Ground Source Heat Pump Coil Optimization

Caleb Froelich MATH 319/ENGR 419 05/22/2020

```
clear variables, close all
clc
```

Data:

```
BTU = [18017;19920;20727;21464;22144;22777;23369;23926;24453;17870;18679;
       19410;20079;20696;21269;21806;22310;22785;23235;23662;24068;24455;
       16352;17056;17693;18273;18808;19302;19763;20193;20596;20975;21332;
       21669;14176;14734;15232;15681;16089;16461;16801;17115;17404;17672;
       17930;18158;18369];

costperBTU = [0.153916531; 0.142329776; 0.138597609; 0.135786440; 0.133699045;
       0.132196828; 0.131189467; 0.130602280; 0.130377363; 0.145212946;
       0.140701046; 0.137334278; 0.134840671; 0.133048770; 0.131834728;
       0.131097512; 0.130781526; 0.130834467; 0.131211312; 0.131883625;
       0.132826568; 0.134018129; 0.135903402; 0.132240380; 0.129599018;
       0.127773377; 0.126590516; 0.125962591; 0.125793120; 0.126037385;
       0.126645971; 0.127581975; 0.128819024; 0.130333976; 0.118793799;
       0.116548147; 0.115199835; 0.114567400; 0.114528118; 0.115002636;
       0.115932260; 0.117253952; 0.118945581; 0.120968786; 0.123240150;
       0.125891364; 0.128830034];

CFM = [700; 900; 1000; 1100; 1200; 1300; 1400; 1500; 1600
       800; 900; 1000; 1100; 1200; 1300; 1400; 1500
       1600; 1700; 1800; 1900; 2000; 800; 900; 1000
       1100; 1200; 1300; 1400; 1500; 1600; 1700; 1800
       1900; 800; 900; 1000; 1100; 1200; 1300; 1400
       1500; 1600; 1700; 1800; 1900; 2000];

GPM = [5; 5; 5; 5; 5; 5; 5; 5
       5; 4; 4; 4; 4; 4; 4; 4
       4; 4; 4; 4; 4; 4; 3; 3
       3; 3; 3; 3; 3; 3; 3; 3
       3; 3; 2; 2; 2; 2; 2; 2
       2; 2; 2; 2; 2; 2; 2];
```

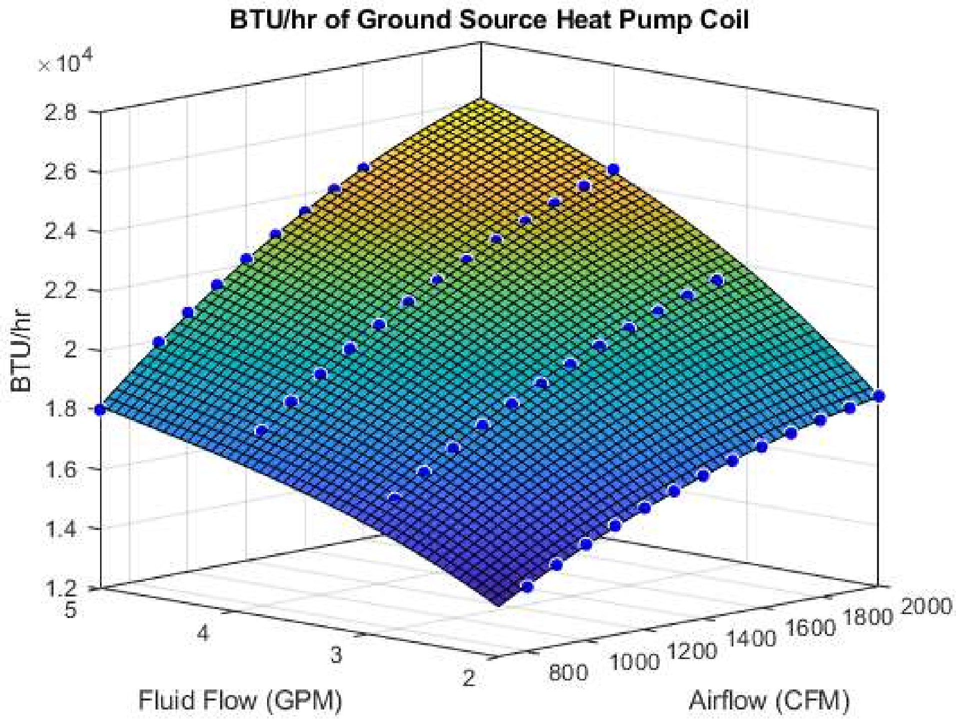
Fit a surface to predict BTU as a function of CFM and GPM.

