ANDRITZ: PROVIDING THE RIGHT SCRUBBER SOLUTION

ANDRITZ is one of the world's leading suppliers of plants, machinery and services for many different branches of industry in the public, municipal and private sectors. The group has its headquarters in Graz, Austria, and operates worldwide with around 29,600 employees and 280 locations. In the exhaust gas cleaning sector, ANDRITZ has been successfully supplying plants for wet and dry separation of sulphur oxide (SOx), nitrogen oxide (NOx), dust, and other air contaminants for more than 35 years.

Cleaning of exhaust gas from shipping is a challenge that is perfectly compatible with the comprehensive know-how ANDRITZ has gathered from supplying and optimising several hundred plants worldwide. In the maritime sector, the company offers proven technologies, such as open-loop and closed-loop wet scrubbers, as well as hybrid designs and is developing its product portfolio continuously in order to provide all customers with the perfect solution for their requirements. The latest of these developments is the innovative, world's first combined desulphurisation/de-dusting plant based on a dry process for shipping.

BACKGROUND

Exhaust gas emissions from maritime engines — especially NOx, SOx, unburned hydrocarbons and dust particles — harbour considerable potential for causing damage to human health and to the environment. In order to counteract this potential, the International Maritime Organization (IMO) has implemented a code of practice for control of emissions from shipping exhaust gases in Annex VI to the MARPOL International Convention for the Prevention of Pollution from Ships. Annex VI regulates the emission limits stipulated for SOx and NOx globally, but also for designated zones, with particular focus on avoiding emissions (ECA zones).

Attention to and awareness of emissions have increased substantially in the past few years. This is also reflected in the development of emission limits in recent years. As from 1 January, 2020, the limits are 0.1% sulphur content in fuel in ECA zones and 0.5% globally. In order to comply with these limits, ships must carry low-sulphur fuel or have a system for desulphurisation of exhaust gases, which is an attractive alternative in terms of operating costs.

To support clients with their strategy to comply with these limits, ANDRITZ has developed different types of desulphurisation systems under the brand name "SeaSOx", based on the company's extensive experience carrying out hundreds of installations over the past few decades. As the only supplier in this field, ANDRITZ offers all types of wet scrubbing systems (open or closed loop, hybrid mode or hybrid-ready) in I-Type or U-Type configuration (circular or rectangular footprint), as well as a unique dry scrubbing solution in single or multi-inlet configuration. In addition to the desulphurisation effect down to 0.1% sulphur content in all scrubbing solutions, the dry system offers many other benefits:

- Simultaneous removal of more than 99% of particulates (verified in independent measurements)
- No discharge water
- No exhaust gas plume
- No corrosion problems
- Easy installation (no dry dock needed).

The dry system has special space requirements, hence it is not always the best solution for all ships. In addition, the operating costs are normally higher than traditional open loop systems, but comparable to or even lower than those of closed loop scrubbers. As ANDRITZ can offer all systems, the best solution for a specific vessel needs to be discussed in detail with the client to understand the specific needs and provide the best solution.

