Introduction

The depropaniser column is part of a series of fractionating units for FCC unit. The scope of APC implementation was to control the top temperature and bottom quality. Eventually RTO will send targets to top temperature and bottom quality.

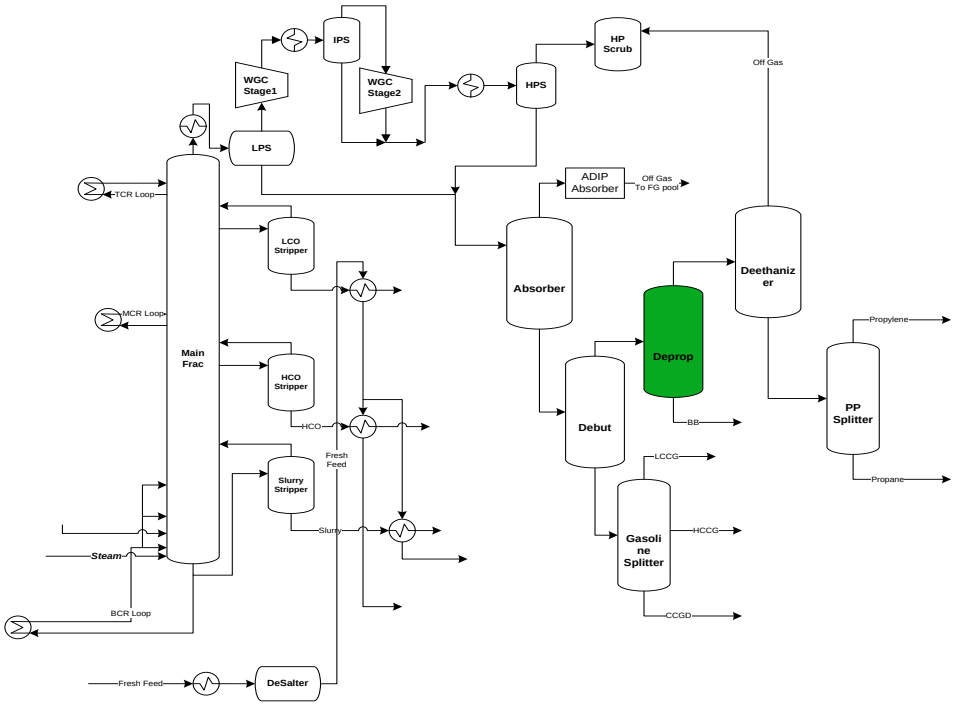

Figure 1: Overall configuration and location of Depropaniser Unit

Challenges:

The FCC has frequent feed diet and composition changes, the existing basic control scheme for depropaniser was sub-optimal and not designed to account for these feed changes. Therefore considerable operator intervention was required to maintain the products within their specification. The column was found to be operated very conservatively. Maintaining top quality was the main concern and the operators were struggling to keep the bottom quality within specification.

As the operators were manually stabilizing column operation – something the base-layer in the DCS should take care of – redesigning of DCS controls was necessary before the unit was ''APC ready''. APC can only work properly if the basic control scheme stabilizes column operation.

Observations:

It was observed that the top cut temperature changed with the bottom reboiler load. Operator was adjusting the reflux to get the temperature spikes in control; this meant that the column was always operating at over the required reflux flow. This caused the bottom reboiler load to vary and leads to off-spec bottom product.

In Addition, the duty controller for reboiler was not calculating the duty correctly. There was always a significant time delay in the change in the calculated duty and actual impact of the change and hence the bottom quality was never controlled. The bottom reboiler was a heat sink for the main fractionator and hence changes in reboiler duty were having a cascading effect on the overall operation.

Baselayer Changes and APC:

The primary change was addition of a base- layer reflux ratio controller as a master to the reflux flow, with APC setting the value of the reflux ratio instead of reflux. This means fixing up the energy balance across the column as well as adding a derivative control loop and thus minimising the operator action needed for feed changes. The level controller for the overhead collector was cascaded to the distillate flow.

Since there is no top quality analyser, the prediction of impurities in the top product was difficult and that introduces a non-linear behaviour (different temperatures when the top product is pure and when there is slight impurity). APC is able to handle this non-linearity in a better way because it can be incorporated into the prediction models.

