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Ship emission reduction effect evaluation of air pollution control countermeasures

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Abstract

In this paper, the methods of waterborne transport data mining, emission reduction scenario analysis and ship emission calculation according to engine power are combined to establish models of ship emission inventory, reduction trend analogy, and investment effect analysis, which can achieve quantitative evaluations of ship emissions inventories, classification ratios and emission reduction effects of different scenarios, including to calculate air pollutant emissions of various kinds of ships in different areas and working conditions; to predict cargo turnovers of inland water, domestic coastal and marine ships and foreign marine ships; to analyze analogically emissions and reductions according to growths of national GDP and waterborne transport; to estimate the ship load tons and numbers of different kinds of vessels, as well as reductions per investment or operating costs of reduction facilities on board. The evaluation results show that the total emission of CO_2 in China's inland water and coastal areas from all kinds of transport ships and in other regions from domestic marine ships reached a peak in about 2020 to 2027 when fuel consumption per unit turnover in 2020 decrease by 27%%~45% compared with that in 2005 and then fell 20%~25% by 2030. In the scenarios when NOx and SOx emission reduction targets designed in accordance with relevant international conventions and domestic laws and regulations, NOx, SOx, PM emission reduction effects in China's from all kinds of transport ships are significant, while the effects were limited or very limited if the reduction were only implemented 50% or 25% of designed targets. According to emission inventory and classification ratios, the control priority should be given to the larger emission sources, in turn: host engines of transport ships in navigation areas, auxiliary engines of transport ships when mooring or berthing in port areas, and the auxiliary operation ships in port areas, and comprehensive prevention and control countermeasures should be taken for effective control of emissions from inland water ships, foreign marine and domestic coast and marine ships in coastal areas.

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1. Introduction

Ship is one of important traffic air pollution sources, from which the major discharging pollutants include NOx, SOx, PM, CO, HC, CO_2, N_2O, CH_4, V, Ni etc. According to "Clean Air Act" amended in 1990, US EPA has completed a comprehensive research of emissions from vehicles and non-road engine. Later, J. CORBETT JAMES et al. announced the emission calculation formula of engine power and fuel methods. Those of pioneering work lay an important foundation for the following research on the emission and control of the ship. E.g., Su Song has used the engine power method to conduct a ship emissions inventory study of Yangshan Deep-water Port of Shanghai international shipping center, which uses statistical analysis method applying ship freight volume to calculate engine power of main engine, auxiliary engine and boiler. And Simon K.W. et al. have tried using AIS data to track the dynamic information of each ship and applied the engine power method for dynamic calculation of temporal and spatial distribution characteristics of pollutant emissions, based on statistical analysis total regional emissions and its temporal distribution. In order to control air pollution from ships, different aspects of energy saving and emission reduction measures are needed, such as ship fuel cleaning, energy efficiency and transport capacity promoting, hull and engine improving, speed and route optimizing, ship exhaust gas purifying and so on. For different measures, the corresponding investment, technical preparation time and emission reduction effect are not identical. Therefore, it is very helpful making a comprehensive evaluation of the representative countermeasures of pollution prevention and control, in which the quantitative reduction effect evaluation is crucial for the decision-making. In this paper, the ship emission inventory model based on the engine power method and waterborne transport data mining, the ship emission reduction trend analogy model and the investment effect analysis model based on the GDP and water transportation turnover trend forecasting and ship status scenario designing are established, and the quantitative analysis of ship emission inventories, classification ratios and emission reduction effects of different scenarios are conducted, in order to provide support to comprehensively promoting the prevention and control measures.

2. Data & Methodology

2.1. Scenario design of ship status

In August 29, 2015, China promulgated the "air pollution prevention law" that proposed the specific requirements of fine management and multi pollutant collaborative control in the principle of multi source supervision and whole process control. In the same period, Chinese Ministry of Transport (MOT) issued “The implementation of ship and port pollution prevention and control special action program (2015, 2020) " that proposed to reduce pollutant emissions and to strengthen the disposal of pollutants as the core, to improve the laws and regulations, standards, specifications as the basis, in order to promote emission control area pilot demonstration as the starting point, according to the law to promote ship and port pollution prevention and control work, and strive to achieve the implementation scheme for China's marine green, recycling, low carbon, sustainable development. MOT also start the implementation program of ship emission control areas of the Pearl River Delta and the Yangtze River Delta, the Bohai Sea (Beijing-Tianjin-Hebei), in which the relevant regions and ports should gradually control the ship fuel sulfur content from existing 3.5% to 0.5%, and further reduced to 0.1%. Using scenario simulation method and taking the above control as background, the representative status of ship ownership, operation, energy saving and emission reduction in different periods in China are designed in this paper.

(1) Status of representative ships

Ships from the construction, operation to eliminate, dismantling has its own life cycle. The numbers of new built and existing ships of different types and load weights in Chinese coastal and inland waterway in different stages form the status of representative ships. Based on data mining analysis of PRC MOT statistical bulletin (2014), the ship load forecasting model (1)~(5) was established, which was used to simulate the annual growth trend of ship