**MULTI FUEL CFB BOILER SIMULATOR**

<table>
<thead>
<tr>
<th>Author:</th>
<th>Approved:</th>
<th>Language:</th>
</tr>
</thead>
<tbody>
<tr>
<td>JJA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SYSTEM DESCRIPTION**

**PRIMARY AIR SYSTEM**

<table>
<thead>
<tr>
<th>Submitted for:</th>
<th>Customer reference:</th>
<th>Other information:</th>
</tr>
</thead>
</table>
TABLE OF CONTENTS

1 GENERAL ..................................................................................................................................3
2 DESIGN DATA ..........................................................................................................................3
3 EQUIPMENT DATA .................................................................................................................4
  3.1 Ducts ........................................................................................................................................7
  3.2 Primary air (PA) fan .....................................................................................................................4
  3.3 Control dampers inlet air .............................................................................................................4
  3.4 Flow measuring device ................................................................................................................4
  3.5 Inlet silencer ................................................................................................................................5
  3.6 Inlet vane ....................................................................................................................................5
  3.7 Steam coil air heater .....................................................................................................................5
  3.8 Tubular air heater ........................................................................................................................5
  3.9 Duct burner dampers ....................................................................................................................5
  3.10 Dampers to fuel feeding .............................................................................................................6
  3.11 Manual dampers to fuel feeding ..................................................................................................6
  3.12 Control dampers inlet to windbox ..............................................................................................6
  3.13 Duct burners ...............................................................................................................................6
  3.14 Booster air fans ............................................................................................................................6
4 AUTOMATION .........................................................................................................................7
  4.1 General .........................................................................................................................................7
  4.2 PA flow control ............................................................................................................................7
  4.3 Air temperature control ................................................................................................................7
5 OPERATION .............................................................................................................................8
  5.1 Start-up prechecks .......................................................................................................................8
  5.2 Start-up ........................................................................................................................................8
  5.3 Normal operation ........................................................................................................................9
  5.4 Shut down ....................................................................................................................................9
  5.5 Operating Disturbances ................................................................................................................9
    5.5.1 Power failure ............................................................................................................................9
    5.5.2 Operating failure ......................................................................................................................9
    5.5.3 High or low bed temperatures .............................................................................................10
    5.5.4 High or low bed pressure ......................................................................................................10
    5.5.5 Intermittent loss of bed inventory from circulation ..............................................................11
    5.5.6 Continuous gradual loss of bed inventory from circulation ...............................................11
    5.5.7 Excessive bed temperature ..................................................................................................11
    5.5.8 Tube leakages .......................................................................................................................12
    5.5.9 Air side or gas side failures .................................................................................................13
6 CONNECTED SYSTEMS ........................................................................................................13
7 APPENDICES ........................................................................................................................13
1 GENERAL

Primary air (PA) is supplied by one 100 % capacity centrifugal fan. Primary air is draft from inside or outside of boiler house through venturi flow measurement. After fan air is heated by steam coil air heater and flue gas air pre heater, after that air flow is led to a two-compartmented windbox under the grid of the combustion chamber. It is used as the source of fluidizing air for the circulating bed of fuel and sorbent in the combustion chamber and supplies most (~55 %) of the combustion air for the process. PA is used for force air for fuel feeding chutes and as spoon air at the hot end of fuel feed screws.

After flue gas air preheater PA flow is divided to four ducts, two to fuel feedings and two to windbox. Before windbox both PA ducts have flow measurement and own control valves, following branch for duct burner booster fan and duct burner.

Duct burners are used to heat PA during boiler start up phase to make it shorter. More about duct burners in “System description of duct burner system”

There is a minimum flow of primary air required to fluidize the bed and prevent back flow of the material through the nozzles. So at low loads the primary air flow remains constant and does not vary with load.

2 DESIGN DATA

Draft losses

<table>
<thead>
<tr>
<th></th>
<th>Pa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ducts, airheater</td>
<td>1092</td>
</tr>
<tr>
<td>Grid</td>
<td>4652</td>
</tr>
<tr>
<td>Bed</td>
<td>8000</td>
</tr>
<tr>
<td>Total</td>
<td>13744</td>
</tr>
</tbody>
</table>
3 EQUIPMENT DATA

3.1 Ducts

Primary air ducts are generally made of 4mm steel plate S235JRG2. Primary air duct from burner chambers and windbox’s are made of 6/4mm 13CrMo45. Chambers them selves are 10mm S235JRG2.

