CO_2 CAPTURE FROM COAL FIRED ELECTRIC POWER GENERATION IN CHINA

Zhang Yongmei[a]*

Keywords: CO_2; capture; coal fired electric power generation; china

Nowadays environmental issues due to emission of greenhouse gases such as CO_2 are discussed. CO_2 capture has also been introduced. Large amount of CO_2 is discharged from Chinese coal fired electric power generation, so CO_2 capture is mainly studied in order to protect the environment. Four types of CO_2 capture technologies such as decarbonation before burning, CO_2 capture after burning, oxygen-rich technologies and chemical looping combustion have been discussed. CO_2 capture is improved by using the above methods. The complete development of CO_2 capture technologies has resulted in good economic and social benefits around the world.

* Corresponding Author
Fax: 86-24-56860869
E-Mail: zh6688551@163.com
[a] Liaoning Shihua University, Fushun, Liaoning, P.R. China.

Introduction

More and more people around the world are paying attention to the effect of greenhouse gases (CO_2, CH_4, NO_x, hydrofluorocarbon, perfluocarbon and SF_6) on the environment. The effects of global warming mainly come from CO_2. *Chinese* Government promises to reduce 40 – 45 % of the amount of CO_2 emissions by 2020 based on 1.8 billion tons of CO_2 discharge in 2005.[1] Ratio of coal used as a fuel to other energies is 7 : 3 in *China*. Furthermore, coal used to generate electricity is above half of total coal consumption. Coal fired electric power generation is one of the main source of CO_2 discharge places in *China*, so it is very important to control the amount of CO_2 discharge from the coal fired electric power generation.[2]

In the present paper, four types of CO_2 capture technologies such as decarbonation before burning, CO_2 capture after burning, oxygen-rich technologies and chemical looping combustion are discussed. Furthermore, the optimal CO_2 capture method has been also pointed out.

Discussion

Decarbonation before burning

Wang Xiaoliang[3] introduced the reaction principle of decarbonation before burning. It meant using the appropriate method to get rid of carbon from a feedstock before burning, and then carbon with energy was separated with other materials in order to take off carbon from the feedstock. An integrated gasification combined cycle (IGCC) is a technology that uses a gasifier to turn coal and other carbon based fuels into gas—synthesis gas (syngas) [4]. Integrated gasification combined cycle systems were advanced type systems. They consisted of air separation unit, gasifier, syngas purification units, water gas shift reactors and CO_2 separation unit. Combined cycle systems encompassed combustor, compressor, heat recovery steam generator and steam turbine, etc. Figure 1 showed an image for an integrated combined gasification.

Coal was sent to a rod mill to produce slurry, which was pumped into a gasifier to burn and generate syngas whose content was CO and H_2. Syngas was transported to a reforming unit where it was transferred into CO_2 and H_2. Furthermore, CO_2 and H_2 were separated. H_2 was burnt at a combustor, so this is the best way to reach zero discharge. This system not only got rid of H_2S but also decreased investment expenditures and operating fees.

CO_2 capture after burning

CO_2 capture after burning meant that CO_2 was separated from flue gas. Three types of methods for separating CO_2 were the chemical absorption method, the membrane separation method and the cryodistillation.[5] The solvent absorption method is one of the most popular chemical methods in the chemical plant. Figure 2 presented a diagram for CO_2 capture after burning.[6] These have the advantages of the solvent absorption method, adding CO_2 to capture unit without changing original units and widely used at coal fired electric power generation. On the other hand, this method had a lot of disadvantages such as consuming a lot of solvent, pretreating flue gas (getting rid of S, NO_x and particles) before CO_2 capture, getting more volume of flue gas due to the existence of nitrogen, investing more money because of CO_2 capture and requiring high energy for separating CO_2 at high - pressure and high - temperature. Although CO_2 capture after burning was very good, it was very difficult to use this method in chemical plants due to poor profits.

Oxygen-rich technologies

Wang Xiaoliang[3] introduced the principle of oxygen-rich technologies and compared between burning coal in an oxygen-rich environment and conventional coal combustion. The content of CO_2 in the flue gas was between 8 % and 16 % during the conventional coal combustion. It was very difficult to separate CO_2 due to low content of CO_2 in the flue gas and more investments were required. How to increase the content of CO_2 in the flue gas was one of the important factors to decrease the energy of CO_2 capture. Oxygen-rich technologies also called combustion in an O_2/CO_2 mixture or an air separation/ flue gas recycle technology. High purity oxygen obtained by using the air separation and partial flue gas instead of air reacted with coal, so the content of CO_2 in the flue gas was improved.

