Ground-Source Heat Pump Coil Optimization

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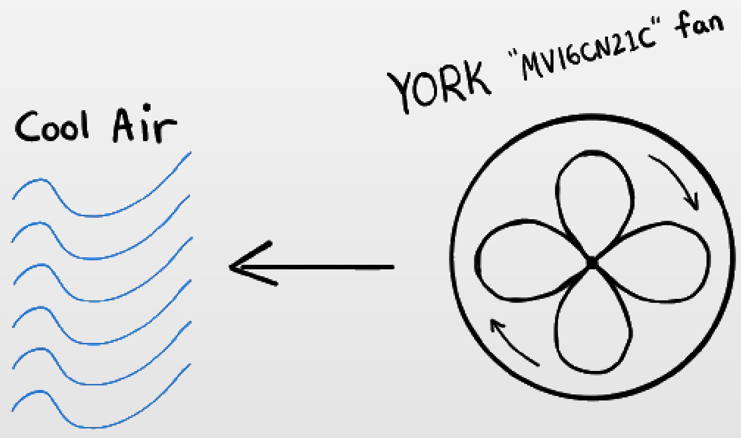
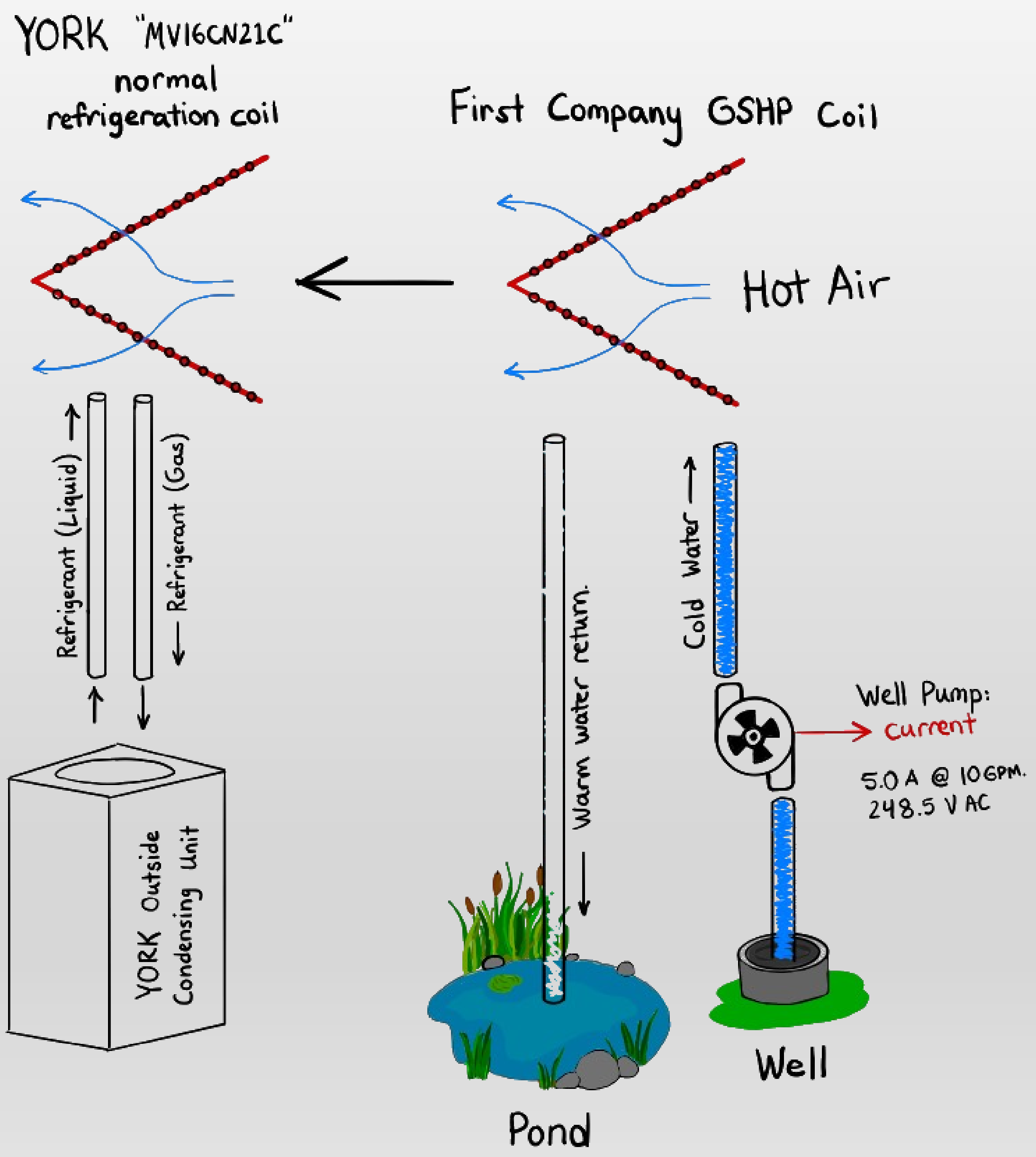
for: MATH 319

