Using Cubic Spline Interpolation in Analysis of Ansys Transient Simulation Results Data

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Simulations were conducted using Ansys Mechanical Transient Thermal to determine how the ambient temperature would affect the temperature of the crystals over time. A previous simulation had already been conducted using Ansys Mechanical Steady-State Thermal, so these simulations were done as a check on the previous results.

For the first simulation, the ambient temperature is initially set to 20°C and increased to 25°C in the space of 1 s. The results of this simulation, the maximum, minimum, and average overall temperatures, were exported from Ansys to a .csv file. I developed a Python program to read in the results from this .csv file and plot the maximum temperature versus time. The maximum temperature means the areas of the crystal array that had the warmest temperatures regardless of material; so, this includes dividers (carbon fiber and mu-metal) as well as crystals.
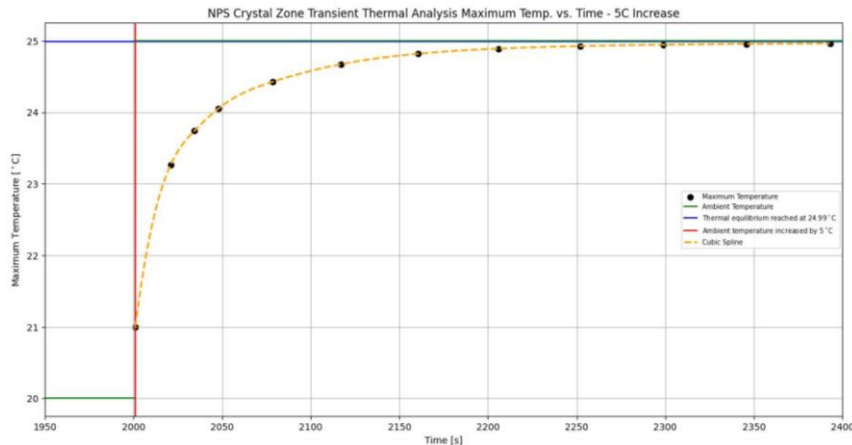
- **Ansys Mechanical Transient simulation conducted where ambient temperature was increased by 5°C**

- **Attempts to fit the curves using polynomials was proving difficult**

- **Simulation results were plotted and fitted using a cubic spline interpolation**

FIG.1. Plot of maximum temperature vs. time for a 5°C increase in ambient temperature

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The first attempt to fit the curve using a polynomial was fairly unsuccessful as the degree of the polynomial was incredibly high (> 10). This led to something known as *Runge's Phenomenon*, where there is a problem with oscillation at the edges of an interval when using polynomial interpolation with polynomials of high degree [1].

Instead of fitting a single, high degree polynomial to all of the values at one, a cubic spline interpolation fits low-degree polynomials to small subsets of the values; for example, fitting nine cubic polynomials between each pair of ten points, instead of fitting a single 10th degree polynomial to all of them [2].

After fitting the curve with a cubic spline interpolation (Figs. 1 and 2), I was able to add additional code to pull out the coefficients (a, b, and d) of the polynomials and get a function of the form $S_1(x) = C + a(x-x_1) + b(x-x_1)^2 + d(x-x_1)^3$ on $[x_1, x_2]$ for each polynomial.

References

[1] https://en.wikipedia.org/wiki/Runge%27s_phenomenon
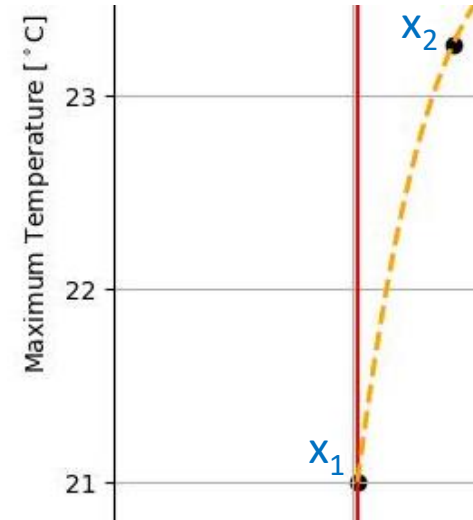[2] https://en.wikipedia.org/wiki/Spline_interpolation

FIG.2. Zoom in on first two data points showing cubic spline between them