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Development of a Real-Time Simulator for A Three-Effect Falling Film Evaporator

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Palmerston North
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Submitted by
Tong Guo
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Supervised by
Dr. Huub Bakker

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Summary

The aim of the project was to create a real-time simulator of a falling film evaporator located in the Collage of Science at Massey University to allow operators to be trained on using the system. This aim was broken into two objectives: the development of a simulink model in Matlab Simulink and secondly the design of control system databases and control screens in Fix32.

A specification was initially laid out for these two objectives. A design of the real-time simulator was then made, based around the specifications. The real-time simulator was implemented and then tested to ensure that the initial specifications were met. The final evaporator simulator was an executable file embodying the simulink model controlled by control screens.

The Simulink model was developed based on an existing mathematical model of the falling film evaporator that was solved in Matlab M-file format. Two steps occurred while developing the Simulink model. First was converting the existing M-file model into Matlab simulink blocks. The second step involved making improvements to the simulink model.

The design of control system database and control screens followed, based around the specifications. The control system database was developed using the Fix32 "Database builder" and included database blocks and chains. Inputs and output blocks were created and configured to match the variables being sent to and from the Simulink simulation. The control screens were designed, based on the existing industrial screens. The pictures of

preheaters, effects, feed water tank, steam pipelines, steam valve and pumps were redrawn to match the real plant as close as possible.

After the creation of the simulink model, the steady-state simulation initialisation values were determined and adjusted through the test. The final test was made by running the Simulink model in conjunction with the modified Fix32 control system. The final test proved that the Real-time simulator was created successfully.

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Introduction

1.1 Background

1.1.1 A Falling-film evaporator

Evaporation is an important process used in the chemical industry, which concentrates a solution containing dissolved or suspended solids by boiling off the solvent. A large proportion of the energy used in industry is given to this process. It is a very appropriate process to study due to its wide use and energy intensity[3].

In a modern evaporation system the evaporator acts as the main process unit in the evaporation process for drying a number of products. Good evaporator control is particularly important because of its widespread use, especially in the New Zealand dairy industry, and the direct effect of better control on energy efficiency and a more consistent product.

The evaporator used in this thesis is a pilot-scale, three-effect, falling-film evaporator that resides in the College of Sciences, Massey University. This system is a scaled version of the type of process used in the dairy industry and was built to provide a platform for research into process identification and control.

1.1.2 Falling-film evaporator existing model

To study problems before the control is implemented on the real system a process model was previously created by a number of researchers[2,3,4]. This existing model can be used to test and refine the performance of the control strategy.

The existing model was completed by Russell (1997)[4] as a suite of Matlab m-files.

1.1.3 Real-time simulator modeling

In order to obtain real time simulation results, a new dynamic mathematical model was created and solved in Matlab Simulink. The model is the mathematical expression of the process. It expresses most of the important dynamic characteristics performance of the process. It would be used by the simulator (a program package that contains dynamic mathematical model and Fix32 SCADA system) and would act as the real process to be run by the operator. In order to provide the best training for the operator the simulation must run behind Fix32, the SCADA package that the operator would use to run the real plant. The real control screens and control database would be used as for the real plant.

The development of the real-time simulator can give lots of benefits to the industry. For example, by running the real-time simulator, the simulation results can display directly on the control screen and the process engineer can change the simulation settings directly. These properties can give the process engineers and operators a better understanding of the characteristics of the evaporator.

In order to obtain a graphical and real-time simulation environment, a real-time simulator was created during this project. This real-time simulator provided a better operation platform to make the simulation running more like a real plant. In addition the equations and parameter settings used in the original dynamic model were improved to make the simulation more accurate.

The real-time simulator was also designed as a control design tool, which could be used to simulate and compare various control strategies. For this reason the real-time simulator contained ordinary differential equations and algebraic relationships and parameters were lumped where appropriate.

Other reasons for doing this project include:

- The real-time simulator could provide off-line operator training. Operators or students can easily gain an understanding of the characteristics and responses of the process.

- The process engineer who wants to apply different operating strategies could use this real-time simulator to determine the effects without the danger of disrupting the actual process.

- The real-time simulator could also be used as a process-monitoring tool by running it in parallel with the plant and noting differences between the two.

1.1.4 SCADA package and Fix32 software

Supervisory Control and Data Acquisition (SCADA) packages are used in industry to monitor and control processes. A SCADA package is a multitasking environment that provides two basic functions: supervisory control and data acquisition. It receives data from the process, performs supervisory control functions, displays information to the operator and receives requests, stores trending data and sends set-points to the process.

Fix32 is an example of a multitasking SCADA system widely used in the industry. It provides process monitoring and control, data collection and graphic display functions.

1.2 Objectives

This project sought to develop a real-time simulator, which contains a falling-film evaporator Simulink model linked to SCADA control screens. The Simulink model was developed based on an existing mathematical model of the falling-film evaporator that was solved in Matlab M-file resident in the College of Sciences, Massey University.

The control screens are used to display the simulation results from the Simulink model and to change the settings of the parameters in the Simulink model.

For this reason the thesis is broken into two parts: developing the real-time mathematical model in Matlab Simulink and designing control screens in the FIX32 SCADA package. Once these two tasks are completed the real-time simulator is converted into executable code which connects with the control screens. The results of the combined

testing are reported at the end of this thesis in chapter 6.

To develop the falling-film evaporator Simulink model, two steps must occur. The first step is converting all the M-files of the old model into Simulink blocks. The second step involves making improvements to the Simulink model.

This work has the following objectives:

- To develop a modeling methodology to convert existing m-file model into Simulink block.
- To improve and correct any mistakes made in the existing m-file model.
- To develop control screens that duplicates those of the real process.
- To build a database for the control screens. The database contains all the results that are received from the real-time Simulink model and all the changes of the parameters made by the operator. All the changes will be sent to the Simulink model directly.