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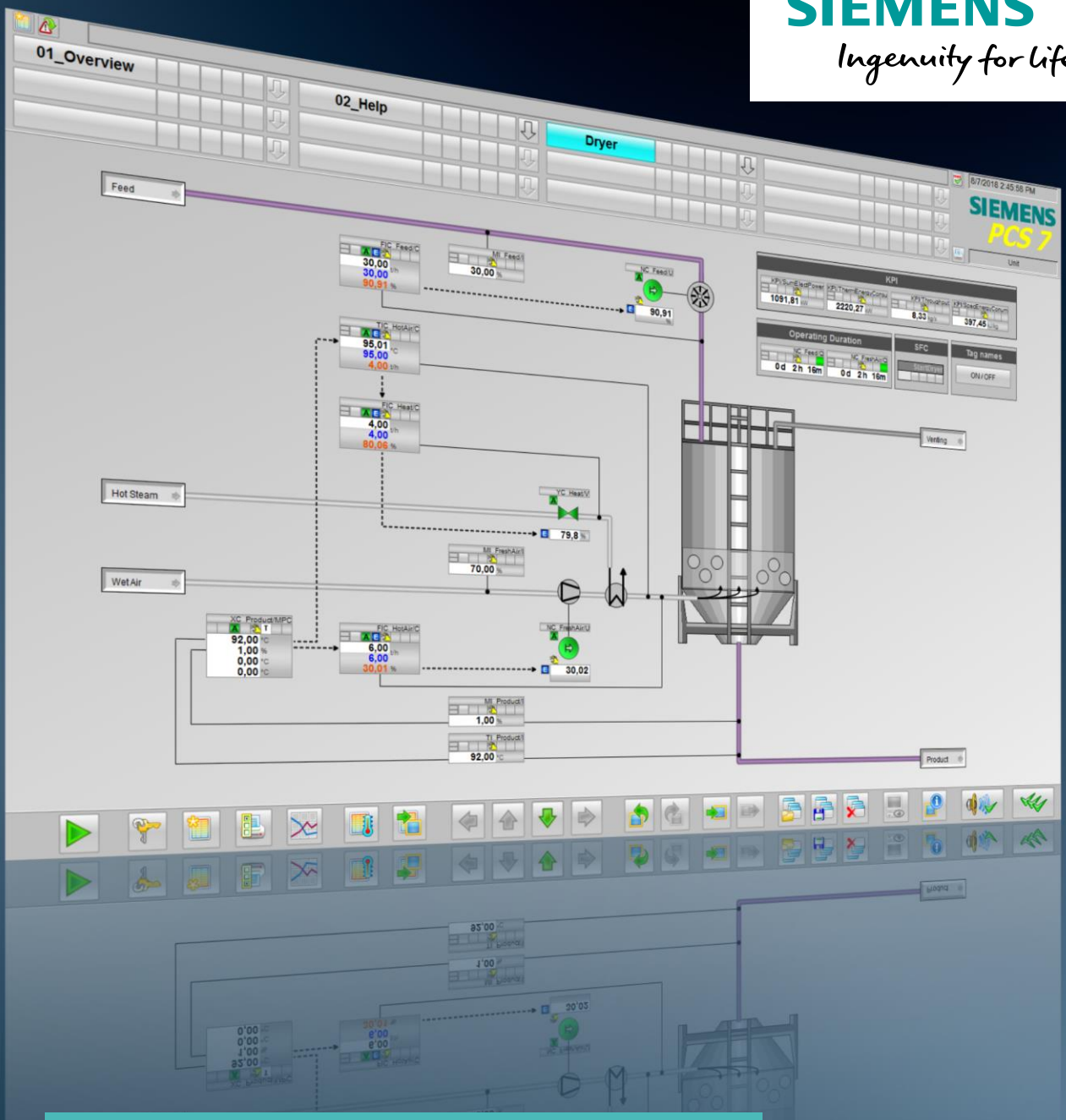

PCS 7 Unit Template "Dryer" using the example of the Chemical Industry

SIMATIC PCS 7

https://support.industry.siemens.com/cs/ww/en/view/74747848

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1 Introduction

1.1 Overview

The standardization of automation engineering for processing plants, such as in the chemical industry, is a major challenge. Different process steps and procedures, different equipment and flexibility in the production make the task even more difficult.

This includes the structuring of the plant according to the physical model of the DIN EN 61512 standard. This specifies the lower four levels, i.e. plant, unit, technical facility and control module. A plant always consists of units. The units can, in turn, comprise technical facilities which can be automated by equipment modules.

Over-drying wastes energy and reduces the weight of the product, which can possibly negatively affect the sales revenue (based on weight). Insufficient drying, on the other hand, can cause difficulties in downstream process stages (e.g. decay, mold, lumps, etc.). Therefore, precise controlling of the particle moisture content has great economic significance.

The unit template "Dryer" provides a template that comprises all typical components, their open- and closed-loop control, the necessary logic and interlocking as well as the visualization. It is modularly structured and based on standardized equipment modules and Control Module Types.

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Advantages

Its utilization offers the following advantages:

- A reduction of the knowledge necessary to develop applications
- A decrease in the configuration effort
- More flexible setup and adaptation due to equipment modules
- Standardized structures

Delimitation

This automation solution is designed for fluidized bed dryers (convection dryers) in continuous operation, but can also be used for spray dryers.

The following special cases are not covered by the "Dryer" unit template:

- Contact dryers, where the moist material is dried through direct contact with heating surfaces
- Dry air dryers, which use dry air for the for the drying process (dew point is less than -30°C)

The technical aspects of the process within the dryer are not realistically simulated. After the simulation has been extended, the unit template could also be used within the framework of an operator training system.

Required experience

Fundamental knowledge of the following specialist fields is a prerequisite:

- Configuration with SIMATIC PCS 7 and APL
- Knowledge of control technology
- Basic knowledge of process technology
- An understanding of the concept of the equipment modules

1.2 Mode of operation

This application example presents a fluidized bed dryer, with which the energy consumption can be optimized by using an MPC (Model Predictive Control) controller. Drying operations require a high amount of energy, which is why optimum and economical drying (as dry as necessary) is the objective.

The "Dryer" unit template contains pre-made, standardized and ready-interconnected equipment modules and Control Module Types. Using this sample solution as a basis, numerous instances with different parameter assignments can be generated and widely integrated in adapted form in automation solutions. The PCS 7 project is configured to be hardware-independent and can be flexibly incorporated in existing projects.

The "Dryer" unit template has been implemented as a PCS 7 multiproject as follows:

- One project for the automation system (AS) and one project for the operator station (OS) are respectively contained in the component view.
- A hierarchy folder has been set up in the technical hierarchy for each equipment module of the dryer.

In the AS project, all open- and closed-loop control functions are implemented in the form of CFC (Continuous Function Chart) plans. Furthermore, the AS project also contains a hierarchy folder with simulation plans that simulate a procedure, e.g. the filling level change, within an equipment module.

All equipment modules are available in the project's master data library as Control Module Types and contain function blocks of the PCS 7 Advanced Process Library (APL).

The OS project comprises the visualization of the dryer with all equipment modules and shows:

- A schematic structure of a dryer
- The relevant parameters (KPI: Key Performance Indicators)
- Control of a continuous production process

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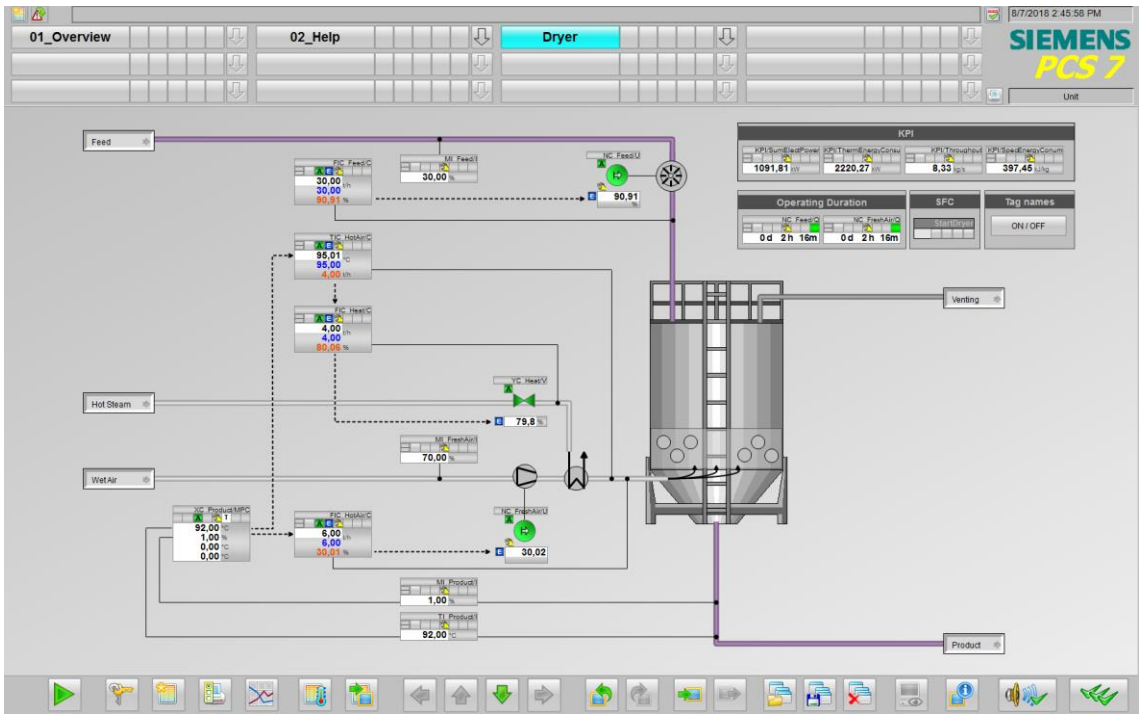
Process picture

The process picture of a dryer consists of the following parts:

- A schematic representation of the subsystem, with input (arranged on the left) and output (arranged on the right) materials
- Graphic modules for controlling the individual components (units)
- SFC for the start and production operation
- Overview of the relevant parameters (Key Performance Indicators) and operating hours display



In the process picture, the operator is provided with an overview of the subsystem and can carry out the necessary operator intervention.

Project-specific settings

Technical data for the working point of the dryer are pre-defined in the lower-level settings. In addition, the rated output of drives and technical specifications of maximum values are pre-selected. These settings affect both the simulation as well as the KPI calculations.

Control concept

An MPC multi-value controller is used for the overriding quality controlling of the dryer (residual moisture of the dried material). It intervenes in the process as a cascade master controller by means of the setpoint value specifications for the temperature and volume of the hot air. In addition, the controller applies the following disturbance variables for a model-based feedforward control.

- Amount of moisture of the moist material (feed)
- Amount of moisture of the fresh air

Not all of these disturbance variables are measurable on every real system. It is recommended to use every disturbance variable that is measurable and has a significant influence on the control variable as the disturbance compensation.

For the subordinate controllers, the PID controller "PIDConL" of the APL is employed for the flow rate of the moist material, the heating steam and the hot air.

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1.3 Components used

This application example has been created with the following hardware and software components:

Component	Note
SIMATIC PCS 7 ES/OS IPC547G W7	For the PCS 7 V9.0 SP1 example project
SIMATIC PCS 7 V9.0 SP1	Part of SIMATIC PCS°7 ES/OS IPC547G W7
S7-PLCSIM	Not part of SIMATIC PCS 7 V9.0 SP1; appropriate licenses are required.
Advanced Process Library V9.0 SP1	Part of SIMATIC PCS°7 V9.0 SP1

NOTE In case of different hardware, please take heed of the minimum requirements for installing the software components. The minimum requirements can be found in the Readme of the PCS 7 under follow link: https://support.industry.siemens.com/cs/ww/en/view/109750097.

This application example consists of the following components:

Component	Note
74747848_Dryer_PROJ_PCS7V90SP1.zip	PCS 7 V9.0 SP1 example project
74747848_Dryer_DOC_PCS7V90SP1_en.pdf	This document

Note The example project for PCS 7 V9.0 SP1 is available for download in the Extranet area of the entry: https://support.industry.siemens.com/cs/ww/en/view/74747848.

This Extranet area is only visible if you have a Managed System Services contract. You can obtain detailed information at: https://support.industry.siemens.com/cs/ww/en/sc/4361.

You can find an overview of all technical information and solutions, available to you exclusively in the Extranet, at the following topics page: https://support.industry.siemens.com/cs/ww/en/view/109755371.

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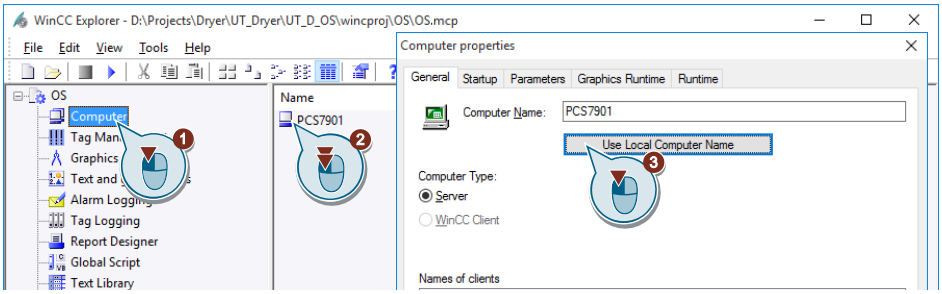
2 Preparation and commissioning

2.1 Preparation

The following instructions describe how to commission the Unit Template by simulating the controller with the "S7 PLCSIM" program. If there is a real controller, you must configure existing hardware components in the HW Config.

1. Copy the file "74747848_Dryer_PROJ_PCS7V90SP1.zip" into any folder on the configuration PC and then open the SIMATIC Manager.
2. Click on "File > Retrieve" in the menu bar and select the file "74747848_Dryer_PROJ_PCS7V90SP1.zip". Then confirm by clicking on "Open".
3. Select the folder in which the project is to be saved and confirm by clicking on "OK".
   The project is retrieved.
4. Confirm the "Retrieve" dialog by clicking on "OK" and then click on "Yes" in the dialog to open the project.
5. Right-click on "UT_Dryer_OS > OS01 > WinCC Appl. > OS" and then click on the menu command "Open object".
6. Confirm the "Configured server not available" dialog with "OK".
7. In WinCC Explorer, open the properties of your computer and, in the opened Properties dialog, click on the "Use Local Computer Name" button.



8. Confirm the "Change computer name" message with "OK".
9. In the WinCC Explorer, click on "File > Exit" and in the subsequent dialog select "Terminate WinCC Explorer and close project".
   Then confirm with "OK".
10. Reopen the WinCC Explorer as described in step 5.
11. Open by double-clicking on "Variables library".
12. In the "WinCC Configuration Studio", open "Variables library > SIMATIC S7 Protocol Suite > TCP/IP" and select the menu command "System parameters".
13. In the "Unit" tab, check the "Logical device names" setting. If the "S7 PLCSIM" program is used, the device name "PLCSIM.TCPIP.1" is selected.
    A restart is required after a device name change.

NOTE If the OS cannot establish a connection with the AS (grayed out module icons), select the logical device name "CP_H1_1" and restart the OS runtime.

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2.2 Commissioning

The following instructions show how the Unit Template is initialized. The project contains an SFC chart where all the important settings are configured so that die system reaches the operating point.

To put into service, it is required that SIMATIC Manager is already open and that the Unit Template has been selected in the component view.

Starting the simulation (S7 PLCSIM)

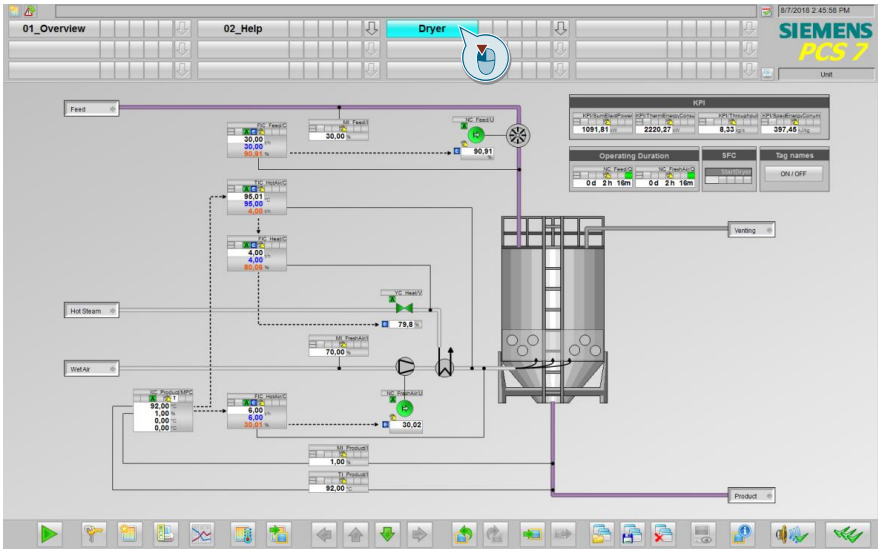
To start the simulation, proceed as follows:

1. Select "Tools > Simulate Modules" from the menu.
   The "S7 PLCSIM" dialog window opens.
2. In the "Open project" dialog, select "Open project from file".
3. Select the file "Dryer.plc" from the path
   <Project path>\UT_Dryer\UT_D_MP\Dryer.plc>.
4. In the menu, change "PLCSIM(MPI)" to "PLCSIM(TCP/IP)".
5. Switch to the component view of the SIMATIC Manager and mark "UT_Dryer_AS > AS01".
6. On the menu bar, click on " PLC > Download" and confirm the "Download" dialog with "Yes".
7. Confirm the "Stop target group" dialog with "OK" and the subsequent "Download" dialog with "Yes".

