THE COPROCESSING OF FOSSIL FUELS AND BIOMASS FOR CO_2 EMISSION REDUCTION IN THE TRANSPORTATION SECTOR

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INTRODUCTION

Research is underway to evaluate the Hydrocarb process for conversion of carbonaceous raw material to clean carbon and methanol products. These products are valuable in the market either as fuel or as chemical commodities. As fuel, methanol and carbon can be used economically, either independently or in slurry form, in efficient heat energies (turbines and internal combustion engines) for both mobile and stationary single and combined cycle power plants. When considering CO_2 emission control in the utilization of fossil fuels, the coprocessing of those fossil fuels with biomass (which may include, wood, municipal solid waste and sewage sludge) is a viable mitigation approach. By coprocessing both types of feedstock to produce methanol and carbon while sequestering all or part of the carbon a significant net CO_2 reduction is achieved if the methanol is substituted for petroleum fuels in the transportation sector. Biomass removes CO_2 from the atmosphere by photosynthesis and is thus a prime feedstock for mitigation of CO_2 emission from mobile sources. Since the availability of biomass will, in most cases, determine the amount of petroleum that can be displace, it is essential to obtain maximum yield in the conversion process.

Basic Hydrocarb Process

The basic Hydrocarb Process would use carbonaceous feedstock or combination of feedstocks to produce, in addition to pure carbon, the coproducts, hydrogen, methane or methanol. The process which combines 3 basic steps; (1) a hydropyrolyzer (HPR) in which the carbonaceous material is hydrogasified with a recycled hydrogen-rich gas to form a methane-rich gas (2) a methane pyrolyzer (MPR) in which methane is decomposed to carbon and hydrogen and (3) a methanol synthesis reactor (MSR) in which the CO is catalytically combined with hydrogen to form methanol (MeOH or CH_3OH) and the remaining hydrogen-rich gas is recycled to the first step (HPR). The principal distinguishing features of the process are that the hydropyrolysis is an exothermic reaction which does not require internal heating, the methane pyrolysis is an endothermic process which does require heating and the recycled hydrogen-rich gas conserves the energy balance in the process.

Process Simulation Computer Model

A Hydrocarb process simulation computer model was developed based on well-known thermodynamic data taking into account equilibrium among the gaseous species CH_4, CO, CO_2, H_2, and H_2O and carbon in the solid phase. This detailed model allows the complete determination of the mass and energy balances around each reactor and around the entire process for various feedstock types and for various pressure and temperature conditions in each of the reactors. From numerous computer runs we cite here only two configurations which are most relevant to CO_2 emissions reduction. In one configuration we obtain a net zero CO_2 emission and in the other configuration we maximize the production and utilization of methanol as transportation fuel and substantially reduce CO_2 emission although not to zero.

Hydrocarb Methanol as an Alternative Transportation Fuel

An analysis can also be made with respect to CO_2 emissions when considering methanol displacing gasoline as a transportation fuel. About 30% of the U.S. anthropogenic CO_2 emission comes from the transportation sector which is about equal to emissions from stationary sources. EPA has estimated that 1.54 gallons of methanol can displace 1 gallon of gasoline in automobiles on a mileage per unit energy basis. Gasoline emits 9 Kg CO_2 per gallon. For maximum Hydrocarb methanol production configuration, the CO_2 emitted is 4 Kg CO_2 per gallon of gasoline displaced. There is thus a 55% reduction in CO_2 emission by the use of Hydrocarb methanol in displacing gasoline. Hydrocarb methanol can yield from 80% to 130% greater reduction in CO_2 emission than the other conventional biomass gasification plant for methanol production.

Cost Estimates

The following is a summary of the conclusions of a preliminary economic study of alternate fuel options. The preliminary capital cost estimate was determined based on a comparative analysis with a Texaco Coal gasification process plant assuming that equal gas througput through the gasifier will have the same capital cost when escalated to 1992 dollars. Credit was taken for elimination of the air separation plant and half credit for acid gas removal which are not needed in the Hydrocarb plant. A reasonable plant capacity handling 5000 dry metric tons of biomass per day (DMT/day) selected mainly by the deliverability and cost of biomass from an area of a fast rotational crop tree plantation (bundled willow). The economic parameters assumed for methanol production based on the maximum yield of methanol option and results in a production cost of $0.405/gallon methanol.

An equivalent gasoline price and incremental cost of gasoline displaced has also been calculated. The U.S. national average gasoline price toward the end of 1989 was $1.12 per gallon. Taking into account methanol displacement, production cost, taxes, markups and distribution cost, the incremental cost of gasoline displaced is equal to $1.01/gallon or 11¢/gallon less than the national average.

A further cost comparison was made with other biomass derived alcohol production processes. Comparing ethanol produced by acid and enzymatic hydrolysis, methanol produced by steam-oxygen gasification and ethanol produced by fermentation. Hydrocarb methanol for a 5000 DMT/day biomass plant costs from 50% to 75% less, on a lower heating value (LHV) basis, than the other ethanol or methanol processes as reported in the literature..

CONCLUSION

The Hydrocarb process has the potential, if the development objectives are achieved, to produce alternative transportation fuel from indigenous resources at lower cost than any other biomass conversion process. Our comparisons suggest the resulting fuel can significantly displace gasoline at a competitive price while mitigating CO_2 emissions and reducing ozone and other toxics in urban atmospheres. This general conclusion could also apply to stationary power generation in peaking and combined cycle power generation plants.