Preliminary market analysis and plant capacity

From processdesign

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Date Presented: Feb. 2, 2014

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Introduction

In forming the design basis it is necessary to determine the opportunity to satisfy a societal need, and assess this based on market analysis which includes current production, projected market demand, and current and projected selling prices (Seider et al., 2004). The market analysis provides economic data which will determine which process alternatives to choose from as well as equipment capacities. This process will help narrow the scope of a project, and establish guidelines for sizing design elements across the project. The market analysis and subsequent plant sizing estimations are the natural first steps in process design, and are incredibly important factors in shaping the future work of process designers down the line. No design project should proceed to the final stages before the overall economic feasibility is considered. A preliminary market analysis is the first step in determining whether a plant will be profitable (Peters and Timmerhaus, 2003).

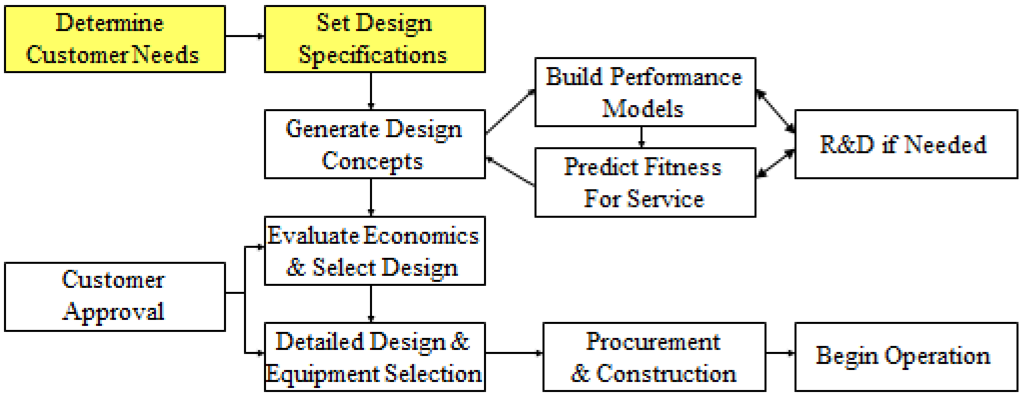

Figure 1. Early market analysis, shown here by the yellow boxes, will affect many elements of later design work, so it is important to produce a detailed report before taking further design steps (Towler and Sinnott, 2013).

Market Analysis

The first step when considering the development of a new product or process is to examine the existing market scenario. It is important to take a survey of current market situations in order to understand whether or not your product or process will be an economically successful venture.

Economic data are difficult to estimate due to inherent volatility in the marketplace (Seider et al., 2004); most companies use market studies to project future market size and prices. A risk analysis is performed using a range of chemical prices to determine the sensitivity of the project economics to specific prices. A commonly used source of national economic price data is the Chemical Marketing Reporter, which is updated biweekly (Seider et al., 2004). For more detailed estimates, e.g. for a specific region, the chemical manufacturer should be contacted. The supply and demand for feeds and products must be considered. This will, clearly, impact the price of these items. Consider the forecast for the supply and demand for these streams as well. Are there any niche markets that are underserved? Is there any technology on the horizon that could impact supply/demand levels? Additionally, are there any competitors running the same process? This could impact the company's profitability, as your process must be unique enough to justify competition with existing organizations.

The scope of a project can also be limited by budget. Engineers must consider the budget they have to work with and various strategies for financing, including issuing more stock, selling bonds, and/or simply borrowing the funds (Biegler et al., 1997).

Plant Sizing and Decision Making

The scale (e.g. flow rates, equipment capacities) of the process is determined based on projected demand for the product (Seider et al., 2004), which was determined in earlier market analyses. From this basic starting point, it becomes necessary to consider a variety of plant alternatives; it is sometimes advantageous to design beyond the requirement, as the market for chemical products will likely fluctuate over the lifetime of the plant, with both positive and negative swings for the company. These early decisions will dramatically affect the operation of the process for years to come. When considering the various attributes of a process, the overall company goals should be the guiding factor for design teams.