All ducts are furnished with necessary fittings such as:
- bellows
- stiffeners
- supports

3.2 Primary air (PA) fan S1 HLB10 AN101

Design values at fan

<table>
<thead>
<tr>
<th>Parameter</th>
<th>110 %</th>
<th>100 % MCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow rate m³n/s</td>
<td>76,9</td>
<td>66,7</td>
</tr>
<tr>
<td>Temp. °C</td>
<td>34</td>
<td>25</td>
</tr>
<tr>
<td>dp kpa</td>
<td>23,9</td>
<td>20,1</td>
</tr>
<tr>
<td>Motor power kW</td>
<td>2361</td>
<td>1905</td>
</tr>
<tr>
<td>Speed rpm</td>
<td>1479</td>
<td>1479</td>
</tr>
</tbody>
</table>

3.3 Control dampers inlet air S1 HLA01/02 AA201

Manufacturer Sammet

- suction inside boiler house mm Ø 2450
- suction outside boiler house mm 2300x2300

Actuator Automatic

Dampers are mechanically bund together. Operating one damper operates also other.

3.4 Flow measuring device S1 HLA10 CF201/202

Venturi type flow measurement in suction duct

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Fe37</td>
</tr>
<tr>
<td>Temperature °C</td>
<td>25</td>
</tr>
<tr>
<td>V dim / V nom Nm³/s</td>
<td>85 / 66,7</td>
</tr>
<tr>
<td>dp dim / dp nom Pa</td>
<td>285 / 175</td>
</tr>
<tr>
<td>p dim Pa</td>
<td>1200</td>
</tr>
</tbody>
</table>
3.5 Inlet silencer

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow area</td>
<td>m²</td>
</tr>
<tr>
<td>Width</td>
<td>m</td>
</tr>
<tr>
<td>Depth</td>
<td>m</td>
</tr>
<tr>
<td>dp</td>
<td>Pa</td>
</tr>
</tbody>
</table>

3.6 Inlet vane

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Fläkt Woods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actuator</td>
<td>Automatic</td>
</tr>
</tbody>
</table>

3.7 Steam coil air heater

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Nema</td>
</tr>
<tr>
<td>Air flow</td>
<td>Nm³/s</td>
</tr>
<tr>
<td>Inlet / Outlet temp</td>
<td>°C</td>
</tr>
<tr>
<td>Steam consumption (dim.)</td>
<td>kg/s</td>
</tr>
<tr>
<td>Weight</td>
<td>kg</td>
</tr>
<tr>
<td>Max.oper. temp.</td>
<td>°C</td>
</tr>
<tr>
<td>Max.oper. pressure</td>
<td>bar(g)</td>
</tr>
<tr>
<td>Capacity</td>
<td>l</td>
</tr>
</tbody>
</table>

3.8 Tubular air heater

The boiler will be equipped with an air heater for primary and secondary air. Air heater is made of horizontal tubes and it is cross current flow type. Flue gas flow is in the shell side and air flow in the tube side. Air heater is located in the second pass after the economizer.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet temp</td>
<td>°C</td>
</tr>
<tr>
<td>Outlet temp</td>
<td>°C</td>
</tr>
</tbody>
</table>

3.9 Duct burner dampers

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>mm</td>
</tr>
<tr>
<td>Actuator</td>
<td></td>
</tr>
</tbody>
</table>

3.5 Inlet silencer

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow area</td>
<td>m²</td>
</tr>
<tr>
<td>Width</td>
<td>m</td>
</tr>
<tr>
<td>Depth</td>
<td>m</td>
</tr>
<tr>
<td>dp</td>
<td>Pa</td>
</tr>
</tbody>
</table>

3.6 Inlet vane

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Fläkt Woods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actuator</td>
<td>Automatic</td>
</tr>
</tbody>
</table>

