EXPERIMENTAL DATA ACQUISITION AND ANALYSIS OF AN UNDERGROUND THERMAL STORAGE MEDIUM

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Introduction to Ground Source Heat Pumps

A ground source heat pump (GSHP) is a system that uses the ground as a heat source/sink to provide heating/cooling to a conditioned space. During the winter, a GSHP uses a heat pump cycle to move heat from the ground into a space in order to heat it. In the summer, the space is cooled as heat is pumped out of the space and back into the ground. GSHPs are a sustainable alternative to conventional HVAC systems because they do not rely on direct fossil fuel consumption, and they are highly efficient as they move heat rather than generate it. In addition, the temperature of the ground remains constant throughout the year, resulting in a greater thermal efficiency, and therefore less energy consumption.

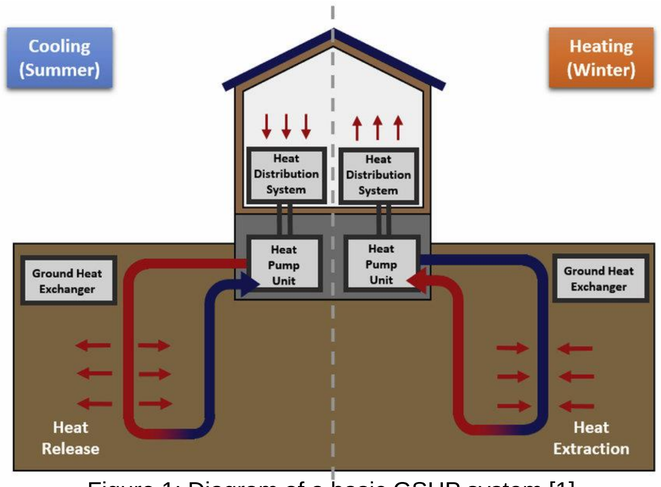


Figure 1: Diagram of a basic GSHP system [1]

Research Problem

There are three main problems surrounding the use of GSHPs:

1. GSHPs are complex and expensive systems that use heat exchangers that are placed inside a borehole drilled deep into the ground. Their installation requires specialized equipment and expertise which result in high costs.
2. Some buildings require greater amounts of heating than cooling, or *vice versa*. In these cases, there is a surplus of heat that is extracted from or pumped into the ground and over time, this thermal imbalance causes the temperature of the ground to change, resulting in decreased efficiency of the GSHP and greater power consumption.
3. Boreholes must be spaced widely apart in order to properly distribute heat in the ground, resulting in a need for a large drilling space that many potential installations lack.

Methodology

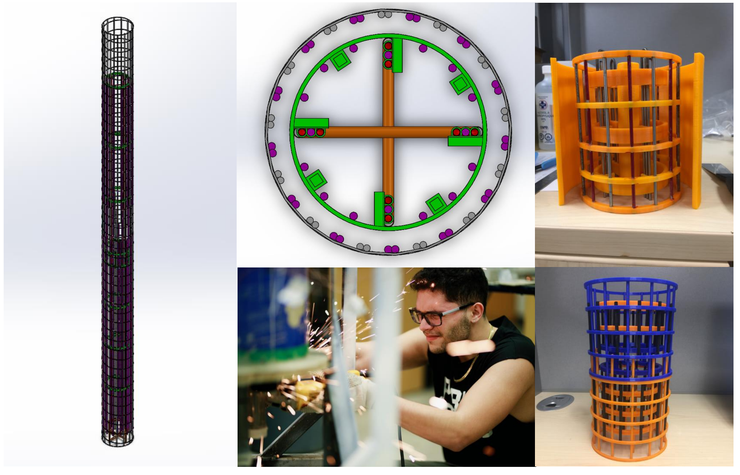
The problems mentioned above can be solved by developing new thermal storage media for GSHP systems that incorporate phase change material (PCM) and heat exchangers into a structural caisson. Structural caissons serve as necessary foundation for buildings, so by installing heat exchanger loops and PCM into pre-existing building foundation, the cost of installing GSHPs is drastically reduced since there is no longer a need to pay for the drilling of separate boreholes. By using PCM as a thermal storage medium, the proposed system will perform better than current GSHP systems due to larger amounts of heat transfer as well as the maintenance of the ground temperature, even when the heating and cooling needs of the building are not balanced. According to numerical models, the monthly performance of the system is expected to be up to 35% greater than conventional systems. In addition, the proposed system will provide significant environmental benefits due to reduced usage of natural gas for space heating and therefore reduced CO_2 emissions.

A demonstration of the proposed system is currently being installed in Caledon, Ontario in collaboration with an industry partner, McClymont & Rak Engineers. The performance of this system will be experimentally monitored using thermocouples and flowmeters to measure inlet and exit water temperatures and flow rates, which will be used to calculate the energy transfer rates to and from the ground. These results will be used to validate numerical models and optimize the system.

My Contributions

My contributions to this research include:

- Performing hydrostatic pressure calculations to find a range of suitable depths at which the system can operate safely under various conditions
- Assisting in the setup of a bench-scale experimental thermal caisson system
- Producing an extremely detailed CAD model of the thermal caisson including assembly drawings and assembly videos
- Writing and troubleshooting a LabVIEW data acquisition program to read and save experimental data for a bench-scale thermal caisson system
- Creation of a miniature 3D-printed model of the thermal caisson for demonstration purposes



Figures 2-6: Pictures of thermal caisson CAD model, 3D printed models, and me assisting in the setup of a bench-scale test

References

[1] reproduced from https://www.researchgate.net/figure/Concept-of-the-ground-source-heat-pump-GSHP-system-for-space-heating-and-cooling_fig1_324242798

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