THE USE OF SIMULINK FOR PROCESS MODELLING IN THE SUGAR INDUSTRY

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Abstract

Process modelling for the purposes of equipment design, simulation or evaluation has been carried out in the sugar industry using a range of different techniques. Methods employed in the past have included the development of specialised simulation tools using computer programming languages or spreadsheets. Some use has also been made of commercial flowsheeting packages, as well as the SUGARS software package which was developed specifically for this application. However, each of these modelling techniques suffers from a number of limitations, with none providing both ease of use and the flexibility to allow detailed in-house process knowledge to be designed into the system. SIMULINK is a commercial software system, overlaid on the MATLAB programming language, which is widely used for modelling, simulating and analysing steady state or dynamic systems using block diagrams. In the current study, the use of the SIMULINK software to develop a library of model blocks describing sugar industry operations is demonstrated, focusing on the diffuser extraction and boiling house operations. The potential of the software for future application is highlighted.

Keywords: modelling; simulation; diffuser; boiling house; flowsheeting; SIMULINK

Introduction

Process modelling in the sugar industry has traditionally been carried out using a variety of different techniques. Methods employed in the past have included the development of computer programs and spreadsheets, the use of commercial flowsheeting packages and application of the SUGARS software package. In evaluating these various process modelling techniques, ease of use should be thought of as the primary concern. Ease of use should be considered both in terms of:

- model development and maintenance, typically carried out by somebody with sugar technology knowledge as well as a certain degree of specialised computer knowledge
- model utilisation for design and operational purposes, typically carried out by those with a knowledge of sugar technology but not necessarily equipped with any specialised computer knowledge.

Both of these groups of users need to be catered for in the development of process modelling technology.

Process modelling in the South African sugar industry

In studying the historical use of process modelling techniques in the South African sugar industry, a search was carried out for all related papers in the *Proceedings of the South African Sugar Technologists' Association*. This search yielded nine papers which covered the development of material and/or energy balances within a sugar factory. Detailed models describing the design or operation of individual items of equipment were ignored for the purposes of the current study, with the focus instead falling on material and energy balance models covering the entire factory or portions thereof. These papers are briefly reviewed here, with particular reference to the process modelling techniques utilised.

Computer programs

The use of purpose-built computer programs for process modelling, developed in conventional high level languages (such as FORTRAN, PASCAL, BASIC, C, etc.), was found to be the most common approach taken by the South African sugar industry in the past. Use of this method has, however, decreased as more user-friendly tools (such as spreadsheet packages) have become more powerful.

Guthrie (1972) developed a computer program to carry out a material balance of an entire raw sugar factory, with a view to including an enthalpy balance at a later stage. Some of the units modelled included milling or bagasse diffusion, clarification and filtration, evaporation and raw boiling house operations. A simple back-end refinery approximation was also developed. Solution of the model was carried out iteratively in order to account for the presence of recycle streams in the model, and output was produced in the form of a page of text listing the various streams in the model and their properties.

Hoesktra (1981) developed a computer program to carry out the design and simulation of sugar mill evaporator stations, which could also be used to predict values for the individual vessel heat transfer coefficients based on data collected from an operating evaporator station. The model itself was reasonably flexible and allowed for heat losses, condensate flash vapour return, vapour throttling between effects, vapour recompression, vapour bleed from many effects, vessel arrangements in series or parallel and for counter-current flow of vapour and juice. The FORTRAN program solved the mass and enthalpy balance equations of the evaporator station by means of the iterative solution of a set of simultaneous linearised equations, providing output in the form of a page of text listing the various streams and vessels in the model and their properties. In order to provide a degree of flexibility, an individual master program segment was written for each application of the model, allowing for the structure of the specific evaporator station to be catered for. However, use of the model thus required a knowledge of computer programming and of the individual subroutines making up the model. At a later stage, the evaporator model was converted to the PASCAL programming language, and is still routinely used.

Reid and Rein (1983) describe the use of a computer program to carry out material and enthalpy balances for a raw boiling house which utilises the conventional three-boiling system. The authors also discuss the use of the evaporator station model of Hoekstra (1981) to assist in the generation of a steam balance for the Felixton II mill. The boiling house model, as detailed in Hoekstra (1983), was written in the PL/1 programming language and catered for centrifugal operation, the addition of movement water and jigger steam, molasses blow-up and sugar remelting. The original model was converted into spreadsheet format at a later stage and is still routinely used.

Hoekstra (1985, 1986) carried out mass and energy balances for a continuous vacuum pan using a computer program developed in the PL/1 language. The model could be used for the design and simulation of continuous pans, as well as to predict heat transfer coefficient values based on data collected from an operating pan. Solution of the model was carried out by assuming each compartment of the pan to be a stirred tank reactor and carrying out an iterative solution of a set of simultaneous non-linear algebraic equations. The output of the model included crystal size distribution predictions and was produced in the form of a page of text listing the various streams and compartments in the model and their properties.

Spreadsheets
Spreadsheet packages have become the modelling tool of choice for most applications in the sugar industry, due to the widespread availability of the software and their ease of use.

Radford (1996) developed a mass, energy and colour balance of a raw sugar mill in spreadsheet form. The spreadsheet also incorporated a crystallisation model and was used to investigate the effect of back-boiling on sugar quality, exhaustion and the mill steam balance.

Hubbard and Love (1998) used spreadsheet software to carry out the reconciliation of process data in an over-specified mass balance model of a continuous centrifugal. The built-in spreadsheet optimisation utility was used for carrying out the required non-linear numerical analysis.

Apart from the specific applications described above, spreadsheet models are widely used in the South African sugar industry for detailed equipment design, boiling house balances, evaporator station balances, milling train balances, mass and energy balances of entire raw mills or refineries and to meet all of the day-to-day process simulation needs of the industry.

Commercial flowsheeting software
Commercial flowsheeting packages, such as ChemChad or PRO/II, are generally not suitable for application in the sugar industry, as they do not contain models of the unit operations and items of equipment commonly used (Radek, 1995). These flowsheeting packages are typically designed for use in the chemical and petrochemical industries and their strengths lie in aspects such as the prediction of vapour-liquid equilibria. Modelling of systems containing non-volatile soluble components such as sucrose thus poses great difficulties. Although no work using commercial flowsheeting software has been published in the South African sugar industry, a number of attempts have been made (at the Sugar Milling Research Institute, the School of Chemical Engineering of the University of Natal and within the individual milling companies) to apply this technology, with little success.

SUGARS software
The SUGARS software package is a process flowsheeting utility which is specific to the beet and cane sugar industries and includes a process economics facility. Stolz and Weiss (1997) used the SUGARS package to develop mass, energy and colour balances for the Malelane and Komati sugar mills. The resulting balances were found to compare favourably with the actual performance of the mills and with the predictions of the spreadsheet model of Radford (1996).

Comparison and evaluation of the process modelling techniques

The users of process modelling technology may be roughly divided into two slightly overlapping groups, namely the model *developers* and the model *end-users*. The model developers are those users who:

- develop models of items of process equipment, incorporating appropriate process knowledge
- model process schemes/flowsheets by linking together input and output streams and the abovementioned equipment models
- solve material and enthalpy balances for the developed process schemes.

These users require a modelling environment which allows for ease of model modification and debugging, as well as allowing for specialised in-house process knowledge to be incorporated in the developed models. Hence *ease of support* and *incorporation of in-house knowledge* are of importance.

The second group of users of process modelling technology consists of the model end-users, who:

- configure the process schemes/flowsheets by linking together equipment models created by the model developers in a standardised manner (according to the degree of flexibility of configuration which has been allowed for by the model developers)
- use the process models to simulate actual factory performance as a tool for design, optimisation or evaluation purposes.

These users require a modelling environment which is simple to use in a flexible way. Hence *ease of use* and *flexibility of configuration* are of importance.

Following on from the above discussion of process model use, four criteria (as highlighted in italics) have been identified which may be used to evaluate the suitability of process modelling systems for use in a commercial or industrial environment. The four modelling techniques discussed in the previous section may thus be compared in terms of these four criteria.

Computer programs
Technical support of computer programs obviously requires a knowledge of the computer language in which the program was developed. However, given the appropriate expertise, a properly structured computer program should be reasonably easy to understand and modify. Incorporation of in-house process knowledge is easy and full customisation of the process model is possible.

Given the current state of technology, computer programs may readily be implemented in a manner which is user-friendly and simple to understand. However, some older applications, such as that developed by Hoekstra (1981), require the end-user to have a knowledge of computer programming, which is a disadvantage. In theory, complete flexibility of process model configuration should be possible for a modelling environment developed using a computer programming language. In practice, however, only a few process scheme layouts are typically provided by model developers, which limits the flexibility of configuration available to the model end-users. Unless all of the possible equipment configurations have been considered beforehand and allowed for by the model developer, this limitation will always exist.

Spreadsheets
In terms of technical support, the logical structure of process models developed in spreadsheet format is notoriously difficult to follow. Modification of an existing spreadsheet is thus time-consuming and difficult. However, little specialised programming knowledge is generally required (unless tools such as spreadsheet macros have been used). Complete customisation of spreadsheet systems is possible, allowing for full incorporation of any specialised in-house process knowledge into the developed models.

Spreadsheet systems are typically familiar to model end-users, which makes them easy to use. As for computer programs, complete flexibility of process model configuration should be possible in a spreadsheet modelling environment. In practice, however, only a few process scheme layouts are typically provided by model developers, which limits the flexibility of configuration available to the model end-users. Unless all of the possible equipment configurations have been considered beforehand and allowed for by the model developer, this limitation will always exist.

Commercial flowsheeting software
Technical support of commercial flowsheeting software by in-house model developers is generally limited only to the possible development of customised user-designed flowsheet blocks, as modification of the built-in model blocks is typically impossible. Specialised programming knowledge is normally required and a number of limitations to block construction may exist. Incorporation of in-house process knowledge into the unit operation blocks provided by the software is not possible.

Flowsheeting packages generally provide a user-friendly modelling interface, although customisation of the user environment is not possible. Wide flexibility of configuration is available with commercial flowsheeting software, in that items of equipment for which model blocks exists may be arranged in any suitable configuration without affecting the successful operation of the modelling system.

SUGARS software
Technical support of the SUGARS software package by in-house model developers is not possible, with no incorporation of in-house process knowledge into the unit operation blocks allowed for.

While a user-friendly modelling interface is provided, customisation of the environment is not possible. Wide flexibility of configuration is available, in that items of equipment for which model blocks exists may be arranged in any suitable configuration without affecting the successful operation of the modelling system.

Process modelling using SIMULINK

SIMULINK is a commercial software system, overlaid on the MATLAB programming language, which is widely used for modelling, simulating and analysing steady state or dynamic systems using block diagrams. SIMULINK models are constructed using a similar method to the manner in which process models are developed using commercial flowsheeting packages, by positioning model blocks on the screen in an appropriate way and then connecting the blocks by means of stream lines. However, the advantage of the SIMULINK environment over commercial flowsheeting packages lies in its complete flexibility with regard to block customisation. User-defined blocks may be generated either by appropriately combining model blocks into subsystems, or by programming using any one of a number of programming languages (namely MATLAB, C, C++, ADA or FORTRAN).

A trivial example of a SIMULINK model which converts a temperature given in degrees Fahrenheit to the equivalent temperature in degrees Celsius is displayed in Figure 1. This simple model consists of two *Constant* blocks, one containing the input temperature in degrees Fahrenheit and one containing the constant value of 32, a *Sum* block, which subtracts one of the constants from the other, as well as a *Gain* block which multiplies its input by 5/9 to produce the output temperature in degrees Celsius.

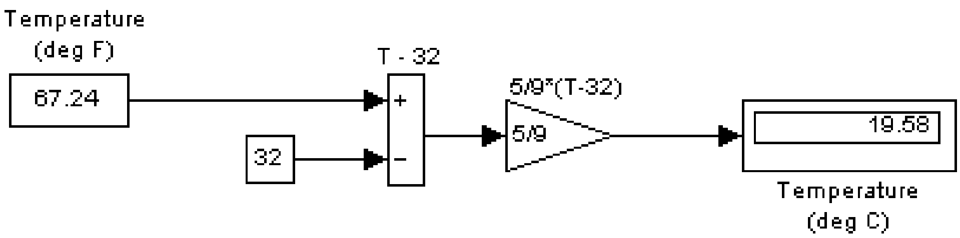

Figure 1. SIMULINK temperature conversion example.

Once a temperature conversion model has been developed, the relevant blocks may be combined to form a temperature conversion subsystem block, which may be stored in the block library for future use. An example of the use of such a temperature conversion subsystem block is displayed in Figure 2. Using this technique, a library of process modelling blocks may easily be developed in SIMULINK. The combination of unit operation blocks developed in this way to form useful process models is then a simple matter, requiring no specialised knowledge of the SIMULINK system.

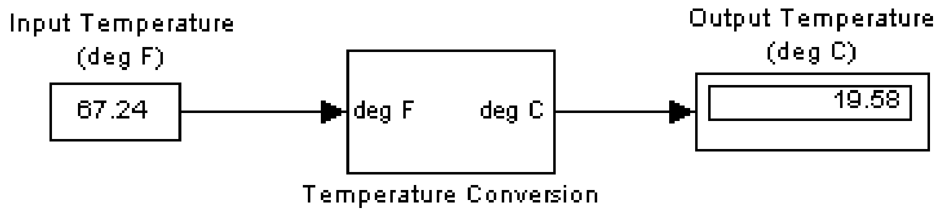

Figure 2. SIMULINK temperature conversion example, using a combined subsystem block.

The development of process models in the SIMULINK environment provides the benefits of commercial flowsheeting packages in terms of ease of use and flexibility of configuration. Additionally, detailed in-house process information may easily be incorporated in the developed models. Technical support of the process models developed in SIMULINK requires specialised knowledge of the MATLAB and SIMULINK environments (although the graphical nature of SIMULINK does lend itself to intuitive understanding of the operation of the system). However, as the use of MATLAB in tertiary educational institutions is widespread, many new engineers will enter the South African sugar industry with some understanding of the basic use of MATLAB and SIMULINK.

