ADDIS ABABA UNIVERSITY
ADDIS ABABA INSTITUTE OF TECHNOLOGY SCHOOL OF CHEMICAL AND BIOENGINEERING

Design and Development of Food Products and Equipment

CHAPTER 1

GENERAL INTRODUCTION

Introduction

A

B

Have a look at figs. A &B. What do you observe?
Who is responsible for the problems you see on the buildings? The designer, construction firm or managment body?

Do you expect similar problems on the food products we obain from any shopping center (locally produced or imported)?

Food production process

Raw material

Production process

Food Product

° *desired quality and volume*

Equip 1

Equip 2

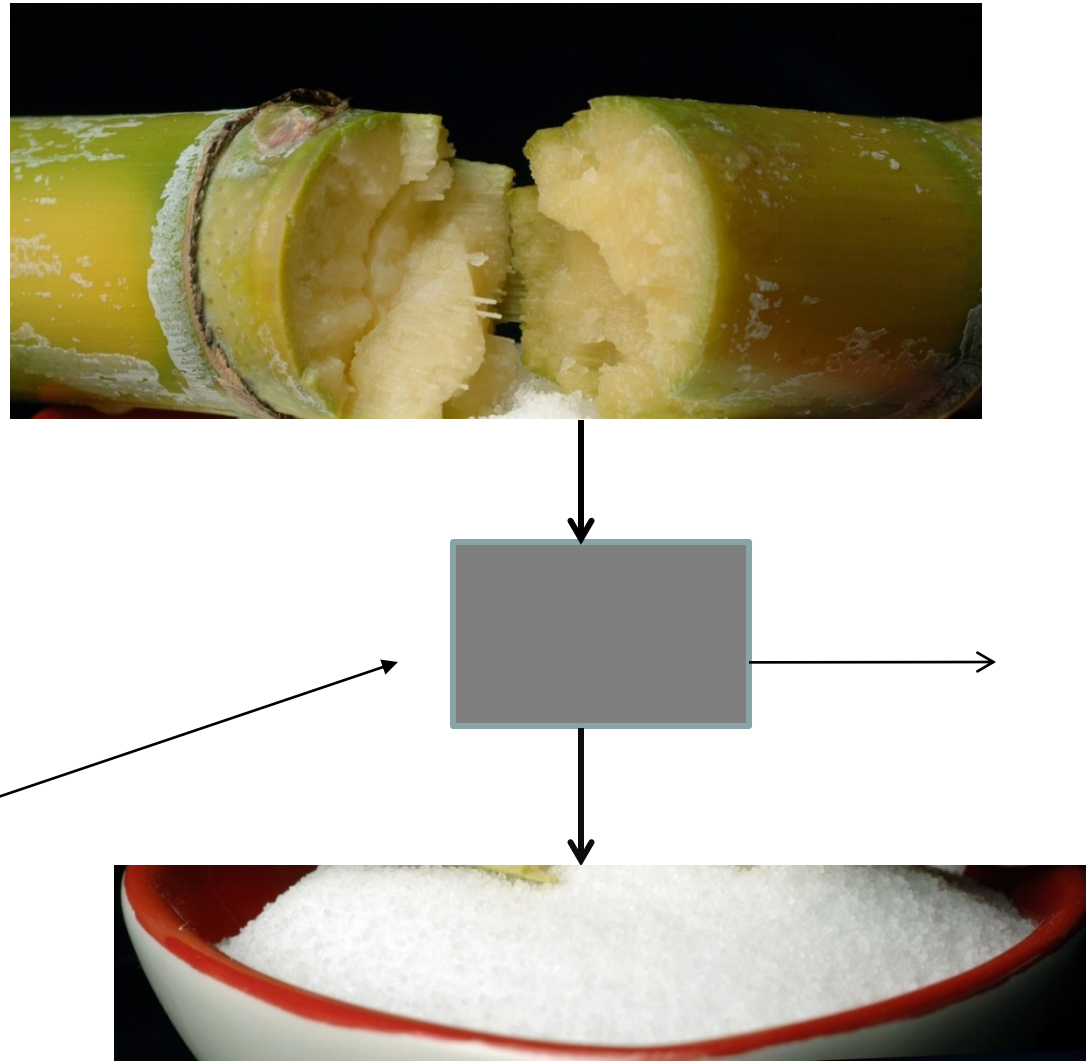
Equip 3

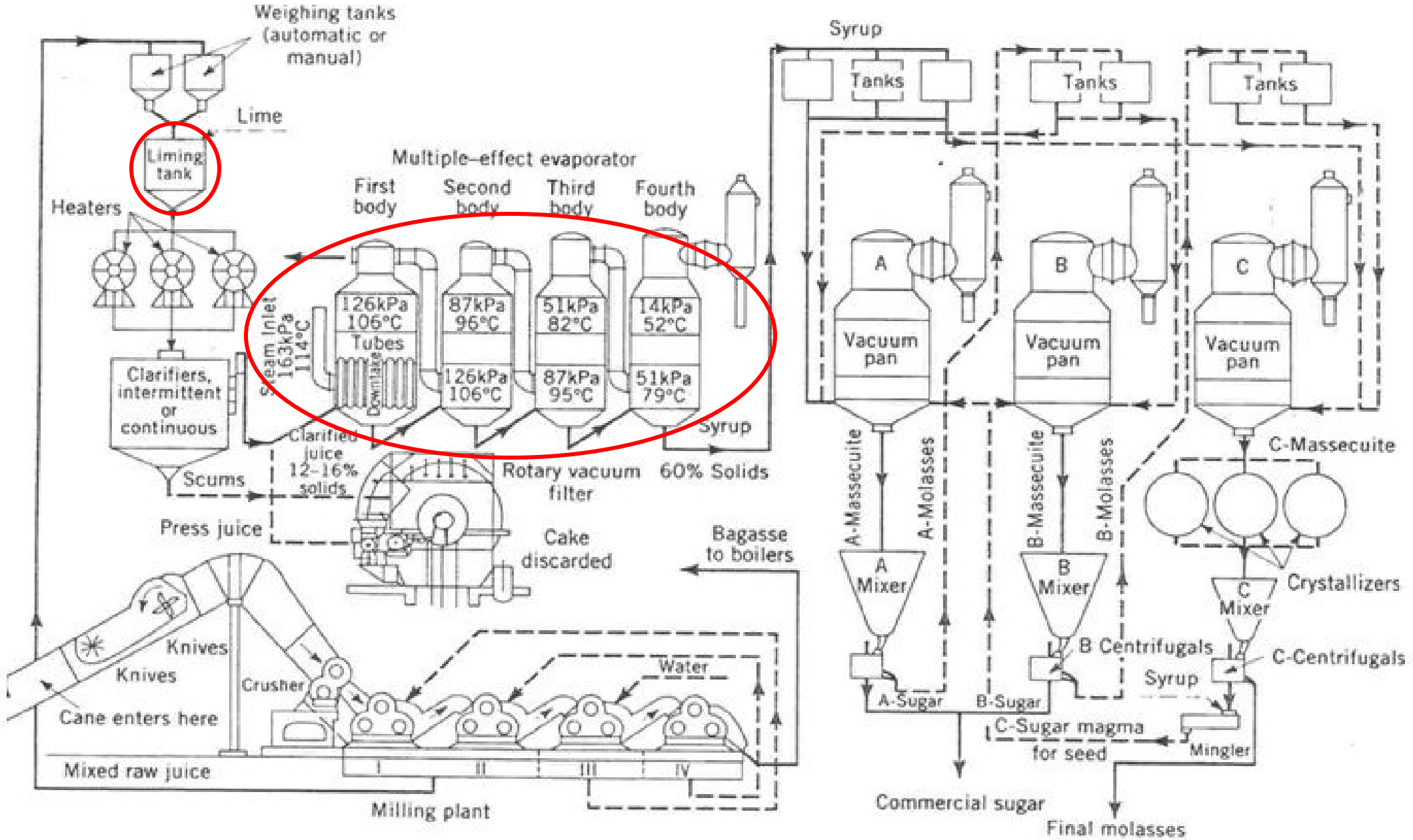
Cont.

Industrial food production process needs knowledge of many disciplines, and involves various equipement

Cont.

- knowledge and understanding of the fundamental sciences and the related engineering subjects
- Ability to apply this knowledge to practical situations
- The economic implication of each design




Weighing tanks (automatic or manual)
Lime
Liming tank
Heaters
Multiple-effect evaporator
First body
Second body
Third body
Fourth body
126kPa 106°C
87kPa 96°C
51kPa 82°C
14kPa 52°C
Tubes
Downtake
Steam inlet 163kPa 114°C
126kPa 106°C
87kPa 95°C
