

Analysis on the Industrial Structure of China's SO₂ Emission

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Abstract: With the use of environmental statistics, this paper studied the industrial structure of China's SO₂ emission. Meanwhile, it analyzed the changes of waste gas emissions, SO₂ emissions and SO₂ emissions concentration of the six key industries, namely, the power, steel, building material, chemical, nonferrous metal and petrochemical coking industries in 2014 in comparison with the condition of 2005. The aim is to provide a reference for the scientific determination of the main orientation of SO₂ emission reduction in China.

1. Introduction

As one of the major air pollutants, SO₂ will be oxidized to form acid rain after it is emitted into the air, and the acid rain formed will lead to soil acidification, thus affecting the growth of plants[1]. Besides, SO₂ is also the precursor of sulfate, an important component of atmospheric fine particulate matter (PM_{2.5}), which is the main driving factor of haze formation[2]. Meanwhile, SO₂ has a series of adverse effects on human health. For example, short-term exposure to SO₂ will induce changes of lung function symptom and respiratory symptom to a certain degree[3]; it can be absorbed into the blood to exert toxic side effects on the body: breaking the enzyme activity, affecting carbohydrate and protein metabolism and causing liver damage[4].

China is the world's largest SO₂ emitter. Its industrial sector accounts for 85% of the total SO₂ emissions in China. Hence, it is necessary to control sulfate and continue to reduce SO₂ emissions significantly. This paper analyzed the industrial structure of industrial SO₂ emission in China, with a view to providing a reference for the scientific determination of the main orientation of SO₂ emission reduction in China

2. Industrial Structures of SO₂ Emissions in China

SO₂ emission amount of each industrial sector in China and their respective proportion in the total industrial emission amount in 2014 are shown in Table 1 and Fig.1. As shown in Table 1 and Fig.1, different Chinese industrial sectors have remarkably different amounts of SO₂ emissions, of which SO₂ is mainly emitted by the following six key industries: 42 (hereinafter referred to as power industry), 31 (hereinafter referred to as steel industry), 30 (hereinafter referred to as building material industry), 32 (hereinafter referred to as chemical industry), 25 (hereinafter referred to as nonferrous metals industry), 26 (hereinafter referred to as petrochemical coking industry). These industrial sectors are commonly referred to as "the six key industries" by national statistical offices. In 2014, the six key industries discharged a total of 13.81 million tons of SO₂, accounting for 87.2% of the total industrial SO₂ emissions according to the statistics. Among the six key industries, power industry contributed to largest SO₂ emissions, accounting for 39.2% of the total industrial SO₂ emissions and 45% of the total SO₂ emissions of the six key industries.

Table 1 China's industrial sectors of SO₂ emissions and its share in 2014

Code	Total/ Million tons	Proportion	Code	Total/ Million tons	Proportion	Code	Total/ Million tons	Proportion
6	11.43	0.72	19	2.6	0.16	32	122.98	7.76
7	2.7	0.17	20	4.73	0.3	33	11.74	0.74
8	2.44	0.15	21	0.29	0.02	34	1.99	0.13
9	1.46	0.09	22	41.22	2.6	35	1.64	0.1
10	3.89	0.25	23	0.56	0.04	36	2.75	0.17
11	0.43	0.03	24	0.19	0.01	37	1.08	0.07
12	0.03	0	25	78.75	4.97	38	0.82	0.05
13	22.4	1.41	26	134.36	8.48	39	0.09	0.01
14	14.64	0.92	27	10.65	0.67	40	6.38	0.4
15	11.99	0.76	28	7.7	0.49	41	0.66	0.04
16	1.03	0.07	29	8.53	0.54	42	621.19	39.2
17	23.47	1.48	30	208.63	13.17	43	1.74	0.11
18	1.83	0.12	31	215.04	13.57	44	0	0

Note: Industry codes in the table are the category codes in the *Classification of National Economy (GB/T 4754-2011)*, for example, 06 for coal mining and washing industry and 07 for oil and gas extraction industry.

