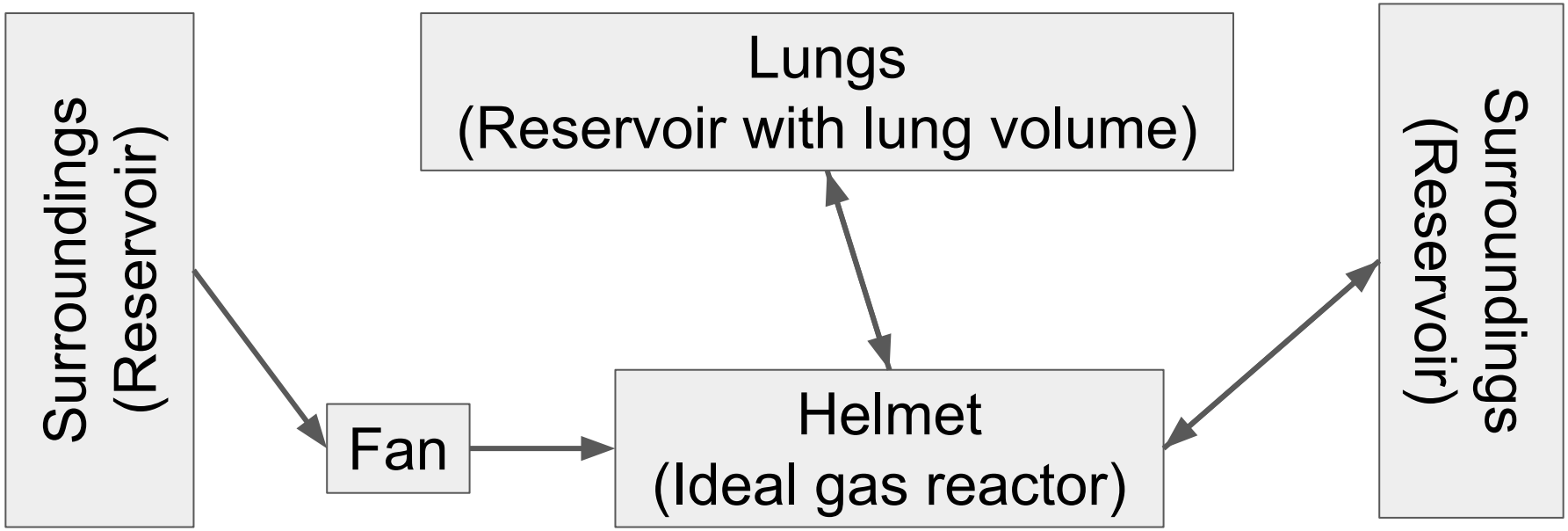
CO_2 Accumulation in the UCPD

0D Modeling

CO_2 Accumulation in the UCPD

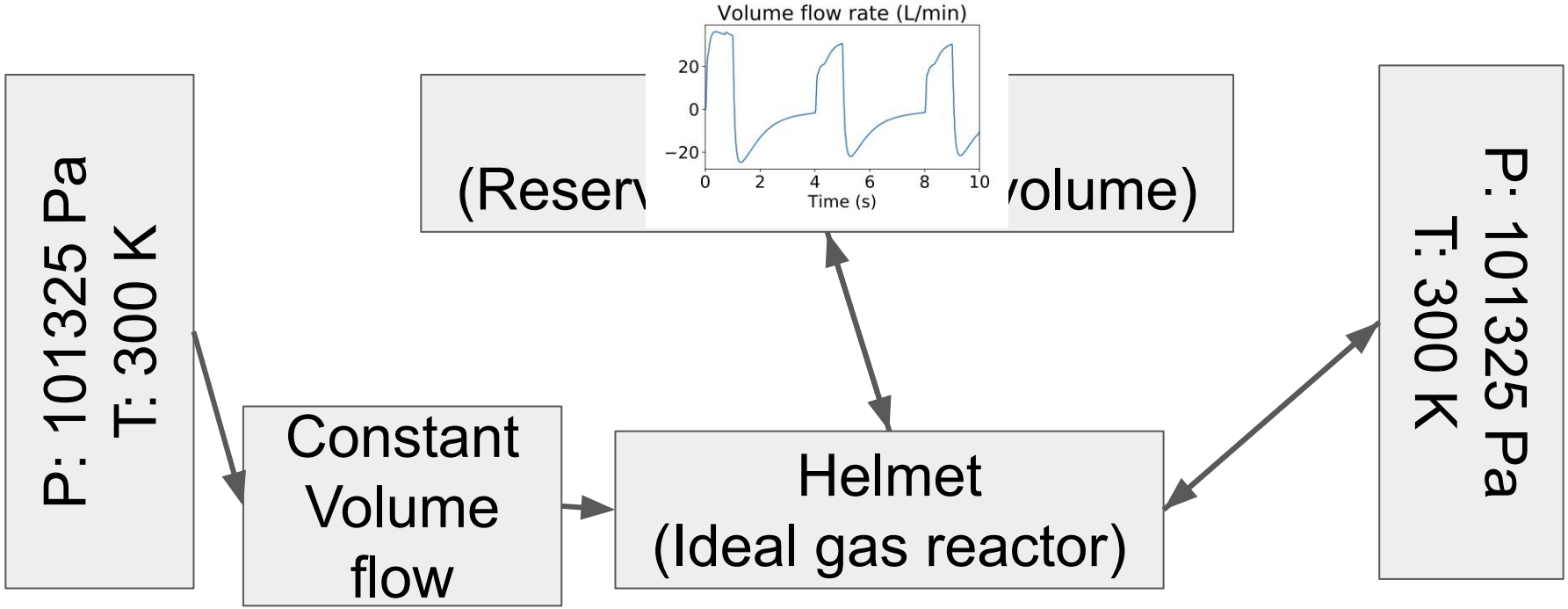
- Helmet is modeled as constant volume chamber with two inlets and one outlet.
- First inlet: Fan blowing air into the helmet at constant volume flow rate
- Second inlet/outlet to lungs: Inhale air from the helmet and exhale CO_2
- Outlet: opening to surroundings
- Concentration of CO_2 in the air 0.04% by volume
- **More than 5% CO_2 is harmful**
- (ref: www.ncbi.nlm.nih.gov/pmc/articles/PMC5380556/pdf/12245_2017_Article_142.pdf)

