Enlightenment from International experiences on air pollution control in airport areas to China

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Abstract. The construction of China's management and prevention and control system regarding air pollutants in airport area is of great significance to improve the regional ambient air quality in Chinese cities. By analyzing the deficiencies of air pollution control in airport areas in China and sorting out the international experience in pollution control, this paper proposes to improve the standard system of aircraft engine emission, establish a database of aircraft engine emission coefficients, carry out technical research on assessment of atmospheric impact caused by aviation emission, and explore the multiple prevention and control paths of aircraft pollution.

1 Introduction

Continuous improvement of environmental quality is an important task in building a beautiful China. At present, China mainly regards automobile exhaust, thermal power and other industrial emissions as the key source of PM2.5 emissions, and has not yet included aircraft emissions in its air pollution control. In contrast, developed countries such as the United States recognized the importance of controlling aircraft exhaust emissions to protect the quality of the atmospheric environment as early as the 1960s and 1970s, and formulated a series of targeted control measures, which achieved good results. Therefore, in China's bid to vigorously develop its aviation industry and continuously improve its air quality at the same time, it is of great significance to improve the ambient air quality in China's urban areas to build China's management, prevention and control system for air pollutants in airport areas by drawing on international experience.

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2 Deficiencies of air pollution control in the airport areas in China

2.1 Contribution of aircraft exhaust to air pollution has not received sufficient attention

According to the “Convention on International Civil Aviation”, the environmental certification standards for aircraft engine emissions are only applicable to emissions in and around the airport at an altitude of not more than 915 meters, mainly involving four stages of aircraft take-off, climb, approach and taxiing, accounting for 13.27%, 28.16%, 9.81%, and 48.7% of total emissions respectively; THC, CO, NOx and SOx accounted for 3.85%, 38.60%, 53.46% and 4.10% the total pollutants emitted respectively. As a result, aircraft exhaust emission can be divided into two parts: emissions on the ground and in the air, with the largest emissions at the taxiing stage, and NO_x being the most pollutant emitted.

According to environmental monitoring agencies, a large passenger aircraft consumes 4 tons of aviation fuel for a take-off and landing, which is estimated to be equivalent to the emissions by 600 cars in a day[1], which does not include pollutant emissions from aircraft auxiliary power units (APUs) and ground support equipment.

According to the *Notice on the Issuance of the National Civil Transport Airport Layout Plan*, China is expected to have three world-class airport clusters, 10 international hubs and 29 regional hubs by 2025. It is foreseeable that with the rapid rise of China’s aviation industry and the extensive layout of civil airports, the pressure of air pollutant emissions from airports on the improvement of air quality will continue to increase.

2.2 There is almost no research on the prediction of aircraft air environment impact and pollution prevention and control in China

Due to the late start of China’s aviation industry, the focus of pollution control and environmental regulation of aircraft is still on noise pollution, and the control of air pollution caused by aircraft has not yet entered the agenda.

First, the standard system for the emission of air pollutants from aircraft engines still needs improvement. The only control for aircraft exhaust is the “Regulations on Turbine Engine Aircraft Fuel Discharge and Exhaust Emissions” which came into effect on April 19, 2002, and the pollutants controlled only include NO_x, HC and CO, with no restrictions on SO_x, VOCs and other pollutants, and the purpose of control is to test the operating conditions of the engine, which cannot meet the needs of environmental management.

Second, the aircraft air pollutant emission coefficient database and emission estimation model are in their infancy. In particular, the path of air pollution prevention and control in the airport area is still unclear, and the prevention and control system is yet to be built in China. In recent years, some scientists have conducted relevant research on China’s aircraft air pollutant emission coefficients, emission estimation models, and environmental impact prediction models with reference to existing research results in Europe and the United States. In 2018, the *Technical Guidelines for Environmental Impact Assessment - Atmospheric Environment* issued by China’s Ministry of Ecology and Environment recommended the prediction model for the atmospheric environmental impact of airport sources. However, from the results of the study, more foreign data are used, and little consideration is given to the types of aircraft in service in China, engine operation conditions, aircraft landing and take-off (LTO) cycle, characteristics of hub, trunk and regional airports, and regional differences between China’s east, west, south and north, etc., and needs further improvement.

3 Status quo of related international research and pollution control

In the 1960s and 1970s, with the rapid development of the aviation industry, the impact of aircraft emissions on the air environment has attracted widespread attention from the international community, and the United States, the European Union and other developed countries and regions in the aviation industry have carried out relevant research, and gradually formed a more complete evaluation and pollution prevention and control for the impact of aircraft on the air environment [2].

3.1 Development of standards for aircraft engine pollutant emission

The Committee on Aviation Environmental Protection (CEAP), a technical committee of the International Civil Aviation Organization (ICAO) Council, promulgated the "Emission Standards for Aircraft Engines" (CAEP1) in 1981 and revised the standards in 1993, 1999, 2005 and 2010 respectively. The U.S. Environmental Protection Agency (EPA) and the Federal Aviation Administration (FAA) jointly developed *Regulations for Emissions from Aircraft Engines* based on the *Clean Air Act*[3], which was enacted in 1970, and established emission limits, effective date, and corresponding standard test methods for the major gaseous pollutants emitted from various types of aircraft engines, and was subsequently revised in 1978 and 1982.

