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AERONAUTIC DEFENSE SPACE

THERMOCOAX Space Products

Spacecraft Thermal Management

New Generation of Heating solution for:

Mechanical pump Loop System Accumulator

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Thermocoax Pedigree

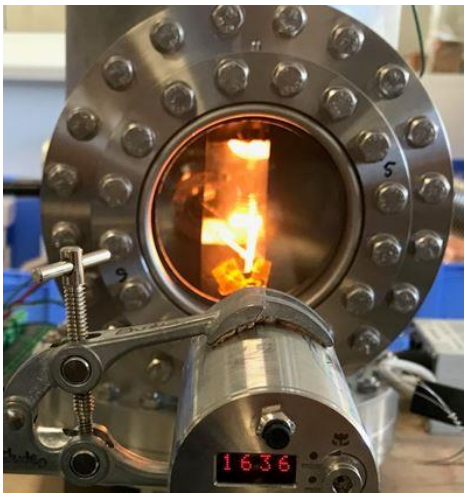
THERMOCOAX is a worldwide key player since 15 years in designing, developing and manufacturing with heating systems for space market.

We are providing solutions for:

- Ground applications:
  - ✓ R&D programs with institutes
  - ✓ Ground equipment

- Flying models:
  - ✓ Heating management system on Satcom.
  - ✓ Catalyst Bed heater for chemical propulsion
  - ✓ Heating solution for Hall Effect thruster

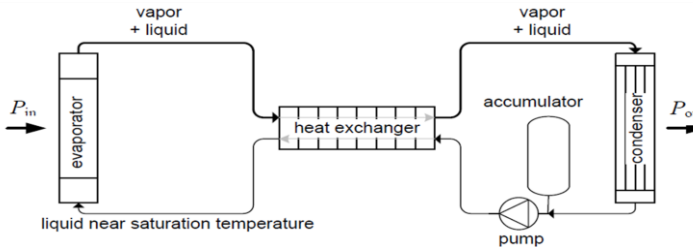
- Scientific Mission:
  - ✓ Heating system on Curiosity Rover
  - ✓ Heating Element on ISS for MSL
  - ✓ Heating Element for pyrolizer on Cassini-Huygens Titan probe



Technical Application of Heating System Unit for MPL technology

Because of the growing size and complexity of satellite platforms and the growing power demand conventional thermal control systems with Heat Pipes (HP) and Loop Heat Pipes (LHP) networks get to their limit. Therefore Large System Integrators developed Mechanically Pumped Loops (MPLs).
The interest was intensified due to platform architecture changes and large distance between dissipative elements and radiator, MPL's becomes a feasible alternative to heat pipe structures with multiple connections.
Also increasing power densities lead to more interest in mechanically pumped loop systems. With power densities over 16 W/cm2 ordinary LHP´s are no longer suitable and therefore a small MPL is one of the options to serve dedicated high heat flux pay-loads.
Recently also a new potential application of MPL's has been identified. A MPL can re-distribute waste heat to locations where the heat is needed. The reduction in heater power has tremendous mass savings and makes non-nuclear deep space missions feasible.

Here a Schematic drawing of a 2 phases-MPL. A pump is used to circulate a working fluid. Downstream of the pump, the fluid first flows to an evaporator, where liquid is evaporated, while heat from the payload is being absorbed.



The vapor then flows to a condenser where it is condensed back into liquid.
An accumulator is required in the system to allow for density changes of the fluid as a result of evaporation and condensation. Furthermore, the saturation pressure (and thereby the saturation temperature) in the system is controlled by the

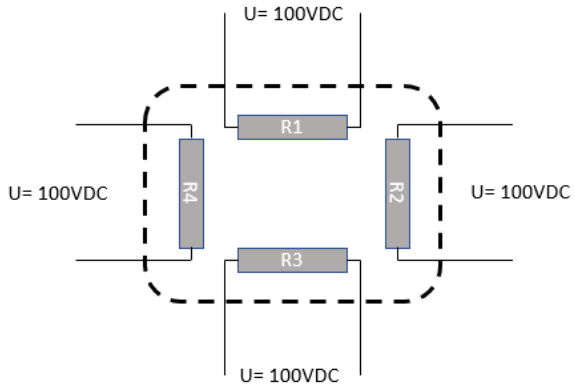
accumulator. When the accumulator is accurately controlled also the P/L evaporator is accurately controlled. This can be achieved by controlling the accumulator heating/cooling. In principle, the accumulator can maintain exactly the desired temperature in the system when the accumulator heating and cooling capacity is very large or when the accumulator is very big.

