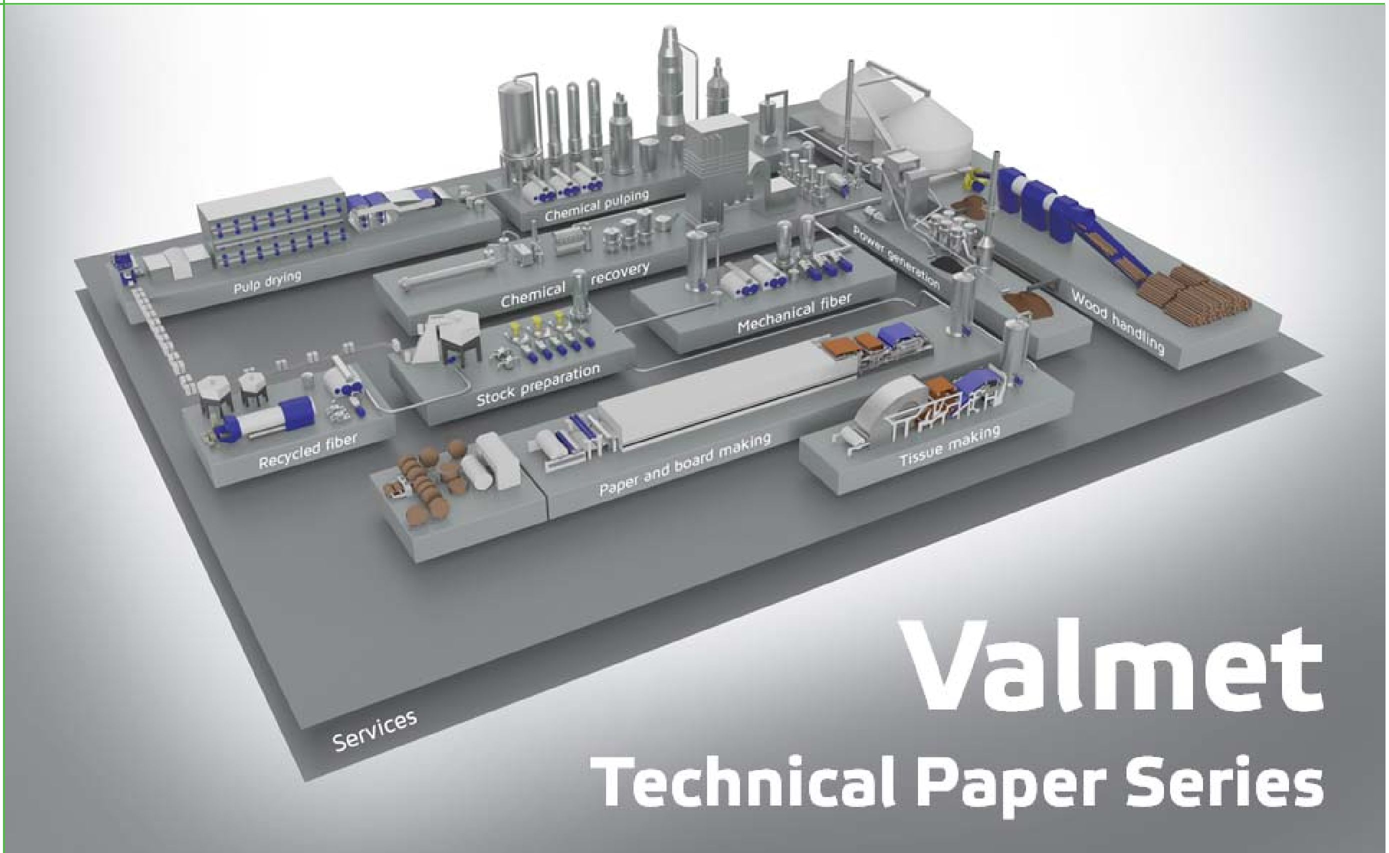

Odorless pulp mill in successful operation

Executive Summary

The sulphur in the cooking process can result in bad odor in the surroundings of a Kraft pulp mill. Together with the odor, sulphur compounds can also be an environmental problem since they are released to the atmosphere. Although emissions are becoming lower as mills are upgraded, odors have continued to be a problem for people living close to the mills, because of the very low odor threshold of sulphur compounds.

