Exhaust Gas Scrubbers for Shipping

A subject of high controversy is the installation of exhaust gas scrubber on ships to reduce the sulphur emissions from stacks from ships which utilize high Sulphur fuel.
Approximately 80% of the fuel used in commercial shipping in 2007-2011 was low-grade, high-sulfur content fuel, which emits significant amounts of carbon dioxide (CO_2), sulfur oxides (SO_x), nitrogen oxides (NO_x), aerosols [with particle matter (PM), containing organic carbon (OC), black carbon (BC), polycyclic hydrocarbons (PAHs), and heavy metals] to the atmosphere during combustion.

Annex VI of MARPOL was adopted through a Protocol of 1997, which finally entered into force on 19 May 2005. As of 8 November 2017, 88 contracting states have ratified the Annex VI Protocol—totaling 96% of the gross tonnage of the world's combined merchant fleet. Annex VI seeks to limit the emissions of the main air pollutants contained in ships' exhaust gas, including SO_x, NO_x, and PM (particulate material), prohibits deliberate emissions of ozone-depleting substances, and regulates shipboard incineration as well as the emissions of VOC from tankers.

In October 2008, the MEPC adopted the revised MARPOL Annex VI and the associated NO_x Technical Code 2008 (Resolution MEPC 176). This included a reduction of the global sulfur cap from 3.50% to 0.50%. After assessing the fuel availability to meet the 0.50% standard, the MEPC endorsed this sulfur cap on fuels from 1 January 2020 at its 70th session on 28 October 2016 (Resolution MEPC 280).

MARPOL Annex VI also introduced emission control areas (ECAs), initially focused on sulfur emissions only and called SECAs (sulfur emission control areas), which aim to reduce emissions of air pollutants in designated sea areas. ECAs are areas where the adoption of special mandatory measures for ships is required to prevent, reduce and control air pollution. Five sulfur emissions control areas with were designated including the Baltic Sea, the North Sea, most of North America, including most of US and Canadian coast, and the US Caribbean Sea area. In the ECAs, the sulfur content of fuel oil used by ships has been limited to less than 0.10% since 2015. There are suggestions that ECA's may expand to China, Australia and other areas. Naturally occurring low sulphur fuel is scarce and refining to reduce sulphur content is expensive. An alternative is to use cheaper high sulphur content fuel in combination with an exhaust gas scrubbers to mitigate SO_x emissions. It is suggested that once the sulphur cap is introduced in 2020 the HSFO will get cheaper and price for LSFO will rise.

Scrubbers now come in various types (open or closed loop and hybrid systems) but the open loop gas scrubbers are the most popular (https://shipinsight.com/articles/scrubbers-ships-work). Seawater is used to spray on the exhaust gases and capture carbon particles and sulphur gases which will form sulphuric acid (Figure 1). The wash is then diluted with more seawater and the sludge is filtered and then diluted further and released into the ocean. The sludge is kept aboard. The pH or acidity of the discharge water should be 6.5 or greater. Normal seawater has a pH of 7.5 to 8.2 as measured on a log scale the ph is 10-17 times more acidic that normal seawater.

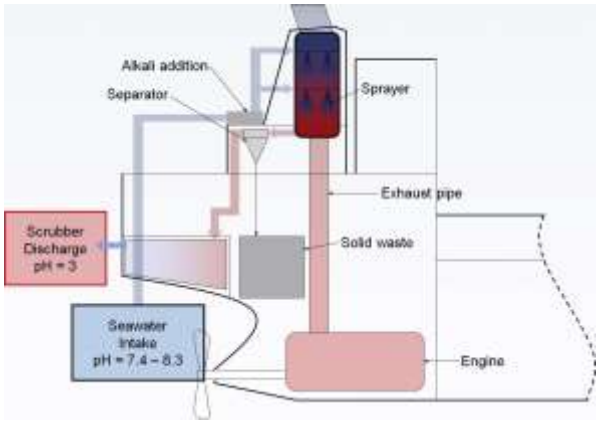

Figure 1: A diagram of a typical open loop wet scrubber

So shipowners and operators have a choice by 2020 of maintain high sulphur fuel which is cheaper and adding a scrubber system ($ 0.5-5 million) or using low sulphur fuel. Cruise lines who rely on good environmental publicity are adapting to this scrubber technology. For example, the owners of *Norwegian Escape* partnered with Oslo-based Yara to install the world's biggest marine SOx scrubber system in a bid to further improve the vessel's environmental credentials.

There have also been calls on the industry to develop new propulsion systems which do not use as much fossil fuel arguing that at some time using traditional fuel oil for ships will simply not make sense. The Auxiliary Sail Propulsion System (ASPS) uses fixed wing technology to assist in propulsion which would save 30% of fuel costs per year thus saving $ 2.5 - $ 3.0 million per year in bunker costs thus making the ships more profitable (http://www.windshiptechnology.com/).

LPG provides a future fit solution for shipping industry for the reduction of exhaust emissions from marine vessels. LPG emits practically negligible SOx and particulate matter. Moreover, it has the ability to emit approximately 80% fewer NOx emissions. Singapore-based BW has just announced that is has signed a contract to retrofit 4 of its ships to dual-fuel LPG and expects to reduce its sulphur emissions by 97%.

This creates controversy in many areas. First, the scrubbers rely on chemistry and that chemistry is complicated. Second, the oceans are acidifying due to carbonic acid formed from the dissolution of CO2 in the ocean. The scrubbers result in the addition of sulphuric and nitric acids, which are stronger acids than carbonic acid. The concerns are what these additions of these acids will do to the marine environment especially the coastal zone. It is clear that the science of the effects on the ocean has not been studied well but with stack emissions making their way to the ocean anyway, perhaps the removal of PM, hydrocarbons, metals etc. into sludge which is stored on board will be slightly beneficial. In the end, new technology will need to be brought to bear on this problem as the regulation is in place and 2020 is not far away.