Example 5.2.3.3 Industrial spreader-stoker CHP plant with SNCR and fabric filter

Description: The spreader-stoker technique described here will be illustrated with three examples of almost identical chip board plants operated in France and Germany. In Table 5.12 all substantial parameters for the three plants are summarised. These plants are mainly used for the valorisation of wood residues and wood dust and provide the heat demand for chip board production. Therefore, a high and constant energy demand is ensured.

	Plant A	Plant B	Plant C
Year of implementation	1994	1997	2000
Rated thermal input (MW)	50	73.5	57.7 (grate firing, maximal 28 MW of it delivered by wood dust burners) + 6.7 (Thermo oil boilers: wood dust + extra light fuel oil)
Gross electric power (MW)		16.6 (maximal) 11 (annual mean)	13.3
Availability	Operational life cycle times >5000 h, availability 99.8 %	Operational life cycle times >5000 h	Operational life cycle times >5000 h
Maximal rated thermal input (MW)		63	35 + 6.7
Overall gross energy efficiency (%)		96.6 max.	c. 85 %
Main steam parameters		450 °C, 67 bar	455 °C, 70 bar
Main fuels	Production residues, waste wood, railway sleepers, etc.		

Table 5.12: Technical data for the three example plants

The following description of the technique refers to all three example plants, unless otherwise specified. The spreader-stoker technique is a combustion on an air-cooled travelling-grate stoker, the fuel being evenly spread on the grate by an injection-stoker, which throws the particles in. While the bigger pieces are evenly burned in a fixed bed combustion on the grate, the smaller particles are ignited in a fluidised bed separately above the combustion chamber (this applies to about 50 % of the fuel). This provides good conditions for a high combustion efficiency and residence times of four to five seconds result. Therefore, the air rate can be minimised (O_2 content in the raw gas of less than 3 %), which also reduces NO_X emissions.

The formation of a fluidised bed is possible because the velocity of the flue-gas is similar to the velocity occurring in fluidised bed combustions. The formation of a fluidised bed also means a staging of the fuel, supporting low NO_X combustion. Also the low maximal temperature of 1250 °C supports this effect.

Half of the air is injected by a jet tray, the other half is blown in at a high pressure through nozzles on the walls. Thus, it is a staged combustion with under stoichiometric conditions at the bottom and high turbulence at the same time.

The spreader-stoker plant realises an intensive combustion at high temperatures with a broad spectrum of fuels. The optimised temperature can be sustained by controlled injection of recirculated flue-gas. The ideal adiabatic temperature of the combustion chamber for simultaneous minimisation of CO and NO_X is 1300 to 1400 °C.

The temperature achieved in reality is about 150 °C below this. The lining of the walls with masonry for thermal isolation is not necessary, which also prevents the formation of boiler slag and, therefore, results in high operational life cycle times (>5000 h).

For the combustion of abrasive dust, there are four pulverised-fuel burners installed in plant C. The maximal rated thermal input is 28 MW and contains plug nozzle burners. These can also be driven by extra light fuel oil.

The heat is used mainly for the drying of splints. In plant B, up to 26 t/h are dried in rotary dryers, which means that the moistness is reduced from 60 to 100 % to about 2 %. The drying is realised indirectly by heated tube bundles of 180 °C. Further on, the heat is conducted by thermo oil at 240 °C to a heated end-squeezer in order to dry and consolidate the chip boards. In this process, a mix of air, water and products of degasification occurs, which is returned as combustion air and thus delivers 30 % of the air needed in the boiler. This design provides high energy efficiency and after-burning of the emissions arising from the drying. The exhaust air from the drying of chipping particles is also applied partly to the boiler. All plants are equipped with bag filters to meet the required limit values for particle emissions.

