

LESSONS LEARNED FROM GASIFIER OPERATING EXPERIENCE

BO OSCARSSON

A BLACK LIQUOR GASIFICATION CYCLE IN A PAPER MILL DIFFERS FROM FOSSIL FUEL GASIFICATION IN A POWER PLANT, BUT IT IS POSSIBLE TO BUILD ON THEIR SIMILARITIES.

TO TALK ABOUT GASIFICATION BRINGS BACK INTERESTING memories for me, as I worked for five years with gasification, beginning in 1975. I designed, operated, and ran an oxygen-blown, slightly pressurized gasifier fueled by Swedish oil shale residues obtained as a byproduct from the mining of uranium-bearing oil shale. The program was intended to develop a method to produce methanol for the domestic transportation industry. The program died a sudden death when a referendum recommended phasing out nuclear power in Sweden. Nevertheless, it was five years of interesting experience that demonstrated that gasification does work if done the right way.

In a black liquor gasification cycle, black liquor will enter into some type of process vessel, either pressurized or atmospheric. Liquor will be processed through the gasifier and partially oxidized. The product gas will go through heat recovery, particulate removal, and a hydrogen sulfide removal system. There will be some type of regeneration system to recover the sulfur component, which will leave the gasification system. The product gas will go to a gas turbine in a conventional combined cycle with heat recovery steam generators (HRSGs) and steam turbines.

Drawing from experiences of the fossil fuel industry, we need to identify the differences between black liquor and other fuelstocks. The key difference is that black liquor has a lower Btu content than most other fuels, excluding biomass. It has a higher water content and a high ash content. The ash is considered in terms of pulping the recoverable inorganic content, roughly 40%-45%, of the black liquor. It is used to make green liquor and then white liquor.

SMELT

The alkaline smelt itself is a challenge, and various companies have learned and seen that both equipment and

refractory development are needed. Smelt from black liquor flows almost like water. Spout plugging could happen, but in general engineering terms, black liquor smelt has a low viscosity.

The chemicals in smelt are used in the mill. It is imperative that we find an economical way to recover and recycle them in a straightforward manner and that we maintain reliability and operating uptime. Sulfur has to be recovered as well, as it is one of the active pulping chemicals. Again, we have to find the most economical way to bring it back into the pulping process in an efficient manner.

OPERATING CYCLE

The operating cycle of the gasifier will be somewhat different than in a power plant because the purpose is really to take the by-product black liquor and process it, so the process or operating strategy will have to follow mill production levels. It will not follow power demand or

EDITOR'S NOTE

This month we continue with a series of articles on gasification and its applications to the pulp and paper industry. This Energy 2000 Special Report has been developed from the TAPPI 1998 Engineering Conference's Gasification Panel Discussion.

The series began in the September issue of Tappi Journal with an introduction by Tom Harriz, session chairman; an article on the impact of integrated gasification on kraft pulping and recovery, by Jim Frederick; and an article by Dick Erickson and Craig Brown on operating experience with a gasification pilot project.

This issue continues the series with two additional articles. One, by Bo Oscarsson, looks at the lessons learned from a gasifier operating experience. The other, by Fred Jahnke, examines some commercial successes of gasification technology outside the pulp and paper industry.

	Commercially available	Commercially available with modifications	Process study and optimization required	Equipment and material verification required
Gasifier excluding refractory	-	✓	✓	-
Refractory and supports	-	✓	-	✓
Quench and gas heat recovery	-	✓	✓	✓
Acid gas removal	✓	-	✓	-
Acid gas process	✓	-	✓	-
Gas turbine	✓	-	✓	-
HRSG and generator	✓	-	✓	-
Air separation plant	✓	-	-	-

I. Current availability of items used in a black liquor gasification cycle

any other demand variable. It will follow mill load unless we build in flexibility and redundancy in a creative manner, using multiple gasifiers, where auxiliary fuel can be processed to a common gas product.

PLANT DESIGN

The need for redundancy and plant availability will be highly dependent on the complexity of the system chosen. Most likely the first generation commercial plants will not have the full heat recovery that we can see in a theoretical plant design approach. The first plants will suffer a small loss of efficiency for the benefit of keeping the system simple to gain experience and still maintain operating uptime.

