Investigation of Energy Conversion Efficiency in Railguns

Rutgers University

Abstract

This study explores the creation of an electromechanical efficiency model for railguns. Railguns in essence are objects that can shoot a conductive projectile. They are composed of parallel conductive rails, a conductive projectile, and capacitors as a power source. The projectile is propped on the rails, and when capacitors discharge their energy through the rails and projectile, it starts to move. This is due to the fact that the current flowing through the rails induces a magnetic field, which accelerates the current-carrying projectile. However, during this whole process, significant amounts of energy are lost. Railguns can be considered RLC circuits, which consist of a resistor, inductor, and capacitor. Although railguns are not conventionally RLC, there are already existing mathematical models for these circuits that describe the current's behavior and ultimately the output energy when the capacitors discharge. By using this model as a starting place for creating a new model, the student created predictive, theoretical equations for what the output energy of the projectile will be. After he built his own working railgun and tested how the energy behaved during energy conversion from the capacitors to the projectile, he found that the existing model using RLC circuits does indeed accurately describe the energy efficiency to a certain point, but it does not consider an additional mechanical loss: friction. Experimental results showed that friction was a significant factor in the energy transfer, and after adjusting the existing equations to account for variable frictional losses, the student created a more accurate model that correctly predicts the output energy efficiency of railguns.