Doosan Lentjes

Supercritical 300 MW class CFB Boiler for low grade coal

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Abstract

In cooperation with its parent company DHI and supported by Doosan Babcock, Doosan Lentjes has developed a reference design for a 300 MW class SC-CFB boiler utilizing low grade coal. The activities have been backed by CFD analysis and physical model testing.

1. Why supercritical CFB

The international commitment to reduce global warming by cutting down the greenhouse gas emissions has become the main driver for high efficient steam generation technology.

Supercritical CFBC installations are able to substantially mitigate the environmental challenge through higher efficiencies compared to subcritical.

Furthermore supercritical steam generation has since long become the state of the art technology for PC-fired steam generators.

Feedback from numerous installations support that there is no difference in plant availability between supercritical and subcritical processes.

Supercritical water/steam cycles are even better suited for sliding pressure operation thus fulfilling the demand for improved operation flexibility.

International project financing institutes have become reluctant or even excluded subcritical projects from receiving financing or back up guarantees.

With the demand for larger unit capacities there is a clear trend towards supercritical CFBC.

IEA investigation supports this by predicting that the development of the installed coal fired capacity in Southeast Asia until 2040 will see a clear preference for new supercritical installation whereas the share of subcritical generation stagnates.

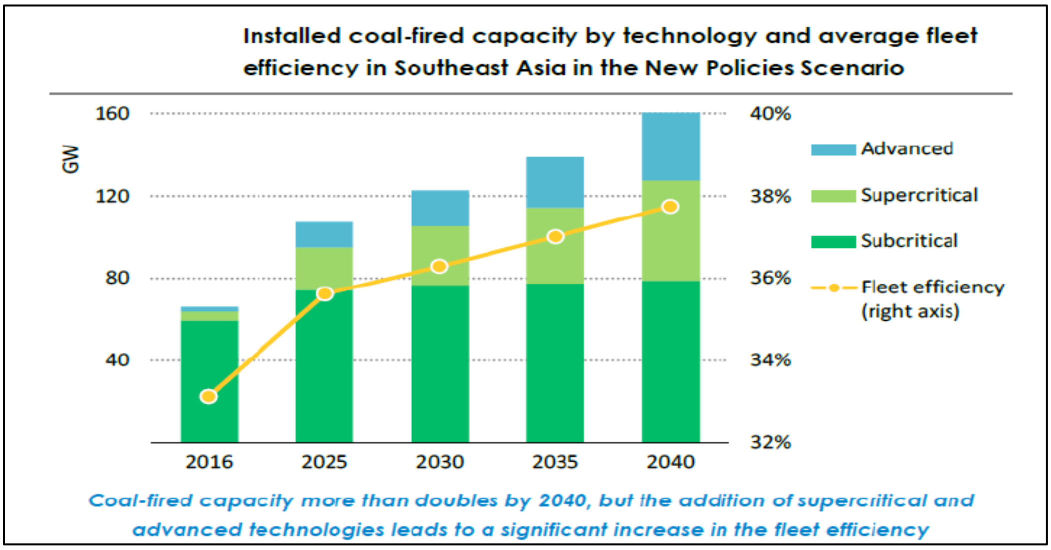

Table 1: Prediction of supercritical steam generation in SE-Asia (source:IEA)

2. Boiler Design Requirements for SC-CFB

Avoiding heavy brick lining by introducing water/steam cooled enclosures of different components instead of hot metal sheet casings has been one of the major design requirements. Failures of brickwork or refractory have been a major source of boiler shutdowns and poor plant availability figures in the past.

