



A SulfoLoop™ **SULFURIC ACID PLANT**

**Closing loops equals huge savings on
chemicals and enables self-sufficiency
in sulfuric acid at pulp mills**

ANDRITZ

ANDRITZ SulfoLoop – CLOSING LOOPS EQUALS HUGE SAVINGS ON CHEMICALS AND ENABLES SELF- SUFFICIENCY IN SULFURIC ACID AT PULP MILLS

INTRODUCTION

ANDRITZ leaves no stone unturned when it comes to providing technology for increasing circularity at pulp mills. One of its latest solutions, SulfoLoop sulfuric acid plant, allows pulp mills to make their own sulfuric acid from sulfur-containing side streams, at the same time as eliminating the purging of waste streams to the environment.

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for the environment and mill
revenues.”**

MINNA LAITINEN
Product Manager, SulfoLoop at ANDRITZ



**“With very high conversion rate,
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from the CNCGs.”**

SAMUEL SCHERMAN JOHANSSON
Technology Manager – Concepts and Studies Clean Air Technologies
Topsoe A/S



ANDRITZ SulfoLoop sulfuric acid plant

The pulp industry has made great progress on the environmental front over the last decades. The most modern pulp mills have now become showcases for other industries when it comes to sustainability and circularity in industrial processes. There are now prime examples of completely fossil-free mills, generating a surplus of energy and with very low carbon footprint as pulp mill operators ceaselessly look for ways to become carbon neutral.

There is also a focus on the use of side streams at pulp mills to make other value added products, for example biomethanol and bioproducts from extracted lignin. In fact, we have now entered the era where pulp mills are being described as "bioproduct mills", and even "biorefineries" as they add innovative products made from renewable sources to their portfolio of offerings.

However, there is still work to be done to ensure environmental and financially beneficial closed loops in pulp production processes. One area that is particularly in focus is the removal of excess sulfur from the pulp mill chemical cycle to limit the dumping of sulfate-containing streams, which is already under the watchful eyes of regulators.

ANDRITZ SulfoLoop not only addresses the issue of sulfate dumping and other environmental issues, it also enables a mill to be self-sufficient in sulfuric acid, thereby making significant savings when it comes to the use of chemicals.

MAJOR ENVIRONMENTAL AND FINANCIAL BENEFITS

The SulfoLoop process involves the recovery of sulfur from concentrated non-condensable gases (CNCGs) from the pulping process, converting them into sulfuric acid to be used in the mill. One of the major benefits of the SulfoLoop solution is it allows the mill to control its sodium and sulfur balance at the same time as enabling the mill to be self-sufficient in sulfuric acid.

Over the last decades pulp mills have been striving for environmental performance which has resulted in the closure of chemical cycles, including emissions and effluent reduction and control. In turn, these improvements have led to increased sulfur in a mill's Na/S balance. This increased sulfur needs to be removed to keep the mill balance. However, taking out sulfur in conventional ways ultimately means purging to the environment coupled with the loss of other chemicals, for example sodium.

In some mills fly ash is purged from the recovery boiler which is then dumped to the waste waters. Another way sulfur is lost is via the chlorine dioxide process at mills which produces sodium sulfate as a byproduct. The sulfate is then purged to the effluent treatment. Neither of these solutions are ideal from an environmental nor economical point of view.

"When it comes to sulfate dumping, there can be environmental issues such as the harming of aquatic ecosystems," explains Minna Laitinen, Product Manager, SulfoLoop at ANDRITZ. "There are already cases where environmental permits have been refused for new pulp mills due to sulfate dumping and there is no doubt that these disposal methods will come under much more scrutiny by environmental regulators in the future."

There is also an economical cost to removing sulfur from the pulp mill recovery cycle. Whenever sodium sulfate is purged, sodium is lost which needs to be replaced in the mill recovery cycle by introducing make-up chemicals, for instance sodium hydroxide, which is highly expensive.

"In a nutshell, the SulfoLoop solution recovers the sulfur coming from the pulp mill processes, thereby eliminating the environmental and financial implications of purging and dumping sodium sulfate," says Laitinen. "Furthermore, and even more beneficial, the recovered sulfur streams are then transformed into concentrated sulfuric acid for all the mill's needs. The SulfoLoop solution is a win-win for the environment and mill revenues."

