OXY-FUEL COMBUSTION

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Abstract: Of the increase in greenhouse gas emissions has resulted in the development of new technologies with lower emissions and technologies that can accommodate capture and sequestration of carbon dioxide. For existing coal-*fired* combustion plants there are two main options for CO_2 *capture: removal of nitrogen from flue* gases or removal of nitrogen from air before combustion to obtain a gas stream ready for geo-sequestration. In oxy-fuel combustion, fuel is combusted in *pure oxygen rather than air. This technology recycles flue gas back* into the furnace to control temperature and makeup the volume of the missing N_2 *to ensure there is sufficient gas* to *maintain the temperature and heat flux profiles in the boiler.*

Key words: oxy-fuel combustion, coal, carbon dioxide capture.

1.INTRODUCTION

Energy production from fossil fuel combustion results in the emission of greenhouse gasses, the dominant contributor being CO_2. Public awareness and legislation have led to a policy of reduction of greenhouse gas emissions, with the regulations partially driven by (international) initiatives such as the Kyoto protocol and the Intergovernmental Panel on Climate Change.

It is well known that greenhouse gas emissions from energy production can be reduced by the use of alternative energy sources such as nuclear power and renewable energy sources. Renewable energy sources are expected to become increasingly important for our future energy demand, however, until these sources can reliably produce significant amounts of energy, the immediate energy demand is likely to be met by conventional fossil fuel combustion, a trend observed by organizations assessing energy policy and use .

Over the past decade, the role of coal as an energy source for the future has gaine d renewed interest for its proven stability in supply and cost and it is, therefore, likely that coal will remain in an important position in the energy mix in the foreseeable future.

The effect of greenhouse gasses on global climate change has been a cknowledged by many governments worldwide, and the reduction of the emissions of these gasses is becoming increasingly important. To maintain the position of coal in the global energy mix in a carbon-constrained world, the greenhouse gas emissions emitted from its utilization must be reduced. To reduce greenhouse gas emissions from coal-fired power generation, several possibilities can be perceived: improving efficiency of power plants; capture and storage of CO_2 from conventional plants; replacement of hydrocarbon fuels with renewable resources; introduction of combined cycles—as-fired or IGCC, which can reach high thermal efficiencies.

Renewable energies may hold hope for reducing greenhouse gas emissions in an extremely long time.

Incremental reduction of greenhouse gas emissions can be achieved by the stepwise implementation of more efficient coal-fired power plants, however, to make a significant reduction in emissions, the CO_2 generated from coal utilization needs to be captured and stored.

2.TECHNOLOGIES FOR CO_2 CAPTURE AND SEQUESTRATION

Several technologies are being developed for CO_2 capture and sequestration from coal fired plants that include:

- Oxy-fuel combustion with the oxygen diluted with an external recycle stream to reduce its combustion temperature;
- CO_2 capture from plants of conventional design by scrubbing of the flue gas;
- Chemical looping. This involves the oxidation of an intermediate by air and the use of the oxidized intermediate to oxidize the fuel;
- IGCC with an air separation unit to provide O_2;
- Oxy-combustion with an internal recycle stream induced by the high momentum oxygen jets in place of external recycle.

The losses of CO_2 compression for storage is independent of the technology producing the CO_2.

CO_2 from conventional combustion processes is present as a dilute gas in the flue gas, resulting in costly capture using amine absorption. CO_2 capture is more easily achieved from a concentrated CO_2 stream, which can be achieved by firing fuels with oxygen to obtain a sequestration-ready gas stream.

The latter technique is termed oxy-fuel combustion. In this technique, the oxygen stream is usually diluted by recycled flue gas (RFG).

The studies, indicate that oxy- fuel combustion is a favourable option but that the comparison depends on the plant considered and the associated emissions technologies employed, which are determined by the regulation regimes of different power plants.

3.OXY-FUEL COMBUSTION TECHNOLOGY DESCRIPTION

Conventional coal-fired boilers use air for combustion in which the nitrogen from the air (approximately 79% by volume) dilutes the CO_2 concentration in the flue gas.

The capture of CO_2 from such dilute mixtures using amine stripping is relatively expensive.

