

Utilization of Conformal Cooling Channels in Spacesuit Design

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Introduction:

- The LCVG(Liquid Ventilation and Cooling garment) is used to maintain the body temperature and pressure. The study aims at efficiently replacing the conventional cooling channels to conformal cooling channels, as a way to sustainability.
- We aim to develop a system that is more efficient and increases the thermal conductivity.
- This can define how space based research can help us on Earth for developing efficient cooling systems, for refrigerators, buildings and uniform for surgeons and miners.

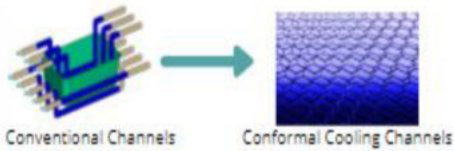


Fig 1: Conventional Channels to Conformal Cooling Channels



Fig2: Layers in a spacesuit showing the tubing(Courtesy: <https://www.deathwishcoffee.com/blogs/news/space-science-the-history-of-spacesuits>)

- The design focuses on one of most sturdy structures found in nature i.e. hexagonal shapes. The pipe follows a hexagonal path allowing for maximum heat exchange and maximum flow of coolant throughout the system of pipes as compared to channels in conventional cooling.

Analysis:

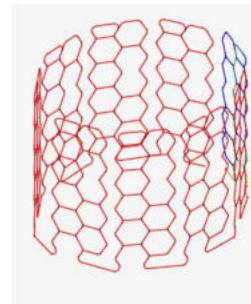


Fig. 5 Overall temperature of the pipes at the end of the simulation

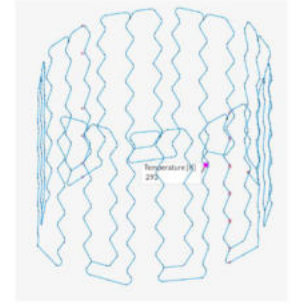


Fig. 6 Flow channels of the water along with temperature at the outlet.

Literature:

- Currently, in the space suit design, materials like ortho-fabrics, aluminized nylar, nylon, dacron etc are used. There are 11 layers in the suit.
- We are aiming at replacing the currently used straight liquid tubes by lattice structure-based tubes, which increases the heat transfer rate. In addition to this, the lattice structure provided a much more ergonomic solution to the suit, which can be worn much easily.
- As a scope for further improvement for cooling, currently used ammonia can be used as a replacement for CFCs, which are currently used in refrigeration. With the use of the proposed channel, and improved coolant we can move towards a sustainable system.



Fig 3: Current LCVG system

Results:

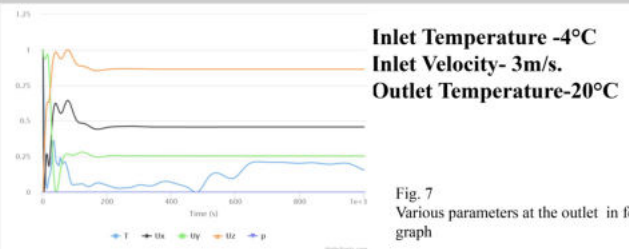
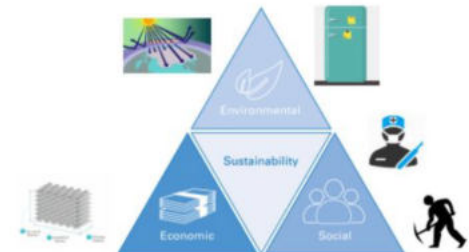


Fig. 7 Various parameters at the outlet in form of a graph

Conclusions:

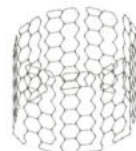
The space based research can help is on earth in an efficient manner of cooling, with lesser materials and optimized systems. Overall optimization of such systems with eco friendly coolants, and identification of integrated simulations for further identification.



Methods:

Design and analysis flow for the channels

Prior Art Search	1
Material Selection	2
Method determination and Comparison	3
Design of channels	4
Analysis	5



We have developed a lattice structure -based conformal cooling design as opposed to a tube-based structure, owing to the advantages that lattice structures provide in cooling, stated below:

- Higher surface area to volume ratio
- Periodic lattice cores have better cooling performance
- Ideal for thermal management
- Highly efficient cross-flow heat exchange



Fig. 4

Important References:

- Motahareh Mokhtari Yazdi and Mohammad Sheikhzadeh, Personal cooling garments: a review, 2014, Journal of Textile Institute, Vol. 105, 1231-1250
- Victor S. Koscheyev et al., The Advanced Design of a Liquid Cooling Garment Through Long-Term Research: Implications of the Test Results on Three Different Garments, 2009, International Conference of Environmental Systems
- Daniel El Murphy et al. Advanced Liquid Cooling and Ventilation Garment Using Thermally Conductive Tubing, 2019, 49th International Conference on Environmental Systems