Project:

MULTI FUEL CFB BOILER SIMULATOR

Author: JJA

Approved:

Language:

Document title:

SYSTEM DESCRIPTION

HP STEAM SYSTEM

Submitted for:

Customer reference:

Other information:
# TABLE OF CONTENTS

1 GENERAL .......................................................................................................................... 3  
2 DESIGN DATA ...................................................................................................................... 4  
3 EQUIPMENT DATA ............................................................................................................. 4  
  3.1 HP-bypass reduction stations ............................................................................................ 4  
  3.2 Reheater safety valves ....................................................................................................... 5  
  3.3 LP-bypass reduction station .............................................................................................. 5  
  3.4 Piping ............................................................................................................................. 6  
4 AUTOMATION AND INSTRUMENTATION ....................................................................... 7  
  4.1 General ............................................................................................................................ 7  
  4.2 Main steam pressure in bypass operation .......................................................................... 7  
  4.3 Cold reheat temperature in bypass operation ................................................................... 7  
  4.4 Reheat steam pressure in bypass operation ...................................................................... 7  
5 OPERATION ........................................................................................................................ 8  
  5.1 General ............................................................................................................................ 8  
  5.2 Start-up ............................................................................................................................ 8  
  5.3 Normal operation ............................................................................................................. 8  
  5.4 Operating disturbances ...................................................................................................... 8  
    5.4.1 Turbine trip .................................................................................................................. 8  
    5.4.2 High level in cold reheat drain pocket ......................................................................... 9  
6 CONNECTED SYSTEMS ..................................................................................................... 9
1 GENERAL

The function of the high pressure steam system is to deliver steam generated in the boiler to the steam turbine. The steam turbine is a two casing turbine with a common HP/IP-casing and a LP-casing. After the expansion in the turbine HP casing, cold reheat steam will be reheated in the boiler reheaters. After reheating, hot reheat steam is delivered to the turbine IP casing and further to the LP-casing.

The high pressure steam system is shown diagram S1LB____-MFB1001. Pipe drains are shown in diagram S1LB____-MFB1002.

Superheated high pressure steam is led from the boiler to the steam turbine through the main steam piping S1 LBA10/20/31/32. Maximum operating values after boiler are 169 bar(g) / 563 °C / 113 kg/s. Nominal live steam parameters at the turbine are 158 bar(g), 558 °C at the 100 % (MCR) load point and 165 bar(g), 560°C with turbine valves wide open.

As safety device for the boiler and main steam piping there are two HP-bypass stations (2 x 50 %) S1 LBH10/20 AA201 bypassing the HP-casing to the cold reheat line.

The HP-bypass stations are also used for start-up and house load operation of the power plant.

From the HP-casing the cold reheat steam is led through cold reheat piping S1 LBC10 to the boiler reheater. Hot reheat steam is led through the hot reheat piping S1 LBB10/31/32 to the IP-turbine. Reheated steam values are 33 bar(g), 561°C.

Cold reheat steam is used for feed water preheating in preheater HP-2. Cold reheat steam is also used as backup for the auxiliary steam system by feeding the auxiliary steam header with the auxiliary steam reduction station at low load and turbine bypass operation. Stabilising steam to the feed water tank in a turbine trip is also taken from the cold reheat pipe with the deaerator steam reduction station.

The function of the LP-bypass station S1 LBB20 AA201 is to bypass the IP/LP-turbine from the hot reheat to the condenser. The LP bypass station is used in start-up and house load operation of the power plant and during a steam turbine trip.

As safety device for the reheater and reheat piping there are two reheater safety valves (2 x 50 %) S1 LBB10 AA401/402.
2 DESIGN DATA

As design basis for the HP-steam system and the turbine extraction piping are the heat & mass balance calculations of the power plant. The design data for bypass station and reheater safety valves are given below.

Safety functions of HP-bypass stations and reheater safety valves are according to standard TRD421.

3 EQUIPMENT DATA

3.1 HP-bypass reduction stations

KKS Code S1 LBH10/20 AA201.

