1. Introduction

In the refining market, alkylate is a high value product which is produced from the reaction between isobutane (iC4) and olefins catalysed by acidic environment. The target alkylate product is a high quality gasoline consisting mainly of a saturated isomer of the octane (2,2,4-trimethyl-pentane) which has been chosen as the reference standard of 100% for the RON quality parameter (Research Octane Number).

A distillation column, commonly named de-isobutaniser (DIB), is used in order to obtain iC4 from mixed streams containing also high quantities of linear butane (nC4) and other heavier compounds (C5+). Due to the similar boiling points of iC4 and nC4, DIB's are normally big pieces of equipment with slow dynamics which operates with high reflux ratios.

The separation of the two compounds is very sensitive to the column pressure, which in turn affects all the column temperature profile. In order to achieve finer control of the iC4 top product quality, measured in terms of nC4 percentage, the client has installed a pressure compensated temperature (PCT) controller on stage #10 of the DIB column, which is the sensitive tray for top quality. The temperature controller output is cascaded to the reflux flow set-point, as shown in Figure 1.

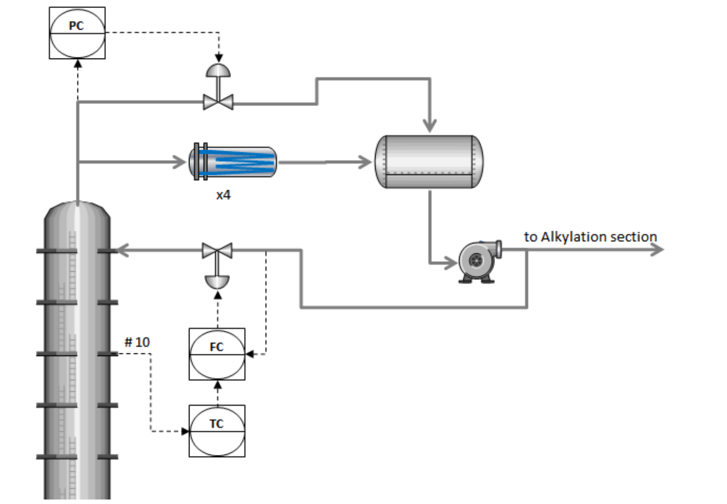

Figure 1 – DIB top section control scheme

Although a PCT is intended to cancel the phase equilibria effects of pressure over a certain temperature, the composition change effect has an influence over this temperature, which is then controlled by the temperature controller to achieve constant top composition. At the same time, the amount of reflux impacts the amount of condensed gases on the top of the column, affecting the required output of the pressure controller.

Process gains change significantly as the condensation capacity changes. Condensing capacity is a function of process parameters, such as the column pressure, but is also affected by other external influences such as cooling water temperature, cooling water network pressure (which changes the cooling water flow), amount of lighter compounds (C3-) in feed composition and ambient temperature. It has been observed in this column other direct weather influences over condensing capacity, for example direct sunlight incidence or rain over the condensers. Moreover, as the condensing capacity becomes constrained, the reflux temperature increases which makes it necessary to increase the reflux for constant tray #10 temperature.

Evidently this is a highly interacting system which can easily fall into an oscillatory behavior.

2. Tuning the PC and the TC as a 2x2 system

In order to obtain direct and crossed dynamic models from reflux flow and pressure valve to tray #10 temperature and pressure, a step test has been carried out with the reflux flow controller in automatic and the pressure controller in manual. The reflux flow controller has been evaluated and retuning was not required.

Figure 2 shows the obtained models scaled to the typical moves of the independent variables:

