Introduction to Chemical Engineering Design

What Chemical Engineers Do?

Chemical engineers apply the principles of chemistry, biology, physics, and math to solve problems that involve the production or use of chemicals, fuel, drugs, food, and many other products. They design processes and equipment for large-scale safe and sustainable manufacturing, plan and test methods of manufacturing products and treating byproducts, and supervise production.

Selected Process Types

Process	Example
1. Chemical Intermediaries	Ethylene
2. Energy	Gasoline
3. Food	Bread
4. Food Additive	Vitamin C
5. Waste Treatment	Activated Sludge Process
6. Pharmaceutical	Aspirin
7. Materials	
a) Polymer	Polyethylene
b) Metallurgical	Steel
8. Personal Products	Lipstick
9. Explosives	Nitrocellulose
10. Fertilizers	Urea

ABET Student Outcomes

a- an ability to apply knowledge of mathematics, science and engineering

c- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

d- an ability to identify, formulate, and solve engineering problems

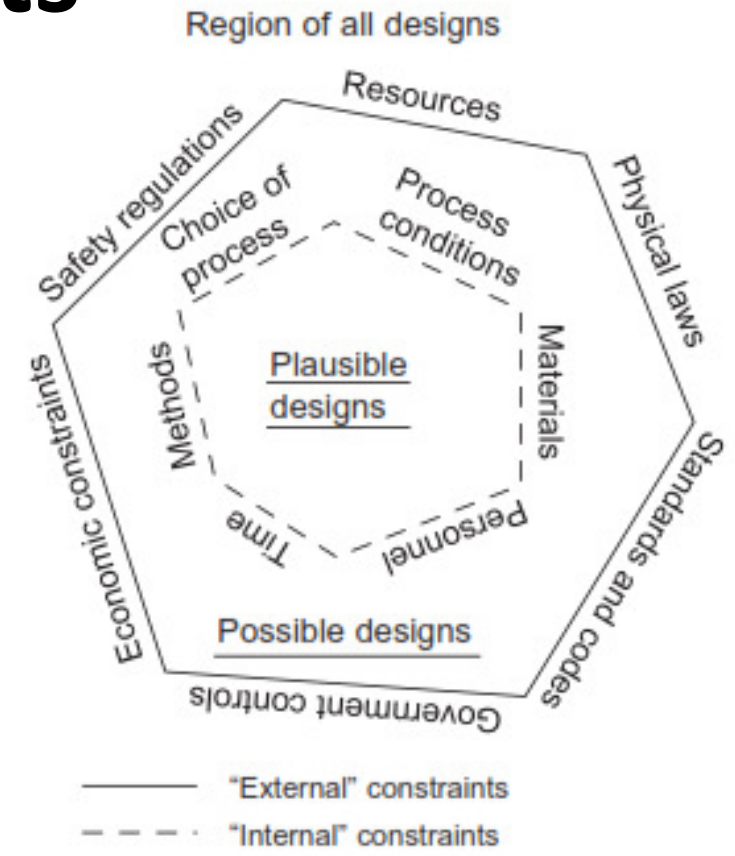
Design is a creative activity

The designer

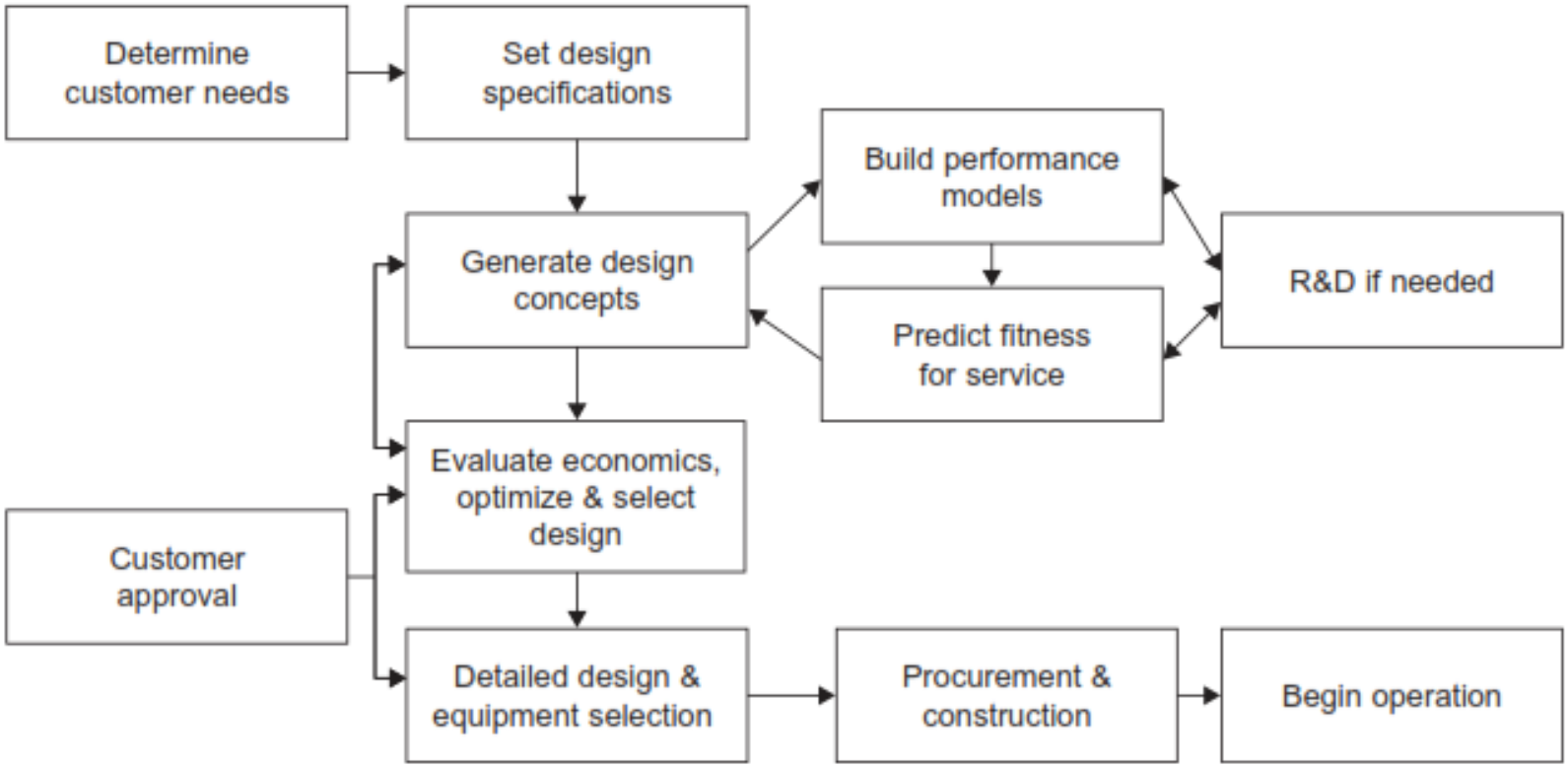
- begins with a specific objective or a customer need in mind
- develop and evaluate possible designs
- arrives at the best way of achieving that objective

There is **rarely** just one possible solution to the design problem

Constraints



- **External constraints**: outside the designer's influence
- **Internal constraints**: designer has some control


Determine customer needs
Set design specifications
Build performance models
Generate design concepts
R&D if needed
Predict fitness for service
Evaluate economics, optimize & select design
Customer approval
Detailed design & equipment selection
Procurement & construction
Begin operation

The Design Objective (the need) and sub-objectives

Setting Design Basis

The most important step in starting a process design is translating the customer need into a design basis. The design basis is a more precise statement of the problem that is to be solved.

It will normally include the production rate and purity specifications of the main product, together with information on constraints that will influence the design such as:

1. The system of units to be used.
2. The national, local or company design codes that must be followed.
3. Details of raw materials that are available.