Sizing

After considering the results of the market analysis, it should be known how much of your desired feeds and inputs are readily available in the region your plant is being built. This amount, which we will define as "F", can be either a flow rate or a definite amount, depending on whether your operation is a continuous or batch operation. Depending on the process chosen, there will be calculated overall conversion of the incoming materials, which we will define as "x". From a simple calculation:

$$x * F = Y$$

Where Y will be an initial estimate for the size of your plant. Depending on the confidence in the calculated yield rate, it may be necessary to slightly tweak Y. If there is low confidence in the value of "x", Y should be decreased to match, while if there is high confidence in the value of "x", no changes to Y will be necessary (Seider et al., 2004).

"F" is a variable largely dependent on your market analysis. The depth and scope of your market analysis will allow for a much more precise estimate for "F", which will allow for much more confident decision making when determining the size of your plant.

Market analysis can also work in the reverse order by responding to a known demand and converting it to an hourly production rate as shown below:

$$MD = HP * 24hr/day * OD$$

$$OD = OF * 365days/yr$$

Where MD is market demand, HP is hourly production, OD is the number of days/year plant is in actively producing material, and Operating Factor (OF) is the capacity the plant will run at (usually between .8 and .9). Both calculations are viable ways to estimate plant capacity, and the choice of calculation is dependent on how market analysis research was conducted (Seider et al., 2004).

The final sizing concern comes from considering the usage of process byproducts. In the following sections, details concerning side products will be discussed in more detail, but it is always necessary to know what will happen with any byproducts produced by your process, whether they are hazardous or beneficial. Hazardous materials may required additional processing, and those byproducts which may be used for other processes in the company may be shipped to other plants, or could be processed on site if the size is available and additional investment may be beneficial.

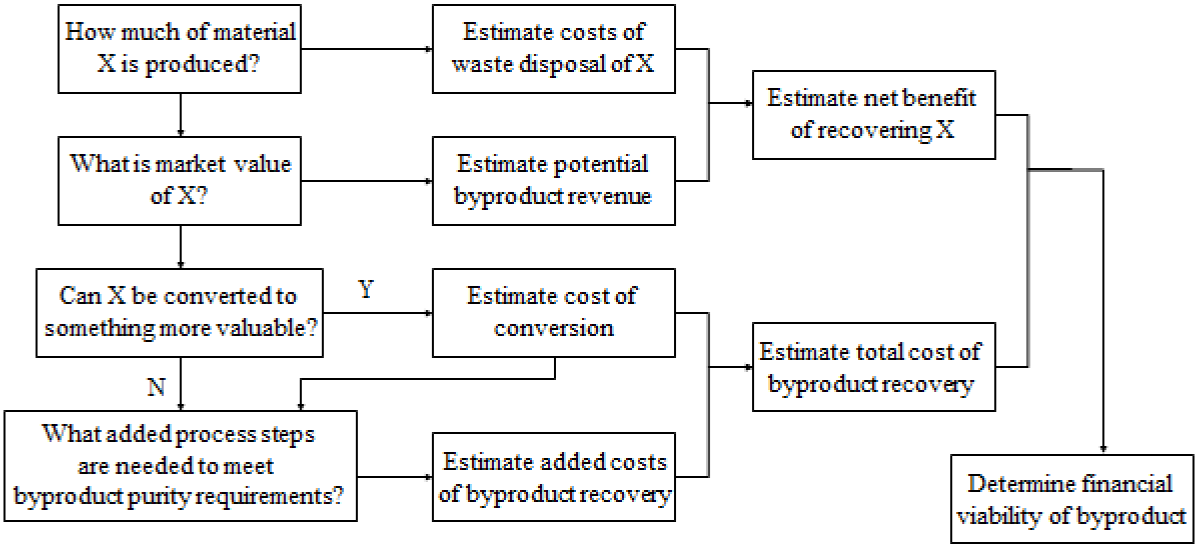

Figure 2. A simple flowsheet which describes the decision making process when determining potential uses of process byproducts. These byproducts may result in an expansion of the plant size, since additional processing may be economically beneficial for the company (Peters and Timmerhaus, 2003).

Technology Alternatives

Consider whether adding on to an existing plant, building at a new location, or tearing down an old plant and starting fresh will be the best move for the company. Could the new process piggy-back off technology the company is already running? The team must decide whether to use in-house chemistry; a common, well proven process; or a new, unconventional solution (Biegler et al., 1997). Consulting any in-house experts should be the first step for a design team. Engineers, operators, and/or researchers with hands-on knowledge of the process can help to create an understanding of the problem and propose alternatives for improving the process (Biegler et al., 1997). Sources of information on processes less familiar to the company include: patent literature, journal articles, encyclopedias of technology, handbooks, textbooks, external corporate files, and consultants. Businesses can also join organizations that carry out studies of their member companies (Biegler et al., 1997). The company will need to pay royalties for the use of any patented chemistry that was not developed in-house. They must also consider environmental concerns and ensure that each process alternative satisfies the large number of environmental regulations.

