Research project meeting summary: Trajectory Module for Launcher MDAO

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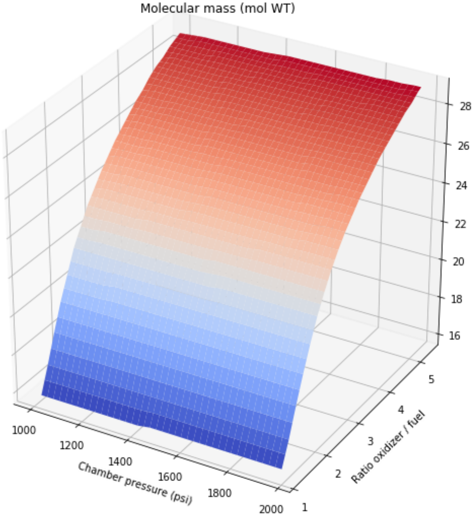
Plan:

1. Review of previous work
2. Key points discussed
3. Future actions

Review of previous work

Linear interpolation of Rocket CEA outputs



Review of previous work

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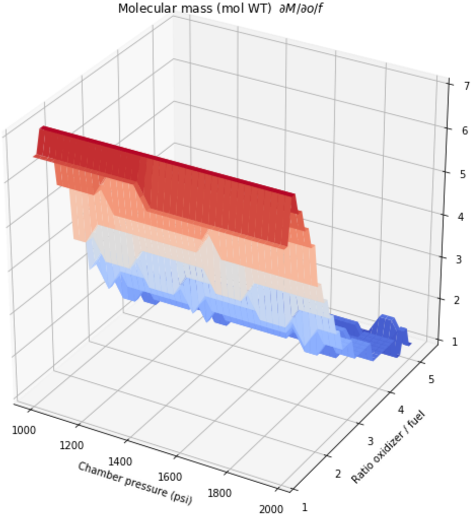
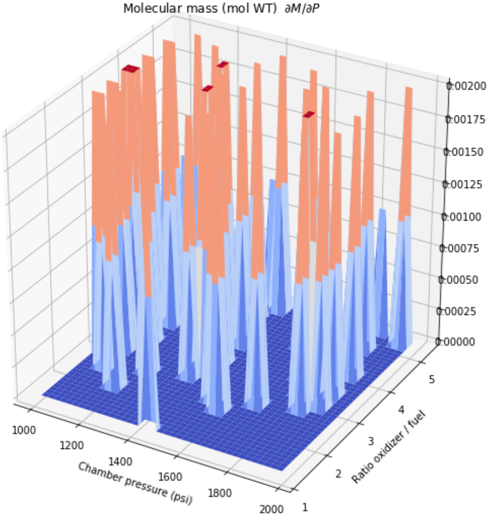
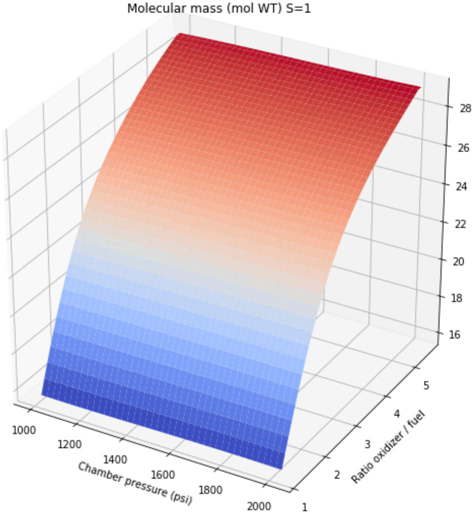


