



SRA Research Project Final Report

Implement supervisory/advisory control of pan and fugal stations: final report 2010/038

SRA Project Code	2010/038 (QUT038)		
Project Title	Implement supervisory/advisory control of pan and fugal stations		
Key Focus Area in SRA Strategic Plan	Milling efficiency and technology		
Research Organisation(s)	Queensland University of Technology		
Chief Investigator(s)	Dr Ross Broadfoot (QUT) and Dr Roland Dodd (CQUniversity)		
Project Objectives	Implement a smart supervisory/advisory control system (SSCS) for pan and fugal station operations and to demonstrate and evaluate its effectiveness and acceptability by factory operators, supervisors and management.		
Milestone Number	7		
Milestone Due Date	1 May 2015	Date submitted	10 June 2015
Reason for delay (if relevant)	Time for report preparation corresponded to peak teaching time at CQUniversity		
Milestone Title	Submission of Final Report		
Success in achieving the objectives	<input type="checkbox"/> Completely Achieved <input checked="" type="checkbox"/> Partially Achieved <input type="checkbox"/> Not Achieved		
SRA measures of success for Key Focus Area (from SRA Strategic Plan)	New technology to improve mill capital use, operating efficiency and sugar quality		



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PART A

Section 1: Executive Summary

Pan stage operations have a major influence on the quality of shipment sugar production, the processing efficiency of the centrifugal and dryer stations, the sugar recovery from final molasses and the steam consumption of raw sugar factories. As well, for many factories, the production capacity of the pan stage is often the rate limiting station of the factory, at least during mid-season operations.

Several Australian factories now operate with only one pan stage operator and a management tool, such as the smart supervisory control system (SSCS) which was being developed in this project, would assist the operator in making better decisions for managing the stage. The SSCS compares the total projected boil-on rates for syrup and molasses (summed for each pan on the stage) with the forecast production of syrup based on cane receival data and the forecast production of A and B molasses from the centrifugals. By using the phase of each pan in an operational model the levels of syrup, A molasses and B molasses in the respective stock tanks are forecast and the information used to forewarn of potential problems or inefficiencies if current operating strategies are maintained. Alternative operating strategies such as changes to cycle times, use of swing pan(s) for A and B massecuite production can be explored to determine the preferred course of action.

Unfortunately progress on the project had slowed due to unavailability of resources at CQUniversity and, as a result, SRA terminated the project. The project had almost reached the stage where the prototype SSCS was to be installed onto the pan stage at Macknade Mill.

The development of the SSCS was undertaken in conjunction with Wilmar Sugar's Computer Services staff in the Herbert region to suit the implementation onto Macknade Mill's pan and fugal station. However the SSCS was developed as much as possible in modular form to facilitate the implementation into other Australian Mills.

A final report "Implement supervisory/advisory control of pan and fugal stations – Final Report" is provided. This report describes the progress achieved in the project and discusses the aspects that require further development prior to prototype testing of the SSCS in the factory.

The main outputs achieved in the project were:-

- Upgrading of the models developed by Chief Investigator Dr Roland Dodd in his PhD thesis which was the forerunner to this project;
- Preliminary development of the graphical user interface. The interface uses touchscreens to allow the operators, supervisors and factory management to input data in order to assess outcomes for various operational scenarios;
- Procedures to estimate the sucrose and impurity quantities produced in syrup from juice analysis and the mass of each rake of cane;
- Techniques to source CITECT and other factory data from read-only databases to suit the SSCS and the security of the factory's data;
- Procedures to determine the boil-on rates for syrup and A and B molasses for each phase of operation in each pan and the effect of net evaporation rate on the respective boil-on rates;

- Procedures to determine the sugar production, and A and B molasses production and composition at the fugal station for intervals of 15 minutes;
- Procedures to determine the appropriate operating conditions (e.g. steam rates, idle times) for each pan to suit a target cycle time;
- Assessment of the potential to reduce and smooth the steam consumption on the pan stage. The evaluations undertaken at Macknade showed minimal scope for making large improvements in the pan stage steam consumption (rate and variation) but this outcome will be site dependent; and
- Procedures that can be applied to recalibrate the key parameters in the SSCS because of inherent errors, assumptions and simplifications. Several parameters are available to assist with cross-checks and recalibrations. It is proposed that where possible the recalibrations of the key parameters will be undertaken frequently (e.g. every 24 h) using rolling averages and trends of data.

