Analytical Interpretations of Geophysical Fluid Mechanics in Coaxial Borehole Heat Exchangers and Respective Applications

Lee, Richard (School: Manhasset High School)

As only 11% of current energy consumption within the United States is renewable, this study investigated means by which geothermal energy may be an effective sustainable heat source for buildings via heat exchangers in boreholes. By utilizing a novel coaxial borehole heat exchanger configuration, geothermal energy output potential was modeled using engineered scripts in both Mathematica and Python. Results from simulations were then run concurrently in Transient System Simulation Tool (TRNSYS) to determine and validate simulated results. With simulations built upon derivations of Navier-Stokes and thermodynamic models for geothermal wells, this study depicted high potential for geothermal energy to be a source of renewable thermal energy. With a growing population dependent on heating and cooling units powered by nonrenewable natural resources in mind, it was also found that geothermal wells configured with coaxial borehole heat exchangers may provide the most optimized means of generating sustainable heat energy, as compared to other borehole heat exchanger designs, due to increased enclosed heat flux and thermal outlet. Ultimately, results depicted a geophysical, linear trend between temperature and depth given a consistent geothermal gradient, and subjectivity of geothermal heat exchanger designs to seasonal temperature gradients.

Awards Won: