Study on Economic Policy Path of Marine Low Sulfur Fuel Oil Development

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Abstract. This paper first introduces the main influencing factors of marine emission species and SO$_x$ emission of ships, and according to the definition of marine fuel oil quality standard and low sulfur fuel, studies the economic cost of the use of low sulfur fuel and the policy cost of Port SO$_x$ emission, and concludes that under the requirement of future sulfur emission control regulations, Marine low sulfur fuel is the inevitable conclusion of development.

Types of Atmospheric Emissions from Ships

There are four kinds of gases and a solid substance in the exhaust emissions of ships, four kinds of gas are three oxides and one kind of hydrocarbons, three kinds of oxides are nitrogen oxygen compound (NO$_x$), sulfur oxides (SO$_x$) and carbon monoxide (CO), a kind of hydrocarbon (CH$_x$) and solid particulate matter (PMX) and other pollutants. NO$_x$ is in the main engine cylinder, because some of the gas is not fully ignited, NO$_x$ emission depends on the combustion temperature, time and air-fuel ratio and other factors. Due to insufficient fuel combustion, the emissions of nitrogen oxides from the ship's exhaust more than 95% may be no, the rest is NO$_2$. CH$_x$ is mainly caused by unburned combustion and combustion during the combustion of fuel in the main engine of the ship. CH$_x$ and NO$_x$ form photochemical smog after intense solar ultraviolet irradiation in atmospheric environment. CO is mainly caused by insufficient combustion of hydrocarbon fuel. Photochemical smog and CO are bad for your health. The main reason of diesel engine emission PMX is that the fuel combustion is uneven or incomplete, and it is formed by oxidation and cracking at high temperature and anoxic conditions. In the process of engine operation, the ambient air temperature, pressure, humidity, fuel, working conditions will affect the formation of engine contaminants. SO$_x$ depends largely on the sulfurcontent of the fuel and is largely unaffected by the engine's operating status, and the rest of the engine exhaust is affected in varying degrees by the engine's fuel combustion status.

SO$_x$ Emission Regulatory Requirements

Annex VI (2008 Amendment) to the MARPOL Convention the emission control of SO$_x$ and PM10 is achieved by limiting the sulfur content of marine fuel. Annex VI (2008 Amendment) of the MARPOL Convention requires that, starting from January 1, 2012, the sulfur content limit for marine heavy fuel oil in the world should be reduced from 4.5% per cent to 3.5% prior to 2018, and that, if passed, the assessment will be made by January 1, 2020. The sulfur content limit for global marine heavy fuel oil will be required to be reduced to 0.5%. The sulfur content of heavy fuel oil used by ships in the SO$_x$ emission Control Zone (SECA) shall not exceed 1%; the sulfur content of marine heavy fuel oil has been further reduced to 0.1% from January 1, 2015.Literature References.

The development process of Sox emission control standards in China can be divided into four stages. In the initial stage, the "inland waterway ships statutory inspection technical Rules" (2008 revision circular) comes into effect, for the first time, the inspection and control of the diesel engine exhaust emission of inland river ships are clearly required, but only the NO$_x$ is required, and no standard is proposed for other pollutants such as SO$_x$. Put forward the specific limit value stage,
"inland waterway ships legal inspection Technical Rules" (2011 edition) formally enters into effect, in which the control standard of the NO\textsubscript{x} emission of the ship and 2008 revises the notification to be consistent, but its application scope extends to the ship which sails all inland waters of our country. The sulfur content of any fuel used on board shall not exceed 4.5%. The limit value further promotion stage, "inland waterway ships statutory inspection technical Rules" (2015 revision circular) formally enters into effect, further reduces the NO\textsubscript{x} emission target limit value (corresponds to MARPOL 73/78 Annex VI Tier II standard), and the marine heavy fuel oil sulfur content limit value adjusts to 3.5%. Clear control of the regional stage, the "Pearl River Delta, Yangtze River Delta, the Bohai Sea (Beijing, Tianjin and Hebei) area of the Ship Emission Control Zone Implementation Scheme" (2015), the formal entry into force, the main port waters in China to set up the ship emission control zone, which is currently our country to control.

