

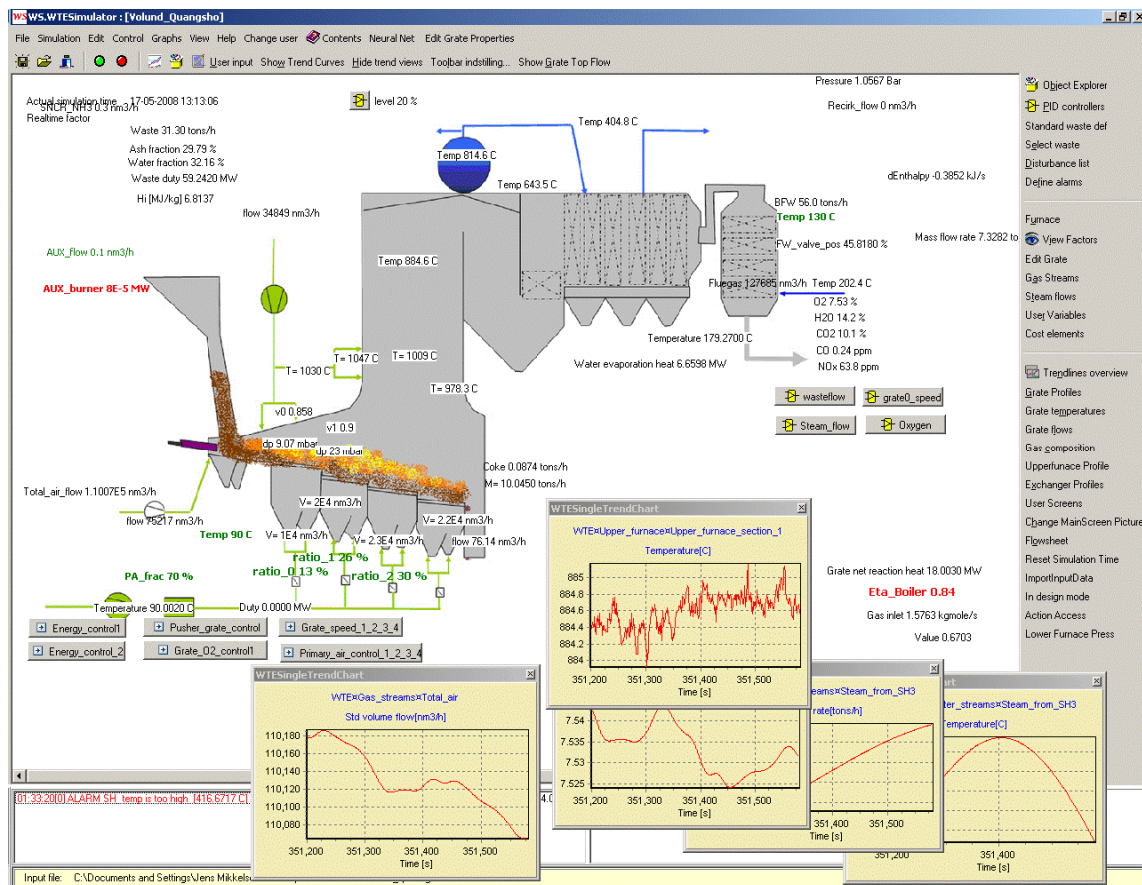
WTE-simulator

Delivered by: Weel & Sandvig

Version: preliminary

2008

USER MANUAL



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1 Introduction

This manual describes how to use the WTE-simulator and its features. The WTE simulator is a tool (software) for simulation especially the dynamic behaviours of waste-to-energy (WTE) plants. The simulation package is among others suitable for analyses of various control strategies and for training of operational staff.

The simulation software is developed by:



1.1 License

Before installation, please see the license agreement for the terms and the conditions for the installation and the use of the WTE-simulator.

1.2 Installation

The software WTE-simulator - version 3.4 is installed by copying the files to your PC's hard disk.

If the WTE-simulator comes with a USB-dongle as license protection, the USB dongle must be inserted in the pc's USB port in order to run the software.

1.3 To start the WTE-simulator

The simulator is started by running the file **ws_sim.exe** either through a linked icon or double clicking the file itself in your file browser. The program starts with a login window (Figure 1). Type in the specified password and press **Ok**. Press **Ok** again in the welcome window that pops up. A window with initial settings pops up (Figure 2). Press the **Ok** button again. The main screen of the simulator then appears.

1.4 Activating menus

Menus (buttons) located in the top menu or in the right menu can be activated by left clicking your mouse.

All menu buttons with text in light grey are options not implemented in the actual simulator, while the buttons with black text are implemented.

1.5 How to start a previously saved simulation case and save a case

In the **File** menu a previously stored simulation case can be loaded (see Figure 3) by pressing **Open case...** (or Ctrl+O), and from the list presented select a simulation case by either double clicking the file or click the file and then press the **Ok** button (see Figure 4). The data from the input file are loaded and analyzed (see Figure 5). Press the **Ok** button when the process is finished.

Storing a simulation is applied by pressing **Save case...** (or Ctrl+S). When saving a case all properties and conditions valid at the time the simulation was stopped are saved and the simulation will continue from this state next time opening the case.

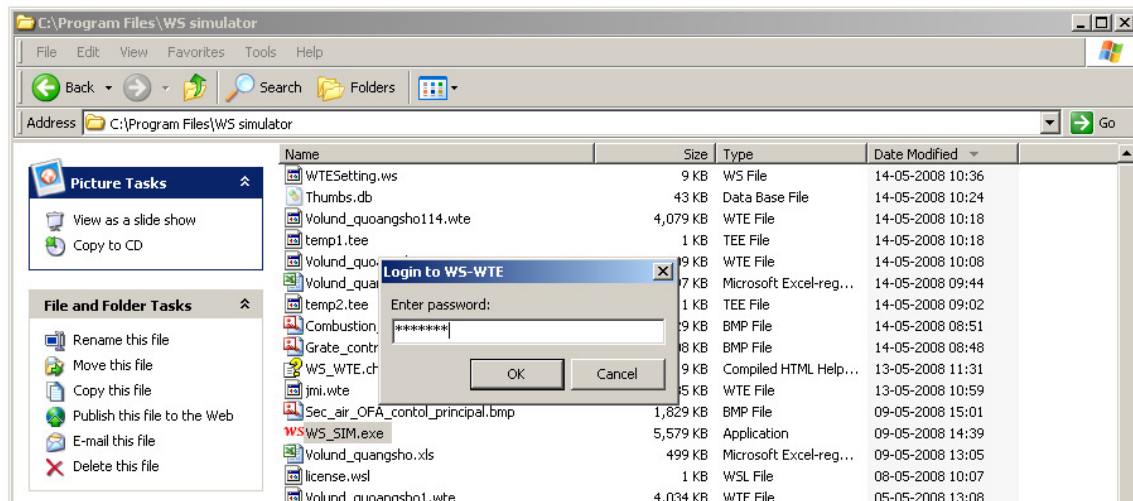


Figure 1. Location of files and login by start up.

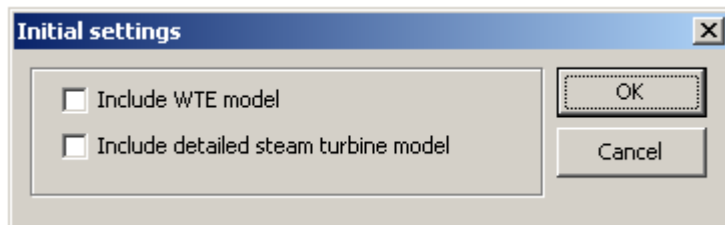


Figure 2. Initial settings.



Figure 3. Open an existing simulation case from the **File** menu.

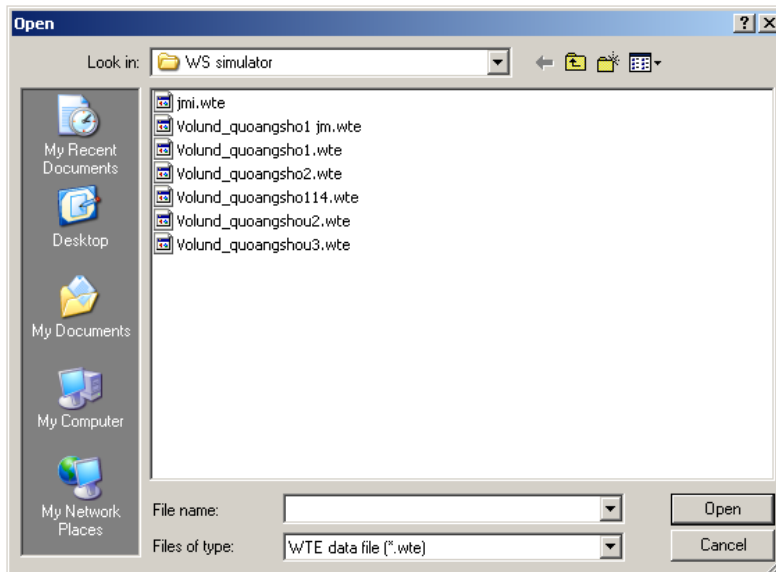


Figure 4. Select from the list of local simulation cases or browse to another location for a stored simulation case.

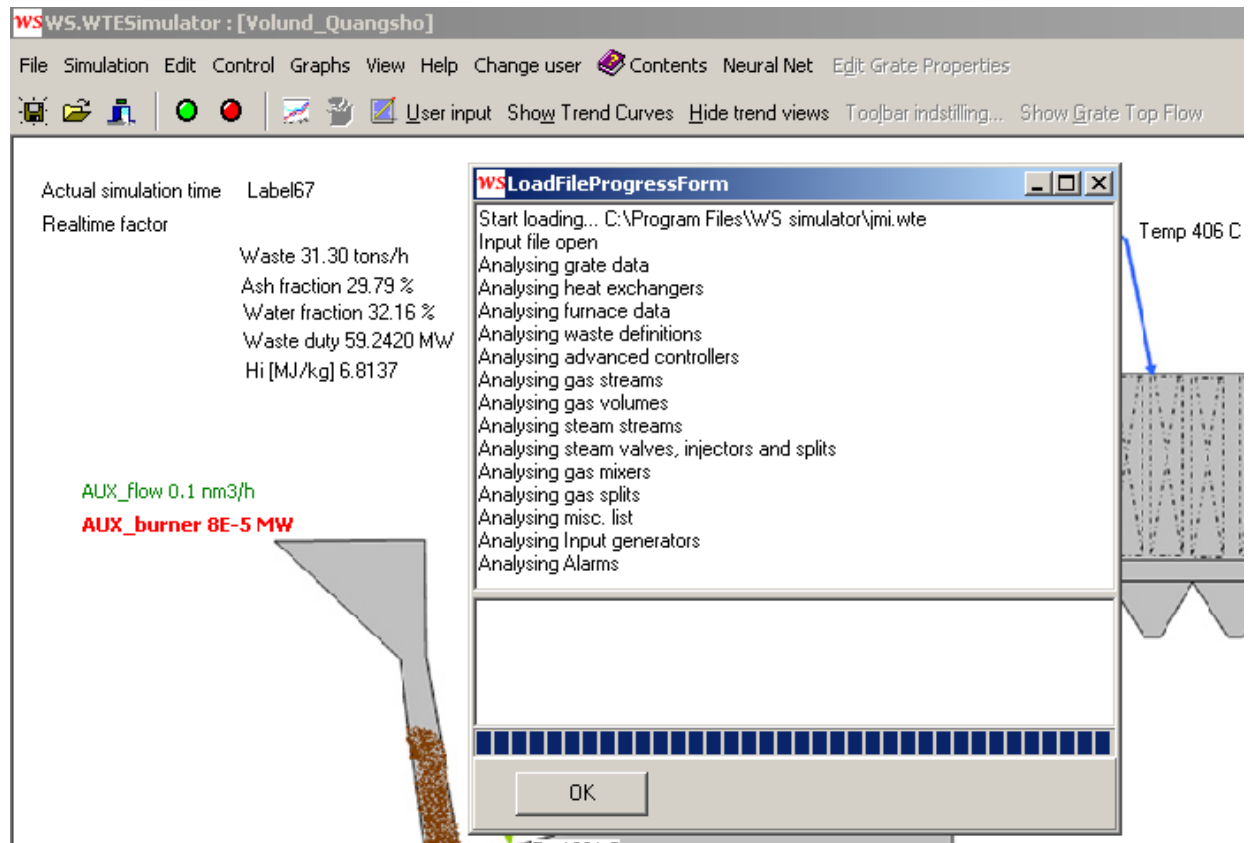


Figure 5. Start-up window showing progress in analyzing the data input from the input file.

2 Basic features

The software starts with the main screen (see Figure 6) where the configuration of the grate fired furnace and boiler is sketched. Now the simulator is ready for starting a simulation on the case loaded.