Activate OS (WinCC runtime)

To activate the OS, proceed according to the following instructions:

1. Right-click on "UT_Dryer_OS > OS01 > WinCC Appl. > OS" and click on the menu command "open object".
2. To activate the OS (WinCC Runtime), select the menu command "File > Activate" in WinCC Explorer.
3. In the "System Login" dialog, enter the user "Unit" as "Login" and "Template" as the password; then confirm with "OK".
4. Select "Dryer" in the icon area



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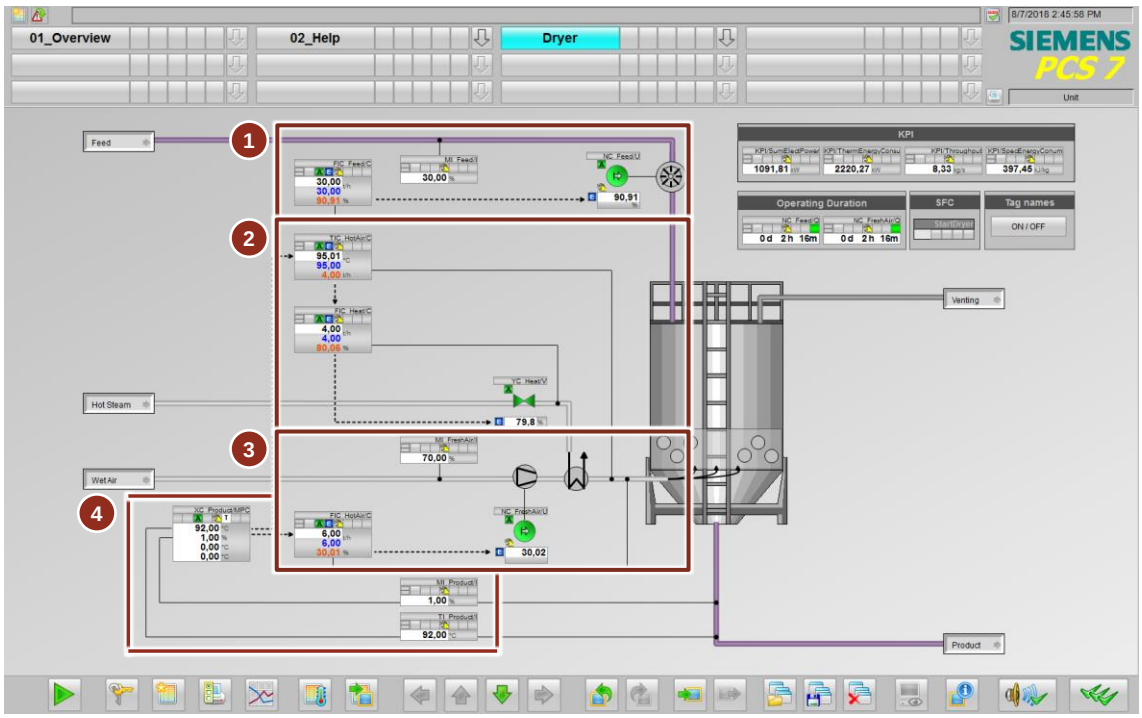
NOTE The dryer is already located in the production process because the AS program execution (PLCSIM) has been started.

2.3 Description of the individual functions



The process picture of the dryer consists of the system sections:

1. "Feed" – moist material input via a rotary feeder, with display of the product moisture content
2. "Heating" – Heating up the fresh air (cascading control of the air temperature by means of the flow rate over the heating element)
3. "Air Supply" – Hot air input (cascading of the air volume flow by means of the fan rotational speed)
4. "Product" – Product output, with measurement and controlling of the residual moisture of the dried material and the exhaust air/product temperature

1. Feed

The input of the moist material is handled by a rotary feeder, which is used for mass flow control (mass flow depends on the rotational speed of the drive). The product moisture content is recorded at a separate measurement point and displayed.

2. Heating

The fresh air is heated up in a heat exchanger by controlling the valve of the heating medium. The hot air temperature is achieved by cascading control loops. The master controller (setpoint from the MPC) records the hot air temperature and assigns a setpoint value for the heating steam mass flow to the slave controller for activation the controlled variable of the heating medium valve.

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3. Air Supply

The fan draws in fresh air, fresh air is heated up in a heat exchanger and feeded into the dryer. The flow rate controller receives its setpoint value from the primary multi-value controller and regulates the volume of compressed fresh air by means of the fan rotational speed.

4. Product

In the product extraction the temperature and the residual moisture of the dried material are recorded. The measurement is carried out by means of suitable measuring transmitters. The recorded values are the control variables (CV1 and CV2) for the multi-value controller.

Parameters (KPI: Key Performance Indicators)

The key performance indicators are measured or calculated:

- Flow rate
- Specific energy consumption, based on the product mass
- Product quality, derived from the mean control deviation of the product moisture content

The following energy-related KPIs are interesting for the dryer, but have not been completely implemented in the sample solution because in an actual application the power consumption of the pumps would be read from the frequency converters.

- Current total energy consumption = thermal energy consumption + power consumption of reagent rotary feeder + power consumption of fan
- Specific energy consumption = energy consumption / flow rate

NOTE The PCS 7 project can be extended with your own KPIs, such as the dwell time.

Operating hours counter

The process picture contains the following operation hour counters:

- Rotary feeder motor
- Fan motor

Additional monitoring functions

The dryer can be supplemented with additional application-specific monitoring functions, if the necessary information can be derived, measured or estimated:

- Monitoring of the clumps in the intake
- Cleaning required in the dryer itself

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2.4 Operation of the application

2.4.1 Overview

Some of the dryer's components can be operated and monitored by means of the process picture. Furthermore, the process-specific key performance indicators can be changed in the subordinate image hierarchy. Based on them, the optimization of the multi-value controller and the KPI calculations can be performed.

The following scenarios relate to handling of the "Dryer" Unit template.

- Economic working point optimization
- Error compensation in case of changes to the moisture content of the reagent
- Treatment of the process simulation and setting options

2.4.2 Scenario A - working point optimization

Description

In this scenario, the working point optimization is performed based on the quality parameters, i.e. the economically optimum working point is automatically sought within the stated specifications for product quality. With the fluidized bed dryer, the economic yield of the facility operation per unit of time [€/h] is defined as a quality criterion. Here, the costs for raw materials and energy, as well as the revenues for the product, are taken into account. Both the thermal energy consumption (heating steam for heating the input air) and the power consumption for the hot-air blower and rotary feeder contribute to the energy costs.

In every situation, the optimization of the steady state working point integrated in the MPC automatically finds the economically optimum combination of air mass flow rate and air temperature for accomplishing the drying task.

This includes defining the minimum and maximum quality values for the product before beginning. In this example they are for the product temperature and product moisture content, whereby the product moisture content allows a narrower tolerance range for the optimization. Increasing the moisture content makes the product heavier, which also increases the weight-based product yield.

In the following scenario, the limits for the product moisture content are extended to ± 0.2 % of the setpoint value and the temperature is extended by ±1 degrees by the setpoint value. Thus, exact adherence to the setpoint value is no longer required, rather adherence to the limit values.

Procedure

1. In the OS, switch to the process picture of the dryer and wait until the working points of 1% product moisture content and 92 °C product temperature have been attained.

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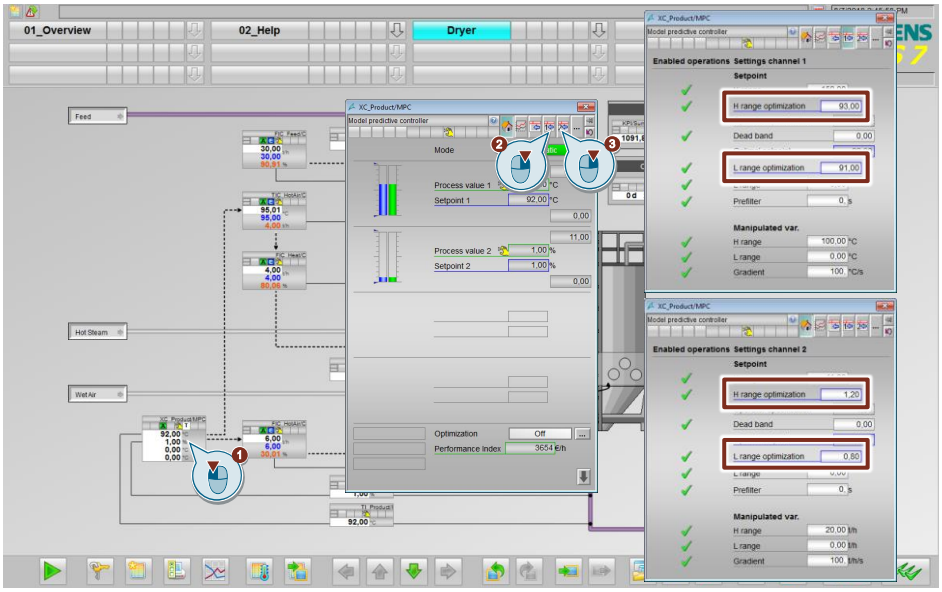
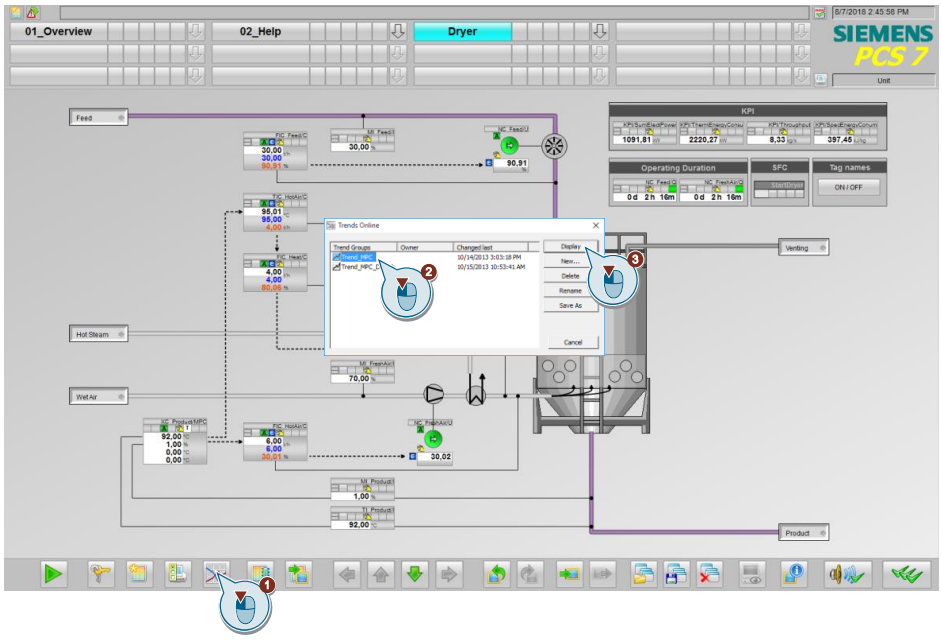
2. Click on the module symbol of the "XC_Product" multi-value controller and verify the limit value settings for the optimization of both control variables.



3. Switch to the start view of the module symbol and take note of the "Performance index" prior to optimization. In this example the index is "3654 €/h".

4. To monitor the MPC control, open the "Trend_MPC" trend display by means of the "Call up / consolidate curve groups" button.



NOTE The trend display can be extended by further values, e.g. slave controller process values, for example.

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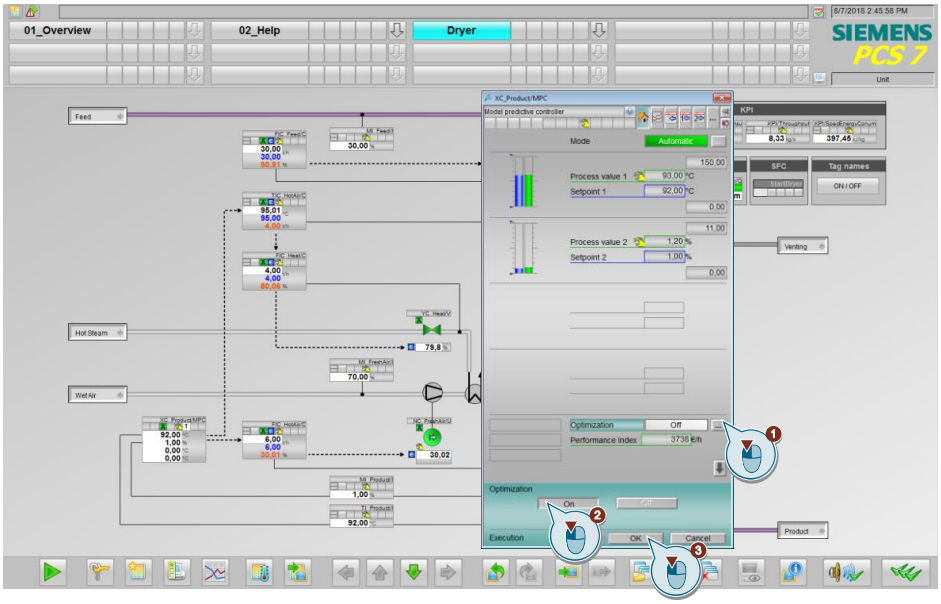
5. To optimize, press the "Optimization" button and monitor the changes to the trend indicator and on the performance index.



NOTE In the "QI_1" and "QI_2" monitoring modules of the multi-value controller measurement point there are limit values defined for the control deviations in the working point in order to enable monitoring of consistent quality. As a result of the abrupt change in the setpoint value for the product temperature of 1°C, a too substantial control deviation occurs, which generates a message reporting an excessive temperature.

6. Acknowledge the message and wait approx. 4 minutes until the working point optimization has almost been completed.
7. Stop the trend tracking in order to carry out an evaluation of the recorded data.

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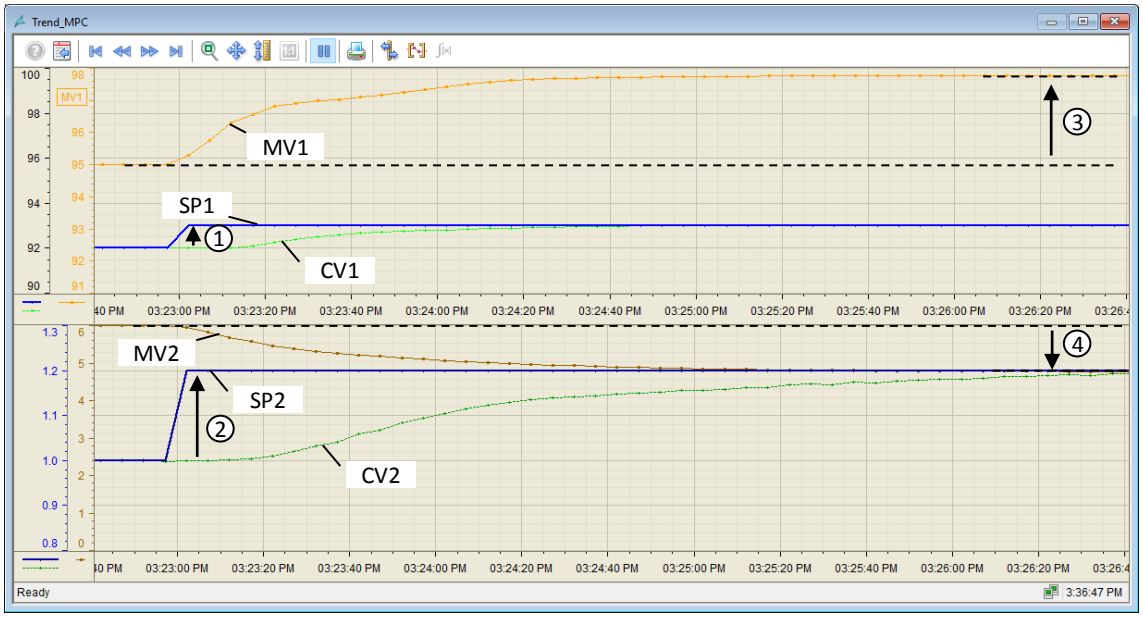
Evaluation



After the optimization has been switched on, the MPC adopts the upper optimization limits as new setpoint values SP1 (1) and SP2 (2). A lower quality level (SP2) of 1.2% (previously 1.0%) is set for the product moisture content (CV2). For the product temperature, a higher output temperature (SP1) of 93°C (previously 92°C) is set.

Due to the higher moisture content, the amount of energy required for drying is reduced and the weight-based product yield is maximized. Economically optimized drying is practiced by increasing the product temperature to the upper limit. Under certain circumstances, the required drying effect can be more cheaply attained with a maximum hot air temperature (3) and lower air mass flow rate than with a lower temperature and accordingly higher air mass flow rate. The heating steam for heating the air is relatively inexpensive energy source, whereas electric power for driving the blower entails higher costs.

NOTE

1. To maintain the quality of the starting product, the setting must be made for the maximum hot air temperature effective for the moist material. This is defined in the setpoint value limits for the slave controller measurement point "TIC_HotAir" and automatically maintained as setpoint value limits in the MPC measurement point.

2. If disturbance variables continually occur during the course of the process, then you can set the multi-value controllers to account for these. To do this, again record all relevant CVs, SPs and DVs with the trend indicator and carry out an MPC configuration using these exported values while modeling the influence of the disturbance variables on the controlled variables.