Airflow Diagram





1. Simplistic model (no pump startup cost)

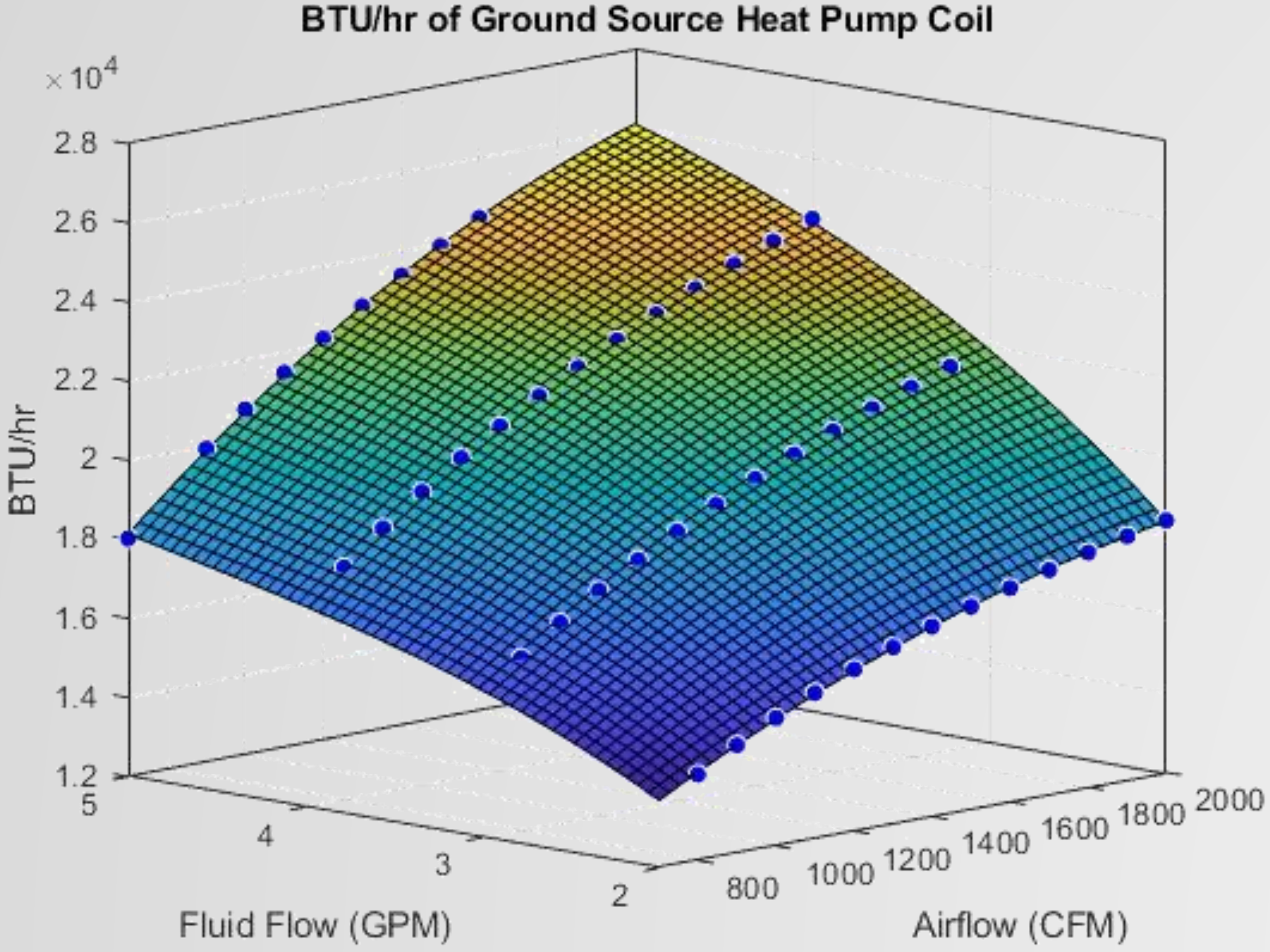
$$C_{pump} = 2.070833 \cdot 60 \cdot (GPM)$$