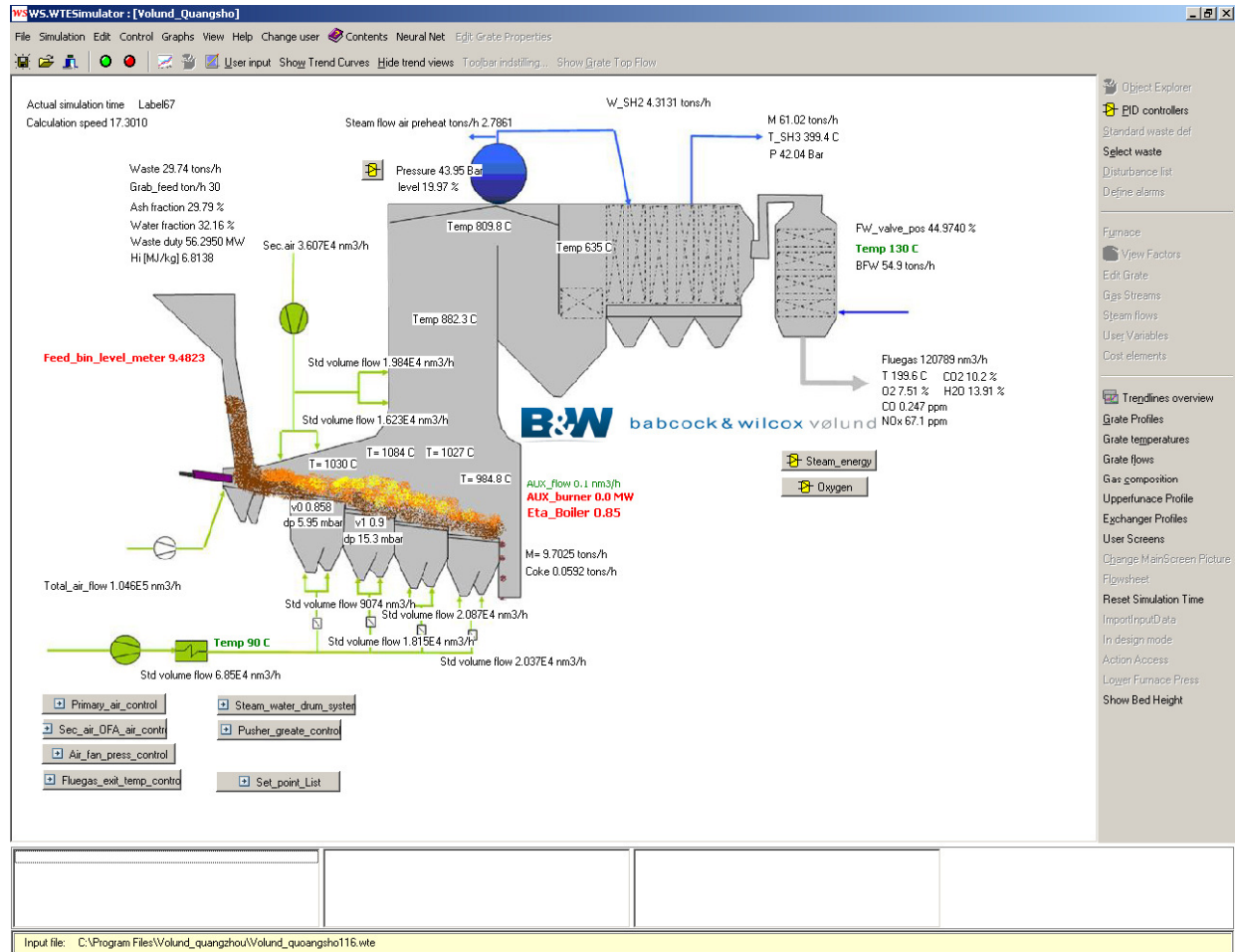


Figure 6. Main screen of the simulator.

The simulation is started by pressing the green button on the top toolbar, and stopped again by pressing the red button (Figure 7, left). The buttons are also available from the top menu **Simulation** (Figure 7, right).

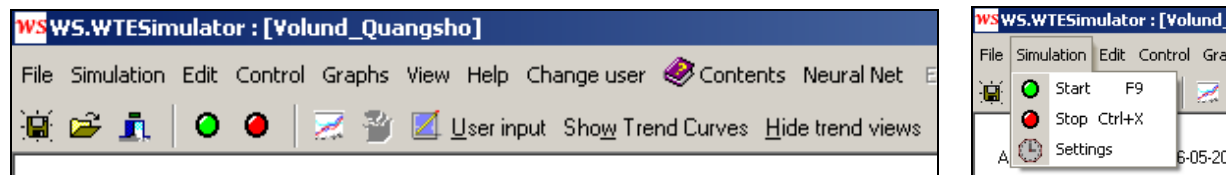


Figure 7. The simulation is started and stopped with the green and red buttons directly on the top toolbar or from the top menu **Simulation**.

2.1 Selection of predefined waste types

The simulator comes with a number of predefined types of wastes, composed of four components (waste1, waste2, ash, water). From the right menu button **Select waste** the drop down menu displays the predefined types of waste to select among (see Figure 8).

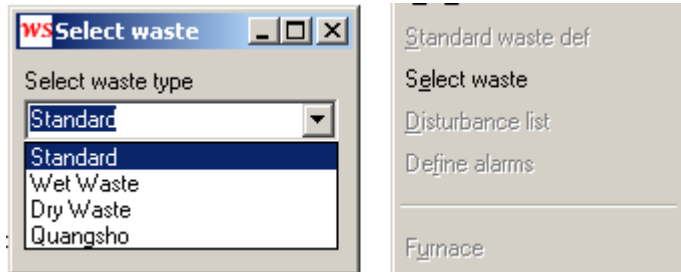


Figure 8. How to select among predefined types of wastes.

2.2 Controllers

The simulator is as standard equipped with a set of controllers typical for a waste-to-energy plant. If the controllers are on (set in auto mode) the controllers over-rule any user input given for the controlled parameter.

A list of the controllers defined in the simulator is presented when pressing the right menu button **PID controllers**.

Controller	Measured object	Measured p	Set point	Current valu	Controlled object	controlled p	Current valu	Active
Pressure control	WTE#Steam_Drum	Pressure [Bar]	44.0000	43.9496	WTE#Steam_Valves#TU	Valve positio	59.8888	Automatic
BFW controller	WTE#Steam_Drum	level [%]	20.0000	19.9691	WTE#Steam_Valves#BF	Valve positio	44.9737	Automatic
PID_recirk	WTE#Upper_furnace#U	Temperature	740.0000	635.0353	WTE#Gas_splits#Gasspli	Flow ratio 0	0.0000	Manuel
PID_O2	WTE#GasVolumes#Exitv	Molefraction	7.5000	7.5073	WTE#User_float_values#	Value []	0.8219	Automatic
PID_grate_speed_resist	WTE#Uservariables#Phi	Value []	0.5000	0.3407	WTE#Grate#Grate_group	Relative gra	0.8578	Manuel
PID_not_working	WTE#Steam_Water_stre	Mass flow ra	63.0000	61.0196	WTE#User_float_values#	Value []	0.9397	Manuel
PID_waterinj_superheate	WTE#Steam_Water_stre	Temperature	400.0000	399.4215	WTE#Steam_Water_stre	Mass flow ra	4.7087	Automatic
PID_control_fluegas_temp	WTE#Gas_streams#Gas	Temperature	200.0000	199.6341	WTE#Steam_splits#H2O	Flow ratio 0	94.9143	Automatic

Figure 9. List of specified PID-controllers is presented from the right menu button **PID controllers**.

The specification of each controller can be viewed by a double click on the controller in the list. The specification of the oxygen controller (PID_O2) is showed in Figure 10 and Figure 11.

Figure 10. Example of specification of a PID-controller for oxygen level in fluegas. First the connected objects (measured process value and regulated parameters) are specified. In addition there are two tab-sheets: “Forbindelse” (Connetion) and “Indstillinger” (Settings).

Activating a controller (corresponding to the term “auto” mode, some times used) is done by clicking the check box **Aktiv** on the tab-sheet **Forbindelse** (Connections) as seen in the example presented in Figure 10.

The controller will now attempt to control the process value (in this case the oxygen level in fluegas) close to the set point by changing the process input parameters via the integrated controller variables adjusted.

If the check box is unchecked, the output signal from the controller is “frozen” to the value that was present at the time the check box was unchecked or at a value specified by the user afterwards in order to manually control the process. The controller is therefore said to be in “*manual mode*”, when the check box is unchecked.

In PID-controllers the three parameters: amplification (Proportional factor), Integration time and Derivative time must all be specified with positive values (larger or equal 0) in the tab-sheet **Indstillinger** (see Figure 11). In addition a band (minimum and maximum value) for the process input parameter must be specified corresponding to 0 and 100% output signal from the controller.

For a PID-controller finally you need to specify weather it should act as a **Direct** or **Inverse** controller in the actual system set up.

Direct means that if the process variable (the variable that needs to be controlled at a specified set point) has a higher value than the set point, the output signal of the controller will decrease the value of the process input variable (e.g. the opening of a valve when having a flow controller). Inverse means the opposite. That is, if the process value has a lower value than the set point the output signal will increase the value of the process input parameter.

Figure 11. The tab-sheet for specification of settings.

The standard version of the simulator typically includes the following controllers. As an option the user can get access to change or expand this set up as needed.

1. Steam/energy controller:

- Set point: mass flow of steam.
- Process input variable: feed of waste (speed of pusher). The steam/energy controller is integrated with the grate controller and the primary air controller.

2. ABZ controller:

- Set point: temperature in the after burning zone (ABZ).
- Process input variable: secondary air and/or flue gas recirculation.

3. Oxygen controller:

- Set point: Oxygen level in flue gas.
- Process input variable: flow of primary air (Nm³).

4. Oxygen controller2:

- Set point: Oxygen level in flue gas.
- Process input variable: flow of secondary air (Nm³).

5. Auxiliary burner controller:

- Set point: ABZ temperature.
- Process input variable: Firing (MW or fuel flow).

6. Grate controller:

- The moving of the grate is controlled proportional to the speed of the pusher.

7. Primary air controller:

- The primary air is controlled proportional to the speed of the pusher.

8. Steam pressure controller:

- Set point: Steam boiler pressure.
- Process input variable: Opening of steam turbine governor valve or bypass valve.

9. Steam drum level controller:

- Set point: water level in steam drum.
- Process input variable: Flow of feed water.

10. Super heater controller:

- Set point: super heater temperature.
- Process input variable: Mass flow of water injected in super heater.

Additional as options:

- A. Furnace pressure controller:
 - a. Set point: pressure inside furnace.
 - b. Process input variable: Output signal to induced draft fan (exhauster).
- B. Controllers based on derivatives can be implemented.
- C. Controllers for individual speed on grate sections.
- D. Mixing on the grate as a function of:
 - a. grate step,
 - b. vibrations,
 - c. fluidization or
 - d. tumbling.
- E. Changeable view factors. The influence from radiation between various elements.
- F. Insert new and redefine existing PID controllers.
- G. Distributed preheated temperature of primary air over the sections.

2.3 PID controllers

In the menu **PID controllers** there is access to the settings of the controllers defined in the simulator for controlling the plant. For editing settings double click the specific controller and a submenu appears, where the settings can be edited, which process variable to measure (process value) and which parameter to manipulate (output signal).

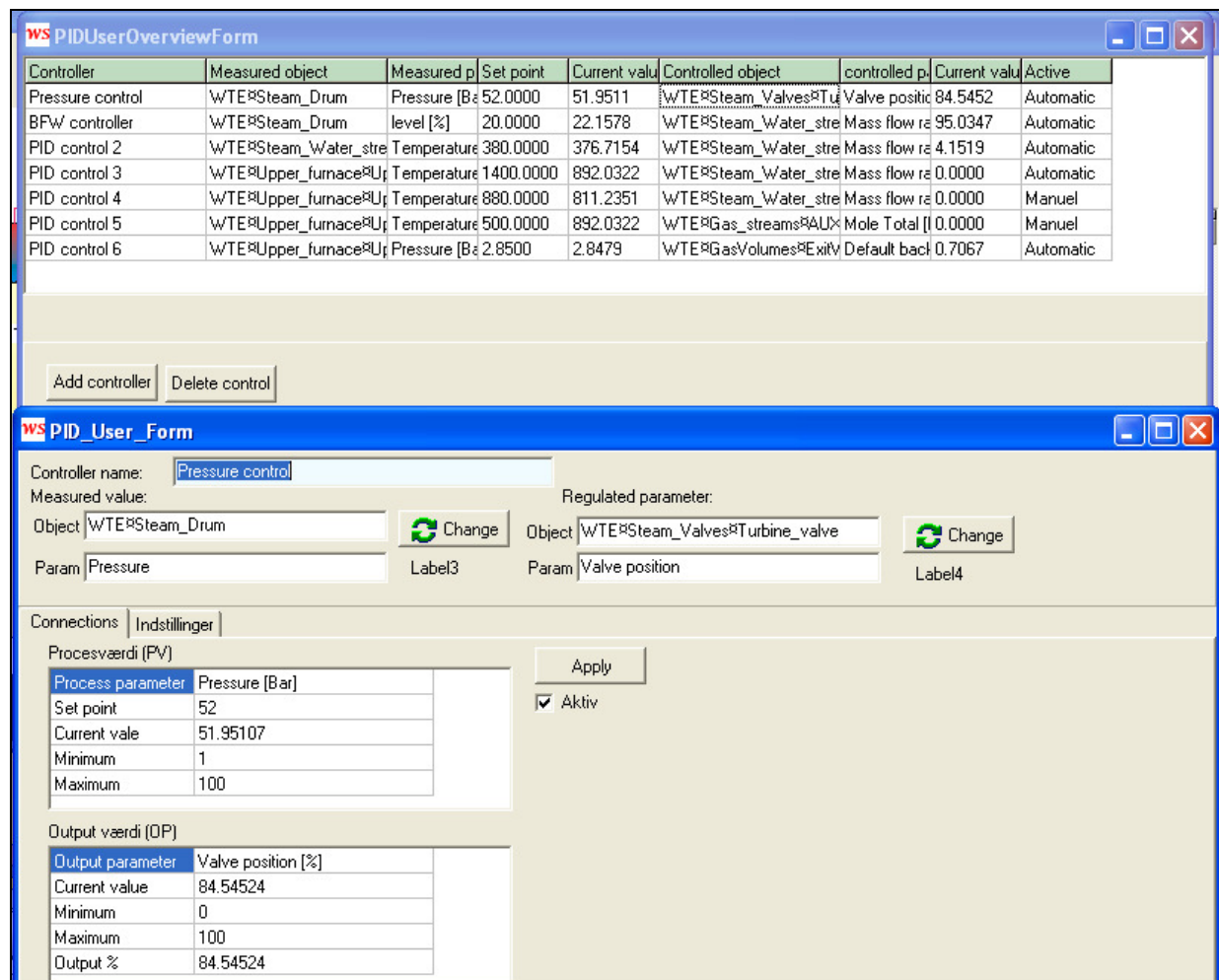


Figure 12. Menu for specification of **PID controllers**.

