Proving a New Refinery Design Using Reliability Throughput Modelling

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SSR Engineering Pty Ltd
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1.0 Introduction

- Damien Willans
- Director, SSR Engineering Pty Ltd
- Incorporated in 2009

Key Highlights:
- Specialize in reliability modeling
- 15 to 20 years minerals processing design backgrounds for both company partners
- Previously in-house reliability modelling, now consulting

Modelling software
- SSR uses a flexible modeling platform - Goldsim
- Goldsim is a numerical analysis platform with a wide range of applications including engineering systems reliability.
Agenda

- 1.0 Introduction 5 min
- 2.0 Modeling new projects 5 min
- 3.0 Case study - New project outline 5 min
- 4.0 Project setup – Client scope, data, documents 10 min
- 5.0 Producing the models 10 min
- 6.0 Model outputs and issues 5 min
- 7.0 Summary 10 min
- Questions 10 min
2.0 Modelling new projects

- Current Scenario
  - Resource demand and industry is booming.
  - Project scales have generated larger scale specialized engineering providers.
  - The larger they are, the harder it is to fully integrate all stages of project design and operations.
  - The path from resource ownership to fully functioning and integrated mine/processing facilities can be lengthy, expensive and rarely seamless.
2.0 Modelling new projects

- Engineering – Construction - Operation
  - Typically in Australia the major resource companies engage large engineering consultants to execute plant design.
  - The key criteria is project cost, combined with a performance guarantee.
  - Final design and construction is often handed off to large construction companies.
  - Plant is handed over to owner/operator for operations and maintenance.

Key point: The facility owner has limited opportunity to prove and optimise the design – particularly in the area of operations and maintenance effects.
3.0 Case study – New project outline

- Project outline
  - A relatively “new” player (in Alumina but not in resources).
  - Massive mine to raw product processing and port development.
  - Compelled to use publically available technology and engineering.
  - Utilizing a large engineering team with wide range of experience and design preferences.
3.0 Case study – New project outline

- Design process
  - Process flowsheet designed with final production number as starting point.
  - An assumed “operating” factor was then applied to get:
    - Final flowsheet data – this was then used to size pumps, filters, piping etc.
  - Entire success of the plant process is dependent on the plant equipment meeting the assumed operating factor, not just initially but over time…
4.0 Project setup – scope, data, documents

- Project definition stage is VERY important.
- 3 major requirements at model definition stage:
  - Client requirements
  - Data sourcing
  - Documentation and review
4.0 Project setup – scope, data, documents

● 4.1 Client requirements

  ▪ Initial requirement was a reliability “model” which had different meanings to each person.
  ▪ My job was to show the potential outcomes from the models and how they could use them.
  ▪ Significant demonstrations of the program (Goldsim) and explaining numerical analysis.
  ▪ All expectations from owners, design engineers and operating partners were documented and updated during the project duration.
4.0 Project setup – scope, data, documents

4.2 Data sourcing

- Very critical to find/collate all available data and get agreement on its use.
- Equally critical to assemble all of the data into a single source document for review by the client early in the modelling process.
- For this project we required process flow diagrams (PFD’s), equipment lists, area process descriptions, initial maintenance assumptions and failure data.
- This (greenfield) project required some existing plant data from the operating partner.
4.0 Project setup – scope, data, documents

- Essential data comes together for 2 very important reasons:
  1. Allows alignment of data and highlights gaps.
  2. Eliminates uncertainty for those who only review the outcomes after modelling project essential completion.
4.3 Project documentation

- Design criteria documents were then compiled for each process area.
- These contained ALL relevant data to be used in each model (i.e., in one specific location).
- Criteria generated significant “discussions” regarding some assumptions – a great tool.
- Invaluable for project final model review stages – when input data is often a point of contention (particularly for new players).
5.0 Producing the models

● Overview

- 5.1 Starting with a plan
- 5.2 Building the models
- 5.3 Developing models the client can use
- 5.4 Building the combined (full-plant) model
5.0 Producing the models

5.1 Start with a plan

- Start by breaking down total plant by areas.
- Build a schedule for the overall project.
- Create the modelling schedule based on model development stages – preliminary, area verification, combined model stage.
- Update progress each week.
5.0 Producing the models

- Build a schedule for the overall project.

