



SRA Research Project Final Report

Advanced computer simulation of sugar factories – SysCAD: revised final report 2010/040

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| SRA Project Code | 2010/040 (QUT040) | | |
| Project Title | Advanced computer simulation of sugar factories - SysCAD | | |
| Key Focus Area in SRA Strategic Plan | Milling Efficiency | | |
| Research Organisation(s) | Queensland University of Technology | | |
| Chief Investigator(s) | Dr Ross Broadfoot, QUT Dr John McFeaters, Kenwalt Australia (KWA) Dr Rodney Stephenson, Kenwalt Australia (KWA) | | |
| Project Objectives | This project aims to develop a highly adaptable ‘whole of sugar factory’ process model that includes the capability to incorporate a variety of adjunct processing options e.g. cogeneration, biofuel production from molasses, juice or fibre, biochemical production. | | |
| Milestone Number | 7 | | |
| Milestone Due Date | 1/12/2014 | Date submitted | 11/12/2014 |
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| Milestone Payment | | | |
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| Success in achieving the objectives | <input checked="" type="checkbox"/> Completely Achieved <input type="checkbox"/> Partially Achieved <input type="checkbox"/> Not Achieved | | |



Sugar Research
Australia



**SRA measures of success
for Key Focus Area (from
SRA Strategic Plan)**

Key Focus Area is Milling efficiency



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Section 1: Executive Summary

Currently, the process modelling of Australian sugar factories utilises comprehensive models of individual sugar processing unit operations. These models have been developed by Sugar Research Institute (SRI) and QUT over several decades and are used extensively in research and consulting for sugar factories. However the capability to model an entire plant using the proven models for the individual unit operations does not exist. Several commercial modelling packages are available but these do not provide the inherent complexities and benefits of the SRI and QUT unit operation models that better suit the more complex investigations for sugar factories and adjunct facilities.

By not having available a proven, “whole of plant” simulation package the sugar milling industry is restricted in its ability to analyse the integration of whole of plant operations. This project has developed a suitable ‘whole of factory’ model – SysCAD. SysCAD can be developed to provide dynamic simulation and so is capable of being used to assess advanced control options for improved operational efficiency. This project has focused on the development of a steady state ‘whole of factory’ model.

The SysCAD models comprise the following steps to build through to the ‘whole of factory’ models:-

- Develop the models for the individual unit operations. A unit operation is the functionality involved in a single item of equipment e.g. turbine, mill, heater, evaporator etc. Each unit operation in SysCAD has inbuilt inlet and outlet streams and calculation functions.
- Upgrade the thermo-physical-chemical properties database to incorporate sugar processing parameters. The functional expressions may be either correlations etc. available in the published literature (for Generic Sugars SysCAD) or SRI confidential correlations (for SRI Sugars SysCAD).
- Incorporate the unit operations models into area models for different sections of the plant. For example, the unit operation of a mill is linked to provide the appropriate configuration for the area model of a milling train.

The incorporated linkages provide the flexibility to allow modelling of a wide range of configurations of the equipment associated with that area of the plant.

SysCAD uses control functions (e.g. proportional and integral action) to manipulate the control variable e.g. vapour flow to the evaporator, to achieve a steady state solution.

Excel spreadsheets were developed to transfer input data to the SysCAD models and to display results from the SysCAD models in a format which is suitable for reporting results.

The area models were developed to incorporate the SRI functional correlations and model complexities (i.e. SRI Sugars SysCAD models). From this position the Generic Sugars SysCAD models can be established by replacing the SRI functional expressions with generic expressions.

- Develop the ‘whole of factory’ model. In the ‘whole of factory’ model the individual area models are linked through ties, at the appropriate process connections (e.g. link the juice from the milling train to the mixed juice tank supplying the primary heaters).

The staff at KWA provided excellent support to the QUT staff in providing training in the fundamental principles of SysCAD modelling, the development of SysCAD unit operations to better suit sugar factories, and importantly guiding QUT staff in debugging software problems.

Staff at Australian sugar factories were not involved in the development of the Sugars SysCAD. It is intended that, following more experience by QUT staff in using SysCAD in real applications, the SysCAD models will be available to milling groups.

SysCAD can operate with selected models for individual stations which can be either generic models (termed Generic Sugars SysCAD) or SysCAD models in which SRI correlations are embedded (termed SRI Sugars SysCAD). There are two main pathways by which the software would be used:-

- Milling companies purchase a licence to use the software. This version may include generic sugar modules or SRI sugar modules for individual stations (or combinations), and
- SRI (QUT) undertakes research and consultation studies on behalf of the industry and sugar milling companies using Generic Sugars SysCAD or SRI Sugars SysCAD.

The main deliverables from the project are the area models and the ‘whole of factory’ SysCAD models. These will be used directly in investigating processing modifications to achieve throughput rate, energy efficiency, recovery and sugar quality improvements. The models can readily be configured to examine the integration of adjunct plant, such as for the production of additional products, with the sugar factory. The deliverables of the project will make contributions to three of SRA’s Key Focus Areas viz. Milling efficiency, Product diversification and value addition, and Knowledge, technology transfer and adoption. Application of the SysCAD models will provide economic, social and environmental benefits.

Section 2: Background

KWA (Kenwalt Australia Pty Ltd) developed the SysCAD process modelling software which is used extensively in the minerals processing industry. SysCAD is ideally suited to the development of a ‘whole of sugar factory model’ as it provides the required flexibility to incorporate appropriate models for the individual plant sections into a whole sugar process model. Importantly, SysCAD also allows dynamic modelling of individual plant sections and of the whole plant.

