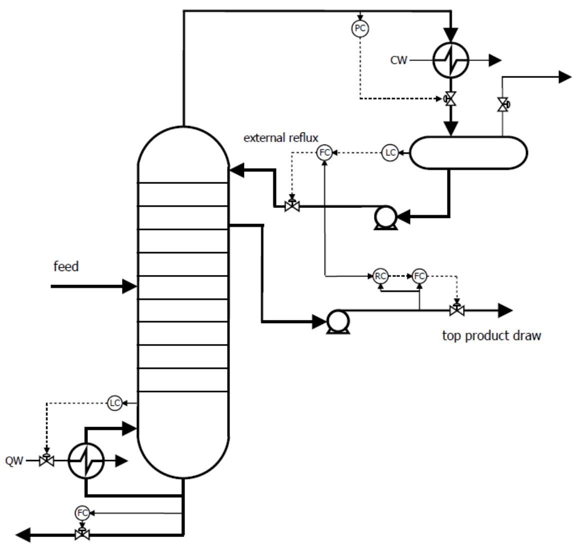
1. Introduction

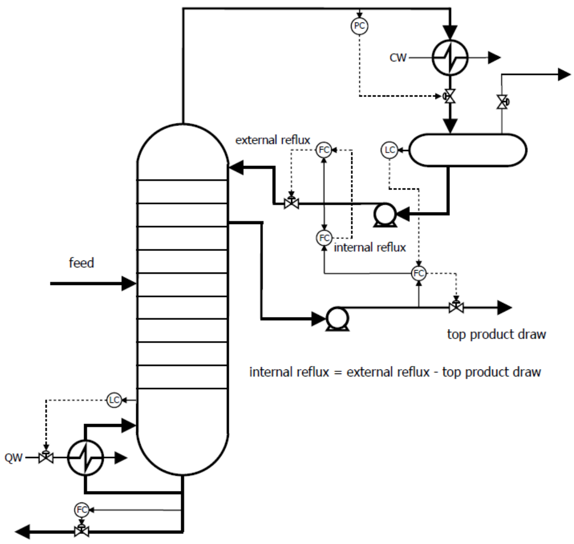
Tuning level controllers can be a challenging task. When you have identified a proper ramp model, this this task becomes much easier when using Aptitune.

Identifying a good ramp model is in practice often a bit more difficult than finding a steady state model.

As part of an APC redo project the base layer configuration of a C3 splitter has been modified and the level controller of the reflux drum had to be retuned. The old APC controller had a ramp model between the top product draw and the reflux drum level. The final ramp rate of this old model is still valid, but the dead time and the begin dynamics will be different now, as will be explained next.

Take a look at next 2 figures: left side old setup and right side new setup.





In the old APC controller, the external reflux FC and the top product draw FC were manipulated variables and the reflux drum level was controlled with the draw FC. When the APC controller was switched off, the reflux drum level controller would cascade to the external reflux flow and the top product draw FC would cascade to a ratio controller RC, which controlled the ratio of the draw flow to external reflux flow. Notice, that this set up is not recommended. The level can only be controlled with the external reflux flow as long as the ratio controller is proper in service. As soon as the product draw is put in Auto, changing the reflux flow will only upset the column and the bottoms level. In the steady state situation, the external reflux cannot change the reflux drum level, because any extra reflux will return to the reflux drum.

In the new base layer setup, the reflux drum level controller will cascade to the top product flow. The external reflux flow will be in cascade with a new internal reflux flow controller. The internal reflux is the reflux flow in the column below the draw tray. This flow is calculated as the external reflux flow – draw flow. The advance of this scheme is that whenever the draw is increased with for instance 1 t/h, also the external reflux is increased very quickly with 1 t/h, leaving the internal reflux the same, which brings stability to the main part of the column.