3.7 Steam coil air heater

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Nema</td>
</tr>
<tr>
<td>Air flow</td>
<td>Nm³/s</td>
</tr>
<tr>
<td>Inlet / Outlet temp</td>
<td>°C</td>
</tr>
<tr>
<td>Steam consumption (dim.)</td>
<td>kg/s</td>
</tr>
<tr>
<td>Weight</td>
<td>kg</td>
</tr>
<tr>
<td>Max.oper. temp.</td>
<td>°C</td>
</tr>
<tr>
<td>Max.oper. pressure</td>
<td>bar(g)</td>
</tr>
<tr>
<td>Capacity</td>
<td>l</td>
</tr>
</tbody>
</table>

3.8 Tubular air heater

The boiler will be equipped with an air heater for primary and secondary air. Air heater is made of horizontal tubes and it is cross current flow type. Flue gas flow is in the shell side and air flow in the tube side. Air heater is located in the second pass after the economizer.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet temp</td>
<td>°C</td>
</tr>
<tr>
<td>Outlet temp</td>
<td>°C</td>
</tr>
</tbody>
</table>

3.9 Duct burner dampers

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>mm</td>
</tr>
<tr>
<td>Actuator</td>
<td></td>
</tr>
</tbody>
</table>
3.10  Dampers to fuel feeding  

Manufacturer: Sammet  
Size, front wall: 1050x1200 mm  
Size, rear wall: 850x600 mm  
Actuator: Aumatic  

3.11  Manual dampers to fuel feeding  

Manufacturer: Sammet  
Size: 600x400 mm  

3.12  Control dampers inlet to windbox  

Manufacturer: Sammet  
Size: 1750x1700 mm  

3.13  Duct burners  

Fuel: Light fuel oil  
$P_{\text{thermal}}$: 6.0 MW  
Oil consumption: 600 kg/h  
Air consumption: 1.9 Nm$^3$/s  

3.14  Booster air fans  

Manufacturer:  
Type:  
Flow rate:  
Temp.: $T_{\text{des}}$:  
Motor power:  
Speed:  
Actuator: Aumatic  

4 AUTOMATION

4.1 General
In this section automation is explained only basic level and more detailed descriptions can be found in Automation Descriptions.

The system calculates the required total air flow according to fuel feeding and amount of PA is calculated by subtracting amount of secondary air away. The system has given fuel and air flow per every fuel unit.

4.2 PA flow control

The primary airflow is controlled by primary air fan inlet vane. Primary air is one of the boiler interlocking quantities. MINIMUM 3 Nm³/s of primary air required by boiler interlocking must be supplied under the furnace grid, regardless of the control mode, to maintain stable combustion.

4.3 Air temperature control

Purpose of the controller is to protect flue gas duct from corrosion by keeping flue gas temperature above the dew point at low loads. Primary air duct is equipped with steam air heater for preheating the air before it enters the flue gas air heaters in the boiler. This steam-heaters steam control valve controls air temperature. Flue gas temperature control loop limits the set point so that the flue gases temperature remains above dew point. This limitation has also effect on the set point of secondary air temperature control.
5 OPERATION

5.1 Start-up prechecks

Before starting up the boiler assure that the system is ready for operation. If somebody has worked in the ducts, check before closing the manholes that the inner parts are ready for operation and no one is in the ducts.

Before starting the fan check that:
- All gas side manhole covers are in place
- All gas side access doors are closed
- Electrostatic precipitator available. Access doors closed and heaters switched on.
- PA fan is operative and properly lubricated
- PA flow controller/inlet vane is operative
- Control system interlocks checked and operative
- DCS screens are selected to the correct unit
- Auxiliary steam for steam coil preheater available
- Instrument air is available and instrument air dryers in service
- Flexible joints of the duct connections allow movement in all directions and all connections are tight.
- There is no water or other liquid or waste things in fan casing, casing drains are open and clean.

5.2 Start-up

NOTE: When starting the fan it is recommended to have the regulator almost closed, however, not completely closed. This procedure must be used especially when the gas reaches its final design temperature, slowly.