Valmet has delivered a unique, practically odorless mill to CMPC Riograndese Ltda in Guaíba, Brazil. The design guidelines were to not vent odorous gases and to aim for zero smells. The gas handling system collects and controls odors from more than 100 sources and all process areas are included. Incineration of non-condensable gases is ensured through multiple, simultaneously available incineration locations. According to CMPC it can be said that the system availability is practically 100% and there is always a system ready to handle NCG and prevent gases from being emitted to the atmosphere.

This paper describes the emphasis CMPC placed in the concept of the odorless mill in Guaíba and its surroundings and outlines the chosen technical solutions to achieve this target. The paper emphasizes the necessity of ensuring that odorous gases are treated also in shutdown and emergency situations, and explains how this has been achieved at the mill.

Background

No venting of odorous gases and a "zero smell" pulp mill. That was the target that Valmet and CMPC started to aim for in year 2011 when the Guaíba (**Figure 1**) line #2 project started. Odors from pulp mills have been a significant challenge globally during the last years, and mills have investigated ways to minimize odors with the ultimate goal of a totally odorless mill. The target in this project was not easy. There already was a pulp production line #1 in operation in Guaíba, and to achieve a totally odorless mill, the systems in the existing mill needed to be upgraded. Moreover, the operability and availability of the gas handling system had to be state of the art.

Figure 1. CMPC Guaíba Mill

The main reason for making a mill odorless is naturally the people who work at the mill and, more importantly, those who live nearby. The odor threshold for different components of non-condensable gases is very low and varies between 0.001 and 0.01 ppm (**Table 1**). The other reason is to reduce emissions to the atmosphere. In pulp mills, the odorous emissions mean sulphur emissions, since the odor comes from TRS (Total Reduced Sulphur) compounds. The sulphur compounds originate from the cooking process and cannot be eliminated at the source. The only way to minimize emissions is to collect and treat the sulphur containing gases safely and effectively.

	Hydrogen sulphide	Methyl-mercaptan	Dimethyl sulphide	Dimethyl disulphide	Turpentine (α pinene)	Methanol
Formula	H_2S	CH_3SH	$(CH_3)_2S$	$(CH_3)_2S_2$	$C_{10}H_{16}$	CH_3OH
Molecular mass	34	48	64	94	132	32
Explosion limit (LEL)	4.3	3.9	2.2	1.1	0.8	5.5
Explosion limit (UEL)	45.0	21.8	19.7	16.1	6.0	36.5
Flame velocity (m/s)			0.6		0.62	0.5
Auto-ignition temp. (ºC)	250	197 (340)	206.0	300	255	385 (465)
Flash point (ºC)	Gas	Gas	-49.0	24.0	34	11
Boiling point (ºC)	-60	6	38	110	150	65
Heat value HHV (MJ/kg)	15	22	31	23	41	22
Volume weight of gas compared to air	1.19	0.87	2.14	3.24	4.70	1.11
Odor threshold (ppm)	0.008	.0004-.003	.001-.01	.003-.011	100	100
Solubility in water	Yes	No	No	Poor	No	Yes

Table 1. Characteristics of different components of non-condensable gases in air [1], [2]

CNCGs are normally incinerated in recovery boilers, where TRS components are oxidized into SO_2 and converted to Na_2SO_4 (**Equations 1 and 2**). During guarantee measurements in Guaíba, the emission of TRS from the recovery boiler stack was 0.4 mg/m^3n @ 8% O_2 and the SO2 emission 0.1 mg/m^3n @ 8% O_2. This shows that the oxidation and sulphur conversion from gas phase to ash in recovery boiler is extremely efficient.

Equation 1: $2H_2S + 3O_2 \rightarrow 2SO2 + 2H_2O$

Equation 2: $SO_2 + O2 + 2Na \rightarrow Na_2SO_4$

Nowadays a worst-case scenario with an inadequate NCG (Non-Condensable Gas) treatment system is that authorities force the mill to shut down until the system is improved. This means that even though it may be difficult to calculate a payback time an investment in gas handling systems, in many cases other consequences can act as a driving force.