Currently, SIMULINK has been used to develop simple mass and energy balance models of various sections of a raw cane sugar mill. A brief outline of some of the models developed so far is provided in the following sections.

Diffuser modelling using SIMULINK

SIMULINK was used to create a simple mass and energy balance model of a cane diffuser system, including the operations of bagasse dewatering and scalding juice heating. Apart from the various equipment blocks required for this model, namely the cane diffuser itself, the scalding juice heaters and the dewatering mills, blocks were also developed to describe process stream inputs into the model, vapour stream inputs into the model, output streams from the model and for stream information display purposes. At this stage, the model consists only of simple material and enthalpy balances, and no attempt has been made to predict sucrose extraction on a stagewise basis. An example of a cane diffuser SIMULINK model is given as Figure 3, with the stream information display blocks omitted from the diagram for clarity.

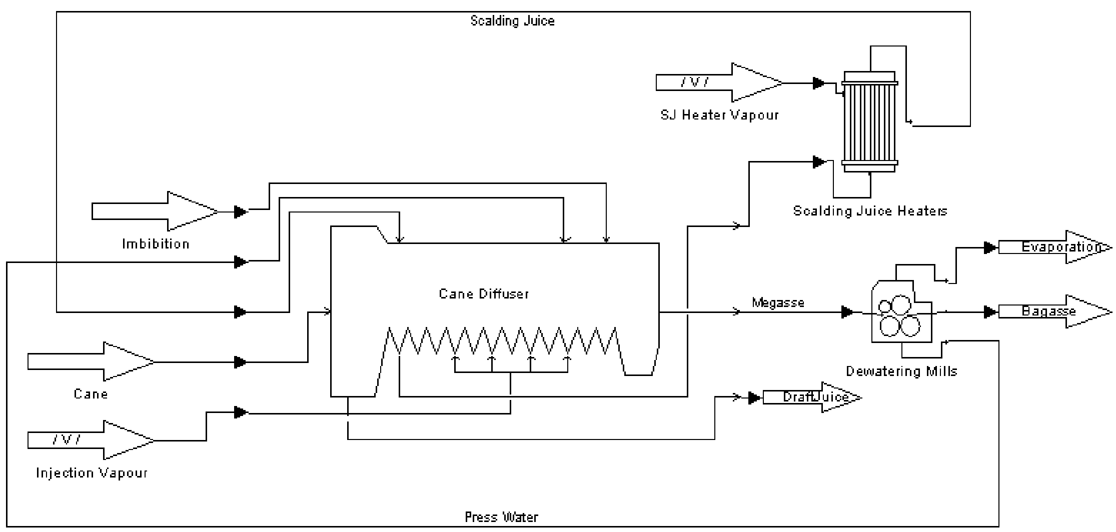

Figure 3. An example of a SIMULINK cane diffuser model.

Each block within the model requires certain input information in order to function. Double-clicking each of the blocks with the mouse opens the data input display screen for that block. The required information can then be entered by the user. An example of the data input display screen for the cane input stream block is displayed in Figure 4. Online help information for each of the blocks is also available. Running the simulation within the SIMULINK environment solves the material and enthalpy balance equations for the model and produces output in the form of stream information display screens, such as the example shown in Figure 5.

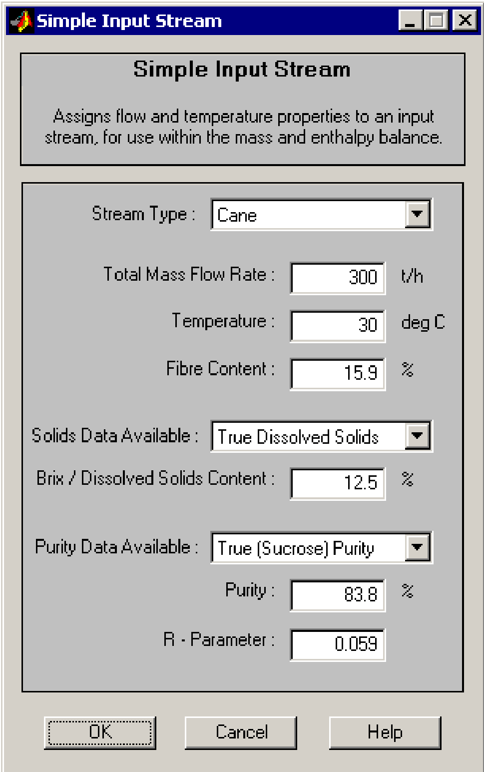

Figure 4. Example of a data input display screen.

