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Stripping of kraft pulping process condensates: regulations, design and operation

Scope

Basic regulations concerning the collection and stripping of foul pulping process condensates are included in this TIP. Typical design and operating information is given based on a standard 900 air dry metric ton (1000 short tons) per day pulp mill. The strippers covered are those that remove total reduced sulfur (TRS) and hazardous air pollutants (HAPs), such as methanol as required by the Cluster Rule.

Definitions

Cluster Rules. A collection of air and water pollution control rules that are “clustered” together to ensure that an improvement in one does not result in deterioration of the other. That is, air pollution control cannot result in an increase in water pollution, and vice-versa. The Cluster Rules are designed to bring pulp mills up to MACT standards for HAPs.

HAP. Hazardous Air Pollutant

MACT. Maximum Achievable Control Technology

Pulping Process Condensates. Any HAP containing liquid that results from contact of water with organic compounds in the pulping process. Examples are digester system condensates, turpentine decanter underflow, and evaporator foul condensates.

Steam Stripper System. A column, feed tank, fiber filter, heat exchangers and condensers used to remove HAP compounds from wastewater or condensates using steam.

Stripper-Off Gas (SOG). The waste stream from the stripper system that contains the pollutants. It typically is 50% water vapor by volume, and 50% methanol and other pollutants.

Volatile Organic Compound (VOC). Any organic compound which will vaporize at room temperature.

Safety precautions

Pulping Process Condensates contain HAPs, especially methanol and turpentine compounds, and as such, may cause injury or death if ingested.

Storage tanks and process lines associated with stripping systems may contain HAPs and reduced sulfur gases in the vapor phase. Such gases are toxic if inhaled. All possible vents from stripping systems must be designed to discharge in such a way that the toxic gases are relieved away from personnel.

HAPs in the vapor phase, especially turpentine compounds, can be explosive if mixed with an appropriate amount of air. Thus, no open flames or welding should be allowed on or around the vessels or process lines of a stripping system. Equipment and tanks must be adequately grounded.

If maintenance work is required on all or part of the stripping system, the affected part must be isolated, drained, purged with air or steam, and checked for the presence of toxic and flammable gases before entry or welding.

Consideration should also be given to installing hydrogen sulfide detectors in areas, especially inside enclosed buildings, where leaks from the stripping system may occur.

Introduction

Foul condensates from the digesters and evaporators contain organic compounds, such as methanol (MeOH) and turpentine, as well as reduced sulfur compounds. These contribute greatly to pulp mill water pollution in the form of Biochemical Oxygen Demand (BOD) and toxicity, and air pollution in the form of Volatile Organic Compounds (VOC), and odor.

Steam stripping is one of the treatments accepted by the U.S. Environmental Protection Agency (EPA). Other acceptable methods are hard piping to biological treatment, reusing the condensates in a process where the vents are collected and incinerated, or any other process that can meet the required removal and destruction efficiencies. By collecting these foul condensates and stripping them, most of the pollutants can be removed and burned, reducing the pollution load to the air and to the secondary treatment system.

To minimize the cost of the stripping system while complying with treatment requirements, efforts are made to minimize the volume of condensate to be stripped and to integrate the stripping system with other equipment such as evaporators.

Condensates for collection

The Cluster Rule requires that the pulping process condensates from the following equipment be collected and treated to remove HAPs.

1. Each digester system.
2. Each turpentine recovery system.
3. Each evaporator system.
4. Each high volume - low concentration (HVLC) non-condensable Gas (NCG) system.
5. Each low volume - high concentration (LVHC) NCG system.

Table 1 shows typical pollutant loads in pulping process condensates from a bleached kraft mill. The volume of condensates formed is independent of species cooked. Note that condensates from hardwood mills will have similar flows, although the turpentine concentrations will be lower, and the methanol concentrations somewhat higher.