2.4 Advanced combined controllers

The WTE-simulator can be tailored with advanced and combined controllers.

2.4.1 Examples: Völund energy control and Sec air control

The two advanced controllers or control systems consist of integrated and combined controllers, where you can manipulate the distribution of primary air and grate speed on the individual sections etc.

To change the air conditions under the grate press the button **Model settings**. The controllers are activated by checking the check box **Auto** otherwise the controller is in "manual" mode, where the user can specify the output signal. In Figure 13 the Voelunds Energy Controller is shown with additional explanations.

The screenshot displays the AFEnergyControllerForm interface. It features several control blocks: 'F(x)' for temperature control, 'Energi' for energy control, and 'Riste' for grate speed control. Each block has 'Auto' checkboxes and various input fields for setpoints and gains. A 'Riste indstillinger' button is visible. At the bottom, a 'Rist forholdstal' submenu is open, showing a table with columns for Rist, Forsterkning, Forholdstal, and Luft fory. Below the table are input fields for 'Flow spjæld 1' and 'Flow spjæld 8'. Red arrows point from text boxes to specific UI elements, explaining their functions.

Double click for and temperature

Double click for PID-controller

Double click for changing set points.

Unchecking the checkbox (manual mode) by double clicking the output signal it can be edited.

The window appears when pressing the button **Grate settings.**

Specification of primary air preheat temperature distribution.

Specification of primary air flow distribution.

Specification of grate speed individually for each section.

Rist	Forsterkning	Forholdstal	Luft fory.
Rist 1	100	ikke relevant	89,85
Rist 2	110	0,3	89,85
Rist 3	120	0,4	89,85
Rist 4	110	0,4	89,85
Rist 5	130	1,15	89,85
Rist 6	150	1	89,85
Rist 7	100	0,8	89,85
Rist 8	100	ikke relevant	89,85

Figure 13. The advanced energy controller: *Voelund energy control* here with the submenu open after pressing the button *Model settings*, for changing the distribution of primary air.

2.5 Dynamic behavior of parameters viewed in trend curves

In dynamic simulation trend curves provide overview of the simulation results. A number of trend views, already defined in the loaded case, may be visible on the screen from the start. Each one can be closed individually or all can be hidden from the top menu **Hide trend views**. The trend views can be made visible again by pressing **Show Trend Curves**.

A number of property data for the operation are presented (such as flue gas flow, steam production, feed and condition of waste, temperature in the after burning zone (ABZ), CO concentration etc).

Trends (time history) of all the presented data on screen can be viewed in a graphical window simply by double clicking the parameter on screen. The trends will not start storing data for a parameter before the parameter has been double clicked unless the trend has already been defined in the simulation case loaded.

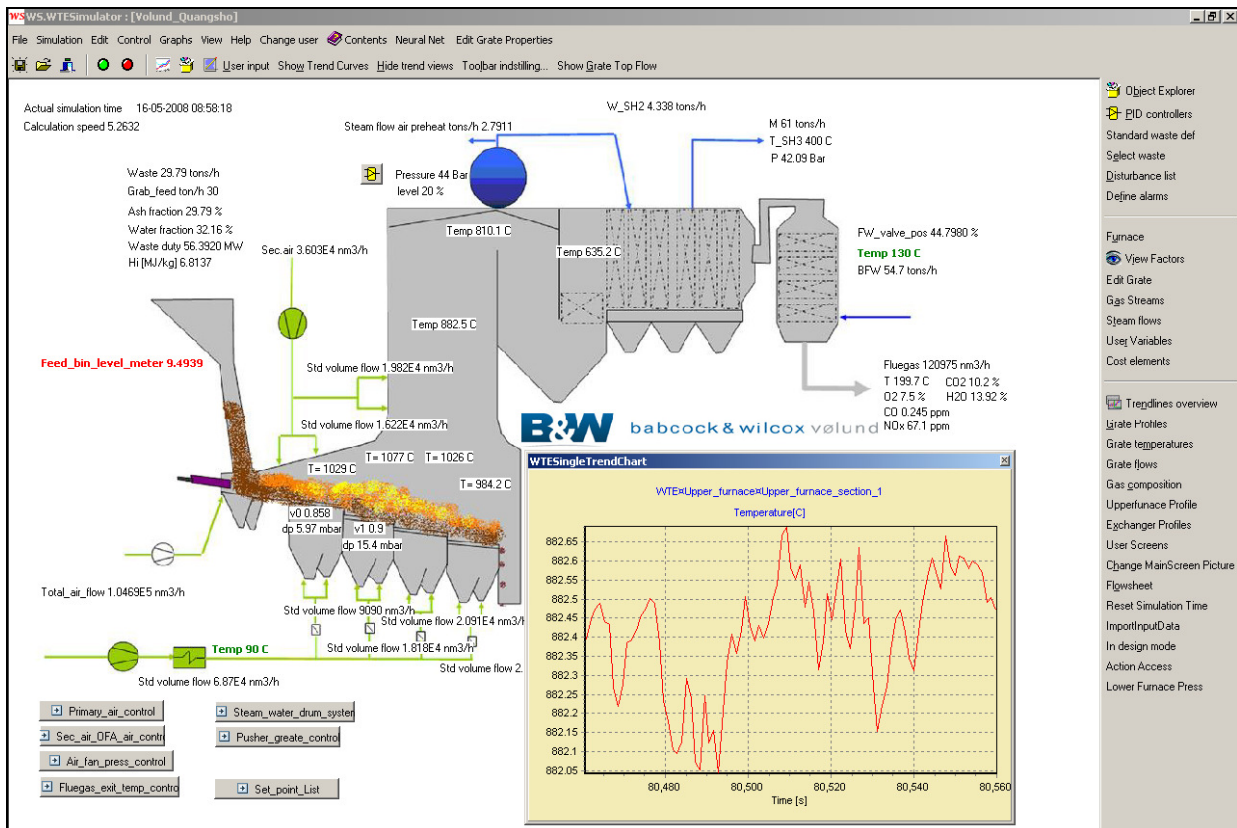


Figure 14. Trend curve of the temperature in the upper furnace section 1. Note the small temperate interval on the vertical axis meaning that the temperature in fact is quite stable. As default axes are auto scaled.

2.5.1 Zoom in trend curves

By pressing the left mouse button while dragging the cursor from an upper left to lower right corner forming a white rectangle (see Figure 15) on the trend curve, the encapsulated area will be shown in the graph (zoomed in) as can be seen in Figure 16.

To zoom out again, simply press the left mouse while forming a rectangle the opposite direction (moving the cursor from lower right corner towards an upper left corner).

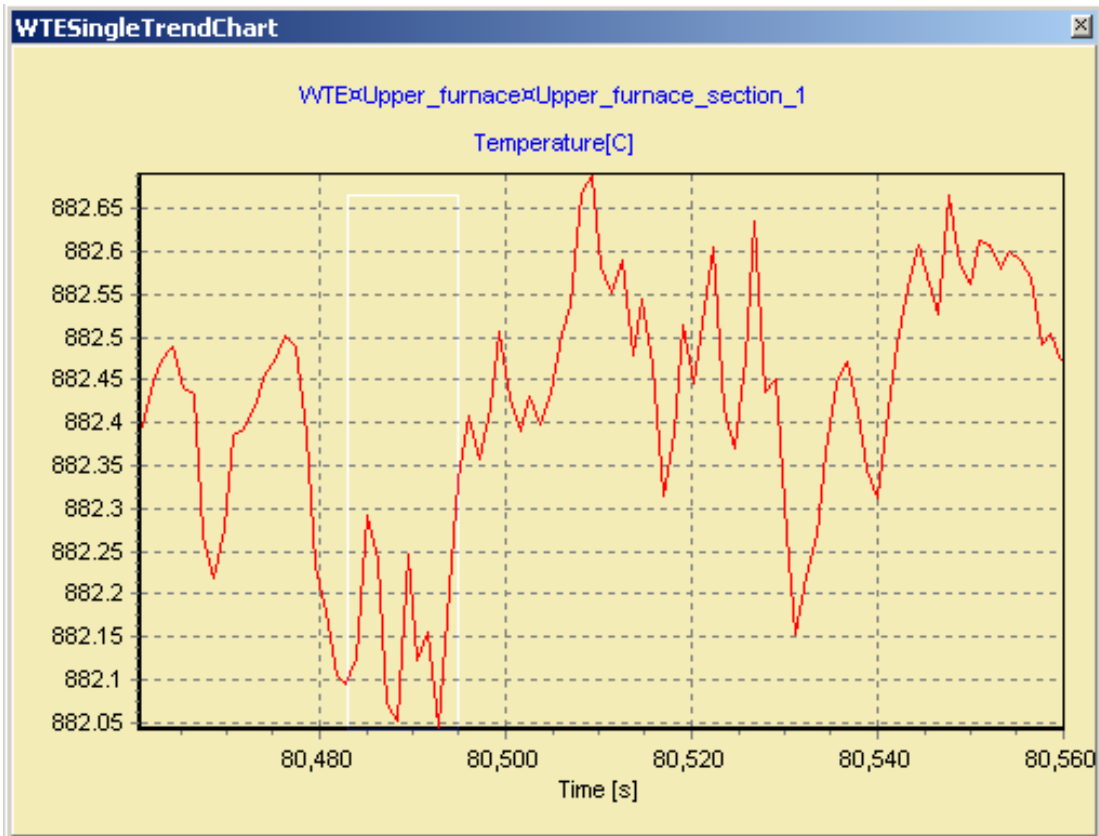


Figure 15. Zooming in by marking a rectangle by dragging the cursor.

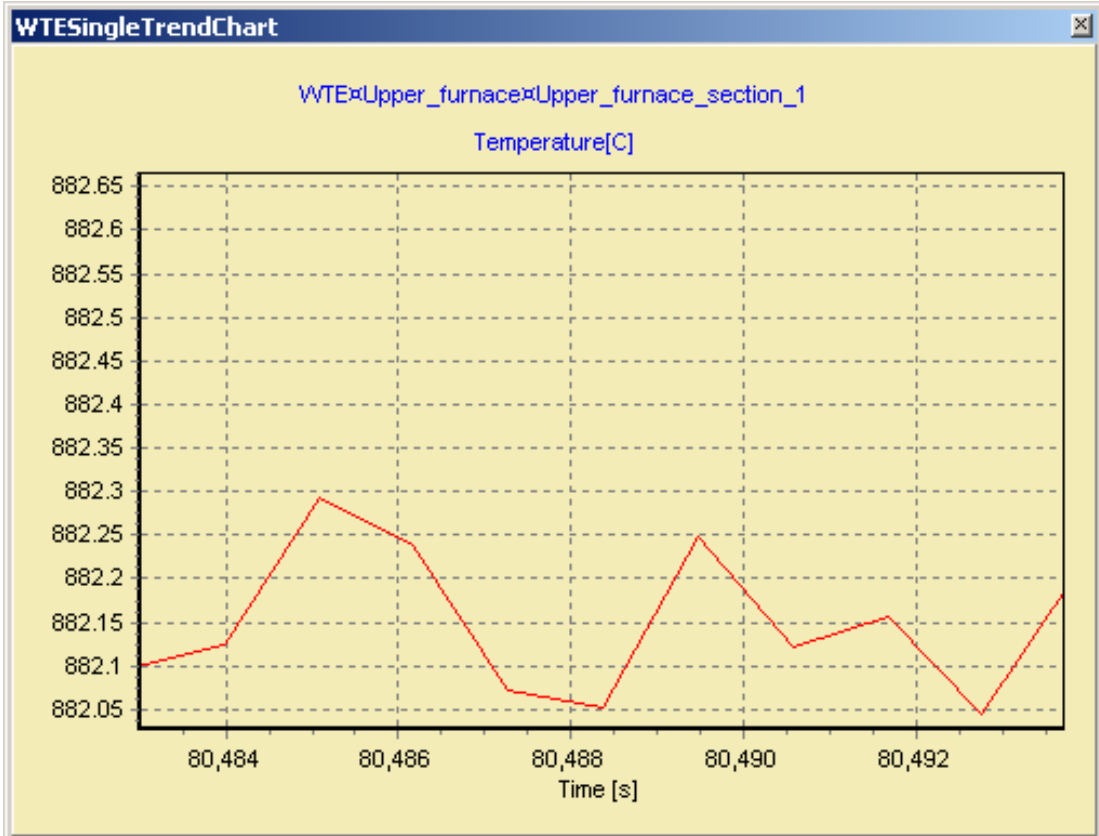


Figure 16. The trend curve from Figure 15 when zoomed to the white rectangle.

As an option, in fact all parameters, defined in the simulator, can be selected for updated presentation (and trended) on the screen. The feature is applied as a simple an efficient Drag & Drop feature in the integrated parameter navigator *Object Explorer* (optinal) located at the top of the right menu. The parameter presentation and labels can hereafter be edited by pressing the right menu *In design mode* (optinal).

2.6 More trends in one graph

From the top toolbar press the button showing a graph (see Figure 17).

A window appears, allowing you to select up to 4 different parameters to be viewed in the same graph. The parameters are selected from 4 identical drop-down menus in the top of the window, as can be seen in Figure 18, where a graph already has been defined.

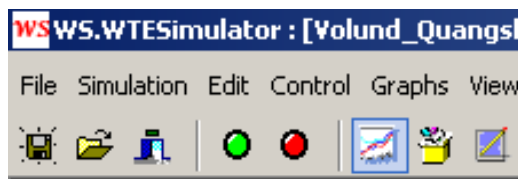


Figure 17. The trend button in the top toolbar.