The Cost of Using Low Sulfur Fuel in Enterprises

The fuel cost of the shipping enterprise is the main cost of the enterprise operation, such as the fleet of the Ocean Shipping Co., Ltd., the fuel cost accounted for 64% of the company's change cost, and accounted for 41% of the total cost. Different quality standards are required for marine fuel oil varieties. Marine fuel Oil GB/T 17411-2012, the provision of marine fuel oil 4 kinds of distillate fuel oil and 6 kinds of residue fuel oil, marine fuel oil performance indicators are required, as shown in Table 1 and Table 2:

<table>
<thead>
<tr>
<th>Performance</th>
<th>DMX</th>
<th>DMA</th>
<th>DMZ</th>
<th>DMB</th>
</tr>
</thead>
<tbody>
<tr>
<td>The viscosity of the motion is not more than</td>
<td>5.5</td>
<td>6.0</td>
<td>6.0</td>
<td>11.0</td>
</tr>
<tr>
<td>The viscosity of the motion is Not less than</td>
<td>1.4</td>
<td>2.0</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Sulfur content (%) less than</td>
<td>1.0</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Table 2. Marine Residue Fuel Oil Varieties.

<table>
<thead>
<tr>
<th>Performance</th>
<th>RMA 10</th>
<th>RMB 30</th>
<th>RMD 80</th>
<th>RME 180</th>
<th>RMG 180</th>
<th>RMG 380</th>
<th>RMG 500</th>
<th>RMG 700</th>
<th>RMK 380</th>
<th>RMK 500</th>
<th>RMK 700</th>
</tr>
</thead>
<tbody>
<tr>
<td>The viscosity of the motion is not more than</td>
<td>10</td>
<td>30</td>
<td>80</td>
<td>180</td>
<td>180</td>
<td>380</td>
<td>500</td>
<td>700</td>
<td>380</td>
<td>380</td>
<td>700</td>
</tr>
<tr>
<td>Sulfur content (%) less than</td>
<td>2.0</td>
<td>2.5</td>
<td>3.0</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

The main reason for the increase in fuel cost is the price difference of different fuel varieties. There is no clear definition of low sulfur fuel in the world, but the Natural Resources Conservation Association has given an interval for low sulfur fuel, which contains sulfur content of 1000-15000ppm (0.1% to 1.5%). The low sulfur fuel is more expensive than ordinary fuel, according to the bunkerworld website, in Singapore on March 31, 2015, the price of fuel oil is as shown in the Table 3.

As can be seen from Table 2, the highest sulfur content of not more than 0.1% of the MGO price to the proportion of quality fuel oil up to about 200 U.S. dollars/ton, so that the equivalent of a ton of low sulfur light oil per burn, fuel cost increase of about 40%, which undoubtedly brings huge cost burden to shipping enterprises.

If the sulfur content of the fuel is less than 0.1% requirements, to a 30,000 DWT cargo ship calculation, with an oil consumption of about 4 tons/day in Hong Kong, the daily conversion of low sulfur fuel costs is about $7900; The ocean-going vessels in the port of Pearl River delta are mainly
container fleets, and a container ship consumes about 7 tons/day on the coast of Hong Kong. Then the
daily conversion of low sulfur fuel costs about 14200 Yuan.

Reduce SO$_x$ Emissions Policy Costs

Different policies have been implemented internationally to reduce SO$_x$ emissions from major port
ships.

The major port cities or regions in Europe and the United States have implemented some of the
measures listed in table 3, some of which have been enforced, some through encouraging policies,
and in some areas through the "Port Clean Air Action Plan" to implement a package of preventive
measures. California's San Pedro Bay Port Clean Air Action Plan is a successful example.

The plan, jointly prepared and implemented by Port Los Angeles and Long Beach port, has drawn
up a roadmap for implementing various emission control measures. Another means of achieving
green ports in the European and American ports is to establish emission control zones (ECA), where
the NO$_x$ and SO$_x$ standards set by ECA are "technologically neutral" and thus contribute to the
implementation of measures and policies to control the emission of ocean-going vessels.

As the area covered by ECA is beyond the jurisdiction of a region or country, the effect of
establishing ECA is much greater than the effectiveness of a "Port Clean Air Action Plan" and more
than the effect of a regional or national law. It should be noted that the costs of the policies mentioned
in Table 4 are derived from projects in the United States and the European Union, so the cost of
implementing similar projects in China may be slightly higher. In addition, these costs are for
ocean-going vessels, and the same technology applies to small vessels, such as river trade, port or
coastal ships, at lower cost.

