Integration of Process Simulation into the Production Accounting Workflow: Case Studies

Paper # 1182 April 2011

Kimberly M. Sibbald and L.R. Sibbald
Recount Resources Ltd.
Calgary

Process modeling (or simulation) is normally used in the oil and gas industry as a purely engineering function to investigate design or operational issues. We present outline case studies including that of a small gas plant complex (400 e3m3/d gas, 20 m3/d liquids) which was modeled and the results integrated into the Production Accounting (PA) function. The process modeling verified inlet metering validity and identified compositional sampling/analysis errors. It also pinpointed metering differences and proration anomalies. Modeling the basic plant process included liquids production through chiller and de-ethanization. Excellent balancing of feeds and sales stream rates and compositions was achieved. This allowed data holes to be filled which in turn allowed the PA component allocation procedure to be much improved. Key benefits of the approach for any similar situation are: a more focused approach for operational staff to isolate measurement problems; support for audit findings; EPAP compliance; and a simplified, more efficient PA work flow based on true balancing of feed and product streams at a component level.

We also present other case study examples that employed process modeling that show: the ability to derive sales analyses for allocation to satisfy a special business arrangement; the effect of lean (CBM type) gas in reducing liquids production in basic refridge plant facilities; a quantification methodology for determining the precise liquids production attributable to any individual production entity; and the determination and correction of a non-performing process (liquids disappearance).

Process Modeling

Process modeling involves the use of a process simulator to describe, using proper thermodynamic calculations, the “trip” that hydrocarbons take through separation, gathering, compression and process right through to sales. In simplest terms, knowing the composition, pressure and temperature allows the relative splits of gas and liquid and their corresponding compositions to be determined. This is a more sophisticated method of detailing the production-to-sales journey. Unlike a typical PA software package, this type of modeling can closely quantify the content and amount of gas and liquid streams anywhere, most importantly at the sales point for balancing purposes.

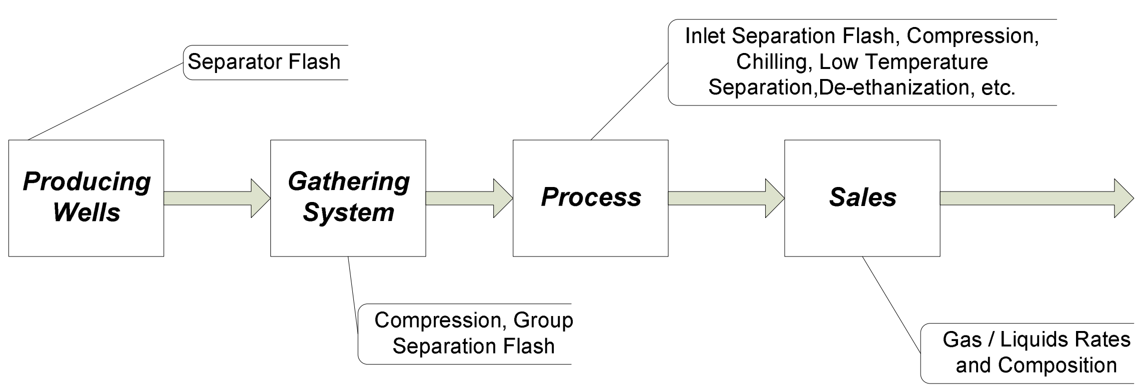

Figure 1 Process Model Capabilities

Case Study A – Balancing Production with Sales / EPAP Support

The initial driver for examining this case was to confirm the allocation for a mixed tested/measured gas production area. This was in line with the client's desire for proper allocation and to support an application for "Site Specific Deviation from Base Requirements" with the ERCB.

The production facility (400 E3m3/day of gas and 20 m3/day of liquids) comprises two plants connected to a common TCPL meter station. The process is a basic refridge facility, including compression, chilling, low temperature separation and liquids de-ethanization. Approximately 350 wells produce to the facility.

These issues required resolution:

1. Accuracy of Sales Stream for Allocation

It was necessary to determine the sales stream contributed by each plant. This was not available in sufficient accuracy due to variations in inlet flow from month to month. In Stream Components (ISC) for each plant could not be accurately set. Because of this, Ideal Product Shrinkage (IPS) could not be determined. IPS is a comparison between theoretical components and actual components leaving the plant derived using a standard production accounting package.