The function of the HP bypass stations is to work as safety device for the boiler and main steam piping. The capacity of the HP bypass stations is the same as the maximum steam generation capacity of the boiler. The safety function pressure impulses are taken from the boiler drum (1) and main steam pipe (2). The HP bypass stations are equipped with a control function acting at lower pressure than the safety function. The temperature after the HP bypass stations is controlled to 400°C. The HP bypass stations will also be used for start-up and house load operation of the power plant.

Number of units 2 x 50%

Pressure set values:

Mechanical design pressure: 184 bar(g)
Safety function (main steam pipe): 183 bar(g)
Safety function (boiler steam drum): 201 bar(g)
Control function set pressure: 173 bar(g)*)
Normal operating pressure: 169 bar(g)

*) Operating pressure set value + 4…6 bar. To be checked during commissioning.

Steam pressure IN/OUT bar(a) 184/51
Steam temperature IN/OUT °C 570/400
Steam flow IN/OUT kg/s 56.6/62.8
Spray water flow kg/s 6.2
Spray water pressure bar(a) 178…199
Spray water temperature °C 143…158

Spray water to HP-bypass reduction stations is taken from the discharge side of the feed water pumps before the HP-preheaters.
3.2 Reheater safety valves
KKS Code S1 LBB10 AA401/402.

The function of the Reheater safety valves is to protect the reheater against overpressure. The capacity of the Reheater safety valves is equal to the outlet capacity of the HP bypass stations. The pressure impulses are taken from the cold reheat pipe (1) and hot reheat pipe (2). The HP bypass stations are equipped with a control function acting at lower pressure than the safety function.

The back pressure of the safety valve (blow-out pipe and silencer) is specified to 15 % of the opening pressure.

The pressure drop of the reheater in HP bypass operation is 6.8 bar. A reheater safety valve is also used as start-up valve for the power plant. Dimensioning criteria for this mode of operation is 11.5 kg/s, pressure 9 bar(g), temperature 180 °C and backpressure 0.5 bar(g).

Number of units: 2 x 50 %
Capacity (main steam): 2 x 62.8 kg/s
Cold reheat:
Safety function: 50 bar(g)
Normal operating pressure: 37 bar(g)
Hot reheat:
Safety function: 43 bar(g)
Safety valve closing: 40.8*)
Control function set pressure: 40 bar(g)**)
LP bypass station opening: 36 bar(g)
Normal operating pressure: 33 bar(g)

*) Safety valve closing to be checked with valve manufacturer (assumed 95% of opening pressure).
***) LP-bypass opening pressure set value + 4 bar. To be checked during commissioning.

3.3 LP-bypass reduction station
KKS Code S1 LBB20 AA201.

The function of the LP bypass station is to bypass the IP/LP-turbine. The LP bypass station is used in start-up and house load operation of the power plant and during a steam turbine trip. The LP bypass station is also controlling the reheater pressure so that the maximum allowed rate of pressure increase 2 bar/min is not be exceeded.

The design criterion for the LP-bypass station is sufficient steam flow in house load operation and plant start-up.
Number of units and capacity: 1 x 79.5 kg/s

Pressure set value:
- Mechanical design pressure: 50 bar(g)
- Control function set pressure: 36 bar(g)*)
- Normal operating pressure: 33 bar(g)
- Safety function close: xx bar(g) (condenser pressure)**)

*) To be checked during commissioning.
**) The LP bypass station will also be closed if the maximum allowable temperature in the condenser 80 °C is exceeded.

Steam pressure IN/OUT bar(g) 43 / 0.03
Steam temperature IN/OUT °C 560 / 60
Steam flow IN/OUT kg/s 79.5 / 110
Spray water flow kg/s 30.5
Spray water pressure bar(g) 14
Spray water temperature °C 23

Spray water to LP-bypass reduction station is taken from the discharge side of the main condensate pumps after gland steam condenser.