2. Level tuning

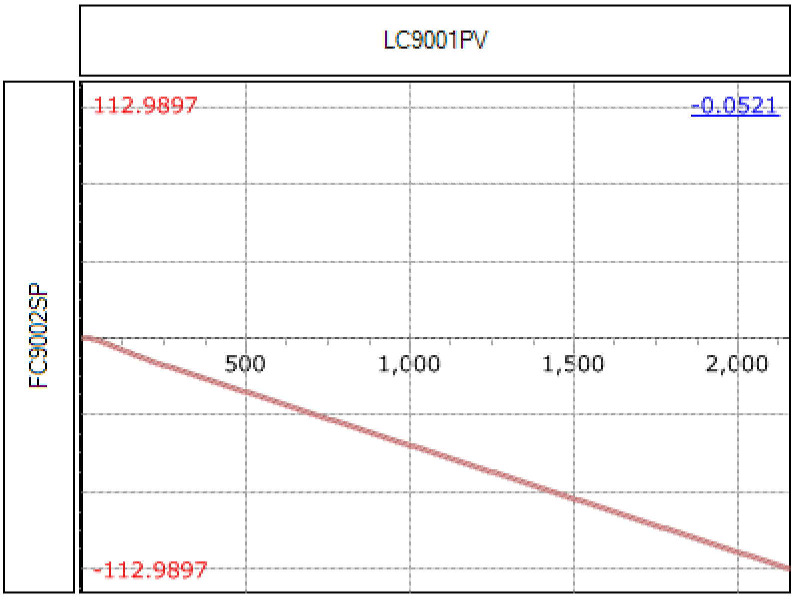
After the modifications it is expected that the reflux drum level controller LC9001 will need different tuning parameters for 2 reasons:

1) Before LC9001 had been cascading to the external reflux flow (FC9001). Now it will cascade to the draw flow FC9002. The dcs system is Honeywell Experion. The output range of 0-100 of LC9001 has to map now to the PV range of FC9002 instead of FC9001. This means that the controller gain of LC9001 needs to be changed if the PV ranges are not the same.
2) The dynamics of the model is expected to change, in particular the dead time.

When trying to use LC9001 with the existing old tuning, it became very clear that new tuning was needed, because LC9001 was oscillating heavily.

To find new, proper, tuning, Aptitune was used.

The old APC controller had the following ramp model between the draw FC9002SP and the reflux drum level LC9001PV:

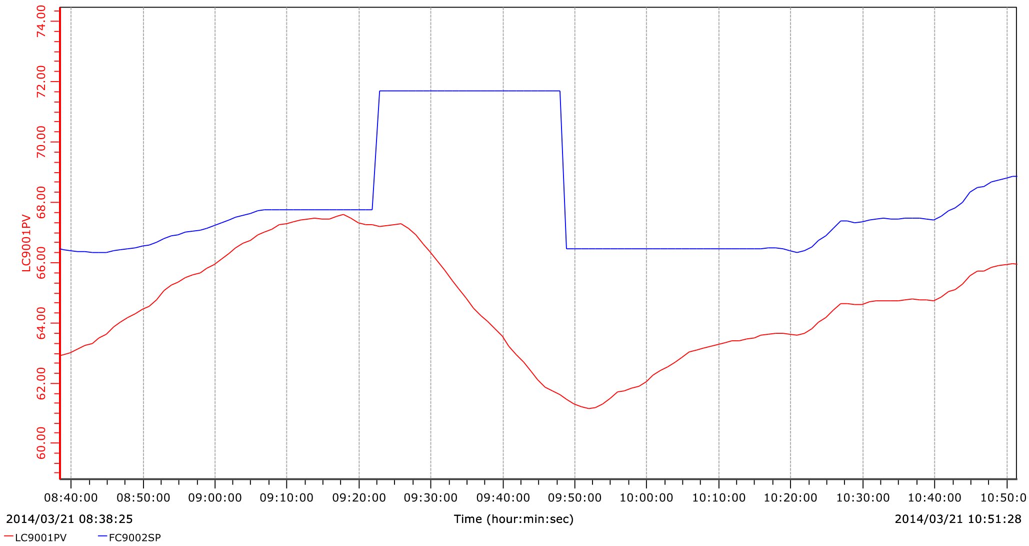


Because it is a C3 splitter with a very long time to steady state, all models in the old APC controller had a model lenth of 36 hours (2160 minutes)! The final ramp rate was -0.0521.