Plant C is fitted with a supplementary SNCR installation. Ammonium hydroxide with 25 mass- % of NH_3 is used as the reducing agent. This is stored aboveground in a tank of stainless steel. Furthermore, plant C is equipped with an adsorption process as a separator. This combined duct sorbent injection (dry adsorption) requires the injection of a ground mix of active carbon/coke and hydrated lime (= adsorbent) in the flue-gas flow which is then separated from it by a fabric filter. During this time, dust, HCl, HF, SO_x, heavy metals, and PCDD/F are adsorbed and thus separated from the flue-gas. Therefore, all types of wood waste can be fired in this plant.

Achieved environmental benefit: By using wood as a biomass fuel, one can achieve an almost neutral CO_2 balance. With the simultaneous utilisation of power and heat, the overall energy efficiency can achieve about 85 to 96.6 %. Only small amounts of waste water arise, coming from the waste water treatment of the water-steam circuit.

At the same time, combustion technology allows low emissions of NO_X and CO to be achieved in the raw gas. Combined with reduction measures like bag filters, SNCR and duct sorption plants, very low concentrations can be achieved for all types of pollutants.

Applicability: The spreader-stoker technique is suitable for a wide range of fuels, exceeds the performance of fluidised bed technology, and is especially used with fuels with highly heterogeneous particle sizes and contaminants (such as metal pieces).

The plants described here are especially designed for applications in the chip board and MDF board industry and are economically viable because of the energetic valorisation of the wood residues and because of the continuous demand for heat. For locations with similar characteristics, the application of this technology is also reasonable.

Cross-media aspects: High amounts of ash result from these plants. Furthermore, water treatment produces waste water. Also, the adsorbent used in the flue-gas cleaning plants has to be deposited.

Operational data: Atmospheric emissions accruing from plant B are shown in Table 5.13.

	Monitoring	Statistics	Measured value (at 11 % O_2)
Dust (mg/Nm^3)	Continuous	Daily mean value	3.4 – 4.3**
CO (mg/Nm^3)	Continuous	Daily mean value	46.7 – 58.3**
NO_X (mg/Nm^3)	Continuous	Daily mean value	183.9 – 190.7**
C total (mg/Nm^3)	Continuous	Daily mean value	1.1 – 1.2**
HCl (mg/Nm^3)	Continuous	Daily mean value	8**
Hg (gas) (mg/Nm^3)	Continuous	Daily mean value out of 2 hour mean values	0.001**
Dioxins/furans (ng TEQ/Nm^3)	Continuous sampling, single values	Mean of 20 days	0.0019
PAH (mg/Nm^3)	Continuous sampling, single values	Mean of 4 days	0.0003
Cd (mg/Nm^3)	Continuous sampling, single values	Mean of 4 days	0.0005
As/Pb/Cu/Ni/Sn (in the particles) (mg/Nm^3)	Continuous sampling, single values	Mean of 4 days	0.053
As (mg/Nm^3)	Continuous sampling, single values	Mean of 4 days	0.0005
Notes: *value for precaution **intervals based on three daily mean values in January 2001			

Table 5.13: Measured atmospheric emissions in 2000/2001

For plant C, a consumption of 120000 t/yr wood is estimated. For plant B, the different types of fuels are used in the amounts listed in Table 5.14.

Fuel	Wood dust	Cardboard pieces	Wood residues out of packaging/loading	Special fuels (railway sleepers)	Timber	Biomass pellets
Contribution to the total fuel consumption	30 %	10 %	10 %	Max. 20 %	Varying	Varying, approx. 15000 t/yr

Table 5.14: Contribution of the different fuel types to the total fuel consumption in plant B

The size of the pieces should be below 100 mm. However, a few pieces can be up to 250 mm. This limit is set by the transport devices, e.g. screw conveyors. For the preparation of all fuels by a hacker, costs of EUR 0.5/t were given for a plant of 60 MW. The accruing boiler ash and fly ash are used in the construction industry.

Economics: The investment for plant B amounted to EUR 36 million.

Driving force for the implementation: The possibility to re-use the by-products and the need to deposit the wood residues in an economically reasonable way.

Reference literature: [98, DFIU, 2001], [101, Vaget, 2001], [102, Fischer, 2000], [78, Finkeldei, 2000].