Public Executive Summary of the Open Space Innovation Platform Project leaded by Vulkam with TCBV and Lynred

"Amorphous metals, a game changer to improve the efficiency of Space Cryocoolers"

ESA/TCBV/Lynred/Vulkam
30/11/2022

www.vulkam.com

VULKAM amorphous metal

The Program in a nutshell

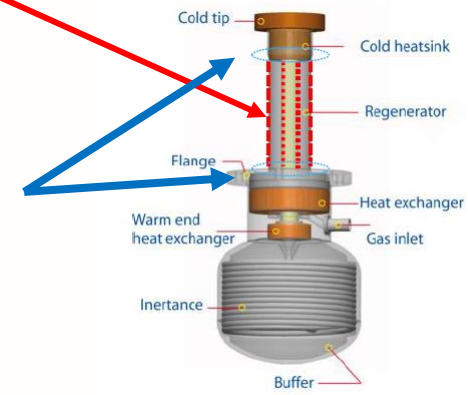
- Vulkam, a French high-tech start-up specialized in amorphous metallic alloys (AMA), has developed a **new range of materials** with mechanical and thermal properties superior to those of Ti6Al4V. Vulkam is the only European company focusing on the industrialization and optimization of amorphous metals.
- As we know, improving the efficiency of a cryogenic cooler is of **great interest to ESA**. Heat conduction losses in the cold finger of cryogenic coolers are one of the main causes of their **lack of efficiency**.
- **Vulkam**, **Lynred** and **Thales Cryogenics** have proposed to ESA a 12 months OSiP evaluation study to assess the potential of these new materials in compact space cryocoolers.

Main Steps conducted during the study:

1. **Theoretical study**: thermal analysis on current product, design and structural analysis of PoC demonstrator, approval approach baseline proposal
2. **Joining optimisation** and qualification of the brazing method on simple parts
3. **Manufacturing of parts** and assembling demonstrators (+vérifications)
4. **Testing** of final samples

The intended application is to replace metal thin-walled circular pipes in either Stirling or Pulse tube cold fingers by a thin-walled tube manufactured from AMA material.

Required helium tight connections between the thin-walled pipes and the Pulse Tube structure



Main results and achievements

1. **The great expectations about thermal conductivity / losses and general behaviour of the Vulkalloy Zr4 have been validated**

   ➔ Consistency between thermal analysis and thermal loss evaluation on demonstrators : 1,8 reduction achieved
   ➔ More than 50% of reduction of thermal parasitic losses
   ➔A significant increase of 'available cooling power' for the same input power

2. **For the first time, deep understanding of brazing behaviour between an amorphous metal and different cristalline alloys has been achieved**

   ➔ Preparation process and metallization have been improved for Vulkalloy® and each materials in regards of Vulkalloy® : An optimal configuration has been found for each base material thanks to this study
   ➔ Manufacturing of parts used for demonstrators have been planned according to the results of this study

3. **Mechanical performance testing not yet conclusive… But we have some significant clues for further investigation**

   ➔ One of the tested configuration appear promising (not far from passing)
   ➔ Joints are points with lowest MOS, not the AMA pipe
   ➔ Multiple isolated key findings will lead to compliancy if properly assembled

4. **Conclusion & perspectives:**

   ➔ Thermal analysis shows significant improvement on thermal efficiency and performance, demonstrated by boil-off measurements on samples
   ➔ Process optimizations, analysis and qualifications necessary on final application