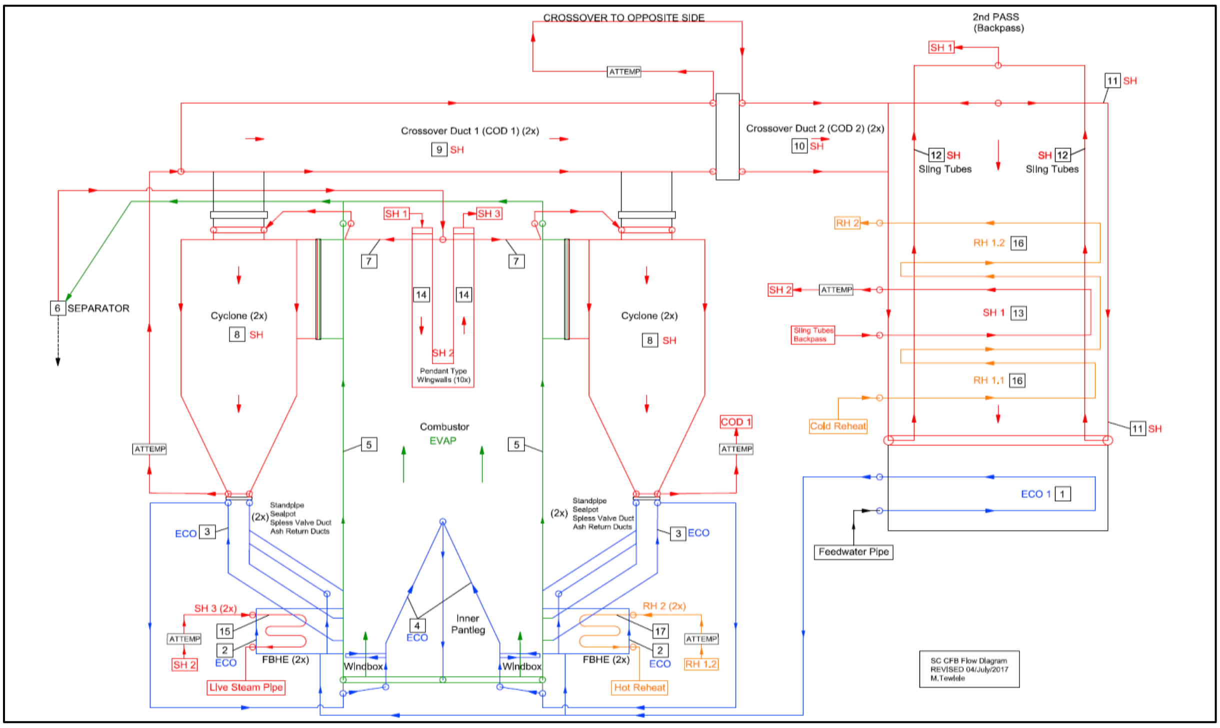

Figure 1: Water/steam circuit of boiler and components

Steam parameters have been chosen to utilize well proven steel grades including austenitic material.

Site Conditions

–	Elevation	860 m (914 mbar)
–	Temperature	3.6... 24 … 35°C
–	Relative Humidity	28 … 52 … 79%

Main Properties

- Super-Critical Water-Steam-Cycle
  - Gross Electrical output 335 MWe
  - SH-Steam 570°C / 258 bar(abs) / 947 t/h NR (1056 t/h BMCR)
  - RH-Steam 595°C / 55 bar(abs) / 781 t/h NR (873 t/h BMCR)
- Fuels
  - Main Fuel Hard Coal (50% ash, LHV :9,9 MJ/kg)
  - Start-up Fuel Fuel Oil

Table 2: Main boiler design data

Combustor size L x W x H (m):	19.68 x 13.74 x 42
Fuel flow (t/h):	88.47 … **272.2** … 367.7
Bed material flow (t/h)	0 … **0** … 0
Limestone (t/h)	6.77 … **17.26** … 37.89
Fly Ash (t/h)	6.249 … **25.5** … 36.24
Bed Ash (t/h)	35.01… **128.4** … 192.2
Total Ash (t/h)	41.73 … **153.9** … 228.4
Flue Gas (1000 m³/h, std)	628.4 … **983.6** … 1 162
Primary Air Flow (1000 m³/h, std)	300.6 … **406.9** … 474.2
Secondary Air Flow (1000 m³/h, std)	204.4 … **413.1** … 495.4

Table 3: Main boiler design results

The feeding system of coal and lime stone has undergone a complete redesign. Supported by thorough research and development activities and backed by CFD and physical modelling Doosan Lentjes introduced 2 circulated ash returns to the combustor per sealpot, thus doubling the number of ports through which the premixed flow of ash, coal and limestone enters the combustor.