0D Modeling in Cantera



Repository: https://github.com/abhishekd18/covid19

0D Modeling in Cantera



CO2 Accumulation

Volume flow rate into the helmet

VFR = 30.0 l/min

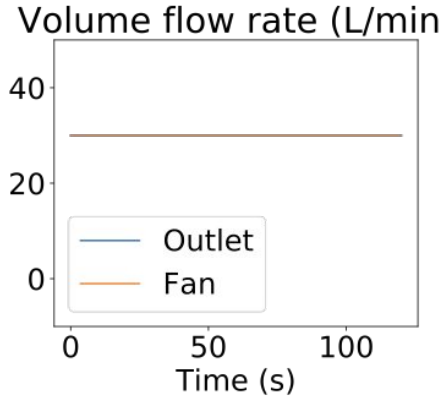
Helmet volume

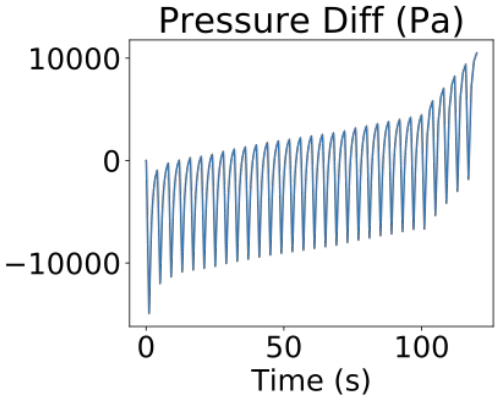
HV = 5.0 l

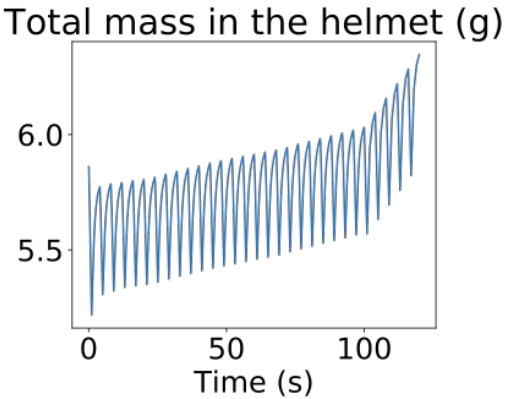
Lungs volume

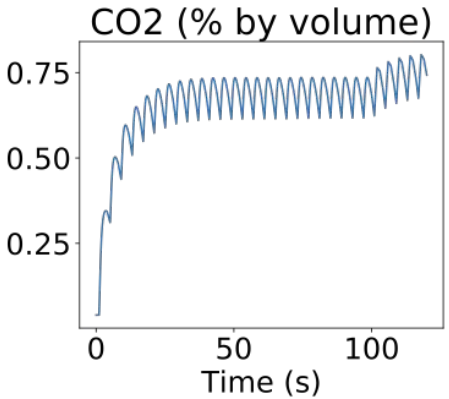
LV = 6.0 l

Less than 1% CO2 accumulation









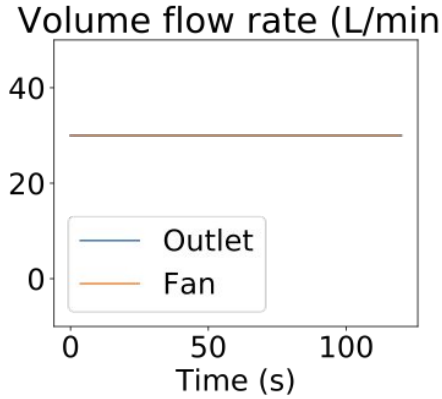
CO2 Accumulation

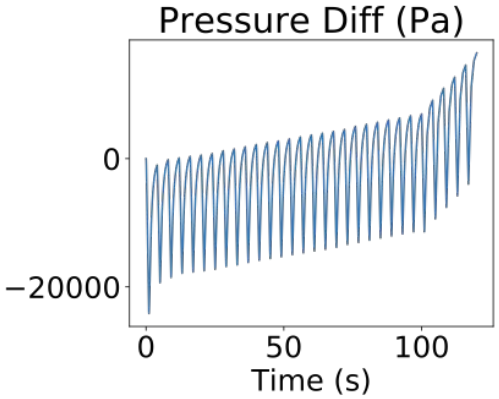
Reduction in Helmet volume

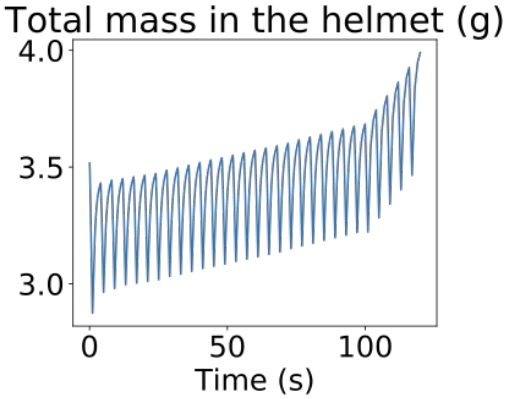
VFR = 30.0 l/min, HV = 3.0 l, LV = 6.0 l