TECHNOLOGY

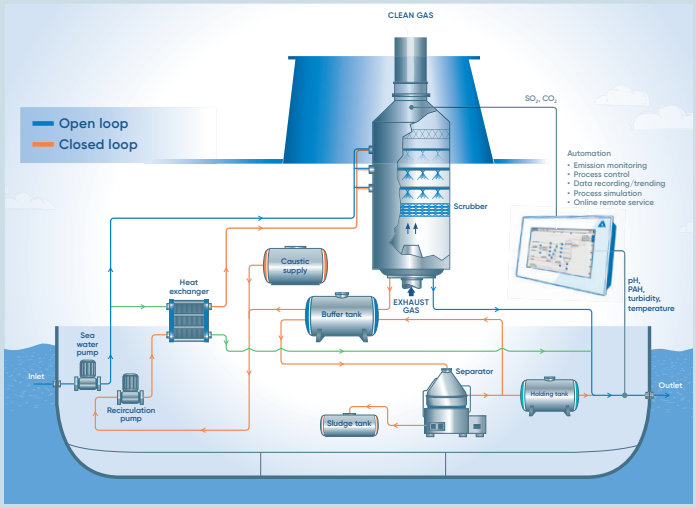
ANDRITZ SeaSOx$_{wet}$

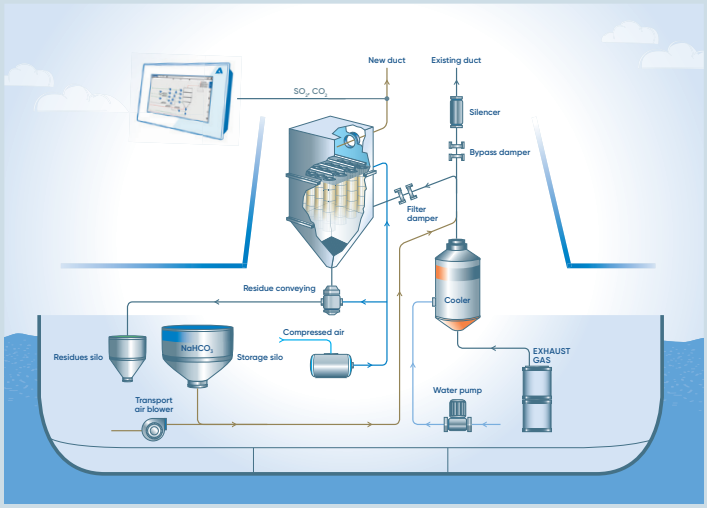
In **open loop** mode, seawater is used as a washing medium to clean the exhaust gas. This simple process makes use of the natural alkalinity of the seawater in the chemical absorption of the SOx. For this reason, the washing medium is pumped from sea chests to the absorber, where absorption takes place by means of spray scrubbing.

The exhaust gas treated can then be released into the environment and the effluent is also discharged. Both the exhaust gas and the effluent have to meet several critical, environmental constraints, which are validated by continuous emission monitoring.

If the natural alkalinity is too low or discharge of the effluent is not allowed, SOx scrubbing is performed in a **closed loop**. In this mode, the washing medium is recycled and a neutralising agent (50% by wt. NaOH, Na_2CO_3, $Mg(OH)_2$) is added in metered doses to obtain a certain absorption capacity. In order to control the absorption temperature and maintain the water balance, an inline heat exchanger is provided on request to cool the washing medium down. Consequently, the effluent has to be cleaned periodically depending on the engine load, the ship's route, and its fuel specification.

For this application, a washing water treatment unit is installed to separate the particles and salts from the washing medium, in accordance with the MARPOL Convention, before it is discharged into the sea. The sludge generated is collected in a separate tank, while the treated washing water





is either stored in the holding tank or discharged into the sea, depending on local discharging restrictions.

A combination of open and closed loop operations is called **hybrid mode**. In hybrid mode, it is possible to switch between these two processes depending on the predominant basic conditions (seawater alkalinity, discharge restrictions, and so on). This option provides high flexibility and enables customers to choose the best process, both economically and technically.

ANDRITZ SeaSOx$_{dry}$

In the SeaSOx$_{dry}$ desulphurisation process, powdered sodium bicarbonate ($NaHCO_3$) is added in metered doses to the exhaust gas stream. As a result of the high temperatures in the exhaust gas, the sodium bicarbonate is activated, causing it to decompose into reactive sodium carbonate that subsequently reacts with the SO_2 and SO_3 in the exhaust gas. This activation process requires temperatures of more than 150°C. The product of this reaction is solid sodium sulphate (Na_2SO_4). The reaction product, the excess sodium bicarbonate, and the soot and heavy metal particles from the exhaust gas form a porous layer — the so-called filter cake — on the surface of the filter bags in the fabric filter installed.

Without this filter cake, it would be impossible to achieve the low SOx emission values required in the ECA zones (0.1%). What is more, the filter cake improves contact between the SOx molecules and the sodium bicarbonate, resulting in much better utilisation and lower consumption of the absorption agent.

When a pre-set, maximum differential pressure is reached, the filter cake is cleaned off the filter bags by jets of compressed air and the solid material produced drops into the filter's collection hopper where it is discharged downwards. A conveying receiver is placed beneath each filter hopper and conveys the solids to the residual material container by means of compressed air. To prevent damage to the filter bags as a result of the exhaust gas temperatures being too high, the gas temperature can be lowered by injecting water. As an alternative, it is possible to install a fan to mix cool outside air with the flow of hot exhaust gas.