How can a mill become odorless?

The first step in making a mill odorless is to identify all sources of odorous gases. There are two different kinds; DNCGs (Diluted Non-Condensable Gases) and CNCGs (Concentrated Non-Condensable Gases). DNCGs are collected from atmospheric sources at the evaporation plant, the white liquor plant and the cooking and fiber line areas. CNCGs are collected from pressurized sources at the evaporation plant and the fiber line. Both DNCG and CNCG are considered dangerous due to their explosive and toxic nature at certain concentrations.

DNCG flows are substantial but their TRS content is fairly low, and according to the Finnish recovery boiler committee *[2]*, the recommended maximum TRS concentration before incineration is below 200 ppm. The CNCGs on the other hand have a lower flow but a high TRS content. According to the Finnish recovery boiler committee *[2]* and depending on the component in question, the TRS content can even be as high as 190,000 ppm, which gives the gases a very strong odor.

To make the mill odorless, all tanks and equipment that produce DNCGs or CNCGs must be included in the gas collection system and the gases must be treated. This also includes vent gases from the recovery boiler dissolving tank and the mix tank.

Design of the gas handling system in Guaíba

After identification of all sources in Guaíba, a concept was created for the collection and overall gas handling system. To be able to ensure that no vents would occur, for any reason, multiple incineration locations where needed and at least some of them had to be kept in stand-by mode.

The Guaíba recovery boilers would be the main incineration locations for DNCGs from the evaporation plant and fiber line areas. White liquor plant DNCGs would be treated separately and incinerated in lime kilns #1 and #2.

The DNCG overall concept is shown in **Figure 2**.

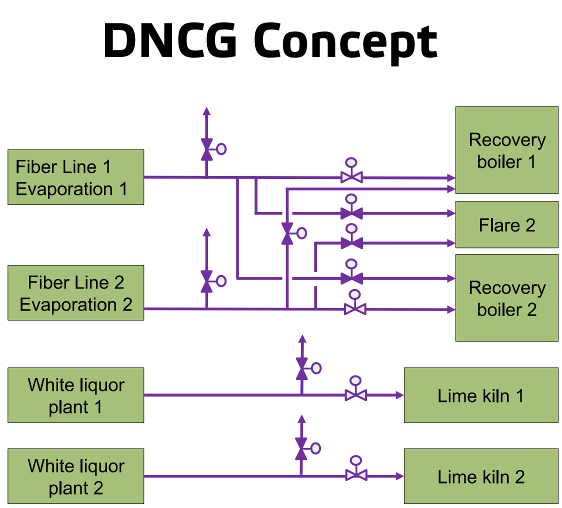

Figure 2. DNCG incineration concept in CMPC Guaíba

For CNCGs the system became extremely complex, since all odorous emissions had to be prevented. See **Figure 3** for the CNCG incineration concept.

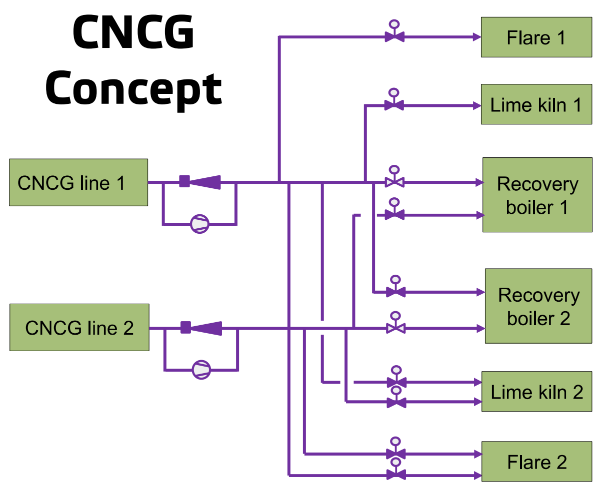

Figure 3. CNCG incineration concept

Operational reliability and safety

Once the incineration concept had been chosen, a decision had to be made on the criticality of the odors. A couple of questions were: how high the costs would be if some of the incineration locations would be on stand-by at all times and how much CMPC was willing to invest in this issue.