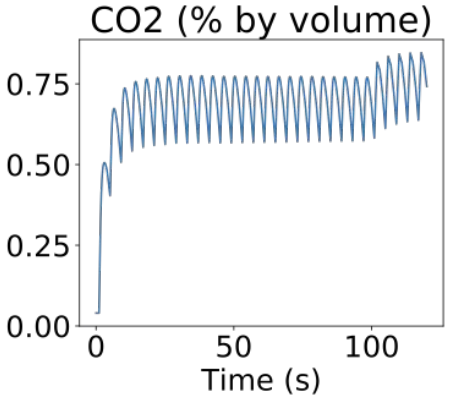
CO2 saturates earlier

Less than 1% CO2 accumulation









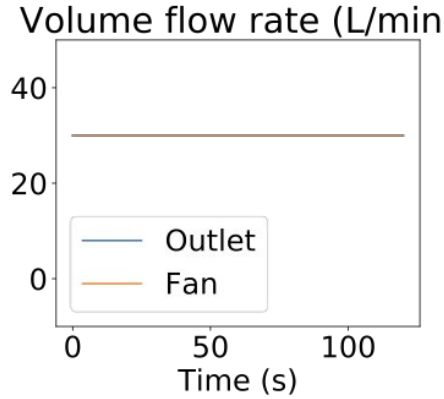
CO2 Accumulation

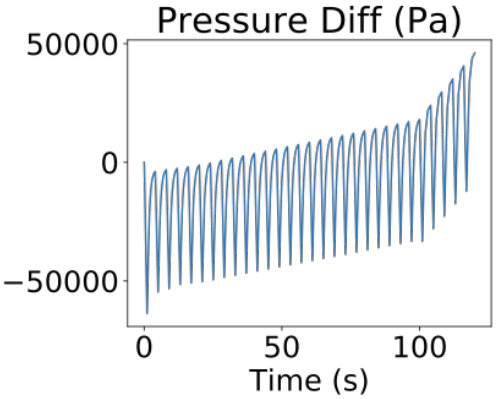
Reduction in Helmet volume

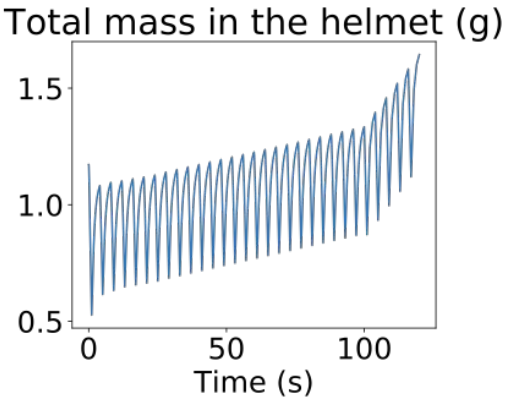
VFR = 30.0 l/min, HV = 1.0 l, LV = 6.0 l

