Vissim for the Refinery and Plant Process Control Engineer: A Tutorial

Edward Dilley, MIChemE, Ceng

Chartered Chemical Engineer, **Peterborough, UK.**

Abstract - **VisSim simulation software can be used effectively by those without extensive applied mathematics skills. In this example of distillation process control in an oil refinery, the software's ease-of-use features provided the means to resolve and troubleshoot process problems for continuous, batch and semi-batch processes. Illustrations show how VisSim was used to control the top- and base-temperatures on a refinery Pentane-splitter tower, study the behavior of an inventory controller, optimize control loops and identify pH control problems with a reaction vessel.**

Keywords - VisSim, computer simulation, mathematical modelling, process control, controller tuning, troubleshooting

I. INTRODUCTION

I've been a VisSim user for nearly 15 years now, and although I'm one of its greatest fans, I felt somewhat daunted when asked to write about my experiences. Most articles on VisSim that I've read describe huge simulation projects staffed by teams of simulation experts who continually push forward the frontiers of applied mathematics.

I'm at the other end of the spectrum. I'm a Chemical Engineer who has specialized in process control application. I've frequently been working alone, and I'm by no means a natural mathematician.

Back in the 1980s I found myself trying to improve distillation control at an oil refinery. I read the textbooks of the time, used the tuning formulae to the best of my ability, and usually managed to make matters worse. 'Surely there must be a better way,' I thought.

Controller-tuning technology improved throughout the 80s, but for me the arrival of VisSim was a breakthrough. At last I was able to see rather than hope, and to demonstrate to others before trying out new controller-tuning. I used Personal Version 1.5, which is still on my laptop as I type this. VisSim is now at Version 5; the mathematical power and graphics capabilities have advanced dramatically, but VisSim got the principles correct from the very start.

II. WHAT ATTRACTED ME TO VISSIM?

I make no apology for saying that VisSim was easy to learn, especially for an engineer who had forgotten most of his college mathematics. What makes it easy? The main factors are:

A. It's Intuitive

The GUI could hardly be easier. Function-blocks are selected by clicking, positioned by dragging and then 'wired' together to force the arithmetic or logic to do what you want. The model is always on display, and you can build it up gradually, checking operation section-by-section. A model doesn't have to be complex to be useful.

B. No Prior Programming Knowledge

You don't need to be a computer programmer to use VisSim – just click, drag and 'wire'. Nor do you need to be a mathematician, though it will help if you know what 'dy/dx' means.

Many of VisSim's function blocks are mathematically powerful, with several options for integration or optimizing methods. However I use just a few function-blocks regularly, and for those with options, I've found that VisSim's default choices work just fine.

C. Plain English

The VisSim manual is a credit to its authors. It's refreshing to have a manual which helps readers rather than confusing them. A hard copy of the manual comes with the boxed package, though everything is supplied in '.pdf' format for on-screen use. (The hard copy does make learning VisSim easier for the novice user.)

D. Tutorials

The supplied tutorials illustrate the principles of simulation and the principles of VisSim.

The examples have been chosen with care to 'kick-start' beginners without swamping them with detail. You can be configuring a simple simulation minutes after loading.

E. Function-Block Reference

VisSim has over 100 standard function-blocks. Each is clearly described in the Block Reference chapter of the manual. Most importantly, the manual gives one or more practical examples of how best to use each block. That's user-friendly.

F. Worked-Examples Library

VisSim provides an extensive library of working VisSim models from a wide range of industries. Most examples demonstrate rigorous ways to simulate process equipment; other examples use techniques such as curve-fitting or economic optimisation. Browsing through the library soon had me thinking of other simulation ideas.

G. Excellent Value

It was affordable, and paid for itself the first time I used it 'for real'.

III. HOW HAS VISSIM HELPED ME TO RESOLVE PROCESS PROBLEMS?

I have over 100 VisSim models in my file, mostly small (less than 100 blocks), but some with several hundred blocks. I've used VisSim for formal controller design, for training operators and technicians, as a control 'scratch-pad' to quickly check out ideas, and most importantly, for process troubleshooting. VisSim has been equally useful for continuous, batch and semi-batch processes.

As a Process Control applications engineer, I've often used VisSim to simulate, tune and optimise PID controllers. VisSim is well-suited to modelling the discrete arithmetic of Digital Control Systems (use the pulse function and unit delay), so I was able to build the exact PID algorithm used by the DCS.

The example below demonstrates my first attempt to control the top- and base-temperatures on a refinery Pentane-splitter tower. Although the two controllers were tuned 'optimally' (look at the straight lines for temperature), several hours after commissioning control, the tower ceased to fractionate. The reflux and reboiler steam flows had wound to minimum! VisSim showed that the cause was severe interaction between the two controllers.

