CO_2 Emissions Measurement in Technological Process of Production: A Case Study of DBTP Thermal Power Plant

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Abstract. This study provides a new CO_2 emissions measurement method in thermoelectric enterprises by the analysis of technological process of production. It is novel that CO_2 emissions related to technological process of production are significant in providing emission-reducing focus and sound management in industrial enterprises. In this study, CO_2 emissions are involved in the process of coal combustion and desulfuration. Based on problems in production flow, we can provide several emission-cutting recommendations for general thermal power enterprises.

Introduction

Over a decade, economic growth in China is heavily dependent on energy consumption. The speed up of heavy industrialization and expansion of high-energy consumption industry, have enabled energy intensity of GDP sustain increasing gradually. In 2011, China's National Audit Office reports that energy consumption in industrial enterprises accounts for 70% of total consumption in China.

Among China's industrial enterprises, power industry takes in 50.24% of national total coal consumption and nearly 40% of national total carbon emissions [1-2]. Specifically, electricity generation in China is mainly dependent on thermal electricity which accounted for 80.51% of total power generation in 2010 and showed over-dependence on coal fuel in China. Recently, enterprises of thermoelectricity cogeneration boom rapidly with power generating capacity accounting for 18% in China and heating steam reaching 81.2% of national heating supply [3]. However, energy efficiency in enterprises of thermoelectricity cogeneration has great disparity with the developed countries, thus leading to severe environmental problems typically acid rain and climate warming [4-5]. Thus, thermal electricity is a typical heavy-polluting-industry and naturally becomes a critical part for management about energy conservation and pollution reduction.

This paper provides a case study of DBTP thermal power plant. Based on the characteristic of technological process of production, this paper provides new evidence in measuring CO_2 emissions in thermoelectric enterprises. In section, we describe enterprise background and data parameters. Section 3 presents specific measurement steps including coal combustion process and desulfuration process. In section 4, this study discusses the main problems in production flow. Finally, section 5 concludes.

Background and data parameters

Datang Baoding thermal power plant (DBTP) is subordinate to China Datang Corp. At present, the operation of DBTP depends on two 125MW dual extraction heating units and two matching circulation fluidized bed boiler under high pressure and high temperature in the level of 450tons/hour. Total installed capacity reaches 250MW with heating capacity approaching 540 tons/hour. These two units are transferred to the process of pilot production respectively in 2002 and

2003. Their steam turbines are cc100-8.83/0.981/0.196 dual extraction condensing type under high temperature and high pressure. Boilers are DG450/9.811 circulating fluid bed under high pressure and high temperature.

As a heavy-energy-consumption enterprise and experimental unit of energy management system, DBTP thermal power plant adopts course analysis and PDCA(plan-check-action-cycle) cycle to operate technological process of production management. DBTP is responsible for power and heat generation and supply. Among that, coal is the main energy source. CO_2 emissions are mainly derived from the process of coal combustion and desulfuration.

Before the calculation of detailed energy consumption and CO_2 emissions, there is a necessity to present coal-used parameters. Burned fuels in these two units are mainly anthracite in power generation and heating. Table 1 illustrates the coal-used statistics of units in 2008-2012. Table 2 describes coal-used parameters of units in 2008-2012.

Tab.1 Coal-used statistics of units in 2008-2012

Year	Total burned-coal quantity (tons)	Burned-coal quantity for power (tons)	Burned-coal quantity for heating (tons)
2008	717053	465627	251426
2009	759300	489012	270287
2010	776051	524248	251803
2011	762308	500602	261706
2012	705455	455420	250035

Tab.2 Coal-used parameters of units in 2008-2012

Year	Electricity (million kwh)	Heating (GJ)	Carbon content of burn coal	Ash content	Carbon content of fly ash
2008	113141	4637688	67.07%	26.56%	6.52%
2009	120629.4	5077561	65.99%	23.85%	5.73%
2010	126375	4503693	65.04%	25.59%	5.31%
2011	122098	4862903	65.13%	24.89%	5.48%
2012	111078	4464938	65.01%	25.12%	5.37%

Empirical measurement

CO_2 emissions measurement for coal combustion

Here, we take two main units of DBTP in 2012 as the example to present the calculation process of CO_2 emissions.

(1) CO_2 emissions for power

Ash content m_A, fly ash and ash residue are computed as Eq. (1).

$$\begin{aligned} m_A &= B\times m_{Aar} = 114401.504 \\ B\times A_f &= m_A\times 90\% = 102961.354 \\ B\times A_Z &= m_A\times 10\% = 11440.1504 \end{aligned} \qquad (1)$$

where P denotes annual electricity; B means annual burned-coal quantity for power; Carbon content of fly ash m_{fc} is 5.37%. Besides, carbon content of ash residue is too low in thermal power plant thus m_{Zc} being regarded as 0 [6].