2. Advanced model (w/ pump startup cost)

$$C_{pump} = 500 \times \frac{(GPM)(10 - GPM)}{6.0383} + 2.070833 \cdot 60 \cdot (GPM)$$

System Characterization

BALTIMORE AIRCOIL COMPANY



The heat transferred from the coil is:

$$
\begin{aligned}
Q_{coil}(\overline{x}) = &-0.102(CFM)^2(GPM) \\
&-0.0005(CFM)(GPM)^2 \\
&+1.7 \cdot 10^{-6}(GPM)^3 - 63.21(CFM)^2 \\
&+2.948(CFM)(GPM) - 0.0846(GPM)^2 \\
&+15.766(GPM) + 2328.35
\end{aligned}
$$

System Characterization

We seek to minimize:

$$\min \quad J(\overline{x}) = \frac{C_{fan}(\overline{x}) + C_{pump}(\overline{x})}{Q_{coil}(\overline{x})}$$

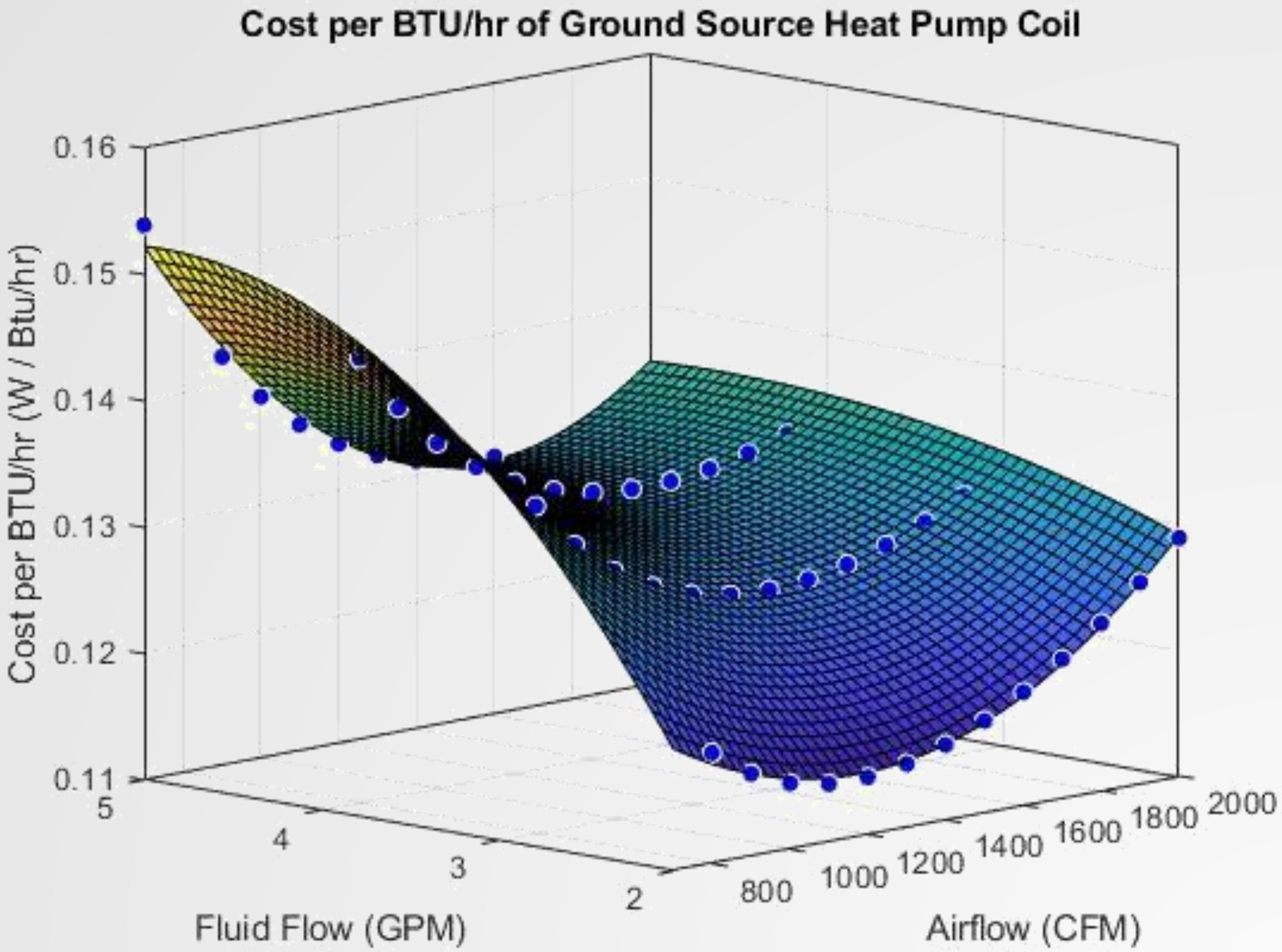
$$\text{w.r.t.} \quad \overline{x} = \{CFM, GPM\}$$

$$\text{s.t} \quad Q_{coil}(\overline{x}) \geq 18{,}000$$

$$688.5 \leq CFM \leq 1524$$

$$0 < GPM \leq 5$$

where J(x) is the cost function in W / Btu/hr, and $C_{fan}(x)$, $C_{pump}(x)$, and $Q_{coil}(x)$ are defined as shown to the right.



Algorithm Selection and Analysis Tool

Key criteria used when selecting the optimization algorithm:

- Repeatable convergence to optimum value.
- Ease of use.
- Low computational demand.

! GRG ! (generalized reduced gradient)

