IPRO 347

Design and Economic Evaluation of Biorefinery Operations

The IPRO team was successful in designing a process that converts biomass into liquid fuels for transportation. The biomass chosen was cow manure because of two main reasons. The abundance of cows in southern Wisconsin provides an ideal place for the process to be built. Also, because most other types of potential biomasses currently have uses, manure was favorable. The process was split into three sections: gasification, gas clean-up and Fischer-Tropsch (FT) reactor. A gasifier is a larger vessel in which a complex carbon structure is partially combusted with a limited amount of oxygen. The resulting gas (syngas) is an energy rich stream of carbon monoxide, carbon dioxide, hydrogen, water, nitrogen, and some impurities. The gasifier chosen is a non-slagging, relatively low-temperature single throat uptake design. The process consists of a total of ten gasifiers, each handling 50 tons of dry manure per day. The next section is used to reduce the impurities to enable the syngas to be used produce fuels via the FT route. Three main compenents of this process were designed. The first of which is a very typical water scrubber, which allows the ash to be removed preventing catalyst clogging further down the process. The second operation is to remove the H_2S, which will poison the FT catalyst. This is done by absorbion onto ZnO in a packed bed. The bed is exchanged out with a second bed daily and then the bed is regenerated with hot air to form a concentrated H2S stream, which can be sold. The final part of the clean-up is to prepare the hydrogen to carbon monoxide ratio by the water gas shift (WGS) reaction. The WGS is carried out as well in a packed bed reactor with a typical catalyst and is pushed towards equilibrium but still staying far away, which allows for quick kinetics. The final section of the process is to produce the long carbon chain structures which will serve as transportation fuel. This is carried out in a Fe-based catalyst packed bed reactor at 20 bar and 253 degree C. The product distribution was estimated from available literature and was consistent with a variety of sources from different locations. The process was then costed using a costing and design reference book. The total process was estimated at $500,000,000. At an interest rate of 5.39% and a payback time of ten years, a daily payment of $200,000 is required. The process generates an estimated 8000 gallons of biodiesel per day, which leaves the total cost per gallon predicted at $25; however, this cost is of course preliminary. With some optimization of the process, integration of heat and electricity, and product tailoring, the cost could easily be reduced to $10. Further modeling of the FT reactor could allow the process to be even more optimized. Additional cost should also be done to determine the final economic viability of this process.