These two features distinguish SysCAD from the SUGARS package which is widely used for undertaking steady state mass and energy balances by sugar factories around the world, including by some Australian factories. QUT also uses SUGARS. SUGARS is very useful for simulating customised flow schemes.

However, SUGARS is limited in the ability to incorporate industry and company specific correlations and kinetic relationships, thus restricting the usefulness and validity of the modelling results under some circumstances.

The ability of SysCAD to overcome these deficiencies was the reason for developing the Sugars SysCAD ‘whole of factory’ model.

Section 3: Outputs and Achievement of Project Objectives

Project objectives, methodology, results and discussion

The objectives for the project were to develop a highly adaptable ‘whole of sugar factory’ process model that includes the capability to incorporate a variety of adjunct processing options e.g. cogeneration, biofuel production from molasses, juice or fibre, biochemical production.

The final report for the project includes descriptions of the following:-

- the unit operation models and the area models for each section of the sugar factory including the steam and water circuits.
- the ‘whole of factory’ model for an Australian sugar factory
- plans for future use of Sugar SysCAD in the industry
- matches of SysCAD output data to the results from other simulations for typical Australian factories
- examples of process modelling for variations to factory operations.

The project has provided substantial skills development and capability in several QUT staff in providing increased understanding of areas of factory operations outside their areas of expertise. Having to develop models and cover all variations of process options that are used in sugar factories broadens and deepens the knowledge base.

Section 4: Outputs and Outcomes

A technical (confidential) report for the project titled “Advanced computer simulation of sugar factories – SysCAD” is provided separately.

The main outputs from the project are:

- SysCAD area models for each section of the sugar factory. These models can be used individually to investigate processing arrangements within that area.
- SysCAD ‘whole of factory’ model.

The main outcomes from the project are:

- Application of the SysCAD area models and ‘whole of factory’ models in investigating changed processing circumstances for sugar factories. The improvements in accuracy and breadth of the assessments provided by the Sugar SysCAD models will benefit sugar factories in economic, social and environmental aspects. For example, improved modelling of proposed processing changes can better define the results, the costs and the risks, and ensure better financial returns on the invested capital.
- Increased skills in QUT staff through developing SysCAD models and changing configurations to allow ‘whole of factory’ modelling of a wide range of variations of sugar factories.

The Sugars SysCAD models will be able to be used by milling companies through the purchase of a licence in which case they would undertake the assessments of proposed plant modifications themselves or alternatively they would contract QUT (or SRI) to undertake the assessments.

Section 5: Intellectual Property (IP) and Confidentiality

QUT owns the intellectual property generated in the project.

No patent applications have been lodged to protect the intellectual property arising from the project.

Collaborators agreements exist between QUT and Sugar Research Institute and Kenwalt Australia to define the terms of licencing the Sugars SysCAD package.

There is no syndicate of mills involved in this project so the Sugars SysCAD is available for use by all mills immediately (subject to obtaining a licence).

Section 6: Industry Communication and Adoption of Outputs

The project delivered the output of Sugar SysCAD software which can be utilised in determining the impacts of changes to sugar milling operations and the implementation of diversification plans. The real benefits will materialise when sugar factories (or through consultations by SRI/QUT) utilise the package in planning major changes to the factory.

Staff at Australian sugar mills have been kept informed of progress on the project through Regional Research Seminar presentations in March/April 2011, 2012, 2013 and 2014. Representatives of SRDC/SRA attended these seminars.

A paper was presented at the 2013 ISSCT conference, Brazil which described the improvements to milling train operations through modelling using the SysCAD model for this process area. The milling train modelling was undertaken by Omkar Thaval as a part of his Master's degree.

The reference to the ISSCT paper is:

Thaval, O. P., & Kent, G. A. (2013). Advanced computer simulation of the milling process. *Proceedings of the XXXVIII International Society of Sugar Cane Technologists*. (Vol. 28, pp. CD-ROM).

There has been no communication with staff at the PEC unit concerning this project.

A paper is being prepared for the 2015 ASSCT conference to summarise the development and capability of the Sugar SysCAD model.

Section 7: Environmental Impact

No adverse environmental impacts have occurred during the conduct of the project and none will directly result from mills implementing the outputs from this project. One of the outcomes of the project should be more detailed evaluation of the environmental impacts when factories plan for modifications to processing arrangements or plan to integrate adjunct plants with sugar factory operations. Hence, using of the Sugar SysCAD modelling package should assist in reducing adverse environmental impacts from such changes to factory operations.

Section 8: Recommendations and Future Industry Needs

The on-going success of Sugar SysCAD depends on a consistent flow of applications so QUT staff who are familiar with its use and complexity can maintain and further develop their skills. It is expected that there will be several projects (both research and consulting) during the next 12 months that will ensure continued use of the software. Continued use will also lead to further improvements and an increased range of configurations that can be readily accommodated.

Further discussions between QUT, Sugar Research Institute and Kenwalt Australia are planned to finalise the licencing arrangements.

Section 9: Publications

As described in Section 6 the publications from the project include:-

- Seminars in 2011, 2012, 2013 and 2014 for staff of SRDC/SRA and Australian Mills
- Paper by Thaval and Kent to the 2013 ISSCT Congress in Brazil titled "Advanced computer simulation of the milling process"
- A paper is being prepared for the 2015 ASSCT conference. The tentative title is "Improving factory performance using an integrated sugar factory model".