Capstone Design Project Abstract

Project Title: Process to Produce a Value-Added Product from Wood Pallets

Sponsor: Green Clean Solar
Team Members: Cate Grill, Charlotte Williams, Jay Lee, Karlie Kazmierczak
Faculty Mentor: James Kastner

Throughout the course of the school year, our team collaborated with Green Clean Solar, a waste management firm, located in Marietta, GA, that specializes in waste from solar panel installations. Our group was tasked with designing a process to convert the wooden pallet waste from these sites into a value-added product. Following market research and consideration of stakeholder needs, design goals were identified as sustainability, profitability, minimal byproducts, scalability, and market appeal. Through a decision chart accessing numerical rankings of various processes and products, biochar production emerged as the most cost-effective and promising approach to repurpose the wooden panels. Biochar manufacturing is a burgeoning industry, particularly driven by the rising demand for sustainable solutions and environmentally friendly fuel sources. It is generated by heating wood chips in the absence of oxygen, producing a highly porous, carbon-rich form of charcoal. Biochar is a promising and versatile product, finding applications in soil amendment, carbon capture, and water purification.

Based upon the design objectives and literature reviews, our team designed a batch process utilizing torrefaction followed by slow pyrolysis, finding it the most economically efficient and promising method that offers high yields. Initially, the wood pallets will be fed into a grinder that will remove any metals and reduce the particle size to approximately 10-30 mm. Subsequently, the ground pallets will undergo torrefaction for 30 minutes at a peak temperature of 250 °C and atmospheric pressure, using a screw conveyor reactor. This process aims to reduce the moisture content of the wood chips by 20-30%. The torrefied biomass will then enter the rotary kiln reactor where it will be pyrolyzed at a peak temperature of 400 °C for 30 min under atmospheric pressure. This will produce a mixture of three products (biochar, bio-oil, and biogas) that will be subjected to downstream processing to separate and refine the solids, liquids, and gasses. In order to maintain a sustainable process design, all of the off gasses will be combusted and recycled for further use.

Using literary research and the relevant chemical equations, mass and energy balances were conducted for each unit incorporated into the proposed process. Based upon the calculations, a batch consisting of 1088.4 kg of wood waste, 30 pallets, results in 841.8 kg of product, in which 36% is biochar. Therefore, our design generates 305.9 kg of biochar for every batch of wood waste processed (30 pallets).

Additionally, thorough research was conducted on the regulatory standards for biochar production, ensuring compliance with current regulations during the development of our process design. The USDA specifies regulations regarding polycyclic aromatic hydrocarbons (PAH) and heavy metal contamination. Further, the Natural Resources Conservation Services (NRCS) mandates the use of IBI certified biochar, guaranteeing its responsible integration as a valuable agricultural input that aligns with organic principles and conservation practices.

To summarize, our team has developed a thorough process to transform and repurpose wood waste into biochar through the use of torrefaction and slow pyrolysis. This plan includes detailed unit operations and conditions, mass and energy balances, a process flow diagram, and a process simulation using Aspen Plus software that adheres to USDA and NRCS regulations. Throughout the design we have prioritized ongoing communication with our client and stakeholders, fostering transparency, and collaboration to advance our shared goals effectively. Ultimately, we have created a design that produces 305.9 kg of biochar for every 30 wood pallets (2400 kg wood waste) processed.