- Check that there are no valid protections for the primary air fan. Primary air fan can be started manually or from the air group/sequence function. It is recommended to use the air fan group start, because sequence makes all the necessary actions to start up the fan after all to required minimum rpm.
- (If started manually, switch on the primary air fan. Set the flow control damper of the primary air on automatic mode. After starting the fan the inlet vane regulator must be opened at 30° (or to minimum required degree, which is will be set during the fan commissioning). Long term use with smaller angles may harm the regulator.)
- The process gas temp. must not rise over the maximum operating temp. of the fan. Too high temperatures cause damage to the fan endangering the operational safety.
5.3 Normal operation

The combustion air amounts are determined according to the beforehand made diagrams. Check that a sufficient amount of primary air is supplied to fuel combustion. If necessary the air relation or the air distribution is changed.

During the operation observe:
- the operation of primary air flow controller (inlet vane locally & automation controller)
- the operation of the primary and secondary air flow rates
- the temperatures of the bearings of the fans
- the vibrations of the fan and the bearings.

5.4 Shut down

- Boiler load is reduced.
- The combustion with solid fuel is changed to oil combustion (if necessary). When no more steam is needed, the burners are stopped.
- The temp. control valve of the steam preheater (SCAH) is closed.
- The control of the primary air fan is set to manual operation and the output is reduced to minimum position.
- The primary air fan is stopped.

5.5 Operating Disturbances

5.5.1 Power failure

In case of a power failure, the primary air fan stops.

5.5.2 Operating failure

LOSS OF SERVICE of the following equipment will initiate an immediate automatic boiler shut down according to the emergency shut down. (Refer to list of the boiler main interlocks.) Primary air fan stopped.
5.5.3 High or low bed temperatures

- Check bed temperature thermocouples for consistent temperature readings throughout the bed.
- Never let the separator inlet temperatures exceed 950 °C. Excessive heat may damage refractory or tube metal.
- Check bed temperature thermocouples for trend in temperature - a sudden increase/decrease in temperature may indicate a faulty thermocouple, but as well problems at the bed as course bottom ash material size.
- Check fuel feeders for proper operation and normal fuel feed rate.
- Check for proper operation of all fans and blowers.
- Check PA to grid, PA to windbox air flows. Be sure of normal air split between PA and SA air flow. If a problem is found, report it and have repairs made as soon as possible.
- Check the excess O\textsubscript{2} in the flue gas. Be sure of normal operation of oxygen analyzers.
- Check for proper steam drum water level. If necessary, blow down gage glasses.
- Verify normal operation of feed water control valves.
- Check bottom ash screw conveyors and drag chain conveyor for proper operation.
- Verify bed material is being removed from the combustion chamber (normal rate).
- Check combustion chamber bed pressure.
- Verify pressure taps are not plugged.
  1. Verify normal air flows and pressure to instruments.
  2. Check for normal hot loop circulation temperatures.
  3. Check for deviations in normal indications.
  4. Monitor the trend recording of bed pressure for sudden changes.

5.5.4 High or low bed pressure

- Do not operate the CFB boiler without sufficient bed material in the combustion chamber to assure proper heat transfer.
- Check bed differential pressure - if abnormal, check pressure taps are not obstructed.
- Check bed pressure for trend.
- Check bed pressure transmitters and associated instruments for normal operation.
- Check for proper operation of all fans and blowers.
- Check for normal indication of pressures at windbox and grid.
- Verify air tight integrity of ductwork.
- Check bottom ash conveyors for proper operation.
- Verify bed material is being removed from the combustion chamber.
- Check for normal operation of limestone feed system.
- Verify normal discharge pressure.
- Verify that all feed lines are warm (not obstructed).
- Check for normal fuel feed rates for the indicated boiler load.
- Verify that solid fuel feeders are performing normally.
5.5.5 Intermittent loss of bed inventory from circulation

- Check for proper and normal fluidizing air flow to all gill seal fluidizing nozzles.
- If the float inside the rotameter is stuck on the bottom of the glass, it is an indication of a plugged nozzle.
- Applying service air to that nozzle may be necessary to unplug that nozzle and re-establish fluidizing air flow.
- Too much fluidizing air flow for an extended period can interfere with normal circulation.
- Check for normal operation and normal discharge pressure from high pressure blower.
- Verify that HP blower inlet filter is not plugged.
- Check for normal indications of bed inventory.
- Check for normal operation of all fans.
- Monitor air flow indications.
- Check all boiler gas side for leaks.

