LIQUID PROPULSION

WEEK 11 REPORT

Tasks assigned for week 11

#142 Research on water-test design

#143 Mass flow rate re-calculation

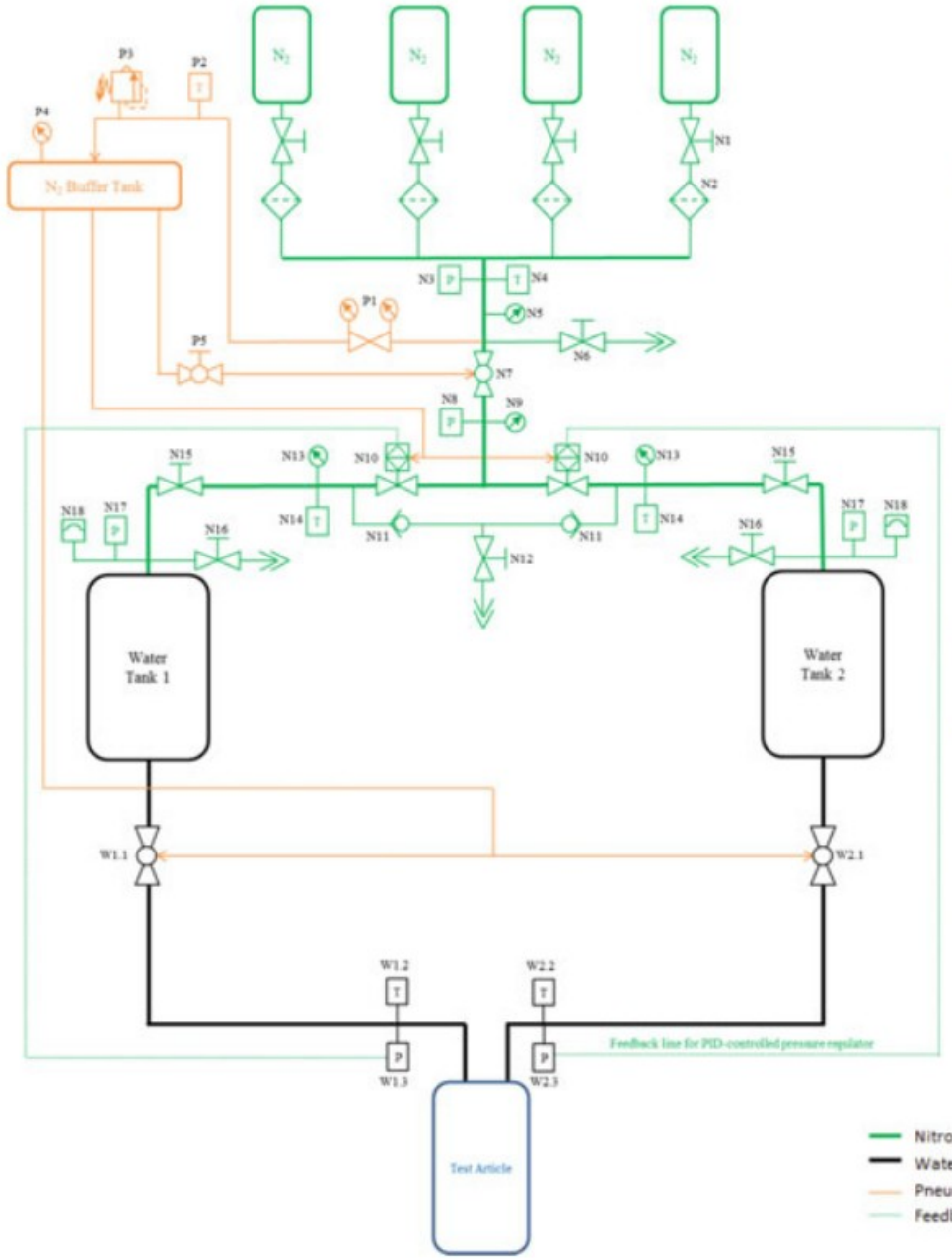
#139 Remote operation

Water-flow test

- Why water-flow test?
- - Flow coefficient
- - Injector spray formation
- - Flow distribution within regeneration cooling

$$C_v = q\sqrt{\frac{G_f}{\Delta P}},$$

Water-Flow Test Stand



Pressurant Line (Nitrogen)

N1	Manual Needle Valve (on T-size Gas Cylinder)
N2	Particulate Filter
N3	Pressure Sensor
N4	Temperature Sensor
N5	Pressure Gauge
N6	Manual Venting Valve
N7	Pneumatic Ball Valve
N8	Pressure Sensor
N9	Pressure Gauge
N10	PID Controlled Electro-Pneumatic Pressure Regulator
N11	Check Valve
N12	Manual Venting Valve
N13	Pressure Gauge
N14	Temperature Sensor
N15	Manual Needle Valve
N16	Manual Venting Valve
N17	Pressure Sensor
N18	Burst Disc