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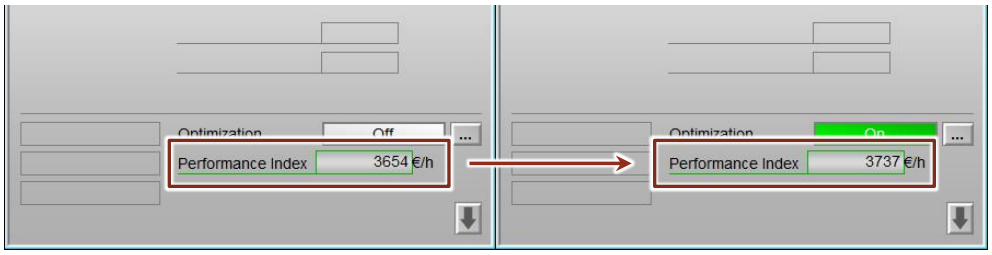


Thanks to the working point optimization, the performance index climbs from €3654/h to €3737/h, this corresponds to an increase of 2.3%. The calculated values depend heavily on the presets (prices, energy values, product yield) and can vary from those of real facilities.

2.4.3 Scenario B - error compensation

Description

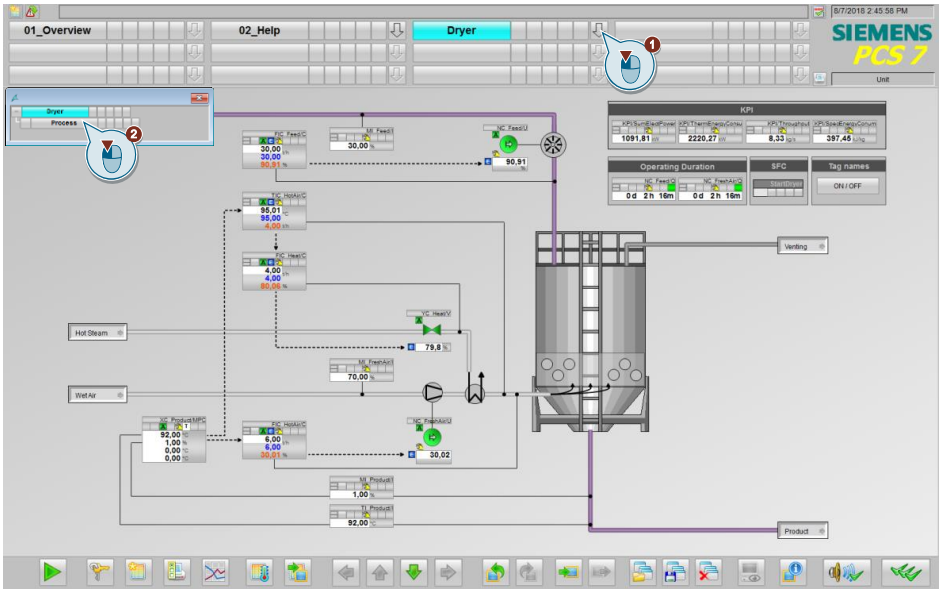
In this scenario, the controller reacts to the changing quality of the input moist material.

It is assumed that the raw material is generated in a batch process and that every batch has somewhat different water content. Thus, at the beginning of each new batch a slight jump in the reagent moisture content can be observed. With regard to the curve representation, the reagent moisture content changes more frequently than in reality, namely abruptly by 1% every 90 s.

The effect on the control variables is monitored in the trend indicator.

Procedure

1. In the OS, switch to the subordinate process picture "Process" of the dryer.



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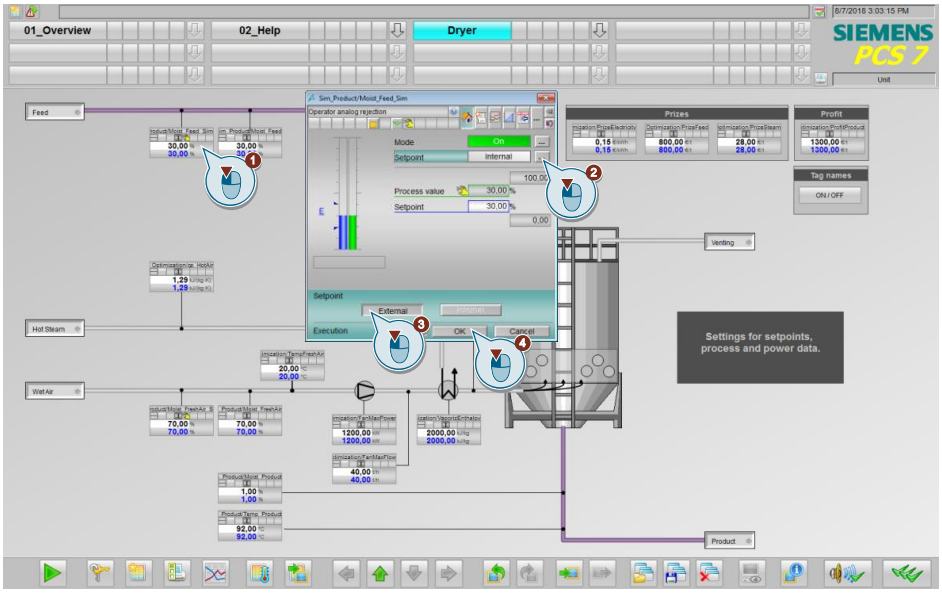
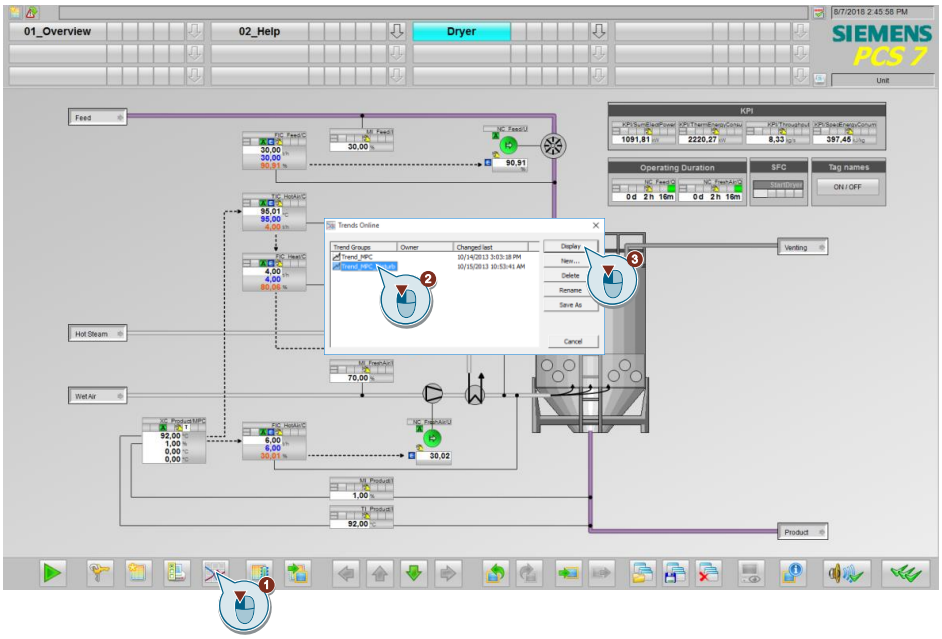
2. Click on the module symbol "Moist_Feed_Sim" and change the setpoint value specification to external setpoint value; adopt the change by pressing the "OK" button.



NOTE A square-wave signal is interconnected at the input point for the external setpoint value.

3. To monitor the MPC control, open the "Trend_MPC_Disturb" trend display by means of the "Call up / consolidate curve groups" button.



NOTE In addition to the MPC target, actual and setpoint values, the trend display also shows the disturbance variables. The trend display can be extended with your own values.

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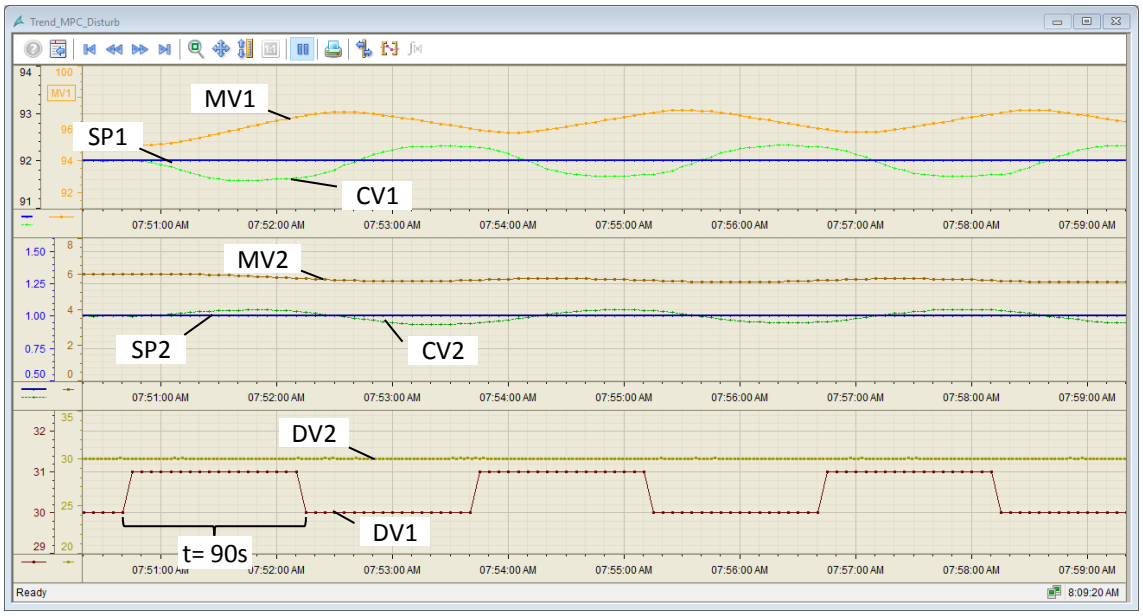
4. Stop the trend tracking after approx. 4 minutes in order to carry out an evaluation of the recorded data.

Evaluation



After the moisture content changes take effect, the moisture content of the moist material (DV1) changes abruptly by 1% every 90 s. This disturbance is detected by the MPC; it tries to keep both process values (CV1 and CV2) as constant as possible by changing the hot air temperature (MV1) and the air mass flow rate (MV2). Due to the varyingly stringent adherence to the control variables during the MPC configuration, the corrective actions are carried out with varying severity. MV1 is more strongly adjusted than MV2. The fluctuations of the product temperature are ± 0.5°C and the fluctuations of the product moisture content ± 0.18%.

NOTE The MPC configured in the example project was set without any model-based compensation for disturbance variables. For better adherence results, again record all relevant CVs, SPs and DVs with the trend indicator and carry out an MPC configuration using these exported values while modeling the influence of the disturbance variables on the controlled variables.

NOTE In the application description "Fluidized bed dryer template for a predictive controller with working point optimization" under https://support.industry.siemens.com/cs/ww/en/view/61926069 you will find details on the MPC template with disturbance compensation. A benchmarking simulation shows the advantages of a multivariable control system via MPC versus a conventional, distributed PID control, and the significance of a dynamic disturbance compensation for the material quality. With a higher material quality the process can be operated closer to the critical constraints, thus substantially sinking energy consumption.

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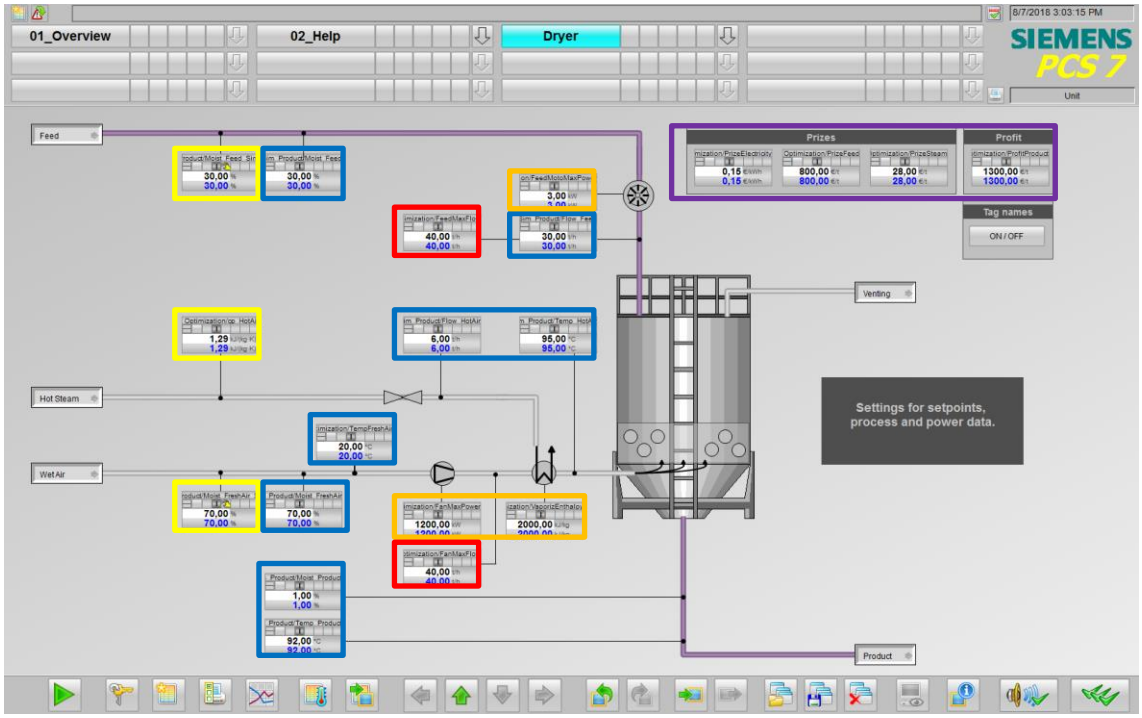
2.4.4 Scenario C – parameterization of the process simulation

Description

In this scenario the elements of the OS picture "Process" and setting options are explained. The various types of parameters are marked in different colors.



Key

- Blue: steady state working point for the process model. You can adapt these numerical values to your real process without the dynamic behavior of the simulation being changed.
- Yellow: the outer boundary conditions for the process (e.g. raw material, ambient air). If you change one of these values during ongoing operations, you will simulate a process disturbance to test the controller.
- Red: maximum flow rate. These process model parameters can be adapted to the technical data of a real plant.
- Brown: rated output of motor, blower and heat exchanger.
- Green: thermodynamic process values (specific evaporation enthalpy).
- Purple: prices (costs, revenues) for economic calculations.

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3 Integrating the unit template in the user project

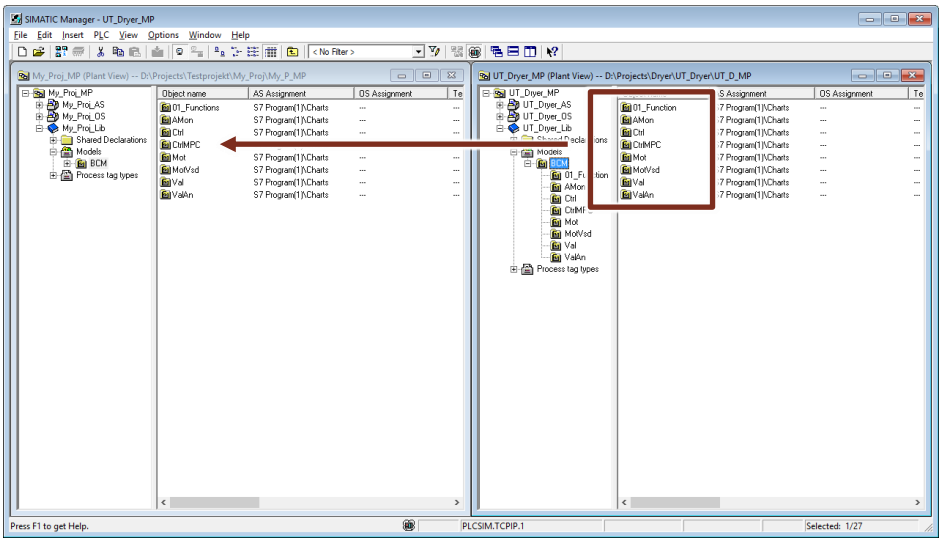
3.1 Preparation

1. Copy the file "74747848_Dryer_PROJ_PCS7V90SP1.zip" to the configuration PC and then open the SIMATIC Manager.
2. Click on "File > Retrieve" in the menu bar and select the file "74747848_Dryer_PROJ_PCS7V90SP1.zip". Then confirm by clicking on "Open".
3. Select the folder in which the project will be saved and confirm with the "OK" button.
   The project will be extracted.
4. In the "Retrieve" dialog, click on the "OK" button and then click on "Yes" in the dialog to open the project.
5. Switch to the "Plant view".
6. At the same time, open the project in which the fermenter is to be integrated.

3.2 Copying templates

Note If you have already worked with CMTs in your existing project, then check that they are identical before skipping to the following steps, since this can lead to errors in your existing project or in the unit template you want to integrate.

1. Switch to the plant view.
2. Copy the "BCM" folder containing the CMTs from the master data library into the target project.



