OPTIMISATION OF COMPLEX AND CRITICAL DECISION MAKING THROUGH AUTOMATION AT AN ALUMINA REFINERY

J.J. Koszo[1], D.J. Smith[2]

[1] *Automation Specialist, DJS Process Consulting Ltd*

[2] *Director, DJS Process Consulting Ltd*

ABSTRACT

Across the large-scale metals processing industry, plants are frequently faced with production issues capable of impacting profitability by the millions, forcing decision makers to act rapidly, often without all the necessary information. Especially true for alumina refineries, complexities within the process make it difficult to foresee the full implications of decisions without heavy reliance on historical experience and rules of thumb. As a result, common practice has teams comprised of highly experienced personnel from operations and engineering backgrounds work together to decide rapidly on how to handle these frequent issues. While this approach is very effective when economics and processes are consistent, this is rarely the case as even fundamental variables such as raw material quality, equipment performance and economics are constantly shifting.

At an alumina refinery, the question was posed whether a third component was missing from this team of operational and engineering personnel in the form of a program, one that the team could use which combines process engineering principles, live process data and programming to instantly calculate the profitability of decisions in real-time. This would synthesise the complex problems and provide the team with critical information about the economic viability of various options, allowing decision makers to quantitatively compare options leading to better decisions.

Taking this approach for two common production hurdles at the refinery, cleaning and maintenance cycles for classification area and production rate management resulted in total savings of at least AUD$6 million in the first year. Development and roll-out of each project was three and four months respectively, demonstrating that this new avenue for optimisation has both the high value opportunity and the low execution time required to make it a highly profitable opportunity at this refinery and likely many others.

1. INTRODUCTION

Due to the complex nature of large scale metals processing and particularly alumina processing, simple issues often have complex and significant production implications. With such large scale, decision makers are often forced to make the best decisions they can as soon as possible. However, with constantly changing process efficiencies, economics and hard to forecast variables such as scale growth the correct response to an issue changes overtime without warning.

The following paper covers the creation and effectiveness of two automated tools developed to instantly provide decision makers with the critical information required to make the best decisions. These tools combine process engineering knowledge, live process data and programming to direct users toward the optimum answers in real time.

Two high impact and common issues were selected as candidates to test if this approach could improve decision making and increase plant profitability.

The first opportunity is how to adapt turnaround cycles for classification thickeners when forced by unexpected events such as accelerated scale growth or mechanical failure. This task is highly complex due to three main factors. Drafting an alternative turnaround cycle can take weeks, changes in the cycle have implications which last at least one year and it is notoriously difficult to predict scale growth rates over the long term.

The second opportunity is optimisation of key production levers such as Bauxite Feed Rate, Digestion Temperature, Evaporation Rate. Due to constantly changing raw material costs, product value and current production bottlenecks the optimum plant configuration is constantly and silently changing. Calculating the optimum configuration is a long and complicated task and thus without automation, impossible to calculate within time constraints.

The aim of these programs is to provide decision makers with the critical information needed to take optimal actions and maximise plant profitability in a time-frame impossible to achieve without automation.

2. METHOD

2.1 Classifier Turnaround Planning Tool

To create a program capable of helping, the problem was broken down into three core steps:

1) Accurate forecasting of scale-growth
2) Flow map with vessel and pipe capabilities from above forecasts
3) Calculate the average online capability of the system through the entire one-year cycle

Using these three core steps a program was developed within VBA (coding language for Microsoft Excel) to carry out the turnaround planning process automatically. Consulting with turnaround planners and process experts frequently allowed fine tuning of the logic.

By automating the scale growth forecast, the program could use these values to predict daily capability and then run through every option for changes to the turnaround cycle to find the best solution. The result is a tool which reduced the time taken to determine the best turnaround cycle from weeks to minutes.

2.2 Production Rate Management Tool

The first step in building this program was to understand the essence of what the program needed to provide the decision maker. After many discussions with the end-users, technical leaders and control room operators the following two key outputs were concluded on:

1) Automatically and instantly calculate the real-time optimum plant configuration
2) Present the user with the relative value of each production lever

By providing the user with both the optimum answer as well as the relative values of each lever, the user has both a starting point (the optimum configuration) and the ability to quantitatively move away from that with the lowest impact when external barriers exist outside of the programs logic.

Once these requirements were understood a strategy for the development of the program could begin. Utilising the already existing plant model to carry out thousands of simulations enabled rapid analysis and laid the groundwork of knowledge upon which the program was built. Merging this knowledge with that of the technical staff who traditionally did this task manually allowed for fast development of the tool and ensured reliability of results.