SulfoLoop: TOPSOE WSA TECHNOLOGY

As part of its CircleToZero initiative, ANDRITZ has already successfully introduced SulfoLoop sulfuric acid plants into the pulp industry, with installations at two mills in Brazil – Klabin Puma Ortigueira and Suzano Ribas do Rio Pardo – with further orders already in place in Sweden at Södra Cell Mönsterås. The solution utilizes WSA (Wet Gas Sulfuric Acid) technology developed by the Danish company Topsoe. The technology is well-proven, having already been licensed to operate at nearly 200 locations worldwide.

Samuel Scherman Johansson, Technology Manager at Topsoe, says, "The foundation of our company revolves around how we can help the world through chemistry, something we have been doing for around 80 years now. The ANDRITZ SulfoLoop sulfuric acid solution, which utilizes Topsoe WSA technology, is a prime example of the type of technology we provide. In fact, Topsoe is the market leader in this area, and is spearheading the development of sulfuric acid catalysts across industries."

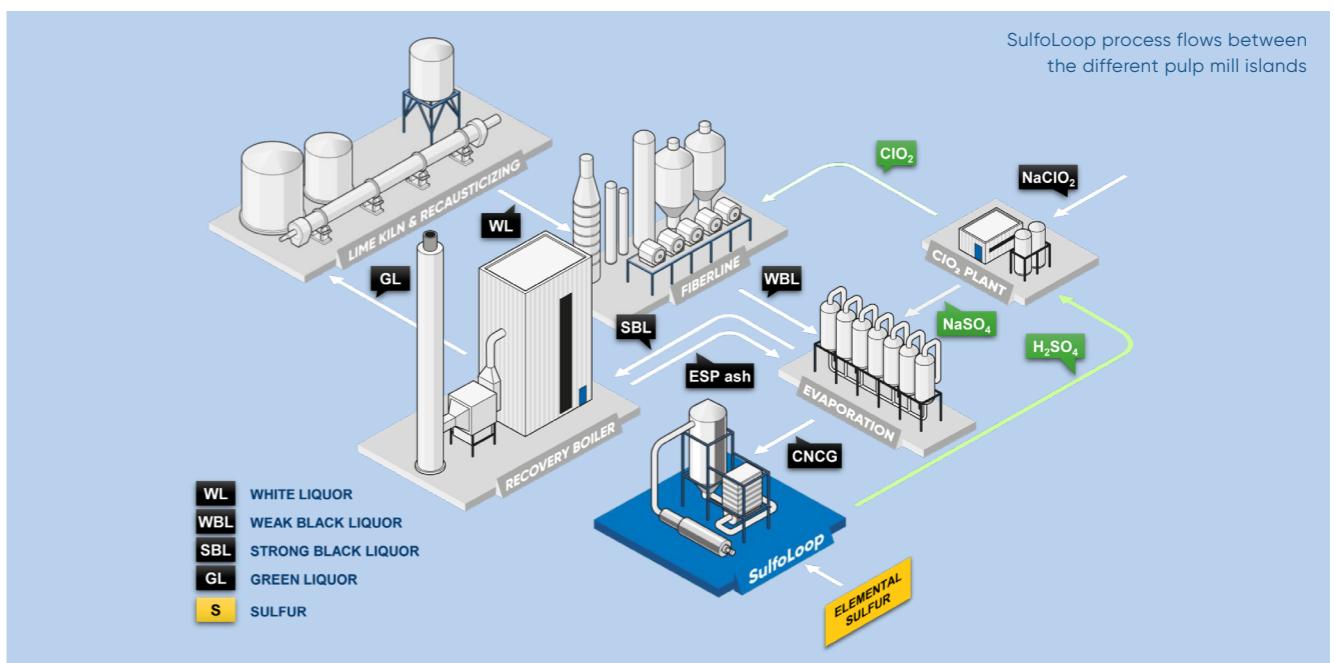
The company has successful plants all over the world in various industries including metals, crude oil, natural gas and viscose plants – basically any industries looking to convert their sulfur containing off-gases or acid gases to sulfuric acid.

The Topsoe WSA technology is well suited to the pulp industry due to its ability to handle gases that contain water, eliminating the need for drying as in the dry sulfuric acid process. The system can also take elemental sulfur to the same combustor for processing.

With the Topsoe WSA-based SulfoLoop solution, the CNCGs from the pulping process that contain sulfur and hydrocarbons are collected and burnt in a combustor to obtain the gases of SO_2 (sulfur dioxide) water, air and CO_2 . This is then cooled and passed over a selected number of catalyst beds where SO_2 is converted to SO_3 (sulfur trioxide).