Although the rules allow various methods of determining removal efficiencies, bleached mills are required to collect selected condensates and treat them to destroy at least 5.1 kg per oven dry megagram of pulp (10.2 pounds of methanol per oven dry ton of pulp (ODTP)). Unbleached mills are required to destroy at least 3.3 kg per oven dry megagram of pulp (6.6 pounds per ODTP).

Methanol loads from brown mills will be about two-thirds of these bleached mill numbers, although the total flow will be about the same. It should be noted that the pollutant loads in any mill may vary greatly from these numbers, and that loads in any one mill will also vary from time to time.

The evaporator condensates in Table 1 are all the condensates, not just the pulping process condensates. The pulping process condensates will be about 30 to 40% of the total flow, and contain 70 to 90% of the pollutants. The volume of pulping process condensates can be further reduced if condensate segregation is practiced.

Table 1. Typical pollutant loads in foul condensates at bleached kraft mills based on unbleached digester production

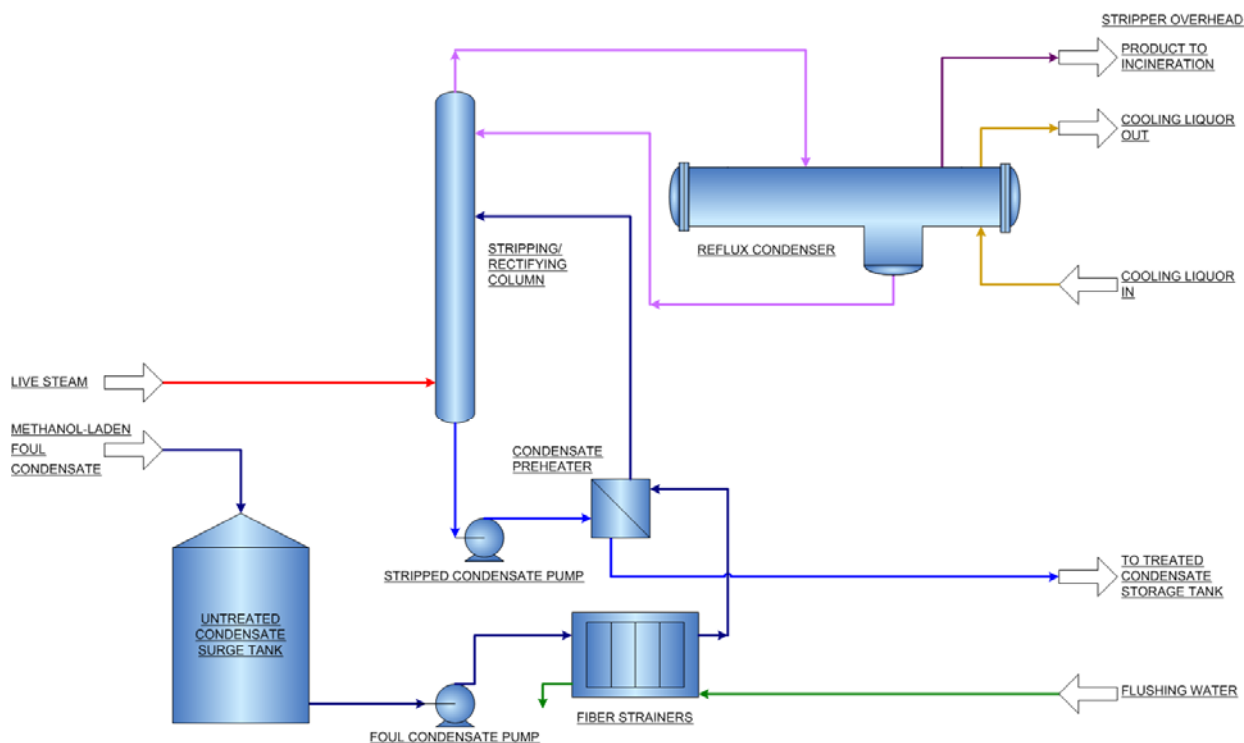
Source	Total flow		Methanol		Turpentine		TRS	
	kg/tonne	lb/ton	kg/tonne	lb/ton	kg/tonne	lb/ton	kg/tonne	lb/ton
<u>Batch digester mill (softwood)</u>								
Digester accumulator overflow	1125	2250	4.0	8.0	0.50	1.0	0.20	0.4
Turpentine Decanter Underflow	250	500	1.5	3.0	0.50	1.0	0.15	0.3
Total evaporator condensate	7000	14000	4.2	8.4	0.25	0.5	1.00	2.0
<u>Continuous digester mill (softwood)</u>								
Turpentine decanter underflow	450	900	2.5	5.0	0.5	1.0	0.12	0.24
Total evaporator condensate	8000	16000	7.5	15.0	0.5	1.0	1.20	2.40

