

# "Proper"-Helix-N=2

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## 1 UCN LD2 Calculations: Helical Groove with 2 Grooves

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[2]: #!/usr/bin/python3.7

from math import *
from mpl_toolkits import mplot3d
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt
import matplotlib.patches as patches
import numpy as np
from numpy import *
```

```
[3]: p_psi=20. # PSI
p=p_psi*6894.76 # Pa
kt=0.104 # W/(m*K) a

T=Tin=23.4 # (K) inlet temp
Tw=20.7 # (K) temperature of cold wall

mdot=0.004 # kg/s
mu=3.5e-5 # Pa*s viscosity

L=10*0.0254 #m length of tube

rho=163.0 # kg/m^3

Cp=6565.4 # J/(kg*K)

Ngrooves=2 # number of grooves

D=4.76*0.0254 # 0.015949 #m diameter of tube, 0.015949 from optimizing dp in ↵
↵backwards-hex-turbulent-tube.py
```

```

R=D/2

wprime= 0.015 #m width of groove

uprime= 0.01 # m width between grooves

depth=0.015 # m depth of groove

sinalpha=(Ngrooves*(wprime + uprime))/(pi*D) #pitch angle

alpha=arcsin(sinalpha)

print('The pitch angle is %f' %sinalpha)

print('Alpha is %f' %alpha)

Lprime=L/sinalpha #m length of wound groove

print('The length of the groove is %f m.' %Lprime)

turns=Lprime/(pi*D)

print('Coiling around a Cu rod of diameter %f m would require %f_
→turns'%(D,turns))

#based off of sketch w/ jeff

w=wprime/sinalpha # m

ahelix=Ngrooves*wprime*depth #Arect+2*Atri ?? m^2 area of one helical groove/
→fin thing

print('The area of the helical fins is %f m^2.'%ahelix)

phelix=Ngrooves*(2*depth+2*wprime) #m

print('The perimeter of the helical grooves is %f m.' %phelix)

Dh=4*ahelix/phelix #m

print('Hydraulic diameter %f m'%Dh)
print()

G=mdot/ahelix # (kg/(m^2*s)) mass flow rate per unit area

print('Mass flux per area(G) is %f kg/(m^2*s)'%G)

```

The pitch angle is 0.131637

Alpha is 0.132021

The length of the groove is 1.929542 m.

Coiling around a Cu rod of diameter 0.120904 m would require 5.080000 turns

The area of the helical fins is 0.000450 m<sup>2</sup>.

The perimeter of the helical grooves is 0.120000 m.

Hydraulic diameter 0.015000 m

Mass flux per area(G) is 8.888889 kg/(m<sup>2</sup>\*s)

The Reynolds Number is found from:

$$Re = \frac{4\dot{m}}{\pi D \mu} \quad (1)$$

```
[4]: Re=Dh*G/mu # should be dimensionless
print('The Reynolds number is %f'%Re)
```

The Reynolds number is 3809.523810

The Deans Number is found from:

$$De = Re \sqrt{\frac{D_h}{D}} \quad (2)$$

```
[5]: De=Re*sqrt(Dh/D)
print('The Deans number is %f.' %De)
```

The Deans number is 1341.825334.

The friction factor is found from:

$$f = 4f_c \left( 0.00725 + 0.076 \left( Re \left( \frac{D}{D_h} \right)^{-2} \right)^{-0.25} \right) \left( \frac{D_h}{D} \right)^{1/2} \quad (3)$$

```
[6]: f = 0.00725 + 0.076*(Re*(D/Dh)**(-2))**(-0.25)
fc = 4*f*(Dh/D)**(1/2)
print('f is %f'%fc)
```

f is 0.048910

The friction factor is also found from:

$$f = 4f_c \left( 0.084 \left( Re \left( \frac{D}{D_h} \right)^{-2} \right)^{-0.2} \right) \left( \frac{D_h}{D} \right)^{1/2} \quad (4)$$

```
[7]: Cpw=5974.156073133989
muw=3.68e-5
Pr=Prw=(muw*Cpw)/(kt)
Prb=(mu*Cp)/kt
f2 = 0.084*(Re*(D/Dh)**(-2))**(-0.2)
fc2 = 4*f2*(Dh/D)**(1/2)
print('f2 is %f'%fc2)
```

f2 is 0.052424

The Nusselt Number is found from:

$$Nu = (4.364) \quad (5)$$

```
[15]: B1=1.174*((3.7e-5)/(3.68e-5))**(0.14)
jh=0.023*Re**(-0.2)*B1
Pr=(mu*Cp)/(kt)
Nu = ((4.364 + (4.636/(1+1342/Pr*De**2)**2))**(3) + (1.816*(De/(1+1.15/Pr))**(3/
↪2)))*(1/3)
print('This is Nuc/Nus %f' %Nu)
Nus = jh*Re*Pr**(1./3.)
print('Nuc is %f' %(Nu*Nus))
```

This is Nuc/Nus 36.264562

Nuc is 934.694678

```
[16]: u=G/rho #m/s
print(u)
```

0.054533060668029994

```
[17]: dp = (fc*Lprime*rho*u**2)/(2*Dh)
print('the pressure drop is %f Pa from f' %dp)
```

the pressure drop is 1.524880 Pa from f

```
[18]: dp2 = (fc2*Lprime*rho*u**2)/(2*Dh)
print('the pressure drop is %f Pa from f2' %dp2)
```

the pressure drop is 1.634446 Pa from f2

The heat transfer coefficient is found by:

$$h_c = \frac{Nu k_t}{D_h} \quad (6)$$

```
[19]: h = Nus*Nu*kt/Dh # (mu*Cp*Pr**(-2/3)*Re*0.023*Re**(-0.2))/(Dh)
print('The heat transfer coeff is %f W/m^2K.' %h)
```

The heat transfer coeff is 6480.549770 W/m<sup>2</sup>K.

The number of transfer units is found from:

$$Ntu = \frac{hA_w}{\dot{m}C_p} \quad (7)$$

where

$$A_w = N(w' + 2depth)L' \quad (8)$$

```
[20]: Aw=Ngrooves*(wprime+2*depth)*Lprime
print('Area of cold wall %f m^2'%Aw)
Ntu=h*Aw/(mdot*Cp)
print('The number of transfer units is %f'%Ntu)
print()
```

Area of cold wall 0.173659 m<sup>2</sup>

The number of transfer units is 42.853612

The total heat transfer is found from:

$$Q = \dot{m}C_p(T_1 - T_2) \quad (9)$$

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

For inlet temperature 23.400000 K and wall temperature 20.700000 K

the outlet temperature is 20.700000 K

and the total heat transfer rate is 70.906320 W

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[ ]:
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