This resulted in a substantially better distribution over the cross section of the combustor and a homogeneous release of fuel heat.

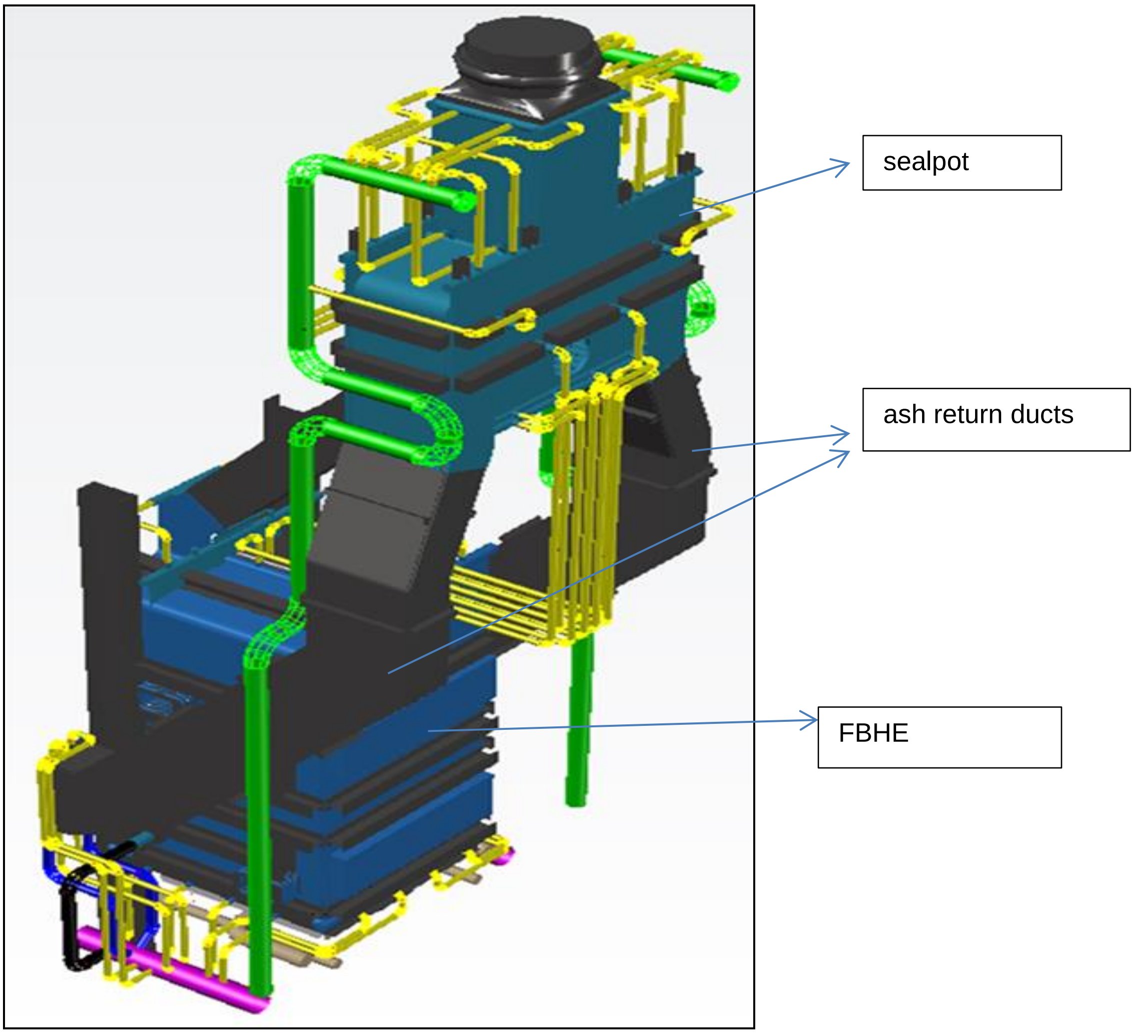

Figure 2: Ash return ducts from sealpot to combustor and FBHE

Optimisation of the fluidized bed heat exchanger (FBHE) has been another priority during the development of a reference product design for a SC-CFB boiler.

