APPLICATION OF MULTIPLE MODELLING PLATFORMS FOR OPTIMISATION OF PRODUCTION RAMP-UP

Andrade, H*, Islam, KA

Process Development and Services Department, Worsley Alumina Pty, WA, Australia

Abstract

This paper describes the use of the Aspen Customer Modeller (ACM), the Brahma and the SysCAD modelling platforms at Worsley Refinery expansion. The ACM has been applied for the optimisation of the production ramp-up. The commissioning stages of the new areas of precipitation and classification were assessed using the results of the different models running under the same input conditions. That allowed a better analysis of the commissioning stages as well as the identification of limitations in the proposed process..

1. Introduction

Worsley Alumina has over 15 years experience of Process modelling using Aspen+, ACM (Aspen Custom Modeller), BRAHMA (Billiton Refinery Alumina Hydrate Model Analysis) and SysCAD. Several smaller Excel based models have also been used for individual facility modelling. Both ACM Precipitation and the BRAHMA models are based on work of Cramer and Visser, 1994. The SysCAD based full plant model has been used for process design of the current expansion project at Worsley. The BRAHMA model has been used successfully for expansions, modifications and analysis of the Worsley precipitation circuit over several years. The ACM White Side model is used at the refinery for analysis of precipitation circuit and for "what-if" analysis.

The current expansion project includes a significant redesign of the precipitation circuit and changing from the current circuit to the new circuit involves a number of distinct steps. To increase the likelihood of a successful transition to the new precipitation circuit and to minimise the effects on product quality and production, process modelling of the transition was conducted.

2. The Modelling Platforms

For modelling the transition of the precipitation circuit a number of factors were identified as important capabilities; particle size distribution (PSD), oxalate precipitation, precipitation yield, energy balance and dynamic capability. A comparison of the capabilities of the SysCAD Full Plant Model (FPM), BRAHMA, and ACM white side models is shown in the Figure 1 below.

	Syscad FPM	BRAHMA	ACM White Side
Particle Size Distribution (PSD)	No	Yes	Yes
Energy balance	Yes	No	Yes
Oxalate Precipitation	Yes	No	Yes
Precipitation yield	Yes (Using A/C profiles from BRAHMA)	Yes (Using Temperature profiles from Syscad)	Yes
Dynamic Capability	No	No	Yes
Graphical User Interface	Windows based	DOS based	Windows based

Figure 1: SysCAD Full Plant Model (FPM), BRAHMA, and ACM White Side Models compared

As seen in Figure 1, the ACM White Side has important advantages when compared with the other model platforms, such as energy balance and PSD profile. So, the ACM White Side model was chosen as the preferential modelling platform for process analysis and optimisation during the Worsley expansion. The extra features of the ACM White Side model compensate the fact that that it is not a full plant model and only covers the precipitation and the classification areas of the process.

3. Aspen Custom Modeller and the Production Ramp-Up

The use of modelling for planning a refinery production ramp-up has got important benefits such as; identification of potential bottlenecks, assessment of project capital options, sensitivity analysis ("what if" scenarios), and project risk profile. The Worsley expansion commissioning team felt the need to simulate the intermediate steps of the commissioning process using the process models to identify equipment, process, and quality constraints and also to optimise production rates without violating any of these constraints.

For the commissioning of the expansion project several steps were identified in the production ramp-up from the existing operating conditions to the final expanded conditions taking into account the new lay-out configuration and the liquor flow and chemistry. Nine commissioning steps were simulated via the ACM White Side model. The initial steps were concerned with the new precipitation tanks start coming online. The later steps were concerned with the configuration of the new classification circuit. The commissioning steps were summarized in seven models as seen in Figure 2, which also describes of each step.

Expansion Commissioning Steps - Brief Summary *	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9
+ 6 New Precipitation Tanks	■	■	■	■	■	■	■	■	■
+ 4 New Precipitation Tanks		■	■	■	■	■	■	■	■
+ 4 New Precipitation Tanks			■	■	■	■	■	■	■
New Precipitation Tanks fed from the new seed system			■	■	■	■	■	■	■
+ 6 New Precipitation Tanks						■	■	■	■
New Precipitation Tanks fed with Green Liquor									■
# ACM Model	Mod 1		Mod 2		Mod 3	Mod 4	Mod 5	Mod 6	Mod 7

*** - NOTE:** From Step 3 to Step 5 there were changes in the classification system alignments and introduction of more equipment. The same applies from the Step 6 to Step 8.

Figure 2: Brief Summary of the Expansion Commissioning Steps

To develop the ACM models regular workshops with the expansion personnel were conducted to make sure the model's structure correctly reflected the expansion configuration. Interactive model runs were carried out with the commissioning team to further assess the correct operation of the models. The configuration and parameters of the models were modified to achieve a model that was agreed on by all parties. This was possible due to the fast ACM model convergence (of the order of one minute per run).