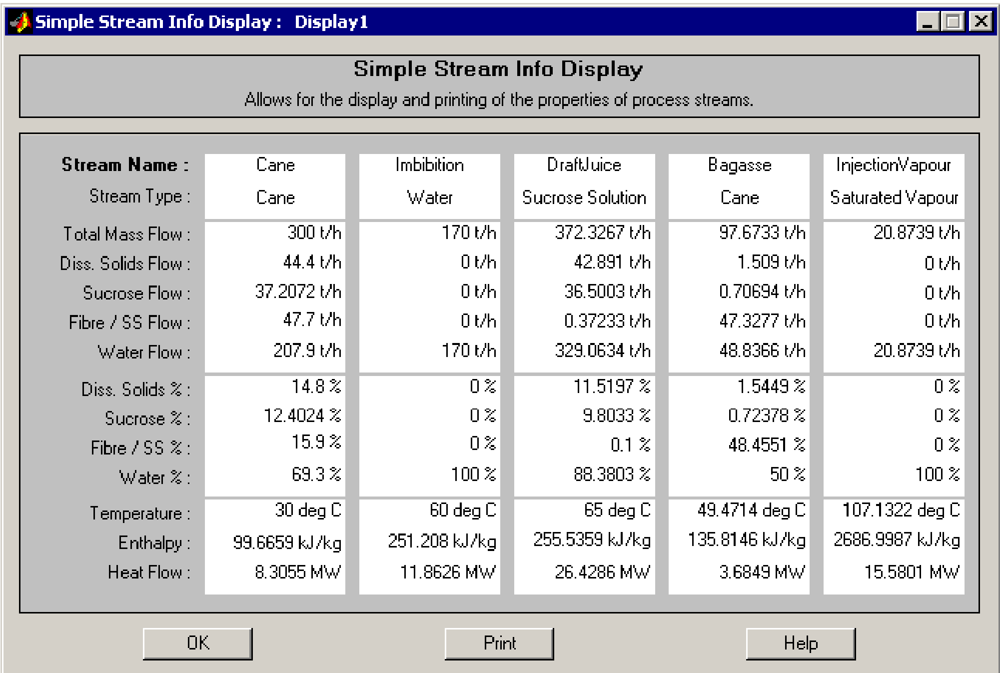

Figure 5. Example of a stream information output screen for the cane diffuser model.

Boiling house balance using SIMULINK

SIMULINK was also used to create a simple material balance for a raw mill boiling house, consisting of model blocks for each pan boiling stage, as well as for such items of equipment as remelters and minglers. Many of the basic blocks developed for the diffuser model, such as stream input blocks and information display blocks, could be re-used in the creation of the boiling house model. An example of a boiling house model created using SIMULINK is shown in Figure 6.

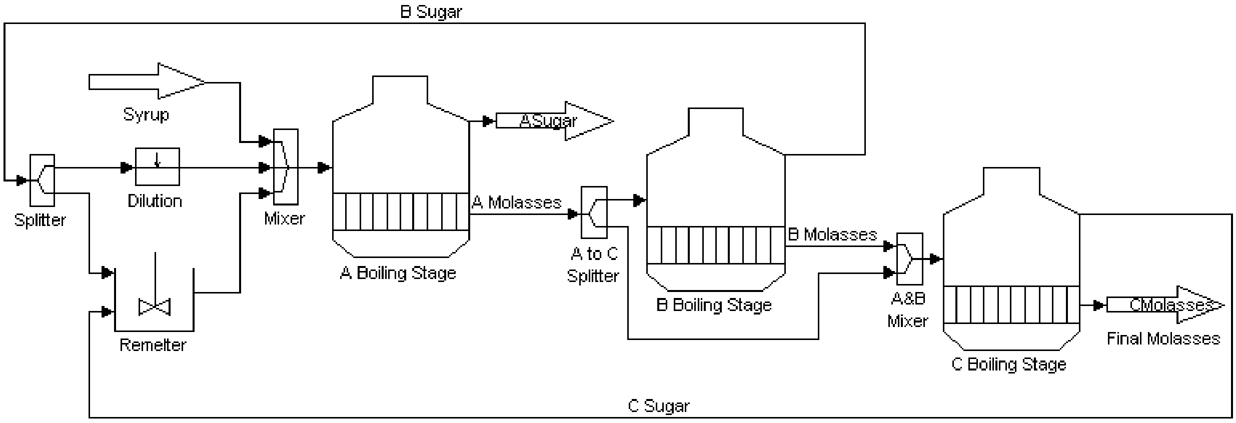

Figure 6. Example of a SIMULINK boiling house balance model.