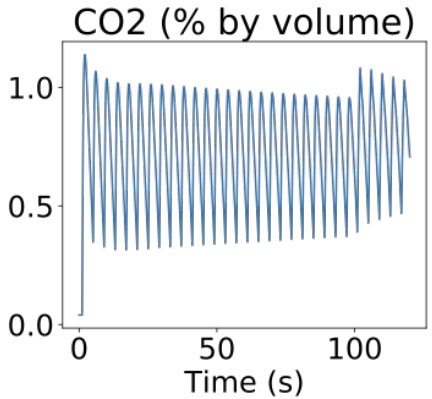
CO2 saturates earlier

Less than 1% CO2 accumulation







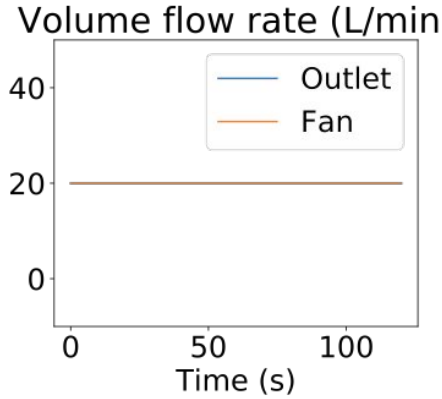


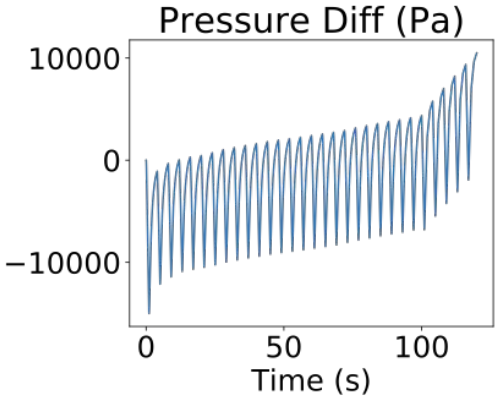
CO2 Accumulation

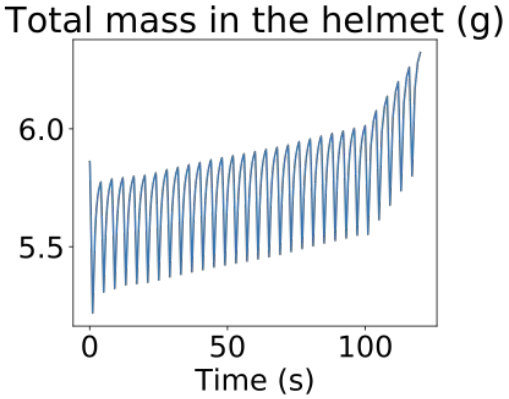
Reduction in Volume flow rate

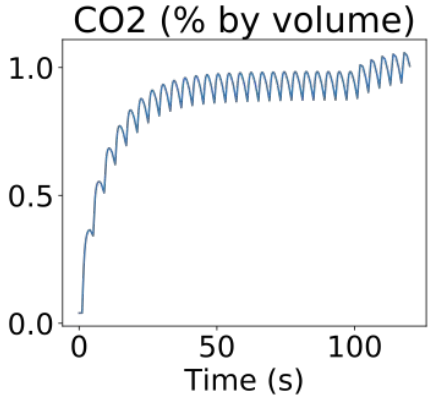
VFR = 20.0 l/min, HV = 5.0 l, LV = 6.0 l

~ 1% CO2 accumulation









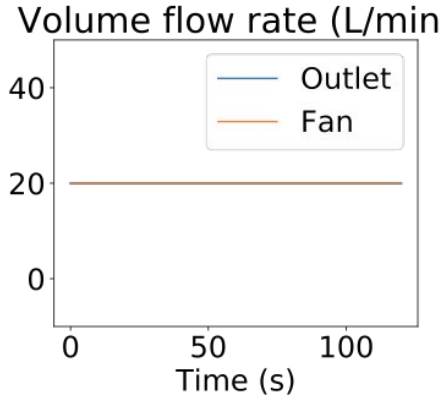
CO2 Accumulation

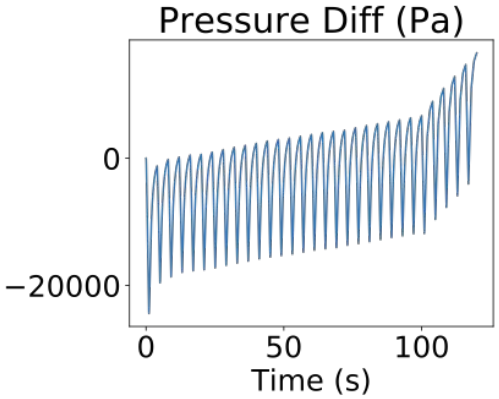
Reduction in Helmet volume

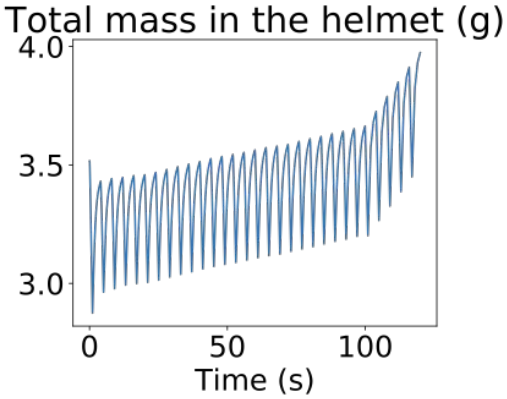
VFR = 20.0 l/min, HV = 3.0 l, LV = 6.0 l