During oxy-fuel combustion, a combination of oxygen typically of greater than 95% purity and recycled flue gas is used for combustion of the fuel. By recycling the flue gas, a gas consisting mainly of CO_2 and water is generated, ready for sequestration without stripping of the CO_2 from the gas stream.

The recycled flue gas is used to control flame temperature and make up the volume of the missing N_2 to ensure there is enough gas to carry the heat through the boiler .

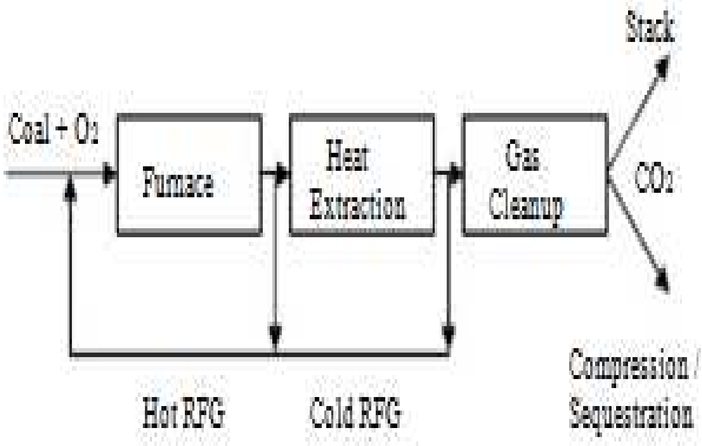

Figure 1. General flow sheet for oxy-fuel combustion

The characteristics of oxy-fuel combustion with recycled flue gas differ with air combustion in several aspects.

The volume of gases flowing through the furnace is reduced somewhat, and the volume of flue gas is reduced by about 80%.

The density of the flue gas is increased, as the molecular weight of CO_2 is 44.

Typically, when air-firing coal, 20% excess air is used. Oxy-fuel requires a percent excess O_2 (defined as the O_2 supplied in excess of that required for stoichiometric combustion of the coal supply) to achieve a similar O_2 fraction in the flue gas as air firing, in the range of 3–5%.

Without removal in the recycle stream, species have higher concentrations than in air firing.

As oxy-fuel combustion combined with sequestration must provide power to several significant unit operations, such as flue gas compression, that are not required in a conventional plant without sequestration, oxy-fuel combustion/sequestration is less efficient per unit of energy produced.

It is more efficient than a conventional plant with sequestration due to the significant energy required to scrub a dilute gas stream prior to compression.

To attain a similar adiabatic flame temperature the O_2 proportion of the gases passing through the burner is higher, typically 30%, higher than that for air of 21%, and necessitating that about 60% of the flue gases are recycled.

The high proportions of CO_2 and H_2O in the furnace gases result in higher gas emissivities, so that similar radiative heat transfer for a boiler retrofitted to oxy-fuel will be attained when the O_2 proportion of the gases passing through the burner is less than 30%.

Most evaluations and studies on oxy-fuel technology are concerned with the application of coal-fired pulverised fuel boilers to produce a CO_2 rich stream ready for sequestration. Other studies have considered its application for oil and gas fired power plants.Coal-fired oxy-fuel combustion has been evaluated for a number of purposes for some years.

A recent emphasis has been to apply the technology to obtain a high CO_2 concentration from coal combustion. Oxy-fuel combustion has been demonstrated at pilot-scale and CO_2 formed during gasification is currently used commercially for enhanced oil recovery (EOR).