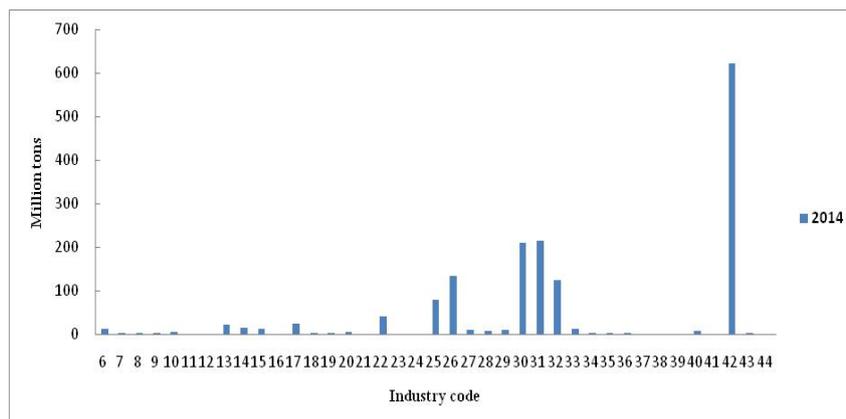


Fig.1 SO₂ emission amount of each industrial sector in China in 2014

3. Changes in SO₂ Emissions of Key Industries and Their Contribution to the Whole Industrial SO₂ Emission Reductions

Since the beginning of the 11th Five-Year Plan, China has regarded the total reduction in SO₂ emissions as a binding target of national economy and social development. Whether each sector has reduced its emissions or not? What are the changes of their emission reduction rates during this decade? Which sector has made the greatest contribution to the reduction in industrial emissions? Answers can be found by comparing the SO₂ emission reduction status of the six key industries in 2005 and that in 2014. Thus, the paper calculated the SO₂ emissions of the six key industries and analyzed their contribution to the whole industrial SO₂ emission reductions and the national SO₂ emission reductions, which is shown in Table 2.

It can be seen from Table 2 that compared with 2005, the six key industries reduced 365.15 million tons of SO₂ emission in 2014, accounting for 98.7% of the whole industrial SO₂ emission reductions and 63.5% of the national SO₂ emission reductions respectively. This can indicate their decisive role in SO₂ emission reductions. All of the reductions were made by power industry whose reduction amount and emission rate were 545.98 million tons and 46.8% respectively, accounting for 147.6% of the whole industrial SO₂ emission reductions and 95% of the national SO₂ emission reductions. On the contrary, SO₂ emissions of the other five industries all showed a growing trend. For steel,

nonferrous metal, building material, chemical and petrochemical coking industries, their SO₂ emissions increased by 72.8, 52.28, -30.27, -17.6 and -7.9 million tons respectively; the growth rates of SO₂ emissions were 51.8%, 73.9%, 17%, 15.1% and 11.1% respectively; the contribution to the whole industrial SO₂ emission reductions was -19.7%, -14.3%, -8.2%, -4.8% and -2.1% respectively; and the contribution to the national SO₂ emission reductions was -12.7%, -9.1%, -5.3%, -3.1% and -1.4% respectively.

Table 2 SO₂ emissions of the six industries with high energy consumption in 2005 and 2014

Sector	2005		2014		2014-2005			
	Total/Million tons	Proportion	Total/Million tons	Proportion	Emission reduction	Emission reduction rate	Contribution to industrial emission reductions	Contribution to national emission reductions
Power	1167.17	59.73	621.19	39.21	545.98	46.8	147.6	95
Steel	142.24	7.28	215.04	13.57	-72.8	-51.8	-19.7	-12.7
Building Material	178.36	9.13	208.63	13.17	-30.27	-17.0	-8.2	-5.3
Chemical	116.76	5.98	134.36	8.48	-17.6	-15.1	-4.8	-3.1
Nonferrous	70.70	3.63	122.98	7.76	-52.28	-73.9	-14.3	-9.1
Petrochemical coking	70.85	3.58	78.75	4.97	-7.9	-11.1	-2.1	-1.4
Total key	1675.23	85.73	1302.2	82.21	365.15	25.0	98.7	63.5

In summary, the vast majority of industrial SO₂ emission reductions came from the six key industries in 2014. However, in fact, among the six key industries, only power industry played a decisive positive role in cutting the industrial SO₂ emissions, while the other five sectors increased the emissions instead of reducing them.