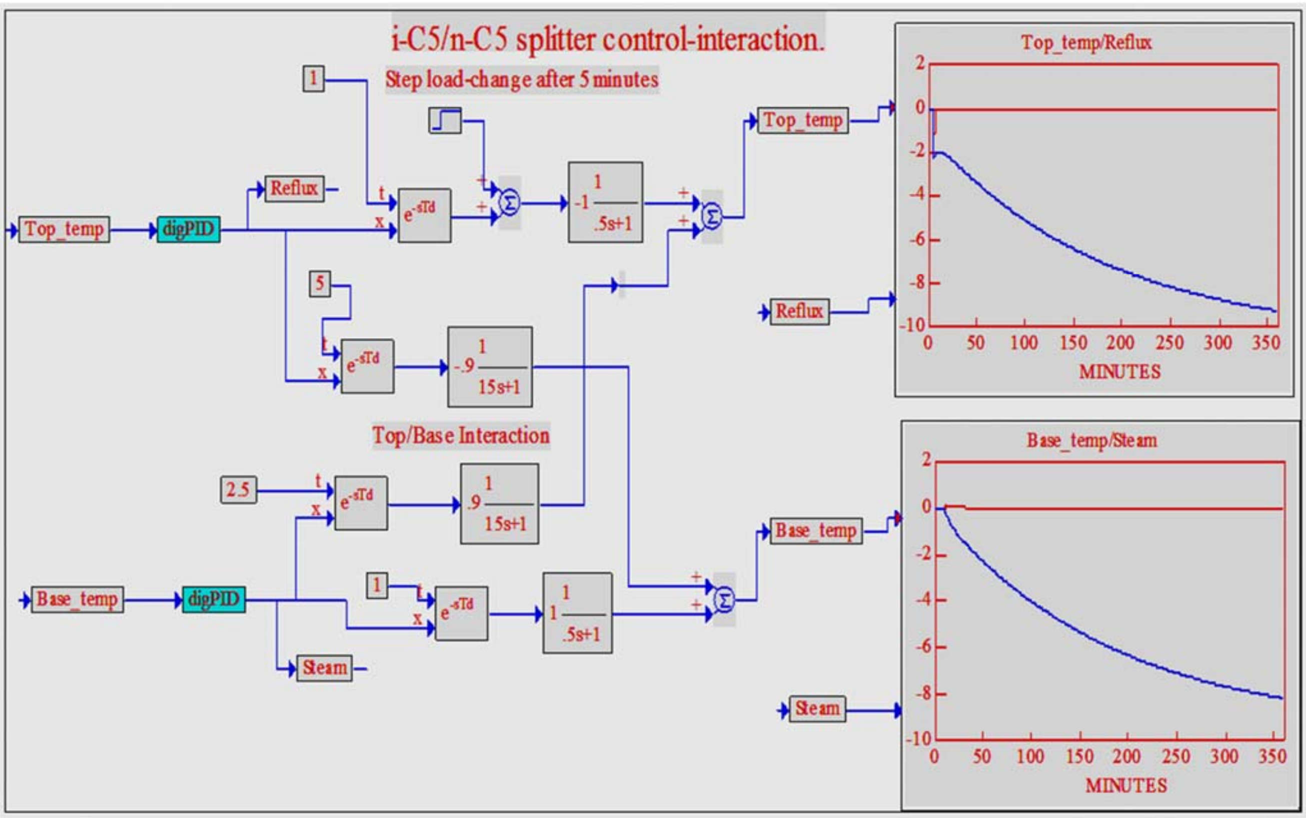

Figure 1. Interaction causing reflux/steam wind-down

Control was stabilized by replacing the top TC with a reflux-ratio controller.

Below are the results of a 'before' and 'after' study of the behavior of an inventory controller. The controller was intended to limit the loading of material on some mechanical conveyors. The operators reported erratic control with unacceptable peak-loading, such that they normally ran the loop in manual mode:

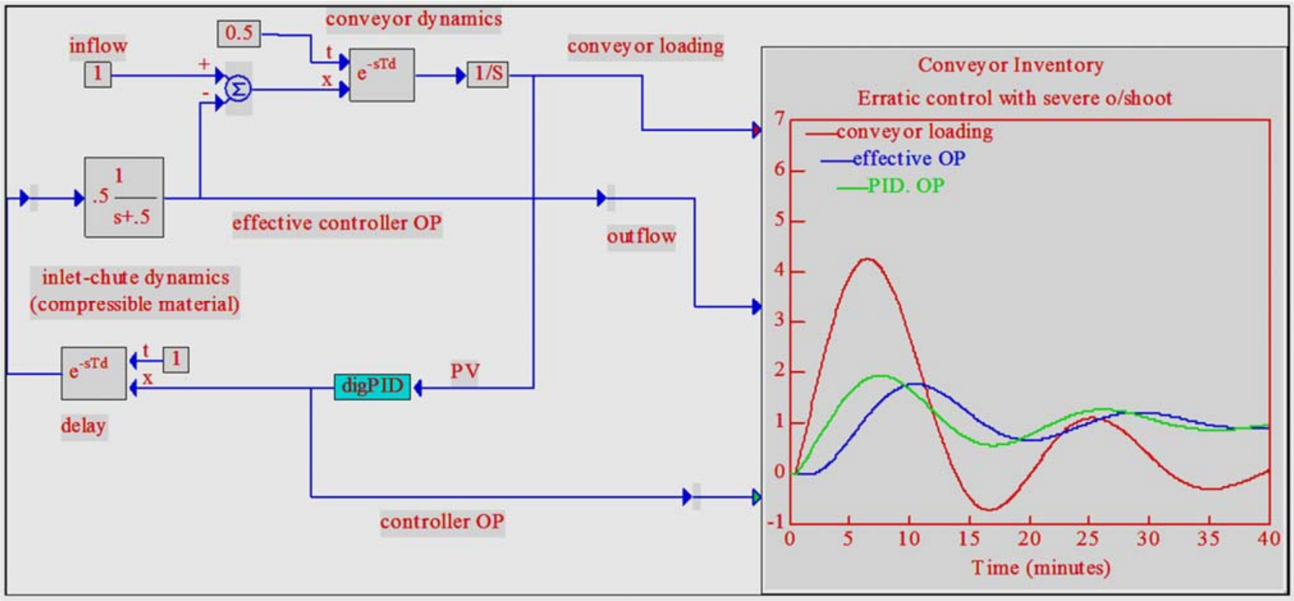

Figure 2. Erratic control and excessive peak-loading

Site inspection and then modelling with VisSim showed that the problems were caused by the compressible nature of the material in the exit chute; the compressibility introduced some unexpected dynamics into the loop.

VisSim confirmed that the solution was to use sufficient derivative action to quieten the loop without overloading the electric motors and gearboxes.

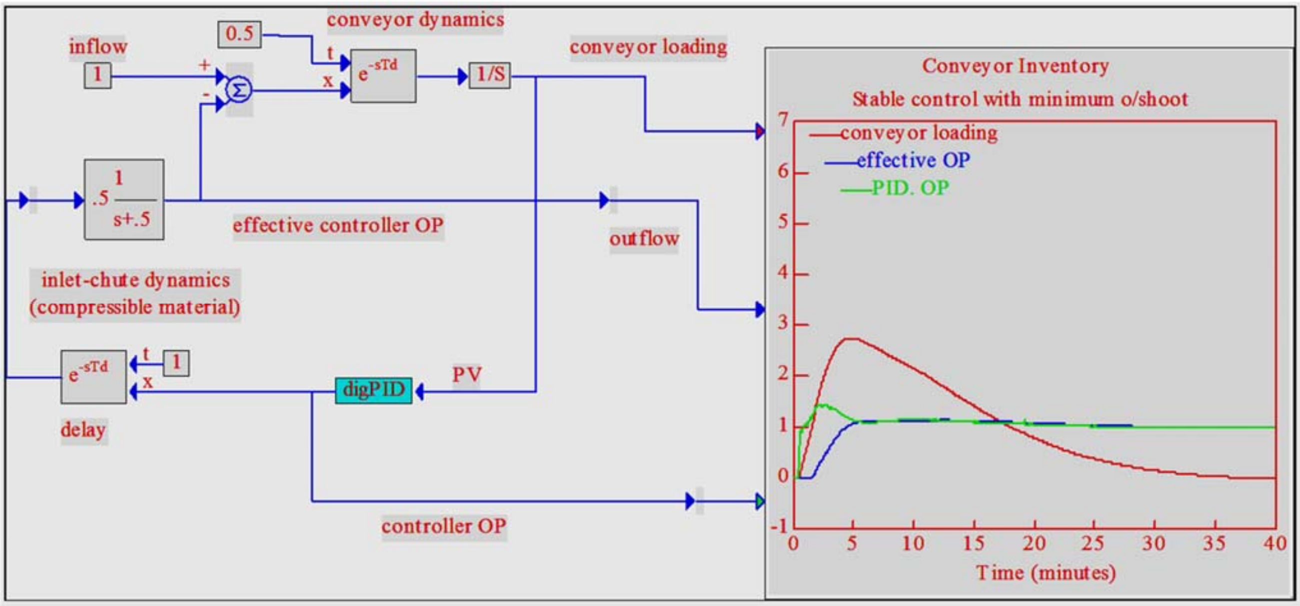

Figure 3. Derivative action stabilizes control, reduces peak

The above examples show how VisSim was used to optimize control loops. But how many times is a ‘Controller Tuning’ problem in reality a process problem, such as a sticking control-valve or a heat-exchanger that’s fouled? VisSim has helped many times in identifying the real problem.