3. Copy the Enumerations from the master data library into the target project.

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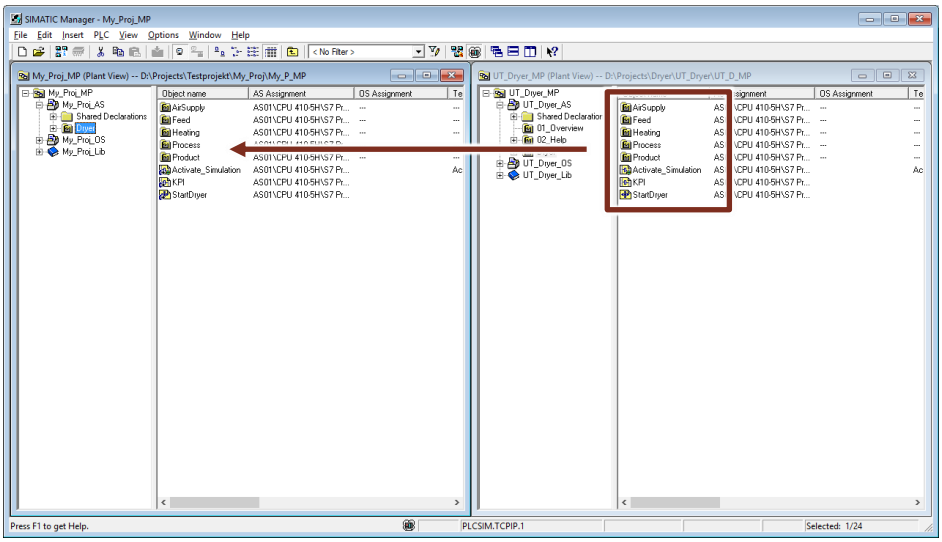
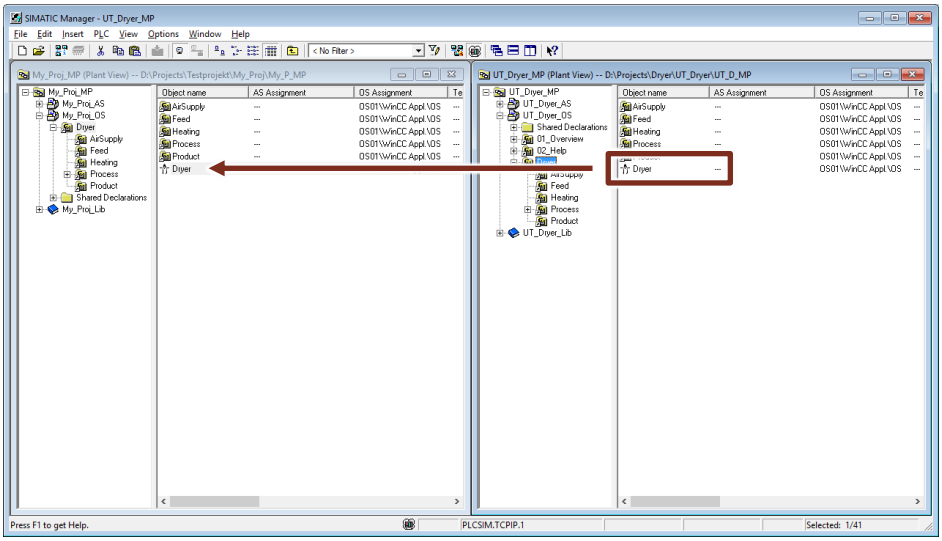
3.3 Copying units

1. Copy the hierarchy folder "Dryer" from the AS project of the Unit Template to the plant view of the target project.



Note The hierarchy folders of the units "01_Overview" and "02_Help" are not necessary for operation.

2. Copy the process screens "Dryer" and "ProcData" from the OS project of the unit template to the plant view of the target project as well. If you wish, you can also copy the pictures "Help" and "Overview".



Note When copying the process screens, make sure that you copy the pictures to the hierarchy level of the target project, which is configured as an OS area.

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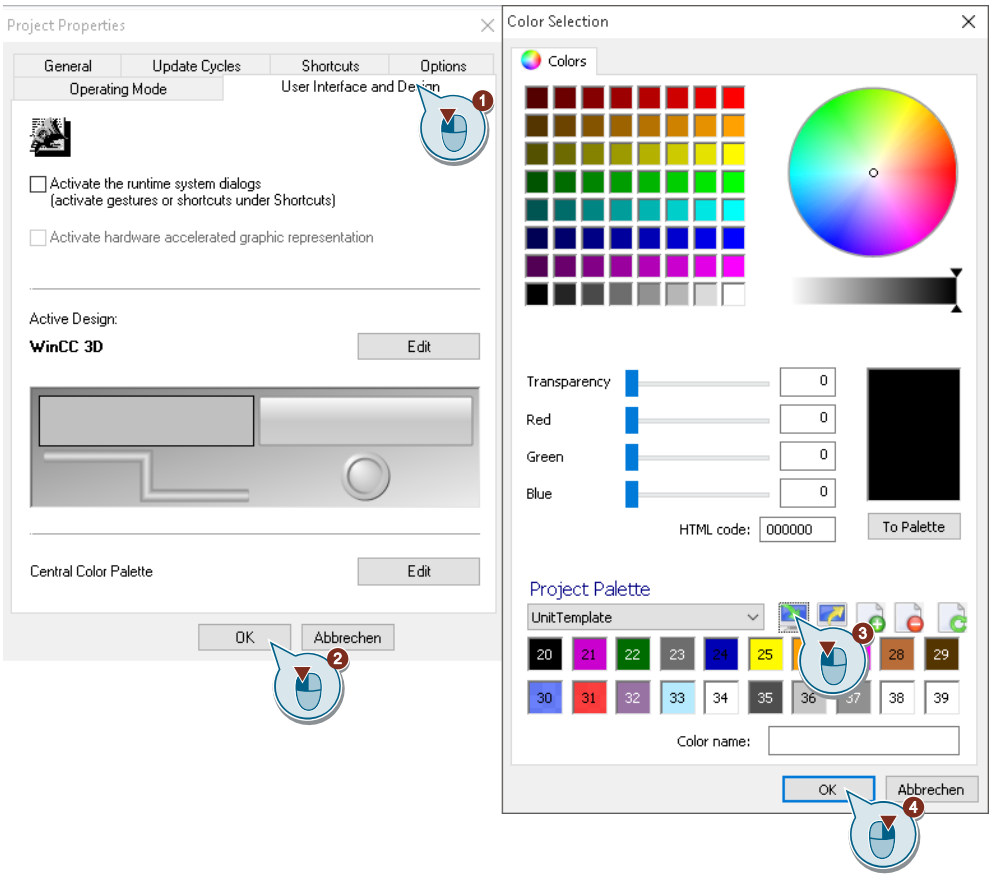
3.4 Adapting the OS project

In order to facilitate the changing of colors in the process screen from a central point, a central color palette was created in the OS project of the Unit Template. To display these colors in the process screen of your own project, you must import the relevant color palette.

1. Select the "OS" in WinCC Explorer and choose "Object properties..." in the shortcut menu.
2. Choose the "User Interface and Design" tab and click the "Edit" button.
3. Import the palette into your own project by means of the "Overwrite" option. The color palette is located in the project folder of the unit template at the path: "<Project path>\UT_Dryer\UT_D_OS\wincproj\OS\GraCS\UnitTemplate.xml>". All existing colors will be replaced.



Note

Please note that all colors are always used when exporting/importing color palettes. It is not possible to export partial color tables.

If you have created your own color tables in your project, you can also export them and use an editor to merge the tables in the XML file. Otherwise you can create a new color table in your project and configure the colors individually. Make sure, too, that the color index does not change, otherwise you will have to adjust the color settings of the objects in the process screen. Of course it is up to you to change the colors according to your requirements.

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4 Engineering

4.1 Equipment modules and measurement points

The "Dryer" unit template consists of pre-made equipment modules and additional CFC charts, e.g. for process simulation. In a PCS 7 project, all control modules – such as of the equipment modules – are based on control modules types from the master data library.

The application example contains the following elements:

- Moist material feed (Feed): Controlling of the moist material feed
- Hot air temperature (Heating): Controlling of the hot air temperature
- Hot air volume (Air Supply): Controlling of the flow rate of the hot air
- Controlling of the product temperature and moisture content (Product)
- Step sequencer (SFC) for starting up the dryer
- Overarching process simulation (Simulation)
- Process parameters (KPI)

Note All necessary descriptions, configurations and procedures pertaining to the

- design, functionality of equipment modules including parameters
- integration of equipment modules
- controllers and control response

can be found in the application description "Equipment Modules for SIMATIC PCS 7 using the example of the Chemical Industry" and the example projects with the individual equipment modules and CMTs at the following link: https://support.industry.siemens.com/cs/ww/en/view/53843373. You will find the information on the specific equipment modules in the chapter "Equipment Modules" and on the CMTs in the chapter "Control Module".

In the following sections you will find the setup of the specific equipment modules as well as the extension and modifications made vis-à-vis the original equipment modules Control Module Types. In addition, the SFC for starting up the dryer is documented.

Note CMTs are pre-configured for different operating ranges. The use of variants allows the corresponding channel block to be selected or deselected based on measured value transfer. It is also possible to use options to activate additional functions without configuring the instance.

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4.2 Moist material feed

The moist material feedback is controlled by continuous regulation of the rotational speed of the drive (frequency converter). The drive impels a rotary feeder that conveys an rpm-dependent amount of the moist material into the dryer. The controller and drive measurement points are implemented with the Control Module Types from the master data library.

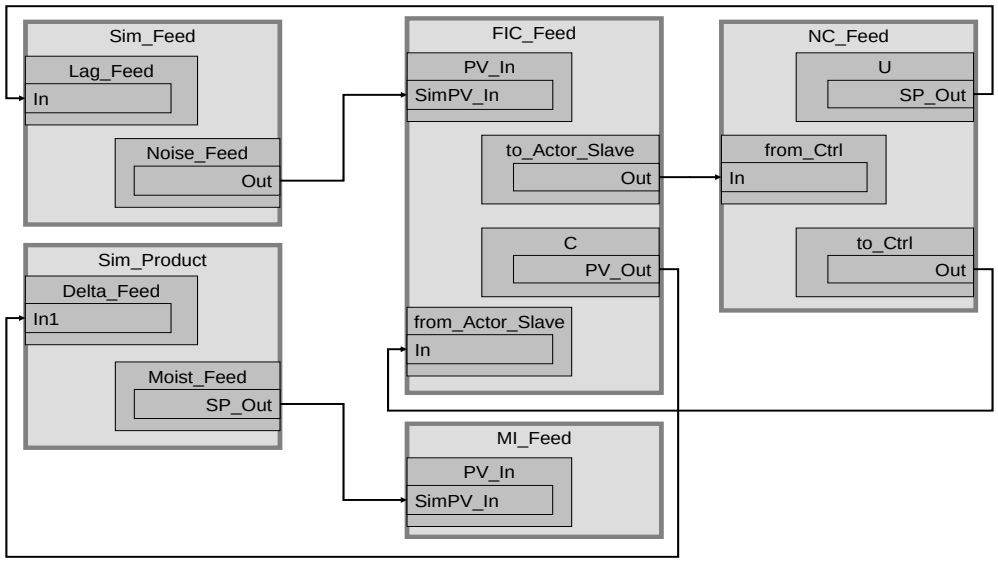
4.2.1 Setup

The rotary feeder is opened and closed by way of the controller measurement point.

The following table provides you with an overview of the elements and Control Module Types used.

CM	CMT	Selected variants	Description
FIC_Feed	"Ctrl"	• PV_In	Controller for the moist material feed amount
NC_Feed	"MotVsd"	• Opt_IF_Ctrl • Q • Rbk • SP_Out	Motor for driving the rotary feeder (moist material feed)
MI_Feed	"AMon"	• PV_In	Measurement point for the moisture content of the input material

In the following figure, the structure with the cross-plan interconnection is depicted in simplified form.



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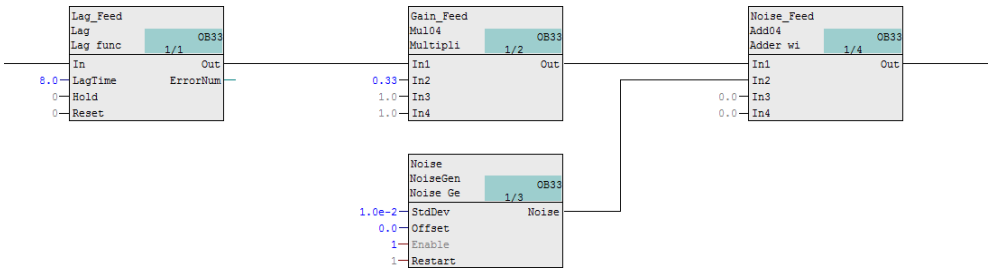
Simulation

In the "Sim_Feed" simulation plan the moist material input through the rotary feeder is simulated.



The Lag_Feed delay (here, 8 seconds) arises due to the inertia of the rotor and the time constant of the flow rate sensor. The Gain_Feed factor (here 0.33) defines how a rotational speed [%], in a steady state, affects the flow rate [t/h]; i.e. in the example, a flow rate of 33 t/h can be reached at maximum rotational speed.

Furthermore, a white noise signal is added to simulate measurement 'noise'.

4.2.2 Parameter assignment

FIC_Feed

The feed input (rotary feeder) of the moist material is recorded and controlled at the "FIC_Feed" measurement point. The setpoint value specification is implemented by the operator or SFC. The "FIC_Feed" measurement point transfers the controller manipulated variable to the "NC_Feed" motor measuring point. The "FIC_Feed" measurement point is an instance from the "Ctrl" Control Module Type.

Module	Connection	Value	Used for
C	Gain	1.18	Controller gain
C	TI	4.446	Controller lag
C	PV_Out		Interconnection for the simulation (Sim_Product\Delta_Feed.In1)
to_Actor_Slave	Out		Interconnection to the motor (NC_Feed\from_Ctrl.In)
from_Actor_Slave	In		Interconnection from the motor (NC_Feed\to_Ctrl.Out)
PV_In	SimOn	1	Activation of the simulation
PV_In	SimPV_In		Interconnection for the simulated process value (Sim_Feed\Noise_Feed.Out)
PV_Scale	HiScale	100.0	Maximum value of the process value
PV_Unit	IN	1328	Unit of the process value (t/h)

NOTE The measurement point can be interconnected as the third actuating variable with the multi-value controller measuring point "XC_Product". In this case, the multi-value controller measurement point must be extended by a third actuating variable corresponding to the "Ctrl_MPC" Control Module Type, and the second disturbance variable "MV3Trk" rewired to "MV4Trk".

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NC_Feed

The motor measurement point "NC_Feed" controls the input feed (conveying of the moist material) of the input material via communications modules, the motor block receives an external setpoint value from the "FIC_Feed" controller measurement point.

The following table shows the configuration of the instance from "MotVsd".

Module	Connection	Value	Used for
from_Ctrl			Interconnection from the controller (FIC_Feed\from_Actor_Slave.In)
to_Ctrl			Interconnection to the controller (FIC_Feed\to_Actor_Slave.Out)
U	SP_Out		Interconnection for the simulation (Sim_Feed\Lag_Feed.In)

MI_Feed

The "MI_Feed" display measurement point uses the moisture content "Moist_Feed_Sim", entered by the operator, from the simulation plan

The following table shows the configuration of the instance from "AMon".

Module	Connection	Value	Used for
PV_In	SimOn	1	Activation of the simulation
PV_In	SimPV_In		Interconnection for the simulated process value (Sim_Product\Moist_Feed_Sim.SP_Out)
PV_Scale	HiScale	100.0	Maximum value of the process value
PV_Unit	PV_InUnit	1342	Unit of the process value as a percentage

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4.3 Hot air temperature (Heating)

Drying of the moist material is accomplished with hot air. This involves feeding fresh air into a heat exchanger via a fan; it is heated to the necessary temperature with heating steam and then fed to the dryer. The controller and drive measurement points are implemented with the Control Module Types from the master data library.

4.3.1 Setup

The control variable of the multi-value controller "XC_Product" is transferred as an external setpoint value to the master controller "TIC_HotAir" of the cascade controller. The master controller (PID controller) records the hot air temperature and transfers its control variable as an external setpoint value to the slave controller "FIC_Heat". The slave controller (PID) records the current flow rate of the heating steam and specifies the control variable for a valve. The following table provides you with an overview of the elements.

