Monopropellant Thrusters

- Good place to apply our basic thermodynamic analysis
- Employed for small, “low” thrust applications
  - small satellite attitude control
- Advantages
  - reliable
  - low complexity
  - safe (storage), good material compatibility
  - low contamination of vehicle due to exhaust

Basic Types

- Three primary types
  1. **Cold gas thrusters**
     - solely pressure driven
  2. **Decomposition-based**
     - exothermic heat release
     - requires catalyst
  3. **Resistojets**
     - a type of electrothermal thruster
     - +electrical energy
**Basic Configuration**

- **Storage**
- **Filter (F)**
  - remove particulates that could clog or damage downstream components
- **Pressure Transducer (P)**
  - for sensing and control
- **Pressure Regulator (R)**
  - allows storage at pressure higher than maximum pressure of downstream components
  - constant pressure operation
- **Valve (V)**
  - on-off control (e.g., solenoid valve)
- **Catalyst (C)**
  - used for decomposition-based propellants

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**Cold Gas Thrusters**

- **Example layout**
  - typical for 1 feed system to supply multiple thrusters
- **Candidate gases**
  - **He**: high $I_{sp}$ (~180 s vacuum)
    - low MW $\Rightarrow$ high $a_0$ $\Rightarrow$ high $c^*$
  - **$N_2$**: med $I_{sp}$ (~80 s)
    - MW=28
  - **$H_2$**: high $I_{sp}$ (~298 s)
    - but storage safety
  - others: Ar, CO$_2$, ...
    - low $I_{sp}$ (high MW)

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*from Honse et al., AIAA 2009-5481*
Example: N₂ In-Space Cold Gas Thruster

- Goals/Find
  1. Steady-state 1) \( I_{sp} \), 2) \( \tau \), 3) "burn time", 4) total impulse

- Assumptions
  1. Perfect regulator
     \( p_o = 10 \text{ atm} \) until \( p_s < 10 \text{ atm} \)
  2. Isothermal tank and regulator
     heat xfer from satellite fast enough to compensate expansion drop in temperature
  3. Thermally and calorically P.G.
     N₂: \( R = 296 \text{ J/kgK} \) and \( \gamma = 1.4 \)
  4. Adiabatic and reversible flow (isentropic) after regulator
  5. Neglect transients
     with 3+4 \( \Rightarrow \) ideal rocket

Analysis: N₂ In-Space Cold Gas Thruster

- \( I_{sp} \)

\[ = 73.8 \text{s} \]
Analysis: \( \text{N}_2 \) In-Space Cold Gas Thruster

- \( \tau \)
  
  \[
  \tau = 8.4N = 1.9lb_f
  \]

- \( \Delta t_b \) steady
  - time until pressure in storage drops to 10bar
  
  \[
  \Delta t_b = 4400s = 1.2hr
  \]

- \( I_{\text{total}} \)
  
  \[
  I_{\text{total}} = 37.1kN_s = 8.3klb_f s
  \]

- Which values would change with throat size?
  
  -

- Which values would change if include \( T_o \) drop?
  
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