Doosan Lentjes opted for an integrated FBHE with water cooled casing which is directly attached to the combustor envelope wall, thus avoiding brick lined connection ducts and complicated expansion joints.

The FBHE itself has also been completely redesigned in order to achieve a homogeneous ash flow over the cross section and to minimise differences in heat flux to the immersed tube bank.

The evaporator has been designed utilizing the Posiflow technology licenced by Siemens. The system is characterized by low mass flow of 600-800 kg/m²s and a low pressure drop of about 3.5 bar.

As the denomination Posiflow suggests, the response of an individual tube to a higher heat flux is positive, this means that the water/steam flow will increase.

CFBC is well suited for vertical evaporator tubing since the heat flux distribution over the height of the furnace is quite even without featuring the high peak known from PC- furnaces.

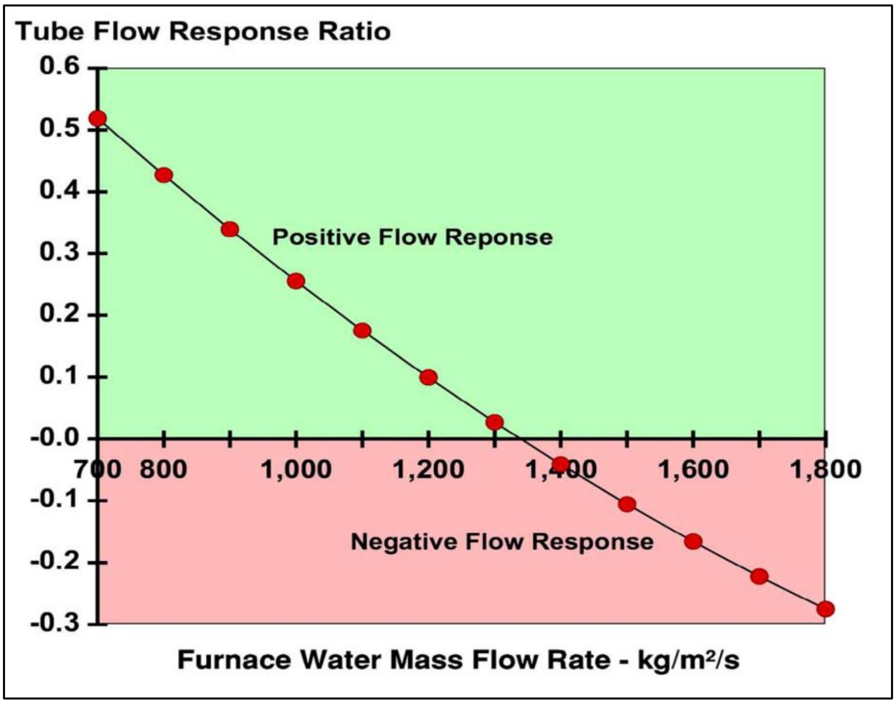

Table 4: Typical water flow response characteristic

High ash content in the coal results in a substantially increased amount of bottom ash which is not entrained into the flue gas and has to be discharged. The bottom ash requires to be cooled down from about 850 °C to 150°C, before it can be conveyed to the storage area.

3. Main Features of the 300 MW SC-CFB Boiler Design

The proven pantleg design, an opposed arrangement of 2x2 cyclones and integrated FBHE's are the main features of the combustor. The flue gas leaving the cyclones enters into a cross-over duct leading to the inlet of the convective pass. The convective pass accommodates most of the heating surfaces. Due to the elevated steam temperatures it has become necessary to arrange a pendent type superheater in the upper part of the combustor.