3. RESULTS AND DISCUSSION

3.1 Classifier Turnaround Planning Tool

With continuous pressure to increase plant production pushing on designed capability limits, the classification thickener area was progressively becoming a more frequent plant bottleneck. Over a 5-year period this was costing on average $3 million AUD/year in an upward trend. In addition to this, the low economic environment meant that a solution without capital expenditure was needed. Given the technical complexity of turnaround planning in this area and the background, the classification thickener area was a perfect candidate for a decision assist approach.

3.1.1 Results

Thanks to involvement from end users and experts during development, roll-out was relatively smooth. Due to the success of the program and ease of use, the final use case shifted slightly from a case-by-case to a weekly basis. This allows users to track the forecasted performance over time more accurately and keep track of scaling rates better than before. By tracking on a weekly basis, decision makers are also able to see when turnaround plans need changing weeks in advance allowing for much better flexibility and control of the section. In combination with increased rigour of cleaning cycles, the first year saw the frequency of classification as the plant bottleneck nearly completely eliminated worth approximately AUD$3 million/year.

3.1.1 Manual Turnaround Schedules

Beyond the automatic scheduling advantages, the program yielded an additional benefit in the form of forecasting for manual turnaround plans. In events where, external forces such as unexpected mechanical failures in neighbouring areas of the plant affect only part of the classification area, the user can input a partial plan manually. This takes only minutes and the program will extrapolate the best plan from this start point as well as forecasting performance throughout the entire period. This not only benefits the classification section but also releases some pressure on neighbouring sections by becoming more flexible. Having a clear and consistent means of forecasting in this historically difficult section has benefited the section greatly by increasing flexibility.

With three months of development, the project clearly demonstrates that a high value capability issue can be resolved without capital expenditure simply by creating a tool to enable optimal use of equipment.

3.2 Production Rate Management Tool

Upon roll-out of this program several discoveries and learnings were made. Unlike the classification planning tool, there was no quantified metric on how far from optimum the plant configuration was on a daily or annual basis. However, early findings immediately conflicted with several key understandings and thus sparked early debate about the validity of the results. As well as challenging key understandings it was also found that over a two week period while the program was running but not in use the typical deviation from optimum was values at between $10,000 to $30,000/day which was significantly higher than expected.

3.2.1 Conflict with Current Process Understanding

Current practice was to maximise Digestion Temperature whenever possible, this was based on recent engineering reports which investigated the economic impact of increasing Digestion Temperature and found that it was economically favourable. Findings from the program however often recommended that users minimise the Digestion Temperature sparking debate. After analysing the results to validate findings it was discovered that while maximising Digester Temperature was indeed a positive economic decision (consistent with the engineering reports) it was not the *most* economic decision.

The key discovery here was that the priority order for each production lever was dependant on the current plant bottleneck; this complex perspective makes sense in hindsight as it is not surprising each lever impacts different areas of the process in different ways.

3.2.2 Trust and Consistency of Results

After working through this altered perspective with users it became clear that this flexible philosophy while highly valuable, heavily relied on one program. Although the conflicts were cleared and agreed on, one primary concern prevented rapid uptake of this program: trust. End-users were concerned that while the program was likely to be feeding them correct information from the calculations, how were they to know if an error had occurred and the program was suddenly providing inaccurate answers, since the results could be so flexible it was difficult to trust.

To eliminate this concern, it was recommended that the program be updated to provide additional answers beyond simply the showing where the optimum plant configuration was. By providing users transparency in the workings behind, users could see the impact of each variable on flowrates at various plant bottlenecks alongside the financial impact of each variable. This not only improved trust of the system but also had the added benefit of enabling users to tweak the optimised result of the program in events where external factors not incorporated into the program prevented it, for example when large sections of the process are offline for maintenance.

3.2.3 Results

Given the unclear history of deviation from optimum it was difficult to fully quantify the benefit from this project. However, it could be calculated for the specific issue with Digester Temperature that the change in operating philosophy was worth approximately AUD$3 million/year. This was just one of several changes and demonstrates that just part of this work yielded significant savings. With a four month total project timeline and the significant savings seen, this project further demonstrated how a tool created to provide critical information to decision makers can be very profitable with high value and low cost of implementation.

4. CONCLUSION

Both projects chosen, to investigate the value of automation in helping decision makers were shown to be successful. With a total benefit of at least AUD$6 million in the first year it is clear that combining process engineering, live process data and programming can provide decision makers with the critical information needed to make better decisions.

Learnings for future include continuing to have significant involvement from relevant experts such as planners or control room operators not only to ensure results are accurate and reliable but also to improve user engagement and transparency of results. Additionally, this approach had unexpected secondary benefits by improving plant flexibility as well as helping extract extra value from production issues by flagging production issues up to weeks in advance rather than days.

With such a high ratio of demonstrated value versus cost of development, it is clear that this approach can significantly improve the profitability of this alumina refinery and likely many other metals processes too.