Vast experience is being generated in the fossil fuel industry and power generation sites operating independent power plants. There are a significant number of plants coming on line based on gasification of heavy fuel oil, petroleum coke, and coal. The amount of power generated is significant; and the experience that is being generated is valid for the black liquor gasification plant from a number of aspects, including the gasifier operating principles. It is the same principle as operating a gasifier on coal, petroleum coke, heavy fuel oil, or black liquor, but one must learn the specifics of the fuel.

The design of the gas handling train and particle removal system downstream of the gasifier are somewhat dependent on the type of fuel. We can deal with those downstream technologies as they are; it is a matter of finding the optimum combination. It depends on which strategy and scenario are selected to bring the sulfur back to the pulp mill and how the product gas will be used.

The operation of the gas turbine and the power generation is not dependent on the fuel's being derived from black liquor. It will be the same as if it were from any other type of gas-generating fuel.

Plant auxiliaries are similar. It is a matter of integrating them in a large facility. Auxiliary equipment is much the

same in a refinery, a chemical complex, or a pulp mill. If the plant is being designed around an oxygen-blown gasifier, an air separation plant is required. That is straightforward commercial technology. There is no additional impact or risk because it is for a black liquor gasifier. The same rule applies to the heat recovery steam generator after the gas turbine; it will be unchanged if black liquor is used as primary fuel.

Previous gasifier projects have been similar regarding money invested, floor plan area, and the integration of a power and steam generating plant into a processing complex. If it is a pulp mill or chemical plant, the same integration concerns exist with the local electric grid, the steam distribution system, and the operation of gas and steam turbines. There are many parallels to draw from design experience, plant operating experience, and initial operations.

With regard to the gasifier, possibly excluding internal refractory, the vessels are commercially available. There may be modifications necessary, but the principle and delivery schedule are known. It could be improved and made more efficient, but for the first commercial generation, this can be considered a proven stage with the possibility for improvement.

REFRACTORY AND RELATED ISSUES

The first Tomlinson unit was built in 1937, and it is still undergoing improvements and modifications after 60 years. It would surprise me if we cannot find ways to make gasification better for at least 20 more years. Refractory is the key, especially with the high sodium content of the black liquor smelt. There is refractory that works. It is a question of how long it works, and there is certainly a need for improved knowledge of refractory as a material itself in contact with smelt.

Many people have said we should be able to know what refractory to use. It is used in the space program, but the concentration of sodium in space is not what it is in the recovery boiler. Here on earth, we have to learn

how to deal with sodium in contact with refractory at 1800°-1900°F operating temperature. The quench process is somewhat equipment specific. Perhaps not all gasifier technologies will require a sodium/water mixture. For those that do, this is the first contact area where the gas is contacted with water or weak wash and green liquor is formed. This equipment exists in various designs. It is certain that modifications and improvements can be made, and it will probably take a couple of technology generations before it is finalized.

Once we get past the refractory issue, the remaining processes are largely commercially available. Acid gas can be handled. The problem is not so much developing the recovery process or the equipment as it is choosing which process is best for the pulp mill. Handling of hydrogen sulfide is commercially proven; it is a matter of choice how to couple the hydrogen sulfide to white liquor production. The process steps that are required are proven and available on a commercial purchase basis. Improvements and optimizations will happen, and new processes may emerge.

The gas turbine is insensitive to the fact that the gas is generated from black liquor. It is a matter of designing for and maintaining the Btu content of the gas we have. There are various tricks of diluting, compensating, and handling fuel gas coming to gas turbines to maintain an optimum cycle. It is a matter of doing a cycle optimization and finding the right way to operate. The heat recovery system is also commercial technology, as well as the air separation plant. A significant number of processes are proven and available.

Table I summarizes the availability of equipment and processes used in black liquor gasification.

Still to be developed is the best combination of options. Maybe the best path is to make the least complex combination in the beginning before moving on to the second and third generation plants. For reliability, redundancy can be applied to reduce the issues surrounding refractory until improved materials or methods can be developed. TJ

Oscarsson is technical director for Fluor Daniel Forest Products, Greenville, SC.