It is important to underline the fact that no waste water (or other residual material) is discharged into the sea, unlike in the open-loop scrubber process. The auxiliary and operating materials do not present any health risks, and the noxious soot and dust from the exhaust gas is contained in the residual material in a bonded state.

CASE STUDIES

The following studies show a typical scrubber choice for these kinds of vessels, both installed by ANDRITZ. Only the technical data is provided in order to have a good basis for comparison and an overview of these systems.

SeaSOx$_{wet}$

The following table shows the boundary conditions of an installed wet scrubber project:

Vessel type	Bulk carrier
Vessel operating area	Worldwide (between China and South America)
Engines connected to EGCS	Main engine only (18.6 MW)
Scrubber operating mode	Open loop
Scrubber type	I-Type (square footprint)
Scrubber design load	85% SMCR
Design exhaust gas flow	130,000 kg/h
Design sulphur content in fuel	3.5%
Sulphur removal efficiency	< 0.5% (0.1% also possible) S fuel equivalent

The following parameters result from design and operation of the system:

Scrubber dimensions (square)	2.8 x 2.8 x 10.9 m (L x W x H)
Pressure drop at design load	< 15 mbar
Wash water flow at design load	800 m³/h
Power consumption	approx. 180 kW

For a bulk carrier operating most of the time in deep waters, an open-loop scrubber is usually the best choice. In ports and coastal areas, the vessel switches to low-sulphur fuels. Additionally, low-sulphur fuel is used to drive the auxiliary engines and also operate the boiler. Most of the fuel is consumed by the main engine. Hence, the SeaSOx$_{wet}$ technology is the right choice.

SeaSOx$_{dry}$

The following table shows the boundary conditions of an installed dry scrubber project:

Ship type	RoRo ferry
Vessel operating area	Mediterranean Sea (between France and Corsica)
Ship owner	La Méridionale
Engines connected to EGCS	Main engine (9.6 MW) **Auxiliary engine (1.26 MW)**
Scrubber operating mode	Dry
Scrubber type	Bag filter with bypass
Scrubber design load	100% MCR for main engine 0% SMCR for auxiliary engine
Design exhaust gas flow	65,000 kg/h
Design sulphur content in fuel	3.5%
Sulphur removal efficiency	< 0.1% S fuel equivalent

The following parameters result from design and operation of the system:

Filter dimensions	12.5 x 4.9 x 13.3 m (L x W x H)
Pressure drop at design load	< 15 mbar
Sodium bicarbonate consumption at design load	230 kg/ton of fuel
PM1 removal rate (per number)	> 99%
Power consumption	approx. 30 kW

La Méridionale requested the installation of a dry system on its RoRo vessel as this technology is able to remove particulates and ultra-fine particulates in addition to SOx. Furthermore, no water is discharged into the sea. The absence of a white or black plume was another advantage for the ship operator as the ship also carries many passengers. The space requirements were a challenge, but collaboration between the ship owner, the ship integrator, Solvay (as sorbent supplier) and ANDRITZ resulted in a favourable solution.

CONCLUSION

The choice of the right system for a specific vessel has always to be discussed in detail. In order to make this decision, the scrubber supplier, the ship owner and the ship operator or charterer have to clarify the boundary conditions (for example, local scrubber restrictions, environmental aspects such as additional particulate removal, routing of the vessel, space availability on board, costs, and so on).

It is not easy to make general recommendations for the choice of system, but the following points can help in coming to the right decision.

Arguments in favour of wet systems:

- Vessel operates mainly in deep waters
- Seagoing time is more than 80% of the operating time
- Ship is a bulk carrier
- Medium-to-large engine loads (more than 8 MW)

Arguments in favour of dry systems:

- The vessel has frequent stays in port
- Ship is a ferry
- Ship is operating in areas with wash water discharge restrictions
- Ship is operating in waters with low alkalinity (Great Lakes, Baltic Sea) or in sensitive areas (coastal regions)
- Small-to-medium engine loads (3–30 MW)

These arguments are only a rough guideline and, of course, higher engine loads are also possible with dry systems for example, as are lower engine loads with a wet system.

In addition, ferries are good candidates for wet systems, but it is also worth considering a dry system, especially for this type of vessel.

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