CM	CMT	Selected variants	Description
TIC_HotAir	"Ctrl"	• PV_In • Opt_IF_Master	Master controller for temperature control, actuated by the MPC.
FIC_Heat	"Ctrl"	• PV_In • Opt_IF_Master	Slave controller for cascading control, with an controlled variable and an actuator.
YC_Heat	"ValAn"	• Opt_IF_Ctrl • RbkReturn	Actuator for heating steam

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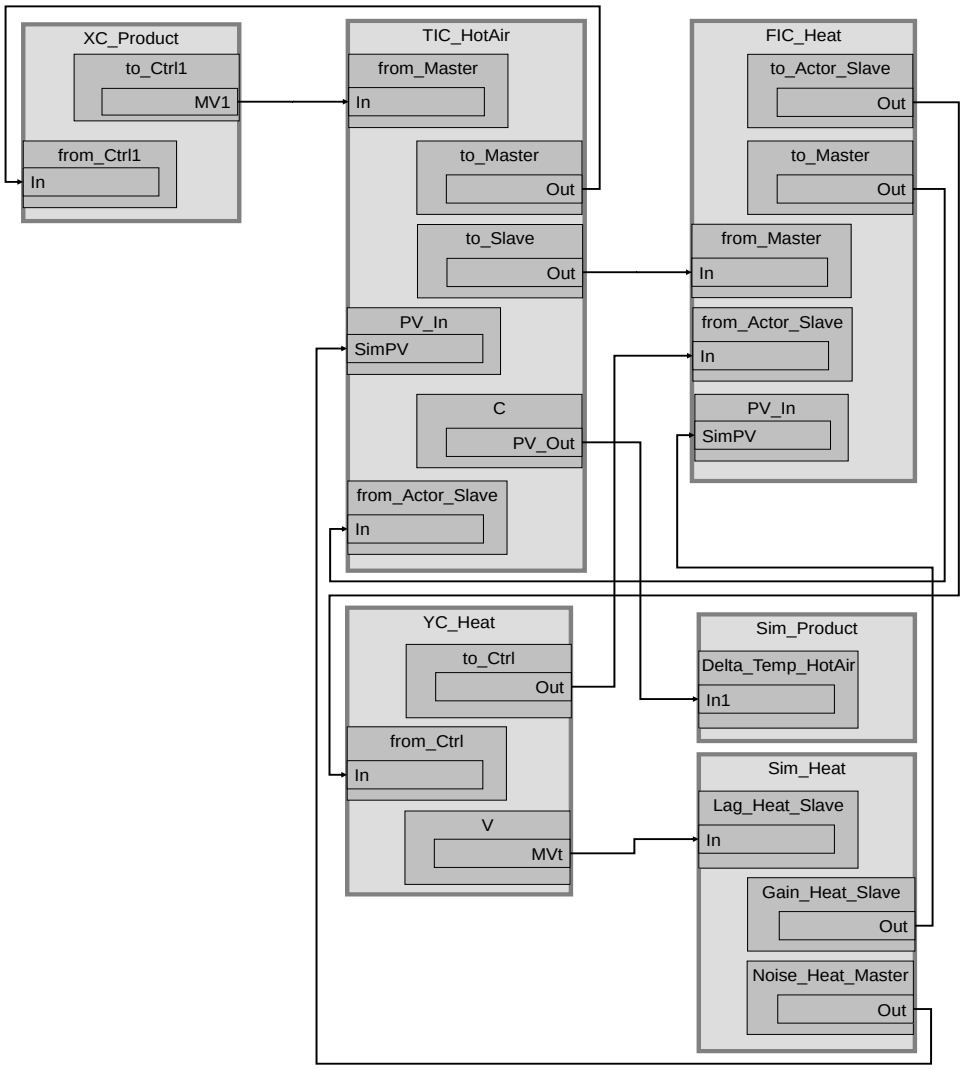
In the following figure the structure with the cross-plan interconnection is depicted in simplified form.



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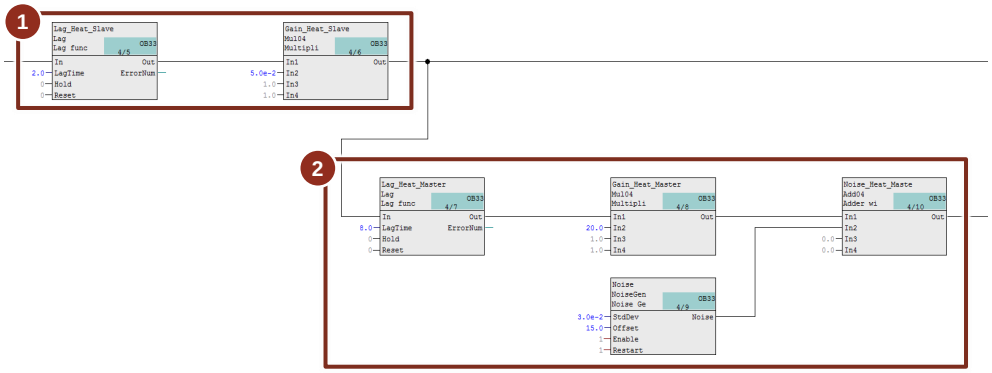
Simulation

In the "Sim_Heat" simulation plan, the hot air temperature is simulated for the master and slave controllers.



1. If a valve is 100% open, with a 2-second delay, 5 t/h (factor 0.05) is sent to the slave controller as the flow rate actual value.
2. With an 8-second delay (as a simulation for the heating up of the heat capacity of the heat exchanger), the twenty-fold value of the heating steam flow rate is sent as actual value of the hot air temperature to the master controller. Furthermore, simulated measurement noise of the temperature sensor can be added.

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4.3.2 Parameter assignment

TIC_HotAir

The hot air temperature is recorded in the "TIC_HotAir" measurement point. The setpoint value is specified through the multi-value controller. The "TIC_HotAir" measurement point transfers the control variable as an external setpoint to the "FIC_Heat" slave controller. Thus, the "TIC_HotAir" measurement point is the master controller for cascading control. The "TIC_HotAir" measurement point is an instance from the Control Module Type "Ctrl".

Module	Connection	Value	Used for
C	Gain	0.929	Controller gain
C	TI	7.262	Controller lag
C	PV_Out		Interconnection for the simulation (Sim_Product\Delta_Temp_HotAir.In1)
from_Master	In		Interconnection from the MPC master controller (XC_Product\to_Ctrl1.Out)
to_Master	Out		Interconnection to the MPC master controller (XC_Product\from_Ctrl1.In)
to_Actor_Slave	Out		Interconnection to the slave controller (FIC_Heat\from_Master.In)
from_Actor_Slave	In		Interconnection from the slave controller (FIC_Heat\to_Master.Out)
PV_In	SimOn	1	Activation of the simulation
PV_In	SimPV_In		Interconnection for the simulated process value (Sim_Feed\Noise_Feed.Out)
PV_Scale	HiScale	200.0	Maximum value of the process value

Module	Connection	Value	Used for
PV_Unit	IN	1001	Unit of the process value in degrees Celsius

FIC_Heat

The flow rate of the heating steam is recorded at the "FIC_Heat" measurement point. The setpoint value specification for the flow rate is implemented through the master controller. The "FIC_Heat" measurement point transfers the control variable to the valve measurement point "YC-Heat". "FIC_Heat" is the slave controller for the cascading control. "FIC_Heat" is an instance of the Control Module Type "Ctrl".

Module	Connection	Value	Used for
C	Gain	2.769	Controller gain
C	TI	1.639	Controller lag
to_Master	Out		Interconnection to the master controller (TIC_HotAir\from_Actor_Slave.In)
from_Master	In		Interconnection from the master controller (TIC_HotAir\to_Actor_Slave.Out)
to_Actor_Slave	Out		Interconnection to the valve (YC_Heat\from_Ctrl.In)
from_Actor_Slave	In		Interconnection from the valve (YC_Heat\to_Ctrl.Out)
PV_In	SimOn	1	Activation of the simulation
PV_In	SimPV_In		Interconnection for the simulated process value (Sim_Heat\Gain_Heat_Slave.Out)
PV_Scale	HiScale	10.0	Maximum value of the process value
PV_Unit	IN	1328	Unit of the process value (t/h)

YC_Heat

The valve measurement point "YC_Heat" controls the flow volume (opening of the feed input) of the heating steam to the heat exchanger. The measurement point contains communications modules for data exchange (control signals and control commands) with the controller measurement point.

The valve module "V" contains an external control variable (through a communications module) from the controller measurement point. Via the simulation block "RbkReturn" the feedback of the valve is generated without a delay between valve control and valve movement.

The following table shows the configuration of the instance from "ValAn".

Module	Connection	Value	Used for
V	MV		Interconnection for the simulation (Sim_Heat\Lag_Heat_Slave.In)
from_Ctrl	In		Interconnection from the controller (FIC_Heat\to_Actor_Slave.Out)
to_Ctrl	Out		Interconnection to the controller (FIC_Heat\from_Actor_Slave.In)
PV_In	SimOn	1	Activate simulation of the read-back value

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Module	Connection	Value	Used for
PV_In	SimPV_In		Interconnected with the simulation of the read-back value from the valve (YC_Cool\V.MV)

4.4 Hot air volume (Air Supply)

Drying of the moist material is accomplished with hot air. This involves feeding fresh air into a heat exchanger; it is heated to the necessary temperature with heating steam and then fed to the dryer. The hot air volume is adjusted by means of the blower rotational speed. The controller and drive measurement points are implemented with the Control Module Types from the master data library.

4.4.1 Setup

The multi-value controller measurement point "XC_Product" records the product temperature and moisture content, and regulates these by means of the hot air temperature and hot air volume. The slave controller "FIC_HotAir" receives its external control variable from the multi-value controller "XC_Product". The slave controller records the flow rate of the hot air and, depending on the specified flow volume (multi-value controller), requires either an increase or decrease in the flow rate. To do this, the slave controller specifies the rotational speed for the blower drive.

The following table provides you with an overview of the elements.

CM	CMT	Selected variants	Description
FIC_HotAir	"Ctrl"	• PV_In • Opt_IF_Master	Controlling of the flow rate of the hot air
NC_FreshAir	"MotVsd"	• Opt_IF_Ctrl • Q • Rbk • SP_Out	Blower rotational speed for compressing the fresh air
MI_Fresh	"AMon"	• PV_In	Measurement point for the moisture content of the fresh air

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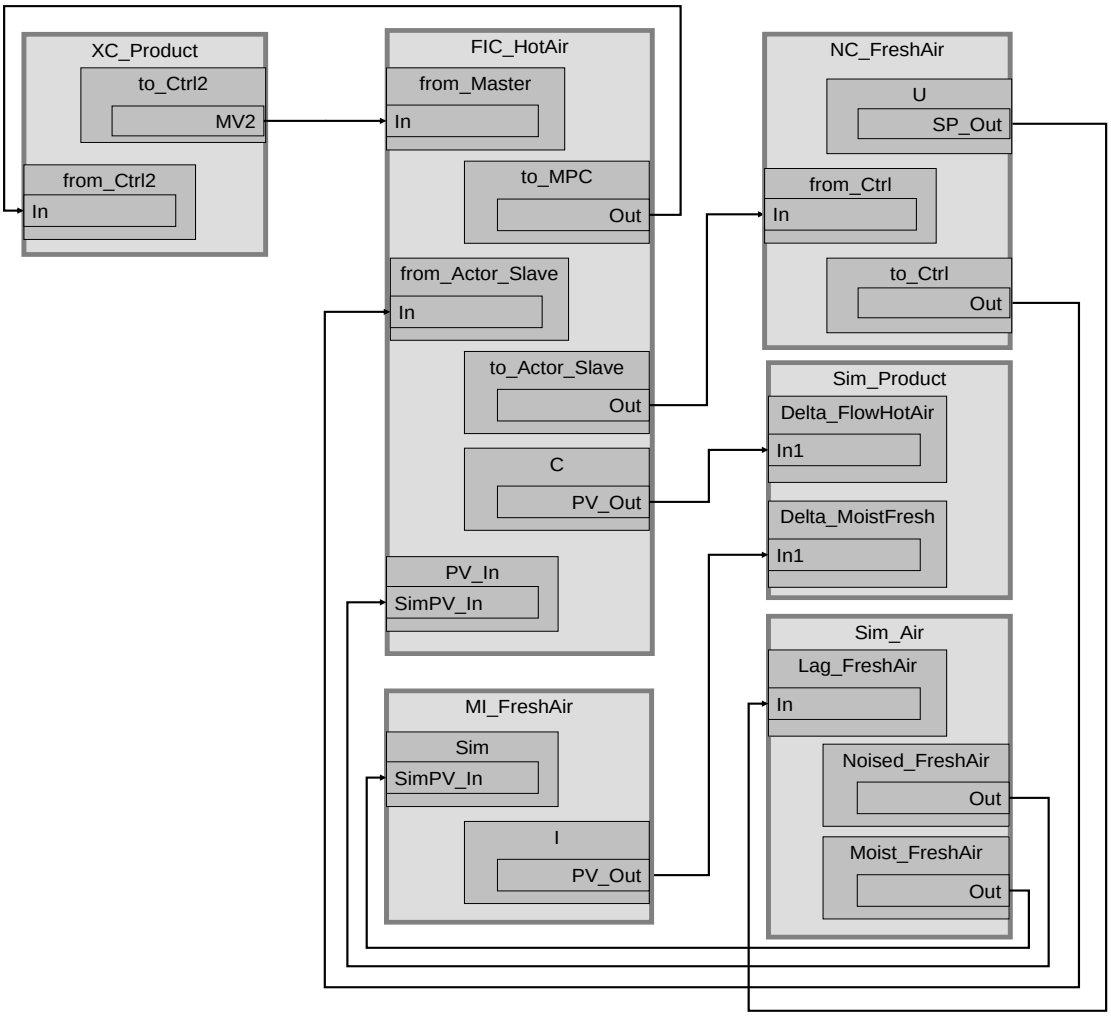
In the following figure the structure with the cross-plan interconnection is depicted in simplified form.



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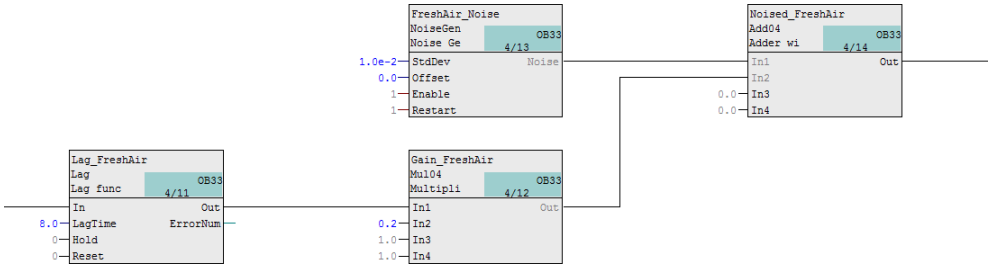
Simulation

The control of the hot air input is simulated in the "Sim_Air" simulation plan.



If a valve is 100% open, with an 8-second delay, 20% (factor 0.2) of the flow rate is emitted. Optionally, a process noise ("FreshAir_Noise") can also be activated.

4.4.2 Parameter assignment

FIC_HotAir

The volume flow of the hot air (blower) is recorded and controlled at the "FIC_HotAir" measurement point. The setpoint value specification for the flow rate is implemented through the master controller "XC_Product". The "FIC_HotAir" measurement point transfers the control variable to the frequency converter of the "NC_FreshAir" blower. "FIC_HotAir" is an instance of the Control Module Type "Ctrl".

Module	Connection	Value	Used for
C	Gain	0.464	Controller gain
C	TI	6.828	Controller lag
C	PV_Out		Interconnection for the simulation (Sim_Product\Delta_FlowHotAir.In1)
C	SP_InHiLim	20	Upper setpoint value limit
from_Master	In		Interconnection from the MPC master controller (XC_Product\to_Ctrl1.Out)
to_Master	Out		Interconnection to the MPC master controller (XC_Product\from_Ctrl1.In)
to_Actor_Slave	Out		Interconnection to the MPC master controller (NC_FreshAir\from_Ctrl.In)
from_Actor_Slave	In		Interconnection from the MPC master controller (NC_FreshAir\to_Ctrl.Out)
PV_In	SimOn	1	Activation of the simulation
PV_In	SimPV_In		Interconnection for the simulated process value (Sim_Air\Noised_FreshAir.Out)
PV_Scale	HiScale	20.0	Maximum value of the process value
PV_Unit	IN	1328	Unit of the process value (t/h)

NC_FreshAir

The motor measurement point "NC_FreshAir" controls the volume flow of the fresh air to the heat exchanger and thus the drying of the moist material. Via communications modules, the motor block receives an external setpoint value from the "FIC_HotAir" controller measurement point.

The following table shows the configuration of the instance from "MotVsd".

Module	Connection	Value	Used for
from_Ctrl			Interconnection from the controller (FIC_HotAir\from_Valve.Out)
to_Ctrl			Interconnection to the controller (FIC_HotAir\to_Valve.Out)
U	SP_Out		Interconnection for the simulation (Sim_Feed\Lag_FreshAir.In)

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MI_FreshAir

The "MI_FreshAir" display measurement point uses the moisture content "Moist_FreshAir_S", entered by the operator, from the simulation plan

The following table shows the configuration of the instance from "AMon".

Module	Connection	Value	Used for
I	PV_Out		Interconnection for the simulated process value (Sim_Product\Delta_MoistFresh.In1)
PV_In	SimOn	1	Activation of the simulation
PV_In	SimPV_In		Interconnection for the simulated process value (Sim_Product\Moist_FreshAir_S.SP_Out)
PV_Scale	HiScale	100.0	Maximum value of the process value
PV_Unit	IN	1342	Unit of the process value as a percentage

4.5 Controlling of the product temperature and moisture content (Product)

With regard to the multivariable control system, it involves quality controlling by which the product quality (i.e. temperature and moisture content) is set based on certain criteria. To set the product quality, the multi-value controller – as master controller – relays its control variable as an external setpoint value for both the hot air temperature and volume controllers.

4.5.1 Setup

Controlling of the product moisture content and product temperature is accomplished by means of the multi-value controller "XC_Product". The controller receives the current measured values from both of the control variables (product moisture content, product temperature) and calculates the setpoint values for the activated slave controllers "FIC_HotAir" and "TIC_HotAir". The control variables are visualized with the "TI_Product" and "MI_Product" measurement points.

The following table provides you with an overview of the elements.