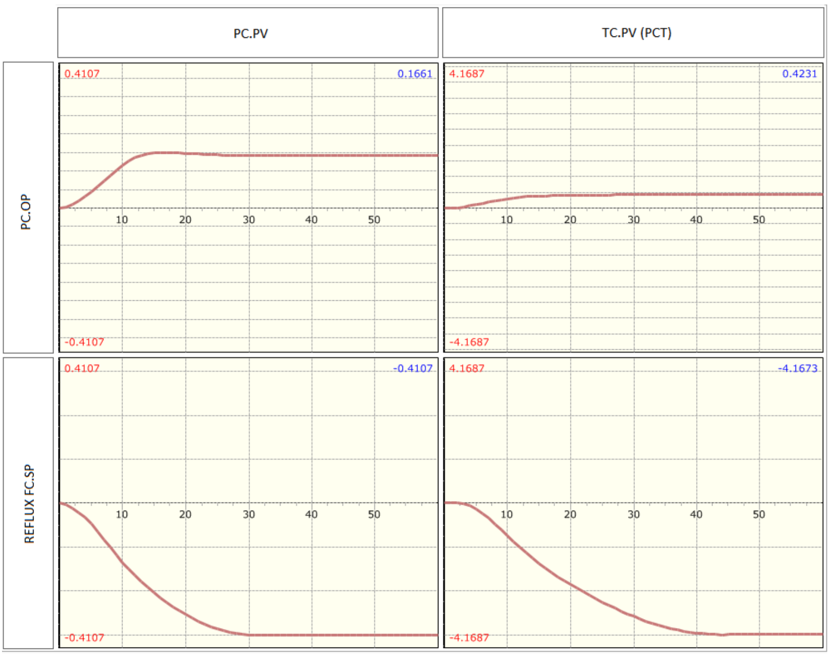

Figure 2 – Open loop step test models – scaled to independents typical steps

Table 1 shows the original tuning parameters and the tuning parameters obtained with INCA Aptitune. The DCS is Honeywell TDC 3000.

Table 1 – Existing and new tuning parameters

Loop	Existing Tuning (original)			INCA Aptitune Tuning (new)		
	K	T1	T2	K	T1	T2
PC	2.50	7.50	1.50	14.0	2.00	0
TC	2.50	9.95	3.20	8.87	9.96	0

Figure 3 shows the simulated behavior comparison between the loops facing typical set-point changes with the existing tuning parameters (red curves) and with the new tuning obtained with INCA Aptitune (blue curves). Figure 4 shows the simulation comparison for typical load disturbances.

