3.68e-5))**(0.14) #viscosity taken from cams sheets
print('This is B1 %f.' %B1)
if Re < 3500 :
    print('It is laminar or in between')
```

```
elif Re > 3500 :
    jh=0.023*Re**(-0.2)*B1
    print('The Colburn factor for the turbulent flow is %f.' %jh)
```

```
This is B1 1.174891.
It is laminar or in between
```

The heat transfer coefficient is found from:

$$hc = \frac{Nuk_t}{D_h} \tag{6}$$

[29]:

```
#Determining Nu
#Nu_3_ii=4.8608 # Table 90 of Shah and London
#Nu=3.657 # circular duct Barron Eq. (6.30)
#Nu=7.541 # Table 6.2 Barron -- parallel plate =~ thin annulus?
#NuT=7.541 # Table 86 of Shah and London, thin annulus
#NuT=7.541 # Table 138 of Shah and London, parallel plate
#NuT=4.861 # Table 138 of Shah and London, parallel plate one side insulated
#Nu=4.8608 # Eq. (283) Shah and London, parallel plate one side insulated
#fRe=64.00 # circular duct Barron Eq. (6.27)
#fRe=96.00 # Table 6.2 Barron
#fRe=24.00*4 # Table Table 86 of Shah and London, thin annulus
if Re < 3500 :
    print('Nu=4.8608 because the flow laminar.')
elif Re > 3500 :
    Nuturb=jh*Re*Pr**(1./3.)
    print('This is the turbulent Nusselt Number %f.' %Nuturb)
Nu=4.8608
fRe=96.00
if Re < 3500 :
    hc=Nu*kt/dh # Barron eq'n 6.15
    print('The heat transfer coefficient for laminar flow is %f W/(m^2*K)'%hc)
elif Re > 3500 :
    hc=Nuturb*kt/dh # Barron eq'n 6.17 makes it incredibly tiny compared to␣
 ↪eq'n 6.15 maybe should be using eq'n 6.40 ??
    print('The heat transfer coefficient for turbulent flow is %f W/(m^2*K)'%hc)
print('The heat transfer coefficient is %f W/(m^2*K)'%hc)
```

```
Nu=4.8608 because the flow laminar.
The heat transfer coefficient for laminar flow is 331.916164 W/(m^2*K)
The heat transfer coefficient is 331.916164 W/(m^2*K)
```

The Ntu is found from:

$$Ntu = \frac{hcA_w}{\dot{m}C_p} \tag{7}$$

[30]:

```
Ntu=hc*Aw/(mdot*Cp)
print('The number of transfer units is %f'%Ntu)
```

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The number of transfer units is 3.640313
```

The total heat transfer rate is found from:

$$\dot{Q} = \dot{m} C_p \Delta T \tag{8}$$

[31]:

```
T1=Tin
T2=T1-(T1-Tw)*(1-exp(-Ntu))
Qtotal=mdot*Cp*(T1-T2) # Eq. (6.43) of Barron
print('The inlet temperature is %f K and the wall temperature is %f'%(T1,Tw))
print('The outlet temperature is %f'%T2)
print('The total heat transfer rate is %f'%Qtotal)
```

```
The inlet temperature is 23.400000 K and the wall temperature is 20.700000
The outlet temperature is 20.770859
The total heat transfer rate is 61.433616
```

The laminar friction factor is found from:

$$f = \frac{fRe}{Re} \tag{9}$$

Where fRe is 96

The pressure drop is found from:

$$\Delta P = \frac{fLG^2}{2D_h \rho} \tag{10}$$

[38]:

```
if Re < 2300 :
    f=fRe/Re
    #f=64/Re #assuming cicular tube
    print('The laminar friction factor is %f.' %f)
elif 3500 > Re > 2300 :
    f=1.2036*Re**(-0.416) #from vijayan
    print('The friction factor is in between laminar and turbulent')
elif Re > 3500 :
    f=0.316*Re**(-0.25)
    print('The turbulent friction factor is %f.' %f)
rho=168
print('The density is %f kg/m^3'%rho)
dp=(f*L*G**2)/(dh*2*rho) #(Pa)
print('The pressure drop is %f Pa'%dp)
```

```
The laminar friction factor is 0.291644.
The density is 168.000000 kg/m^3
The pressure drop is 8.282900 Pa
```

[ ]:

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