2. Mixed Test and Measurement Environment

The gathering system has a mixture of measured deep gas wells and unmeasured shallow gas wells utilizing common group measurement points. Due to the physical configuration of the gathering system, it is not economically viable to segregate the unmeasured wells from the measured wells (Directive 17 specification), nor is it feasible to install measurement on the tested wells. A method to reliably allocate within regulatory compliance was required.

3. Metering Bust between Groups and an Inlet

There was a suspected but unresolved excessive metering error between the sum of the groups tied in to one of the three inlets to the plant and the inlet meter. Figure 2 shows the Case schematic.

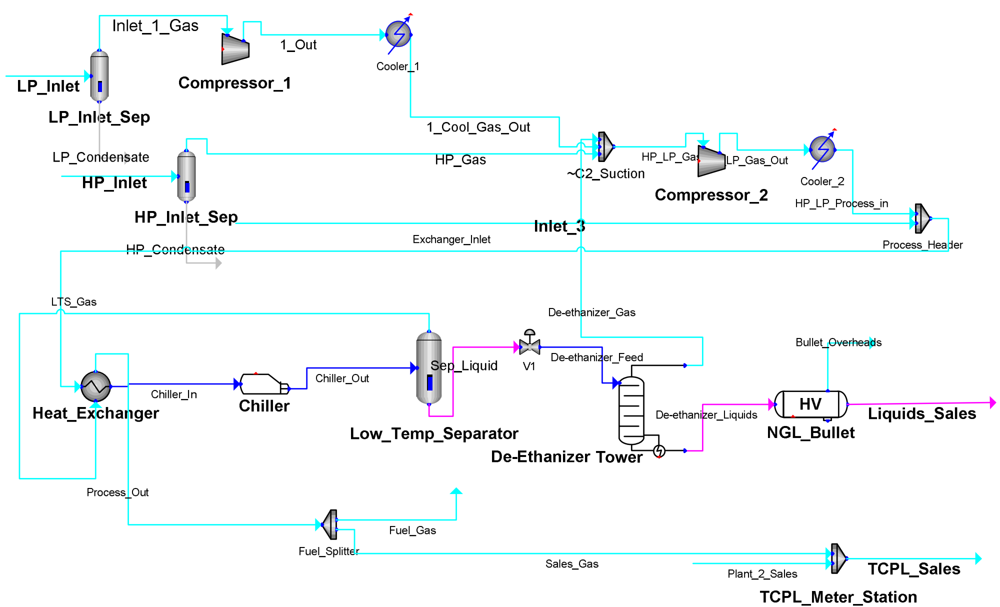

Figure 2 Process Model Schematic Case A

The model was constructed in this case using inlet level inputs; rates and compositions from the inlets were used and modeled forward into the process. Inlet 3 was found to have an erroneous analysis in that too rich a stream was indicated caused by an invalid sample that likely contained some trapped liquid. The erroneous analysis was discovered by the process modeling and other physical analyses downstream of the inlet backed this up. Beyond this, the model showed that good balancing between production inlet meters and ultimate gas and liquids sales was shown by model descriptions very close to sales figures.

The process model produced the following solutions:

1. With the ISC generated by the process model at a plant level determined, the IPS balance was significantly improved over previous months using Model derived compositional analyses. Figure 3 below shows the improvement in allocation from January to August, the latter being the first month using the new allocation methodology