Using a linear model:

```
% Set up fittype and options.
ft = 'poly23';

% Fit model to data.
[fitresult1, ~] = fit( [CFM,GPM], BTU, ft, 'Normalize', 'on' )
```

```
% Plot fit with data.
figure( 'Name', 'Cost Per BTU' );
plot( fitresult1, [CFM,GPM], BTU );

% legend( h, 'Cost per BTU', 'BTU vs. CFM, GPM', 'Location', 'NorthEast', 'Interpreter', 'none'
);
% Label axes
title( 'BTU/hr of Ground Source Heat Pump Coil' );
xlabel( 'Airflow (CFM)', 'Interpreter', 'none' );
ylabel( 'Fluid Flow (GPM)', 'Interpreter', 'none' );
zlabel( 'BTU/hr', 'Interpreter', 'none' );
grid on
view( -46.3, 11.8 );

fprintf('BTU/hr as a function of CFM and GPM is: \n' )
fprintf('%.2f + %.2f*x + %.2f*y + %.2f*x^2 + %.2f*x*y + %.2f*y^2 + %.2f*x^2*y + %.2f*x*y^2 +
%.2f*y^3 \n', fitresult1.p00, fitresult1.p10, fitresult1.p01, fitresult1.p20, fitresult1.p11,
fitresult1.p02, fitresult1.p21, fitresult1.p12, fitresult1.p03)
fprintf('\nWhere x = CFM and y = GPM.\n' )
```

```
     Linear model Poly23:
     fitresult1(x,y) = p00 + p10*x + p01*y + p20*x^2 + p11*x*y + p02*y^2 + p21*x^2*y
                    + p12*x*y^2 + p03*y^3
       where x is normalized by mean 1347 and std 362.9
       and where y is normalized by mean 3.383 and std 1.095
     Coefficients (with 95% confidence bounds):
       p00 =   2.038e+04  (2.036e+04, 2.041e+04)
       p10 =        1861  (1841, 1882)
       p01 =        2297  (2252, 2343)
       p20 =      -240.5  (-254.9, -226.2)
       p11 =       353.7  (338.7, 368.6)
       p02 =      -443.3  (-461, -425.6)
       p21 =      -44.41  (-59.93, -28.89)
       p12 =      -73.12  (-92.93, -53.3)
       p03 =       80.54  (55.72, 105.3)

BTU/hr as a function of CFM and GPM is:
20384.29 + 1861.18*x + 2297.13*y + -240.55*x^2 + 353.65*x*y + -443.28*y^2 + -44.41*x^2*y + -
73.12*x*y^2 + 80.54*y^3

Where x = CFM and y = GPM.
```

