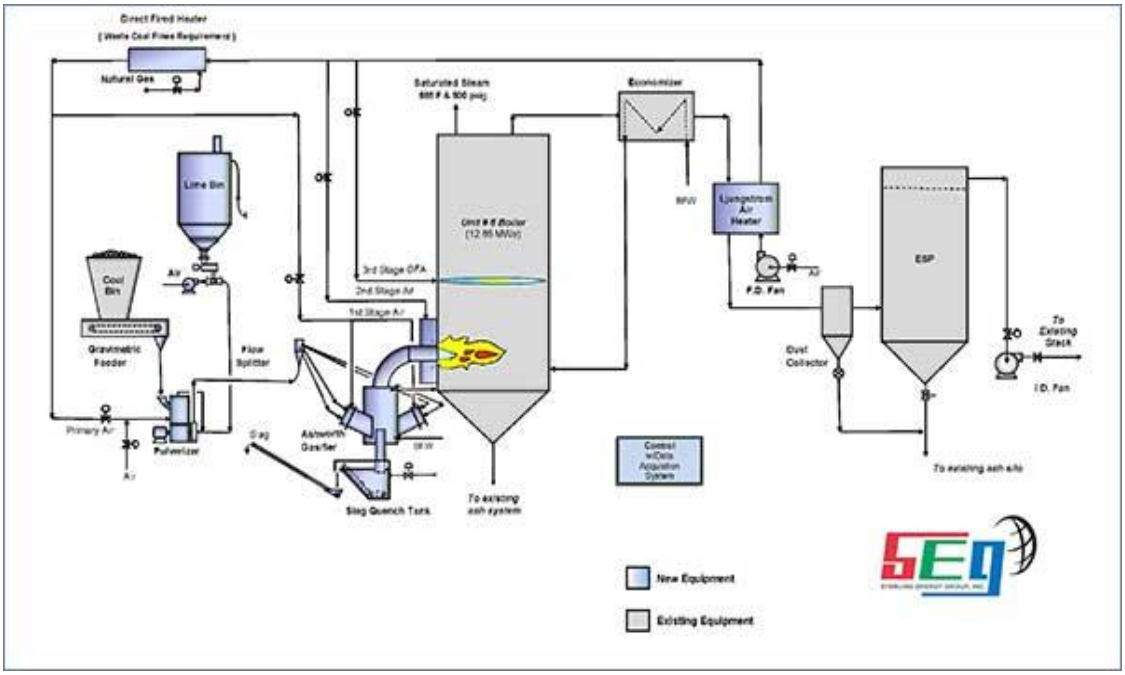
# Expanded potential of coal gasification

By Mark Becker

BRUSSELS, May 1, 2014 (PPI Magazine) - As higher standards for air emissions approach for the paper industry, the need has increased to find pollution controls for coal-fired boilers that are both effective and lower cost. Roughly 50 pulp and paper mills in the US have coal-fired boilers and are now faced with complying with upcoming regulations. This is a global issue because coal is used in the paper industry in most regions of the world due to its availability and low cost.




The utilities industry also faces issues with the same pollutants in attempts to comply with their own set of upcoming regulations with some of these companies having up to 70-80% of their power generation from coal-fired boilers. The challenge here is that controls for PM, NOx, $SO_2$, and mercury are often separate systems, requiring large amounts of capital, and difficulties with simultaneously achieving optimal removal efficiencies with all pollutants. The high cost of these technologies is a major factor in delaying implementation of improved controls at a more rapid pace, and is also resulting in large numbers of older boilers that will retire due to the cost of the controls not being justified.

Some countries such as the US have chosen to avoid converting some of the coal-fired assets by increasing the natural gas-fired generating capacity. This approach can be considered impractical in areas of the world where natural gas is either expensive or not locally available. Natural gas

conversion from coal isn't always the best long-term solution due to having a higher current cost than coal and the projected rise in cost.

As a result, further development of coal combustion technology is needed. Among the many options, recent developments in coal gasification may provide the solution to the various issues mentioned. Although gasification technology has been used to produce a syngas to replace petroleum and natural gas or to provide carbon capture, focus on removal of traditional pollutants is another application in need of further development. Gasification is not a new technology because it was widely used for producing "town gas" for lighting and cooking in the 1800s before it was replaced by electricity and natural gas. It also had a short-term surge in popularity during World War II when petroleum supplies were limited.

Many gasification projects have been attempted over the past couple decades to provide an alternative to petroleum or natural gas, but the use of gasification for pollutant control still has considerable undeveloped potential. The potential for one system to remove multiple pollutants was identified by Bob Ashworth in 1980 that involved the use of a simple gasifier design.

This technology was based on the oxygen-fired Rummel molten slag bath gasification technology used in Germany in the 1940s to produce a synthesis gas for ammonia production. The Rummel gasifier, burning German brown coal with high alkaline ash content, captured 70+% of the coal sulfur in the molten slag that was removed from the gasifier.

