rTPCflowmeter_v2

June 23, 2020

[17]:
```
import numpy as np
from scipy import interpolate
```

[18]:
```
import matplotlib.pyplot as plt
%matplotlib inline
plt.rcParams["figure.figsize"] = (15,8)
x=np.linspace(5.0,150.0,300)
```

1 Calibration

1.1 Setup for atmosphere Argon and Stainless Steel ball

https://www.mathesongas.com/pdfs/flowchart/602%20(E300)/ARGON%20602(E300)%20SS%200%20PSIG.pdf

$\phi_{\mathrm{Ar}}(z)$

[19]:
```
ro,cal=np.loadtxt('ARGON_602(E300)_SS_0_PSIG.dat',unpack=True) # sccm
arflow=interpolate.interp1d(ro, cal)
```

1.2 Setup for atmosphere Carbon Dioxide and Stainless Steel ball

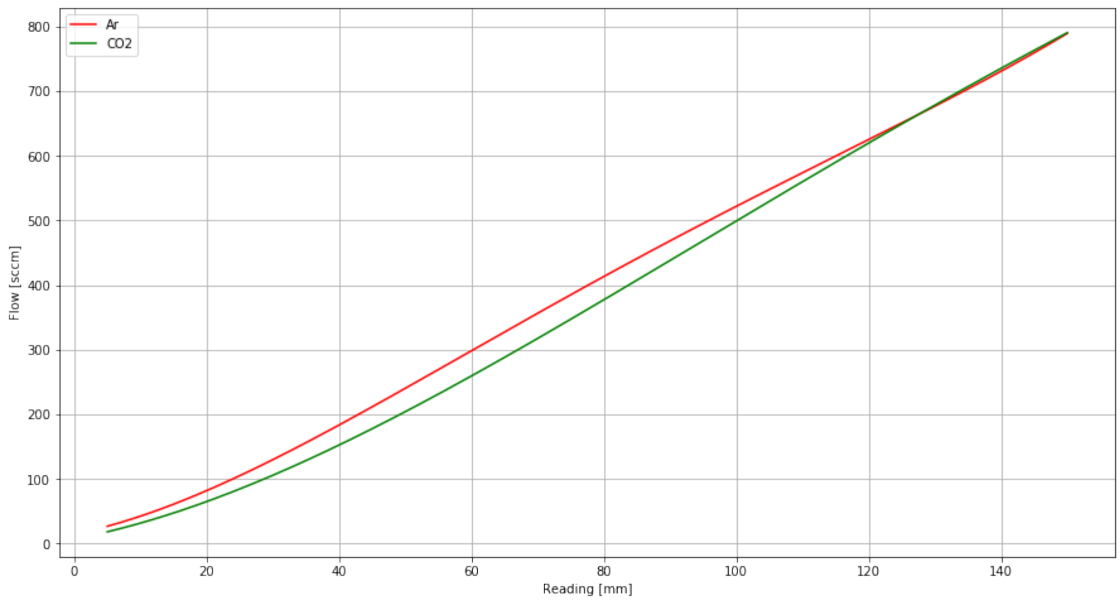
https://www.mathesongas.com/pdfs/flowchart/602%20(E300)/CARBON%20DIOXIDE%20602(E300)%20SS%20

$\phi_{\mathrm{CO_2}}(z)$

[20]:
```
ro,cal=np.loadtxt('CARBON_DIOXIDE_602(E300)_SS_0_PSIG.dat',unpack=True) # sccm
co2flow=interpolate.interp1d(ro, cal)
```

1.3 Plots

[21]:
```
plt.plot(x, arflow(x), 'r', label='Ar')
plt.plot(x, co2flow(x),'g', label='CO2')
plt.xlabel('Reading [mm]')
plt.ylabel('Flow [sccm]')
plt.grid()
plt.legend(loc='upper left')
plt.show()
```