5.5.6 Continuous gradual loss of bed inventory from circulation

- Check operation of bottom ash removal system.
- Verify normal operation and conditions of bottom ash removal system.
- Check for gas tight integrity of combustion chamber.
- Walk down the boiler looking for bed material or gas leaks.
- Check the function of air fans and that they are set on correct operation modes.

5.5.7 Excessive bed temperature

- Check the bed quality and material circulation, when the bed temperature cannot be maintained below 950°C!
- Adjustment in the air flow distribution may be activated.
- Check, that recirculation fan is in operation, recirculation gas flow = bed temperature controller functions properly and is set on correct mode. Check also the set point of the bed temperature controller. Increase recirculation gas flow (to the primary duct), if possible, and note the change. Normally, increasing the primary air together with the recirculation gas flow to the grid will accomplish this.
- A reduction in fuel feed and/or an increase in total air flow may be required to control high temperatures.
- This reduces the bed temperature rapidly to reduce the high temperature, which if allowed to continue, may reach the ash fusion temperature for the fuel being burned.
- If the bed temperature cannot be controlled using the above procedure, the boiler must be shut down.
5.5.8 Tube leakages

- If a major leak occurs - burst of a tube - during operation, the combustion chamber pressure may rise due to the increase in flow caused by the sudden evaporation to steam.
- Should such a burst occur the ID fan flow should be increased and fuel flow stopped. At the same time steps should be taken to reduce the boiler pressure immediately with the start-up (or turbine by-pass) valve.
- Feed water should be brought to the boiler so, that the boiler parts do not overheat and only stopped when the flue gas temperatures have dropped below 400 °C. Keep the drum level at minimum.
- If the water level has been completely lost, do not bring cold feed water to a hot drum max. allowed difference ~ 50 °C. Check the feed water temperature after economiser and compare it to drum temperatures (drum material temperatures remains long time, because of thickness, ~110 mm, of the drum casing).
- Secondary air flow can be reduced but not completely stopped, while there is still combustible material (particle and gas) in the flue gases.
- Primary air for fluidising should be stopped, if the leakage is big. This will stop the burning at once in the bed. Otherwise primary air for fluidising can be kept at minimum flow until all the remaining fuel in the bed has burnt completely, and it helps also to get the rest of the bed ash away from the grid.
- Remove bed material via the ash cooler, if the leakage is entering the bed. Check, that (small amounts of) unburned fuel will not start to burn at the ash conveyors causing a fire.

For smaller leakages follow normal shut down procedures.
- Secondary air flow can be reduced but not completely stopped, while there is still combustible material in the gases.
- Primary air for fluidising can be kept at minimum flow until all the remaining fuel in the bed has burnt completely.
- Remove bed material via the ash cooler, if the leakage is entering the bed.
- Try to determine the approximate location of the leakage by walking round the boiler.
- Economiser leak may be detectable by sound or by an increase of make-up water flow.
- Note, that water leaks can lead to erosion of adjacent tubes and may cause plugging of ash hoppers and air heaters.
- Steam leaks in superheaters can cause considerable damage to adjacent tubes due to steam cutting.
- Operator judgement must be used to assess the seriousness of the failure and to decide whether an emergency or normal shut down should be performed.
- Monitor the leakage rate and cooling down rate.
5.5.9 Air side or gas side failures

- Trip of HP –blower automatically starts the stand-by blower. If HP –blower pressure decreases too low, the stand-by blower is started to support HP air system.
- The reason for pressure decrease may be leakage in piping, blower troubles or control valve (the by-pass valve) malfunction.
- LOSS OF SERVICE of the following equipment will initiate an immediate automatic boiler shut down according to the emergency shut down. (Refer to list of the boiler main interlocks – one of these interlock criteria is exceeded and boiler interlock system is released.)
  1. Primary air fan stopped.
  2. Secondary air fan stopped.
  3. Neither of high pressure blowers running.

6 CONNECTED SYSTEMS

- Flue gas system S1 HN__-MFB0001…0003
- HP –air (Intrex) system S1 QDA_-MFB0001
- Secondary air system S1 HL__-MFB0002
- Rec.gas system S1 HN__-MFB0002
- Aux. steam S1 LBG_-MFB1001

7 APPENDICES

Control- and logic diagrams