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Air Liquide Advanced technologies

ID : 3125316

Title : NEW COMPONENT DEVELOPMENTS FOR ELECTRIC PROPULSION SYSTEMS

Theme :

Resume :

Electric Propulsion is a major breakthrough in platform architecture, reducing dimensions and mass thus leading to different options for launchers, modifying daily operation program and orbit raising program. Electric propulsion is now used for all range of satellites, from scientific missions to telecom bus, from nano-satellites to 6 tons platforms, from one time project to constellations.

Electric propulsion uses mainly xenon as propellant; other gases like krypton may also be used. Propulsion subsystems are very conservative in their way of handling propellant and delivering it to thrusters. Air Liquide Advanced Technologies has developed a high pressure gas mass flow controller which brings a new breakthrough in propulsion subsystem design. This paper presents development status and roadmap of Electric Propulsion products at Air Liquide.
New component for electric propulsion
Space Propulsion Forum

Roma, 05/05/2016  I  Aurélien Moureaux  I  SPACE BUSINESS UNIT
Mass flow regulation

■ Whatever the gas:
  - Helium
  - Hydrogen
  - Oxygen
  - Nitrogen
  - Xenon
  - Specific Mixtures
  - ...

■ From capillary ... to DN 50
Ariane – Helium Pressure regulator

- Pressure regulation on Ariane 5 EPS:
  - 2 stages mechanical pressure regulator
  - Operational temperature: de –100°C à +70°C
  - Still in production

- Developments for A5 ME & A6:
  - Full pressurization plate: regulator/relief valve/plenum/back-flow control
  - Operational temperature: de –120°C à +50°C
  - Extension based on A5 EPS pressure regulator (modified mass-flow and pressure)
Solutions – Downscale

- Space products downscale

<table>
<thead>
<tr>
<th>Mass</th>
<th>✓</th>
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<tbody>
<tr>
<td>Performances</td>
<td>✓</td>
</tr>
<tr>
<td>Costs / Time</td>
<td>✗</td>
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</table>
Typical Electric Propulsion System

- Pressure regulator
  - Up to 200 bar
- 4 XFC
  - Low inlet pressure 2-3 bar
  - Complex elements
  - Electronically driven
- +Filters
- +Latch valves
- +redundances...

⇒ Complex
⇒ Heavy
⇒ Costly
Thermally controlled Valve

- Onboard:
  - Rosetta
  - ExoMars (MOMA)
- Mass # 5g
- Electric power # 2 W

- Xenon / Krypton / N₂ / He etc.
- Inlet pressure: 5-200 bar
- Temperature range: -60/+60 °C
- Tightness < 1.10-8 mbar.l/s Ghe
Thermally controlled Valve

- Pressure Regulation
  - Gas Chromatograph
  - Thruster

- Mass flow control
  - Thruster
    - Current driving
Proposed architecture

- No pressure regulator

- 4 XFC
  - High inlet pressure
  - High leak tightness
  - Electronically driven

- Simpler
- Lighter
- Cost saving
Thermally controlled Valve

Leakage < $10^{-9}$ Ncc/s GHe
Thermally controlled Valve

Mass flow as a function of valve temperature at a constant inlet pressure
Thermally controlled Valve

Mass flow: 0 – 20 mg/s
Inlet pressure: 5-150 bar
High pressure inlet XFC

- Mass flow command
- Mass flow meter
- Thruster

Diagram showing the control system with transfer function (g/h He → mg/s Xe) and mass flow measurement.

Graph showing D1 [mg/sec Xe] against Temp [sec].
High pressure inlet XFC

Diagram showing the flow from discharge current command, through a PID controller, to a valve, and finally to the thruster.
Thermally controlled Valve

- Pressure Regulator
- Mass flow regulator
- Pulse-width modulation
- Current driving

- High Pressure
- Very good Tightness
- Xenon / Krypton
- Helium
- N₂
## Micro Latched Valve

### Magnetic Bi-stable Latch Valve

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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<tbody>
<tr>
<td>Inlet pressure</td>
<td>5 bar</td>
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<tr>
<td>Mass</td>
<td>&lt; 5 grams</td>
</tr>
<tr>
<td>Size</td>
<td>10mm x 10mm x 20mm</td>
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<tr>
<td>Power</td>
<td>5 W</td>
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<tr>
<td>Opening time</td>
<td>&lt; 100 ms</td>
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<tr>
<td>Leakage</td>
<td>&lt; $10^{-5}$ Ncc (GHe)</td>
</tr>
<tr>
<td>Number of cycles</td>
<td>10,000</td>
</tr>
</tbody>
</table>
Conclusion

■ Components qualified in Helium
■ Onboard ExoMars 2018

■ Electronic regulation
  ▪ Any mass flow within the range

■ Examples of use:
  ▪ Gas Chromatograph
  ▪ Electric Propulsion
  ▪ Inflatable structures
  ▪ Cold Gas Propulsion

■ Firings with thrusters (2016)
End of presentation
Thank you for your attention