2 Flow of a the gas mixture

Mixture fraction $f_{\mathrm{Ar}} = 1 - f_{\mathrm{CO_2}}$

[22]:
```
f_co2=0.3
```

2.1 Determination of the return fraction

Take the reading from the middle of the ball z_{in} and z_{out}

[23]:
```
zin=101
zout=66
```

Determine input Ar flow as $f_{\mathrm{Ar}}\phi_{\mathrm{Ar}}(z_{\mathrm{in}})$

[24]:
```
inar=arflow(zin)*(1.0-f_co2)
print(f'Ar inflow {inar:.1f} sccm')
```

```
Ar inflow 369.0 sccm
```

Determine input CO_2 flow as $f_{\mathrm{CO_2}}\phi_{\mathrm{CO_2}}(z_{\mathrm{in}})$

[25]:
```
inco2=co2flow(zin)*f_co2
print(f'CO2 inflow {inco2:.1f} sccm')
```

```
CO2 inflow 151.6 sccm
```

Determine input flow as $\phi_{\mathrm{in}} = f_{\mathrm{CO_2}}\phi_{\mathrm{CO_2}}(z_{\mathrm{in}}) + f_{\mathrm{Ar}}\phi_{\mathrm{Ar}}(z_{\mathrm{in}})$

[26]:
```
inFlow=inar+inco2
print(f'Gas Mixture inflow {inFlow:.1f} sccm')
```

```
Gas Mixture inflow 520.6 sccm
```

Determine output flow ϕ_{out} as above by replacing $z_{\mathrm{in}} \to z_{\mathrm{out}}$

[27]:
```
outFlow=arflow(zout)*(1.0-f_co2)+co2flow(zout)*f_co2
print(f'Gas Mixture outflow {outFlow:.1f} sccm')
```

```
Gas Mixture outflow 321.6 sccm
```

Determine return fraction as $\frac{\phi_{\mathrm{out}}}{\phi_{\mathrm{in}}}$

[28]:
```
print(f'Return fraction {outFlow/inFlow*100.0:.1f}%')
```

```
Return fraction 61.8%
```

2.2 Determination of the flow prior to mixing

Carbon Dioxide flow $\phi_{\mathrm{CO_2}}(z_1)$ for reading z_1

[29]:
```
z1=41 # reading
inCO2Flow=co2flow(z1)
print(f'CO2 inflow {inCO2Flow:.1f} sccm')
```

```
CO2 inflow 157.5 sccm
```

Argon flow $\phi_{\mathrm{Ar}}(z_2)$ for reading z_2

[30]:
```
z2=89
inArFlow=arflow(z2)
print(f'Ar inflow {inArFlow:.1f} sccm')
```

```
Ar inflow 463.1 sccm
```

Total flow prior to mixing $\phi_{\mathrm{sum}} = \phi_{\mathrm{CO_2}}(z_1) + \phi_{\mathrm{Ar}}(z_2)$

[31]:
```
totFlow=inCO2Flow+inArFlow
print(f'Total input Flow {totFlow:.1f} sccm')
```

```
Total input Flow 620.7 sccm
```

Calculate $\mathrm{CO_2}$ fraction $f_{\mathrm{CO_2}} = \frac{\phi_{\mathrm{CO_2}}(z_1)}{\phi_{\mathrm{sum}}}$

[32]:
```
co2frac=inCO2Flow/totFlow
print(f'CO2 fraction {co2frac*100:.1f}%')
```

```
CO2 fraction 25.4%
```

3 Conclusion

The weighted average of the calibrated flow for the two components of the gas mixture, where the weights are given by the volume fraction of each component, seems to yield resonable values for the input flow. The calculated value of the return is in accordance with what was previously seen with Argon only.

However, if one tries to determine the input flow from the rotameters prior to mixing, the sum flow is about 20% higher. The largest difference between the two methods appears in the determination of the Ar flow. It follows that the fraction of carbon dioxide is lower than expected.

[ ]:

```
```