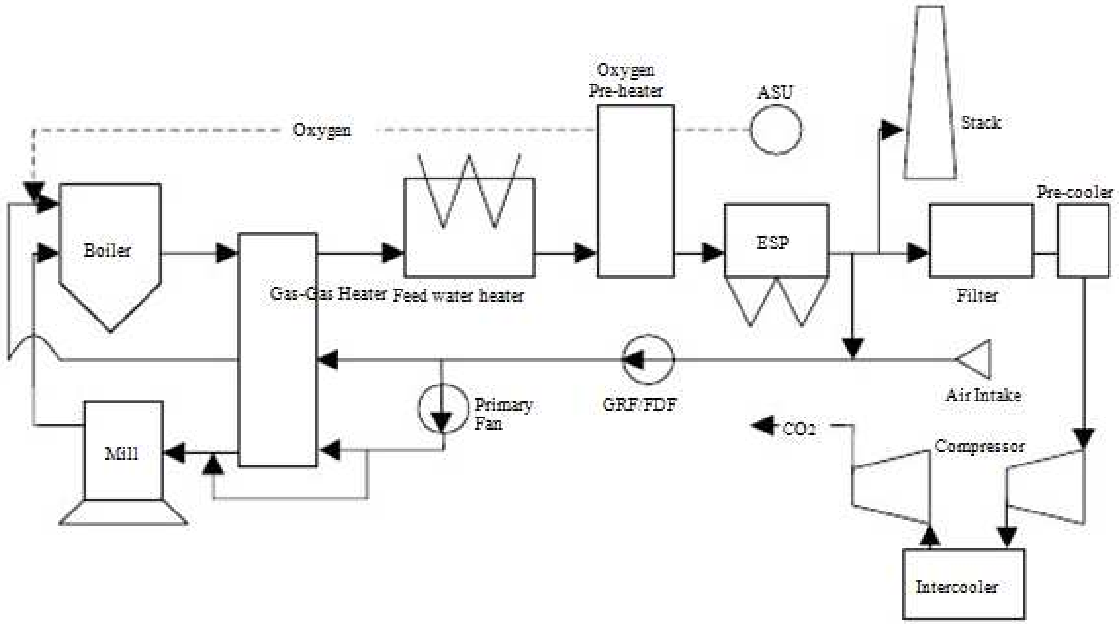

Figure 2. Pulverized coal-fired power plant using oxy firing combustion

Oxygen is separated from air and then mixed with a recycle stream of flue gases from the boiler. Fuel is fired in the resulting gas stream and the flue gases are partially recycled. Water vapour is condensed from the flue gases to produce a stream of high purity supercritical CO_2.

Oxy-fuel combustion and CO_2 capture from flue gases is a near-zero emission technology that can be adapted to both new and existing pulverised coal-fired power stations. In oxy-fuel technology the concentration of carbon dioxide in the flue gas is increased from approximately 17 to 70% by mass. The carbon dioxide can then be captured by cooling and compression for subsequent transportation and storage. In this form oxy-fuel combustion involves modification to familiar coal technology to include oxygen separation, flue gas recycling, CO_2 compression, transport, and storage.

The addition of these operations does bring possible reduction in availability. The extra cost associated with implementing sequestration will also increase capital and operating costs.

CO_2 sequestration is an area undergoing strong development in research and development and will not be discussed in great detail in this paper. However, it is noted that there are several methods of CO_2 sequestration which lead to different requirements with respect to the purity of the gas to be sequestered. Although, all sequestration options have different requirements with respect to CO_2 purity, the energy requirement for CO_2 compression is in all cases reduced as the purity of the CO_2 increases.

4. CONCLUSIONS

The studies demonstrated the feasibility of pulverised coal oxy-fuel combustion as a technology applicable to pf power plants for CO_2 recovery or capture.

Oxy-fuel combustion technology can be implemented as an effective retrofit technology for boiler; however, it affects combustion performance and heat transfer parameters.

Oxy-fuel combustion achieves clean coal combustion, lowering NOx and possibly mercury emissions on a basis of mass per unit of energy produced by the coal and increasing CO_2 concentration for recovery or sequestration.

Oxy-fuel combustion to produce electricity is far less efficient as the plant must drive both an oxygen plant and gas compression, which together typically result in a 9% reduction in plant efficiency.

The expressions of emissions in terms of concentration (ppm), though avoided by most authors, is in appropriate as the gas volume is dependent on gas oxygen concentration and the recycle ratio. The total gas volume is generally less in oxy-fuel combustion.

Oxy-fuel combustion pulverised coal combustion is technically and economically feasible for retrofitting existing power plants.

Oxy-fuel combustion for CO_2 recovery and sequestration is a competitive power generation technology.

5.REFERENCES

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