At the time of termination the main work outstanding for the project was to implement the prototype SSCS into the pan stage control room at Macknade Mill on the dedicated computer and operator interface touchscreen. The original work program planned for a two year staged development within the factory once the prototype was installed, with the expectation that, after the first year of operation, further refinements would need to be implemented. A two year staged development program is still considered to be necessary.

Once fully implemented the SSCS should result in improved use of the installed equipment on the pan and fugal stages to achieve increased sugar recovery, improved sugar quality and reduced steam consumption while fulfilling the production rate requirements.

The outputs from the project address SRA's Key Focus Area of providing technology to improve mill capital use, operating efficiency and sugar quality.

Through the course of the project substantial support was provided by the management, supervisors and operators at Macknade Mill and by Mr Steven Dahlstrom of Wilmar Sugar's Computer Services in the Herbert region. The project team greatly appreciates their assistance and support.

Section 2: Background

For several years, the benefit of a supervisory/advisory support tool for pan stage operations in sugar factories has been recognised internationally and within the Australian sugar industry. However no system is currently operating to the extent considered necessary for strongly beneficial results.

Dr Roland Dodd undertook a PhD through RMIT (in association with Sugar Research Institute) to develop a framework for a supervisory/advisory control system for pan and fugal stations. This work was completed in 2009 and provided the basic models and architecture for this current project.

Supervisors and operators currently rely on their knowledge and experience of the process, and the operational plan for the pan and fugal stations nominated by the production manager, to manage the operations of the shift. However, the complexity of the task in operating the pan and fugal stations in an optimal way has increased and at the same time the financial implications of those outcomes have increased. To achieve a truly optimal result, management decisions for the pan and centrifugal stations must be undertaken in relatively short time frames e.g. during each hour, and compliance with a rigid operational plan set by the production manager may not be appropriate.

Ideally the production manager will set the production objectives for the shift and the supervisor/operators will make real time optimal decisions to meet those objectives.

A smart supervisory control system (SSCS) was developed as a management tool to assist the supervisors and operators in making better decisions for managing the pan stage and fugal station. Macknade Mill was selected as the host site.

Section 3: Outputs and Achievement of Project Objectives

Project objectives, methodology, results and discussion

The development work for the SSCS was largely completed. This is demonstrated by the extensive list of outputs in the following section. However the implementation step to install the SSCS onto the Macknade pan stage and to evaluate its performance was severely delayed. Progress was impacted by health problems experienced by two of the investigators (one being on extended carer's leave) and shortage of staff to provide teaching relief at CQUniversity following a major restructure. As a consequence the objective to implement the SSCS was not achieved at the time that SRA terminated the project.

Section 4: Outputs and Outcomes

The main outputs achieved in the project were:-

- Upgrading of the models developed by Chief Investigator Dr Roland Dodd in his PhD thesis which was the forerunner to this project;
- Preliminary development of the graphical user interface. The interface uses touchscreens to allow the operators, supervisors and factory management to input data in order to assess outcomes for various operational scenarios;
- Procedures to estimate the sucrose and impurity quantities produced in syrup from juice analysis and the mass of each rake of cane;
- Techniques to source CITECT and other factory data from read-only databases to suit the SSCS and the security of the factory's data;
- Procedures to determine the boil-on rates for syrup and A and B molasses for each phase of operation in each pan and the effect of net evaporation rate on the respective boil-on rates;
- Procedures to determine the sugar production, and A and B molasses production and composition at the fugal station for intervals of 15 minutes;
- Procedures to determine the appropriate operating conditions (e.g. steam rates, idle times) for each pan to suit a target cycle time;
- Assessment of the potential to reduce and smooth the steam consumption on the pan stage; and
- Procedures that can be applied to recalibrate the key parameters in the SSCS because of inherent errors, assumptions and simplifications. Several parameters are available to assist with cross-checks and recalibrations. It is proposed that where possible the recalibrations of

the key parameters will be undertaken frequently (e.g. every 24 h) using rolling averages and trends of data.