CM	CMT	Selected variants	Description
XC_Product	"CtrlMPC"	• Opt_CPM_1 • Opt_CPM_2 • Opt_Ctrl_1 • Opt_Ctrl_2	Multi-value controller, serves as master controller for hot air and product feed input
TI_Product	"AMon"	• PV_In • Opt_IF_MPC	Measurement point for displaying the product temperature
MI_Product	"AMon"	• PV_In • Opt_IF_MPC	Measurement point for displaying the moisture content of the product

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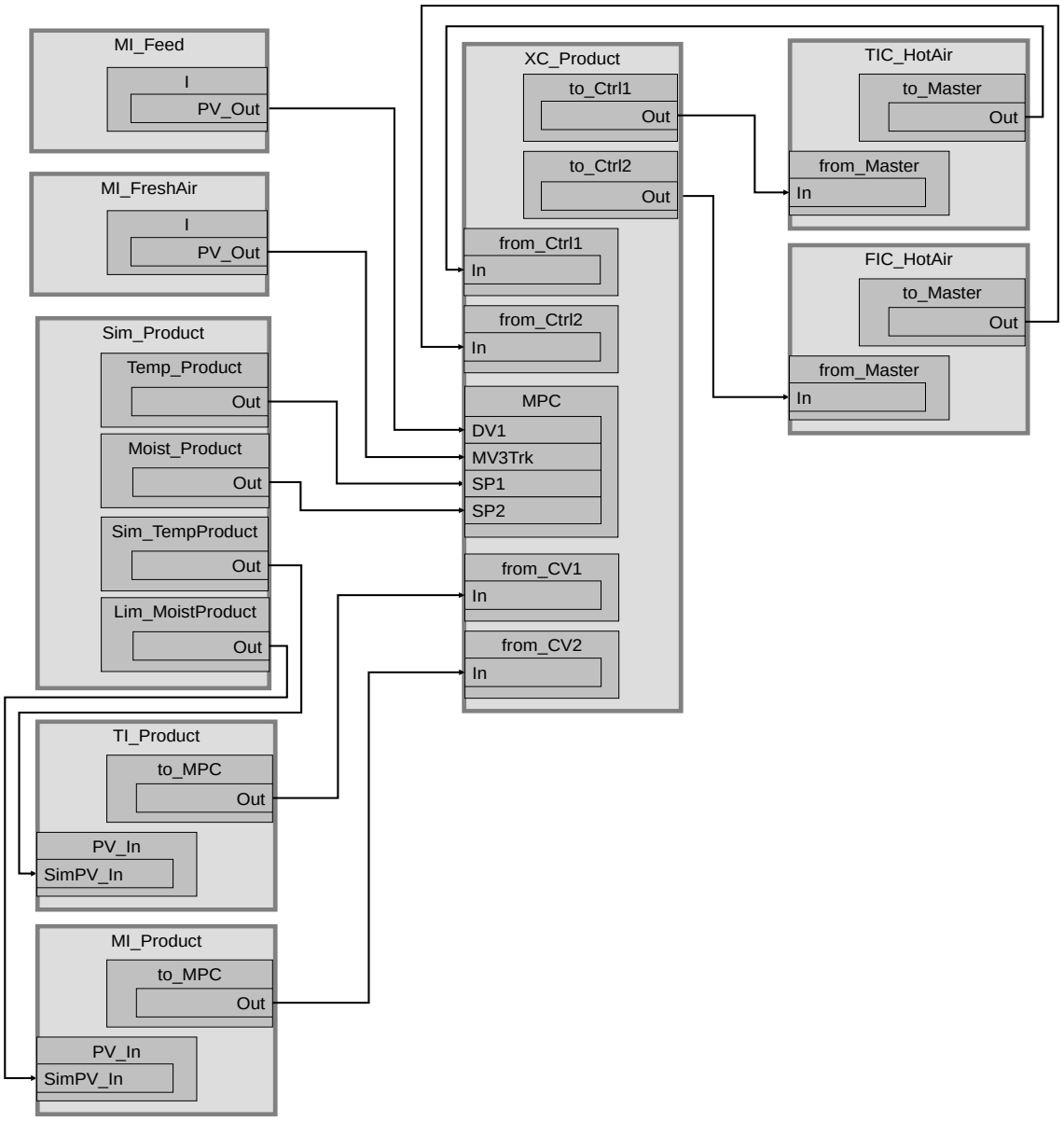
In the following figure the structure with the cross-plan interconnection is depicted in simplified form.



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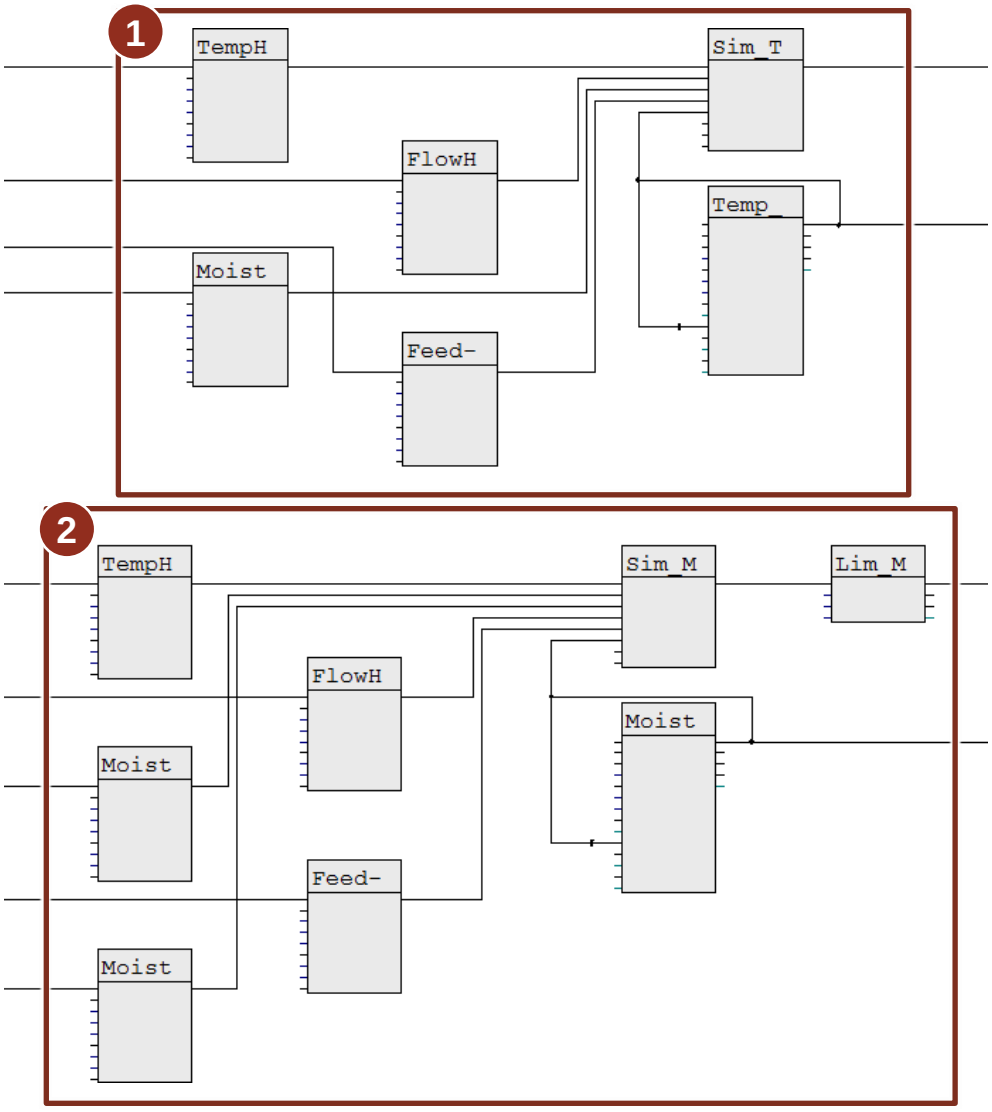
Simulation



In the "Sim_Product" simulation plan, the working points for moisture content of the moist material and dry air, volume flow of the moist material, hot air, and the temperature of the hot air are pre-defined. In addition, the calculation of the product moisture content (1) and the product temperature (2) takes place. The individual partial transfer functions of the routing model affect both of the quality actual values (temperature and moisture content). For a detailed description of the simulation, please refer to Chapter 4.6 "Process simulation (Simulation)".

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4.5.2 Parameter assignment

XC_Product

For quality controlling with the multi-value controller measurement point "XC_Product", the following relevant values are used and interconnected.

CVs (control variables):

- Residual moisture of the dried material
- Product temperature (corresponds to the temperature in the lower part of the dryer)

MVs (control variables for subordinate slave controllers):

- Volume flow of the hot air
- Temperature of the hot air (cascade of the steam flow rate)

DVs (disturbance variables)

- Moisture content of the material to be dried (DV1)
- Moisture content of the input air (DV2 MV3Trk)

The measurement point contains communications modules for connecting slave controllers and for displaying control variables, and is an instance from the Control Module Type "Ctrl_MPC".

NOTE The Control Module Type is designed for three control and measured variables, of which two are used for the dryer.

Module	Connection	Value	Used for
MPC	SP1		Interconnection of the setpoint for the product temperature (Sim_Product\Temp_Product.SP_Out)
MPC	SP2		Interconnection of the setpoint for the product moisture content (Sim_Product\Moist_Product.SP_Out)
MPC	DV1		Interconnection of the moisture content disturbance variable of the moist material input (Feed\\MI_Feed\I.PV_Out)
MPC	DV_On	1	Activation of the moisture content disturbance variable of the moist material input feed
MPC	MV3TrkOn	1	Activation of the moisture content of the fresh air volume as second disturbance variable
MPC	MV3Trk		Interconnection of the moisture content of the fresh air volume as second disturbance variable (DV2) (MI_FreshAIr\I.PV_Out)
MPC	DB_No	16	DB number with controller data
SP10ptHiLim	In1	1.0	SP1 upper limit for MPC optimization
SP10ptLoLim	In1	1.0	SP1 lower limit for MPC optimization
SP20ptHiLim	In2	0.2	SP2 upper limit for MPC optimization
SP20ptLoLim	In2	-0.2	SP2 lower limit for MPC optimization

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Module	Connection	Value	Used for
to_Ctrl1	Out		Interconnection to the hot air temperature measurement point (Heating\\TIC_HotAir\from_Master.In)
from_Ctrl1	In		Interconnection from the hot air temperature measurement point (Heating\\TIC_HotAir\to_Master.Out)
to_Ctrl2	Out		Interconnection to the hot air volume flow measurement point (AirSupply\\FIC_HotAir\from_Master.In)
from_Ctrl2	In		Interconnection from the hot air volume flow measurement point (AirSupply\\FIC_HotAir\to_Master.Out)
from_CV1	In		Interconnection from the product temperature display (Product\\TI_Product\to_MPC.In)
from_CV2	In		Interconnection from the product moisture content display (Product\\MI_Product\to_MPC.In)

NOTE Commissioning of the multi-value controller was carried out based on the "fluidized bed dryer" application description of a model predictive controller, with working point optimization. You will find the example under https://support.industry.siemens.com/cs/ww/en/view/61926069.

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TI_Product

The display measurement point "TI_Product" is used to display and monitor the product temperature (control value) of the multivariable measurement point. The operator can set alarm and warning limit values.

The following table shows the configuration of the instance from "AMon".

Module	Connection	Value	Used for
to_MPC	Out		Interconnection to the control variable of the multi-value controller (XC_Product\from_CV1.Out)
PV_In	SimOn	1	Activation of the simulation
PV_In	SimPV_In		Interconnection for the simulated product temperature (Sim_Product\Sim_TempProduct.Out)
PV_Scale	HiScale	150.0	Maximum value of the process value
PV_Unit	IN	1001	Unit of the process value (degrees Celsius)

MI_Product

The display measurement point "MI_Product" is used to display and monitor the product moisture content (control value) of the multivariable measurement point. The operator can set alarm and warning limit values.

The following table shows the configuration of the instance from "AMon".

Module	Connection	Value	Used for
to_MPC	Out		Interconnection to the control variable of the multi-value controller (XC_Product\from_CV2.Out)
PV_In	SimOn	1	Activation of the simulation
PV_In	SimPV_In		Interconnection for the simulated product moisture content (Sim_Product\Lim_MoistProduct.Out)
PV_Scale	HiScale	11.0	Maximum value of the process value
PV_Unit	IN	1342	Process value unit (%)

4.6 Process simulation (Simulation)

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The CFC chart "Sim_Product" contains all of those parts of the simulation model that not only describe an individual system section but also have an overarching nature. A matrix with linear, dynamic transfer functions is used as a model for process simulation. The process model is a 2x5 multi-variable system, whereby the influence of each input variable on every output variable is simulated by a separate partial transfer function. The model describes the temporal behavior of process deviations from the working point. The leading signs of the partial transfer functions are physically plausible. For example, an increase of "TempHotAir" leads to a reduction of "MoistProduct", i.e. the partial transfer function from u1 to y1 has a negative prefix. The time constants are, however, significantly faster than in a real plant. Additionally, in real plants downtimes can also occur in the partial transfer functions.

In the following figure, the process model is depicted with the corresponding names.

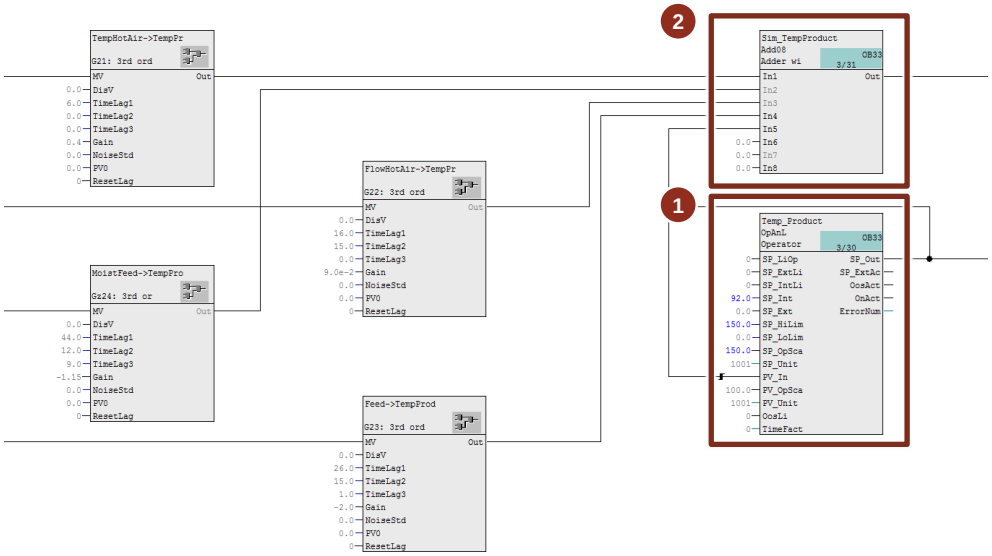
	TempHotAir	FlowHotAir	MoistFreshAir	Feed	MoistFeed
MoistProduct	y1u1	y1u2	y1u3	y1u4	y1u5
TempProduct	y2u1	y2u2	-	y2u4	y2u5

The partial transfer functions influence, with different dynamic models (PT_1, PT_2 or PT_3 behavior), the respective output values (product temperature and moisture content). Each partial transfer function receives the respective differential value from the predefined working point and the current value of the input variables and outputs them correspondent to its transfer functions at the output point. At the end, for each process output variable y_i the associated working point is added.

NOTE All PT_n transfer functions are structured as 'plan in plan' according to the same principle, whereby only the required functional parts are activated. A transfer function contains three sequentially switched delay elements and a booster element. Furthermore, noise can be added to the output signal.

In the sheets 1 to 3, the individual working points for the moisture content of the moist material and dry air, volume flow of the moist material, hot air, and the temperature of the hot air are pre-defined. These working points are compared with associated process values and the resulting difference is relayed to the subsequent transfer functions.

The following figure shows sheet 4 for the calculation of the product temperature.



1. **Working point**
   The working point of the temperature (output variable of the process model) is output at this module.
2. **Control variable with working point**
   The product temperature is calculated at this module by adding up the calculated deviations from the individual transfer functions at the working point.

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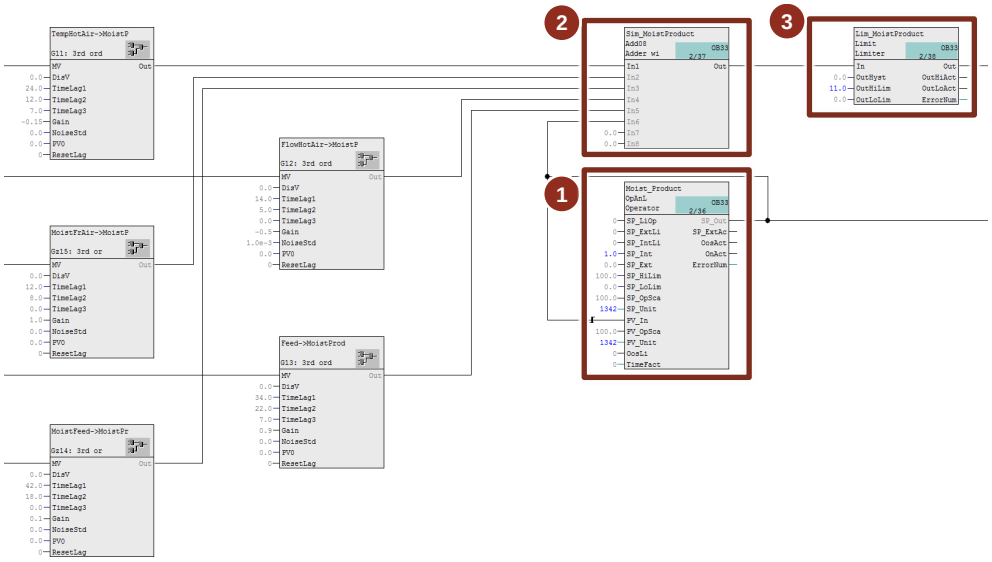
The following figure shows sheet 5 for the calculation of the product moisture content.



