Comparative Investigation of Ceramic Materials for Enhanced Thermal Management in Micro Heat Exchangers

📍 **Overview:**

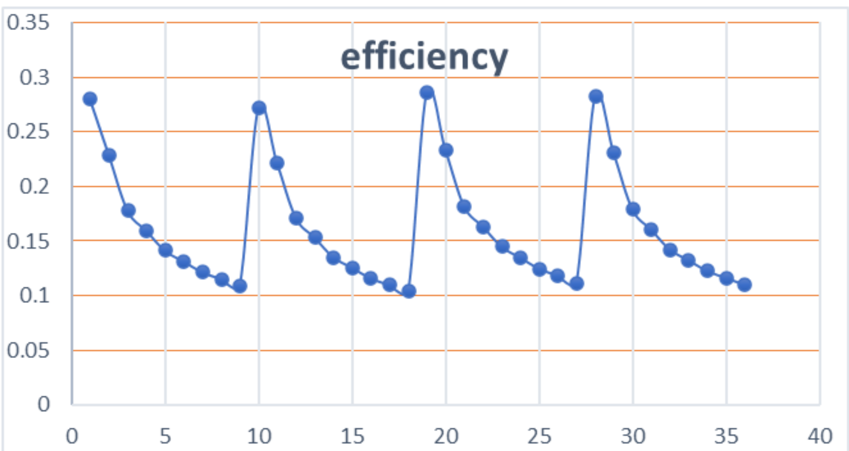
This project explored advanced ceramic materials : **HZSC (Hafnium Zirconium Silicon Carbide)**, **ZrB_2 (Zirconium Diboride)**, and **TiB_2 (Titanium Diboride)** to enhance the performance of **Micro Heat Exchangers (MHEs)** using CFD simulations. These materials were evaluated based on thermal conductivity, heat transfer efficiency, pressure drop, and mechanical stability, aiming to optimize MHE designs for high-efficiency cooling systems in automotive, electronics, and renewable energy sectors.

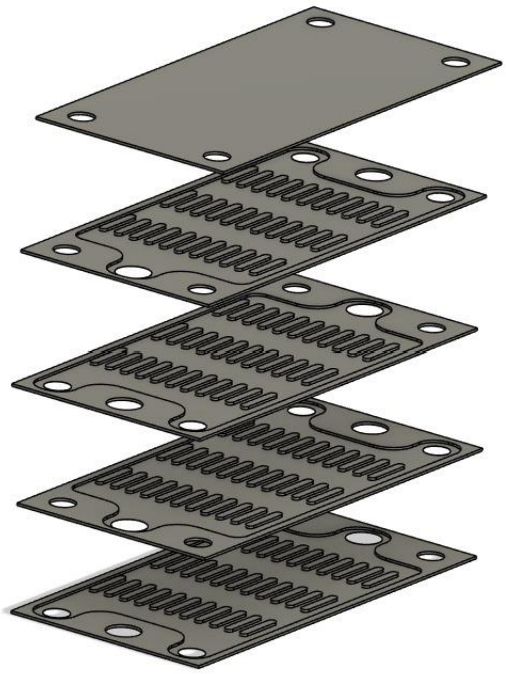
🎯 **Key Objectives:**

- Compare thermal and mechanical properties of selected ceramics.
- Evaluate heat transfer performance in various microchannel geometries.
- Identify the most efficient material and channel design for industrial thermal applications.

🛠 **Methodology:**

- CFD simulations using **ANSYS Fluent** with **water** as the working fluid.
- Analyzed **triangular, circular, and rectangular microchannel profiles** for performance variations.
- Compared ceramics using metrics: thermal conductivity, pressure drop, mechanical strength, and efficiency.





📊 **Findings:**

- **TiB_2** emerged as the most effective material, offering **high thermal conductivity** and **mechanical robustness**.
- **Triangular microchannels** had the best heat transfer but suffered from higher pressure drops.
- **HZSC** offered low conductivity but minimized pressure loss ideal for low-resistance flow systems.

📌 **Conclusion:**
TiB_2, paired with optimized triangular microchannel geometry, provides a superior solution for high-performance MHEs. This research lays the groundwork for energy-efficient, durable, and compact heat exchangers in modern engineering applications. Future exploration could involve **TiB_2 combined with nanofluids** for further enhancement.