Review of previous work

Linear interpolation of Rocket CEA outputs

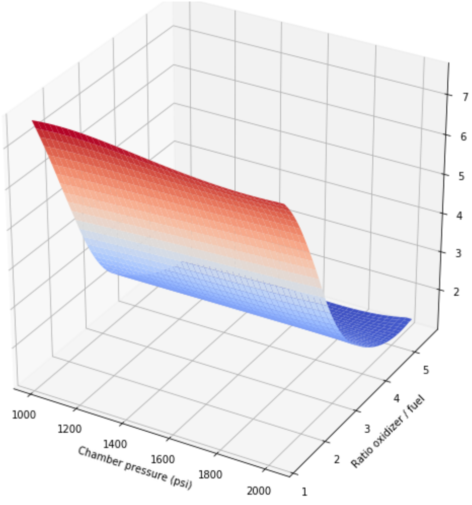




Molecular mass (mol WT) S=1
28
26
24
22
20
18
16
1000
1200
1400
1600
1800
2000
Chamber pressure (psi)
1
2
3
4
5
Ratio oxidizer / fuel

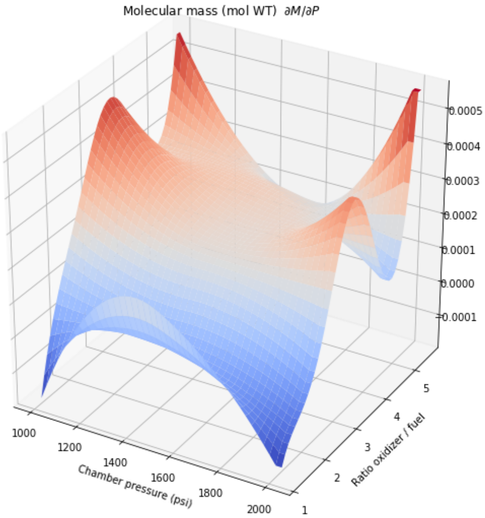
Review of previous work

Bivariate Spline for comparisson



Review of previous work

Bivariate Spline for comparisson



Review of previous work

Error in I_{sp} calculation

$$Isp = \lambda_n . \frac{C^*}{g_0}\left(\gamma_t \sqrt{\left(\frac{2}{\gamma_t - 1}\right) . \left(\frac{2}{\gamma_t + 1}\right)^{\frac{\gamma_t+1}{\gamma_t-1}} . \left(1 - \frac{Pe}{Pc}\right)^{\frac{\gamma_t-1}{\gamma_t}}} + \frac{\epsilon}{Pc}(Pe - P_a)\right)$$

Figure: I_{sp} as a function of C_f used in LAST from Dr. Balesdent's thesis

$$C_F = \frac{F}{p_1 A_t} = \frac{v_2^2 A_2}{p_1 A_t V_2} + \frac{p_2 A_2}{p_1 A_t} - \frac{p_3 A_2}{p_1 A_t}$$
$$= \sqrt{\frac{2k^2}{k-1}\left(\frac{2}{k+1}\right)^{(k+1)/(k-1)}\left[1 - \left(\frac{p_2}{p_1}\right)^{(k-1)/k}\right]} + \frac{p_2 - p_3}{p_1}\frac{A_2}{A_t}$$

Figure: C_f as in Sutton - Rocket Propulsion Elements

- $1 \leq C_f \leq 2$, according to Sutton

Key points discussed

Proposal to further decompose the calculation of $I_{sp_{vac}}$

In order to compare results against the literature I think it would be convenient to further divide the calculation of $I_{sp_{vac}}$ like this

1. Calculate effective exhaust velocity at vacuum: c_{vac}
2. Calculate thrust coefficient at vacuum: $C_{f_{vac}} = \frac{c_{vac}}{c^\star}$
3. Calculate $I_{sp_{vac}} = \lambda_n * \frac{c^\star}{g_0} * C_{f_{vac}}$

- Right now the values of nozzle exit area and exit pressure behave as expected when running the optimization
- Still, there as some convergence problems as the optimizer fails to satisfy inequality constraints
- I'm trying to use Linux to have accesss to more performant open source optimizers as IPOPT and PyOptSparse's SLSQP. Dr. Urbano suggests to use a virtual machine.
- Dr. URbano suggest to use previous code (without propulsion optimization) with inputs takne from the unconverged simulations.
- it would be good to separate λ_n into $\mathrm{eta}_{\mathrm{c}^\star}$ and $\mathrm{eta}_{\mathrm{C_f}}$

- Keep trying with the propulsion optimization based on the things discussed during this meeting