At one site, pH control problems with a reaction vessel had halved the process throughput. VisSim helped track down the real culprit:

Suspect #1: was it the pH controller (standard PID)? Process step tests and simulation with VisSim showed that the controller-tuning was optimal even though control was in fact unacceptably poor.

Suspect #2: was it the chemistry? Were we trying to control at the wrong part of the pH curve? We couldn't be sure, because nobody had a pH curve for the di-protic weak acid vs. di-basic weak base used. A chemistry reference book and VisSim produced the pH curve, and laboratory tests confirmed we weren't trying to do the impossible:

Suspect #3 was then revealed and highlighted: process conditions had changed such that the reaction vessel was now undersized for the throughput required and the feedstock composition. The vessel was modified to double the capacity, following which pH control was excellent.

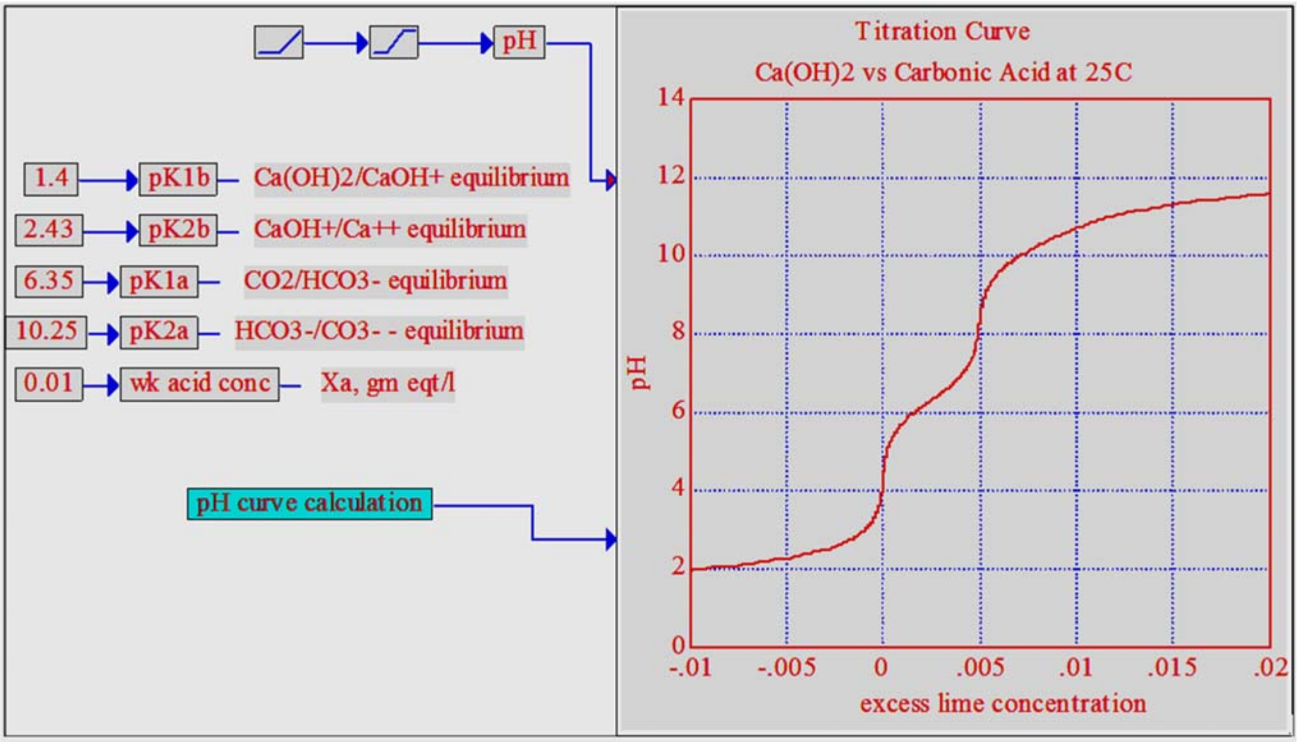

Figure 4. VisSim-derived pH curve used in troubleshooting

IV. CONCLUSION

For the Process Control Engineer, a powerful and easy-to-use simulation tool is as essential as a good spreadsheet and word processor. VisSim meets the needs, is excellent value, and has proved its worth. And what's more, it's fun!

About the author

Ed Dilley is a chartered chemical engineer with 30 years' experience of applied process control. He has worked in the oil, petrochemical, polymer and food industries. He now lives in Peterborough, UK.