Technical Description of Heating System for Accumulator

The purpose is to make a rod heater to be installed in the middle of the accumulator.

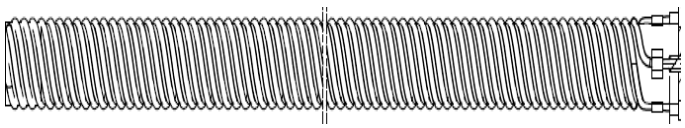
The rod heater is equipped with 2 main heating loops of several hundred of watts each. The loop N°2 is twice less powerful than the loop N°1. Added to these heating loops, two identical other heating loops are wrapped with for the redundancy.

Electrical Scheme



Each heating element is a bifilar technology with one connector for the power supply 100 volts or other value

Wrapped of 4 heating elements:



Heating cables, junction boxes and lead cables

Mechanical interface is designed to be adapted to the accumulator and environmental constrains especially the ones of the take off.

Mechanical Interface:

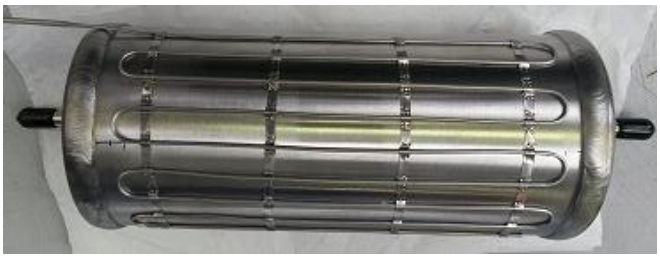
Example of power:

Primary:
Loop 1: 250 watts
Loop 2: 125 watts
Redundancy:
Loop 3: 250 watts
Loop 4: 125 watts

Heating cable length: 2.11 meters
Cold length: 80 to 88mm
Power dissipated: 1 to 3watt/cm²

Alternative thermal solution:

Depending of the accumulator characteristic and performance, the heating cables can be installed and vacuum brazed on the outer envelop:



Additional component of the MPL system cab be heated such pipes:

Acceptance Test Criteria of the heater:

- Helium Leak Test
- X-ray of the heating part
- X-ray of the junction MIC/lead wires
- Lead attachment strength test 20N
- Visual and mechanical examination
- Overvoltage: 1.5 * nominal power for 1mn
- Burn In > 80 hours
- Line Resistance
- Insulation Resistance under 250V @200°C
- Dielectric 250Vac, 50Hz/60s
- Weight
- Final Manufacturing Report

est List for Qualification Program

hermocoax drives and realizes the qualification test program in accordance with our customer's specification.
Our engineers write the QTP for customer approval prior running the test.

Most of the tests on the Accumulator Heater are performed in HERMOCOAX's labs testing (thermal, humidity, electrical..).

Those are requiring heavy equipment (vibration, acceleration, shocks..) are subcontracted to external laboratories or supported by our customers with the complete propulsion system.

-Typical Qualification Test list on Catalyst Bed Heater:

- Vibration
- Acceleration
- Mechanical shock
- Pyrotechnic Shock
- Helium leak test
- Burn-in test
- Humidity test
- Hot Firing test
- Electrical Cycling test
- Thermal cycling test
- Lead Attachment Test
- Dielectric Test

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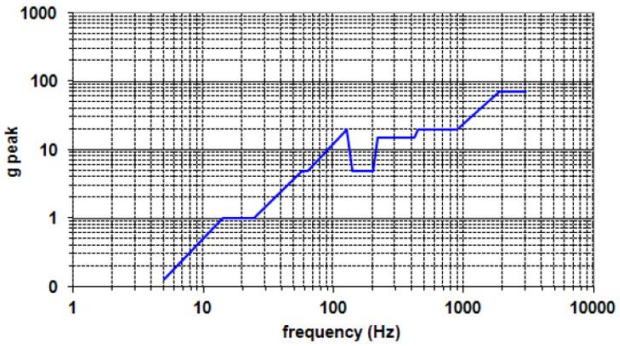
- Destructive Physical Analysis
- XRay Examination



- Packaging and Cleanness:

A specific packaging is organized for insure excellent condition of the Catalyst Bed Heater during transportation and storage:

- hermocoax supplies new GEO Satcom, 100 volts and 100% electrical propulsion

  First launch happened with SES17 October 2021

- Hermocoax is a major player for heating system on board GEO, MEO and LEO with very robust and long life time technology.

- HERMOCOAX's is focusing on high quality heater product for the best stability and repeatability during functioning. We understand our customers' challenge to manufacture spacecrafts for 15 years and more for better life of human being.

  New large constellation programs are under construction,