3.4 Piping

Dimensioning of the main high pressure steam pipelines is as follows:

<table>
<thead>
<tr>
<th>TAG number</th>
<th>S1 LBA10</th>
<th>S1 LBC10</th>
<th>S1 LBB10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating values:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass flow kg/s</td>
<td>113.2</td>
<td>108.5</td>
<td>98.4</td>
</tr>
<tr>
<td>Temperature °C</td>
<td>563</td>
<td>348</td>
<td>561</td>
</tr>
<tr>
<td>Pressure bar(g)</td>
<td>169</td>
<td>37</td>
<td>33</td>
</tr>
<tr>
<td>Mech. design values:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design temp. °C</td>
<td>570</td>
<td>450</td>
<td>570</td>
</tr>
<tr>
<td>Design pressure bar(g)</td>
<td>184</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Material</td>
<td>X11CrMoWVNb911</td>
<td>15Mo3</td>
<td>X10CrMoVNb91</td>
</tr>
<tr>
<td>Du x s (main pipe)</td>
<td>355.6 x 40</td>
<td>610 x 22.2</td>
<td>610 x 25</td>
</tr>
</tbody>
</table>
4 AUTOMATION AND INSTRUMENTATION

4.1 General

In normal operation the steam conditions of main steam and reheat steam is controlled with boiler and turbine. These are described in boiler and turbine system descriptions. Below the main control loops in bypass operation are described.

4.2 Main steam pressure in bypass operation

In bypass operation the main steam pressure is controlled with the HP-bypass stations.

4.3 Cold reheat temperature in bypass operation

In bypass operation the cold reheat temperature is controlled with the HP-bypass station spray water control valves.

4.4 Reheat steam pressure in bypass operation

In bypass operation the reheater steam pressure is controlled with the LP-bypass station as long as the reheater steam flow is below the maximum capacity of the LP-bypass station. Thereafter the reheater pressure is controlled with the reheater safety valves.
5 OPERATION

5.1 General

Different modes of operations such as plant start-up, normal operation, shut-down and disturbances are described separately. Below is given only special consideration for the HP-steam system.

5.2 Start-up

In the start-up (manually operated) drain as well venting valves are fully open. Venting valves are gradually closed with increasing pressure and at the drum pressure of 1,5 – 2 bar(g) completely closed. Drain valves are gradually closed with increasing pressure (8…12 barg) and temperature in order to avoid excessive steam blow-out, but all the time the valve opening has to be sufficient to remove all condensate from the pipe.

Fully closed drain valve is not allowed before superheated steam (>30 °C superh.) conditions exist. This situation should be at the pressure of 8…12 bar(g).

Ensure, that main steam pipe steam trap is left in operation. Ensure, that all pressure gauges and measurements check valves are open.

Heating instructions for the steam turbine are given in turbine system descriptions.

5.3 Normal operation

Under normal operating conditions no special consideration is needed except for normal supervision of the operation. Drainage of pipes during normal operation is arranged with steam traps where needed.

5.4 Operating disturbances

5.4.1 Turbine trip

After a turbine trip steam flow in the turbine side branches of the HP-piping will stop. This results in cooling of the piping towards saturated steam conditions. If needed, necessary drain valves have to be opened to intermediate position to maintain superheated steam conditions.
When turbine trip occurs, it will form pressure hammer effect in the steam piping, when steam flow shortly “stops”. Automation is build to avoid this effect, therefore HP by-pass to hot reheat is opened as well LP by-pass is opened if vacuum of the condenser is not broken. During the turbine trip it is possible, that safety-/start valve will shortly open also. When turbine trip occurs also load of the boiler will be reduced to certain level.

In bypass operation the main steam pressure is controlled with the HP-bypass station and reheat pressure is controlled with the LP by-pass valve or safety-/start up valves.

5.4.2 High level in cold reheat drain pocket

The main drain point in the cold reheat line is equipped with a level measurement in the drain pocket. If the water level in the drain pocket rises above set point drain stop valves S1 LCB10 AA103…104 will automatically open.

6 CONNECTED SYSTEMS

Superheaters S1 HAH__.MFB0001
Feed water system S1 LA__.MFB1001
HP -preheating S1 LAD__.MFB1001
Reheater S1 HAJ__.MFB0001
Condenser S1 LC__.MFB1001
Steam turbine S1 LB__.BFB2503
Turbine hall drains S1 LB__.MFB1002
Water & steam, main flow chart S1 L____.MFB1001