

## 7.15 Pulp production

### 7.15.1 Coverage

This chapter covers sulphate (Kraft) and sulphite pulping processes which are the most commonly used processes. Pulp production [5] processes are sources of nitrogen oxides (NO<sub>x</sub>), sulphur dioxide (SO<sub>2</sub>) and dust (TSP).

### 7.15.2 Emission sources

For chemical pulping process as Kraft process and sulphite process, wood is needed. Wood is first debarked and then reduced into chips which are screened. The removed material from the screening operation can be used in the process as solid fuel or be sold for other purposes.

The screened material is then cooked in a cooking plant with different chemical depending on the process. The cooking stage can be continuous or batch.

**The sulphate or Kraft process** is the most used pulping process, due to the quality of the produced pulp and to its applicability to all wood species.

During the cooking stage of the Kraft process, fibres are liberated from the screened chips using a solution of white liquor to dissolve the lignin. White liquor is composed of sodium hydroxide and sodium sulphide.

The pulp formed in the cooking plant contains fibres and spent cooking liquor; black liquor. Black liquor is removed from the pulp during washing steps and is led to the recovery process. During this recovery process, chemicals and energy are recovered. The recovery system normally enables the whole production process to be self-sufficient in heat and energy.

After the cooking step, delignification can be continued by an oxygen delignification. Then the pulp is purified.

The next step of the process is the bleaching, it is only necessary to obtain brighter Kraft pulp. The bleaching is generally composed of a sequence of separate bleaching stages (4-5). During those stages, chlorine dioxide, oxygen, ozone and peroxide can be used as bleaching agent.

After the bleaching, pulp is purified.

Depending on the type of plant; pulp mill or integrated pulp and paper mill, the final pulp is dried to be transported or directly used as it is. [1],[5].

After the cooking step, black liquor is removed and led to a recovery process. To be used as performing fuel, recovered black liquor needs to be concentrated. It is concentrated by evaporation to 65-75% dry-solids content. During the evaporation, non condensable gases and condensates are recovered. Non condensable gases are burnt with malodorous gases while condensates are purified and used as chemicals during the washing of the pulp.

The concentrated black liquor is burnt in a recovery boiler to recover the sodium and sulphur content in a suitable chemical form to regenerate the pulping chemicals and recover energy from the flue gases. [1],[5].

The recovery system also enables the regeneration of chemicals; the smelt from recovery boiler are recovered and dissolved in water or white liquor. The solution is then clarified and causticized with lime to form sodium hydroxide, which is then used to produce white liquor.

The calcium carbonate recovered from the causticizing is used in a lime kiln to regenerate lime.

Air emissions from this process come mainly from recovery boiler, lime kiln, auxiliary boilers and pulp drying.

The **recovery boiler** is however the main source of emissions in the Kraft process. The boiler is fed with concentrated black liquor, which is the cause of NO<sub>x</sub>, SO<sub>2</sub> and dust emissions. These emissions are influenced by the efficiency of the combustion and the sulphur content of the black liquor.

The **lime kiln** is responsible of similar emissions as in lime production.

A bark boiler and other boilers are used in the Kraft process as auxiliary boilers to cover the energy demand of the pulp production. These boilers can be fed with solid, liquid or gaseous fuel. [1]

**The sulphite process** is less used than the Kraft process, due to the lower quality of the produced pulp and to its non applicability to certain wood species. Environmental issues are in most cases more expensive to solve than in the Kraft process.

In the sulphite process, the same processes are used, only the chemicals used are different. Hence, recovering and regenerating steps are slightly different.

The white liquor used in the cooking plant is composed of magnesium sulphite and magnesium bisulphite. The cooking step is most of the time a batch process.

As in the Kraft process, chemicals and energy are recovered to enable the whole production process to be self-sufficient in heat and energy.