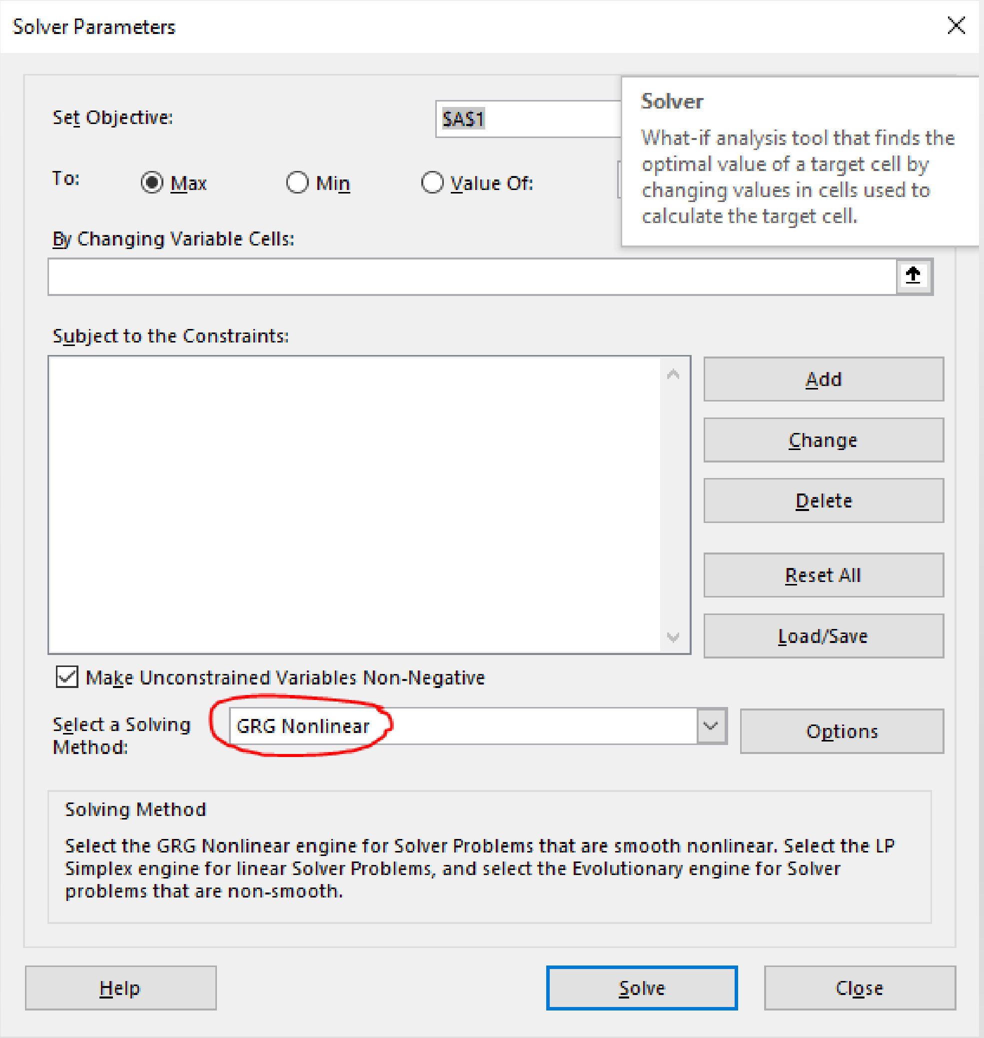
aka… the method of feasible directions.

Advantages:

- Fast convergence
- Implemented in Excel.

Disadvantages:

- Dependent on IC’s
- Needs smooth, continuous functions.



Optimization Results

Our optimization led to a constrained minimum of:

$J(\overline{x}) = 0.1198 \;\; \mathrm{W/(Btu/hr)}$ located at:

$\overline{\mathrm{x}} = \{1518.95, 2.308\}$

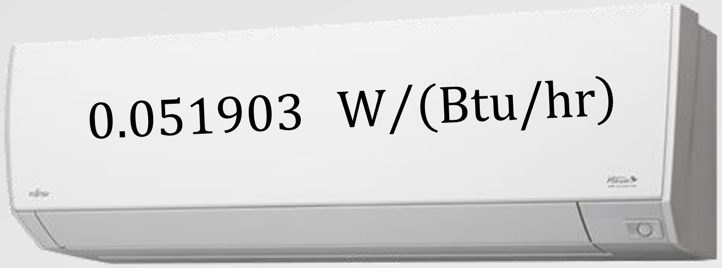
Assumptions made:

1. Efficiency of coil.
2. Pump starting power.

No startup power: $J(\overline{x}) = 0.031965 \;\; \mathrm{W/(Btu/hr)}$

(pressurized system)

Breakeven point: $\mathrm{W_0} = 78.42 \; \mathrm{W}$



$0.051903 \;\; \mathrm{W/(Btu/hr)}$

$0.11812 \;\; \mathrm{W/(Btu/hr)}$

Questions?

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or…. message me on teams.