3.2 Establishment of pollutant emission database and estimation model

3.2.1 Aircraft air pollutant emission coefficient database

The ICAO requires engine manufacturers to conduct engine air pollutant emission measurements under static conditions at sea level at 7%, 30%, 85% and 100% of rated thrusts respectively, in accordance with relevant procedures, in order to obtain an aircraft engine production certificate. As a result, ICAO has obtained the air pollutant emission data of aircraft engines for various models and fuel consumption, and established a database of aircraft engine air pollutant emission coefficients (ICAO Doc 9649, Aircraft Engine Emissions Databank), which is currently hosted online by the European Aviation Safety Agency.

3.2.2 Aircraft air pollutant emission estimation model

The European research project "Methodologies for Estimating Air Pollutant Emissions from Transport" (MEET)[3] of 1997 summarizes methodologies for estimating pollutant emissions from aircraft, and combines air traffic data, airport data, flight routes, aircraft/engine performance data and emission coefficients to divide aircraft engine emissions into aircraft start-up, taxi-out, take-off, climb, cruise, descending, landing, taxi-in, and on the ground, and makes estimation on the air pollutant emissions in 2010 and 2020. In 2001, United Airlines established the System for assessing Aviation Global emissions (SAG) to develop a global commercial aircraft emissions inventory of different pollutants. In 2011, a related study in the UK counted the working hours of different types of aircraft at each airport and estimated the aviation pollution emissions from UK airports in that year based on the ICAO standard emissions model. The establishment of the estimation model for the emission of air pollutants from aircraft has laid a foundation for calculating the source intensity of air pollution in the aviation industry.

3.2.3 Airport air impact prediction model

In 1997, the FAA and the United States Air Force (UASF) jointly released the EDMS (first version) airport atmospheric environmental impact prediction software. After years of continuous improvement, the EDMS software has been upgraded from versions 3.0, 4.0, and 5.0 to version 5.1.4 in 2013, which could predict the impact of the emission of dozens of pollutants such as CO, NOx, SO_2 THC, NMHC and VOCs from different types of aircraft, motor vehicles and stationary sources in the airport area on atmospheric environmental quality[4]. In addition, there are relatively more applications of the ADMS-Airport developed by Cambridge Environmental Research in the UK, and the LASPORT airport atmosphere prediction model developed by Janicke Consulting in conjunction with the German Airports Association.

The development of the airport air environment impact prediction model has laid a solid foundation for studying the impact of airports on ambient air. In 2004, K.N. Yu et al. measured the hourly concentration changes of CO, NO_x, SO_2 and PM2.5 near the Hong Kong International Airport, and the results showed that aircraft were a significant source of CO and PM2.5 near the airport[5]. In 2005, Alper Unal et al. evaluated the atmospheric impact of Atlanta International Airport and showed that the impact of aircraft on the ambient air quality of the airport area was 6 to 20 times greater than their impact on the area surrounding the airport[6].

3.2.4 Air pollution prevention and control system for the aviation industry

The U.S. has conducted research on saving jet fuel and reducing air pollutant emissions in different ways, including reducing airport delays, enhancing airport operational efficiency, optimizing flight procedures, and improving aircraft climbing performance. One study showed that reducing airport delays can save 17% of jet fuel, reduce SO_2 emissions by 17%, NO_x emissions by 7%, and PM2.5 emissions by 15%; and improving airport operational efficiency can reduce fuel consumption and corresponding pollutant emissions by 6.9% to 10.4%.

4 Implications of international experience to China for its control of aircraft air pollution

4.1 Improve the air pollutant emission standard system for aircraft engines to solidify the basis for pollution prevention and control judgment

First, improve the types of air pollutants in the standard system, including conventional pollutants and characteristic pollutants emitted by aircraft engines; second, formulate emission standards based upon different types of engines, fuel standards, existing and proposed emission sources; third, formulate emission standards based upon the different air quality standards in different regions.

4.2 Establish a database of aircraft air pollutant emission coefficients and lay the foundation for source intensity estimation

It is to determine the main pollutant types in the pollutants list by focusing on precursor pollutants such as SO_2, CO, HC, NO_x, and $PM_{2.5}$, and to establish a database of fuel consumption coefficients and emission coefficients of various major air pollutants that match the overall operating status and pollutant emission characteristics of aircraft in China.

4.3 Carry out research on technologies related to aircraft atmospheric impact assessment and strengthen technical support capabilities

First, according to the flight trajectories of various types of aircraft on different runways and in the air, statistically analyze the distribution of aircraft air pollutants from different perspectives and at different times, and propose the principles and methods for their classification. Based upon the characteristics of the airport, the meteorological conditions and the flight trajectory of the aircraft, study the optimal method for determining the level of aircraft air pollution from different perspectives, and the three-dimensional dynamic emission source intensity estimation model of aircraft air pollutants. Second, study the construction of a prediction model for the aircraft emissions of major air pollutants and their environmental impacts to make up for the deficiencies of the prediction model in the Chinese air guidelines.

4.4 Explore the multiple prevention and control paths of aircraft air pollution and strengthen the construction of pollution prevention and control capabilities

The EIA of airport planning needs to improve the environmental rationality of the airport planning and to mitigate the ambient air impact from the optimization of airport site selection, airport internal layout, airport size, flight procedures and other aspects. It also needs to focus on the paths to reduce aircraft engine pollutant emissions from the optimization of aircraft engine design, to the improvement of aviation oil quality, and the improvement of aircraft testing and maintenance, etc. Meanwhile, It should be considered that the emission reduction path through the environmental management paths such as the elimination of outdated aircraft models, establishment environmental thresholds for other auxiliary facilities, etc.

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