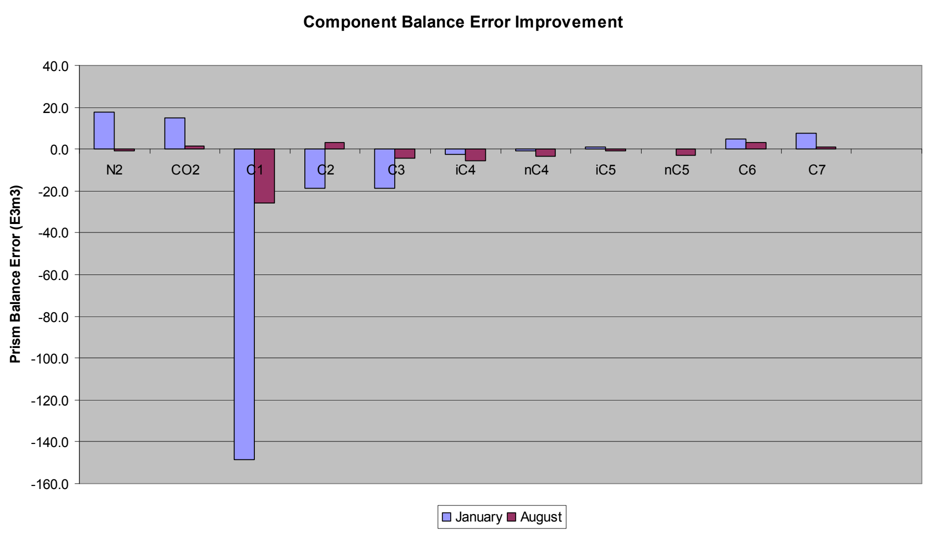

Figure 3: Allocation Improvement – Case A

2. Site specific exemption approval applications must include 6 months for production data in support of the application. Once proven, the model was used in place of 6 months of allocation data. Due to the prior reporting methodology, an accurate six month snap shot of production data was not available. The model is felt to be excellent support for the exemption application.

3. The model was used to define and quantify the metering issue. The inlet meters were confirmed as reliable due to the excellent balances achieved that matched sales figures. Because of this, the balances between the group level and inlets were examined. The problem was isolated to one group battery attached to the HP inlet, where the metering difference existed. Further investigation revealed metering deficiencies at that group. Shut-in of that group's production over period of a few days confirmed the actual contribution and that excessive over-reporting of group volumes was the problem. Further work with the model (method outlined later) quantified the level of over-allocation of liquids going back many months.

Case Study B – Dual Facility Issue – Owner Gas Allocation

Figure 4 below shows the following situation: Two facilities with different ownership; CBM gas (Owner A) going to Facility A, along with stream of mixed ownership; mixed Owner A CBM and non-owner A richer gas flowing partially to Facility A through a slipstream meter with the rest flowing to Facility B. Business arrangements dictated that, for accounting allocation purposes, Owner A gas would be deemed to go through Facility A, while the rest of the gas through Facility B. Processes involved in the plant were compression and gas dehydration.

The accounting requirement was met by first setting up a process model and confirming the over-all balance using the physical inputs and matching to sales. Then the model was modified so that the overall balance was maintained, but only Owner A CBM gas flowed to Facility A. This required the model to be run with a "virtual" balancing operation that split out the CBM gas from the rest of the stream and the resultant inlet streams flowed to the respective facilities. From there, the ISC were derived for the exits of Facilities A and B, and these used for allocation by Production Accounting. Table 1 shows the model-derived virtual sales streams used for accounting compared to the real streams. The combined sales streams (TCPL) are identical.