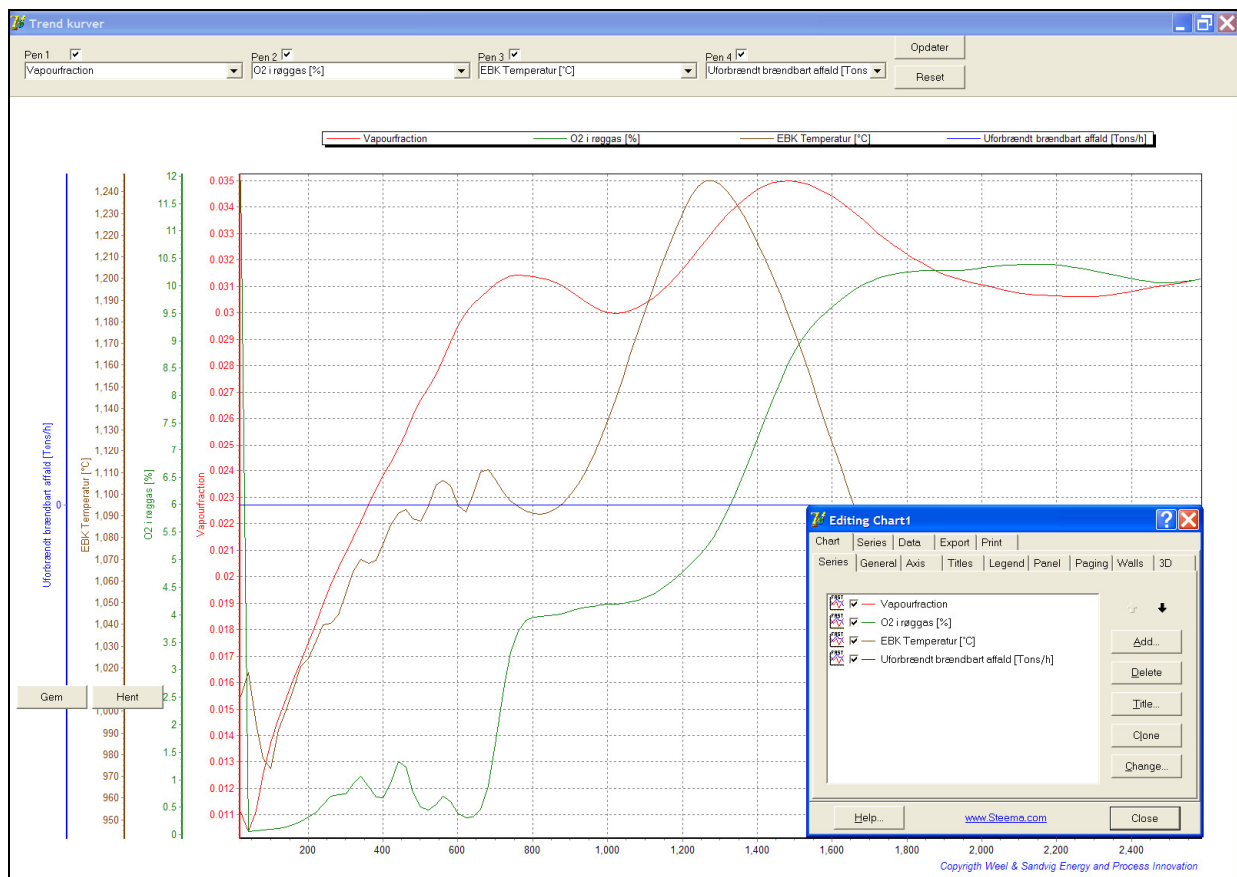


Figure 18. Export of trends is applied by double clicking the left mouse button. From the *Editing Chart1* window, that appears, select the *Export* sheet and specify what to export. While pressing down the right mouse button, with the cursor drag from upper left to lower right to get a zoomed view of the rectangle area encapsulated. To zoom out again simply drag the cursor the opposite way (from lower right to upper left while pressing down the left mouse button).

The drop-down menus allow for browsing through the variables. A process variable is selected for presentation in the graph by a double click on the process value.

2.6.1 Export of data to MS Excel

The trend chart of up to 4 parameters can be edited by double clicking the graph. An *Editing Chart* window appears (see the lower left corner in Figure 18) allowing for changing a number of settings for the graph. From this Editing Chart window you can also copy the picture, exporting the data to a spreadsheet etc.

The zooming feature works the same as for the trend curves explained in section 2.5.1.

2.7 Grate temperature profiles

From the right menu button **Grate temperatures** a graphical presentation of the average temperatures for gas and solids in the bed cells is applied (see Figure 19).

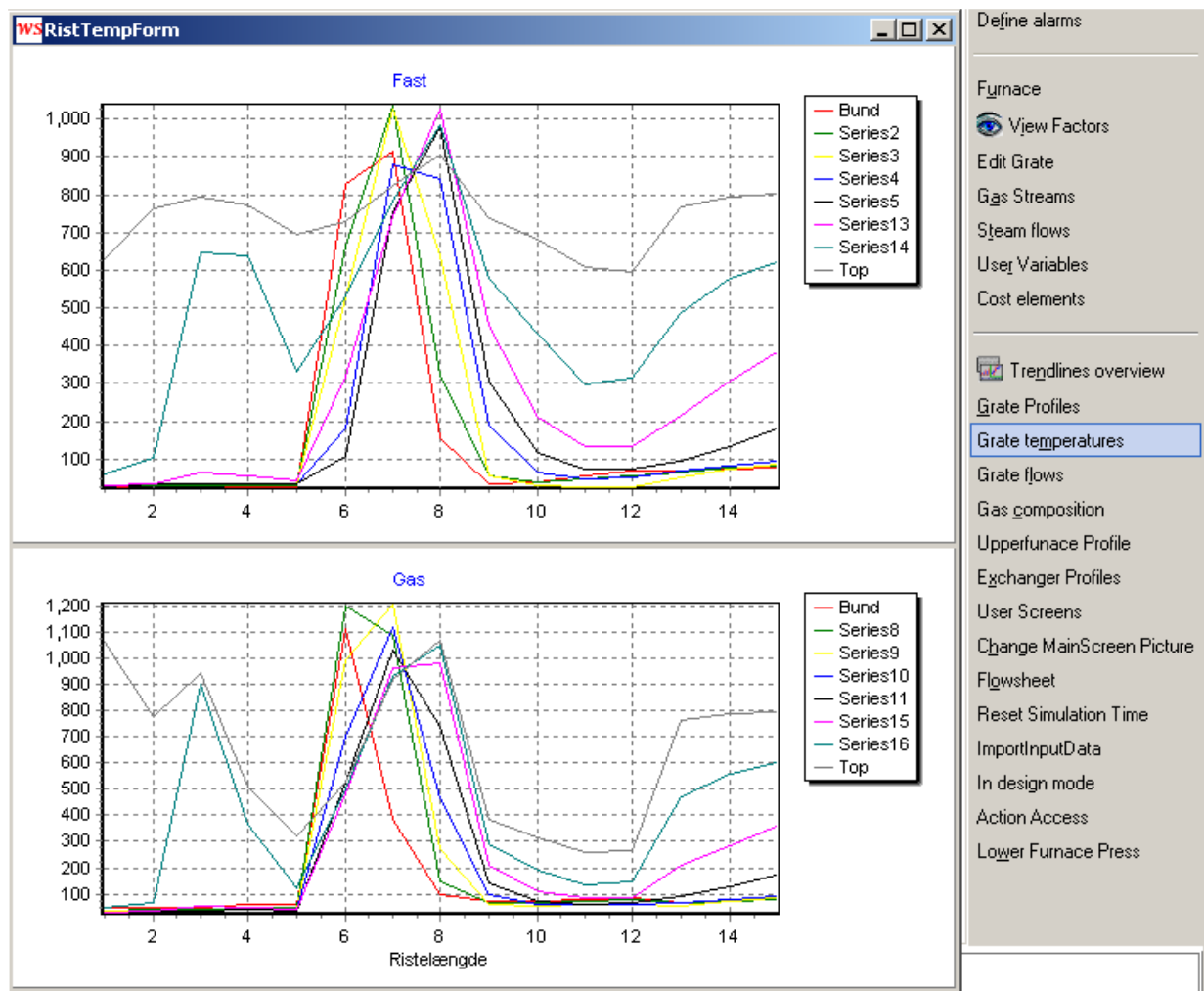


Figure 19. Temperatures in bed (8 vertical layers and 15 sections along the flow direction). The top graph shows the temperatures of solids while the lower graph shows the temperatures of gas in the layers and sections.

2.8 Grate Profiles

A large number of parameters defined in the bed layer can be viewed in a graphical interpolated colour graduated plot diagram. This can be useful to get a good understanding and depicted of is going on in the bed layers.

The tool **Grate Profiles** is activated from the right menu. In top of the window the parameters to display can be selected from two drop-down menus (see Figure 20 and Figure 21). The plot is made by interpolation (splines) of the cells mean values calculated in the simulator. The number of cells are typically 8 in height and 15 in the flow direction equal to 120 cells.

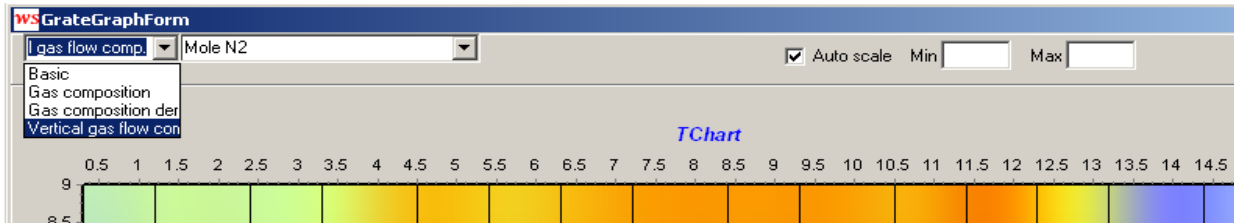


Figure 20. Select which group of variables from the first drop-down menu.

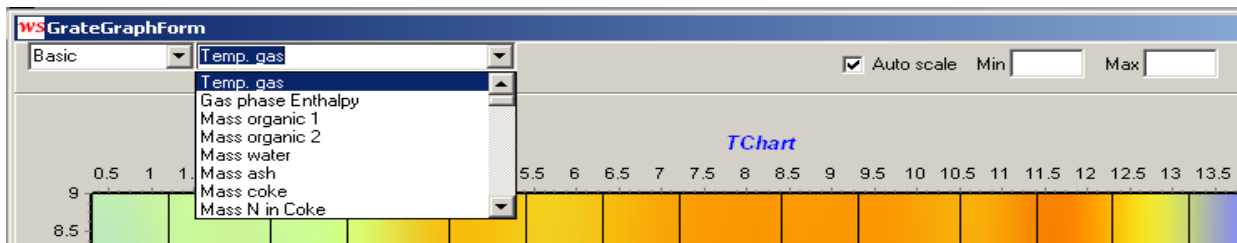


Figure 21. Then select which parameter to display from the secondary drop-down menu.

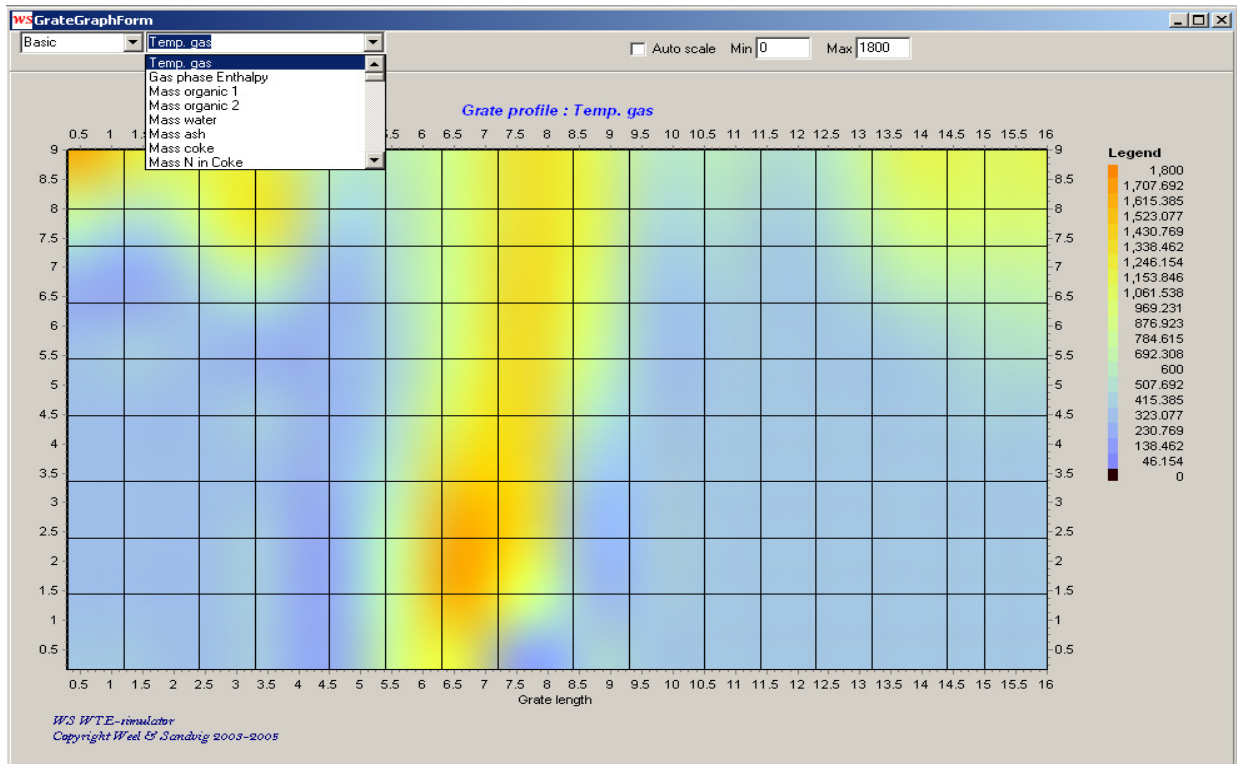


Figure 22. Interpolated temperature plot (cross-sectional view from the side) of gases in the grate bed layer. The waste is entering the grate from the left moving to the right along the grate. The vertical axis describes the vertical layers (relative height) of the grate bed.

