Regression Analysis of the EIC Test Stand's Measured Data and Ansys Fluent Simulated Data

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This note presents the regression analysis of the temperatures observed on the test stand and the Ansys Fluent CFD predicted data for the inside surface of the aluminum pipe that represents silicon layer 1 of the EIC.

A python program was developed to calculate the linear regression parameters, Table I, q.v. [1] for observed and Ansys results.

```
In [42]: runfile('C:/Users/campero/.spyder-py3/regression-plots.py', wdir='C:/Users/
campero/.spyder-py3')
                            OLS Regression Results
==============================================================================
Dep. Variable:           ObservedTemp   R-squared:                       0.967
Model:                            OLS   Adj. R-squared:                  0.962
Method:                 Least Squares   F-statistic:                     177.1
Date:                Thu, 08 Jun 2023   Prob (F-statistic):           1.11e-05
Time:                        16:21:54   Log-Likelihood:                -16.189
No. Observations:                   8   AIC:                             36.38
Df Residuals:                       6   BIC:                             36.54
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        -10.4763      3.848     -2.723      0.035     -19.892      -1.061
AnsysTemp      1.3259      0.100     13.306      0.000       1.082       1.570
==============================================================================
Omnibus:                        0.572   Durbin-Watson:                   1.621
Prob(Omnibus):                  0.751   Jarque-Bera (JB):                0.371
Skew:                          -0.426   Prob(JB):                        0.831
Kurtosis:                       2.380   Cond. No.                         199.
==============================================================================
```

TABLE I. Python ordinary least squares (OLS) results. R2≈0.97 and adjusted R2≈ 0.96. The standard error is 3.648°C.

The calculated R-squared value for the regression model is 96.72% and its standard error is 3.648°C, indicating the regression explains the variation between the measurements and the simulated Ansys Fluent results.

The best fit plot, Fig. 1 has an unphysical offset. The fit is valid only in the measurement range.

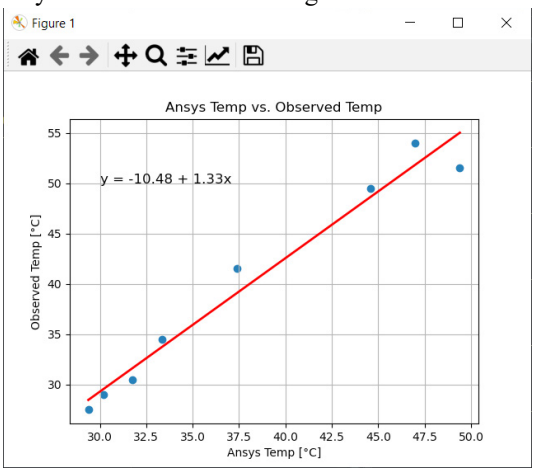

FIG. 1 Best fit.

Figure 2 shows the Ansys Fluent results vs observed temperature values—represented by the blue dots. The red squares represent the best fit line values, vertical black lines at each best-fit-line value shows the calculated standard error of 3.648°C. Observed data points (blue) are within the standard error (black) of the model.

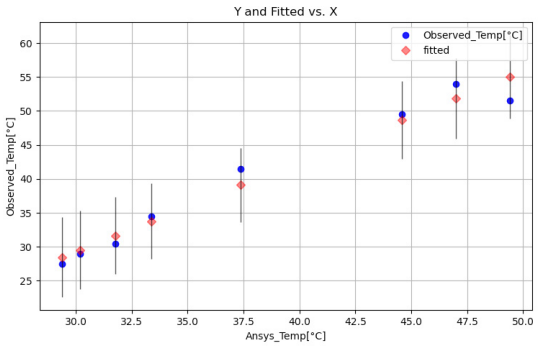

FIG. 2. Best fit line values (red) with standard error at observed values(blue).

The residuals vs the simulated Ansys temperature plot, Fig. 3, shows the model is unbiased—the residuals are randomly scattered around the zero line.

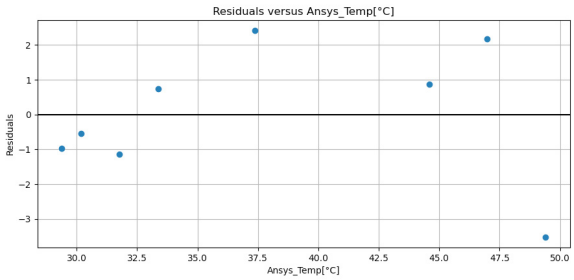

FIG. 3 Residuals vs Ansys temperature.

The generated Quantile-Quantile plot, Fig. 4, shows that both observed and simulated data are normally distributed, since the data values in the plot fall along a straight line at a 45° angle.

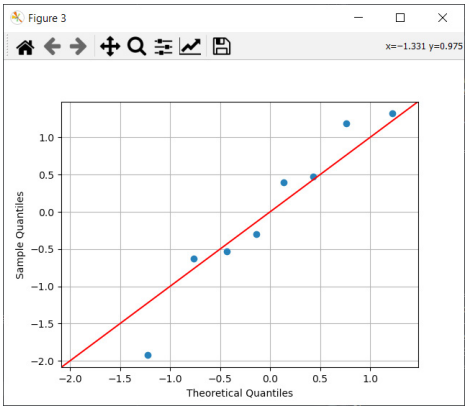

FIG. 4. Quantile vs quantile plot.

To conclude, the linear regression analysis validates the goodness-of-fit between the test stand measurements and the Ansys Fluent results.

[1] P. Campero, et al., *Ansys Fluent Thermal Analysis of the Beamline Test Stand Assembled with Aerogel*, DSG Note 2023-24, 2023.