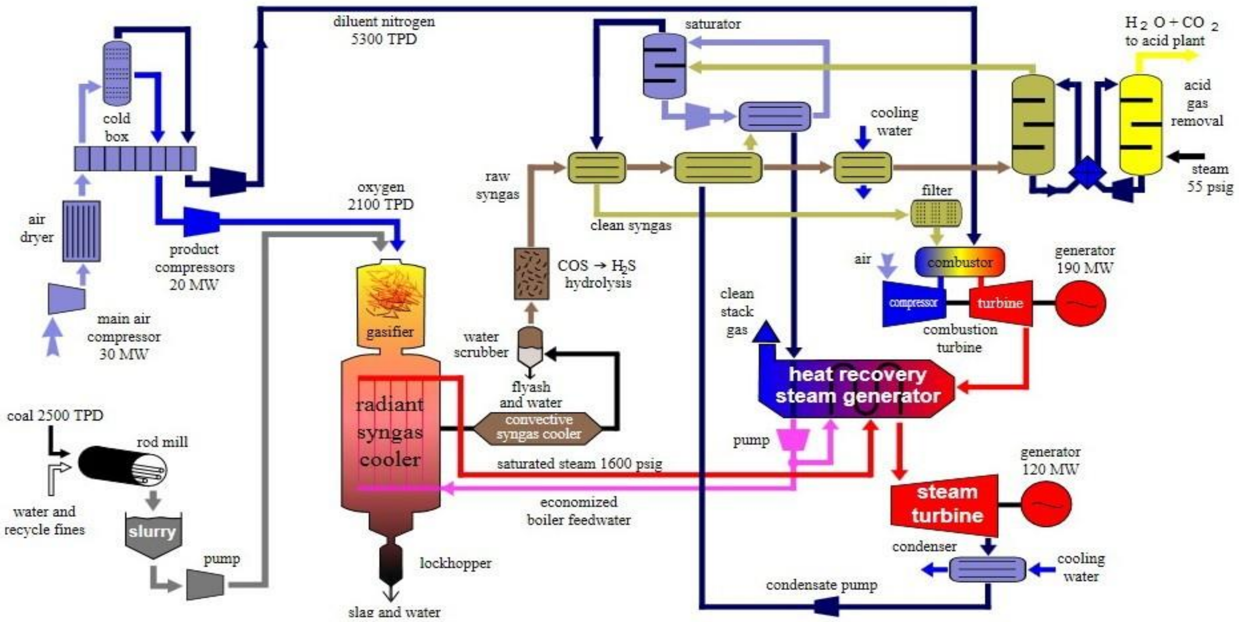

Figure 1. An integrated gasification combined cycle

Reusing the flue gas adjusted the boiler's temperature. At the same time the boiler thermal efficiency was increased due to reusing the flue gas instead of nitrogen in the air. Oxygen-rich technologies not only got high purity oxygen but also controlled coal pollution.

They are new type of coal burning technologies. Oxygen-rich technologies consisted of four types of combustion technologies such as aerobic combustion, oxygen combustion, oxy-fuel combustion and air-oxygen combustion. These advantages for oxygen-rich technologies were listed as follows. The content of CO_2 in the flue gas reached 95 % and CO_2 was directly liquefied to recovery without the flue gas separation. High purity SO_2 existed in the boiler due to reusing the flue gas, so it improved desulfuration efficiency. The amount of the flue gas discharge was decreased about 80 % due to reusing the flue gas, so the heat loss was decreased and the boiler efficiency was improved. The radiant efficiency for burning coal in an oxygen-rich environment is better than that of the conventional coal combustion because high purity CO_2 and H_2O in the boiler made the flue gas have high specific heat and radiation coefficient. Figure 3 showed an image for oxygen-rich technologies.

