Proceedings of the Canadian Society for Mechanical Engineering International Congress
32nd Annual Conference of the Computational Fluid Dynamics Society of Canada
Canadian Society of Rheology Symposium
CSME-CFDSC-CSR 2025
May 25–28, 2025, Montréal, Québec, Canada

Effect of Temperature and Heating Rate on Rock Thermal Properties

Adel Ahmadihosseini[1*], Agus Sasmito[2], Ferri Hassani[2], Leyla Amiri[1]
[1]Mechanical Engineering, Université de Sherbrooke, Sherbrooke, Canada
[2]Mining and Materials Engineering, McGill University, Montreal, Canada
*adel.ahmadihosseini@usherbrooke.ca

ABSTRACT

Understanding rock thermal properties is essential for industries that rely on heat transfer in rock-based materials. These properties are particularly critical in applications with extreme temperature variations and rapid heating rates, such as geothermal energy systems, rock thermal energy storage, and microwave-assisted rock treatment. However, accurately characterizing these properties presents challenges due to the inherent heterogeneity of rock minerals. This study investigates the thermal behavior of basalt and copper ore through over 100 characterization experiments, including Differential Scanning Calorimetry (DSC) for heat capacity, Laser Flash Analysis (LFA) for thermal diffusivity, and Thermomechanical Analysis (TMA) for thermal expansion coefficient measurements. Each test was conducted following ASTM standards, carefully considering sample preparation and experimental procedures. Results demonstrate that rock thermal properties highly depend on temperature and heating rate. Notably, exothermic and endothermic transitions were observed, indicating phase changes that significantly affect data interpretation. Higher heating rates were found to delay phase transitions, emphasizing the need to account for heating conditions in thermal property analysis. These findings have important practical implications: while many applications typically experience gradual temperature changes (approximately 10°C per minute), there exist other applications, such as microwave treatment, that can induce orders of magnitude increase in heating rates exceeding 1000°C per minute, leading to localized thermal stresses and phase transformations. This research underscores the necessity of incorporating both temperature and heating rate effects when evaluating rock thermal properties. A more comprehensive understanding of these factors can enhance predictive models and optimize thermal processes in rock engineering applications.