The resulting stream of SO_3 , water and air are cooled with the process gas cooler. In this phase, SO_3 and water are forming sulfuric acid in the gas phase. When this is cooled further in the WSA condenser, sulfuric acid is condensing and reaching high concentration. The concentrated sulfuric acid is collected at the bottom of the Topsoe WSA condenser. The sulfuric acid is then ready to be stored or used at the mill. The small amount of SO_2 remaining in the gas is washed with sodium hydroxide solution, and the formed salt solution can be either returned to the cycle, or used as sodium bisulfite in pulp bleaching. The clean gas is then sent to the stack.

Central to the Topsoe WSA technology is the WSA condenser, which is capable of producing concentrated sulfuric acid above 95%, typically up to 98%, regardless of the initial amount of water in the feedstock gas. The process does not require additional steps such as concentration of the product acid. Another key benefit of the WSA is that everything upstream of the condenser is kept above acid dew point, thereby avoiding corrosion. The process gas only reaches the acid dew point when it is condensed inside the glass tubes of the WSA condenser, instead of high corrosion risk quench cooling, used in other technologies.



Getting technical

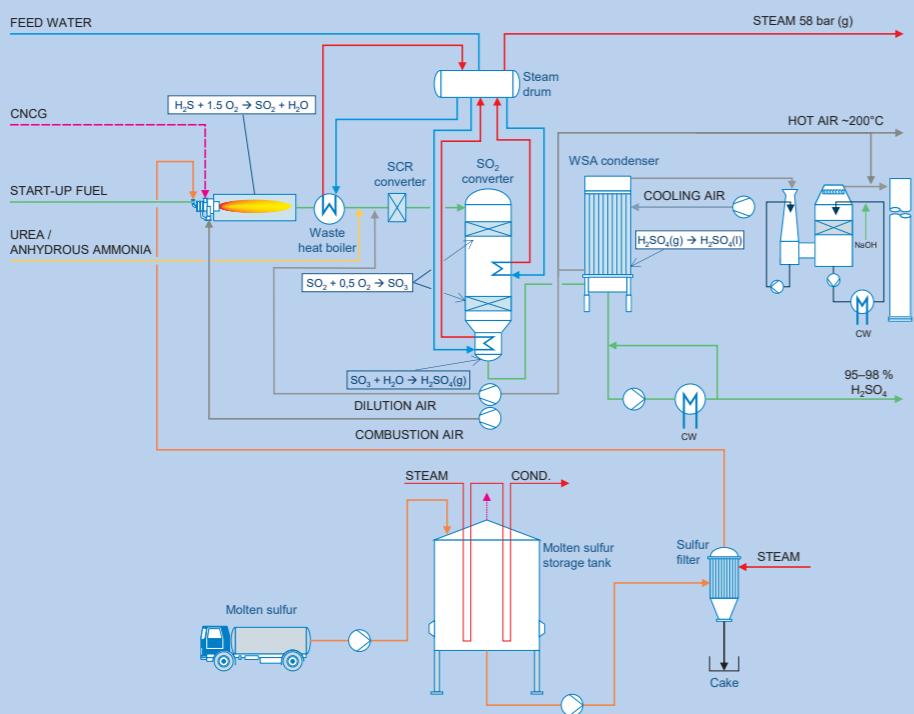
SULFURIC ACID | WET GAS SULFURIC ACID (WSA)

The Topsoe WSA process is a wet gas catalytic process. The concentrated sulfuric acid is produced by condensation from a wet process gas. Drying of the process gas prior to treatment in a Topsoe WSA plant is completely unnecessary, which means generation of wastewater and loss of sulfur are avoided.

The purpose of the first step in the process is to produce an SO₂-rich gas at the operating temperature of the oxidation catalyst in the SO₂ converter. Sulfurous feeds are oxidized to SO₂ by combustion and then cooled to the optimum catalytic conversion temperature in a waste heat boiler. The excess heat from this operation is recovered as steam.

The catalytic conversion of SO₂ to SO₃ takes place in one or more catalyst beds. The reaction heat is recovered between the catalyst beds by production of saturated or superheated steam. After the last conversion step, the gas is cooled and the SO₃ reacts with water vapor to form gas-phase sulfuric acid. The process gas is finally cooled by a countercurrent flow of air in Topsoe's proprietary WSA condenser.

Clean tail gas exits at the top of the WSA condenser and the sulfuric acid is collected in the bottom section from where it is cooled and sent to storage. Hot air generated in the WSA condenser may be used to preheat combustion air of the recovery boiler, to ensure optimal energy efficiency.



