Designing a Small Borehole Drill String for a Sonic Drill Rig

Overview
Thar Geothermal has developed geothermal heating and cooling systems that use a natural refrigerant with enhanced energy efficiency and a reduced environmental footprint. A cost effective method to install a ground heat exchanger would expand market opportunities. The project evaluates the potential of a Thar Geothermal sonic drill rig design to meet this need by drilling sub 3” diameter boreholes, economically.

Objective
To validate the solidity of Thar Geothermal’s theoretical, sonic drill rig design:
- Develop a 3D model of sonic drill
- Stress and strain analysis on the drill pipe
- Harmonic analysis of the drill pipe
- Drilling capability

Approach
- After consulting with Thar Geothermal, the team learned that the sonic drill will be used for small diameter holes. Currently, there is no market for drilling holes small diameters and at depths less than 300 feet. When the team conducted an official onsite visit, Thar has an interest in this type of drilling because of its unique R744 DX geo systems. For example, talk about how you gathered the customer needs and/or requirements
- It was necessary to create an Analytical Hierarchy Process, or AHP, matrix to determine the focus of the project and weight the customer needs. The AHP matrix concludes that accuracy, reliability, and ease of use are the most important needs
- The team should pay close attention to patent US 6739410 B2 because Thar’s representative indicated he wanted a design that would use a similar feature for counter-rotating masses
- Using the ANSYS software for the theoretical prototype, the team performed a series of tests utilizing model created in SolidWorks. In order to model the modal shapes accurately, equations gained from the motor output were applied to the ANSYS model. A spring on the bottom of the pipe is used to model the stiffness and the damping of the geology. The spring on the top models an actual spring on the drill head mount. The team was only interested in the axial modal shapes the drill pipe was experiencing.
- A taguchi array was used to narrow the number of runs down to 8. The ANSYS model yields the following data for each run: stress and strain that the drill pipe are experiencing along with the actual displacement of the drill bit
- The results were validated by comparing the team’s final results to the known, geological failure of limestone and sandstone, along with the yield strength and fatigue strength of 4130 steel (standard metal in drill applications)

Outcomes
In conclusion, the team has verified that this method of electric sonic drilling is feasible for geologies of sandstone and limestone. The drill piping recommendations show a specific range of 40-80 scheduled, 2.5-inch diameter piping of 4130 steel. The depth can range from 100 to 300 feet and can be used for both limestone and sandstone.