As the SSCS was not implemented onto the pan stage at the time of termination of the project the outcomes in terms of demonstrated benefits related to the primary objective are limited. However the industry has benefited from the knowledge obtained through several of the outputs. While these outputs were developed to suit the implementation of the SSCS for the Macknade pan and fugal stages the general principles should be applicable widely within the industry. The outputs of general benefit to the industry include:-

- Predicting the sucrose and impurity quantities produced in syrup from juice analysis and the mass for each rake of cane;
- Determining the boil-on rates for syrup and A and B molasses for each phase of operation in each pan and the effect of net evaporation rate on the respective boil-on rates;
- Determining the sugar production, and A and B molasses production and composition at the fugal station for intervals of 15 minutes;
- Determining the appropriate operating conditions (e.g. steam rates, idle times) for each pan to suit a target cycle time;
- Assessing the potential to reduce and smooth the steam consumption on the pan stage.

The project has been undertaken in close collaboration with the operators, supervisors and management at Macknade Mill and with Mr Steven Dahlstrom of Wilmar Sugar's Computer Services in the Herbert region.

The project has been beneficial in terms of building human capacity. This benefit not only applies to the investigators on the project but to staff at Macknade Mill.

Section 5: Intellectual Property (IP) and Confidentiality

This project was fully funded by SRDC and subsequently SRA. No syndicate of mills was formed to provide funding and so there are no confidentiality restrictions due to syndication.

Each of the project outputs listed above provides Intellectual Property generated by the project. In accordance with the Research Agreement the Intellectual Property belongs to the Queensland University of Technology. There are no confidentiality restrictions on the use of this intellectual property.

Publications associated with the work in the project include:-

“Implementation plans for supervisory control of pan stage operations” by Dodd, Broadfoot, Yu and Chiou. Paper to the 2010 Congress of ISSCT.

“Management of a high grade pan stage schedule to reduce steam consumption” by Broadfoot and Mann. Paper to the 2014 Conference of the ASSCT.

Section 6: Industry Communication and Adoption of Outputs

During the course of the project seminar presentations were provided for all Australian Mills at the Regional Research Seminars in 2010, 2011, 2012, 2013 and 2014. The main aspects discussed were

- Framework for the SSCS and model development
- Expected application of the SSCS by mills and the associated benefits
- Predicting the sucrose and impurity quantities produced in syrup from juice analysis and the mass of each rake of cane;
- Determining the boil-on rates for syrup and A and B molasses for each phase of operation in each pan and the effect of net evaporation rate on the respective boil-on rates;
- Determining the appropriate operating conditions (e.g. steam rates, idle times) for each pan to suit a target cycle time;
- Assessing the potential to reduce and smooth the steam consumption on the pan stage.

There has been no communication with the PEC unit at SRA.

a) What new information, if any, is available on the adoption of project outputs?

The results of the investigation into reducing and smoothing the steam consumption on the pan stage at Macknade Mill should be beneficial to all Australian Mills.

b) List any newsletters, fact sheets or any other media coverage.

Nil. The main communication with mills has been at the Regional Research Seminars.

c) Identify any further opportunities to disseminate and promote project outputs at seminars, field days etc.

This final report should provide mills with a good overview of the work undertaken in the project to date and the potential benefit to mills if the opportunity is provided to take the project to completion.

Section 7: Environmental Impact

No adverse environmental impacts have occurred during the conduct of the project and none will result from mills implementing the outputs from this project.

Section 8: Recommendations and Future Industry Needs

It is strongly recommended that a new project is undertaken to finalise the development of the SSCS, to implement the system, refine the models and calibration systems in the SSCS to allow a full evaluation of the application of the SSCS. Ideally the implementation would be undertaken at Macknade Mill as the factory specific information has been determined. However this is not essential.

In the last year or two there has been discussion on the benefits of transforming factory control and supervision to a central control room with well skilled supervisors and roving operators covering large sections of the plant. Supervisory control systems such as the SSCS would be very helpful in this circumstance. The system would be located in the central control room and used to forward plan operations in order to achieve high levels of operational efficiency. It is likely that other supervisory/advisory systems would be developed to service other sections of the factory. To fully realise the benefits of these systems, integration of specific SSCS systems into a whole of factory management system would facilitate factory control from a central control room.

Section 9: Publications

Please refer to the 2010 ISSCT proceedings and the 2014 ASSCT proceedings for the two papers:-

“Implementation plans for supervisory control of pan stage operations” by Dodd, Broadfoot, Yu and Chiou. Paper to the 2010 Congress of ISSCT.

“Management of a high grade pan stage schedule to reduce steam consumption” by Broadfoot and Mann. Paper to the 2014 Conference of the ASSCT.