It was clear that no CNCGs could be released to atmosphere at any time, no matter what the cost. The availability of the system was seen as very important and shutting down the mill was considered to be the ultimate means to prevent odorous emissions. But this had to be avoided as much as possible.

First of all, this meant that the system had to be designed to handle gases at all incineration locations at all times by keeping CNCG lines constantly hot with steam. Keeping the CNCG lines hot prevents buildup of condensates that can produce pressure interlocking and trip the burner before the incineration even starts. Another way to increase the availability of the CNCG system was to duplicate the critical instruments, such as level switches. If collection of foul condensate is interrupted, level interlocks at the droplet separators will stop the incineration to ensure system safety.

To prevent vents from occurring for any reason, the CNCG system can withstand pressure up to even 1 bar(g) to enable "bottling up" of gases. This means that on-off valves can be simultaneously closed toward all incineration locations while gas is stored inside piping. During this period the pressure will rise, but the CNCG related piping is carefully designed to ensure an uninterrupted gas treatment and switching between incineration locations without opening the high vent at any circumstance.

For safety reasons, the CNCG high vent still remains as a part of the system, but it is only used in a case of emergency to protect the system from, for example, too high pressure. At all other times, the system shuts down and the production of CNCGs is stopped rather than venting the gases to the atmosphere. High vent is not even used during flushing of the CNCG lines with steam. During evaporation plant start-up, the air inside the evaporation train piping is flushed to the flare burner.

All CNCG distribution systems were designed to be identical to make it easy for the operators to operate them. This also enabled the use of identical spare parts for key components.

In order to further minimize SO_2 emissions, in certain situations one part of the TRS components is washed away in a TRS scrubber prior to incineration. These situations include the diverting of the CNCGs to the lime kiln burner or the flare burner, and the simultaneous burning of the CNCGs of both lines (G1 and G2) in only one of the recovery boilers (trip or stop of the other recovery boiler).

Other measures to minimize odor

All possible measures were taken to minimize odor, and special attention was paid to the condensate collection systems. Disturbances because of accumulation of condensate should be minimized and, on the other hand, the possibility of having a misdirected flow of gases because of empty water seals should be avoided. The system for collection of foul condensate became quite extensive. Special attention was paid to CNCG foul condensate piping design, condensate removal points and inclinations of piping to ensure that all condensate is safely transferred to pumping tanks and further to the foul condensate tank.

After the normal operation conditions and most common disturbances had been taken into account, the blackout situations and annual mill shutdowns were next. It was clear that even though the mill shuts down for some reason (no electricity, annual shutdown) the tanks would still continue to produce odorous gases until emptied and flushed. Annual shutdown procedures were easy to determine, since this is a planned shutdown. The decision was to keep the new flare burner #2 in operation until the mill starts up again and other incineration locations are again available. Normal maintenance for flare #2 will be done during mill operation. Unexpected blackouts were more difficult to prepare for since vents are not allowed at any circumstance.

At least one of the incineration locations had to be in operation even during a power supply failure, mill water supply failure and/or failure of instrument air. The CNCG collection had to be ensured even in case of a failure in steam supply, so a vacuum pump was installed in parallel with the steam ejector. Operability of the system was ensured by connecting critical components, such as the vacuum pump, to an uninterrupted power supply (UPS). Critical instruments were also connected to the UPS and the combustion air fan for the flare was connected to a diesel rotary uninterruptible power supply (DRUPS). It was also necessary to ensure proper operation in the case of a failure or a temporary shutdown of the DCS (Distributed Control System) on line #1 or line #2. The DCS operability was ensured by having own process stations for NCGs in the DCS, and powering it with an uninterruptible power supply (UPS).