The models' configuration was changed with each commissioning step. New tanks and equipment were brought into the models and new areas were included as required. Process stream alignments were redirected to fit the configuration requirements of each step. The performance characteristics of individual unit operations were kept constant even though their arrangement in the circuit changed, for example the solids recovery of the cyclones. In terms of the modelling inputs the chemical properties of the liquor were kept constant but the flow was varied to optimise each step of the commissioning process..

Due to the iterative nature of the model development and the numerous models required for the commissioning process robust version management and data presentation systems were needed. To avoid misunderstandings between the numerous models the final versions of the developed ACM models were stored in a specific location, the master folder. Any required model change was then made by copying that model from the master to a work area and then, replacing the master version with the new modified model later once it had been verified.

Detailed notes on each model structure and key streams line-ups were organised and put together in a standardised tabular format making for an easy assessment and the identification of opportunities. This was done using linked interface files generated via Microsoft Excel. There was an Excel interface file for every commissioning step. The model outputs were assessed in two ways: graphicly showing trends of defined process parameters, and via more detailed data table containing the properties of the streams from block flow diagrams. The featured outputs were organised according to the expansion team requirements.

4. Results

The ACM modelling gave an estimate of the plant yield and production ramp-up profiles across the expansion commissioning steps, as per Figure 3. At the same time, it provided information on the expected the plant liquor chemistry and the production flow profiles through the commissioning stages. Using the model results it was possible to verify the plant restrictions and adjust the commissioning steps to match the constraints, for example pump capacity or the solids concentration limitation in a precipitator tank. Where the process or the equipment requirements could not be achieved, even after the commissioning step was adjusted, new solutions were discussed such as modification to equipment design or specification.

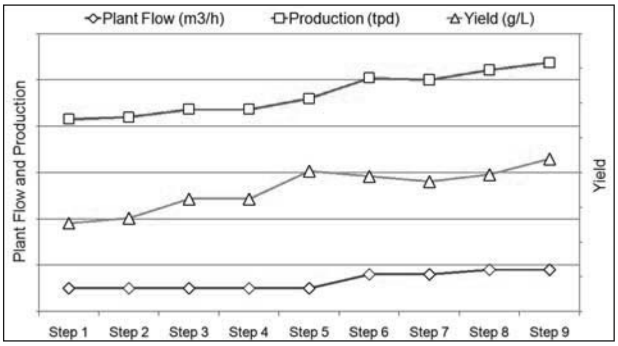

Figure 3: Input Flow and Modelled Production and Yield during the Expansion Commissioning Steps

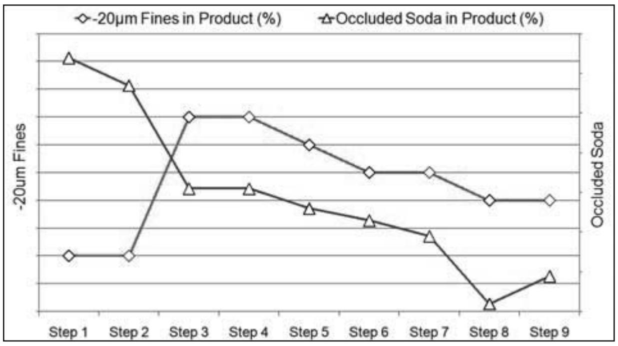

Figure 4: Modelled -20µm Fines and Occluded Soda in Product during the Expansion Commissioning Steps

The modelling also provided profiles of product quality indicators across the commissioning steps. For example the shift in product fines and occluded soda observed in Figure 4 between steps 2 and 3 can be explained by the introduction of the new seed system feeding the new precipitation tanks at the Step 3.

Other significant benefits from using the ACM models for the expansion commissioning steps were:

- Optimising the feed flow distribution to the different precipitation banks across all the steps.
- Identifying the need and magnitude of temperature adjustments needed to avoid excessive nucleation turning the precipitation circuit fine in the middle of the commissioning process.
- Quantifying the amount of spent liquor dilution needed to avoid high final discharge solids.
- The models also helped to define in which commissioning step the flash cooling system of the new precipitation bank should start operation, as well as how much cooling was needed to achieve the target final discharge temperatures.

It was noted that the ACM White Side model presented a few limitations. The particle size distribution (PSD) modelling needs more rigorous calibration and validation for predictive results but is good at indicating trends.. Also, the hydro-cyclone classification was based on a fixed partition curve, a more predictive cyclone model is currently under development.

5. Conclusions and recommendations

The applied ACM modelling methodology was successful in optimising plant performance in terms of production at every expansion commissioning step within the constraints of the process specifications and operational capability. There is an opportunity to apply this type of modelling earlier in the project development process to derive even more benefits from the model.

6. Acknowledgements

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