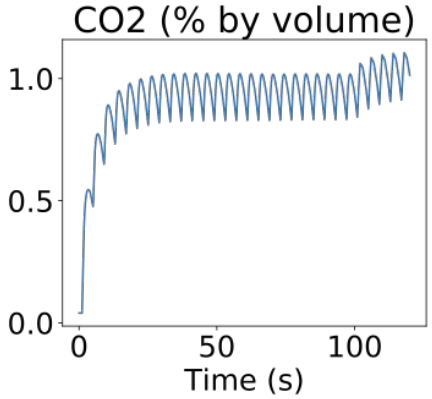
CO2 saturates earlier

~ 1% CO2 accumulation









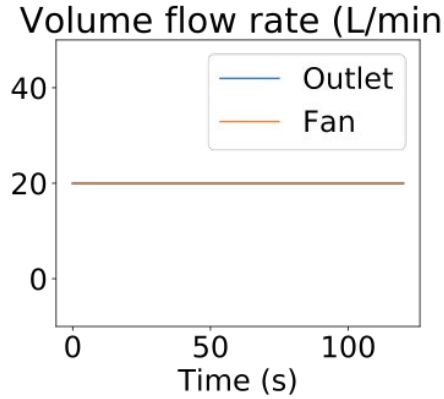
CO2 Accumulation

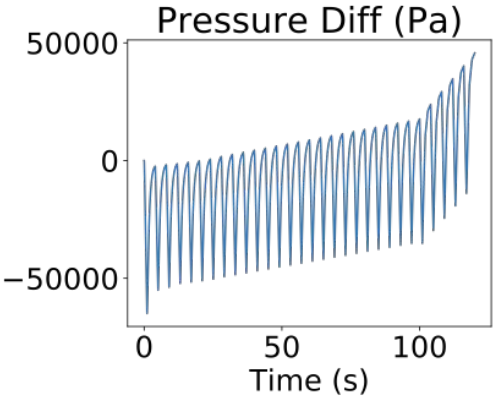
Reduction in Helmet volume

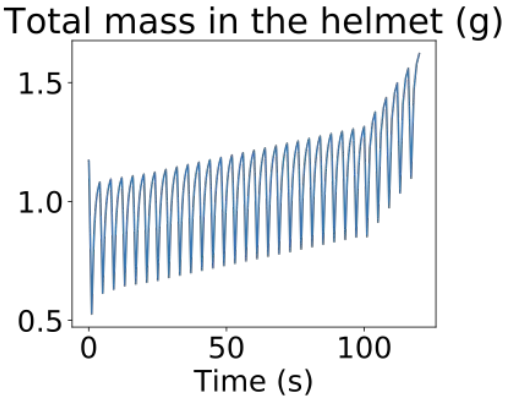
VFR = 20.0 l/min, HV = 1.0 l, LV = 6.0 l