Currently, the model blocks which have been defined only carry out simple overall material and enthalpy balances for the boiling house. No attempt has yet been made to simulate the operation or capacity of individual items of equipment.

As an example of the architecture of a typical SIMULINK unit operation block, Figure 7 displays the contents of the input stream block, which converts user inputs regarding the properties of the stream (as shown in Figure 4) into a complete vectorised description of the stream properties which can be used within the simulation model.

The rectangular blocks to the left of the figure indicate property values entered by the user in the data entry screen. These numerical values are then appropriately combined within the block to form the output property vector, which exits the subsystem block at the right of the figure. Three additional subsystem blocks are themselves used within Figure 7, namely the *Brix Conversion* block which converts any input of refractometer brix into a true dissolved solids by means of a correlation, the *Purity Conversion* block which converts any input of apparent purity into a true sucrose purity by means of a correlation, and the *Enthalpy Calculation* block which contains a physical property correlation equation. The correlations contained within the brix and purity conversion blocks are an example of the incorporation of in-house process knowledge into a SIMULINK model (Love, 2002).

As a case study, the SIMULINK boiling house balance was used to investigate the effect of introducing the double curing of C massecuite at the Maidstone mill. For ease of presentation, the results of the simulation were entered into spreadsheet summary format, and are displayed in the appendix to the current study.

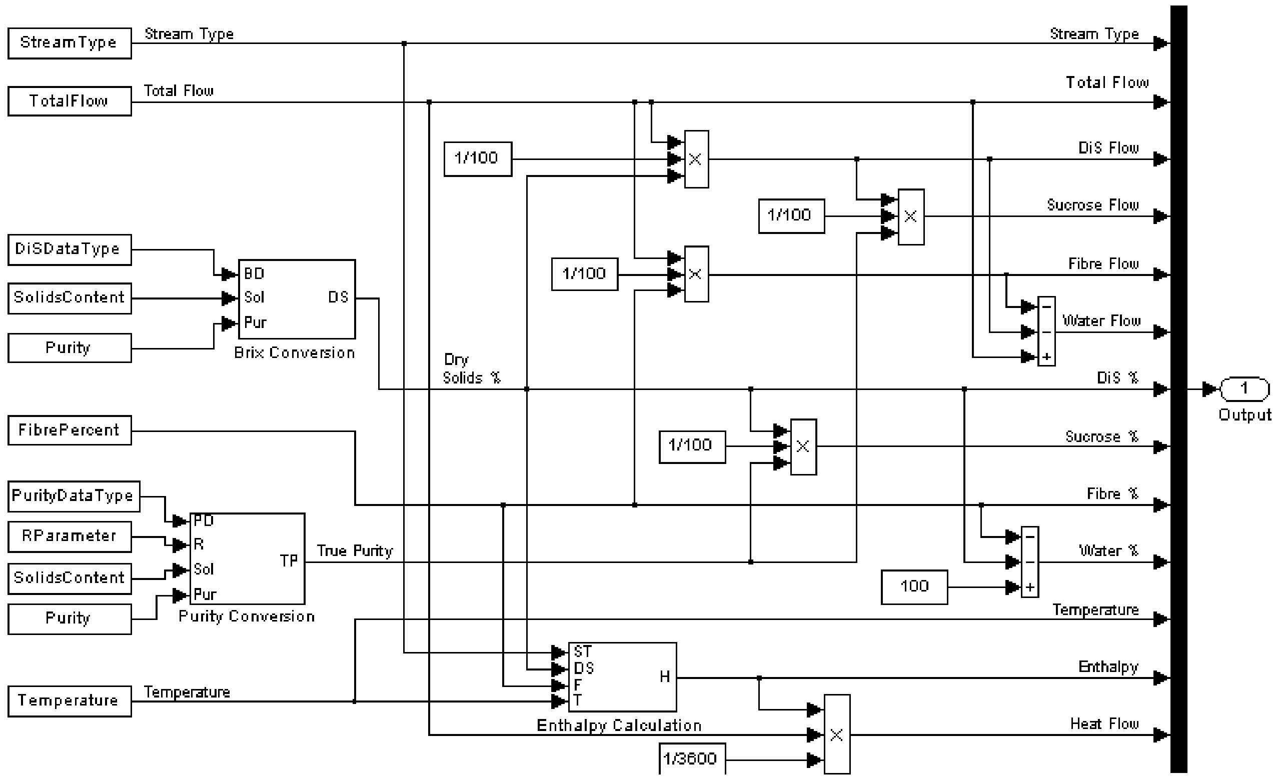

Figure 7. Architecture of the input stream block.

Conclusions

SIMULINK is an interactive block modelling environment, overlaid on the MATLAB programming language, which is widely used for modelling and simulation of steady state and dynamic systems. The use of SIMULINK for the development of process models in the sugar industry has been demonstrated. This approach to process modelling provides the advantages of commercial flowsheeting software in terms of ease of use and flexibility of configuration, while also facilitating the incorporation of in-house proprietary knowledge into the developed models.