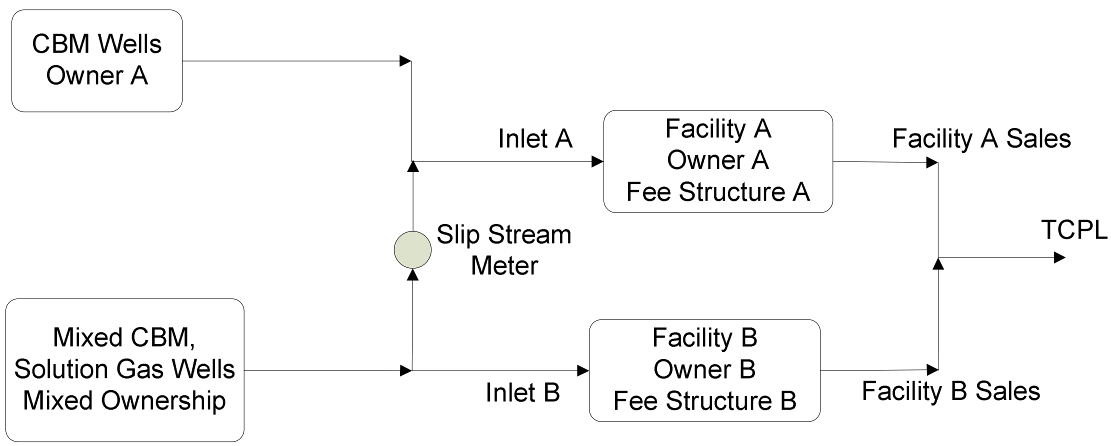

Figure 4 – Dual Facility Set-Up Case B

	Facility A Sales		***Facility B Sales***		***TCPL***	
	Real Flow	***Virtual***	***Real Flow***	***Virtual***	***Real Flow***	***Virtual***
Rate E3m3/d	75.84	75.84	51.93	51.93	127.78	127.78
Mole Fraction						
C1	0.9445	0.9827	0.9056	0.8510	0.9287	0.9287
C2	0.0239	0.0055	0.0402	0.0664	0.0305	0.0305
C3	0.0112	0.0005	0.0210	0.0362	0.0151	0.0151
iC4	0.0025	0.0001	0.0046	0.0079	0.0033	0.0033
nC4	0.0033	0.0000	0.0064	0.0112	0.0046	0.0046
iC5	0.0011	0.0000	0.0021	0.0036	0.0015	0.0015
nC5	0.0010	0.0000	0.0019	0.0032	0.0013	0.0013
C6+	0.0419	0.0061	0.0742	0.1253	0.0550	0.0550

Table 1: Production Accounting Streams – Real vs. Virtual from Process Model Case B

Case Study C: Process Liquids Issues

1. Effect of lean (CBM type) gas on reducing liquids output (business drivers)

It is well known to process engineers, but perhaps not widely known among production accountants that introduction of lean gas, typical of shallow gas producers including CBM type wells, reduces sales liquids from a typical plant.

Figure 5 below shows the effect on liquids sales from a currently operating refridge plant. The amount of this reduction effect is dependent upon the actual richer gas composition and the process conditions (Chiller/Low Temperature Separator Pressure and Temperature) but is real and relevant in any environment involving the mixing of CBM/Shallow gas and richer gas process streams.

This effect could be an issue in multi-ownership producer environments. In this case, each 10 E3m3/day of shallow gas is reducing the liquids sales attributable to solution gas wells by over 20 m3/month. While the components not being liquefied are going to the sales gas stream, the slight increase in rate and heating value of the sales gas stream due to this is minimal. The net loss in revenue due to reduced liquids can be significant.

In these situations, this knowledge is key to a Production Accountant's need to explain changes to sales streams when dealing with internal management or partners.