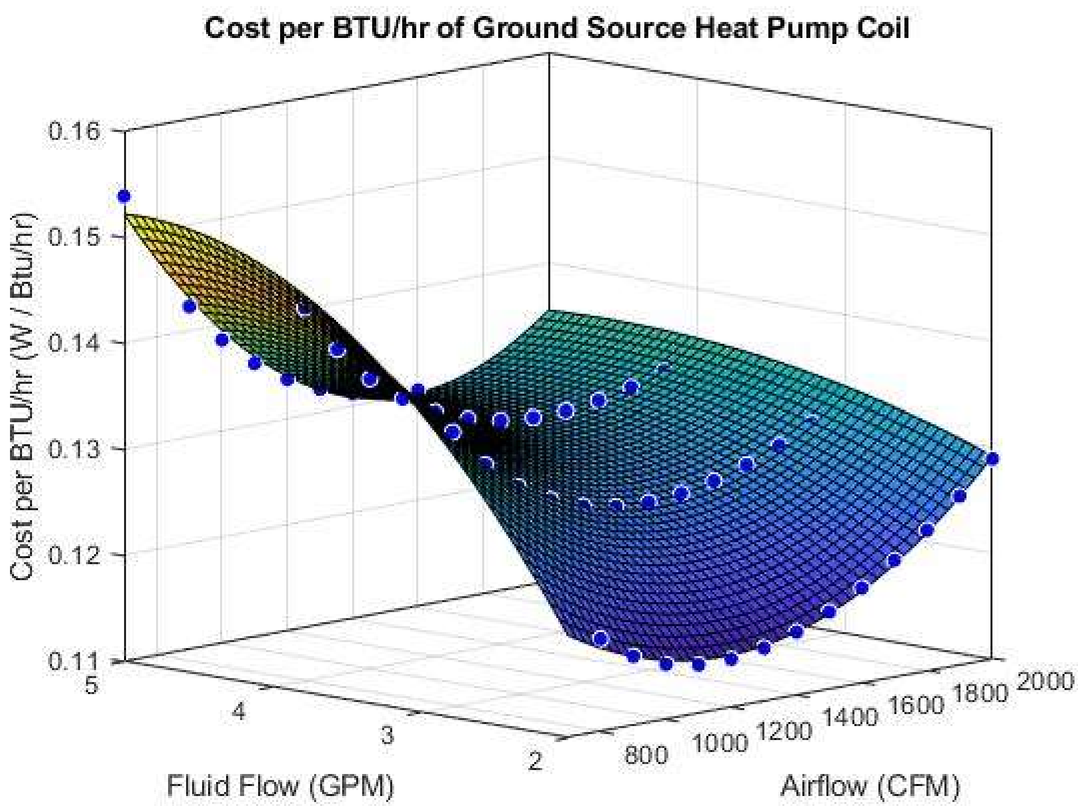


Fit a surface to predict cost per BTU/hr as a function of CFM and GPM.

Using a linear model:

```
% Set up fittype and options.
ft = 'poly23';

% Fit model to data.
[fitresult2, ~] = fit( [CFM,GPM], costperBTU, ft, 'Normalize', 'on' );

% Plot fit with data.
figure( 'Name', 'Cost Per BTU/hr' );
plot( fitresult2, [CFM,GPM], costperBTU );

% legend( h, 'Cost per BTU', 'BTU vs. CFM, GPM', 'Location', 'NorthEast', 'Interpreter', 'none'
);
% Label axes
title( 'Cost per BTU/hr of Ground Source Heat Pump Coil' );
xlabel( 'Airflow (CFM)', 'Interpreter', 'none' );
ylabel( 'Fluid Flow (GPM)', 'Interpreter', 'none' );
zlabel( 'Cost per BTU/hr (W / Btu/hr)', 'Interpreter', 'none' );
grid on
view( -46.3, 11.8 );

fprintf('Cost per BTU/hr as a function of CFM and GPM is: \n' )
fprintf('%.2d + %.2d*x + %.2d*y + %.2d*x^2 + %.2d*x*y + %.2d*y^2 + %.2d*x^2*y + %.2d*x*y^2 +
%.2d*y^3 \n', fitresult2.p00, fitresult2.p10, fitresult2.p01, fitresult2.p20, fitresult2.p11,
fitresult2.p02, fitresult2.p21, fitresult2.p12, fitresult2.p03)
fprintf('\nWhere x = CFM and y = GPM.\n' )
```

```
Cost per BTU/hr as a function of CFM and GPM is:
1.28e-01 + -2.61e-03*x + 6.38e-03*y + 3.28e-03*x^2 + -2.87e-03*x*y + -2.95e-03*y^2 + 4.16e-04*x^2*y + 9.78e-04*x*y^2 + 3.41e-05*y^3

Where x = CFM and y = GPM.
```



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