<table>
<thead>
<tr>
<th>Project Schedule</th>
<th>Wk 1</th>
<th>Wk 2</th>
<th>Wk 3</th>
<th>Wk 4</th>
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| **Stage 2:** Prelim. model/verification |      |      |      |      |      |      |      |      |      |       |       |       |
| Materials Handling | 1      |      |      |      |      |      |      |      |      |       |       |       |
| Grinding           | 2      |      |      |      |      |      |      |      |      |       |       |       |
| Digestion          | 3      |      |      |      |      |      |      |      |      |       |       |       |
| Evaporation        | 4      |      |      |      |      |      |      |      |      |       |       |       |
| Mud Clarification  | 5      |      |      |      |      |      |      |      |      |       |       |       |
| Mud Washing        | 6      |      |      |      |      |      |      |      |      |       |       |       |
| Mud Disposal       | 7      |      |      |      |      |      |      |      |      |       |       |       |
| Liquor Filtration  | 8      |      |      |      |      |      |      |      |      |       |       |       |
| Heat Interchange area | 9      |      |      |      |      |      |      |      |      |       |       |       |
| Precipitation      | 10     |      |      |      |      |      |      |      |      |       |       |       |
| Hydrate Classification | 11     |      |      |      |      |      |      |      |      |       |       |       |
| Seed Preparation   | 12     |      |      |      |      |      |      |      |      |       |       |       |
| Product Washing    | 13     |      |      |      |      |      |      |      |      |       |       |       |
| Calcination        | 14     |      |      |      |      |      |      |      |      |       |       |       |
| Alumina Handling   | 15     |      |      |      |      |      |      |      |      |       |       |       |

| **Stage 3:** Combined plant model |      |      |      |      |      |      |      |      |      |       |       |       |
| Assembly           |      |      |      |      |      |      |      |      |      |       |       |       |
| Check and run scenarios |      |      |      |      |      |      |      |      |      |       |       |       |
| Final report & handover |      |      |      |      |      |      |      |      |      |       |       |       |
5.0 Producing the models

5.2 Building the models

- Start with a structure in mind.
- Inputs ➔ Model ➔ Outputs
- Input data includes:
  - Process criteria, flowrates
  - Equipment capacities (Nor / Max / Design)
  - Operating rules
  - Planned maintenance freq and durations
  - Unplanned stoppages (failure data)
5.0 Producing the models

- Goldsim model architecture is flexible…
5.0 Producing the models

- So consistent model structures are essential.
5.0 Producing the models

- Input data screen:
5.0 Producing the models

- Process flows:

![Diagram of process flows](image-url)
5.0 Producing the models

- Reliability/Equipment elements:

All elements are linked to upstream elements in order to operate. Final element (Product pump) is referenced by high level Mill element in order to allow go / no-go in the flow circuit.
5.0 Producing the models

- Calculated output screen:
5.3 Developing models the client can use

- Goldsim uses dashboards for client model interface.
- Line up inputs in design criteria exactly with model dashboards.
- Discuss resultant model outcomes face to face.
- Input/Output dashboards for this project included the Grinding area.
5.0 Producing the models

- Client model interface – model inputs:

![Diagram showing various maintenance schedules and flow inputs for a grinding mill circuit.](image-url)
5.0 Producing the models

- Client model interface – model outputs:

![GoldSim Pro - Grinding_mill_circuit for presentation](image)

- Grinding Circuit Outputs

  - Mill Cct #1 Flow Average (tph): 67.74
  - Mill Cct #2 Flow Average (tph): 67.47
  - Mill Cct #3 Flow Average (tph): 64.74
  - Total - Mill Cct Flow Average (tph): 99.98

