CH402 Chemical Engineering Process Design Capstone Problem 2 Statement

Closing Critical Gaps to Enable a Circular Economy of Plastics

Introduction:

This year's capstone design problem is somewhat different from past years. It is a real problem that must ultimately be solved through collaboration of engineers, businesses, governments and citizens across the world. Your solutions and ideas are important. And they are needed. Innovative solutions will be shared with technical leaders from the Alliance to End Plastic Waste and its member companies.

The Societal / Business Challenge:

Plastics are extraordinary materials. They enhance our lives across a vast array of engineered applications beneficial to modern society, including lightweight, durable materials for transportation, construction, agriculture, food preservation, medical supplies, energy storage, electronics… the list is long. Despite their benefits, each year, many millions of tons of plastics, worth billions of dollars, are buried in landfills, burned, or leaked to the environment, with a significant fraction of mismanaged plastic waste finding its way into ocean waters and impacting marine ecosystems in ways we are still discovering. The fraction of global production that is recovered, re-used or repurposed remains far too small. This problem, the problem of plastic waste, is a critical societal problem that must be solved. And it must be solved on a global scale.

Our challenge, as engineers, citizens, governments, and businesses, is to meet the critical needs that plastics serve while enabling an efficient, effective global circular economy that eliminates waste. This means solving the entire circle. It is not enough to take one step and leave the rest to others. We need to step up and contribute to completing the circle. The entire circle.

You are role-playing as a chemical process engineers at a commercial employer. Your employer, Global Petrochemicals, is a leading manufacturer of basic chemicals and high-performance polymers with a large, sophisticated customer base. Global's customers and the consumers of their ultimate products demand action to reduce plastic waste. As a result, the firm has made an industry-leading commitment to both its customers and investors to make a significant, impactful step to produce 10% of its virgin resin-quality plastics from recovered plastic waste in the near future, growing this fraction aggressively after this aggressive short-term goal. This is an ambitious goal requiring application of new process technology and major investments. It also requires that you establish efficient & effective plastic waste collection and sorting in an area suffering from a severe problem of plastic waste leakage to the environment.

Your final report must include responses to both Part 1 and Part 2 of this challenging problem:

Part 1: The Process Engineering Challenge: Design of a Pyoil Purification Unit for Supply of Recycled Feedstock to a Steam Cracker. Background and technical information are contained in Appendix 1.

Your team has been tasked to design a unit that will purify a stream of pyrolysis oil derived from pyrolyzed plastic waste so as to meet the specifications for feed to an ethylene plant (also known as a steam cracker) at your company's integrated petrochemical site in the Southeast Asia. As part of this project development, you are also tasked to consider the process safety and economic performance of this facility.

Part 2: The Innovation Challenge: Cold Eyes Review of the Bali Manual Sorting Facility and Recommendations for Improved Performance. Background and technical information are contained in Appendix 2.

The plastics pyrolysis unit that feeds the purification unit that you will be designing is partially fed by a recovered flexible plastics stream coming from a community-based, manual sorting facility in Bali, Indonesia. Your firm is helping to finance this newly built sorting operation and is depending on its reliable operation. The Bali facility is a very basic one that will recover all of the household waste from the surrounding communities (which would otherwise be burned, buried, or leaked into the environment, and ultimately into the ocean). Your firm needs to ensure sustainable operation of the community sorting facility to ensure feedstock security for its circular plastic products. Because your engineering team is considered strong in cross-disciplinary critical thinking, you have been given a second assignment in parallel to the design of the purification unit. This second assignment requires you to provide "cold eyes analysis" of the Bali operation to generate innovative ideas that will improve the facility's operation with an aim towards closing three critical gaps that will ensure its long-term contribution to your business. Your assignment is to develop at least one proposed improvement idea that would contribute to closing each of the following three gaps:

1. **The Quantity gap:** The Bali facility must generate more sorted plastic waste to supply your plastics pyrolysis unit. If the quantity is insufficient, the pyrolysis unit investment will fail to meet its critical financial objectives. What ideas do you have to increase community participation in waste collection? Do you have ideas to increase the fraction of plastic waste manually recovered from the household waste collected (esp. the flexible plastic waste)? What can be done to increase the throughput of the sorting facility?
2. **The Quality gap:** The plastics pyrolysis technology that your company has chosen is sensitive to contamination that would exceed your pyoil purification unit's capability to operate reliably and make on-spec steam cracker feed. It is not economic to add investment to the purification unit to deal with every imaginable contaminant – the majority of contaminants must be removed at the

source, in the sorting facility. What ideas do you have to decrease the contamination levels in the plastic waste that is recovered in the sorting facility (that will ensure that the recovered plastic will be adequate for the pyrolysis unit that it is intended to feed)? What can be done to help households segregate their waste more comprehensively and increase the value of the waste by decreasing downstream contamination? What can be done within the Bali Sorting Facility to reduce the contamination level in the sorted flexible plastic waste stream that is sent as feedstock to the pyrolysis unit?

3. **The Affordability gap:** The value proposition for the circular economy depends on efficient operation at every step in order to minimize cost. What ideas do you have that can reduce the overall cost per ton recovered in the sorting facility? Or to generate additional sources of revenue from the operation that can offset collection costs? What can be done to reduce the cost of household collection, sorting operations, or cost of logistics for transportation of waste into and out of the sorting facility or to identify additional sources of revenue or added value of outputs?