1. **Working point**
   The working point of the product moisture content is output at this module.
2. **Control variable with working point**
   The product moisture content is calculated at this module by adding up the individual transfer functions or calculated deviations at the working point.
3. **Limitation of the product moisture content**
   Before being relayed to the multi-value controller, the input signal is checked as a measured variable to verify if it exceeds or goes below limits; if necessary, it is limited to a threshold value.

You can adjust the numerical values for the working point to the technical data of your plant without the dynamic response of the process simulation being changed as a result.

An artificial fault, in the form of a fluctuation in the reagent moisture content, can also be depicted. It is assumed that the raw material is generated in a batch process and that every batch has a somewhat different water content. Thus, at the beginning of each new batch a slight jump in the reagent moisture content can be observed. With regard to the curve representation, the reagent moisture content changes more frequently than in reality, namely abruptly by 1% every 90 s. The fault is activated by changing the setpoint value specification to external at the "Moist_Feed_Sim" module.

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4.7 MPC optimizing (Optimization)

The CFC chart "Optimization" contains "OpAnL" modules for inputting process-related technical data and limits, as well as basic economic information (revenue and costs). Based on these criteria, an economically-oriented working point optimization and control can be performed. In this case, the controller does not work according to an exact setpoint value but instead must only keep the controlled variables within a defined zone, i.e. in a temperature and moisture content range permissible for the product quality. The optimization is decisive as to which working point within this zone is preferable for economic reasons in order to minimize energy consumption and maximize the revenue generated by plant operation. In every situation, the optimization of the steady state working point integrated in the MPC automatically finds the economically optimum combination of air mass flow rate and air temperature for accomplishing the drying task. To do this, the dependencies of the economic yield on the setpoint and controlled variables must be known.

NOTE Commissioning of the multi-value controller was carried out based on the "fluidized bed dryer" application description of a model predictive controller, with working point optimization. You will find the example under https://support.industry.siemens.com/cs/ww/en/view/61926069.

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4.8 Step sequencer (SFC)

Step sequencers support the plant operator in starting up and shutting down a facility, or in case of malfunctions, and can be specifically adapted to circumstances.

The dryer is designed for continuous operation insofar as individual parameters (moist material input feed or moisture content of the moist material/fresh air) can only minimally change in the ongoing process. The dryer includes the "Run" step sequencer for starting up the dryer, which leads the individual elements of the dryer in the respective working points. In addition, during the start-up phase the messages of the display and controller measurement points are suppressed.

Setpoint values for the controlled variables are specified for the multi-value controller when the dryer is started. Subsequently, in each step a controller switches its operating mode to automatic with an external setpoint value. In the transition that follows, the "Automatic" operating mode and control deviation are checked.

With regard to real dryers, this SFC can only be regarded as a reference point and was created to meet the simulation requirements. For use in real facilities, start-up controlling must be devised appropriate to the process-related requirements. Here it must be clarified, for example, whether the dryer must first be filled with reagent and then the hot air started up, or vice versa.

NOTE To determine the setpoint value and operating mode selection, the necessary parameterization is used, incl. the schematic representations from the function manual "SIMATIC Process Control System PCS 7 Advanced Process Library (V9.0 SP1)". You will find the function manual and further documentation summarized under https://support.industry.siemens.com/cs/ww/en/view/109754967.

4.9 Process parameters (KPI)

The CFC chart "KPI" comprises key performance indicators that inform the operator about the process performance and energy requirement. The following key performance indicators are calculated and shown in the visualization:

1. Sheet: Electrical power (current energy consumption) (KW) = motor speed (%) * rated output of the motor (KW) + blower rotational speed (%) * rated output of the blower (KW)

   $P_{ElecEnergy} = S_{Feed} \cdot P_{FeedMaxPower} + S_{Fan} \cdot P_{FanMaxPower}$

2. Sheet: Heat output (current thermal energy consumption) (KW) = heating steam volume (t/h) * evaporation enthalpy * 1000 / 3600

   $P_{ThermEnergy} = m_{Steam} \cdot C_{VaporEnthalpy} \cdot 0.28$

3. Sheet: Product throughput (kg/s) = input feed of moist material (t/h) * 1000 / 3600

   $m_{Product} = m_{Feed} \cdot 0.28$

4. Sheet: Specific energy consumption (kJ/kg): Total energy consumption/product throughput

   $$h_{SpecEnergyConsumption} = \frac{P_{ThermEnergy} + P_{ElecEnergy}}{m_{Product}}$$

NOTE To calculate the energy consumption, relevant technical data (rated capacities, etc.) have been pre-selected in the CFC chart "Optimization". You can adapt these to your specific application.

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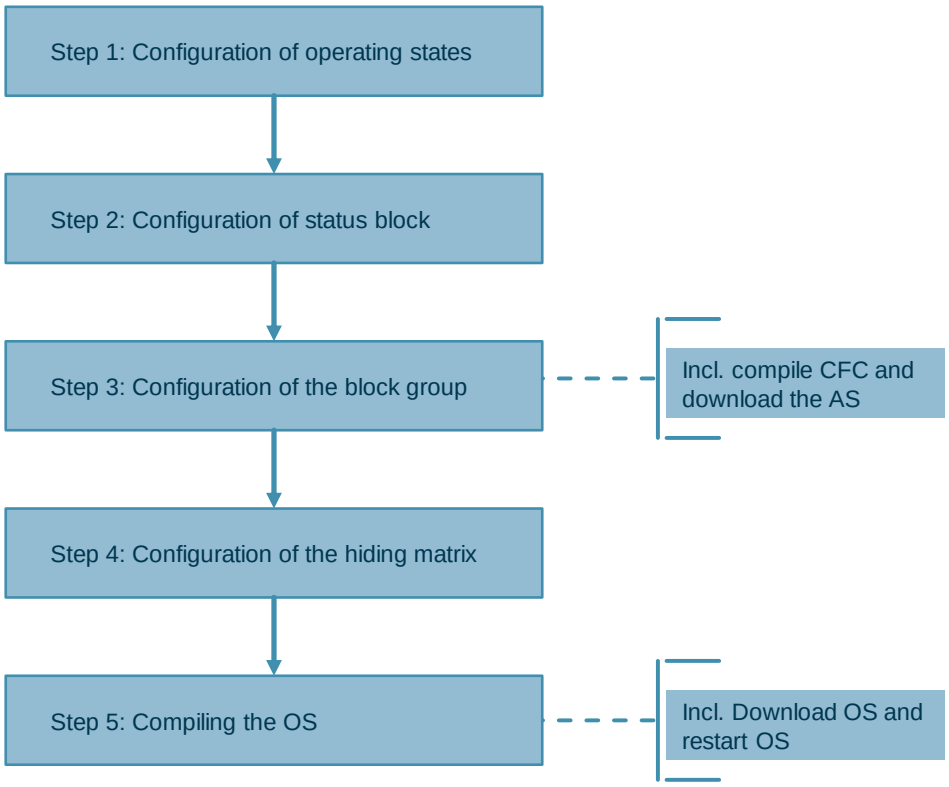
4.10 Smart Alarm Hiding

With the Smart Alarm Hiding, alarms of a measuring point can be filtered or hidden depending on the plant state. This means that the filtered and hidden alarm messages of the measuring points are also sent to the alarm system where they are processed and archived.

A reduction in the message traffic is thus achieved in process mode, which simplifies the operation of a system.

Smart Alarm Hiding in the example project

The following sequence has been followed for the configuration of Smart Alarm Hiding.



Note Further information on Smart Alarm Hiding can be found at the following link: https://support.industry.siemens.com/cs/ww/en/view/55699984.

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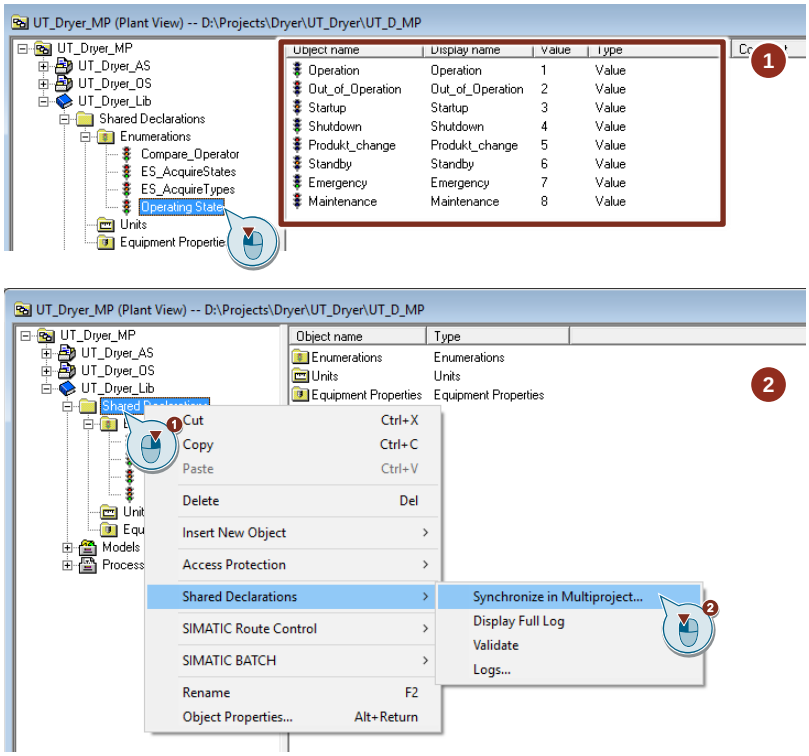
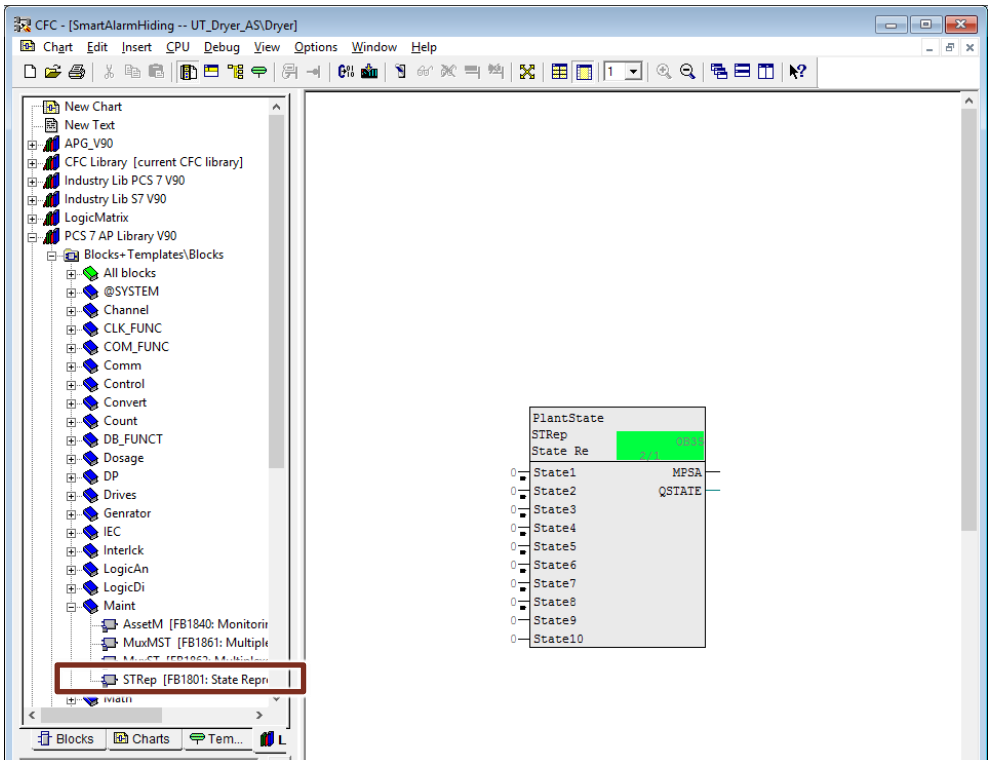
Step 1:

The operating states are configured (1) in the master data library and synchronized in the multiproject (2) as follows. The created enumeration is called "Operating State".



Step 2:

The "STRep" status block is configured and the "State" inputs correspond to the operating states created in step 1.



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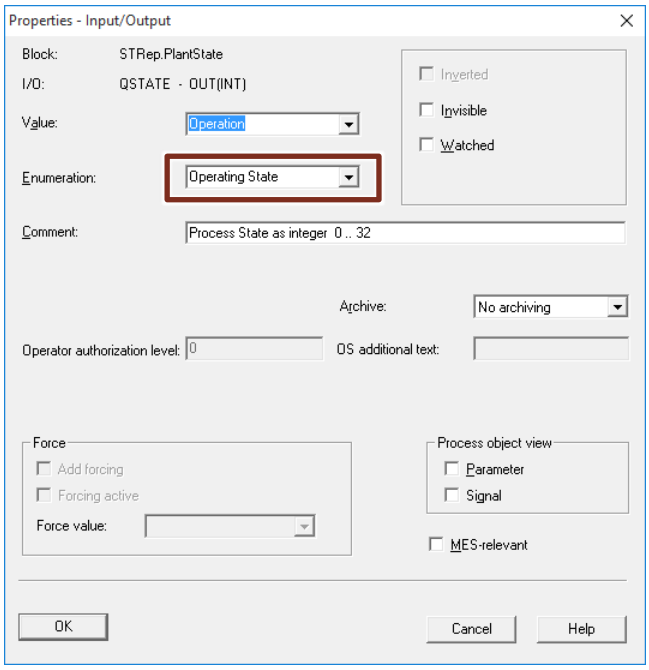
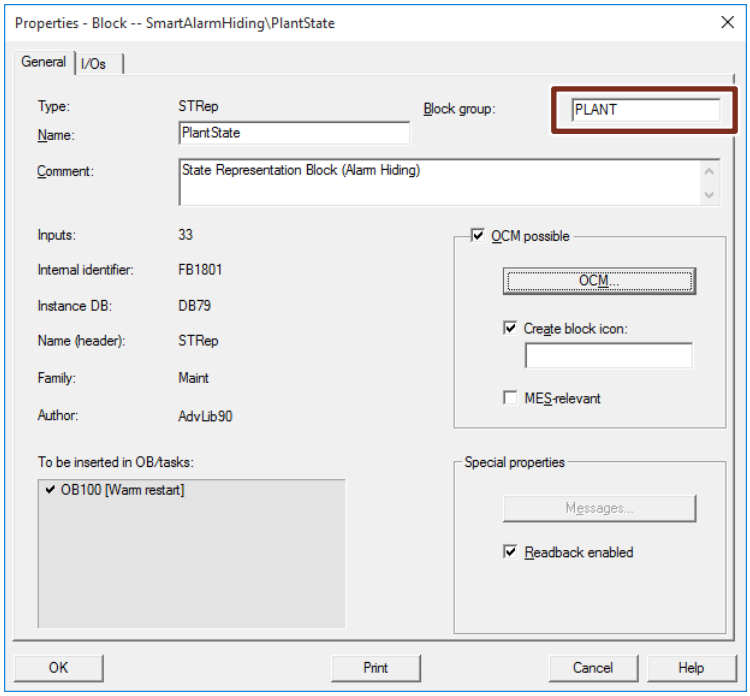
Note

In the project, the plant state is selected via the step sequencers. A direct interconnection of upstream blocks is also possible, however only one position (SFC or upstream block) can be activated at any time.

The enumeration "Operating State" is assigned in the object properties of the output "QSTATE".



The block group "PLANT" is predefined in the block properties.



