Quiz: RWE Power - Niederaußem power plant

Facts and figures about the power plant

The power plant at Niederaußem has a gross cumulative power of 3669 MW. It consists of 8 separate units and among these units, we will discuss the BoA1 unit which we have visited during our trip and which started its operation in 2003. The BoA1 unit has a gross power output of 1027MW and an electrical efficiency of 44%.

Fuel preprocessing

Brown coal has about 60 % moisture content and it cannot be dried by the hot air. The reason for this is that brown coal has a high percentage of volatile hydrocarbons and the hot air will simply cause risk of ignition in the beater mills which are used to pulverize the coal. So to avoid this risk, flue gas at about 1000^{o}C is taken from the boiler via duct and the raw coal is added to this duct. The flue gas dries the coal and there is no risk of ignition as the flue gas has only a very small percentage of oxygen. The coal is then added to the beater mill. From there the pulverized coal goes to the burners.

Boiler

The coal enters the boiler and is then ignited and burnt inside the boiler. The evaporated water remains as steam in the feed flow to the flame, causing a lower heating value of around 8000 kJ/kg. The low the adiabatic flame temperature in such cases would not cause significant thermal NOx, but the fuel bound nitrogen is still producing fuel NOx. A staged combustion process is used here to reduce the production of NOx. Above the main burners, some more coal is injected to the NOx reduction zone through the reduction burners, converting NOx to N_2, and CO is finally oxidized to CO_2 by the two-stage over fire air on top. In the reduction zone, an air ratio of 0.98 is maintained while in the over fire air zone, an air ratio of 1.05-1.1 is used. This is shown in the diagram on the figure 1. The boiler is made up of tube walls. Inside the boiler and at the top portion there are horizontal tube bundles. The lower part of the tube wall is the evaporator and the upper part is the first super heater stage. Rest of the super heater stages, all reheater stages and economizers are present as the tube bundles inside. This arrangement is shown in the figure. The first superheater is not shown as it is the tube wall of the upper part.

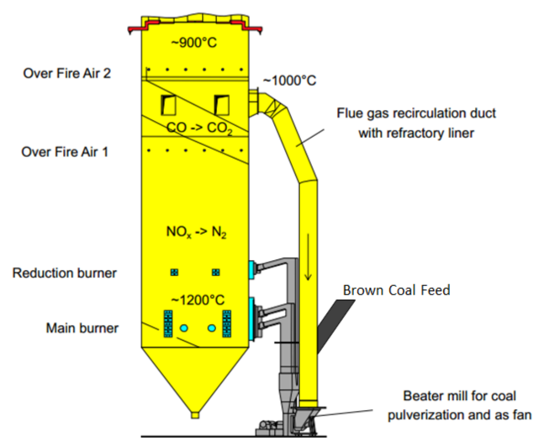


Figure 1

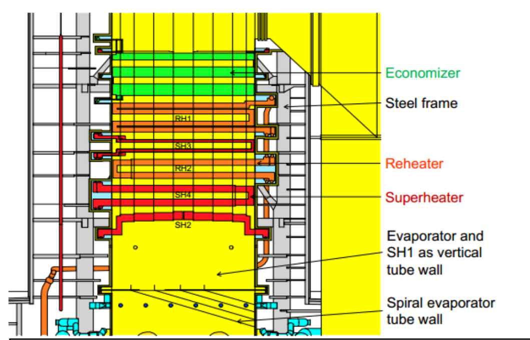


Figure 2

In the boiler, shown in the Figure 2, the heat is either transferred via radiation or convection. The radiative heat transfer is dependent on the fourth power of flue gas temperature. So heat transfer by radiation decreases drastically with temperature of flue gas. The convective heat transfer is dependent on the flue gas temperature and the flue gas velocity. In the evaporator section of tube wall, radiation is the dominant heat transfer mechanism and convection plays a very minimal role. In the first two tube bundles (SH1 and SH2) which are in the path of flue gas, radiation is again the dominant heat transfer mechanism, as flue gas temperature is high and flue gas velocity is low) and in the rest of the tube bundles, where flue gas temperature is low and the flue gas velocity is high, convection is the dominant heat transfer mechanism. The efficiency of the boiler is around 94.4 %.