  - Percent online time (typ):
    - 67.74
    - 67.47
    - 64.74
    - 99.98

- 4.82 mtonne
  - Grinding - Annual output (Ore + Liq)

- 4.82 mtonne
  - Grinding - Ideal Annual output (Ore + Liq)

- 2.85
  - Mills online (Avg)
5.4 Building the combined plant model
- Each area is built as a standalone model.
- Utilise standard input/output formats.
- Create a combined model by adding all process area models into one location.
- Combined model simply connects inputs and outputs to provide a continuous circuit.
- Important to re-evaluate operating and maintenance connections between areas (!!!)
5.0 Producing the models

- Combined model assembly:
5.0 Producing the models

- Combined model – Overall Outputs:
5.0 Producing the models

- Combined model – System/Equipment analysis:
5.0 Producing the models

- Combined model – Bulk equipment analysis:

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6.0 Model Outputs and Issues

• 6.1 Project requirements
  ▪ Phased development – client is always confident of outcomes at each project milestone (no black box !!).
  ▪ Use agreed inputs via reviewed design criteria.
  ▪ Determine all model scenarios to be evaluated.
  ▪ Present findings with a wider audience in mind (visual comparisons rather than just numbers).
6.0 Model Outputs and Issues

- Multiple model scenario investigations:
  - S1 - Evaluate baseline operating and maintenance criteria using initial design.
    - Look for areas with largest production shortfall and identify causes (Ops / Mtce / Design?).
  - S2 - Examine initial design assumptions – redundancy.
6.0 Model Outputs and Issues

- Multiple model scenario investigations:
  - S3 - Case studies included minimum level of equipment (i.e., no spares) to show where they are really needed.
  - S4 – Ran area and combined models both with and without failure modes to show both sensitivity (to failures) and plant potential in ideal conditions.
6.0 Model Outputs and Issues

- Model Results – by Area – as designed:

![Graph showing Model Outputs and Issues]
6.0 Model Outputs and Issues

- Model Results – by Area – minimum asset case:

![Graph of Area Capacity](image-url)
6.0 Model Outputs and Issues

- Model Results – Combined Output:

Plant Alumina Capacity - Fall Data + No Fall Data - Equiv Alumina mtpa (10Yr dur)
7.0 Summary

- Case Study project outcomes
  - Clear definition and alignment of design data was achieved before detailed design process.
  - Proved the design engineer’s operating factor assumption was exceeded (for given criteria!).
  - Provided a statistical basis for the plant design capacity for the client’s project cost estimate.
7.0 Summary

- Case Study project outcomes
  - Also showed several process areas where value improvements could be investigated.
  - Client now has a tool to validate further maintenance strategy inputs vs. plant capacity.
7.0 Summary

- Capacity modelling vs. project stages
  - Early adoption (Feasibility/Study stage) – Capital savings through optimizing equipment capacities and redundancy.
  - During Design (Prelim/Basic engineering) – Value engineering processes, confirming effects of maintenance and operating strategies on adopted design.
7.0 Summary

- Capacity modelling vs. project stages
  - Detailed Engineering and construction – Use to refine and verify maintenance strategy development processes (e.g., RCM). Also provide initial resourcing estimates for labour, commodities (spares) etc.
  - After Startup – Verify model vs. plant outputs, then use for both capital and maintenance program validation.
7.0 Summary

- Value adding
  - Resourcing – Run the models to gauge resource requirements for varying strategies (labour, spares, commodities etc).
  - Energy – Energy use is time and condition related – so can be built into these models (e.g., pump efficiency vs. changeout freq).
  - Model company wide operational and mtce initiatives across multiple facility models before making the change (!).
Where to Get More Information

- Web links
  - www.ssr-eng.com
  - www.goldsim.com
- E-mail: damien@ssr-eng.com
- or: info@ssr-eng.com
Questions

Thank you for your attention 😊

Do you have any questions?