Short description
Unit Template
Gas Fired Steam Boiler

SIMATIC PCS 7 V9.0 SP1 / SIS compact V9.0 SP1

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Table of contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Overview</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Contents of the Unit Template</td>
<td>6</td>
</tr>
<tr>
<td>3.1</td>
<td>Process graphics</td>
<td>6</td>
</tr>
<tr>
<td>3.2</td>
<td>Simulation</td>
<td>7</td>
</tr>
<tr>
<td>3.3</td>
<td>Safety system</td>
<td>8</td>
</tr>
<tr>
<td>3.3.1</td>
<td>Boiler protection</td>
<td>8</td>
</tr>
<tr>
<td>3.3.2</td>
<td>Boiler pre-purge</td>
<td>9</td>
</tr>
<tr>
<td>3.3.3</td>
<td>Burner protection</td>
<td>9</td>
</tr>
<tr>
<td>3.4</td>
<td>Burner control</td>
<td>10</td>
</tr>
<tr>
<td>3.5</td>
<td>Closed-loop control</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Appendix</td>
<td>11</td>
</tr>
<tr>
<td>4.1</td>
<td>Service and Support</td>
<td>11</td>
</tr>
<tr>
<td>4.2</td>
<td>Links and Literature</td>
<td>12</td>
</tr>
<tr>
<td>4.3</td>
<td>Change documentation</td>
<td>12</td>
</tr>
</tbody>
</table>
1 Introduction

The unit template “Gas Fired Steam Boiler” contains a template for a steam generator, including all the typical components, their control and safety technology, including visualization.

This brief description is intended to give you an overview of the structure and the functionalities of the unit template.

The complete documentation and the sample project for PCS 7 and SIS compact are available free of charge. For more information on obtaining the unit template, see the corresponding entry page in Industry Online Support:

- SIMATIC PCS 7 Unit Template “Gas Fired Steam Boiler”
- SIMATIC SIS Compact Unit Template “Gas Fired Steam Boiler”

2 Overview

In the unit template, a steam boiler for steam generation is implemented which is heated by two identical gas burners. Included are a model-based predictive controller (Model Predictive Control, MPC) in a furnace for steam generation as well as various safety functions of a boiler and burner control system similar to those found in industrial plants.

Figure 2-1 Structure of the steam generator
Mode of operation

The burners supply the steam boiler with heat energy through the combustion of natural gas. Closed-loop control of the combustion air required is separate for each of the burners.

Feed water is supplied to the steam generator by a pump and a control valve. Before the water reaches the drum it is pre-heated by the exhaust air stream. In the boiler the feed water is heated up and vaporized via riser pipes. The saturated steam flows from the drum and is overheated in the flue gas path. A part of the saturated steam is conducted past the overheater via a bypass, to be mixed with the overheated steam.

During operation it is possible to switch between the burners without a problem, so that either only one of the burners alone or both burners together can be active. This automation solution takes the number of active burners into account when regulating and for the safety functions.

Scope of Operation of the Unit Template

The following functions are components of the unit template “Gas Fired Steam Boiler”:

- Boiler protection
- Burner protection
- Supervisory MPC control
- Boiler control
- Burner control

Norms

The “Gas Fired Steam Boiler” unit template is based on the specifications of the following standards:

- DIN EN 746-2:2010
  Industrial Thermoprocessing Equipment, Part 2: Safety requirements for combustion and fuel handling systems
  Automatic forced draught burners for gaseous fuels
- DIN EN 50156-1:2015
  Electrical Equipment For Furnaces And Ancillary Equipment, Part 1: Requirements For Application Design and Installation
- DIN EN 1643:2014
  Valve proving systems for automatic shut-off valves
- DIN EN 12067-2:2004
  Gas/air ratio controls for gas burners and gas-burning appliances
  Part 2: Electronic types
- IEC 61511:2016
  Functional safety -- Safety systems for the process industry
- ISO 13577
  Industrial furnaces and associated processing equipment -- Safety --
3 Contents of the Unit Template

The following chapters consist of excerpts from the documentation and are intended to give you an insight into the contents of the unit template.

3.1 Process graphics

The unit template contains three process graphics for operating and monitoring the steam generator with the Operator Station (OS):

- Steam Generator
- Burners 1 and 2
- Feedwater & Steam

Figure 3-1 shows the process graphic of the steam boiler where the operator can obtain an overview of the entire plant unit and can also carry out important operating functions.

