The manufacture of synthetic gas and ethanol from biomass using the Pearson thermo-chemical steam reforming and catalytic conversion processes

Stanley R. Pearson
Pearson Technologies of Mississippi Inc., P.O. Box 766, 20088 Norm Connell Drive, Aberdeen, MS 39730
Fax: 225-768-9974/ 662-369-1168

Summary

Pearson Technologies of Mississippi Inc. ("PTMI"), a wholly owned subsidiary of Ethxx International Inc., a private Ontario, Canada corporation, has constructed a 30-ton per day wood waste to ethanol facility in North Mississippi. The process consists of a syngas producing front-end with a Fischer-Tropsch back-end. Syngas is produced using a multi-stage steam reformer (gasifier) with a "cold gas" efficiency of 81%. The number of stages and operating conditions are dependant upon the end-use of the gas. The second stage is a fairly straightforward Fischer-Tropsch synthesis loop, using a proprietary catalyst developed by Pearson Technologies Inc ("PTI"). Single-pass conversion to ethanol is from 15% to 60% with a total conversion of 99+ %, with recycle.

The gasifier has converted a wide range of feedstocks to synthetic gas ("syngas") including wood waste (whole tree), bagasse, rice hulls, animal manure, lignite and creosote, at a pilot plant in North Mississippi. The catalysts have been developed in cooperation with the Chemical Engineering Department of a major US University. The syngas is produced at a cost of approximately $1.20 per million BTU's ("mmBTU's"), at a concentration by volume of approximately 50% that of natural gas. Further, the process produces no emissions, as there is no oxidation. The omission of oxygen from the process also results in a very low capital cost for the manufacturing facilities. The syngas can be used either for electricity generation (by driving a gas turbine) or for commercial production of alcohols and other chemicals.

Process Description

The syngas manufacturing step begins with feedstock preparation. In the case of wood waste this begins with drying, grinding of the wood and removal of all foreign objects. This prepared feed is now injected into the reactor along with a small amount of steam. This mixture is heated for a short time, and as the gas exits the reactor heat is recovered along with the removal of trace quantities of inorganic material. This gas is now cleaned of any remaining non-gaseous material.

The gas is now compressed to the pressure that is selected for operation of the Fischer-Tropsch alcohol reactor. The feed gas is mixed with recycle gas from the gas-liquid separator, preheated and returned to the reactor. The partially reacted gas and the alcohol produced exits the reactor, is cooled and the liquids (alcohols) removed in the separator. The liquids are sent to storage and the un-reacted syngas is recycled to the reactor.

The crude liquids are taken from storage and sent through 3 distillation columns where the light ends are removed and sent back to the reactor loop. The second column produces ethanol and the third column produces a small amount of heavy alcohols.

Process Factors

<u>Gas (front-end) Section:</u> Following are key factors related to the steam reforming section;

1. Mol ratio of products are a function of a number of variables: pressure, temperature, contact time, feed ratios and feedstock type.
2. The number of reactor stages also determines the gas composition.

3. Pressure is also a critical variable. If the gas is to be used as fuel in a high performance gas turbine, the pressure is raised so as not to require fuel gas compression - a major benefit.
4. Turn down ratio is 0 to 100% load.
5. CO_2 and CH_4 free gas can be produced with the proper reactor stage(s), temperature and pressure. In the case of higher alcohol production, this ability is a significant advantage, and avoids a complex recycle system.

Alcohol (back-end) Section/ other chemicals: Following are key factors in alcohol and chemicals production;

1. High pressure operations of the gasifier feeds downstream processes. Whether it is ammonia, alcohols, gas-turbine-generator fuel, or any other end-product, it lowers the compression cost of the process. We can also control the mol weight of the syngas. While this is not critical for power generation, it is of value to the costs of further compression.
2. We have conducted a significant amount of research on the possible use of existing methanol and ammonia plants. Different formulations of catalysts must be used to operate at relatively low pressures of some methanol plants, also, certain methanol plant designs have high recycle rates, which we do not normally use. We have been able to accommodate each of these situations. While higher alcohols prefer higher pressures and temperatures, we have been able to modify our catalysts to operate productively at lower pressures and temperatures.
3. After compression we send the gas through heat exchangers and cross-exchangers to properly pre-heat the gas to the design temperature. This sets up the alcohol reactor for proper temperature control. Temperature control is the most important variable in the alcohol process, and must be done accurately and precisely. Ethanol reactors are not self-quenching (as is methanol) and can "run away".
4. The reactor exit gas is cross-exchanged and cooled resulting in condensation of the product. The liquids are separated and sent to storage. The un-reacted gas is mixed with fresh make-up gas and is re-fed to the alcohol loop.
5. Some by-products ***can*** be made, depending on the catalyst used, and must be purged from the alcohol loop and recycled through appropriate process units to be re-fed to the alcohol unit.
6. The liquids are withdrawn from the storage tank and sent through 3 distillation columns. Here the light ends are removed and the heavy ends (alcohols) are separated. Also carbon beds, molecular sieves, etc., are used to produce specification grade material.
7. Very little alloy material is required, with two exceptions: The condensing sections of the plant where minor quantities of CO_2 exist in the gas; and the construction of the alcohol reactor.

Technology rollout

The Pearson process' low cost of producing syngas and absence of greenhouse gas emissions, coupled with the urgent economic need for biomass-driven energy ("green energy") suggests that a primary use of the process should be to fuel power plants in areas where biomass is plentiful. However, the need for fuel ethanol to replace MTBE is becoming a priority for a growing number of jurisdictions. The flexibility of the Pearson process in using a wide variety of feedstocks enables the thermo-chemical production of fuel ethanol while simultaneously solving the problem of incineration of biomass wastes. We must achieve a balanced, but rapid rollout of both uses, and have developed a "Progeneration" model that collocates the production of electrical power and ethanol from local biomass. It is also a useful feature of the Pearson process that Fischer-Tropsch facilities made idle by the high cost of natural gas can be converted to ethanol production with the expenditure of reasonable amounts of capital to retrofit them. This would facilitate the rapid increase in supply necessary for continued observance of clean air regulations following a US-wide ban on MTBE. Both uses suggest that the technology be licensed to ensure that the maximum benefit be conveyed to the economy and the global environment.