Ashworth was involved with the development of a two-stage gasifier-combustor at Florida Power Corporation (FPC) that reduced both sulfur and nitrogen oxide emissions. FPC demonstrated a two-stage 12 million Btu/hr gasifier-combustor in 1984 at the Foster Wheeler Development Center in Livingston, NJ. With this air blown technique, sulfur dioxide ($SO_2$) reductions of up to 60% and nitrogen oxide ($NO_X$) emissions of 0.25 lb/million Btu were achieved when firing eastern bituminous coal. ClearStack Combustion Corp, then later ClearStack Power, was formed to develop this technology further.

A three-stage gasifier-combustor technology was developed by ClearStack to achieve ultra-low $NO_X$ emissions and to improve sulfur capture. Both of these goals were achieved and as a bonus mercury and other air metal toxics were captured in the slag as well in testing of the three-stage technique at the Lincoln Developmental Center in 2003.

One of the distinctive features of this approach is the ability to eliminate the majority of the equipment that is typically required after a gasifier to cool and clean the syngas. By directly injecting the syngas into the boiler it is possible to have a much simpler system thus making boiler retrofit projects less expensive and with minimal training for operators.

The use of the ClearStack entrained-flow design is beneficial for pollutant removal applications because it provides the necessary temperature to provide a slag. This slag is a molten form of the ash, which about 80% is removed prior to the boiler. By injecting limestone along with the coal, it's possible to remove 90% to 100% of the sulfur, and the gasifier's control of the stoichiometric air ratio allows for tight control of nitrogen oxide formation as low as 0.095 lb/MMBtu (40.8 g/GJ). Mercury reduction was also documented to be 93% to 100%.

Additional benefits exist with the use of a slagging gasifier including the reduction of ash disposal requirements. Instead of having the continued cost and environmental issues associated with ash disposal, the ash and slag can be sold, providing other saleable byproducts for the mill, and reduced landfill load. Since the advent of low $NO_X$ burners, many coal-fired power plants that once sold their fly ash to the cement industry could no longer do so due to high carbon content. With the Ashworth Gasifier the high carbon conversion of the old excess air burners returns to provide a fly ash with 5-wt% carbon or less. This ash can then be sold for the production of high quality fly ash cement.

The slag and boiler ash that is produced by the gasifier can also be sold as a byproduct and is currently being used as a wear-resistant component in surface coatings of asphalt in road paving. Finer-sized slag can be used as blasting grit and is commonly used for coating roofing shingles. The Toxicity Characteristic Leaching Procedure (TCLP) tests showed the regulated concentrations of Ag, As, Ba, Cd, Cr, Hg, Pb, and Se in the leachate were all well below the EPA regulatory limit for both the fly ash and slag.

Another one of the benefits of installing a gasifier for multi-pollutant control is that the resulting efficiency impact of the gasifier system is much lower than other emission control alternatives. This is because the auxiliary power demand of the gasifier system is relatively small so the effect on the saleable power is less than a system with high-pressure pumps and equipment that results in an increased boiler pressure drop. The additional power demand for a gasifier can be estimated as 0.05% of the generated power versus 2.9% for a combination of wet scrubber and selective catalytic reduction controls. This amounts to an incremental 10,000-ton/yr of $CO_2$ emissions for the lesser efficient option on a 50-MW generation system.

Having successfully demonstrated the technology at the Lincoln Development Center in Lincoln, IL, ClearStack is looking to conduct a rebuild on a 12.65 MWe boiler owned by the Sterling Energy Group in Crawfordsville, IN. The intent of the project is to not only make it be in compliance with upcoming air emission regulations for this boiler built in 1965, but also to allow selection of lower-cost local coals that have a higher sulfur content. This flexibility in fuel source will allow selection of lower cost fuels and provide evaluation of other coals for other potential installations. The intent is to conduct trials to document the thermal and pollutant removal efficiencies along with any adjustments needed for optimal operating conditions.

The installed cost of a gasifier upgrade is approximately US$220 (303 EUR) per kWe for a 50-MWe boiler, and this gasifier system can be used to upgrade any size or type of boiler at a fraction of the cost of other alternatives. Additional costs will occur for some systems if coal pulverizers or over-fire air aren't already in place. Other than the gasifier and corresponding slag quench tank (see drawing) the main equipment to install is a limestone storage and feed system.

As the ClearStack gasifier technology continues to be developed, there are plans to further expand this technology to other coal using industries. This may begin with re-powering of an existing coal-fired boiler in a partnership with an energy research organization from the region. This will allow development of the technology to address the energy priorities of the region and help to communicate the benefits to nearby coal users. One of the priorities expected to be

evaluated includes biomass co-firing to further reduce the amount of coal used per megawatt produced.

With the increased standards for air emissions from coal-fired boilers, there is a greater need than ever to make progress with a simpler and more effective technology to remove all of the traditional pollutants. The continued development of coal gasification provides a lower cost alternative for pollutant removal that is expected to help support coal usage in the future.

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