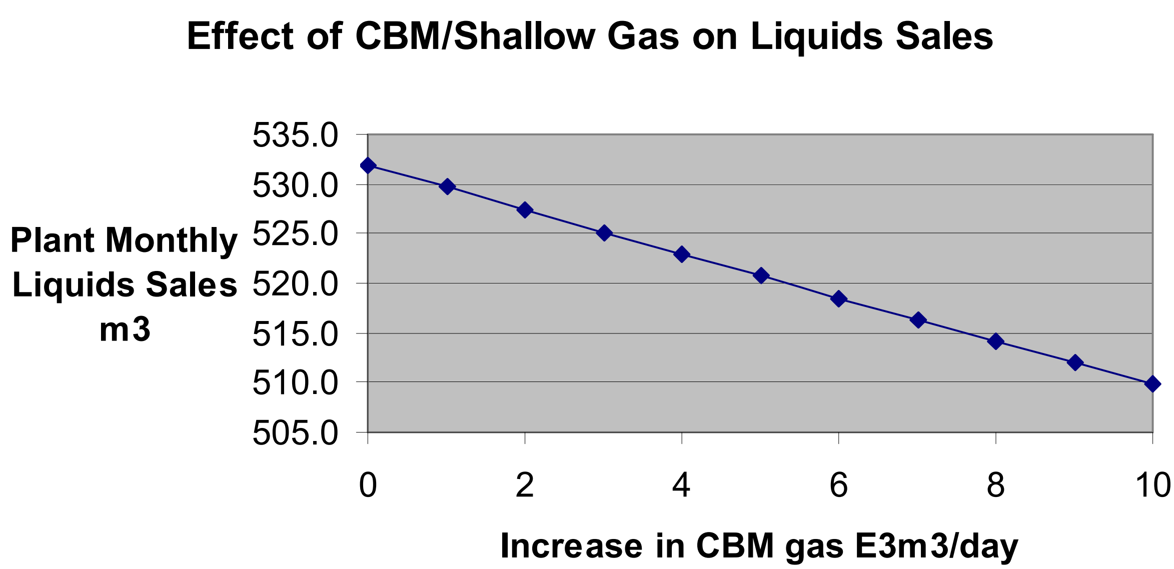

Figure 5: Reduction of Liquids Sales Caused by CBM gas in Process Stream Case C1

2. Quantification of liquids contribution from individual producers (audit, other business drivers)

In a recent case (see Case A above), it was required to quantify the over-allocation of liquids to an historically over-reported metering group. Process modeling addressed this easily since the model was already set-up. Individual wells in the Group were turned on and off to quantify the effect on net liquids production from the facility, while all other inputs were held constant. The liquids production associated with the corrected historic production level was therefore determined. In this case, the impact was significant, with over-allocation adding up to several hundred thousand dollars.

The calculation was straightforward using the process model and did not require re-running of accounting systems going back many months.

3. Solving the Mystery of Process Liquids “Disappearance”

In a final example of the benefit of process modeling, the disappearance of liquids production from a central Alberta refridge facility was investigated. The plant production of liquids had deteriorated gradually becoming zero in early 2010. As part of a more general accounting support effort, a model was built of the facility. Since the model was built, it was a straightforward matter to investigate the liquids issue using the current process stream and operating parameters. Figure 6 below shows that at no level of process pressure (thought initially to be a possible reason for lack of liquids) should the liquids have disappeared. One of the reasons cited for the lack of liquids was the gradual increase of CBM gas into the process stream over the last few years. But this had largely occurred more than two years previously, and liquids were still being produced at that time, although at a reduced level due to the CBM effect described above.

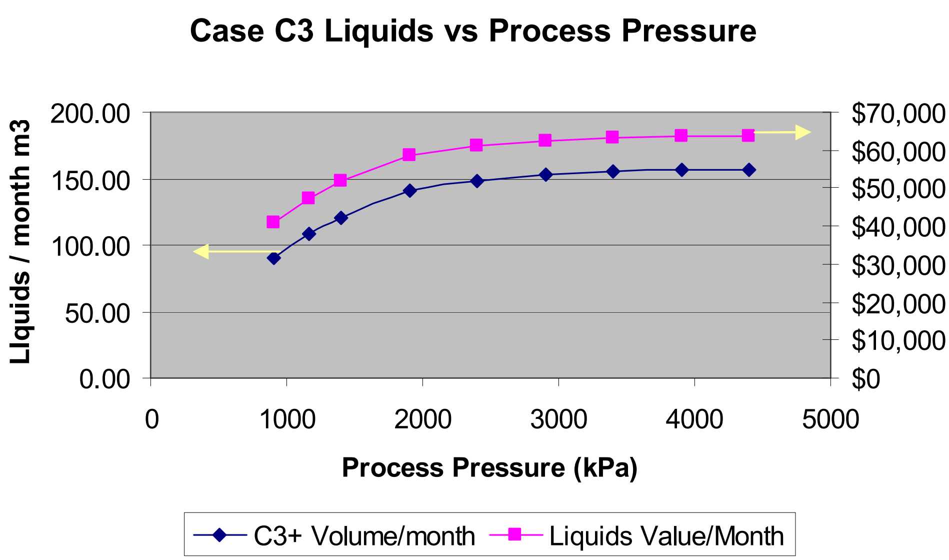

Figure 6: Process Model Prediction of Liquid Sales Case C3

When technical personnel investigated, the cause of the process deficiency was identified and corrected. This required no capital cost. The process is back to producing sales liquids to the tune of greater than $50,000 incremental revenue per month. While this benefit was produced by the process model technical determination, the driver was the desire to balance the facility from a PA perspective.

Conclusion and Outlook

The benefits of the integration of process modeling into the production accounting work process are easily demonstrated by the case study examples shown.

We are only beginning to use process modeling as support to the Production Accounting function. The basic requirements are: up to date compositional analyses, a proper flow schematic and a sufficiently detailed process description. All of these are already prerequisites for production accounting to be properly done. Once set-up for each processing facility, a process model can be used to address unique issues or as a regular monthly run. Trouble shooting balance issues in monthly accounting program runs (that often run into deadlines) is more properly and efficiently done with process modeling back-up.

It is also easily seen how process models would be beneficial in an audit process, to address and quantify allocation problems whether from the producer or processor viewpoint.