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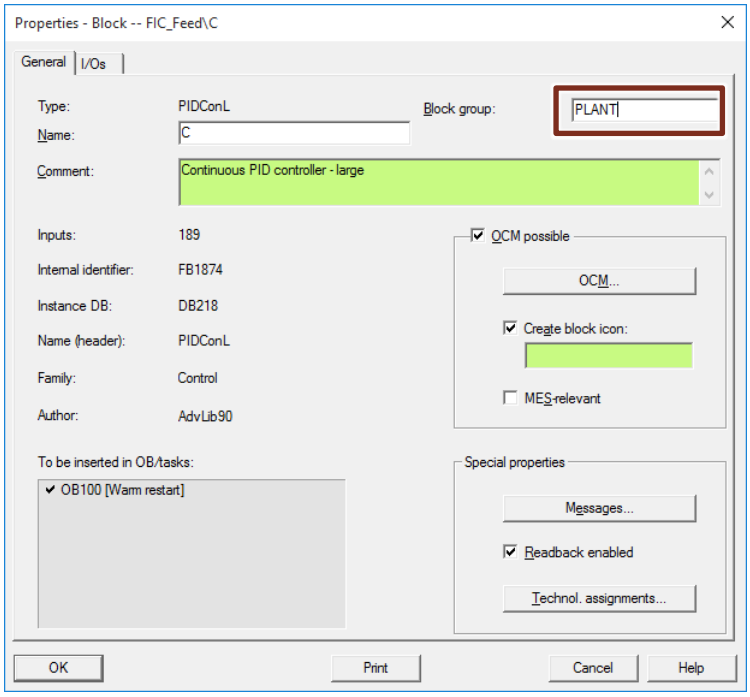
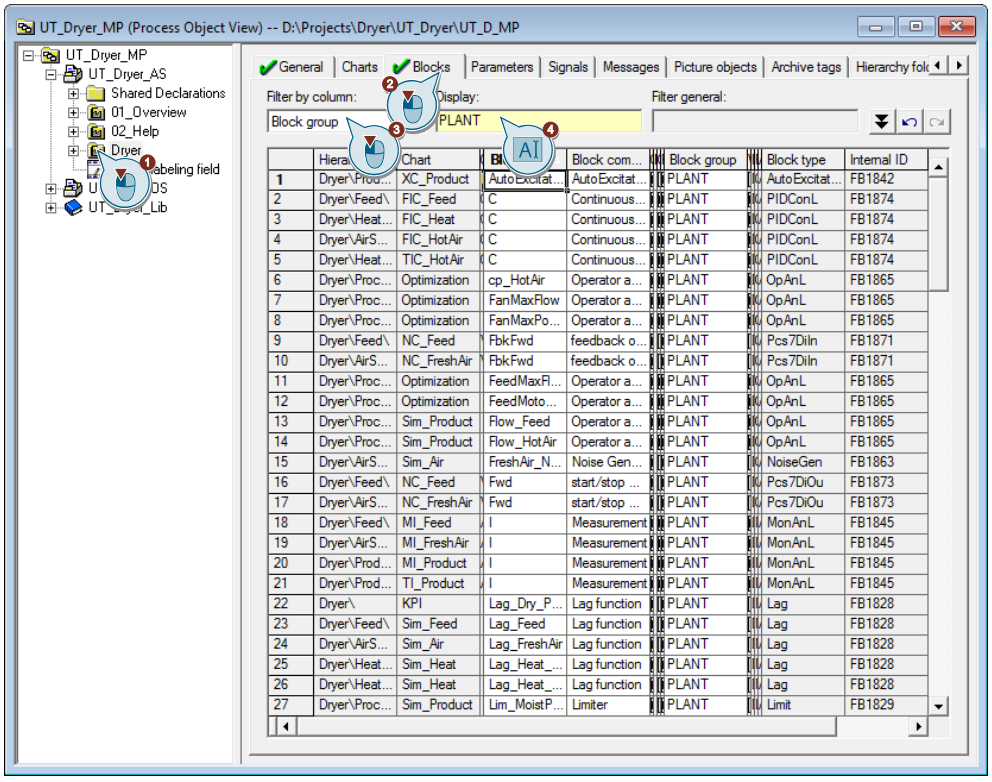
Step 3:

The technological blocks are assigned to the "PLANT" block group.



The following technological blocks belong to the "PLANT" block group:



Note The block group defines which technological elements belong together. It is recommended to define the block group at the unit level.

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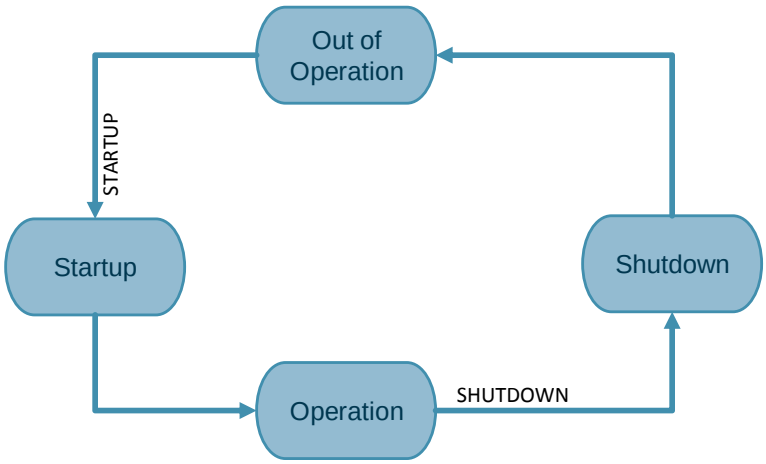
Step 4:

The Hiding Matrix has been configured for the following plant states:

	Plant state	Activation via	suppressed messages
1.	Operation	End of sequencer STARTUP	None
2.	Out_of_Operation	End of sequencer SHUTDOWN	All messages and alarms
3.	Startup	Start of sequencer STARTUP	Lower limit values of the temperature measurement, upper limit values of the product moisture and KPI
4.	Shutdown	Start of sequencer SHUTDOWN	Lower limit values of the temperature measurement, upper limit values of the product moisture and KPI
5.	Product_change	n. A.	
6.	Standby	n. A.	
7.	Emergency	n. A.	
8.	Maintenance	n. A.	



Step 5:

The OS in the project has already been compiled and prepared for operation.

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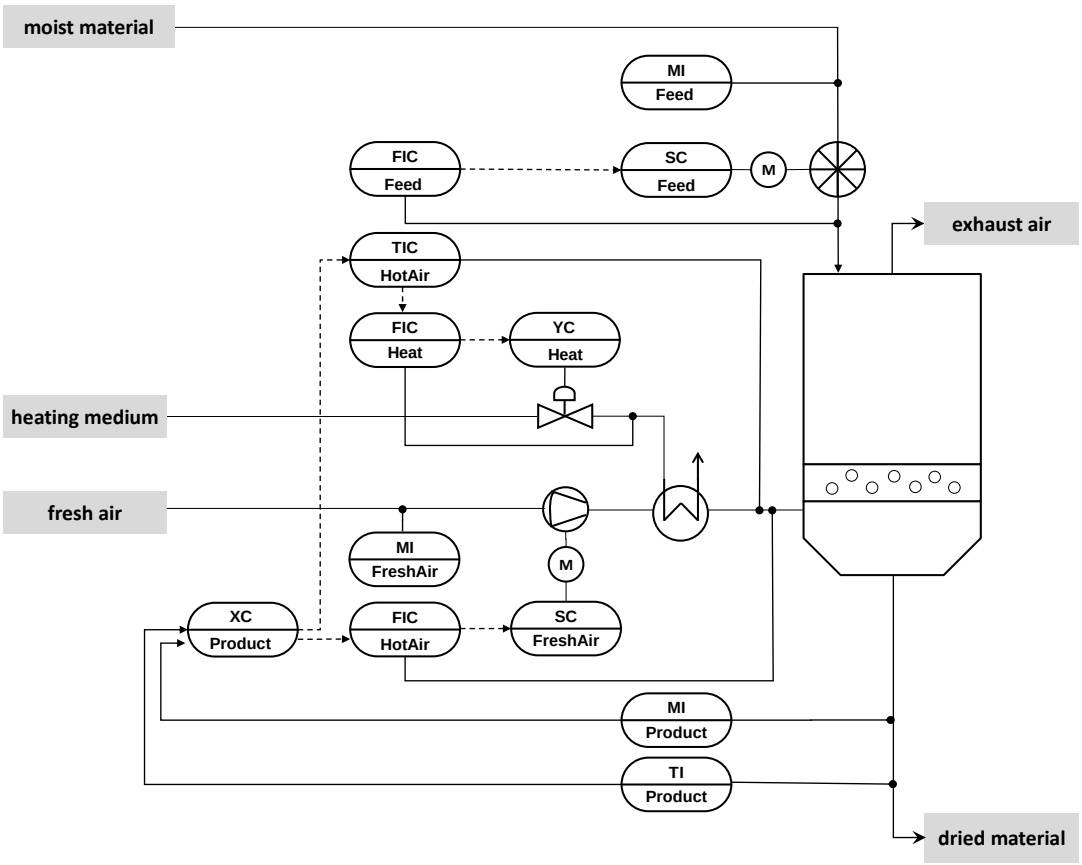
5 Basic

5.1 P&I diagram

The following image shows the individual elements of the dryer in a piping and instrument flow chart.



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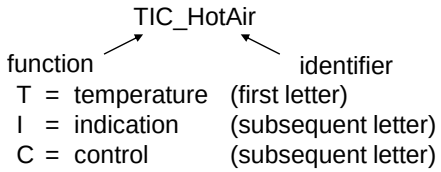
5.2 Project structure

5.2.1 Naming convention of the CFC chart structures

A uniform naming convention was used for identifying the measurement points, whereby the function has been named according to the European standard EN 62424. The following figure shows the composition of a measurement point name:



The following table contains all letters used in the application their meanings:

First letter:	Meaning
F	Flow
L	Level
M	Moisture
N	Motor
P	Pressure
Q	Quantity
S	Speed (velocity, rotational speed, frequency)
T	Temperature
X	Freely selectable first letter
Y	Control valve

Subsequent letter	Meaning
C	Control
F	Fraction
I	Indication
S	Switching (binary control function or switching function (non-safety-related)

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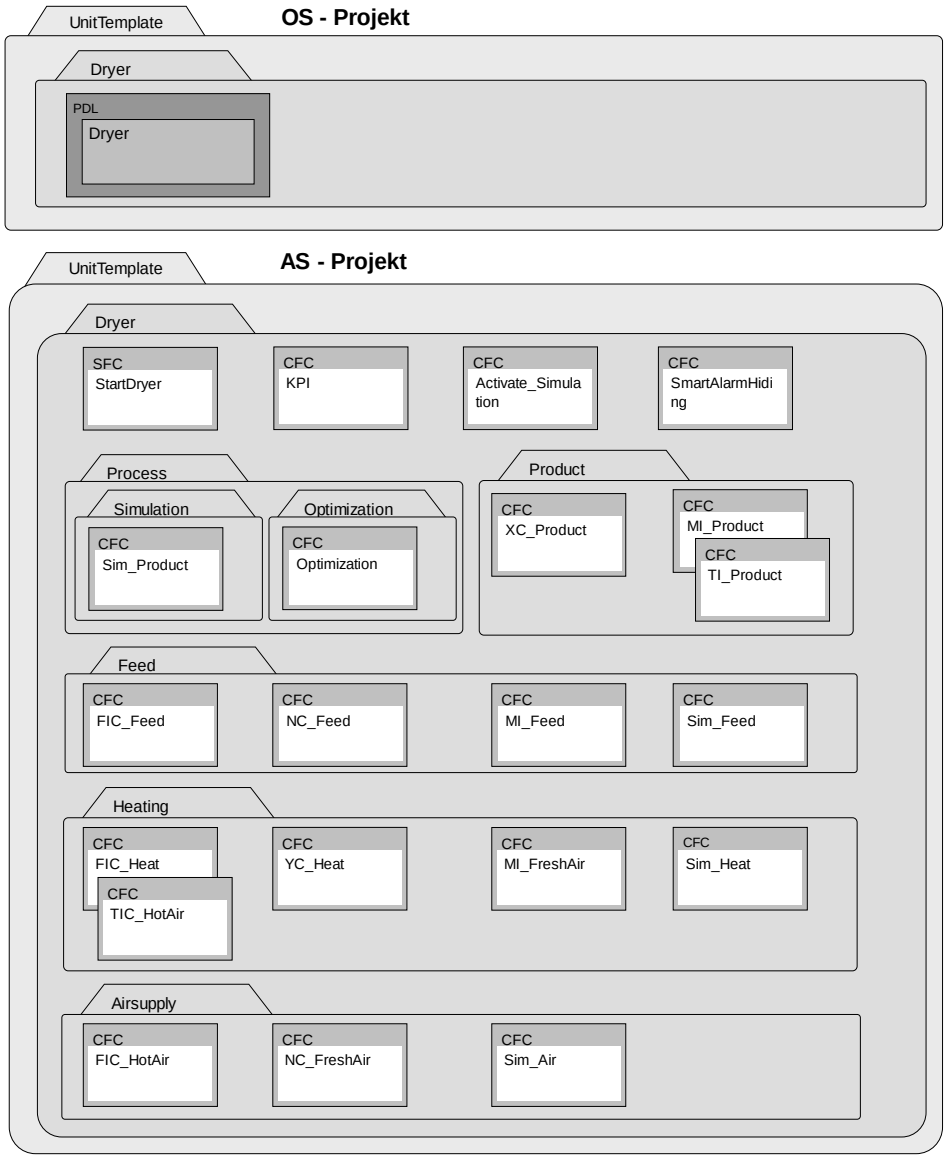
5.2.2 Plan view

The unit template "Dryer" is implemented in the plan view in two hierarchy levels.

In the AS project "UnitTemplate_AS", the first hierarchy level is empty and in the subordinate hierarchy level there is only respectively one hierarchy folder, with the necessary CFC charts and the associated process simulation, for each equipment module of the dryer.

The first hierarchy level of the OS project "UnitTemplate_OS" is empty. The process picture "Dryer.pdl" of the dryer is located in the subordinate hierarchy folder. All plans with the prefix "Sim_*" are intended for the simulation and could be removed for use in a real plant. Contrarily, the program section "Optimization" is intended for real plant operations.

In the following figure the PCS 7 multiproject structure is depicted.



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5.3 Classification of dryers

5.3.1 Contact dryers

With contact dryers, the material comes directly in contact with a heating surface, which heats up and dehydrates the material. Air is not absolutely necessary for the drying.

Among others, contact dryers are available in the following forms / versions:

- Lyophilisator / freeze-dryer
- Paddle dryer
- Screw dryer
- Tube dryer
- Tumble dryer
- Plate dryer
- Roller dryer
- Cylinder dryer

5.3.2 Convection dryer

With a convection dryer, the material is dehydrated by means of dry air (or other hot gases) Depending on the application, the air that is utilized can be treated after it has been exhausted by the dryer (air outlet), i.e. it can have any dust or moisture removed, for example.

Among others, convection dryers are available in the following forms / versions:

- Jet tower dryer
- Cabinet dryer
- Dryer-pulverizer
- Spray dryer
- Flash dryer
- Drum dryer
- Tunnel dryer
- Fluidized bed dryer

5.3.3 Dry air dryer

With dry air dryers, the material is dried by perfused with air. In a previous step, the air is dried in a cell filled with a desiccant.

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5.4 Drying process (progression)

In order to attain the necessary moisture content for the raw or starting material or to maintain a consistent quality (product moisture content) for the finished product, the product is subjected to a drying process (thermal drying).

During thermal drying, the moisture to be removed evaporates or vaporizes. This process requires more energy than a strictly mechanical dehydration. Thus, the moist material is often mechanically dehydrated, e.g. with a centrifuge or suction filter, in an upstream step prior to thermal drying.

The thermal drying process can be broken down into the following sub-processes:

1. Heat transfer from the hot air to the moist material
1. Phase transformation
2. Removal of the solvent vapor

During drying, the following aspects should be viewed more closely and examined:

a. During thermal drying the moist material is thermally stressed. This results in limits for the permissible temperature range, which must be ascertained in advance. The temperature range must be restricted for safety reasons, in order to prevent ignition of the drying material under any circumstances.
b. Dehydration that is too strong or weak can damage the product quality.
c. A measurement of the chronological progression of the drying ("drying curve") in a laboratory setup in batch mode helps when specifying a dwell time for the continuous operation of the dryer.

An economical drying process can be deduced from the stated points, consequently reducing the investment and operating costs.

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5.5 Drying curve

A valid drying progression curve can be deduced from a measured drying curve (laboratory setup) for the processing plant.

The drying curve shows the progression (characteristic) trend of the drying process, beginning with the initial moisture content (moist material) up to the desired residual moisture (dry material or product).

The drying progression curve is divided into the following three drying phases:

1. Maximum drying speed: the material is moist on the surface and shows maximum evaporation at a continuously low temperature
2. Medium drying speed: the material shows dry areas on the surface (which makes vapor transport more difficult) and increasingly heats up
3. Slow drying speed: the last drops evaporate and the drying is determined by the absorbent balance between the ambient air and the solid matter

6 Appendix

6.1 Service and support

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https://support.industry.siemens.com/cs/ww/en/sc/2067

6.2 Links and literature

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to this entry page of this application example https://support.industry.siemens.com/cs/ww/en/view/74747848
\3\	SIMATIC PCS 7 overview (collection of links for FAQ, manuals, compendium, forum, application examples and multimedia) https://support.industry.siemens.com/cs/ww/en/view/63481413
\4\	How do you do a controller optimization with the PCS 7 PID Tuner? https://support.industry.siemens.com/cs/ww/en/view/8031495
\5\	Equipment Modules for PCS 7 using the example of the Chemical Industry https://support.industry.siemens.com/cs/ww/en/view/53843373
\6\	PCS 7 Unit Template industry "Stirred Tank Reactor" using the example of the Chemical Industry https://support.industry.siemens.com/cs/ww/en/view/60546560
\7\	PCS 7 Unit Template "Fermenter" using the example of the Chemical Industry https://support.industry.siemens.com/cs/ww/en/view/68098270
\8\	PCS 7 Unit Template "Distillation Column" using the example of the Chemical Industry https://support.industry.siemens.com/cs/ww/en/view/48418663
\9\	How do you procure documentation for PCS 7 (including the PCS 7 Manual Collection)? https://support.industry.siemens.com/cs/ww/en/view/59538371
\10\	Fluidized Bed Dryer - Design of Model Predictive Control with Economical Steady State Optimization https://support.industry.siemens.com/cs/ww/en/view/109754967
\11\	SIMATIC Process Control System PCS 7 Advanced Process Library (V9.0 SP1) https://support.industry.siemens.com/cs/ww/en/view/109754967
\12\	Practical manual for controllers with SIMATIC S7 and SIMATIC PCS 7 for process automation Müller, Jürgen / Pfeiffer, Bernd-Markus / Wieser, Roland Publicis Kommunikationsagentur ISBN 978-3895783401
\13\	Control and optimization of dryers Pfeiffer, B-M.: Efficient operation of fluidized bed dryers with Advanced Process Control VDI-Kongress Automation 2013, Baden-Baden. VDI-Berichte 2209, P. 201-206, VDI Verlag, Düsseldorf.

6.3 Change documentation

Version	Date	Modifications
V1.0	11/2013	First version
V1.1	10/2018	Update for PCS 7 V9.0 SP1, Integration of Smart Alarm Hiding, Note on Managed System Services in Chapter 1.3

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