Water Lines 1 & 2

W1.1	Pneumatic Ball Valve
W1.2	Pressure Sensor
W1.3	Temperature Sensor
W2.1	Pneumatic Ball Valve
W2.2	Pressure Sensor
W2.3	Temperature Sensor

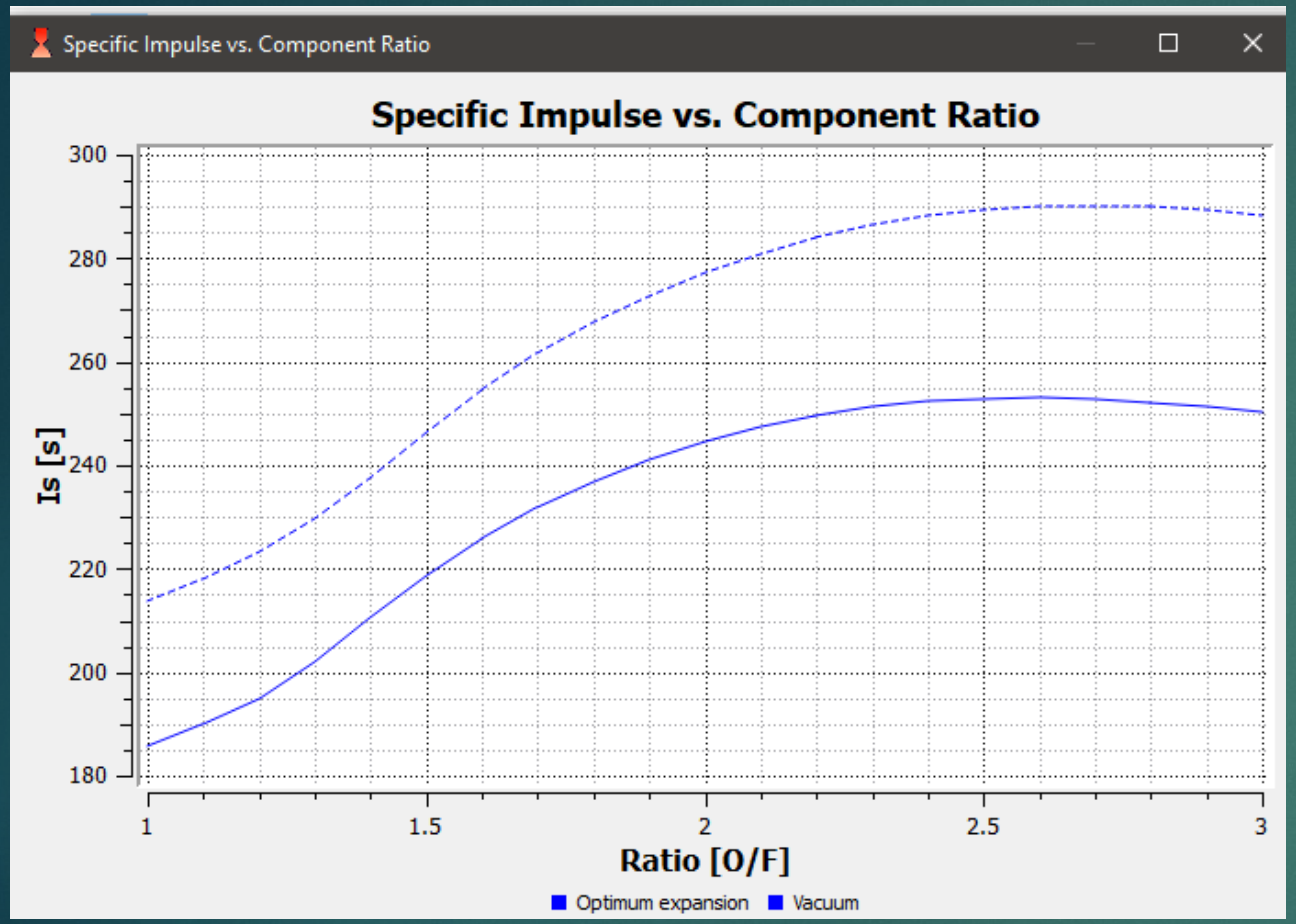
Pneumatic Supply (Nitrogen)

P1	Manual Pressure Regulator
P2	Temperature Sensor
P3	Pressure Relief Valve
P4	Pressure Gauge
P5	Manual Ball Valve

