Multiphysics Modeling Of Magnetohydrodynamics Power Generation

Merouane Khammar[1], Lijun Wu[1], Seven Chen[1], Philip Geddis[1]

[1]Natural Resources Canada

Abstract

The gravitational liquid-metal magnetohydrodynamic (LMMHD) power conversion system is a potential technology for the conversion of waste heat into electrical energy. In this system, A magnetohydrodynamic (MHD) generator converts the kinetic energy of liquid metal flow into electrical energy. This study uses Comsol Multiphysics to simulate the MHD power generator designed to operate in the LMMHD power conversion system.
Figure 1 shows a three-dimensional view of the LMMHD generator, while Figures 2 and 3 show cut-out views along the y-z and x-y plans, respectively. The generator comprises a flow channel with a rectangular cross-sectional area where liquid metal flows along the z direction. A magnetic field generated by permanent magnets is applied along the y direction. Sixteen electrode pairs positioned on both sides of the flow channel are connected to an external load. The flow of liquid metal through the magnetic field induces an electric current between the electrodes in the x direction.
The governing equations of the LMMHD generator solved in COMSOL are the electromagnetic equations and the hydrodynamic continuity and momentum conservation equations. Lorentz force is applied on the liquid metal flowing through the magnetic field. The CFD module is used to simulate liquid metal flow and the AC/DC module is used to simulate MHD power generation resulting from the flow of liquid metal through the permanent magnetic field.
A no slip boundary condition is imposed on the walls of the channel including the surfaces of the electrodes. A constant velocity boundary condition is used at the inlet of the generator, and a constant pressure is used at the outlet. All walls of the MHD channel are electrically insulated except for the electrode surfaces. An external resistance is connected to the electrodes using the electrical circuit interface.
The distributions of the electric current density, magnetic field and liquid metal velocity in the flow channel are presented. Various power loss mechanisms are quantified and their impact on the efficiency of the generator are assessed. The influence of the magnetic field and load resistance on the generator's performance is also analysed.