For DNCGs, the concept was less comprehensive. During normal operation, the DNCGs of the white liquor plant are led to the lime kilns. During disturbances, they will be taken to the atmosphere, since the levels of odorous compounds are low. During recovery boiler outages (either RB1 or RB2), fiber line and evaporation plant gases can be diverted to the other recovery boiler. If both recovery boilers are simultaneously out of operation, all line #1 DNCGs and evaporation plant DNCGs from line #2 will be incinerated in flare #2. This is because evaporation plant gases are the most odorous DNCGs. At a blackout, other sources either stop (like pulp washers) or produce less odor (such as tanks that contain cooler liquids) so line #2 DNCGs from the fiber line will be led to a 150 m high stack. If for some reason flare #2 is not available for DNCG incineration, both lines will divert DNCGs to 150 m high stacks.

Operational experience

Judging from the mill start-up, the results have been more than promising. Before the implementation of the new NCG system, the Guaíba mill used a separate incinerator for incineration of NCGs. The diesel oil consumption of the incinerator was around 1.5 tons per day. Now gases are burned in the recovery boilers, and the estimated savings in oil consumption are approximately 530 tons per year.

Earlier, the NCG incineration concept was to shut down the mill when the NCG incinerator could not take the gases. This meant production losses of about 1300 Adt of pulp per year (**Figure 4**). Nowadays, the NCGs can always be directed to one of several incineration locations.

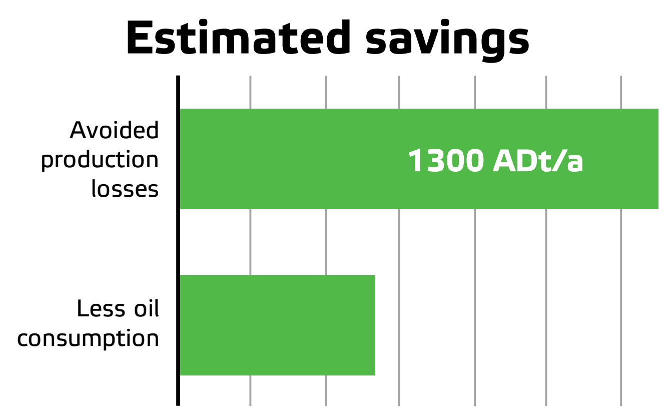

Figure 4. Estimated savings per year after the new NCG system was started up

The new NCG system has also efficiently prevented emissions of odorous gases. During a period of 12 months, there have been 20 incidents when DNCGs have been turned from one incineration location to another, instead of venting them to the atmosphere. This means that the system has prevented emissions and disturbance to the surroundings due to DNCGs 20 times.

For CNCGs, the new operating concept with a flare connected to the emergency system and bottling the gases has prevented venting four times during the same period.

So, the total number of incidents where emissions of odors were prevented was 24 times (**Figure 5**) for the 12-month period.

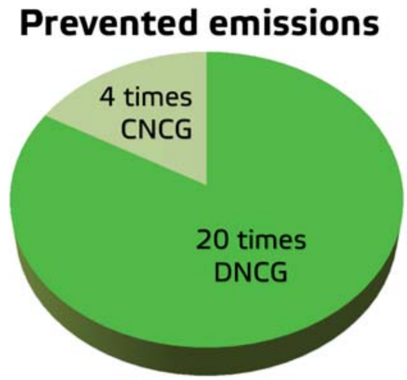

Figure 5. Prevented odor emissions after mill wide NCG system was implemented

Conclusions

The world is changing and environmental issues are continuously becoming more and more important. This has been one of the drivers for companies to improve NCG systems and develop new concepts to handle odorous gases.

In CMPC Guaíba an odorless pulp mill has now been running for almost two years. Besides reducing emissions and preventing explosions, the installation also contains many safety aspects that provide a safe working environment for the personnel at the pulp mill.

CMPC Guaíba is an odorless mill without compromising safety!

Figure 6. Aerial view of Guaíba pulp mill

References

1. Burgess, T. and Young, R., "The explosive nature of non-condensable gases", Proc. 1992 Tappi Environmental Conf., 81 – 95 (1992).
2. "Recommended procedure for incineration of non-condensable gases", rev B, Finnish Recovery Boiler Committee (2014).

This white paper combines technical information obtained from Valmet personnel (Asta Humalajoki) and published Valmet articles and papers. Special thanks extended to Daniel Sidoruk, CMPC Riograndese Ltda.

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