A further feature of SIMULINK is the ability to build a number of unit operation blocks at differing levels of complexity. For instance, one set of model blocks may be developed to model a large section of a factory, such as a boiling house, while a second set of model blocks could be developed to model an individual item of equipment, such as a batch pan. Additionally, a further set of blocks could be developed to carry out detailed analysis and design of a unit such as a continuous vacuum pan, incorporating a stagewise balance of the individual pan compartments. SIMULINK thus allows the user a great deal of flexibility as to the level of modelling complexity desired.

Future work using SIMULINK will focus on the development of a mass and energy balance of an evaporator station, with the ultimate objective being the development of a simulation model of the entire sugar production process. Detailed design models of individual items of equipment are also planned, as the block modelling approach lends itself particularly well to the simulation of stagewise unit operations, such as continuous pans and cane diffusers.

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APPENDIX

Results of the boiling house SIMULINK model for double curing at Maidstone

<u>BOILING HOUSE BALANCE SUMMARY : Maidstone Mill (Current Scenario)</u>

A - BOILING	Total Flow	Dissolved Solids		Sucrose		Sucrose Purity	Water	
		Flow	Content	Flow	Content		Flow	Content
	[t/h]	[t/h]	[%]	[t/h]	[%]	[%]	[t/h]	[%]
Evaporator Syrup Feed	82.50	54.62	66.20	45.28	54.88	82.90	27.89	33.80
Footing ex Mingler	0.70	0.63	90.00	0.59	84.43	93.81	0.07	10.00
Remelt Recycle	29.27	19.61	67.00	17.60	60.13	89.74	9.66	33.00
A - Massecuite	112.47	74.86	66.56	63.47	56.43	84.78	37.62	33.45
A - Sugar Product (VHP)	40.49	40.44	99.88	40.24	99.40	99.52	0.05	0.12
A - Molasses	49.17	34.42	70.00	23.23	47.23	67.48	14.75	30.00

Exhaustion=62,8%

Split : 86.54 % to B-Boiling

B - BOILING	Total Flow	Dissolved Solids		Sucrose		Sucrose Purity	Water	
		Flow	Content	Flow	Content		Flow	Content
	[t/h]	[t/h]	[%]	[t/h]	[%]	[%]	[t/h]	[%]
A - Molasses	42.55	29.79	70.00	20.10	47.23	67.48	12.76	30.00
B - Massecuite	42.55	29.79	70.00	20.10	47.23	67.48	12.76	30.00
B - Sugar to Mingler	13.02	12.62	97.00	11.84	91.00	93.81	0.39	3.00
B - Molasses	24.52	17.16	70.00	8.25	33.67	48.10	7.35	30.00

Exhaustion=52,2%

MINGLER	Total Flow	Dissolved Solids		Sucrose		Sucrose Purity	Water	
		Flow	Content	Flow	Content		Flow	Content
	[t/h]	[t/h]	[%]	[t/h]	[%]	[%]	[t/h]	[%]
B - Sugar	13.02	12.62	97.00	11.84	91.00	93.81	0.39	3.00
Footing to A - Boiling	0.70	0.63	90.00	0.59	84.43	93.81	0.07	10.00
Magma to Remelter	13.32	11.99	90.00	11.25	84.43	93.81	1.33	10.00

C - BOILING	Total Flow	Dissolved Solids		Sucrose		Sucrose Purity	Water	
		Flow	Content	Flow	Content		Flow	Content
	[t/h]	[t/h]	[%]	[t/h]	[%]	[%]	[t/h]	[%]
B - Molasses	24.52	17.16	70.00	8.25	33.67	48.10	7.35	30.00
A - Molasses	6.62	4.63	70.00	3.13	47.23	67.48	1.99	30.00
C - Massecuite	31.14	21.79	69.99	11.38	36.54	52.20	9.34	29.98
Final Molasses	16.78	14.18	84.50	5.03	30.00	35.50	2.60	15.50
C - Sugar to Remelter	7.94	7.62	96.00	6.35	80.00	83.33	0.32	4.00

REMELTER	Total Flow	Dissolved Solids		Sucrose		Sucrose Purity	Water	
		Flow	Content	Flow	Content		Flow	Content
	[t/h]	[t/h]	[%]	[t/h]	[%]	[%]	[t/h]	[%]
B - Sugar Magma	13.32	11.99	90.00	11.25	84.43	93.81	1.33	10.00
C - Sugar	7.94	7.62	96.00	6.35	80.00	83.33	0.32	4.00
Remelt Recycle	29.27	19.61	67.00	17.60	60.13	89.74	9.66	33.00