4. Information on potential sites where the plant might be located, including climate data, seismic conditions and infrastructure availability.
5. Information on the conditions, availability and price of utility services such as fuel gas, steam, cooling water, process air, process water and electricity, that will be needed to run the process.

Generation of Possible Design Concepts

- The majority of process designs are based on designs that previously existed. The first step in devising a process design will be to sketch out a rough block diagram showing the main stages in the process; and to list the primary function (objective) and the major constraints for each stage. Experience should then indicate what types of unit operations and equipment should be considered. The steps involved in determining the sequence of unit operations that constitutes a process
- Experienced engineers usually prefer the tried and tested methods, rather than possibly more exciting but untried novel designs. The work that is required to develop new processes, and the cost, are usually underestimated. Commercialization of new technology is difficult and expensive and few companies are willing to make multi-million dollar investments in technology that is not well proven.

- The amount of work, and the way it is tackled, will depend on the degree of novelty in a design project. Development of new processes inevitably requires much more interaction with researchers and collection of data from laboratories and pilot plants. Chemical engineering projects can be divided into three types, depending on the novelty involved:

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1. Modifications, and additions, to existing plant; usually carried out by the plant design group.
2. New production capacity to meet growing sales demand, and the sale of established processes by contractors. Repetition of existing designs, with only minor design changes, including designs of vendor's or competitor's processes carried out to understand whether they have a compellingly better cost of production.
3. New processes, developed from laboratory research, through pilot plant, to a commercial process. Even here, most of the unit operations and process equipment will use established designs.

Fitness Testing

- The design engineer must determine how well each design concept meets the identified need.