Safety Considerations

Each process alternative should be considered from a safety standpoint. The team should attempt to determine whether any reasonable combination of events could lead to an unsafe situation: fire, explosion, or release of toxic chemicals. If any process is particularly hazardous to operate (for example, it requires the use of a noxious gas), this aspect should be heavily weighted in the decision-making process. This can often lead to situations where additional processing of hazardous materials must be required before removal from the plant site, which can dramatically increase costs. Processing hazardous side products will increase feed material requirements, plant space requirements, and utility costs, leading to higher capital investment for the additional equipment and higher operating costs than may have been initially estimated.

Fine-tuned electronic control of potentially dangerous processes will often be required to ensure operator safety and prevent explosions or leaks. The level of detail required in electronic control will also lead to rapidly rising costs, as more controllers required more servers, electrical wiring, and climate-controlled buildings in order for complex systems to operate. As seen in the "Incident at Morales" film, cutting costs at the control level can have fatal results, so designers must be careful to ensure that every dangerous outcome is properly controlled, no matter the costs associated with such an expansion.

Utility Concerns

Rising utility costs will have an enormous impact on the financial viability of a process design. The cost of powering a larger plant can rise exponentially as the size of the plant increases, sometimes without a significant rise in revenues. Optimizing this balance is important when considering the sizing of an operation. Estimates of utility prices, such as electricity, cooling water, and steam, can be found tabulated in reference texts (Seider et al., 2004). For more accurate estimates local utility companies should be contacted.

Next Steps

Once a process has been chosen, the design team generates and evaluates a conceptual flowsheet. The team considers various alternative designs and strategies to come up with the more detailed process flow diagram. The plant can then be modeled using simulation software. With each new level of detail considered, the team should be mindful of the needed investment and the expected return (Biegler et al., 1997).

Examples

Example 1:

Primitive Design Problem: "An opportunity has arisen to satisfy a new demand for vinyl chloride monomer, on the order of 800 million pounds per year, in a petrochemical complex on the Gulf Coast, given that an existing plant owned by the company produces 1 billion pounds per year of this commodity chemical. Because vinyl chloride monomer is an extremely toxic substance, it is recommended that all new facilities be designed carefully to satisfy governmental health and safety regulations."

The scale of this process is determined by the primitive design problem to be 100,000 lb/hr, which is approximately 800 million pounds per year assuming 330 operating days per year, giving an operating factor of 0.904 (Seider et al., 2004).

Example 2:

Fictional Design Project: ChemEng, a small chemical firm, is interested in investing in technology to convert glycerol to propylene glycol. The company has tasked a design team with conducting a preliminary market analysis and suggesting a capacity for the proposed plant.

The following facts are important aspects of a basic market analysis. They should be researched by the design team and reported to the managers of ChemEng.

- The overabundance of glycerol caused by the growing biodiesel market has driven prices for glycerol to about $500/ton.
- The supply of glycerol will continue to outpace the demand in 2014 at a growth rate of 2.5% per annum.
- The production grades of glycerol are crude (40-88% purity), technical grade (98% purity), and USP (United States Pharmaceutical) grade.
- Propylene glycol is relatively expensive at around $1500/ton.

- Supply of propylene glycol struggles to keep up with an increasing global demand currently at 1.8m tons.
- The two grades of propylene glycol are industrial (99.5% purity) and USP/EP (99.8% purity)
- There are two plants running similar technology with a capacity of 100,000-tons currently in operation by Archer Daniels Midland and Oleon. There is also a 200,000-ton Global Bio-chemical Technology Group facility.

Based on the market analysis, a plant capacity of 180,000 tons would be reasonable. This would be 10% of the global propylene glycol market and is in line with similar plants in operation.

Conclusion

Market analysis provides an important stepping-off point when beginning the design of a chemical process. Preliminary economic estimates will influence decisions concerning the sizing of your operation, which will have long-term effects on the profitability and viability of a chemical product, so it is important to pay close attention to the results of these early analyses.

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