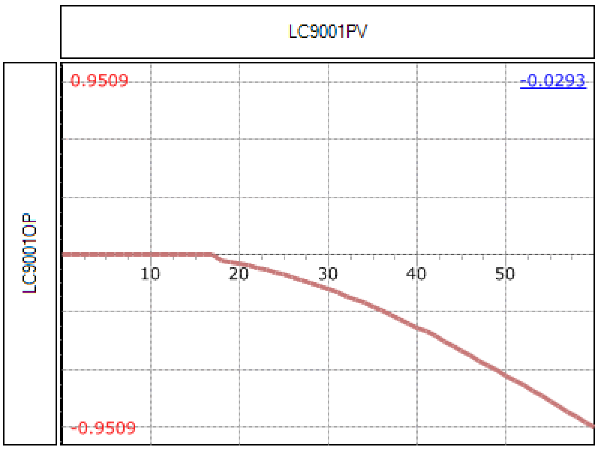
Due to the long model length, it is not so clear to see, but this old model starts with a dead time of 17 minutes. Due to the implementation of the internal reflux controller, it is expected that this dead time will be now much shorter.

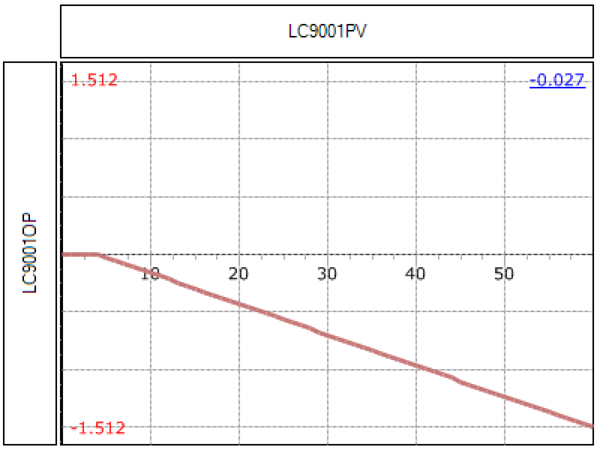
To find this out, a short step experiment has been performed, making 2 steps on the setpoint of draw flow FC9002.

This short experiment of about 1 hour showed that the dead time is only 4 minutes with the new setup.

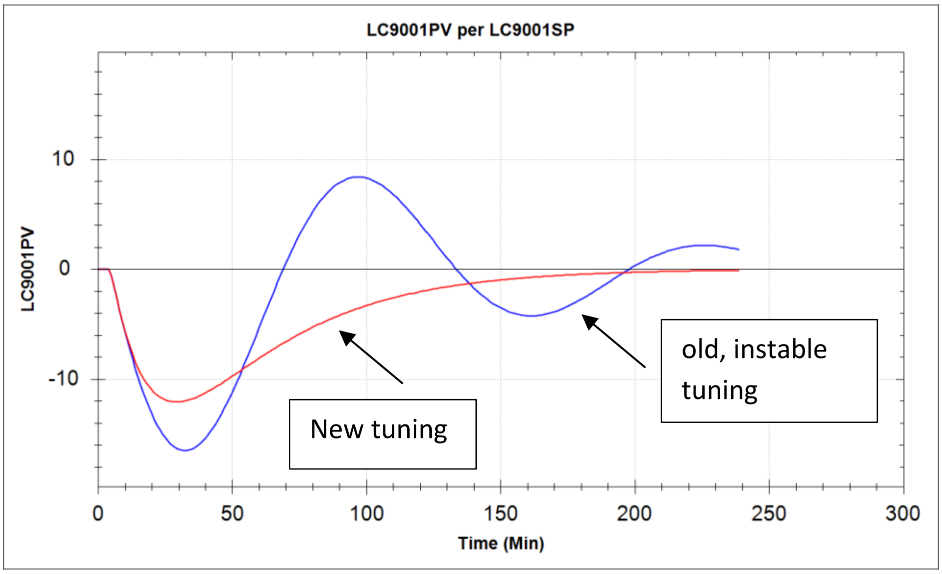


With this new dead time information and the ramp rate of the original model a new ramp model has been constructed in Aptitune, creating a model with 4 minutes dead time and a fixed ramp rate. The PV range of FC9002 is 0-50. In the model LC9001.OP has been used as input, which has range 0-100. Therefore, the original ramp rate of -0.0521 has been divided by 2 and rounded off upwards. Next 2 plots are showing the begin part of the original model (converted, using LC9001.OP) and the new constructed model.