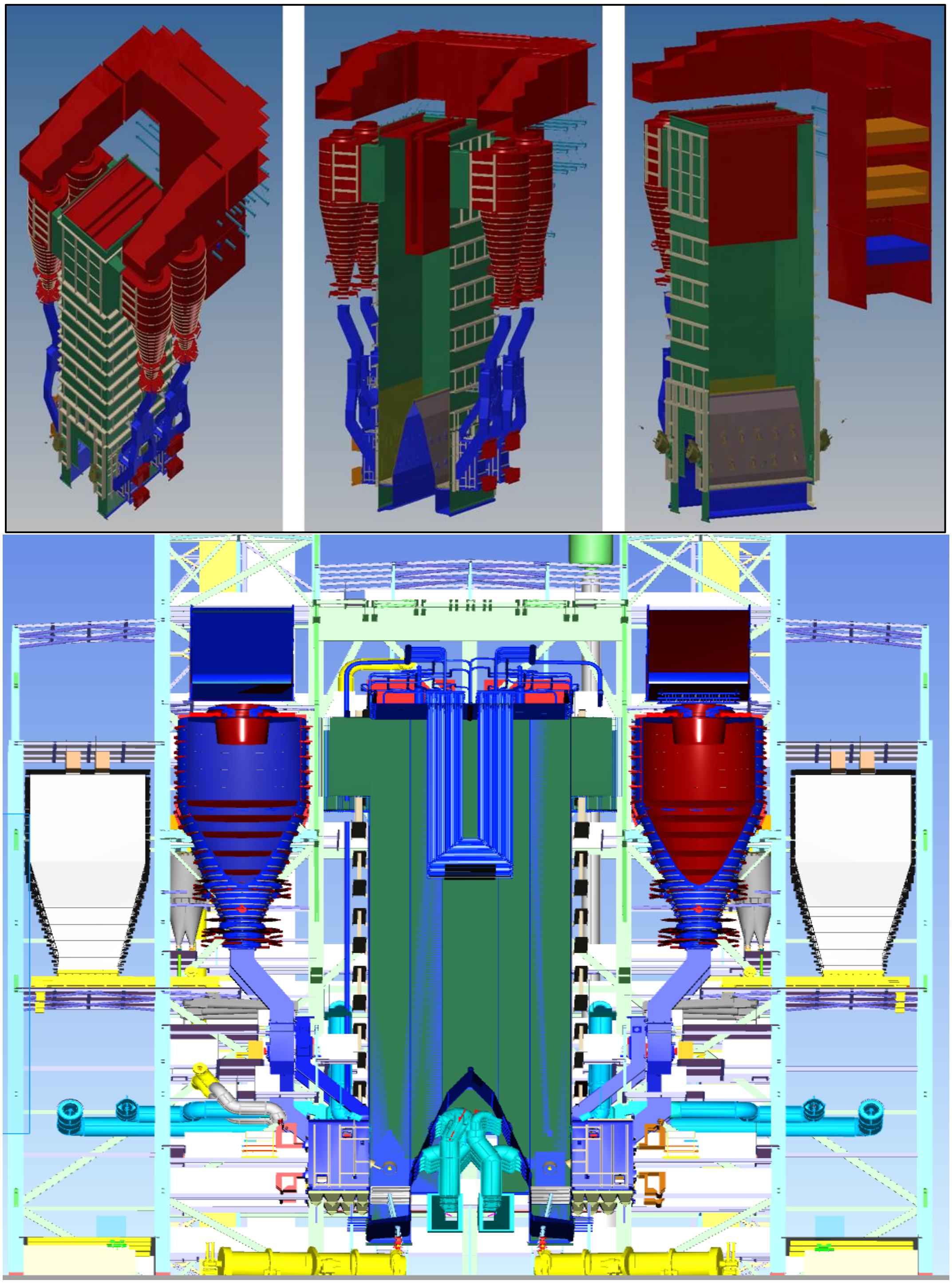

Figure 3: Overall boiler arrangement

The start-up burner system comprises 6 overhead burners, 2 each on front and rear wall and 1 on each side wall of combustor.

The fluidizing air nozzles have been redesigned, supported by CFD and model testing. Results from a reference installation verify the theoretical findings. Main objective has been to avoid any back flow of ash into the nozzle and subsequently into the windbox.

