INTERNATIONAL MOLYBDENUM ASSOCIATION
THE VOICE OF THE MOLYBDENUM INDUSTRY

Low sulfur on the high seas

Maritime shipping remains one of the most cost-efficient global transport methods, especially compared with air freight. Its rapid growth since the 1970s and the containerisation of cargo have kept pace with the global economy, however this has also increased its environmental impact. New regulations limiting the sulfur content of engine fuel mean that ships must either use cleaner, more expensive fuel, or install equipment to take sulfur out of exhaust gases, a process in which molybdenum plays a key role.

When thinking about air pollution, some familiar sources come to mind – power stations, incinerators, planes, cars and trucks; but what about ships? Some 90% of global trade is carried by sea, with the total volume of freight increasing to nearly 10 billion tonnes in 2014, four times the level recorded in 1970. It is estimated that there are now more than 100,000 transport ships in use around the world.

This steady rise in sea freight means that emissions from shipping continue to increase. A recent study estimated that if nothing changes, emissions from shipping will be the largest single source of air pollution in Europe by 2020.

Ships are usually powered by diesel engines, typically run on heavy fuel oil. Often described as the leftovers from the refining process, this incredibly viscous fuel, which at room temperature has a consistency similar to peanut butter, is inexpensive but very dirty and extremely high in sulfur. It typically contains up to 35,000 parts per million – or 3,500 times the amount in the ultra-low sulfur diesel routinely in use on European roads. It is the reason that maritime shipping accounts for 8% of global emissions of sulfur dioxide (SO_2).

Acid rain and premature deaths

Sulfur dioxide is released when the fuel is burned, dispersing into the atmosphere in the exhaust gases. Depending on environmental conditions, sulfur dioxide will readily react with tiny droplets of water to form sulfuric acid, the cause of acid rain. Acid rain is between 10 and 100 ›

Nearly 10 billion tonnes of freight were moved by sea in 2014. © iStockphoto/dan_prat

The scrubber vessel of a marine flue gas desufurisation (FGD) unit ready to be shipped. © CR Ocean Engineering

times as acidic as ordinary rain, causing damage to trees, plants and buildings.

If it is not dissolved in the atmosphere, it presents a different hazard, as when inhaled, sulfur dioxide is known to cause respiratory problems and is associated with inflammation leading to heart and lung failure. A 2011 Danish study estimated that some 50,000 premature deaths in Europe are linked to air pollution from maritime shipping.

So what is being done about this environmental menace? The International Maritime Organisation develops and implements emission control regulations to reduce pollution by shipping. The MARPOL Annex VI regulations were first adopted in 1997, limiting the main air pollutants in ship exhausts. The latest revisions see the global cap on the sulfur content of fuel reduced from 3.5% to 0.5%, effective from January 2020.

However, an earlier amendment which came into force in January 2015 reduced the limit for sulfur content to 0.1% in the Baltic Sea, North Sea, North American and U.S. Caribbean Emission Control Areas. This means that ships over 400 gross tonnes sailing in these areas must now either use more expensive low-sulfur fuel, or opt to retrofit flue gas desulfurization (FGD) onboard to remove sulfur from exhaust gases and therefore comply with the new regulations.

FGD units on ships typically employ a process called wet scrubbing to remove up to 99% of sulfur dioxide from engine emissions. A liquid is sprayed through columns of exhaust gas, turning the sulfur to sulfuric acid, in a very similar way to how acid rain is formed in the atmosphere.

Where the resulting liquid can be safely discharged (on open seas with moderate to high alkalinity), an open loop system using only seawater to scrub the exhaust gases can be deployed. In waters with low alkalinity such as ports, harbors, lakes and canals, a closed loop system must be used, which does not discharge the scrubbing liquid. These systems use water mixed with sodium hydroxide (caustic soda) to neutralize the sulfuric acid formed and remove the sulfur.
In practice, many emission control units use both closed and open loop systems for greater flexibility and efficiency of operation.

The protective role of molybdenum

The environment within parts of the FGD units is extremely aggressive, and it is here that molybdenum plays a crucial role by greatly increasing the corrosion resistance of stainless steel. Several grades of stainless steel are typically specified within a FGD unit, depending on the potential for corrosion. Grade 316L is found in closed loop designs which do not use seawater. Open loop and hybrid systems are more corrosive due to the seawater. Therefore, more corrosion resistant, molybdenum-containing duplex, super duplex and super austenitic stainless steels as well as nickel-based alloys are used.
These grades, are particularly needed in pumps, valves and the scrubber tower itself, depending on the different manufacturers' specification.

Many recently built ships and those in construction are designed with FGD units built in, or have dual fuel engines to burn cleaner fuels. Older vessels can be relatively easily retrofitted with FGD units, in some cases inside the ship's funnel. The FGD route is cheaper than converting engines to run on alternative fuels (such as gas oil, natural gas or LNG), or switching to low-sulfur fuel, with manufacturers estimating a payback time of around two years. Fears that shortages of low-sulfur fuel could occur when the global 0.5% global cap is applied may also encourage more operators to invest in FGD units ahead of 2020.

Molybdenum already contributes to the protection of the environment in many ways, from playing a key role in renewable energy technologies to making cleaner fuel and more efficient, lighter but safer vehicles. Optimizing the global movement of goods is a key requirement in ensuring that the transport sector can make an overall positive contribution to sustainable development. Shipping has a large part to play in this, and the global reduction of sulfur emissions is a very significant step, one in which molybdenum has a key facilitating role. (AH)

A marine FGD scrubber vessel being retrofitted to a cargo ship. © CR Ocean Engineering