Finite Element Analysis of Heat Conduction

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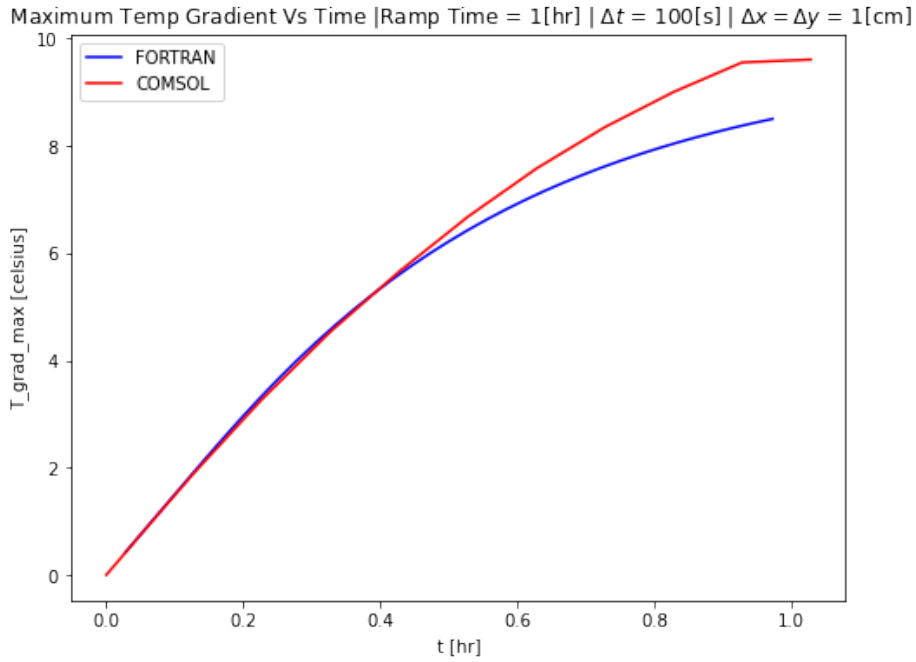
1 Finite Element Analysis

We present the results from the finite element analysis implemented in FORTRAN and COMSOL.

2 Fast and Slow Ramps

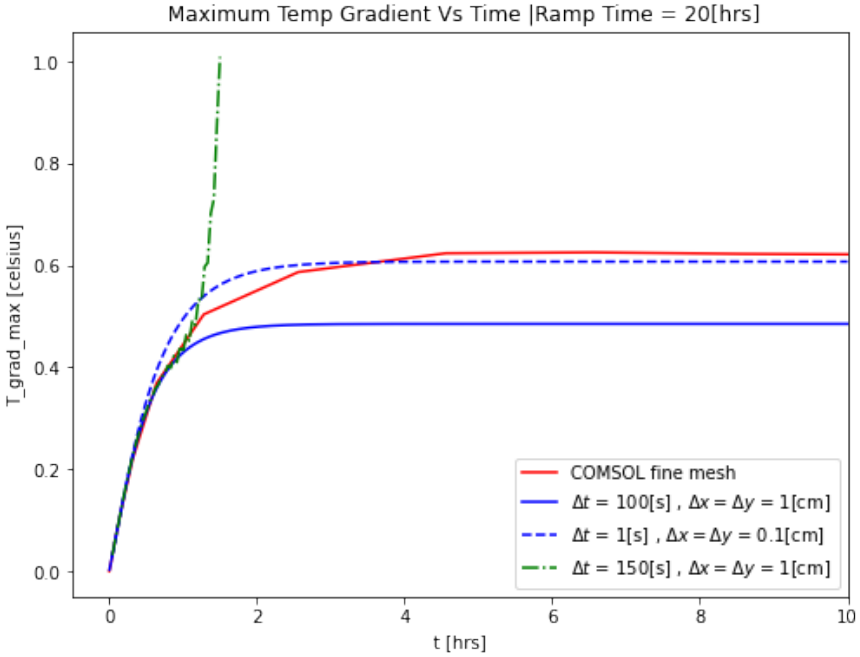
2.1 Fast Ramps

Here is our plot for a fast ramp time of one hour. We plotted the FORTRAN fine element analysis and COMSOL fine mesh results. As can be seen in the plot, the max temperature gradient exceeds the 1 degree celsius constraint very quickly.



2.2 Slow Ramps

Here we experimented with different settings for our FORTRAN FEA and COMSOL analysis.



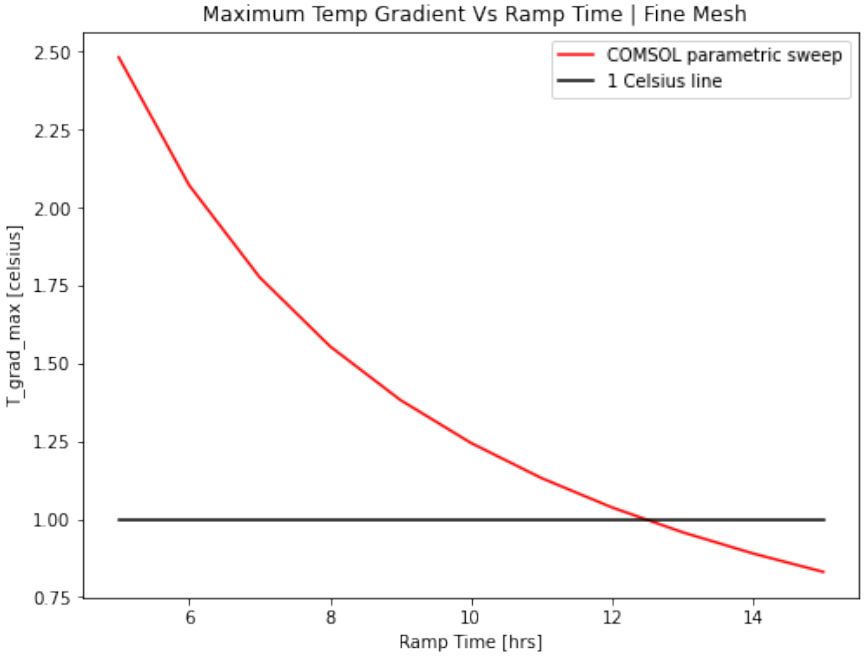
All plots are taken over a ramp time of 20 hours. All except the green line satisfy our constraint that the maximum gradient be always less than 1 celsius. The green line violates the convergence bound for the time step given that our spatial steps are 1 cm. Therefore, the physics does not converge and is nonphysical. We get good agreements with the COMSOL analysis when we decrease our time step to 1 s.

3 Optimal Ramp Time

We performed parametric sweeps both in FORTRAN and COMSOL over the ramp time parameter to find the optimal ramp time for the problem.

The FORTRAN parametric sweep is a simple minimization algorithm applied to the range $[1 - 20]$ hours. The goal is to find the minimum ramp time that respects the 1 degree constraint. **With a time step of 100 seconds and space step of 1 cm we found that the optimal ramp time is 9.8 hours.**

In COMSOL the parametric sweep gives an optimal time of 13 hours:



We believe the small disagreement comes from using a time step that is not small enough in our FORTRAN parametric sweep.