Figure 3-1 Process graphic of the steam boiler

In addition, each burner has its own subordinate process graphic for operations involving only one burner.

Figure 3-2 Process graphic of Burner 1
3 Contents of the Unit Template

The feed water & steam process graphic contains the control for the steam temperature and the drum level.

Figure 3-3 Feed water & steam process graphic

3.2 Simulation

For the execution of tests, the unit template includes a simulation with a functional test environment that can be run in S7 PLCSIM or a CPU 410. Part of the simulation is a simple process simulation which shows the significant aspects of the behavior of a steam boiler and the simulation of the protective interlocks. A complete data model of the devices or concrete settings does not form part of this simulation.

In the simulation process graphics, the simulation can be switched on and off and the protective interlocks can be tested as required, see Figure 3-4.

Figure 3-4 Simulation process graphics of "Unit Boiler" and "1stEMBurner".
3.3 Safety system

In all operating states of a steam boiler, safety requirements must be fulfilled in accordance with the applicable standards.

The overarching safety criteria for system protection are implemented in the boiler protection and boiler pre-purging, under compliance with relevant regulations. The burner-specific protection criteria have been implemented for each burner.

Figure 3-5 Process graphic for system protection

3.3.1 Boiler protection

Boiler protection ensures compliance with the requirements that concern the entire boiler. If one of the criteria monitored here leaves the permissible range, the firing system is switched off immediately.

Figure 3-6 shows the visualization of the shutdown commands on the OS.
3.3.2 Boiler pre-purge

Before igniting the first burner, it must be ensured that there is no flammable gas mixture in the boiler combustion chamber or flue gas duct. This is achieved by producing a corresponding air flow rate through all critical areas before ignition. This procedure is called pre-purging.

Boiler pre-purge is controlled by an SFC sequence (PCS 7 version) respectively a sequential control system (SIS compact version) and monitored by a fail-safe CFC chart based on pre-purge criteria.

Figure 3-7 Section of process graphic – Pre-purge criteria

3.3.3 Burner protection

The burner protection is implemented by a safety release of the superordinate boiler protection (“boiler protection”) and the actual burner protection interlocks (“burner protection”).

Figure 3-8 shows the visualization of the burner protection function on the OS.

Figure 3-8 Section of process graphic EM Burner 1 – Burner protection
3.4 Burner control

The burner control unit is a sequence controller and serves for the automatic start-up and shutdown of the gas burner. It is based on the functions of the Burner component library for S7 F Systems (see §3) and is divided into individual functions according to the requirements of EN 746-2, each of which is independently programmed.

Protection functions of the burner control

In addition to the general burner protection measures, control and, where appropriate, monitoring of the fuel/air ratio in accordance with DIN EN 12067-2:2004 shall be carried out in a sufficiently accurate manner.

In the unit template the following protection measures have thereby been implemented for burner open- and closed-loop control:

- Protective function for monitoring the fuel/air ratio λ by means of gas and air flow.
- Protective function for position monitoring of fuel and combustion air actuators:
- Feedback circuit monitoring of the gas fast-action stop valves and ignition system

3.5 Closed-loop control

The closed-loop control of the steam boiler is implemented with a structure consisting of subordinate PI controllers and a supervisory model-based predictive multi-variable controller (MPC).

Figure 3.9 Overview of the steam boiler regulation
4 Appendix

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4.2 Links and Literature

Table 4-1

<table>
<thead>
<tr>
<th>No.</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1\</td>
<td>Siemens Industry Online Support</td>
</tr>
<tr>
<td></td>
<td><a href="https://support.industry.siemens.com">https://support.industry.siemens.com</a></td>
</tr>
<tr>
<td>2\</td>
<td>Link to this entry page of this application example</td>
</tr>
<tr>
<td>3\</td>
<td>Burner Technology for S7 F Systems (Burner Library)</td>
</tr>
<tr>
<td>4\</td>
<td>SIMATIC PCS 7 Unit Template “Gas Fired Steam Boiler”</td>
</tr>
<tr>
<td>5\</td>
<td>SIMATIC SIS Compact Unit Template “Gas Fired Steam Boiler”</td>
</tr>
</tbody>
</table>

4.3 Change documentation

Table 4-2

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Modifications</th>
</tr>
</thead>
<tbody>
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<td>First version</td>
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