Total carbon amount in unburned ash is computed as Eq. (2).

$$m_{C_1}=\frac{BA_f m_{Fc}}{1-m_{Fc}}+\frac{BA_z m_{Zc}}{1-m_{Zc}}=\frac{BA_f m_{Fc}}{1-m_{Fc}}=\frac{102961.354\times5.37\%}{1-5.37\%}=5842.7821 \quad (2)$$

Total burned carbon amount in coal fed into the furnace, follows Eq. (3).

$$m_{C_2}=B\times Car-m_{C_1}=B(Car-\frac{A_f m_{Fc}}{1-m_{Fc}})=290.226\times10^6 \quad (3)$$

CO_2 emissions per unit electricity is calculated as Eq. (4).

$$\overline{V_{CO_2}}=V_{CO_2}/P=\frac{22.4}{12}m_{C_2}/P=4877.2 \quad (4)$$

Thus, total CO_2 emissions for power is obtained from Eq. (5).

$$V'_{CO_2}=541.75\times106 \quad (5)$$

(2) CO_2 emissions for heating

The measurement of total CO_2 emissions for heating is in accordance with above-mentioned measurement steps. Eq. (6) concludes with the result [7].

$$V'_{CO_2}=195.62\times106 \quad (6)$$

Thereafter, we can obtain total CO_2 emissions in 2008-2012 shown in Table 3.

Tab.3 Total CO2 emissions for coal combustion in 2008-2012

Year	CO_2 emissions for power(m^3)	CO_2 emissions per unit electricity (m^3/MW·h)	CO_2 emissions for heating(m^3)	CO_2 emissions per unit heat(m^3/GJ)	Total CO_2 emissions(m^3)
2008	5.685×10^8	5024	3.07×10^8	66.2	8.754×10^8
2009	5.905×10^8	4895	3.264×10^8	64.3	9.168×10^8
2010	6.238×10^8	4936	2.996×10^8	66.5	9.235×10^8
2011	5.942×10^8	4866	3.143×10^8	64.6	9.085×10^8
2012	5.417×10^8	4877	2.804×10^8	62.8	8.221×10^8

CO_2 emissions measurement for desulfuration

During the technological process of production in DBTP, lime spread with larger surface area and run through the overall reactor. Then, lime is drawn into the upper barrel by smoke. Under that circumstance, continuous blending of fly ash and desulfurizer in smoke, makes some quicklime into cyclone separator and sends isolated particles back to circulating fluidized bed. However, quicklime enters reaction tower by transmission device. Due to the large contact area, SO_2 in smoke is thoroughly exposed to lime thus being absorbed as the following chemical formulas. Table 4 demonstrates total CO_2 emissions for desulfuration in 2008-2012 [8-9].

$$Ca(OH)_2+SO_2\rightarrow CaSO_3\cdot\frac{1}{2}H_2O$$

$$Ca(OH)_2+SO_3+H_2O\rightarrow CaSO_4\cdot2H_2O$$

$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$
$$Ca(OH)_2 + 2HF \rightarrow CaF_2 + 2H_2O$$
$$Ca(OH)_2 + SO_2 + \frac{1}{2}O_2 \rightarrow CaSO_4 + H_2O$$
$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

Tab.4 Total CO2 emissions for desulfuration in 2008-2012

Year	2008	2009	2010	2011	2012
Burned-coal amount(tons)	717053	759300	776051	762308	705455
Sulfur content (%)	1.529	1.461	1.596	1.543	1.569
Desulfurization rate (%)	72.8	73.1	82.8	83.7	84.1
Total CO_2 emissions(tons)	10973.457	11153.31	14104.836	14403.712	14781.069

Results and discussions

Based on the characteristic of technological process of production, this paper provides new evidence in measuring CO_2 emissions in thermoelectric enterprises. Findings from this will prove useful to the literature by providing new evidence on CO_2 emissions measurement in thermal power enterprises in the point of production flow. In consideration of this, some main problems in the process of coal combustion and desulfuration are concluded.

Performance and heat rate of steam turbine

With regard to admission mode, constant-pressure operation of running units, has lead to overlarge overlap, thus bringing in severe damage of energy consumption in adjust valve and simultaneously high power consumption.

In views of flow path, there exist several problems. Bad seal in high-pressure steam intubation leading to the leakage of main stream is the reason behind higher pumping temperature accounting for 5℃ above normal. This condition maybe contributed to overlarge gap of the first laps of gland sealing in high and middle balance piston. Moreover, there exist some other problems due to energy efficiency, such as high heat consumption of unit, large air leakage.

Boiler

In coal pulverizing system, outlet pipe of classifier is overlong; Returning power amount is so large and heavy punch of clapper flap valve in this power pipe is lower that circulating ratio soars and hinders the whole efficiency; Wide and frequent current fluctuation of coal mill appear; Unburned carbon content of fly ash and ash are overlarge. Air and flue gas system is inferior for undersize and unadjusted baffle of air door, decreasing unit load and relevantly decreasing rotate speed of pulverized coal feeder, secondary blowing rate failing to satisfy demand. In dust pelletizing system, tapping effect and material level of ESP (electrostatic precipitator) are inadequacy; Compressed air is with high moisture due to deficient compressed air system. Desulfuration system is restricted to large desulfurizer, calcium carbonate under 90% requirements, thermotechnical measurement imperfection, serious corrosion of flue.

Other production flow

Condensate pump has a high power-consumed rate, which accounts for 0.2% above similar units on the average. In addition, it fails to achieve whole-process frequency conversion.

Electrically driven feed pump has a high power-consumed rate at 2.8%, which accounts for 0.6% above similar units on the average. The pattern of constant pressure in units, high feed-water main and fluid coupling in pump are the reasons behind this high power consumption.

Conclusions

In this study, a new method for measuring CO_2 emissions in thermal power enterprises from the point of technological process of production is analyzed. Based on problems in production flow, we can provide several emission-cutting recommendations for general thermal power plant from key aspects. Typically, energy-saved manufacturing management, energy-saved fuel management, energy-saved imperfection management, energy metrological management and optimization of operation pattern are main emission-cutting focus.

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