Air emissions from this process come from the same sources as in the Kraft process and recovery boiler is also the main source of emissions. [1]

### 7.15.3 BAT, Associated Emission Levels (AEL)

If not stated otherwise the data refer to yearly average values, standard conditions and the reference oxygen content is:

- 6% with solid fuel or biofuel;
- 3% with liquid fuel or gaseous fuel

**SO<sub>2</sub>:**

#### **Kraft process**

The recovery boiler is the major source of SO<sub>2</sub> emissions. Therefore BAT to reduce SO<sub>2</sub> emission levels in pulp industry is first of all reducing emissions from this boiler.

Malodorous gases from cooking plant, delignification step or evaporation of the black liquor need to be collected and incinerated in the lime kiln, the recovery boiler or the auxiliary boilers. Emissions from incineration need to be controlled.

In the recovery boiler, the use of high dry solids content of black liquor is a primary measure to reduce SO<sub>2</sub> emissions. A high dry solid content >75% permits to reduce significantly emissions.

In order to reduce SO<sub>2</sub> emissions from the recovery boiler, a flue gas wet scrubber can be installed as secondary measures. The scrubbing enables the removal of SO<sub>2</sub> and dust. The pH is controlled and regulated by addition of liquor or sodium hydroxide. SO<sub>2</sub> reacts with the scrubbing liquor to form sodium sulphite (Na<sub>2</sub>SO<sub>3</sub>) or sodium sulphate (Na<sub>2</sub>SO<sub>4</sub>). The usual removal efficiency of this scrubbing is > 90 %. For initial concentration levels of 50 – 200 mg/Nm<sup>3</sup>, levels of 10 - 50 mg/m<sup>3</sup> can be reached. The reduction of SO<sub>2</sub> emissions from other boilers involves the use of low sulphur content fuels or the use of scrubber to control emissions. [1]

The following table gives an overview of BAT associated SO<sub>2</sub> emission levels for Kraft pulping process using different techniques.

**Table 1: Associated SO<sub>2</sub> emission levels with BAT to reduce emissions in Kraft pulping process. [1]**

Emission source	Techniques	Associated emission level with BAT (mg S/Nm <sup>3</sup> )
Recovery boiler (5% O <sub>2</sub> )	SO <sub>2</sub> scrubbing system <i>If with High dry solids content of black liquor (&gt;75%)</i>	10 – 50 <i>it goes to 5 – 10</i>
Auxiliary boilers	Use of fuel with low sulphur content	100 – 200 <sup>1</sup> 25 – 50 <sup>2</sup> <5 <sup>3</sup> <15 <sup>4</sup>
	SO <sub>2</sub> scrubbing system	50 – 100 <sup>1</sup>

<sup>1</sup> feed with coal or heavy fuel oil

<sup>2</sup> feed with gas oil

<sup>3</sup> feed with gas

<sup>4</sup> feed with biofuel

### Sulphite process

As for Kraft pulping process, the recovery boiler is responsible for the major part of SO<sub>2</sub> emissions in the sulphite pulping process.

Similar primary measures can be applied to reduce emissions.

In order to reduce SO<sub>2</sub> emissions from the recovery boiler, a flue gas multi staged scrubber can be used. SO<sub>2</sub> emissions from the other boilers can be reduced using the same reduction techniques as for Kraft process.

The following table gives an overview of BAT associated SO<sub>2</sub> emission levels for sulphite pulping process using different techniques.

**Table 2: Associated SO<sub>2</sub> emission levels with BAT to reduce emissions in sulphite pulping process. [1]**

Emission source	Techniques	Associated emission level with BAT (mgS/Nm <sup>3</sup> )
Recovery boiler (5% O <sub>2</sub> )	SO <sub>2</sub> multi-staged scrubber	50 – 150
Auxiliary boilers	Use of fuel with low sulphur content	100 – 200 <sup>1</sup> 25 – 50 <sup>2</sup> <5 <sup>3</sup> <15 <sup>4</sup>
	SO <sub>2</sub> scrubbing system	50 – 100 <sup>1</sup>

<sup>1</sup> feed with coal or heavy fuel oil

<sup>2</sup> feed with gas oil

<sup>3</sup> feed with gas

<sup>4</sup> feed with biofuel

### NO<sub>x</sub>:

#### Kraft process

The main sources of NO<sub>x</sub> emissions in the Kraft process are the lime kiln and the recovery boiler. The recovery boiler is responsible for the largest part of NO<sub>x</sub> emission due to the amount of black liquor burnt. Low NO<sub>x</sub> burners and modified combustion conditions with staged air feed system can reduce the emission levels.