There are four types of condensates that come from evaporators. The first is clean condensate, which is the condensed steam used to drive the evaporators. The second is combined condensate, which comprises condensates that are not foul enough to consider collecting and treating. The final two, contaminated condensate and foul condensate are the process condensates of interest. When condensate segregation is practiced, the pollutants split between the contaminated and foul condensates. The foul condensates are the worst and must be collected and treated. The contaminated condensates may or may not be collected and treated.

Stripper system

Figure 1 shows a typical steam stripper system. For a standard 900 metric ton per day Kraft pulp mill, the system typically will treat 1,100 liters (300 gallons) per minute of condensate. Again, this volume can vary greatly depending on types of digesters, evaporators and degree of condensate segregation. Steam use is typically 13,600 kg (30,000 lb) per hour, for a steam-to-condensate ratio of 0.20, but can vary from 0.15 to 0.22, depending on the application.

A feed tank is required to absorb swings in incoming condensate flow and to provide storage when the column is down, and the bigger the storage tank, the better. A thirty minute retention time is a minimum, but several hours are better. The vessel should be 300 series stainless steel. It must be vented into a gas collection and incineration system. The vent should enter the concentrated NCG system (CNCG), sometimes referred to as the Low Volume High Concentration (LVHC) NCG system.



FOUL CONDENSATE METHANOL STRIPPING SYSTEM

Fig. 1. Stripping system schematic

The tank is operated as a surge tank, and turpentine in the condensate may separate and collect in a layer on the top of the condensate. The feed tank must either be designed to prevent the turpentine accumulation, or include a skimming or laundering provisions to remove the turpentine. One technique to minimize turpentine accumulation is to deliver condensate that may contain appreciable turpentine to the suction side of the stripper feed tank discharge pump, bypassing the feed tank entirely.

Fiber filters are a standard part of stripper system design, and used to prevent fiber pluggage of the condensate heat exchanger and stripping column. The heat exchanger should heat the incoming foul condensate to within 10°C (20°F) of the column temperature, exchanging heat with the stripped condensate leaving bottom of the column. If the heat exchanger is less efficient than this, then too much of the incoming steam will condense, and either stripping efficiency will drop, or the steam flow must be increased. Shell and tube, spiral, and plate-type heat exchangers have all been used in this service. All parts of the heat exchanger in contact with condensate should be 300 series stainless steel. Gaskets should be TFE based.

Two types of columns are used for stripping; packed columns and valve tray columns. Packed columns are generally less costly for small diameter columns. Packing material is stainless steel pall rings. The disadvantages of packed columns are poor turndown ratio and plugging of the packing by fiber and organics carried in the condensate. Valve tray columns are an advanced form of a bubble cap tray column. They have the advantages of maintaining high efficiency over a wide operating range, a constant pressure drop at varying vapor load rates, and self-cleaning of the trays. As a general rule, packed columns are used for small strippers, while valve tray columns are used for large strippers. The valve tray steam stripping column has become the standard for meeting environmental requirements.

The reflux condensers can be mounted vertically or horizontally. All parts in contact with the vapor and condensate should be 300 series stainless steel. The coolant, typically water or weak black liquor, normally passes through the tubes. Some installations successfully pre-heat demineralized boiler feedwater as the heat sink. Two-stage