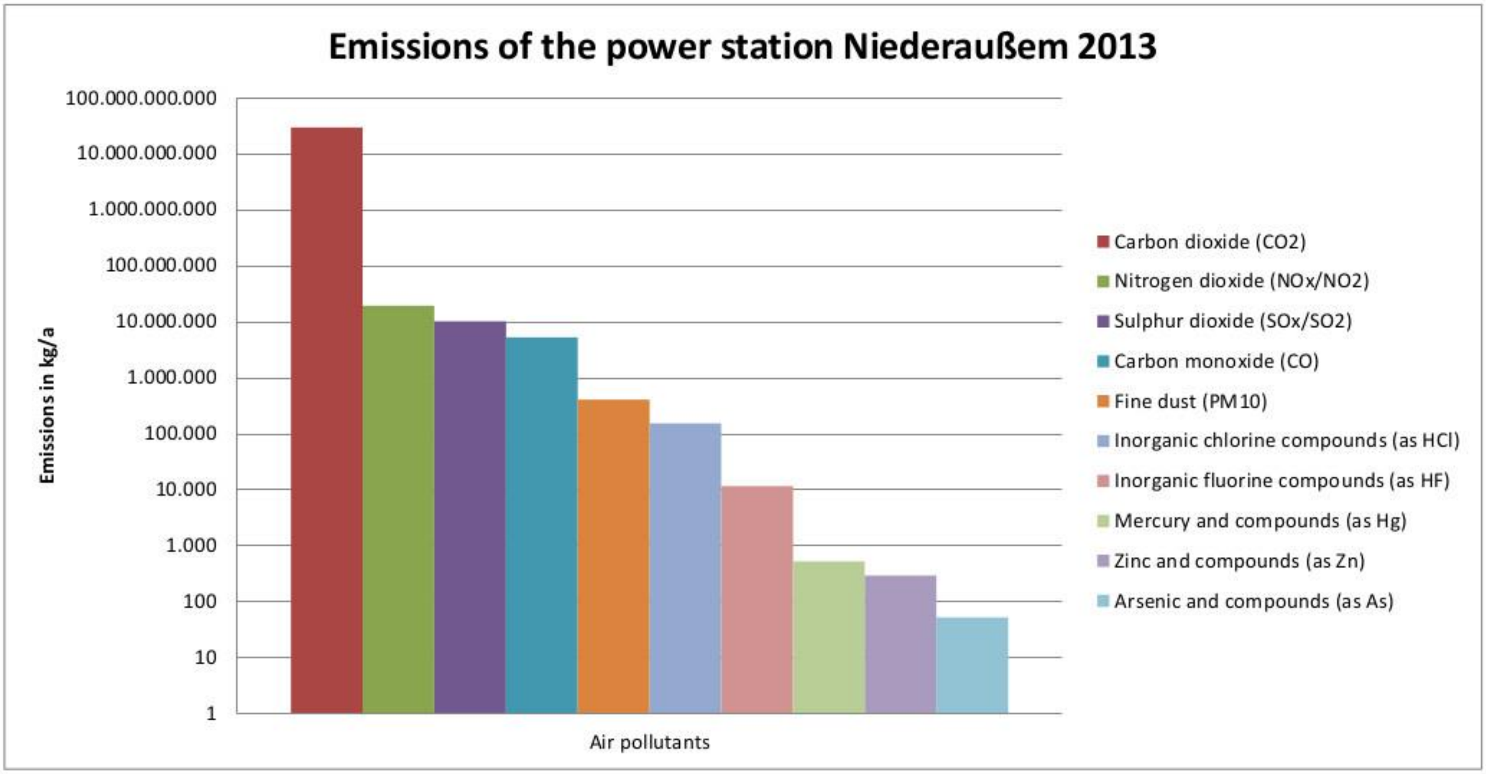
Steam turbines

Superheated steam is produced at a rate of 800 Kg/s in the boiler [1]. This superheated steam produced in the boiler is then passed through the turbines and thermal energy of pressurized steam is converted to kinetic energy of the turbine through expansion and finally by a generator, this mechanical energy of turbine converted to electrical energy. The steam first passes through the HP turbine and then it goes for reheating in the boiler again. After reheating, it expands through intermediate pressure turbine and finally through three low pressure turbines. The HP turbine has unidirectional flow of steam while IP turbine and LP turbines has bidirectional flows. Retrofitting of these turbines have been done in which the conventional twisted profile blades and vanes have been replaced with the modern 3D blade and vanes. As a result of this retrofitting, the turbine produce 140 MW more gross power with the same amount of coal. The steam turbines installed have thermodynamic efficiency (isentropic efficiency) of around 94 %.

Environmental impact

Average utilization of coal (2004-2006) is 25.38 million t/annum. The average full load hours (2004 – 2006) are 6900 h/a. According to the guide, now the plant is just running for mid load and not base load anymore, so the full load hours of the plant might be decreased. BoA is a German abbreviation standing for “Lignite-Fired Power Station with Optimized Plant Engineering.” The BoA1 unit is one of the most modern power plants in the world, but the environmental impact is still high. Therefore RWE started the “coal innovation center” where methods and prototypes are tested to optimize the power plant. Improvements at many points in the power-plant process lead to enhanced efficiency overall, improving the use of the fuel, lignite, while simultaneously lowering carbon dioxide emissions per kilowatt hour of electricity generated.

At the core of the BoA technology is an increase in the pressure and temperature of the superheated main steam. With the same amount of power generated, BoA consumes less coal, so that it produces less fuel related pollutants. The measures taken to improve air and lower the environmental impact of carbon dioxide are: The high-performance scrubber REA plus, Fluidized bed drying with internal waste heat utilization, pilot plant for CO2 scrubbing. So that the annual carbon-dioxide emissions of the 1000-MW BoA unit are up to three million tons lower than in comparable power generation by older systems, dust, Sulphur dioxide and nitrogen oxide emissions are down some 30% [2]. Exhaust gases and pollutants released from the plants are shown in the graph below [3].



[1] High Performance Light Water Reactor: Design and Analyses, Thomas Schulenberg (page 186)
[2]http://www.rwe.com/web/cms/mediablob/en/234504/data/2378/5/rwe-powerag/innovations/coal-innovation-centre/Brochure-The-Niederaussem-Coal-Innovation-Centre.pdf
[3] http://de.wikipedia.org/wiki/Kraftwerk_Niederau%C3%9Fem