6.5. EMISSIONS ADVANTAGES OF GASIFICATION

Gasification-based processes for power production characteristically result in much lower emissions of pollutants compared to conventional coal combustion. This can be traced to the fundamental difference between gasification and combustion: in combustion, air and fuel are mixed, combusted and then exhausted at near atmospheric pressure, while in gasification oxygen is normally supplied to the gasifiers and just enough fuel is combusted to provide the heat to gasify the rest. Since air contains a large amount of nitrogen along with trace amounts of other gases which are not necessary in the combustion reaction, combustion gases are much less dense than syngas produced from the same fuel. Pollutants in the combustion exhaust are therefore at much lower concentrations than the syngas, making them difficult to remove. Moreover, gasification is usually operated at high pressure (compared to combustion at near ambient). The inherent advantages in removing syngas contaminants prior to utilization of the syngas[1] emerge as follows:

- Relatively high concentration of pollutant species and pollutant species precursors (most notably hydrogen sulfide (H_2S) in syngas which would form sulfur oxides (SOx) upon syngas combustion), versus much lower concentration that would be found in the combustion flue gas, improves removal;
- High-pressure gasifier operation significantly reduces the gas volume requiring treatment;
- Conversion of H_2S into elemental sulfur (or sulfuric acid) is technically much easier and more economical than capture and conversion of SO_2 into salable by-products;
- The higher temperature and pressure process streams involved in gasification allow for easier removal of carbon dioxide (CO_2) for geological storage or for sale as a byproduct;
- The oil and gas industries already have significant commercial experience with efficient removal of acid gases (H_2S and CO_2) and particulates from natural gas.
- Removal of corrosive and abrasive species prevents potential damage to the conversion devices such as gas turbines, resulting from contamination, corrosion, or erosion of materials.

Emissions Regulations

The Clean Air Act, enacted by Congress in 1963, requires the United States Environmental Protection Agency (EPA) to create National Ambient Air Quality Standards (NAAQS) for any pollutants which effect public health and welfare. As of 2007, the EPA had established standards for ozone, carbon monoxide, sulfur dioxide, lead, nitrogen dioxide, and coarse and fine particulates. These standards are reviewed and updated every five years.

These NAAQS, known as Title I, are administered by each state in conjunction with the EPA. Each state must submit a State Implementation Plan (SIP) to the EPA for approval which details how the state will comply with the NAAQS. The SIP may be more stringent than the Federal requirements, but must meet them at a minimum.

The complications of varying state and local implementation plans generally translate into great variation in the permitting process for new power plants based on their proposed sites. Various state and local regulations and whether or not those areas meet the NAAQS play a large role in the negotiation process for emissions requirements at new plants. Also, the future of emissions regulation is cloudy and more stringent regulations, along with the inevitable increase in worldwide electrical demand, could play a substantial role in determining the eventual market penetration of gasification technology for electrical production.

NETL Comparison of Pulverized Coal Combustion and IGCC Pollutant Emissions

The National Energy Technology Laboratory (NETL) published a detailed performance comparison of three different IGCC technologies along with subcritical and supercritical pulverized coal (PC) power plants (Natural Gas Combined Cycle (NGCC) was also included, however since coal is not the feedstock in that scenario it is not discussed here) entitled Cost and Performance Baseline for Fossil Fuel Plants1 in 2007. Design principles for the IGCC systems were based on best current design practices listed in the Electric Power Research Institute's CoalFleet User Design Basis Specification for Coal-Based Integrated Gasification Combined Cycle (IGCC) Power Plants: Version 4, while the PC plants were modeled based on incorporating the best commercially available technology that could be implemented in a plant to start operation in 2010. Those comparisons illustrated the typical magnitude of emissions reductions possible for the main pollutants/emissions of concern for IGCC-based systems. The three IGCC technologies far outperformed both subcritical and supercritical PC plants in minimizing these criteria emissions. More detailed discussion for individual emissions types can be found at those pages specific to the species in question:

- SOx
- NOx
- PM
- CO_2

Summary

In summary, gasification has inherent advantages over combustion for emissions control. Emission control is simpler in gasification than in combustion because the produced syngas in gasification is at higher temperature and pressure than the exhaust gases produced in combustion. These higher temperatures and pressures allow for easier removal of sulfur and nitrous oxides (SOx, and NOx), and volatile trace contaminants such as mercury, arsenic, selenium, cadmium, etc. Gasification systems can achieve almost an order of magnitude lower criteria emissions levels than typical current U.S. permit levels and +95% mercury removal with minimal cost increase.[2]

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1. Simbeck, D., et al., “Coal Gasification Guidebook: Status, Applications, and Technologies,” Report prepared for EPRI by SFA Pacific, Inc., TR-102034, Dec 1993.
2. The Future of Coal - An MIT Interdisciplinary Study (Mar 2007)