An additional constraint of minimum reflux flow was added to MPC during commissioning to counter the effect of frequent feed changes to the column, effectively limiting the valve output of the ratio controller to a certain value.

In order to take into account the pressure changes in the column due to ambient condition changes, the two temperature measurements were converted to pressure compensated temperature.

Results

Below some before –after results are shown.

In the below trends,

Red: Reflux flow
Light green: Depropaniser Top temperature

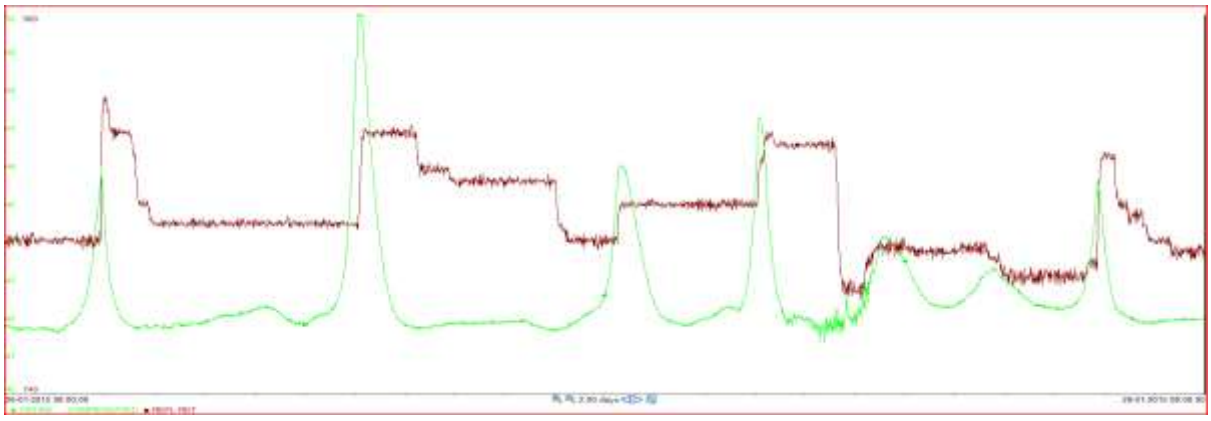

Figure 2: Before trends for the top temperature with APC OFF due to the cyclic disturbances

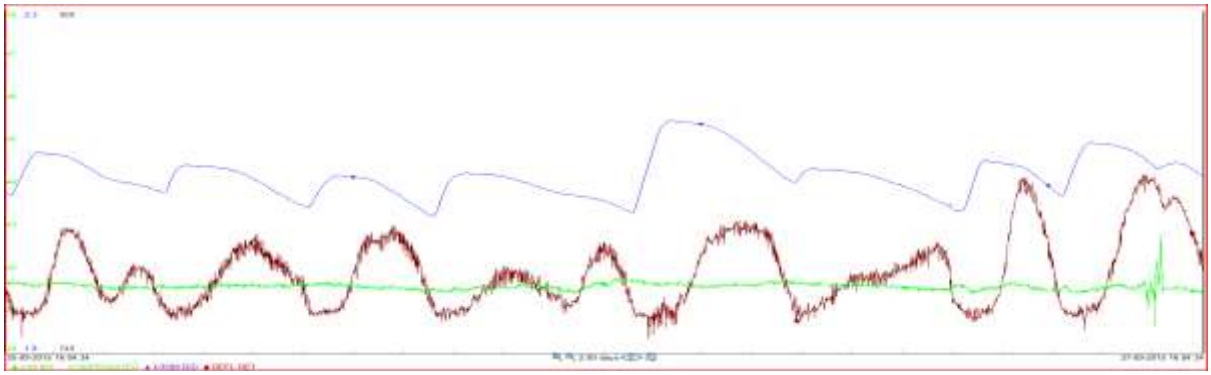

Figure 3: New APC control with modified reflux ratio control for top temperature

In the below trend:

Black: C3 in Bottoms

Red: Depropaniser bottom temperature

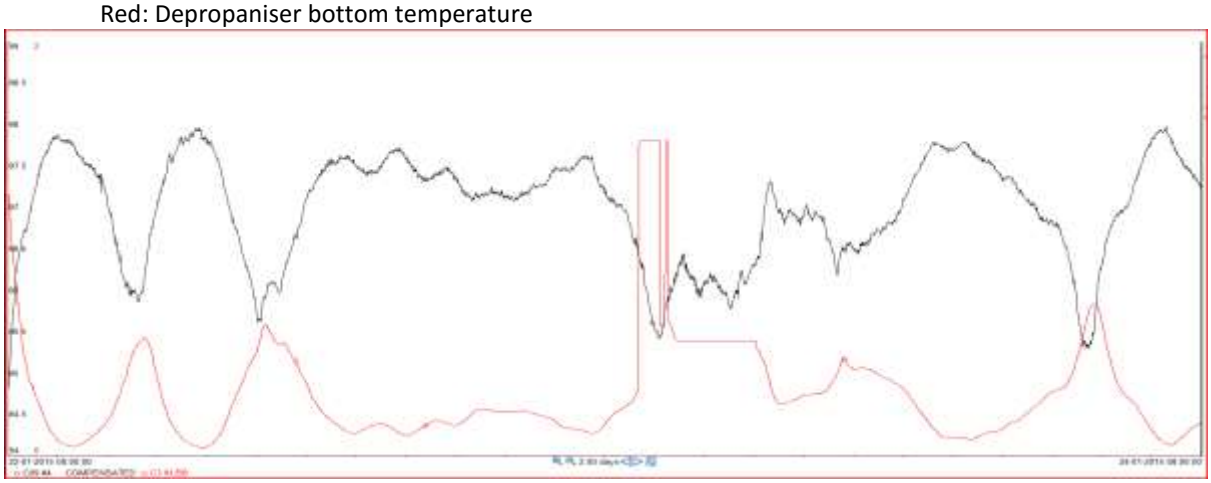

Figure 4: Disturbance in bottom temperature due to over-refluxing and analyser goes off-range

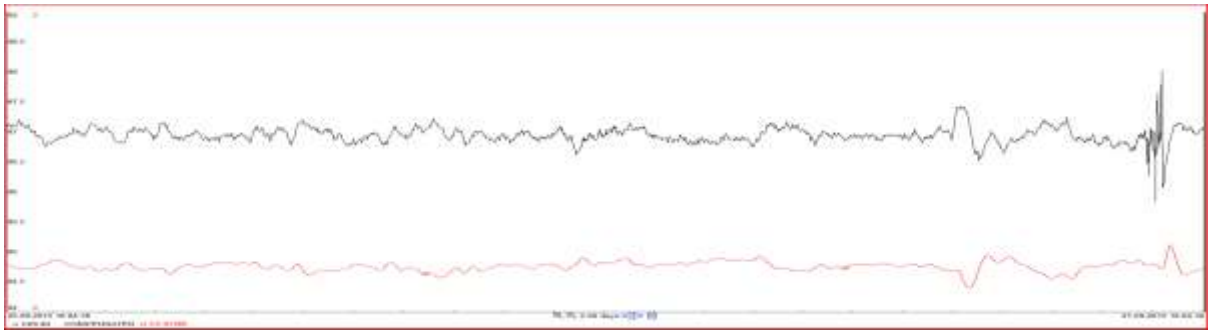

Figure 5: New APC maximises the bottom quality up to the max. Specifications

What did we achieve?

Intangible benefits:

- Reduce the interactions between the top and bottom temperatures, so that feed changes will not affect the top cut-temp and hence quality.

- Have a running MPC application which reduces the variation in C3 in bottom to a minimum while maintaining the top quality.

The various optimisation benefits which are difficult to quantify are:

- Heat load reduction was an obvious benefit as we are limiting the over-refluxing into the column, but since the reboiler duty is a heat sink for the FCC main fractionator unit, calculating it is difficult.
- Controlling the deviation in the bottom spec to a minimum. The bottom product is consumed in-house and currently the refinery planning team (RTO in future) fixes the bottom specification based on economics. Hence the final effect of having minimum deviation cannot be individually calculated.

Conclusion:

The unit is a good candidate for MPC, operations are very happy with a more stable operation of the unit.