2.9 Grate flows

From the right menu button **Grate flows**: curves for mass flow of combustibles and char for various debts in the grate (one curve for each relative depth) as function of the grate length (sections).

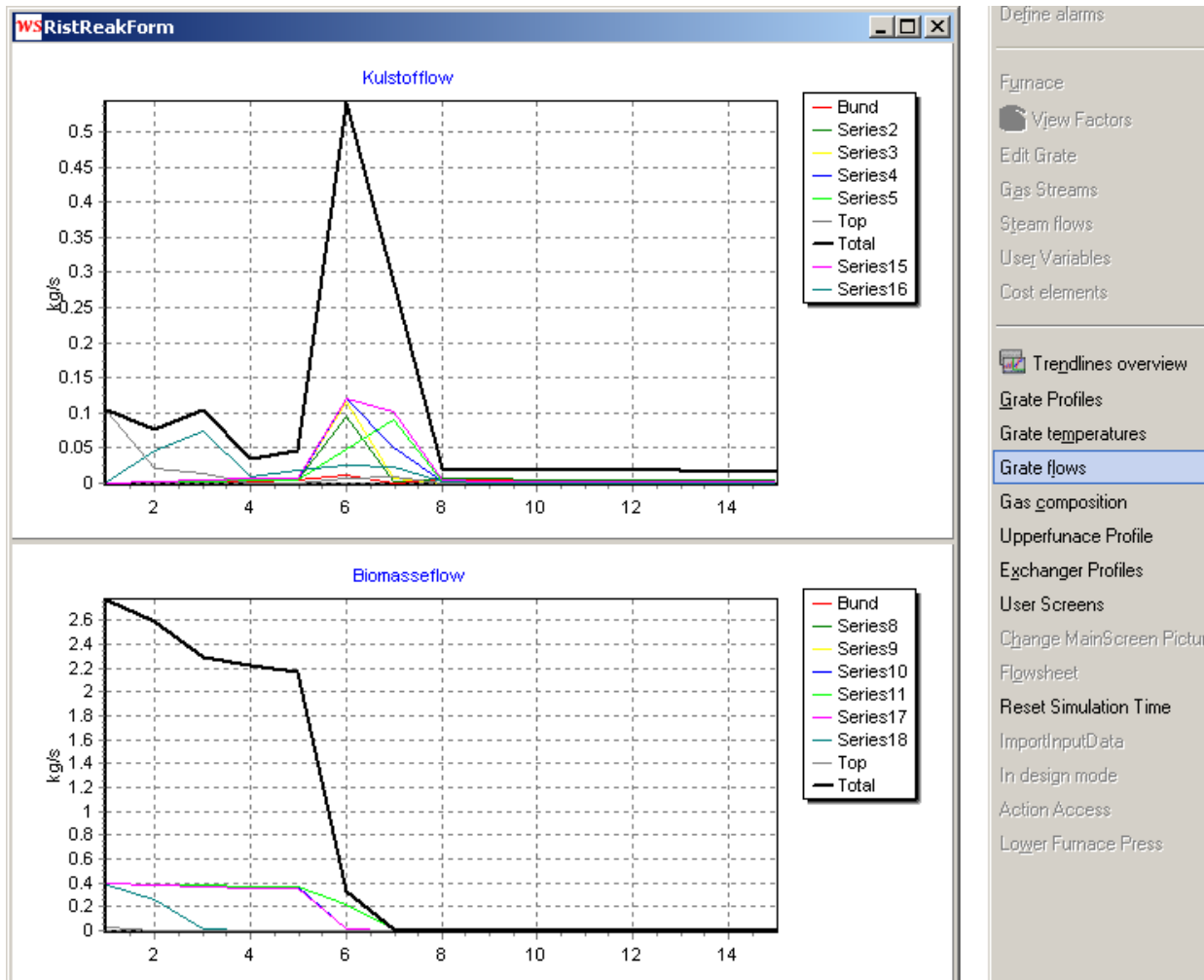


Figure 23. The graphical representation from Grate flows.

2.10 Gas composition

The composition of gasses leaving the top of the grate layer as function of the grate length (sections) is displayed (see Figure 24) by pressing the right menu button **Gas composition**.

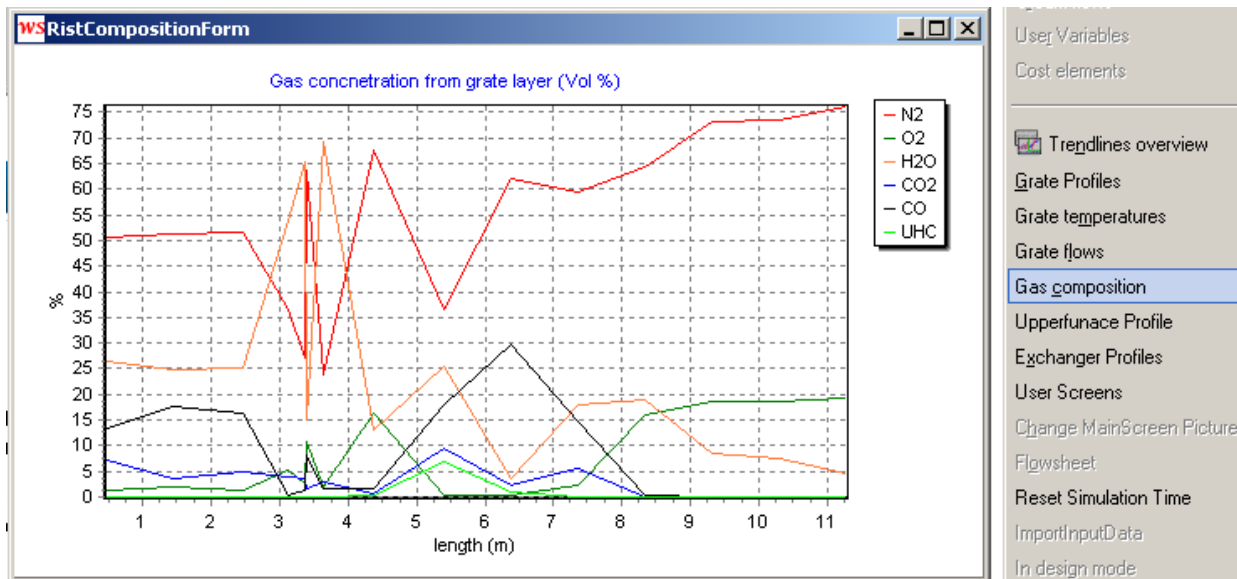


Figure 24. The composition of gases leaving the top layer in the bed.

2.11 Upperfurnace Profile

The right menu button **Upperfurnace Profile** can be used for displaying a number of parameters in the radiation parts like for instance the temperature profile of the flue gases as function of the distance travelled in the radiation parts (see Figure 25). Note the distance in meters from the beginning of the radiation part and downstream is at the vertical axis, and the selected parameter on the horizontal axis.

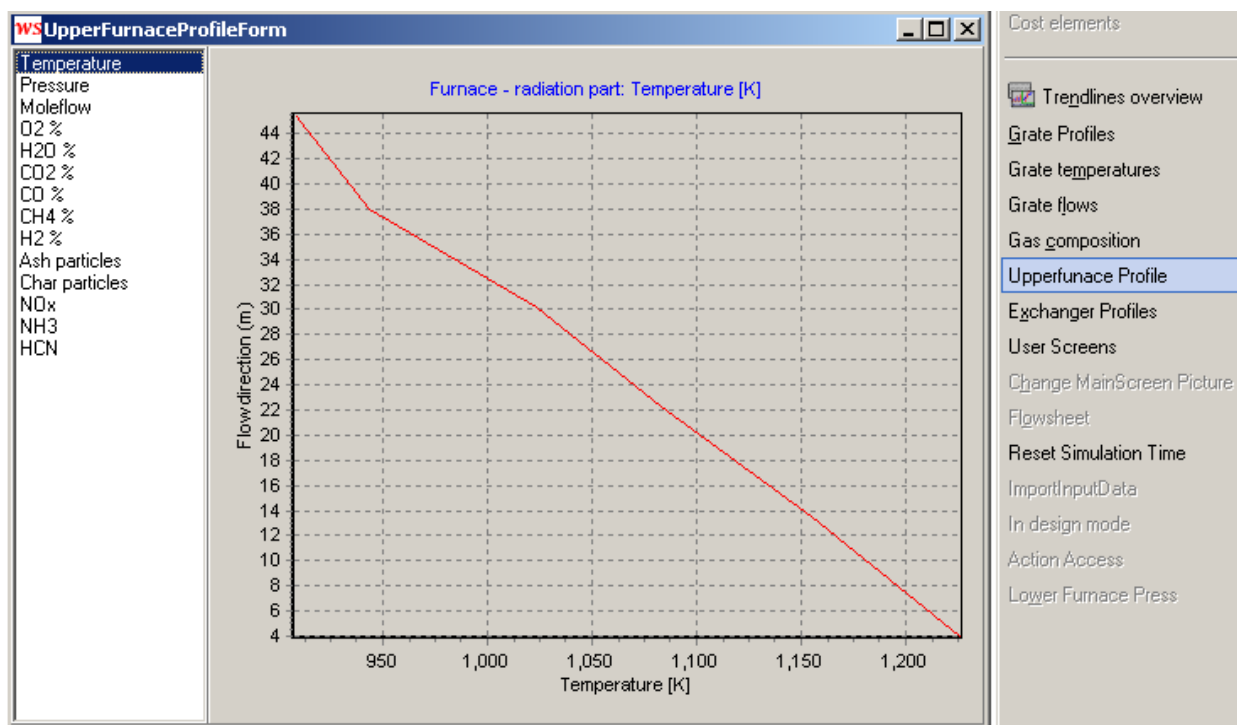


Figure 25. Displaying of temperature profile in the radiation parts from the menu: **UpperFurnace Profile**.

2.12 Exchanger Profiles

Temperature profiles of heat exchangers can be displayed in the menu **Exchanger Profiles** (see Figure 26). A list of the heat exchangers is displayed. Clicking one of the heat exchangers displays the profile for the very exchanger. By double clicking one of the exchangers in the list (SH1, SH2 etc.) allows you to edit and redefine the heat exchanger in the pop up window *Edit Heat exchanger*. In the sheet **Main** the specifications like co or counter current flow regime, heat transfer area and reference conditions for heat transfer are specified. In the sheet **Connections** the processes connected to the heat exchanger can be specified.

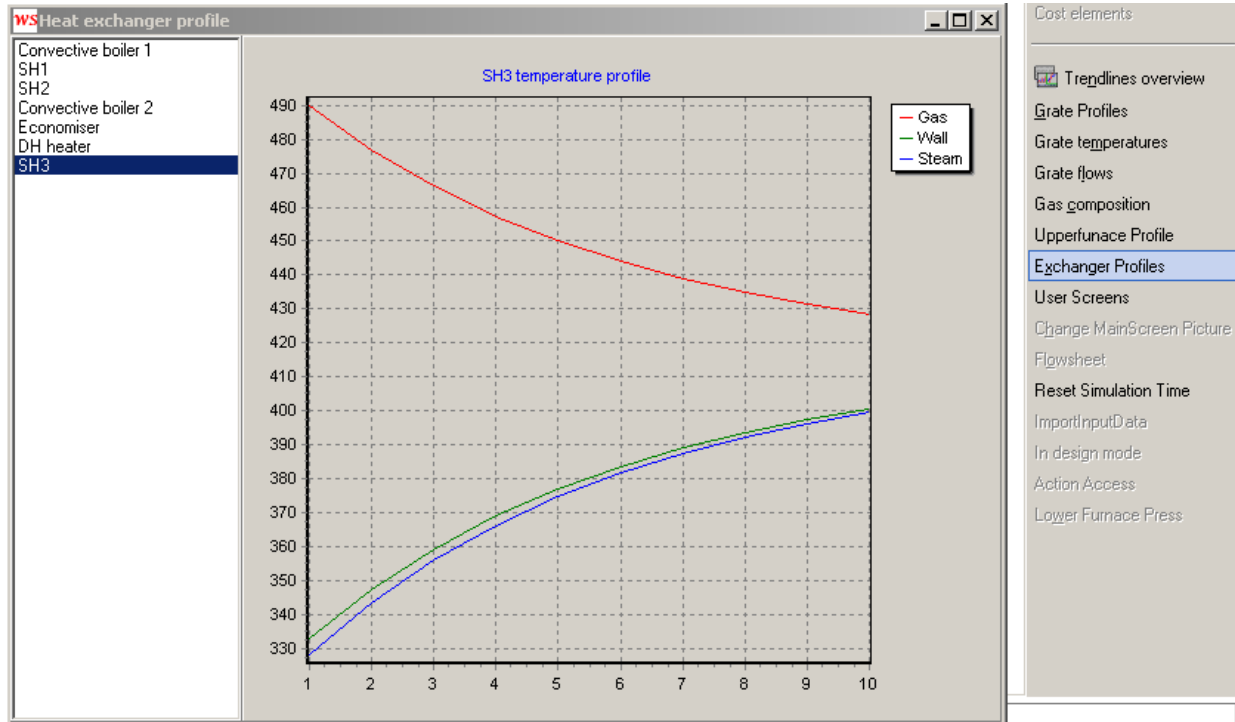


Figure 26. View of heat exchanger profiles in the convective zone from the menu Exchanger Profiles.

The specification of the individual heat exchangers can be viewed by double clicking the exchangers in the list to the left (see Figure 27).

Double clicking the graph allows for editing and for export of data to e.g. spreadsheet.

