ProTips™

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Column Damping

As a rate-based modelling tool, ProTreat® simulations solve an immense number of equations through numerical integration to obtain values for each tray or segment of packing. The equations always need initialization since it is an iterative calculation and the place from which they start is not always able to smoothly progress to convergence. In these cases, the answer to the problem is user defined damping.

Background on Damping

Damping has many different meanings and applications from trigonometry and music to the PageRank algorithm used by search engines to determine the most relevant websites to display. In computer programs such as ProTreat, damping is applied in numerical methods to suppress instabilities in systems of highly non-linear equations. Damping works by reducing the step size of the iteration. By doing so, a step that might be destabilizing the calculations and projecting out of the bounds of feasibility would have a much better chance of being able to recover and come to convergence. However, one must bear in mind that damping has no physical significance and is a numerical facet alone. For instance, a column that needs damping to solve may operate fine in the real world, and vice-versa.

Damping in ProTreat®

Column damping in ProTreat is specified in the column dialogue under the Convergence tab as seen in Figure 1. By default, the damping factor being applied is set as 1.0, the number of Damped Iterations is set as 0, and the number of flowsheet loop cycles to which damping is being applied is set as 0. This indicates that no damping is being applied.

The Damping Factor is the value determined by the user as a number typically between 1.0 and 0.01 (damping lower than 0.01 should not normally be needed). Damped Iterations are the number of column iterations for which the Damping Factor will be applied. This means that if a user specifies a Damping factor of 0.1 for 10 Damped Iterations, the column will apply the factor of 0.1 for the first 10 column iterations. The number of loop cycles indicates the number of times the column is encountered where the damping will be applied. So for the same example, if a user specifies a Damping Factor of 0.1 for 10 Damped iterations to be applied to the first 3 loop cycles, this means that for the first 3 times the column is solved in a loop, a damping factor of 0.1 will be applied to the first 10 column iterations each time.

In order for damping to be applied to a column, the damping factor needs to be a number less than 1 and the damped iterations and number of loop cycles it is applied to need to be greater than or equal to 1. If either the damped iterations or the loop cycles are zero, the damping will not be applied.

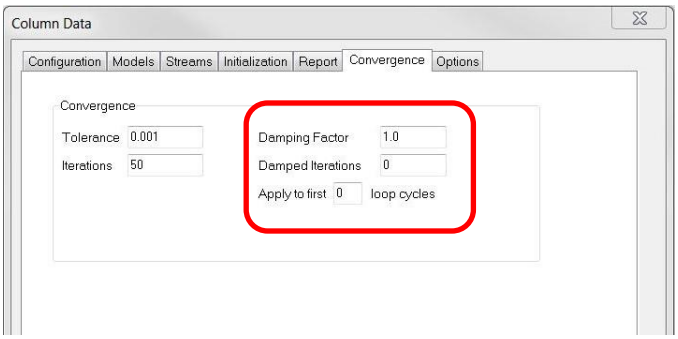

Figure 1. ProTreat Column Convergence Tab

Damping should only be applied if the column is unable to proceed past a certain point in the calculations which causes a fatal error to occur. A column that is not converging, but is behaving perfectly normal could simply need more iterations to reach convergence. It should also be noted that a column cannot be declared converged while on an iteration on which damping has been applied.

PROTIP: ProTreat should typically not need to have any damping applied. However, in the case that damping is needed, a damped value of 0.1 for 3 to 5 iterations is a good starting place. If the calculations are still becoming unstable after exiting the damped iteration count, try increasing the number of damped iterations until either the calculations stabilize or the number of damped iterations become equal the column iteration count. If the calculations are unstable at a damping factor of 0.1, a lower damping factor between 0.1 and 0.01 may be required. If significant damping is required, there may be a systematic error somewhere either in the column internals or by an incorrect specification in the streams feeding the column. Numerical values entered in the wrong units are also quite common and can cause some unexpected results.