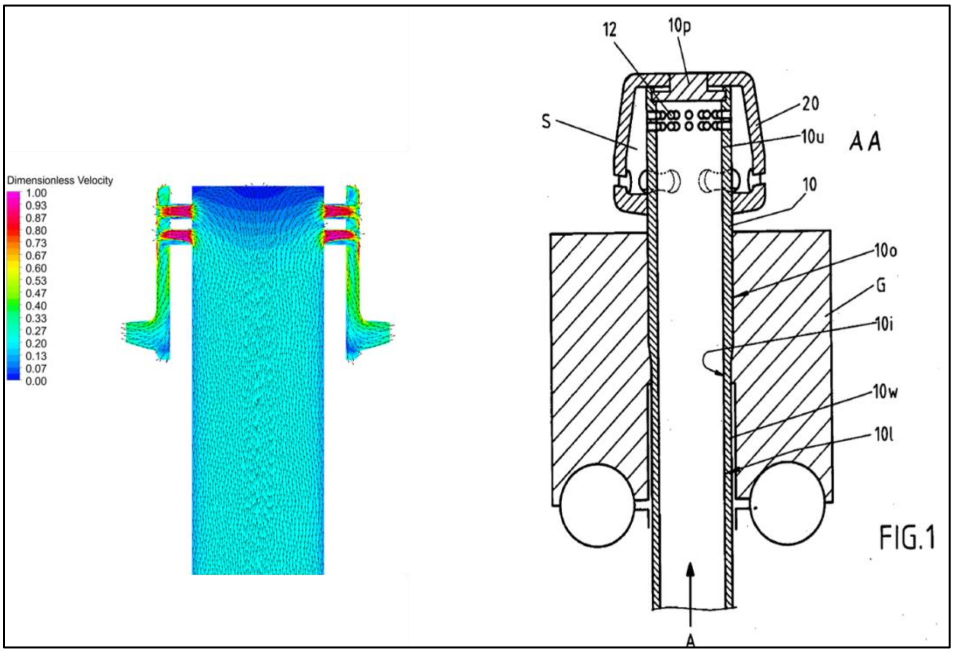

Figure 4: Nozzle design

Coal and limestone are fed on the circulated ash flow and enters via 2x4 ducts into the combustor. Flue gas, primary and secondary air system has been designed according to a 2x 60 % approach thus enabling part load operation in case of unavailability of one fan or one rotary air preheater.