The screenshot shows a software window titled "Edit Heat exchanger : SH3" with three tabs: "Main", "Connections", and "Initiate". The "Main" tab is active. The window contains the following fields and options:

- Heat exchanger name: SH3
- Counter current:
- Exit steam flow k:
- Design properties section:
 - Area: 1100.0000 m²
 - Hex mass: 8000.0000 kg
 - h ref gas: 0.0300 kJ/(kgK)
 - ref gas flow: 0.8681 kgmole/s
 - h ref steam water: 1.0000 kJ/(kgK)
 - ref steam water flow: 36.0000 tons/h
 - Gas content: 10.0000 kgmole
 - Water steam mass: 10.0000 kg

Figure 27. Design specifications of heat exchangers.

2.13 User input

The following parameters are defined as input variables in the simulator.

1. Composition of the waste consisting of four components (waste1, waste2, ash, water).
2. Mass flow of waste (corresponds to the speed of the pusher).
3. Temperature of primary air.
4. Volume flow of primary air.
5. Flow distribution of primary air (up to 13 individual zones, all depending on simulator version).
6. Temperature distribution of primary air (option for individual air preheat in each section, depending on simulator version)
7. Flow of secondary air.
8. Temperature of secondary air.
9. Flue gas recirculation.
10. Speed of grate. (As standard version there is one grate. The number can be expanded).
11. Auxiliary burners.
12. Randomized disturbances can be initiated and their absolute values specified.

When specifying the composition of waste the program normalizes automatically the four concentrations (waste1, waste2, ash and water) to equal 100.

2.14 Set up of calculation speed and sampling intervals

In the top menu **Simulation** by pressing **Settings** the speed of calculation can be increased by specifying large time steps and vice versa.

Here you can also change the updating time interval (sampling rate) for process variables. All process variables will have the same updating interval. When following trends for variables, the number of samples (length of history) can be specified individually for each variable in the trend views.

The default value of time step is 0.1 seconds and the sampling rate (time interval) is 1 seconds (see Figure 28).

Normally calculation speed for a PC with a processor clock frequency of 2 GHz the simulation speed is about 10 times real time. For training exercises where the user has to control the plant (the simulator) in manual, this is too fast. In such cases a time step less than 0.01 seconds may be more appropriate.

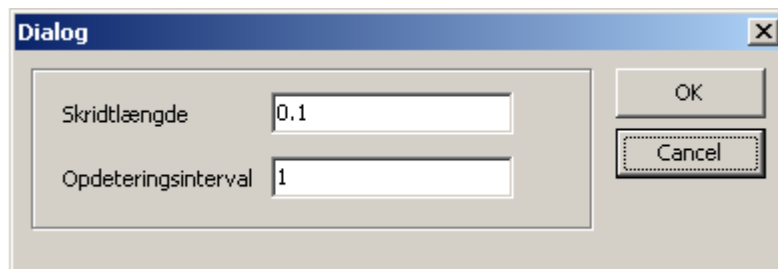


Figure 28. Window for specification of time step and sampling interval in seconds.

In some cases it is necessary to decrease the time step in order to escape problems for the numerical solver and for improving accuracy.

The sampling rate can be varied in order to avoid a too large data file with results. In case fast transients need being investigated thoroughly, the sampling rate should be specified fast (small time period) in order to be able to identify eventual peaks.

2.15 Reset Simulation Time

The menu **Reset Simulation Time** allows for resetting the simulation time to zero, which might be wanted when displaying trends graphically. The feature however is not fully reliable in the present version, as there might be problems with the PID-controllers after resetting (if the Reset Simulation Time is activated immediately after the case file is loaded it will work well).

2.16 Show Bed Height

The bed height can be viewed (cross-sectional view from the side) by pressing the right menu button **Show Bed Height** (see Figure 29).

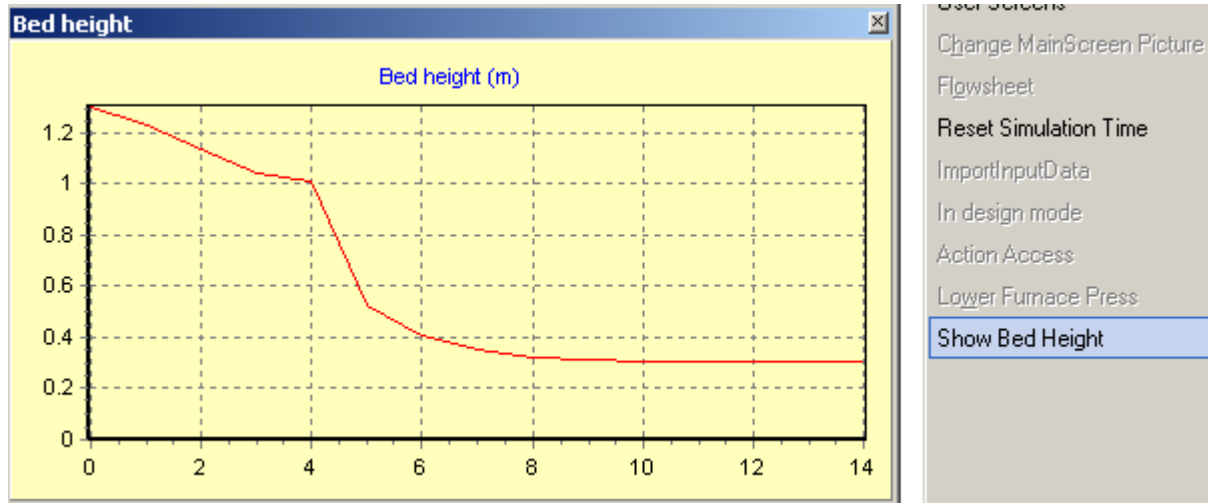


Figure 29. View of the bed height along the grate. The moving direction is from left to right.

2.17 Error messages

If the message "floating point division by zero" appears (as shown in Figure 30), the simulator needs to be shut down and restarted. The simulation can start from the last saved state.

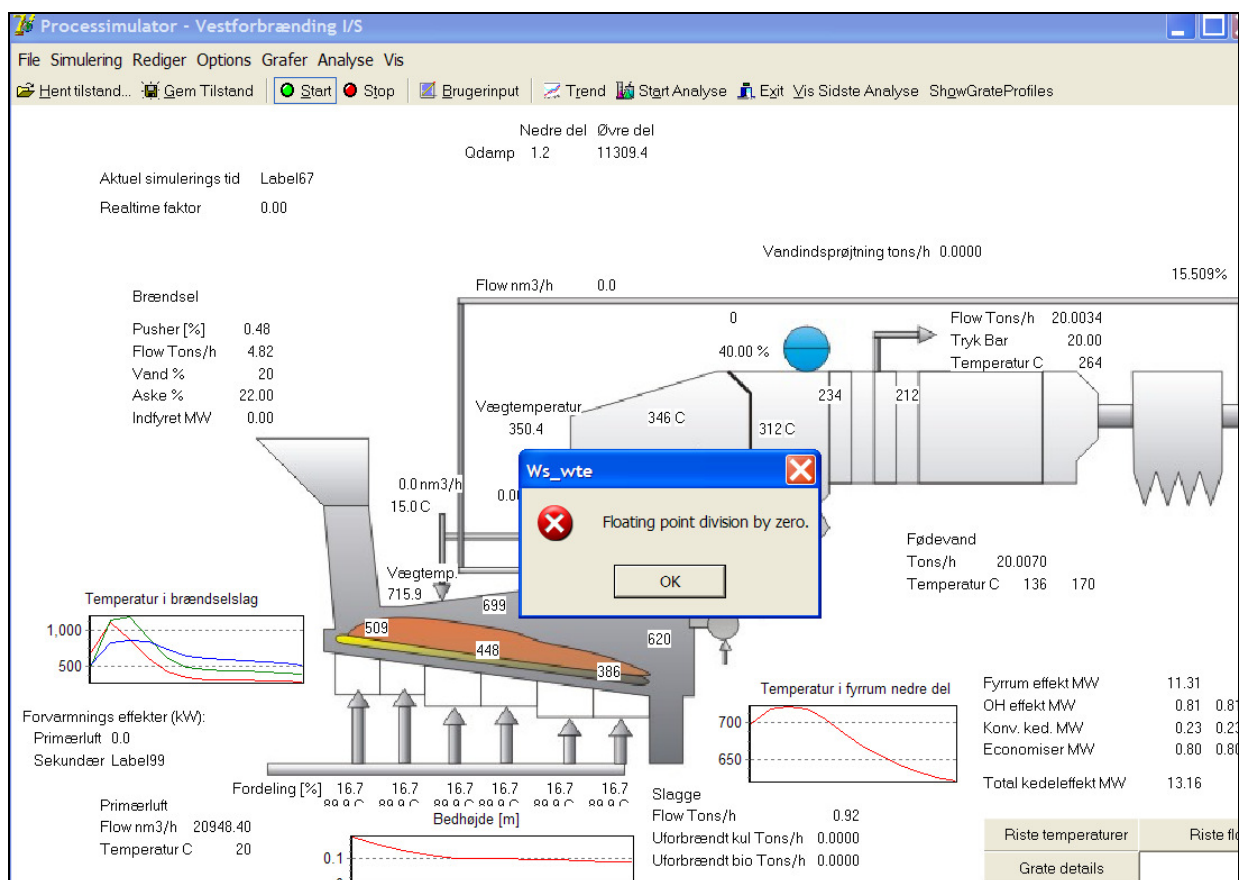


Figure 30. Error message. The simulator needs being closed and restarted.

3 Case examples

Some screen dumps in the following case examples are from an earlier version of the WTE-simulator and might have a different arrangement of menu tools.

3.1 Editing the water content in the waste (fuel)

1. Activate **Object explorer** in the menu **Edit** and expand **Grate** if not already expanded (by double clicking "Grate" or click once the symbol [+]).
2. Then click **Waste feed**, for showing the table with the composition of the waste (see Figure 31).
3. The composition can be edited (remember the sum must equal 100%).
4. When the change has been entered press the button **Apply changes** for making the new data active.

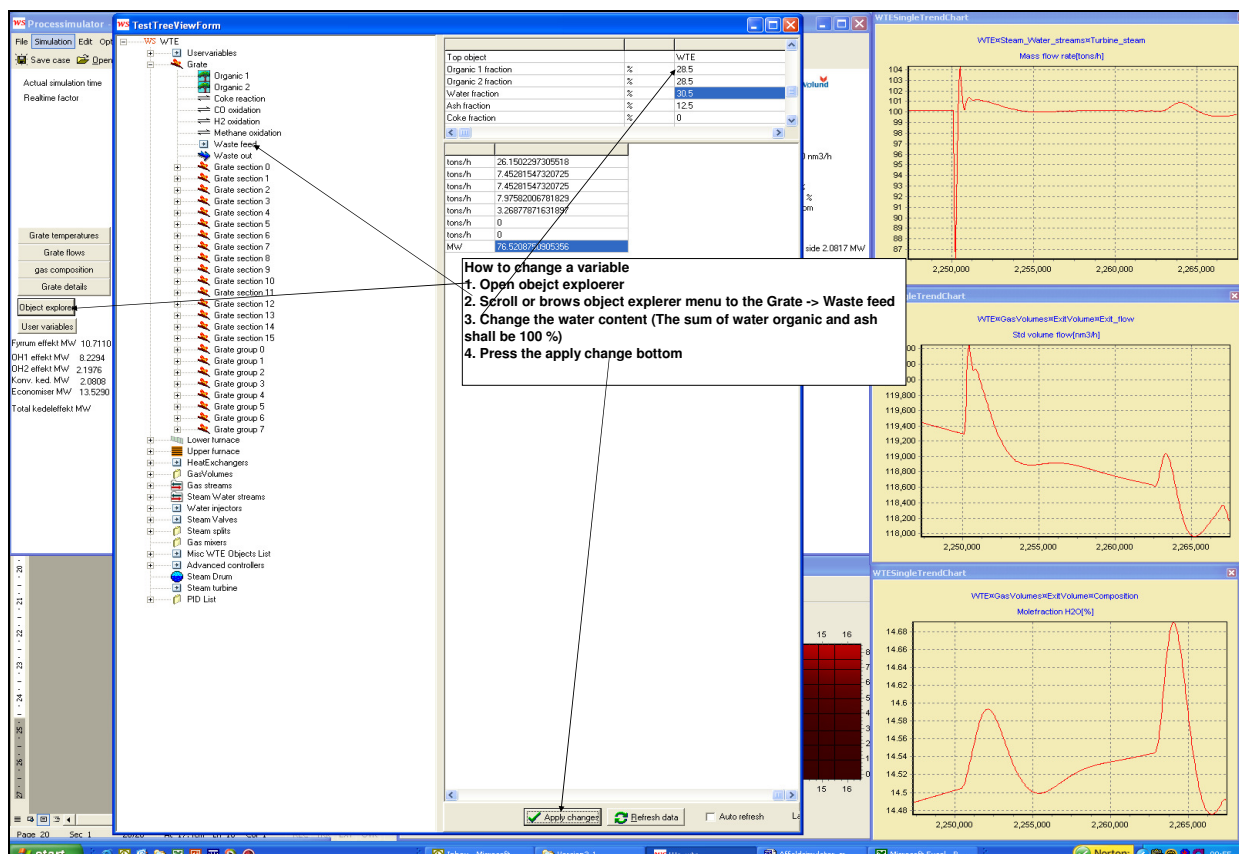


Figure 31. How to change the water content in the waste from the menu button **Object explorer**.