4. Analysis of SO₂ Emissions, Waste Gas and SO₂ Emission Concentration of the Key Industries

SO₂ emissions of various industries depend on their emission amount of waste gas and SO₂ emission concentration. Therefore, the paper analyzed changes of waste gas emissions and SO₂ emission concentration of the six major sectors in 2005 and 2014, so as to analyze the reason why SO₂ emissions of power industry are contrary to those of the other five major industries, as shown in Table 3.

Table 3 SO₂ emission concentration of the six key industries in 2005 and 2014

Sector	Waste gas emissions (billion Nm ³)			SO ₂ emissions (million t)			SO ₂ emission concentration (mg/ Nm ³)		
	2005	2014	Change rate (%)	2005	2014	Change rate (%)	2005	2014	Change rate (%)
Power	88347	215094	143.5	1167.2	621.19	-46.8	1321.1	288.80	-78.1
Steel	56190	181694	223.4	142.24	215.04	51.2	253.14	118.35	-53.3
Building Material	49860	128460	157.6	178.36	208.63	17	357.72	162.41	-54.6
Chemical	15887	41783	163	116.76	134.36	15.1	734.94	321.57	-56.3
Non-ferrous	13183	36166	174.3	70.70	122.98	73.9	536.30	340.04	-36.6
Petrochemical coking	9129	21291	133.2	70.85	78.75	11.1	776.1	369.87	-52.3

As can be seen from Table 3, compared with 2005, the emission amounts of waste gas of the six industries with high energy consumption all increased significantly in 2014, while the average SO₂ emission concentration dropped obviously with specific drop range being different in different industries. The drop rate of SO₂ emission concentration reached 78.1% in power industry, which was significantly higher than that in the other five sectors; its emission amount of waste gas increased by 143.5%, which was the lowest among the six key industries, only slightly higher than petrochemical coking industry; this decided that power industry became the only industry with obvious SO₂ emission reductions. The emission growth rate of waste gas of steel industry reached 223.4%, much higher than that of the other five industries, while nonferrous metals industry had a reduction rate of SO₂ emission concentration of 36.6%, notably lower than that of the other five industries; these resulted in the rapid increase of SO₂ emissions of the two industries.

According to the above analysis, from 2005 to 2014, the industrial SO₂ emission reductions in China mainly depended on the sharp reduction in SO₂ emission concentration of power industry. Although SO₂ emission concentration of the other five industries also dropped, their drop rates were much lower than that of power industry.

5. Conclusions

In the paper, we analyzed the industrial structure of industrial SO₂ emission in six key industries in China. The changes in SO₂ emission, emission concentration and exhaust emission in the six key industries in 2005 and 2014 were calculated and compared. The three conclusions in the study were drawn as follows. Firstly, SO₂ emissions of various industrial sectors in China were mainly from six high pollution sectors, including power, steel, building materials, chemical, nonferrous metals, and petrochemical coking. Secondly, the majority of the industrial SO₂ emission reduction was ascribed to six key sectors in 2014. However, only the power industry played a decisive positive role in the industrial SO₂ emission reduction. The emissions from other five sectors were still increasing. Thirdly, from 2005 to 2014, industrial SO₂ emissions reduction in China mainly depended on the power industry, in which SO₂ emission concentration significantly reduced and exhaust emission was small growth. In order to further decrease SO₂ emission, it is necessary to optimize the power structure, reduce total electricity consumption, and develop various energy forms, including island solar energy, sea wind energy, tidal energy, wave energy and other renewable energy sources. Moreover, strict policies should be developed to reduce the excess industrial capacity, optimize the industrial structure of the five industries, and develop new emission reduction technologies.

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