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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 Methanol (MeOH) as required by the Cluster Rule.

Definitions

Cluster Rules. A combined 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, are 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.

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.

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 stage where vapor from the weak liquor feed stages is condensed.
4. Each High Volume, Low Concentration Noncondensable Gas (NCG) system (or dilute NCG system).
5. Each Low Volume, High Concentration NCG system (or concentrated NCG system).

Item 3 is somewhat confusing. Consider that for a six-effect evaporator, if weak liquor is fed to the fifth and sixth effects, then the condensates from the sixth effect and surface condenser are pulping process condensates that should be collected and treated.

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 somewhat lower, and the TRS concentrations somewhat higher.

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

Source	Total flow		MeOH		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

Pollutant loads from Brown Stock mills will be about two thirds of these 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.

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 condensates 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.

Stripping is a common method of treating these condensates. Other methods are hard piping to biological treatment, anaerobic digestion, and reusing the condensates in an enclosed system, such that any emissions are collected and incinerated.

Stripper system

Figure 1 shows a typical steam stripper system. For a standard 900 metric ton per day Kraft pulp mill, the system will treat 1100 L (300 g) 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.

The stripper column will be 2 meters (6 feet) in diameter, by 18 m (60 ft) high. It will operate at 170 kPa (10 psig). It will contain 20 valve trays, five in the top or rectifying section, and fifteen in the bottom or stripping section. The entire column will be built of 304 or 316 stainless steel. More or less trays can be used depending on the efficiency desired, and on the final methanol concentration. More trays give higher efficiency and/or concentration, but at a higher capital cost.

Fiber filters are a standard part of stripper system design, although their value is questionable. Many mills have operated for years with fiber filters bypassed.

The heat exchanger must heat the incoming foul condensate to within 10°C (20°F) of the column temperature. If the heat exchanger is less efficient than this, 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.

The clean condensate from the bottom of the column tends to scale the heat exchanger. For this reason, the clean condensate should go through the tubes in a shell and tube heat exchanger. The exact nature of the scale is not known, but it is believed by some to be polymerized turpentine compounds, which are formed in the column, and which plate out when the condensate is cooled. The rate of scaling seems to increase as the operating temperature of the system increases.

The condensates also have some pulp fiber in them. If spiral or plate type heat exchangers are used, the gap between the plates must be wide enough to pass the fibers through. Otherwise, the heat exchangers will plug quickly.

Regardless of the type of heat exchangers used, provisions for cleaning and/or back washing should be included in the design. All parts of the heat exchanger in contact with condensate should be 300 series stainless steel.

The clean condensate is normally reused in the process, typically as wash water for brown stock washers. Clean condensates are also used as make up water in recaust areas.