Nitrogen Pressurant Line ¾"
Water Supply Lines ¾"
Pneumatic Line ¼"
Feedback Line for PID Controllers

Schematic of LE's water-flow test stand USC

Mass flow rates & O/F RPA

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# Table 3. Theoretical (ideal) performance
#-------------------------------------------------------------------------------------------------------
#          Parameter      Sea level      Optimum ex          Vacuum            Unit
#-------------------------------------------------------------------------------------------------------
Characteristic velocity      0.0000       1846.9100          0.0000             m/s
Effective exhaust velocity         2622.7500       2627.6000       2994.0400             m/s
Specific impulse (by mass)         2622.7500       2627.6000       2994.0400           N·s/kg
Specific impulse (by weight)        267.4500        267.9400        305.3100                s
  Thrust coefficient          1.4201          1.4227          1.6211
#-------------------------------------------------------------------------------------------------------
#
#-------------------------------------------------------------------------------------------------------
#
# Table 4. Estimated delivered performance
#-------------------------------------------------------------------------------------------------------
#          Parameter      Sea level      Optimum ex          Vacuum            Unit
#-------------------------------------------------------------------------------------------------------
Characteristic velocity      0.0000       1795.5400          0.0000             m/s
Effective exhaust velocity         2474.6200       2479.4800       2845.9100             m/s
Specific impulse (by mass)         2474.6200       2479.4800       2845.9100           N·s/kg
Specific impulse (by weight)        252.3400        252.8400        290.2000                s
  Thrust coefficient          1.3782          1.3809          1.5850
#-------------------------------------------------------------------------------------------------------
#
#<b>Ambient condition for optimum expansion:</b>  H=0.11 km, p=0.987 atm
```

Optimum O/F

```
Exploded formula:  (O)1.432 (C)0.568 (H)1.704
              O/F:     2.6823988
            O/F 0:     3.7246217 (stoichiometric)
            alpha:     0.7201802 (oxidizer excess coefficient)
```

Mass flow rates

MASS FLOW RATE

Target thrust=2KN

Target chamber pressure=2Mpa

Exit pressure=0.1Mpa

$$V_e=\sqrt{2\frac{RK}{K-1}\frac{T_0}{M}\left[1-\left(\frac{P_e}{P_0}\right)^{\frac{k-1}{k}}\right]}$$

I_{SP}(from the simulation) = 252.34s

$V_e=I_{sp}*g$=2474.62 m/s

$\dot{m}=F_{thrust}/V_e$=2000N/2474.62=0.8082 kg/s

Optimum O/F ratio from simulation chosen as from the graph=2.5

$$\dot{m}_{oxygen}=\frac{\dot{m}}{1+O/F}$$

$=\frac{0.8082}{1+2.5}$=0.23091kg/s

$$\dot{m}_{fuel}=\dot{m}-\dot{m}_{oxygen}$$

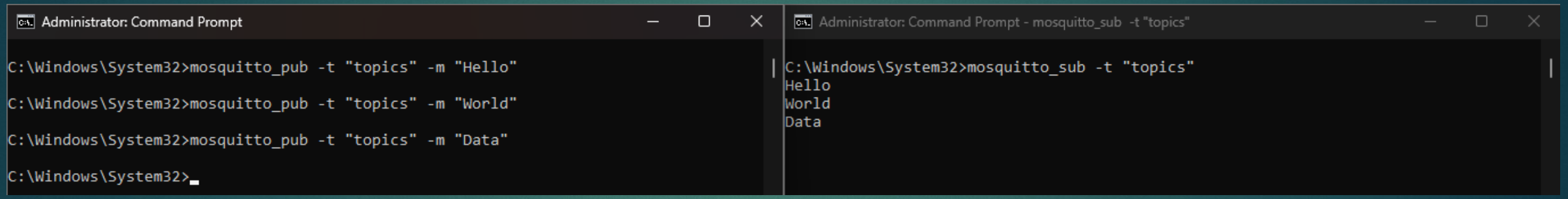
=0.57729kg/s

- Finding of previous report
- mass flow rate of Gox = 0.67093 kg/s
- mass flow rate of ethanol = 0.5161 kg/s
- Isp = 240s

Challenges in previous report

- Unavailability of components locally
- No suitable filling system or station could be found
- Pressure accumulator is made up of Nitrile rubber which is incompatible with ethanol

Remote operation



- We choose MQTT as way of transmitting sensor data i.e. pressure data, flow rate
- It works by publishing and subscribing to the same topic
- MQTT is used where low bandwidth and low power consumption are crucial

Task allocated for next week

- Design P & I D of water-test in 3D
- Water-test control circuitry
- Identify materials required
- Remote operation

THANK YOU