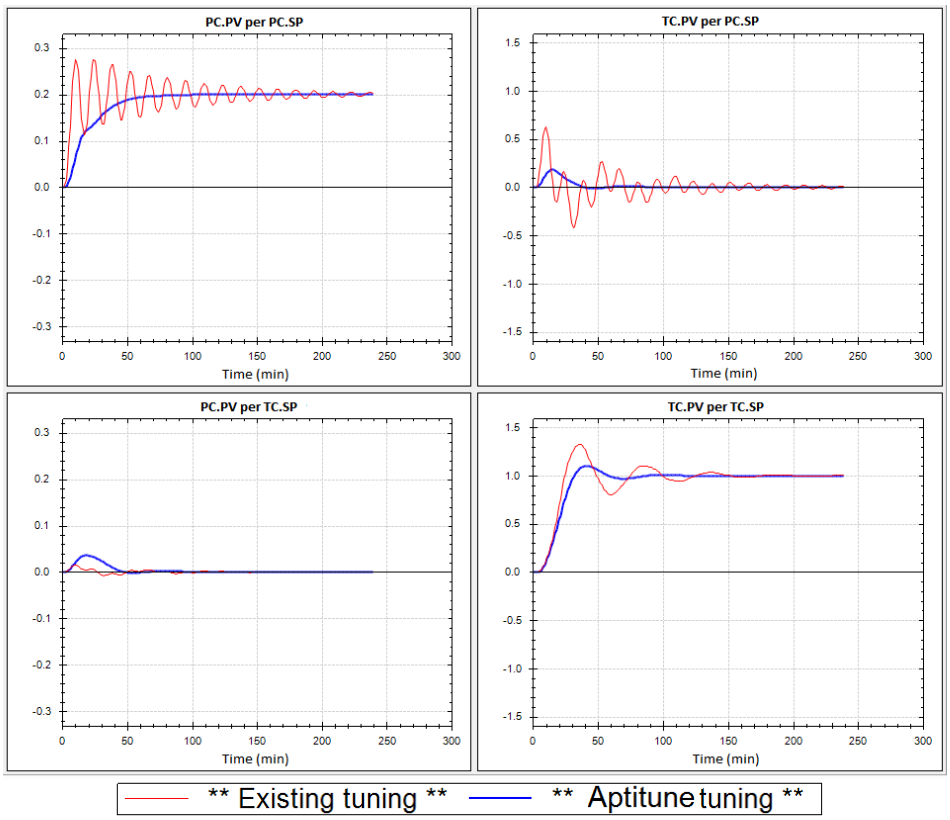

Figure 3 – 2x2 simulated typical step test response

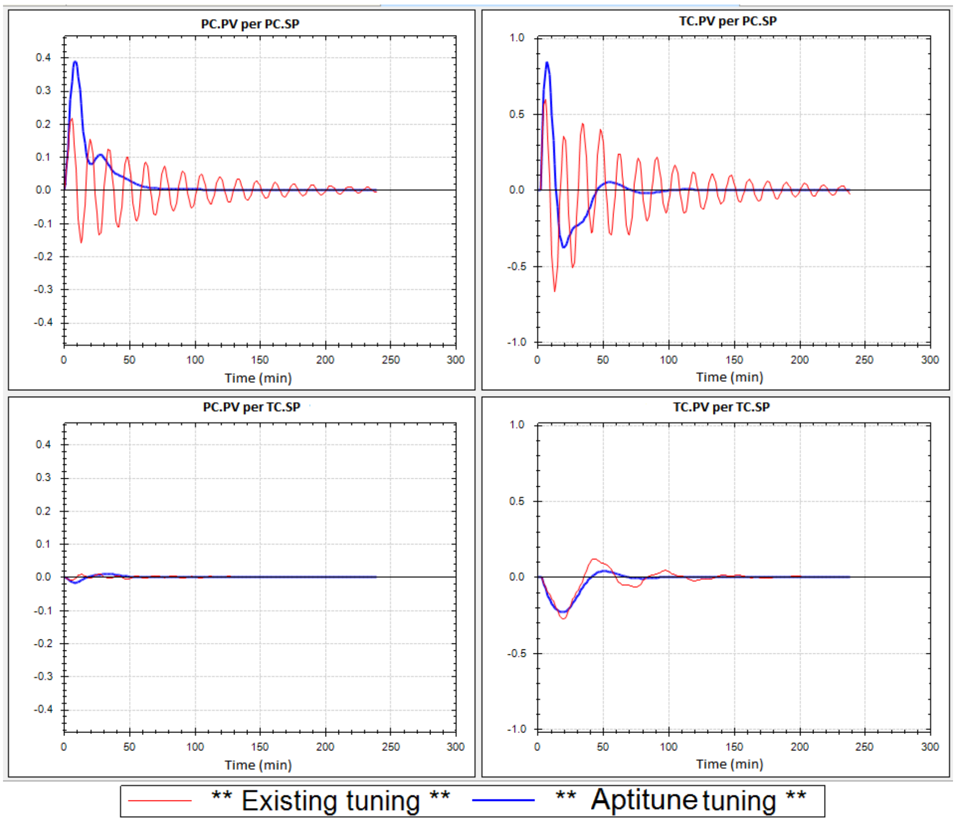

Figure 4 – 2x2 simulated typical load disturbance response

Figure 5 and Figure 6 show real data comparing the existing tuning with oscillations and the loops performance after the new tuning implementation for both DIB top temperature and pressure, respectively.