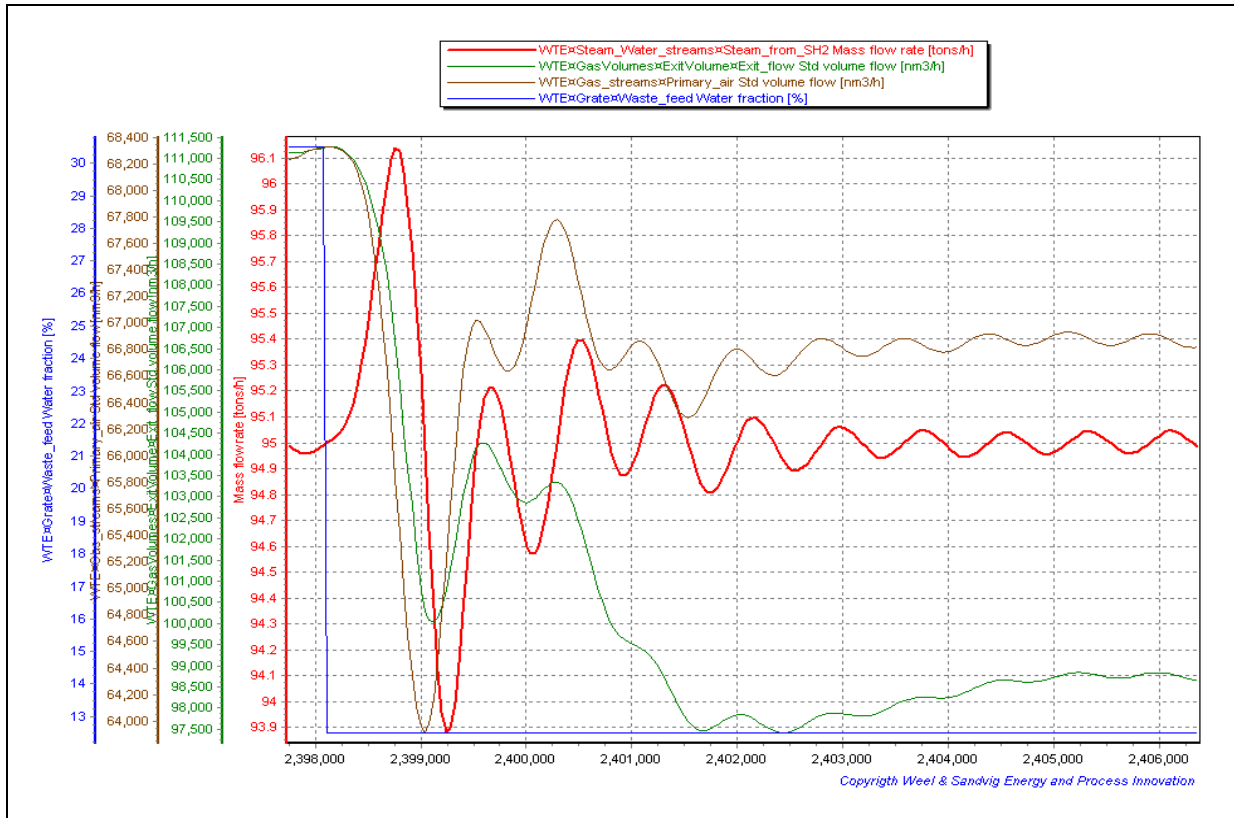


Figure 32. Step response changing the composition of waste from 30.5 % water and 12.5 % ash to 12,5 % water and 30.5 % ash.

3.2 Changing the set point of steam flow

Press the button **Energy controller** and double click the area where the set point for steam flow is specified and displayed (see Figure 33).

Now type the new value in the input window, just popped up, and press the OK button.

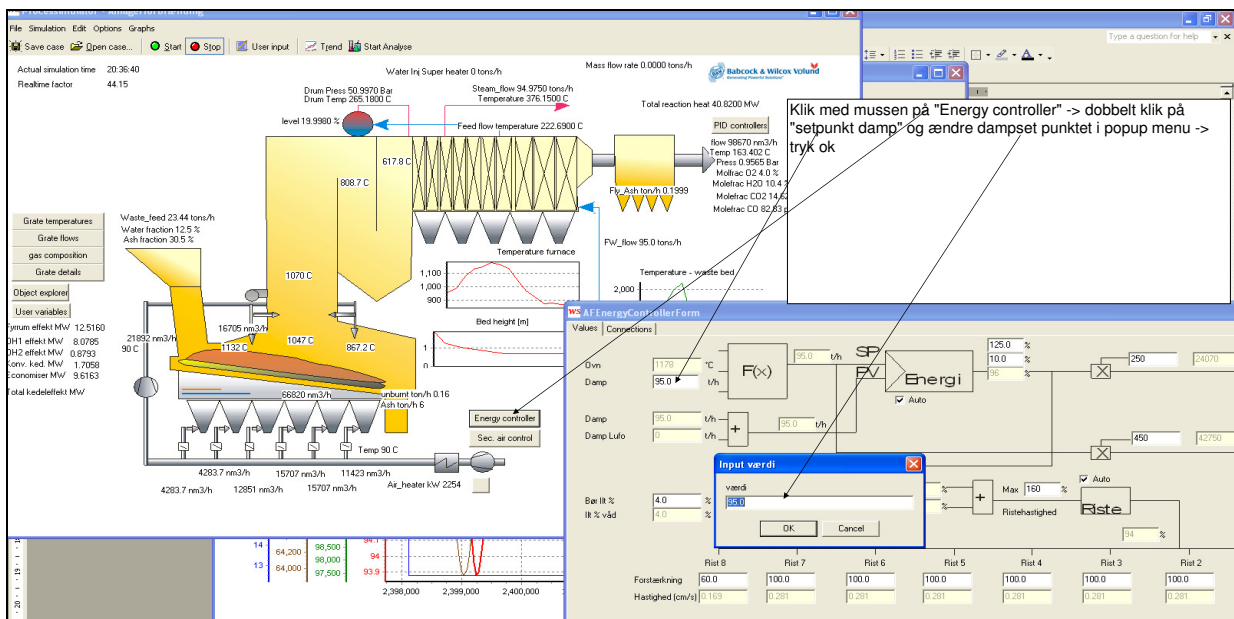


Figure 33. How to change the set point of steam flow.

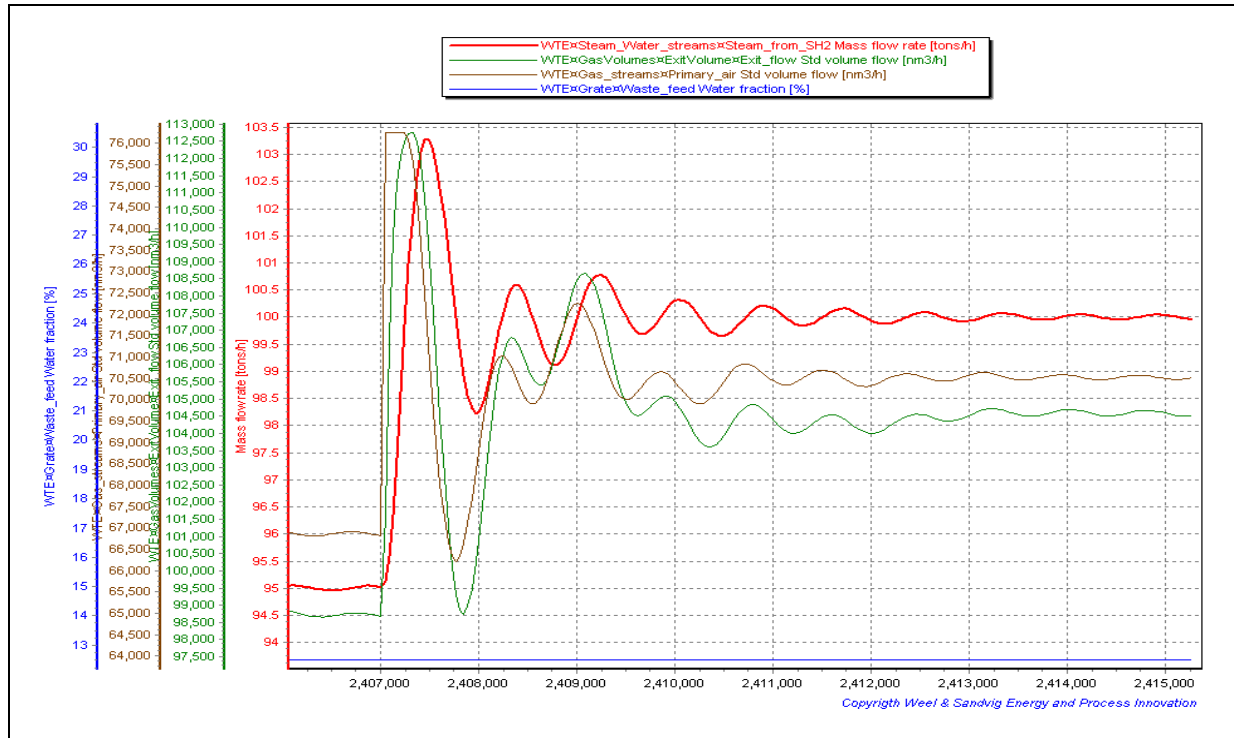


Figure 34. Step response by changing the set point of steam flow from 95 ton/h to 100 ton/h.

In Figure 35 and Figure 36 another situation of suddenly changing the set point of steam pressure is depicted.

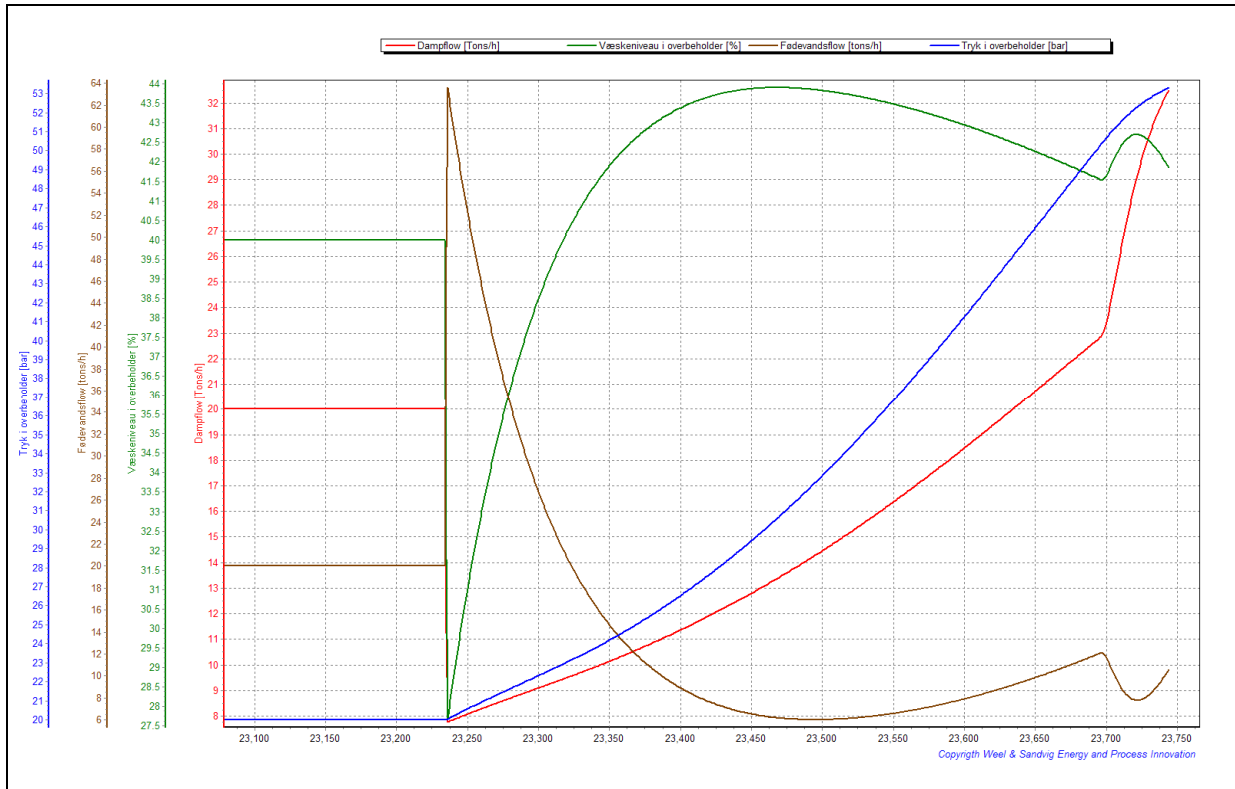


Figure 35. Step response by suddenly change of the set point of steam pressure from 20 bar to 55 bar (closing of steam valve) at low load.

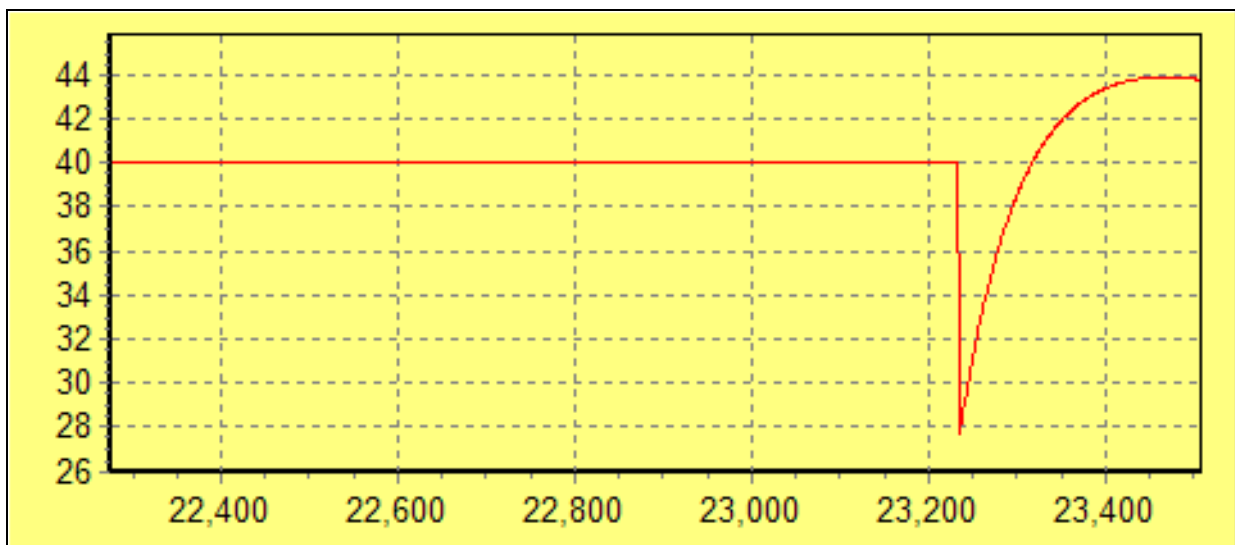


Figure 36. The level in the steam drum falls within 5 seconds from 40% to 28% by a suddenly change of the set point of steam pressure from 20 to 55 bar (at low load), see also Figure 35.