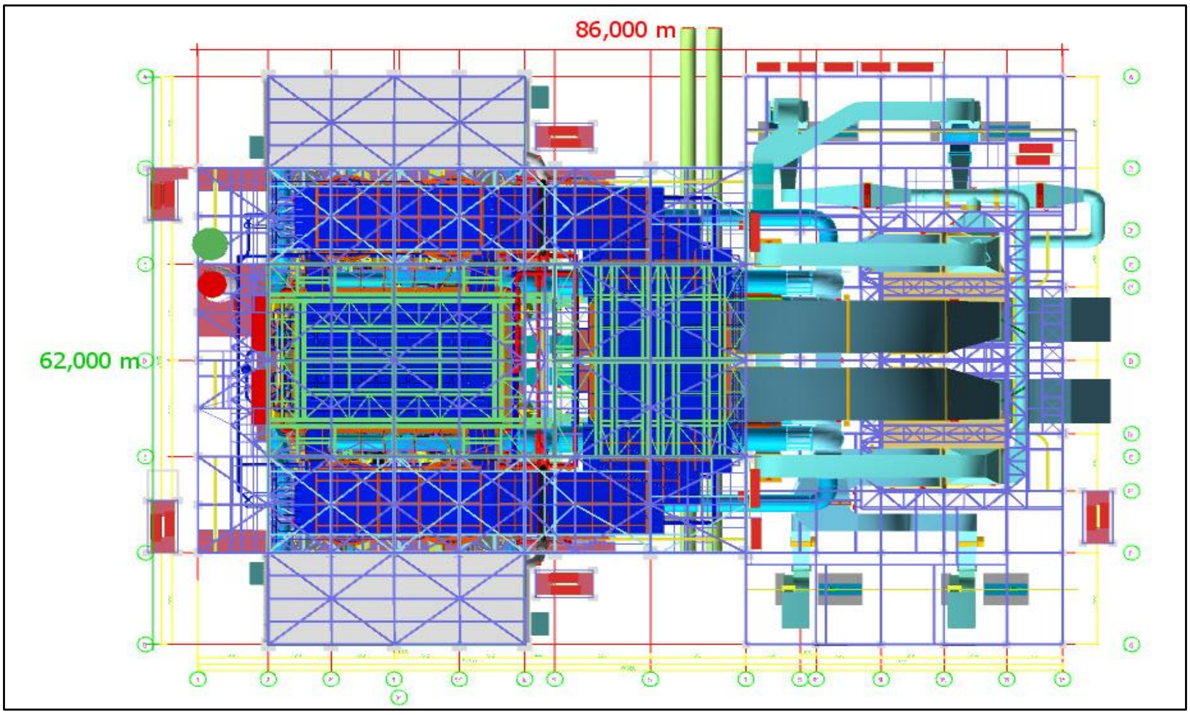

Figure 5: Footprint of boiler house

Doosan Lentjes has opted for compact rotary ash coolers (RAC) which feature a high throughput of ash and low auxiliary power consumption. The conveying system downstream of the RAC has been designed with a 100 % redundancy.

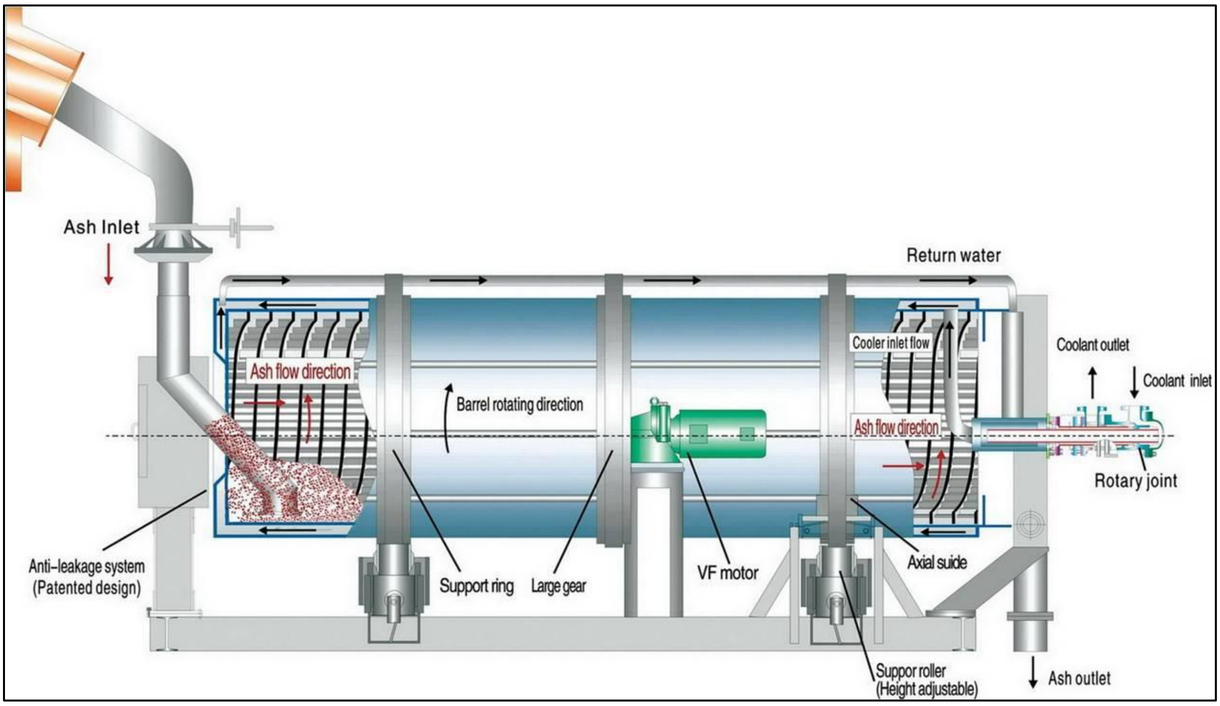

Figure 6: rotary ash cooler (source: Songling)

4. Summary

Doosan Lentjes has developed a reference design for a 300 MW class SC-CFB boiler utilizing high ash coal.

Based on proven design principles applied at various reference installations and supported by thorough process design along with CFD analysis and physical model testing in its laboratories Doosan Lentjes is well prepared to deliver state of the art solutions to meet future demand on SC-CFB technology.