Thermal instabilities in a Liquid Metal Battery.

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Efforts towards reducing the carbon footprint due to human activities have accelerated the growth of research and implementation of renewable sources of energy. Since the electric grid does not have the capacity to store the electrical energy generated by such intermittent sources. The development of reliable systems of energy storage represents a big technological issue. There exist different systems (electrochemical, compressed air energy storage, hydraulic, etc.,) to store electrical energy, each having its own advantages and disadvantages related to the storage capacity, the storage duration, the cost and life cycle. This gives room to develop a new system of energy storage and one proposed such system is Liquid metal battery (LMB). A LMB is a system of super imposed non-miscible three fluid layers in stable density stratification. The top electrode is made of pure liquid alkaline metal, bottom electrode is made of dense liquid metal alloy. These layers sandwich the electrolyte layer made of molten salt [1]. LMBs have been a center of interest since the past decade and there have been several theoretical and numerical studies showing that electrical and magnetic fields can generate flows that can short circuit a LMB when the interfaces deform largely and the two liquid electrodes come in contact [2].

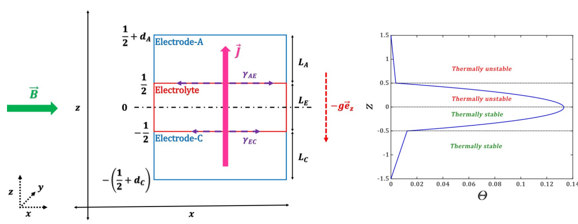

Figure 1. Geometrical configuration of a LMB and the conduction state temperature profile. This arises due to difference in thermal conductivites of electrodes and electrolyte.

The present work is focused on sources of thermoconvective (Rayleigh-Bénard) and thermocapillary (Marangoni) instabilities. The electric current applied across the LMB generates an internal heating in the electrolyte, this creates a temperature unstable stratification leading to internally heating-driven convection, which can affect the performance of a LMB. We have studied the thresholds of thermal convection for different electrode thickness and the external heat exchange. The variation of interfacial force due to temperature difference and their effects on thresholds of thermal convection, and the effect of an imposed external horizontal magnetic field. From these thresholds, for a LMB where the electrodes have the same thickness as the electrolyte, we try to identify the dimensional thickness that a LMB needs to be developed such that high densities of current can be applied and at the same time have the least parasitic Ohmic voltage losses.

References

1. H. Kim, D. A. Boysen, J. M. Newhouse, B. L. Spatocco, B. Chung, P. J. Burke, D. J. Bradwelln K. Jiang, A. A. Tomaszowska, K. Wang, WE. Wei, L. A. Ortiz, S. A. Barriage, S. M. Poizeau & D. R. Sadoway, *Chem. Rev.*, **113(3)**, 2075-2099 (2013).
2. D. Agarwal, R. Potnuru, C. Kaushik, V. R. Darla, K. Kulkarni, A. Garg, R. K. Gupta, N. Tiwari & K. S. Nalwa, *Renew. Sustain. energy Rev.*, **158**, 112167 (2022).