The high combustion temperature in the lime kiln is also responsible of NO<sub>x</sub> emissions. The level of emissions is influenced by the type of fuel used. Primary measures such as adjusting functioning parameters like flame shape or air distribution, can control the NO<sub>x</sub> emissions.

Auxiliary boilers within the pulp industry are of a very large range size (from 10 to above 200 MW). Therefore, different measures can be applied from small boiler to large boilers. In smaller boilers, structural and primary measures are cost effective while in larger boilers, secondary measures can also be applied. [1]

The following table gives an overview of BAT associated NO<sub>x</sub> emission levels for Kraft pulping process.

**Table 3: Associated NO<sub>x</sub> emission levels with BAT to reduce emissions in Kraft pulping process. [1]**

Emission source	Techniques	Associated emission level with BAT (mg/Nm <sup>3</sup> )
Recovery boiler (5% O <sub>2</sub> )	Low NO <sub>x</sub> burner, staged air feed system	80 – 120
Lime kiln	adjusting parameters : oil firing gas firing	80 – 180 <sup>5</sup> 300 – 540 <sup>5</sup>
Auxiliary boilers	structural and primary measures	80 – 110 <sup>1</sup> 45 - 60 <sup>2</sup> 30 - 60 <sup>3</sup> 60 – 100 <sup>4</sup>
	SNCR	50 - 80 <sup>1</sup> 40 – 70 <sup>4</sup>

<sup>1</sup> feed with coal or heavy fuel oil

<sup>2</sup> feed with gas oil

<sup>3</sup> feed with gas

<sup>4</sup> feed with biofuel

<sup>5</sup> As written in the Bref document, it could be an error]

### Sulphite process

The main sources of NO<sub>x</sub> emissions in the sulphite process are the boilers. Hence, NO<sub>x</sub> emissions from those boilers can also be reduced using the same reduction techniques as for Kraft process.

The following table gives an overview of BAT associated NO<sub>x</sub> emission levels for sulphite pulping process in pulp industry.

**Table 4: Associated NO<sub>x</sub> emission levels with BAT to reduce emissions in sulphite pulping process. [1]**

Emission source	Techniques	Associated emission level with BAT (mg/Nm <sup>3</sup> )
Recovery boiler (5% O <sub>2</sub> )	Low NO <sub>x</sub> burner, staged air feed system	200 - 300
Auxiliary boiler	Structural and primary measures	80 - 110 <sup>1</sup> 45 - 60 <sup>2</sup> 30 - 60 <sup>3</sup> 60 - 100 <sup>4</sup>
	SNCR	50 - 80 <sup>1</sup> 40 - 70 <sup>4</sup>

<sup>1</sup> feed with coal or heavy fuel oil

<sup>2</sup> feed with gas oil

<sup>3</sup> feed with gas

<sup>4</sup> feed with biofuel

## Dust:

### Kraft process

In kraft pulp mills, dust emissions come from different sources, mainly the lime kiln, the auxiliary boiler and the recovery boiler. Emissions can be controlled by electrostatic precipitator and/or SO<sub>2</sub> scrubbers depending on the emission source process. Bag filters can also be used. [7]

The SO<sub>2</sub> scrubbers used on boilers also enable the control of the dust emissions.

For new boilers, only the use of ESP is considered to be BAT to reduce dust emission levels. For existing boilers, the combination of ESP and scrubbers is necessary. SO<sub>2</sub> scrubber combined with an ESP can achieve about 15 mg/Nm<sup>3</sup> of dust emissions.

The following table gives an overview of BAT associated dust emission levels for Kraft pulping process.

