DESIGNING AN ADDITIVE MANUFACTURED MICRO PUMP FOR SPACE APPLICATIONS

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Introduction

- Pumped two-phase loops are essential to handle future thermal power densities in space applications (50-300 W/m² is expected).
- But, space pump reliability is the reason not to apply pumps in space on commercial satellites.
- Single-point of failure: pump failure is spacecraft failure.
- Robust space pump technology is required.

Concept solution

- Multi-parallel micro pump
- Many micro pumps operate together in a pump assembly.
- One pump failure is not an issue anymore. \( \frac{n-1}{n} \) Pump capacity is still available.
- The number of micro pumps in the pump assembly is tailored to the flow and pressure head requirements.

Micro pump working principle

- Discharge stroke (left) and suction stroke (right) through a reciprocating diaphragm motion.
- Piezo electric disk actuates the micro pump.
- Passive check valves control the flow direction.

Micro pump prototyping using SLM

- SLM parts that are laser welded are leak tight < 1 \cdot 10^{-9} \text{ mbar l/s}.
- Quality control using X-ray micro-CT.

Design optimized for SLM

- Modular design with stackable disks.
- Bottom part with standardized 51 pins electronics connector.
- This concept has 6 micro pumps in 3 layers.
- Targeted flow rate = 20 ml/min and pressure head = 250 mbar.
- Total weight is 103g; each additional disk add \(-25g\).

SLM production of parts

- Parts are produced with selective laser melting.
- Local post processing to enable laser welding.

Conclusions

- Live testing is on-going.
- Concept is patent pending.
- One design fits all.
- Tailorable to meet various flow and pressure head requirements.
- Non-destructive testing using micro-CT can also be used for automated quality control.
- Additive manufacturing is a game changer for space applications.
- SLM can meet the stringent requirements for this application.
- Novel robust pump technology only manufacturable using SLM.
- 90% overall weight reduction is projected.