Figures used in the abstract

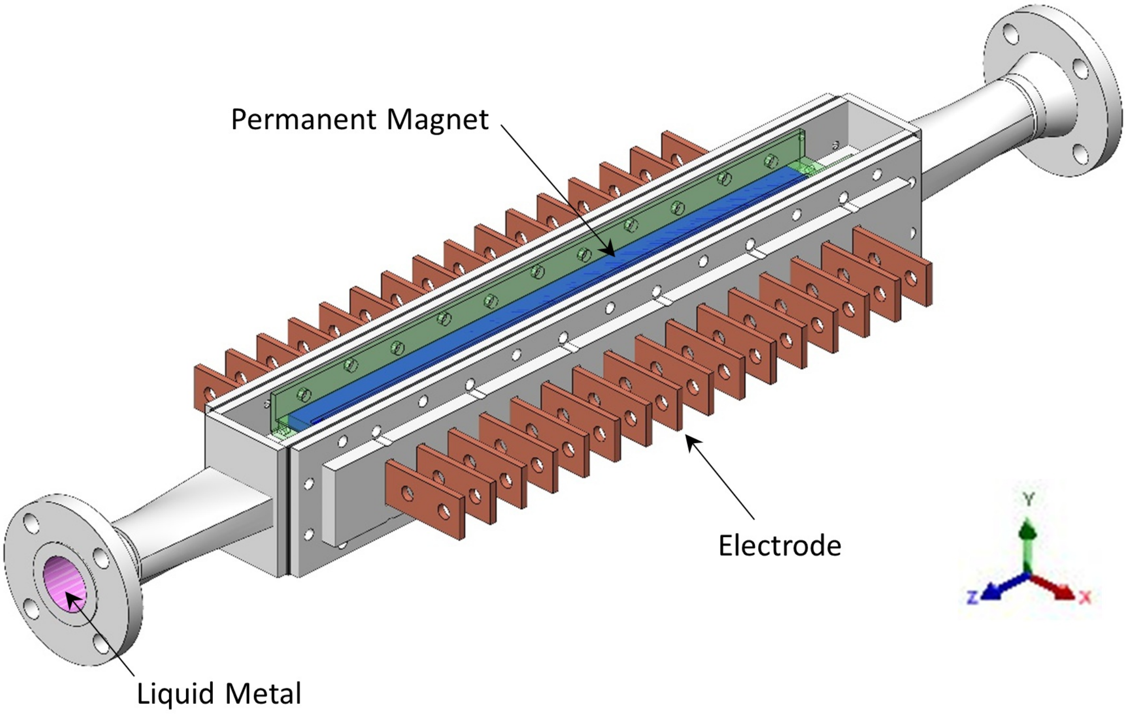

Figure 1 : Assembly drawing of the MHD generator

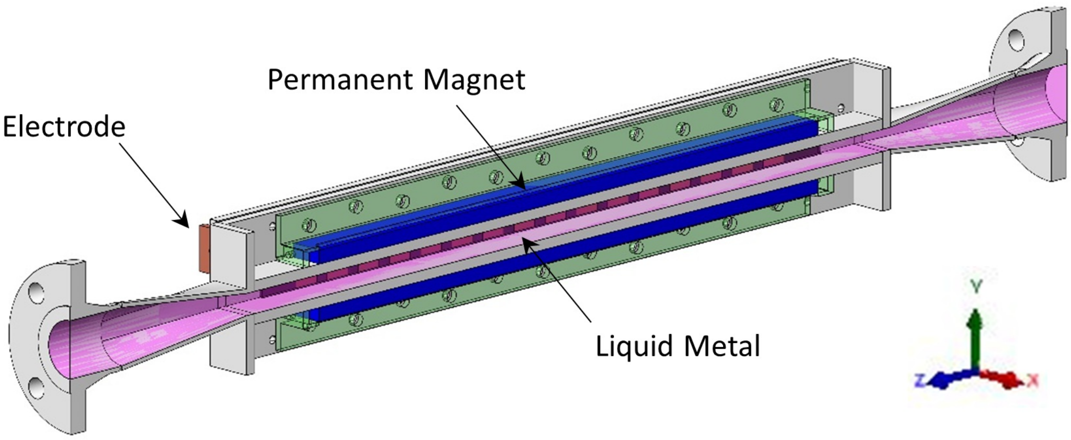

Figure 2 : MHD generator 3D view with cut-out section along the y-z plane

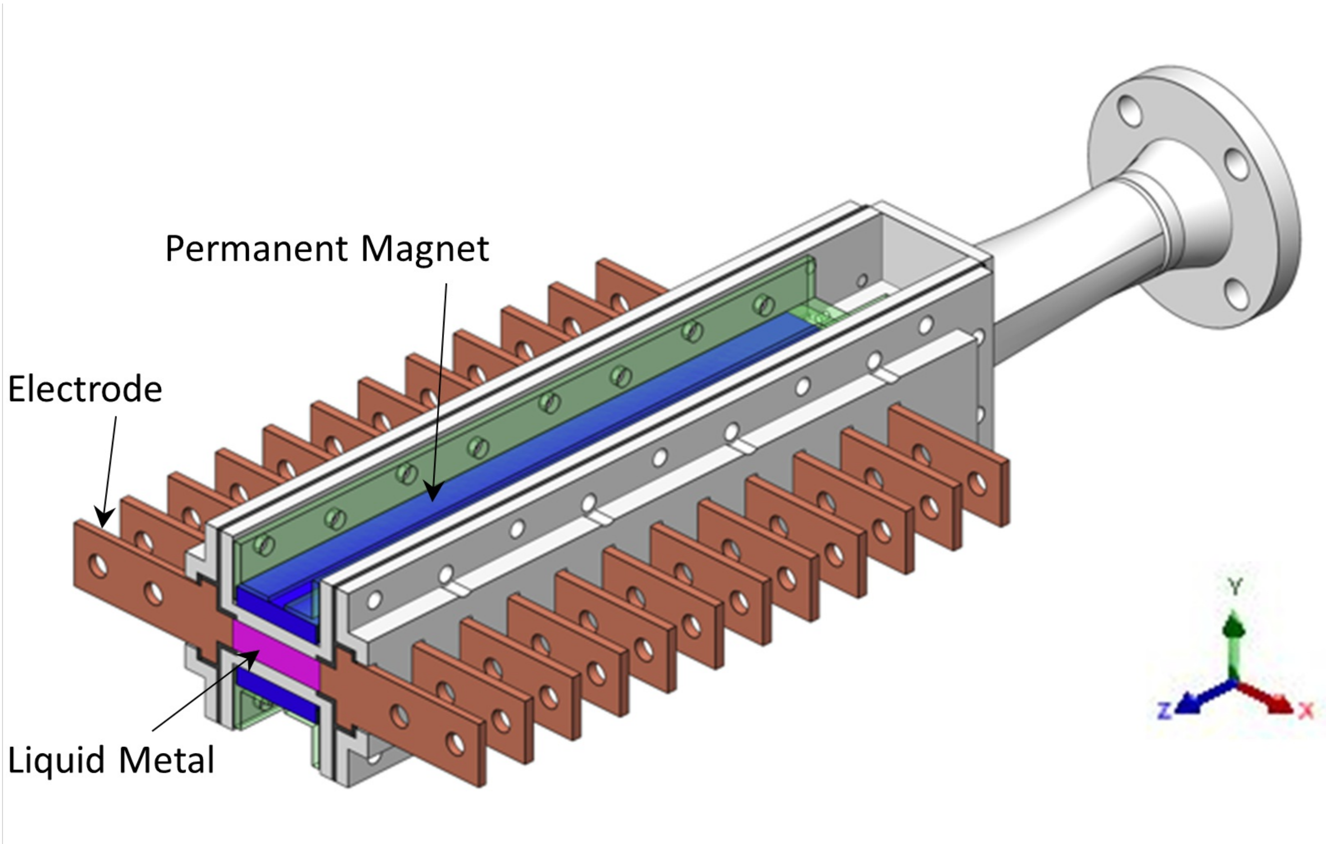

Figure 3 : MHD generator with cross-section cut-out view along the x-y plane