BOILING HOUSE BALANCE SUMMARY : Maidstone Mill (Double Curing at Fixed A-Exhaustion)

A - BOILING	Total Flow	Dissolved Solids		Sucrose		Sucrose	Water	
		Flow	Content	Flow	Content	Purity	Flow	Content
	[t/h]	[t/h]	[%]	[t/h]	[%]	[%]	[t/h]	[%]
Evaporator Syrup Feed	82.50	54.62	66.20	45.28	54.88	82.90	27.89	33.80
Footing ex Mingler	0.76	0.69	90.00	0.64	84.43	93.81	0.08	10.00
Remelt Recycle	27.85	18.66	67.00	17.50	62.84	93.79	9.19	33.00
A - Massecuite	111.11	73.97	66.57	63.42	57.08	85.74	37.16	33.44
A - Sugar Product (VHP)	40.49	40.44	99.88	40.24	99.40	99.52	0.05	0.12
A - Molasses	47.89	33.52	70.00	23.18	48.40	69.14	14.37	30.00

Exhaustion=62,8%

Split : 93.64 % to B-Boiling

B - BOILING	Total Flow	Dissolved Solids		Sucrose		Sucrose	Water	
		Flow	Content	Flow	Content	Purity	Flow	Content
	[t/h]	[t/h]	[%]	[t/h]	[%]	[%]	[t/h]	[%]
A - Molasses	44.84	31.39	70.00	21.71	48.40	69.14	13.46	30.00
B - Massecuite	44.84	31.39	70.00	21.71	48.40	69.14	13.46	30.00
B - Sugar to Mingler	14.13	13.70	97.00	12.86	91.00	93.81	0.42	3.00
B - Molasses	25.26	17.68	70.00	8.85	35.01	50.02	7.58	30.00

Exhaustion=52,2%

MINGLER	Total Flow	Dissolved Solids		Sucrose		Sucrose	Water	
		Flow	Content	Flow	Content	Purity	Flow	Content
	[t/h]	[t/h]	[%]	[t/h]	[%]	[%]	[t/h]	[%]
B - Sugar	14.13	13.70	97.00	12.86	91.00	93.81	0.42	3.00
Footing to A - Boiling	0.76	0.69	90.00	0.64	84.43	93.81	0.08	10.00
Magma to Remelter	14.46	13.01	90.00	12.22	84.43	93.81	1.45	10.00

Split: 90.60 to C-Boiling

C - BOILING	Total Flow	Dissolved Solids		Sucrose		Sucrose	Water	
		Flow	Content	Flow	Content	Purity	Flow	Content
	[t/h]	[t/h]	[%]	[t/h]	[%]	[%]	[t/h]	[%]
B - Molasses	22.89	16.02	70.00	8.02	35.01	50.02	6.87	30.00
A - Molasses	3.05	2.13	70.00	1.47	48.40	69.14	0.91	30.00
C2 - Wash ex Dble Curing	4.55	3.64	80.00	1.89	41.60	52.00	0.91	20.00
C - Massecuite	30.48	21.79	71.49	11.38	37.34	52.24	8.69	28.51
Final Molasses	16.78	14.18	84.50	5.03	30.00	35.50	2.60	15.50
C1-Sugar to Dble Curing	7.94	7.62	96.00	6.35	80.00	83.33	0.32	4.00

DOUBLE CURING	Total Flow	Dissolved Solids		Sucrose		Sucrose	Water	
		Flow	Content	Flow	Content	Purity	Flow	Content
	[t/h]	[t/h]	[%]	[t/h]	[%]	[%]	[t/h]	[%]
C1 - Sugar	7.94	7.62	96.00	6.35	80.00	83.33	0.32	4.00
B - Molasses	2.37	1.66	70.00	0.83	35.01	50.02	0.71	30.00
C2 - Magma	10.31	9.28	89.99	7.18	69.63	77.38	1.03	10.01
C2 - Wash to C - Boiling	4.55	3.64	80.00	1.89	41.60	52.00	0.91	20.00
C2 - Sugar to Remelter	5.87	5.64	96.00	5.29	90.00	93.75	0.23	4.00

REMELTER	Total Flow	Dissolved Solids		Sucrose		Sucrose	Water	
		Flow	Content	Flow	Content	Purity	Flow	Content
	[t/h]	[t/h]	[%]	[t/h]	[%]	[%]	[t/h]	[%]
B - Sugar Magma	14.46	13.01	90.00	12.22	84.43	93.81	1.45	10.00
C2 - Sugar	7.94	7.62	96.00	6.35	80.00	83.33	0.32	4.00
Remelt Recycle	27.85	18.66	67.00	17.50	62.84	93.79	9.19	33.00