Therefore, the number listed in Table 3 can only be used as a general reference and should be
validated in the light of the specific circumstances of the country in practice.

Table 3. SOx Emission Control.

<table>
<thead>
<tr>
<th>Type of policy</th>
<th>Measures</th>
<th>Cost (sample)</th>
<th>Impact factors</th>
<th>Implemented areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard for improving the design of ship engine</td>
<td>Engine standards (domestic and ocean-going vessels)</td>
<td>Exhaust GAS SCRUBBER: Unit cost US $70-400 million Operating costs: 1% to 3% of the cost of fuel, as well as maintenance costs and other consumables, such as sodium hydroxide (if used)</td>
<td>Large space, waste water discharged by wet exhaust scrubber may lead to ocean acidification</td>
<td>The United States and the European Union; China is drawing up emission standards for marine engines</td>
</tr>
<tr>
<td>and exhaust gas treatment device</td>
<td></td>
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<td></td>
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<tr>
<td>Fuel conversion</td>
<td>Sulfur content limitation of national or regional fuel oil</td>
<td>Low sulfuroil cost: higher than the price of marine fuel oil; If necessary, add additional fuel tank installation cost;</td>
<td>Create a small number of infrastructure; Whether there is fuel supply; Monitoring the quality of fuel is facing challenges;</td>
<td>The United States, the European Union and Hong Kong</td>
</tr>
<tr>
<td></td>
<td>Limits on sulfur content of fuels used when offshore ships</td>
<td></td>
<td>Create a small number of infrastructure;</td>
<td>Mandatory: The United States and the European Union</td>
</tr>
<tr>
<td></td>
<td>Concerns about competitiveness; Whether there is fuel supply; The challenges of policy implementation;</td>
<td>Voluntary: Hong Kong and Singapore</td>
<td></td>
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<td>---------------</td>
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<tr>
<td>LNG</td>
<td>The cost of the engine and fuel system is equivalent to the cost of purchasing a ship, but if you can buy 10-20% LNG, the payback period is about 2.6 to 7.4 years, and it can save a lot of operating costs after the payback period.</td>
<td>Currently mainly in Norway; Developed rapidly in the European Union and North America;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shore Power</td>
<td>Shore: Per berth installation cost US $15 million (USA); US $17.8 million (Europe); On board: US $2 million per ship</td>
<td>Enforcement in California, USA; The United States and the European Union major ports to build an onshore electricity infrastructure; Shenzhen Port Shekou Container terminals, Shanghai Waigaoqiao Wharf, Qingdao Port in Shandong and Lianyungang, Jiangsu Province are piloting the application of shore electricity;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change the mode of operation</td>
<td>Reduce the speed of the ship</td>
<td>To prolong the voyage time, if the speed limit has been implemented for safety reasons, the benefit will be less.</td>
<td>Port of California, New York and New Jersey</td>
<td></td>
</tr>
</tbody>
</table>
Bright Prospects for Low Sulfur Fuel

Sulfur emission regulations are "precepts", the development of low sulfur fuel is inevitable. The technical rules for the legal inspection of inland waterways (2015) stipulates that the sulfur content of any fuel used by ships shall be reduced from 4.5% to 3.5%, and that the first ocean shipping in 2020 must use a sulfur content of not more than 0.5% of the fuel, as required by international regulations. Although table 4 also puts forward the control measures to improve the design standard of ship engine and exhaust gas treatment device and change operation mode to reduce the sulfur emission of ships, but these are only the "reprocessing" approach, and the emission regulations are the direct sulfur content limit for the source fuel of the ship's exhaust emissions.

Therefore, any ship sailing on a global scale at the latest not later than January 1, 2025 must use low sulfur fuel, in order to keep pace with international standards, our country will probably step up the standard of marine fuel sulfur limit for marine diesel engine emission standards, because of the imbalance of economic development in different regions, Pearl River Delta, Yangtze River Delta, Bohai Bay and other regions to implement regional emission standards first, with the expansion of regional emission standards, the future development of low sulfur fuel is inevitable.

References