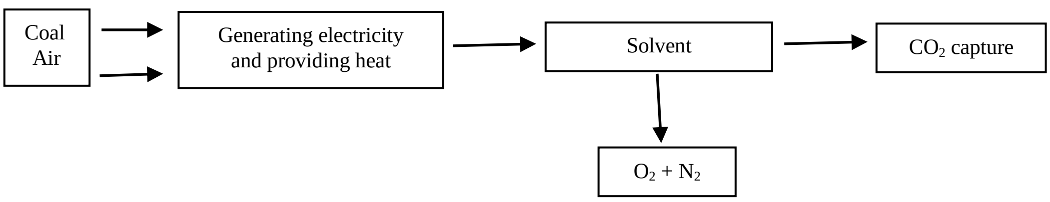

Figure 2. General scheme of CO_2 capture after burning

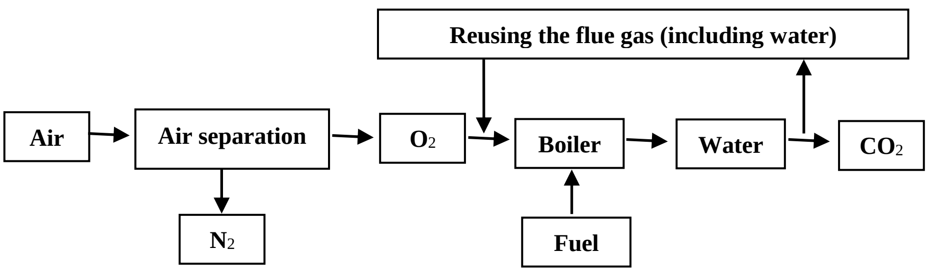

Figure 3. General scheme of oxygen-rich technologies

Chemical looping combustion

Lyngfelt[7] discussed the principle of the chemical looping combustion. The chemical looping combustion was a new type of the burning method. It broke the conventional combustion method. The chemical looping combustion did not directly burn fuel with O_2 in the air. Oxygen carriers (metallic oxides) were used to move between the air reactor and the fuel reactor so the chemical energy from fuel was released. Figure 4 presented a diagram for chemical looping combustion. The fuel was pumped into the fuel reactor and reacted with metallic oxides (MeO). Eqn. (1) was written as follows. CO_2 and H_2O were discharged from the top of the fuel reactor. High purity CO_2 was almost obtained when H_2O was condensed. The reduced metal oxide (Me) was transported from the fuel reactor to the air reactor. Me reacted with O_2 in the air reactor, so Me was reused several times. Eqn. (2) was written as follows.

$$(2n+m)MeO+C_nH_{2m} \rightarrow (2n+m)Me+ mH_2O + nCO_2 \qquad (1)$$

$$Me + \frac{1}{2} O_2 \rightarrow MeO \qquad (2)$$

These are having the advantages of the chemical looping combustion, such as getting high purity CO_2, increasing combustion efficiency due to two step chemical reactions and decreasing the heat loss and effectively controlling the produced NO_x and its discharge.

Conclusion

Based on the above discussion and review, four types of CO_2 capture technologies such as decarbonation before burning, CO_2 capture after burning, oxygen-rich technologies and chemical looping combustion have been introduced. The decarbonation before burning is one of best ways because H_2 is produced to burn at a combustor and this way, probably, reaches zero discharge. Furthermore, this system not only gets rid of H_2S but also decreases investment expenditures and operating fees. CO_2 capture after burning is one of the worst methods because chemical plants obtain less income.

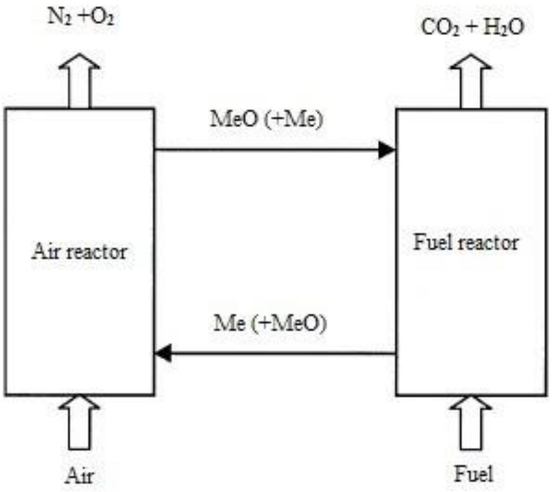

Figure 4. Diagram of chemical looping combustion

References

[1]Yang, H. Q., Xu, Z. H. and Fan, M. H., *J. Environ. Sci.*, **2008**, *20*, 14.

[2]Huang, B., Liu, L. B. and Xu, S. S., *Electrical Equip.*, **2008**, *19*(5), 3.

[3]Wang, X. L., Wu, J. H. and Zhao, Q., *Dongfang Electrical Rev.*, **2011**, *25*(98), 1.

[4]http://en.wikipedia.org/wiki/*integrated_gasification_combined_cycle.*

[5]Olajire, A. A., *Energy*, **2010**, *35*(6), 2610.

[6]Zhang, H., Re, H. W., Lu, J. G. and Ji, Y., *J. Nanjing Univ. Inform. Sci. Technol.*, **2009**, *1*(2), 129.

[7]Lyngfelt, A., Leckner, B. and Mattisson, T., *Chem. Eng. Sci.*, **2001**, *56*, 3101.

Received: 10.12.2012.

Accepted: 31.01.2013.