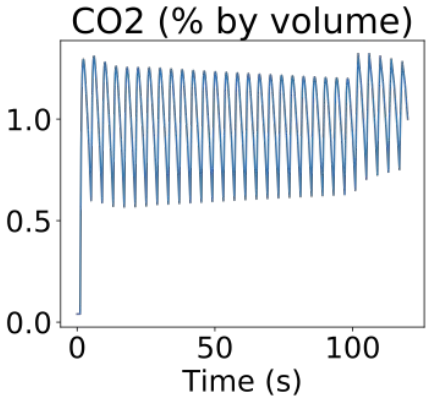
CO2 saturates earlier

~ 1% CO2 accumulation







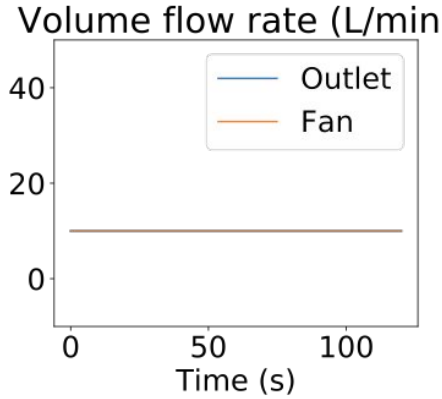


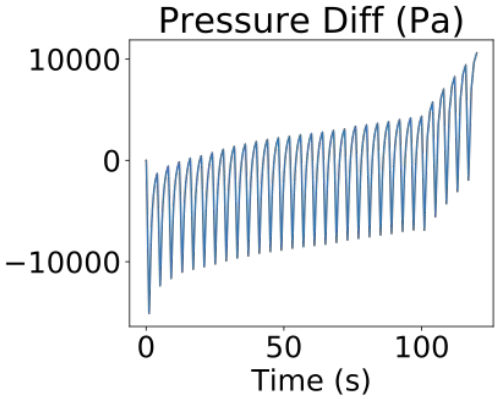
CO2 Accumulation

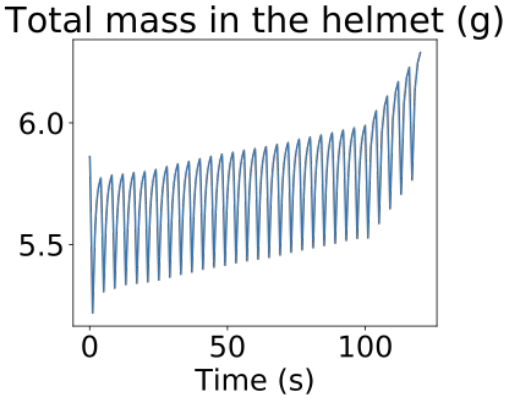
Reduction in Volume flow rate

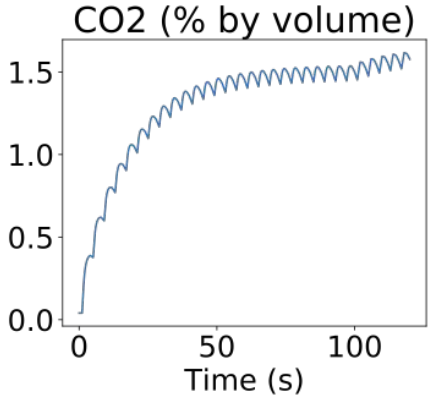
VFR = 10.0 l/min, HV = 5.0 l, LV = 6.0 l