**Table 5: Associated dust emission levels with BAT to reduce emissions in the Kraft pulping process. [1] [2]**

Emission source	Techniques	Associated emission level with BAT (mg/Nm <sup>3</sup> )
Lime kiln	ESP	<b>dust:</b> 30 – 50
Recovery boilers (5% O <sub>2</sub> )	ESP and SO <sub>2</sub> scrubbers	<b>dust:</b> 30 – 50
Auxiliary boilers	ESP	<sup>1</sup> <b>dust:</b> 10 – 30 <sup>2</sup> <b>dust:</b> 10 – 40 <sup>3</sup> <b>dust:</b> < 5

<sup>1</sup> feed with coal or biofuel or gas oil

<sup>1</sup> feed with heavy fuel oil

<sup>3</sup> feed with gas

### Sulphite process

In sulphite pulp mills, dust emissions come from different sources, mainly the lime kiln, the auxiliary boiler and the recovery boiler. Emissions can be controlled using the same systems as for the Kraft process.

The following table gives an overview of BAT associated dust emission levels for sulphite pulping process.

**Table 6: Associated dust emission levels with BAT to reduce emissions in the sulphite pulping process.[1], [2]**

Emission source	Techniques	Associated emission level with BAT (mg/Nm <sup>3</sup> )
Recovery boilers (5% O <sub>2</sub> )	ESP and SO <sub>2</sub> scrubbers	<b>dust:</b> 5 - 20
Auxiliary boilers	ESP	<sup>1</sup> <b>dust:</b> 10 – 30 <sup>2</sup> <b>dust:</b> 10 – 40 <sup>3</sup> <b>dust:</b> < 5

<sup>1</sup> feed with coal or biofuel

<sup>1</sup> feed with heavy fuel oil

<sup>3</sup> feed with gas

#### 7.15.4 Emerging techniques

The installation of SNCR on recovery boilers, main source of NO<sub>x</sub> emissions, is considered as emerging reduction technique in pulp industry, as it is a new application of this common technique.

The investment for a complete installation of SNCR (*NO<sub>x</sub>OUT* process) on a recovery boiler (black liquor load: 1600 t dry solids/day) is about 2.2 - 2.8 Meuros.

Due to its low rate of use, no emerging techniques are identified for emissions reduction in the sulphite process. [1]

#### 7.15.5 Cost data for emission reduction techniques

SO<sub>2</sub> scrubbers on recovery boilers come usually as a package from the supplier. Investment ~~costs~~ for a bleached Kraft mill with a production capacity of 250000 and 500000 t/y amount to 7.2 Meuros and 10.4 Meuros respectively. They include scrubber, scrubber liquor pumps, circulation pumps, electrification and instrumentation. Operating costs amount to 0.58 Meuro/y and 0.92 Meuros/y respectively. [1]

The investment to add a SNCR process to the bark boiler for the same production capacity plant is about 0.7-1.15 Meuros. The investment costs include injection equipment, pipes, pumps, tanks and rebuild/adoption of the boiler. The operating costs are mainly due to urea consumption, about 1-2 kg urea is required per kg NO<sub>x</sub> removed. [1]

The installation of electrostatic precipitator costs about 3-4 Meuros for the bark boiler (auxiliary boiler) and 5-6 Meuros for the lime kiln. Operating costs are less than 0.3 Meuros/y in both cases. [1]

Investments for low NO<sub>x</sub> technology in auxiliary boilers or lime kilns are 0.5 - 0.8 Meuros.

#### 7.15.6 References used in chapter 7.15

- [1] Reference document on Best Available Techniques in the pulp and paper industry, December 2001.
- [2] EPA 42 – volume 1 chapter 1, September 1998.
- [3] Auswertung von staub- und Feinstaubemissionsdaten der Datenbank nordrhein-westfälischer Emissionserklärungen, LUA NRW, 2003.
- [4] Arrêté du 3 avril 2000 relatif à l'industrie papetière, JO 17-06-2000.
- [5] Comments from Almut Reichart, UBA, 12/2008
- [6] "Compilation of the answers-to-questions-and proposal of EGTEI secretariat.doc", EGTEI, 02/2009.
- [7] Comments from Thomas Krutzler, UBA Austria, 03/2009.
- [8] "EGTEI-State of progress.doc", for WGSR, March 2009.