BEFORE AFTER

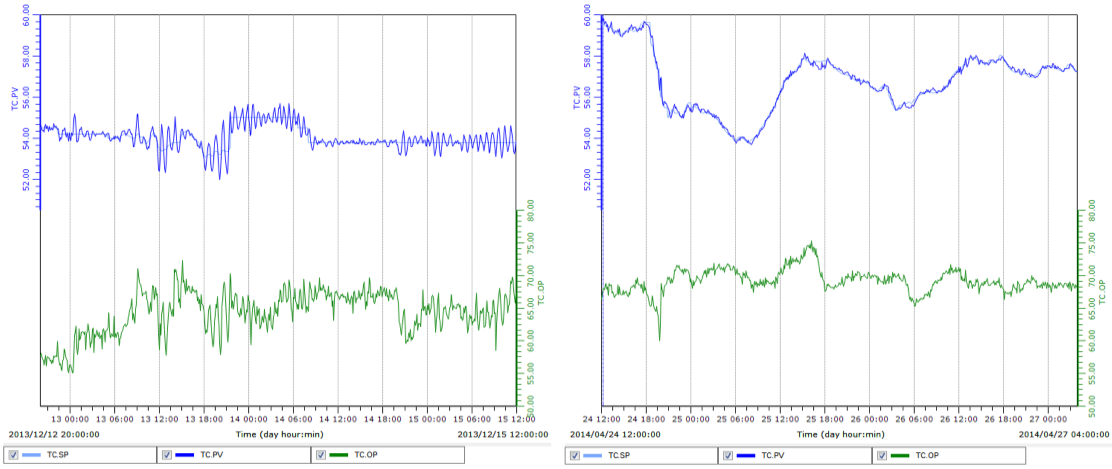

Figure 5 – DIB top temperature control: before and after "Aptituning" it

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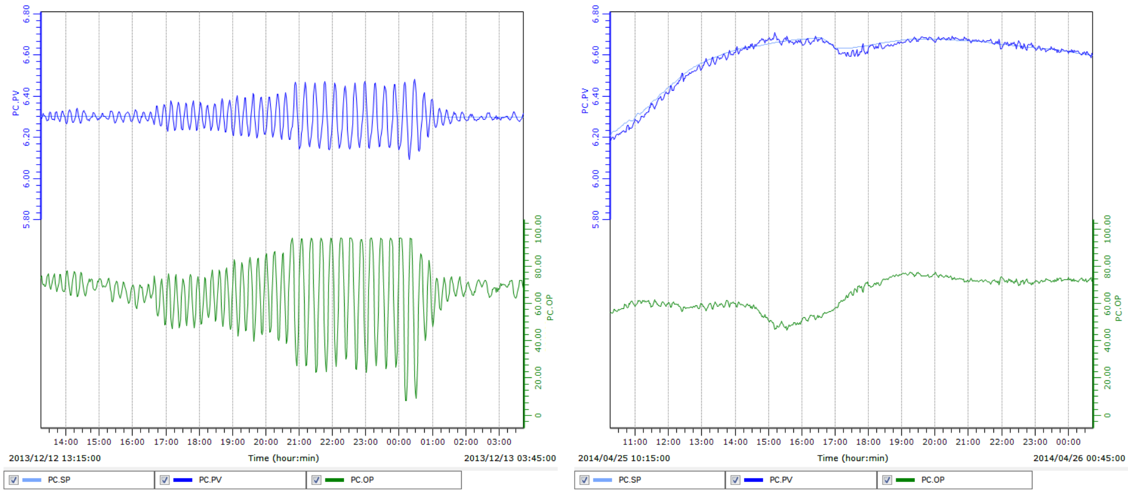

Figure 5 – DIB top pressure control: before and after "Aptituning" it

During IPCOS assignment with the client, the condensing capacity of the DIB has also been affected by another external influence: half of the existing condensers have been taken out of service for maintenance. The implemented tuning showed robustness both for operation with half or all condensers in service. Figure 7 shows data of both loops operating with only 2 condensers (a), the transition moment when the other 2 heat exchangers have been put back in service (b) and the loops operating with the full set of condensers without any change in the tuning (c).

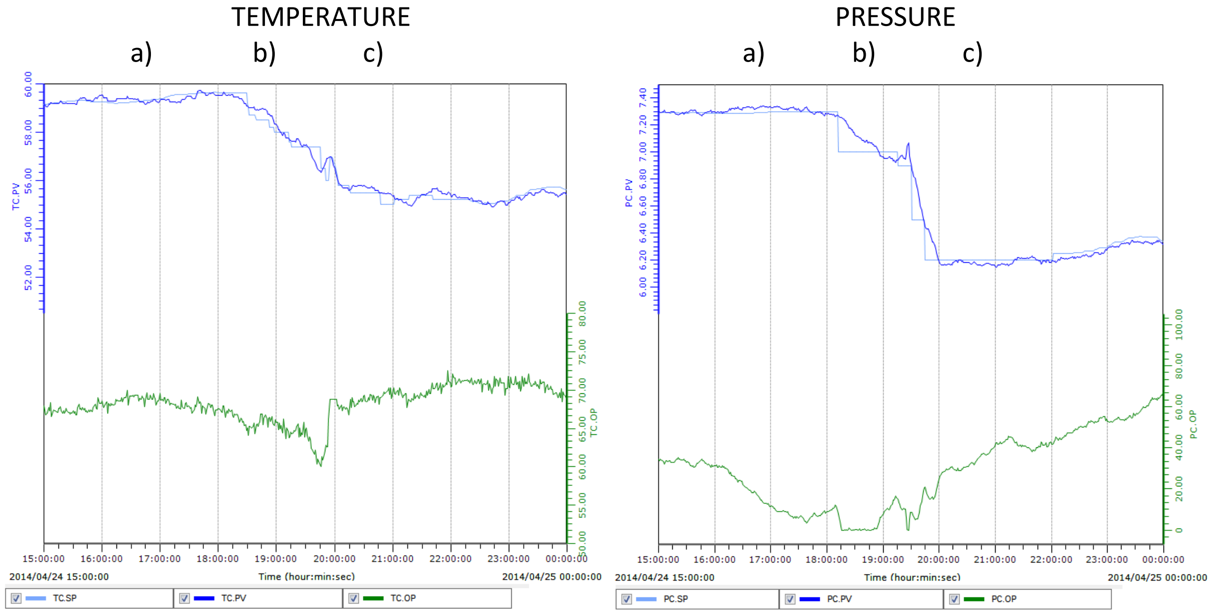

Figure 7 – DIB top section control performance after "Aptituning" during condensers maneuver

3. Conclusion

The DIB top pressure and stage #10 temperature controllers do not fall into oscillatory behavior anymore after implementing the 2x2 tuning obtained with INCA Aptitune. Tuning has been proven robust enough to perform well even facing significant process changes.

The referred DIB column has a model predictive controller implemented on top of it. The top pressure and the PCT controllers are active in this this APC system as driven handles – i.e., MV's, manipulated variables. One common reason for operators to turn the APC application off was related to oscillations before the loops have been retuned with INCA Aptitune. Amongst other APC specific improvements, tuning these loops have contributed to raise the utilization of the APC application from about 40% up to 70%.