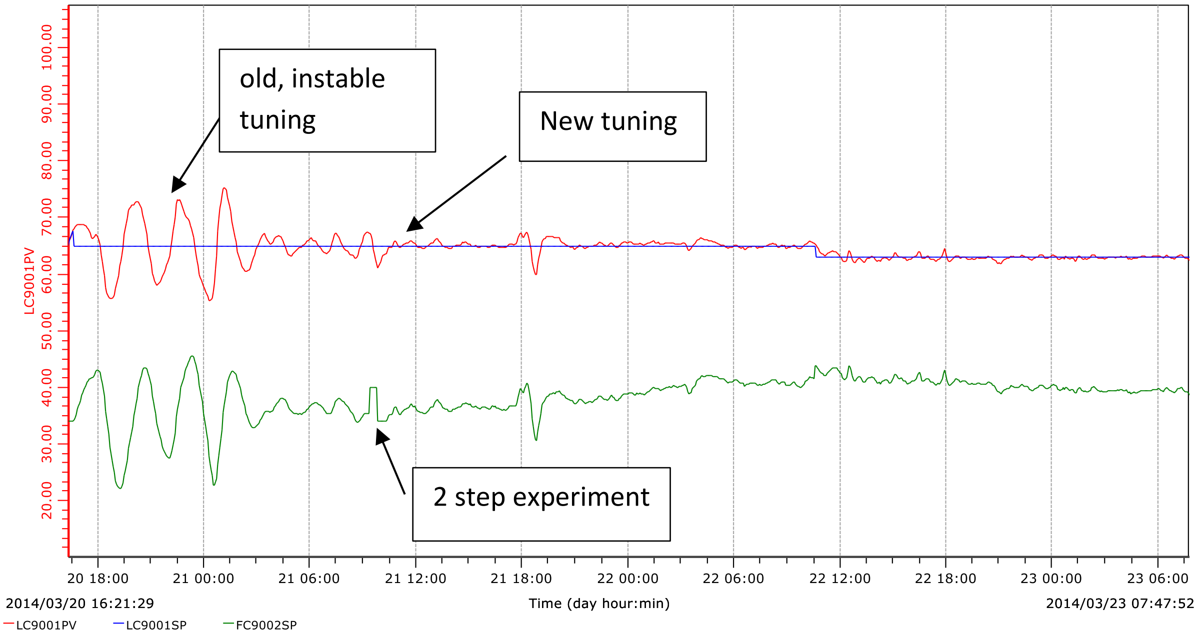


The constructed model of the right side has been used in Aptitune to obtain optimised PID tuning parameters. Following disturbance rejection plot clearly shows the performance improvement of the new tuning against the oscillatory existing old tuning.



3. Results

The new tuning, found with Aptitune, is much better than the old tuning, as the next plot is showing.



The new base layer configuration is stabilizing the column operation a lot, because the internal reflux is now controlled. In the old setup it would swing with reflux drum level and external reflux swings. Thanks to this new setup and proper tuning, the column needed much less operator attention and with APC the column could run stable at higher feed rates.

4. Conclusion

The base layer change significantly improved the stable operation of the column.

A priori knowledge has been used to obtain a proper ramp model, rather than doing a more time consuming steptest to obtain such a model. Only a very short step test has been done to estimate the dead time.

In particular, in the situation where the tuning parameters are far away from optimal values, Aptitune is showing its great value, because by the often used strategy of just tweaking the tuning parameters, it will take forever to get there. Now it goes in one shot.