~ 1.5% CO2 accumulation







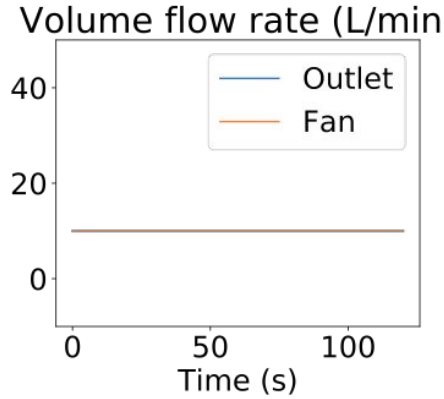


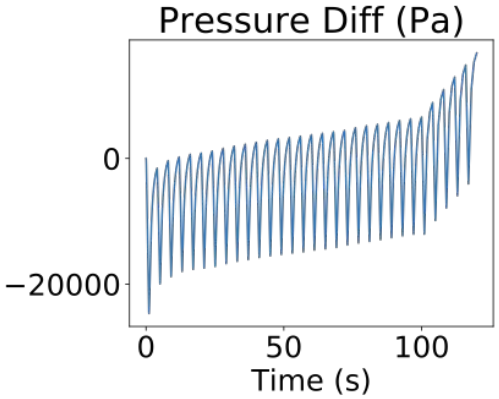
CO2 Accumulation

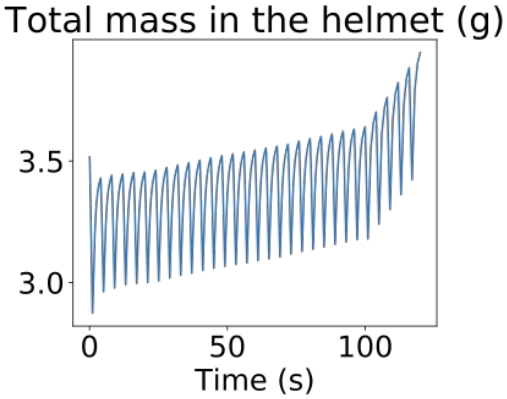
Reduction in Volume flow rate

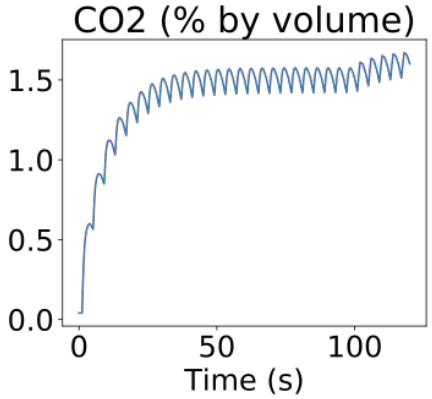
VFR = 10.0 l/min, HV = 3.0 l, LV = 6.0 l

~ 1.5% CO2 accumulation







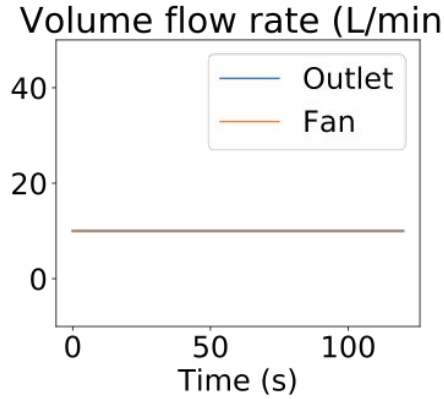


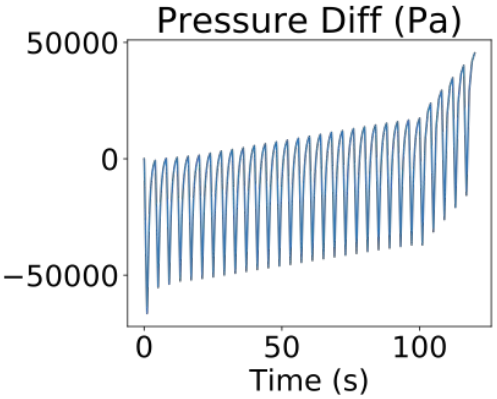
CO2 Accumulation

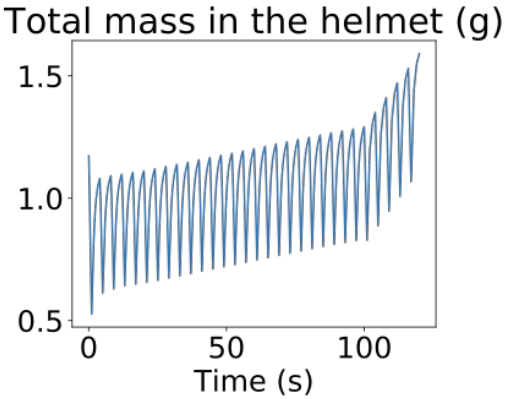
Reduction in Volume flow rate

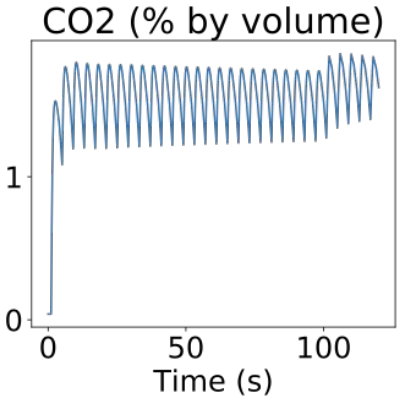
VFR = 10.0 l/min, HV = 1.0 l, LV = 6.0 l

~ 1.5% CO2 accumulation









Summary

- Preliminary 0D modeling study for current design indicates approximately 1% CO_2 concentration inside the closed helmet with fan
- CO_2 concentration in the current design is below harmful levels of more than 5%
- Reduction in volume flow rate of fan is likely to increase CO_2 concentration
- Reduction in the helmet volume saturates the CO_2 levels quickly and also result in more fluctuations indicating more fresh air mixing within the helmet