~\CSI Code\Pneumatic Valve Simulations\running_friction_calcs.py

```python
import numpy as np
import sys
import json, CoolProp.CoolProp as CP
from CoolProp.CoolProp import PropsSI
import matplotlib.pyplot as plt
import numpy as np
import math
from decimal import Decimal, ROUND_DOWN

sys.setrecursionlimit (1000000)
# All values in units of lbs, lbf, or in

# Surface Area (in^2)
pistonSA = 0.434
chambSA = 0.987

# Pressure Guide (psi)
oxPress = 850

# Carbon Dioxide Properties
CP.set_config_string(CP.ALTERNATIVE_REFPROP_PATH, 'c:\Program Files (x86)\REFPROP')
initTemp = 75 # Degrees Farenheit
initCO2m = 16 # grams
initFillVol = 0.22087 # in^3

def vaporizationH (temp): # Enthalpy of vaporization for nitrous oxide in J/kg
    return PropsSI("H", "T", temp, "Q", 1, "REFPROP::Carbon dioxide") - PropsSI("H", "T", temp, "Q", 0, "REFPROP::Carbon dioxide")

def specificHeat (temp): # Isobaric specific heat capacity of nitrous oxide
    return PropsSI("CVMASS", "T", temp, "Q", 1, "REFPROP::Carbon dioxide")

# O-Ring Friction Variables:

# Hydraulic Friction Method

def get_fh (press):
    return press * 0.0273 + 10.167

# - Upper Rod Seal:
upperRod_dP = oxPress # from initial design
upperRod_fc = 0.65    # lbf/in, from Parker ORD
upperRod_fh = 35      # lbf/in^2
upperRod_Ar = 0.53    # in^2
upperRod_Lr = 3.92    # in

upperRod_F = (upperRod_fc * upperRod_Lr) + (upperRod_Ar * upperRod_fh)

# - Piston Seal:
# Piston dP is defined in the method
piston_fc = 0.85 # lbf/in, from Parker ORD
# Piston fh is defined in the method
piston_Ap = 0.61 # in^2
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piston_Lp = 5.31 # in
piston_M = 0.125 # lbs

def piston_F (curValvePress):
    dP = oxPress - curValvePress
    piston_fh = get_fh (dP)

    return (piston_fc * piston_Lp) + (piston_fh * piston_Ap)

# - Lower Rod Seal
# Lower rod dP is defined
lowerRod_fc = 0.5  # lbf/in, from Parker ORD
# Lower rod fh is defined in the method
lowerRod_Ar = 0.53 # in^2
lowerRod_Lr = 3.92 # in

def lowerRod_F (curValvePress):
    dP = oxPress - curValvePress
    lowerRod_fh = get_fh (dP)

    return (lowerRod_fc * lowerRod_Lr) + (lowerRod_fh * lowerRod_Ar)

# Force Balance

pistonForce = pistonSA * oxPress
xi = 0.27
xf = 0.77
k = 46.66

dt = 0.00001 # time step

def main (x, v, t, valvePress, curTemp, curCO2m):

    force = (valvePress * chambSA) - (oxPress * pistonSA) - piston_F (valvePress) - lowerRod_F (valvePress) - upperRod_F - k * x

    a = force/piston_M
    vn = v + a*dt
    xn = vn*dt + x
    tn = t + dt

    # Additional Volume Calcs
    curTempK = (curTemp - 32) * 5/9 + 273.15
    dV = (xn - x) * chambSA
    dV_metric = dV * 1.63871 * 10**(-5)
    dM = dV_metric * PropsSI ("D", "T", curTempK, "Q", 1, "REFPROP::Carbon dioxide")
    curTempK -= (vaporizationH (curTempK) * (dM * 0.453592)) / (curCO2m * specificHeat (curTempK))
    curCO2m -= dM
    valvePress = 0.000145038 * PropsSI ("P", "T", curTempK, "Q", 1, "REFPROP::Carbon dioxide")
    curTemp = 32 + ((curTempK - 273.15) * 9/5)

    if (xn < xf):
        return main (xn, vn, tn, valvePress, curTemp, curCO2m)
    return xn, tn, vn, valvePress, curTemp, curCO2m

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initTempK = (initTemp - 32) * 5/9 + 273.15
v_metric = initFillVol * 1.63871 * 10**(-5)
mass = v_metric * PropsSI ("D", "T", initTempK, "Q", 1, "REFPROP::Carbon dioxide")
initTempK -= (vaporizationH (initTempK) * (mass * 0.453592)) / (initCO2m * specificHeat (initTempK))
initCO2m -= 1000*mass
initTemp = 32 + ((initTempK - 273.15) * 9/5)
startValvePress = 0.000145038 * PropsSI ("P", "T", initTempK, "Q", 1, "REFPROP::Carbon dioxide")

if (startValvePress * chambSA > (3 * (piston_F (startValvePress) + lowerRod_F (startValvePress) + upperRod_F)) + oxPress * pistonSA + k * xi):
    actuationDistance, actuationTime, finalVelocity, finalValvePress, finalTemp, finalCO2m = main (xi, 0 ,0, startValvePress, initTemp, initCO2m / 1000)

print ("Valve Actuation Distance (in): " + str(actuationDistance))
print ("Valve Actuation Time (ms):     " + str(actuationTime * 1000))
print ("Piston Final Velocity (in/s):  " + str(finalVelocity))
print ("Final Valve Pressure (psi):    " + str(finalValvePress))
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