3.3 Changing the flow of primary air

The flow of primary air can be changed by pressing the button **Energy controller** and double click the input cell for primary air multiplication factor (see Figure 37).

In the pop-up input window type the new value and press the **Ok** button.

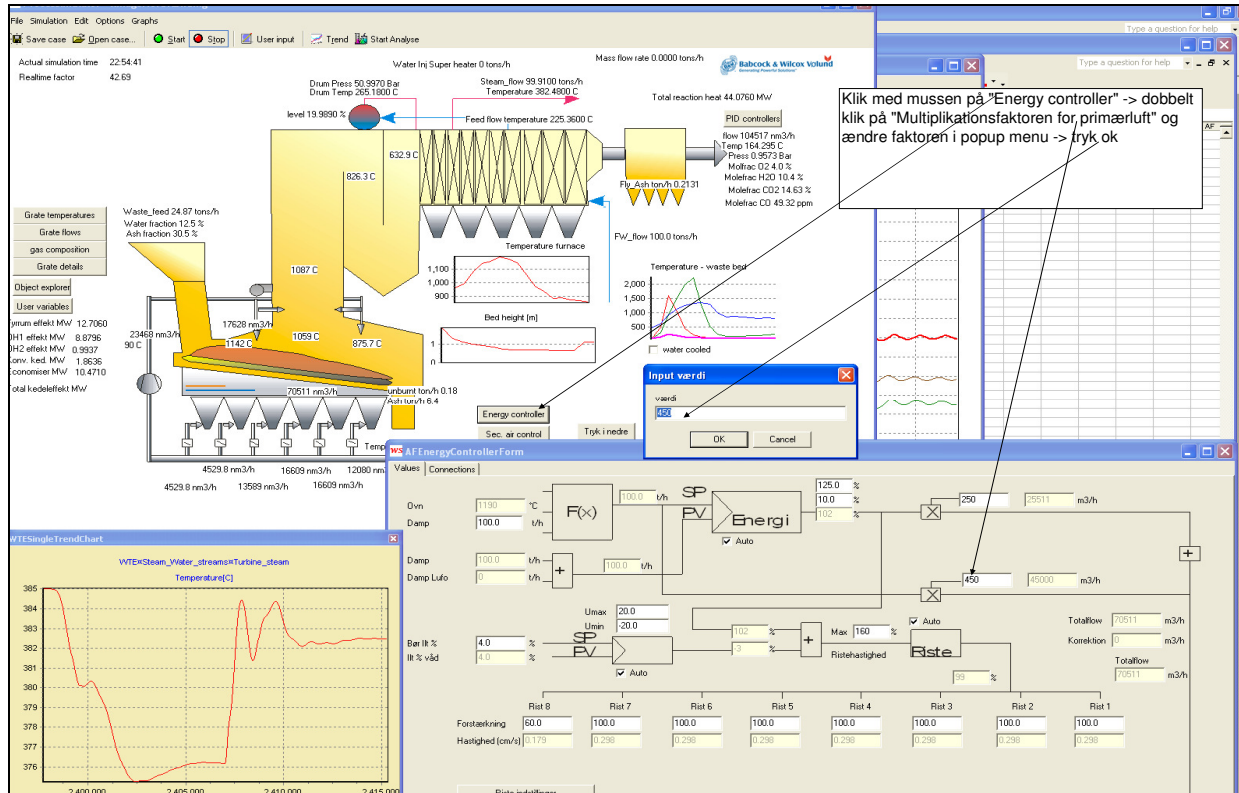


Figure37. Changing the multiplication factor for primary air flow.

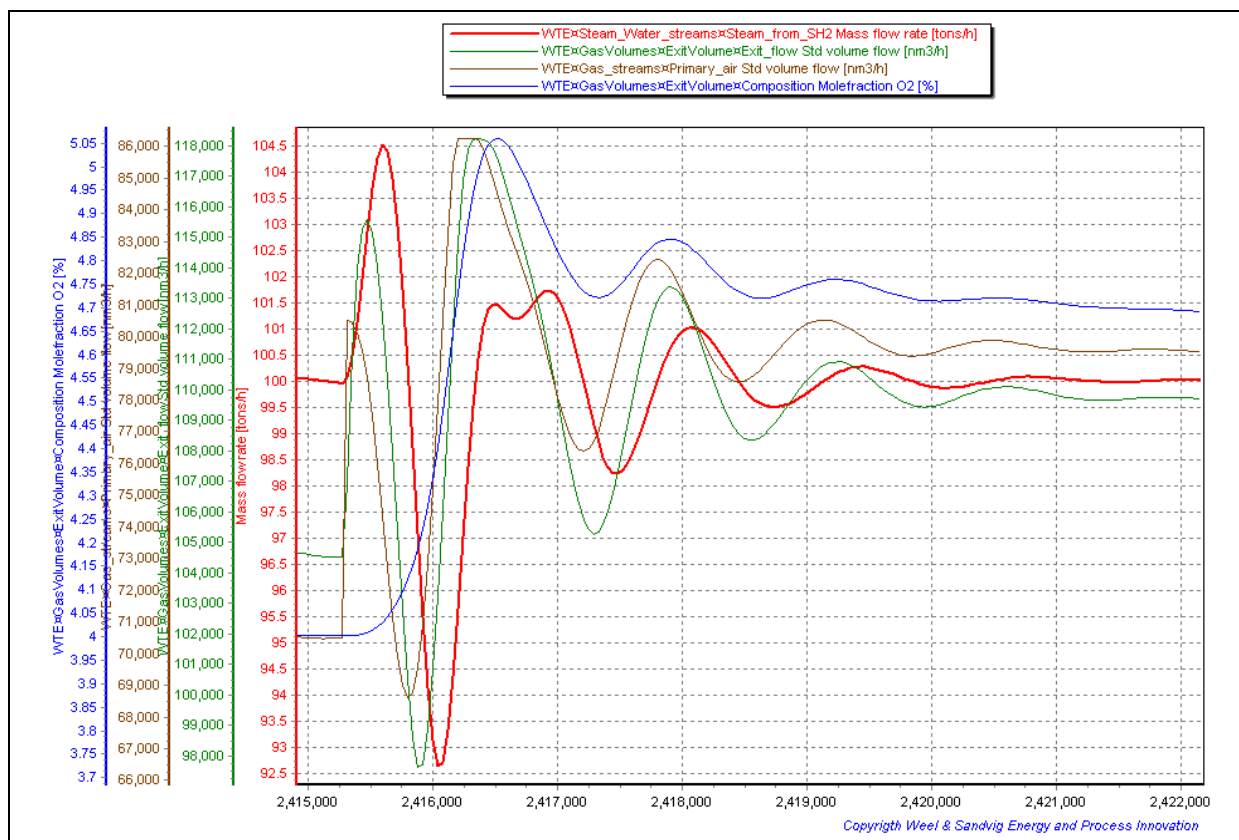


Figure 38. Step response from an abrupt change of primary air flow factor.

4 Short description of model formulation

4.1 Waste devolatilisation

The organic part of waste is described with two organic components: Organic waste 1 and Organic waste 2. The Organic components are specified with the part of the waste that is volatile and the composition of the volatiles. The heating value must be specified separately. The devolatilisation is formulated using the Arrhenius expression:

$$k = A \left(\frac{E_a}{T \cdot R} \right)$$

An **Ea** value equal to 80000 corresponds to the devolatilisation process takes place at temperatures between 120°C and 220°C. In Figure 40 (left) the rates of devolatilisation are shown for three types of biomasses (three values of **Ea**) as function of temperature. To the right the devolatilisation process in terms of mass fraction (left axis) and in terms of speed (right axis) are shown as function of temperature.

The screenshot shows a software window titled "OrganicWasteValueEditor" with two panels for "Organic waste 1" and "Organic waste 2". Each panel contains a table of parameters. At the bottom, there are "OK" and "Cancel" buttons.

Organic waste 1			Organic waste 2		
Heat of conversion	kJ/kg	-200	Heat of conversion	kJ/kg	-200
Arrhenius Ea		80000	Arrhenius Ea		125000
Arrhenius A		200000000	Arrhenius A		700000000
LHV	kJ/kg	19500	LHV	kJ/kg	19500
Volatile fraction	%	65	Volatile fraction	%	65
Volatile H2 fraction	%	3.3	Volatile H2 fraction	%	3.3
Volatile CH4 fraction	%	10.1	Volatile CH4 fraction	%	10.1
Volatile CO2 fraction	%	49.4	Volatile CO2 fraction	%	49.4
Volatile CO fraction	%	37.2	Volatile CO fraction	%	37.2
Volatile N2 fraction	%	0	Volatile N2 fraction	%	0
Volatile O2 fraction	%	0	Volatile O2 fraction	%	0

Figure 39. Specifications of the two types of waste: composition, lower heating value and devolatilisation parameters (Arrhenius).

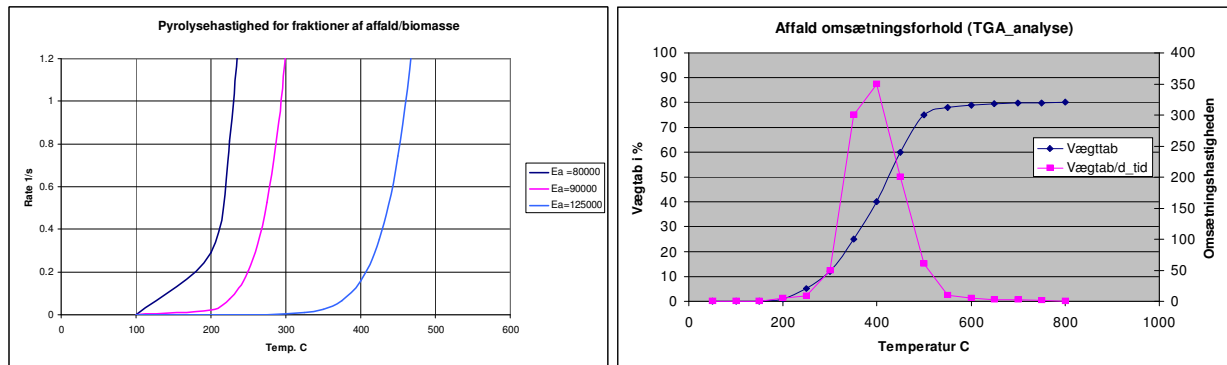


Figure 40. Devolatilisation rate for various biomass / waste fractions.

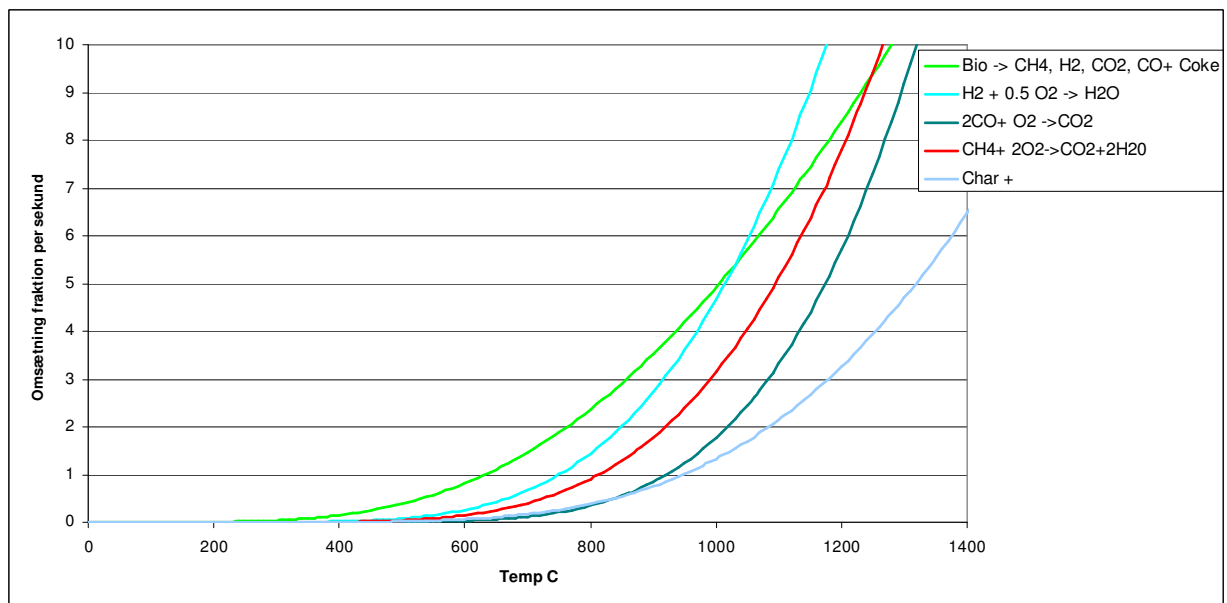


Figure 41. Example of devolatilisation of waste for individual components.

4.2 Mixing on grate

Mixing of waste takes place along the grate and especially from one grate element to the next. The bed of waste on the grate is divided vertically and horizontally into a number of elements called cells. A **Mixing Ratio** defines for each vertical section (on a grate element), how much of the solid phase is mixed before entering the next vertical section (on the next grate section downstream).

If the values for all vertical sections are equal to zero corresponds to a fully stratified bed layer on the grate. A value equal to 1 means that the solids in a vertical section are fully mixed before entering the next section downstream, meaning that all cells here has the same composition of solids. Crossing a high step in the grate the values should normally be between 0.8 and 1.