Johansson says, "With very high conversion rate, the Topsoe WSA system can convert over 99% of the sulfur from the CNCGs. To meet the mill's sulfuric acid needs, the WSA can be designed to also take in molten sulfur as feed to the combustor. As a rule of thumb, 1 metric ton of sulfur is needed to produce roughly 3 metric tons of sulfuric acid. In practice, this means that elemental sulfur is needed just a third of the needed amount of purchased sulfuric acid, which also means further

reduction in chemical transportation and savings in chemical costs. Elemental sulfur can also function as a sole support fuel for CNCG."

"The reason why WSA technology fits so well into a pulp mill is that operators can control the whole sulfur loop in the plant – the amount of sulfur you are using and how much acid you are producing."

MAJOR BENEFITS OF THE SulfoLoop WSA SYSTEM

WSA technology responds perfectly to the most stringent emission limits. Take nitrogen oxide (NOx) as an example, which is one of the major pollutants from combustion processes. When the waste gas incineration Best Available Techniques (BAT) in pulp mills (2014/687/EU), calls for maximum of 400 mg/Nm³ at 9% O₂, WSA can reach one tenth of the upper BAT limit. NOx emission limits are tightening all around the world due to the impact of NOx to human health. In some countries, pulp mills are incentivized to reduce the emissions more than the environmental permit requires. In these countries, reduced NOx can also lead to additional revenues.

Another major benefit of the WSA system is that 80–90% of the extensive heat available can be recovered. The heat comes from all the exothermic reactions including oxidation of H₂S and mercaptans into SO₂, conversion into SO₃, hydrolyzation into H₂SO₄ and condensation to liquid acid. This heat can be recovered as high-pressure steam for generating more energy at the mill. Additionally, the condenser uses ambient air as cooling media, significantly decreasing the need for cooling water and producing hot air that can be used in other processes, such as secondary air in the recovery boiler.

Laitinen adds, "With the SulfoLoop WSA system we are recovering steam with high pressure, typically 58 bar(g), from which we can make saturated or superheated steam to then be utilized in the soot blowing system for the boilers or in some cases even sent to the turbine to produce electricity."

INSTALLATION, PRODUCTION AND ROI

Installation of a SulfoLoop solution at a pulp mill is not a complicated process due to ANDRITZ's extensive expertise in pulp mill projects and installation can take place while the mill is in full production. Laitinen explains, "The SulfoLoop sulfuric acid plant is a stand-alone unit contained within the mill and installation basically involves developing or adapting a mill-wide CNC system to the process. Concentrated gases from the pulping process, including the evaporation plant and fiberline are then taken to the SulfoLoop plant to be processed further to produce sulfuric acid."

Laitinen stresses that lifecycle costs of a SulfoLoop plant are the lowest on the market when compared to other systems, she says, "It is a given that diluted sulfuric acid is a very corrosive chemical, but working above the acid dew point and producing concentrated acid avoids the corrosion of elements over time. The over-



ANDRITZ SulfoLoop sulfuric acid plant 3D illustration

all maintenance costs of the SulfoLoop plant are also much lower when compared to competing systems."

Johansson adds, "With numerous plants running 24/7, 365 days a year across the world and decades of experience, as well as having our own sulfuric acid catalyst, we are confident in saying that Topsoe WSA is the leading technology in this area."

When it comes to return on investment, there are various factors that make a difference, Laitinen explains, "The return on investment very much depends on the local market costs of sulfuric acid, make-up chemicals such as sodium hydroxide and the price of sodium sulfate and elemental sulfur, however we estimate that the minimum return on investment with a SulfoLoop plant is 3–7 years on the chemicals savings and recovered energy alone."

Laitinen concludes, "Added to the savings in chemicals, for many mills it can be even more important that the SulfoLoop solution reduces the risk and dependence on the chemical markets. The mill with SulfoLoop does not need to worry that much about volatility of the chemical prices, nor being afraid that someday the whole mill needs to be shut down due to unavailability of sulfuric acid, as happened in Brazil in 2018."

The sulfuric acid plant also brings flexibility to each specific pulp mill. The solution can be tailored to the individual process demands, such as the need for sodium bisulfite, steam parameters and future upgrades. All SulfoLoop plant operations are fully supported with the latest digital platforms and local on-site support from ANDRITZ and Topsoe experts to ensure highest availability for the whole plant lifecycle.



CONTACT US

To find out more about how your mill can become self-sufficient in sulfuric acid, please contact us at: CircleToZero@andritz.com

SulfoLoop sulfuric acid plants are part of ANDRITZ's CircleToZero initiative which includes new technologies aimed at optimizing pulp mill side steams. The initiative aims to eliminate all unused side streams, create new added-value products and lay the foundation for zero emissions and zero waste production.

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