51kPa 79°C
Syrup
Clarifiers, intermittent or continuous
Scums
Clarified juice 12–16% solids
Rotary vacuum filter
60% Solids
Press juice
Cake discarded
Bagasse to boilers
Knives
Knives
Crusher
Water
Cane enters here
Mixed raw juice
I
II
III
IV
Milling plant
Syrup
Tanks
Tanks
Tanks
A
B
C
Vacuum pan
Vacuum pan
Vacuum pan
A-Massecuite
A-Molasses
B-Massecuite
B-Molasses
C-Massecuite
A Mixer
B Mixer
C Mixer
Crystallizers
B Centrifugals
C-Centrifugals
Syrup
A-Sugar
B-Sugar
C-Sugar magma for seed
Mingler
Commercial sugar
Final molasses

Cont.

- Design
  - ✓A creative activity, and as such can be one of the most rewarding and satisfying activities undertaken by engineers
  - ✓It is the synthesis, the putting together, of ideas to achieve a desired purpose
    - It needs practical realization of the limits imposed by industrial conditions
  - ✓It involves a wide variety of skills

Cont.

- The designer starts with an objective in mind, a need, and by developing and evaluating possible designs, arrives at what he/she considers the best way of achieving that objective
- This involves a combination of procedures/unit operations to achieve the intended changes to the raw materials
- Each unit operation has a specific, identifiable and predictable effect on a food

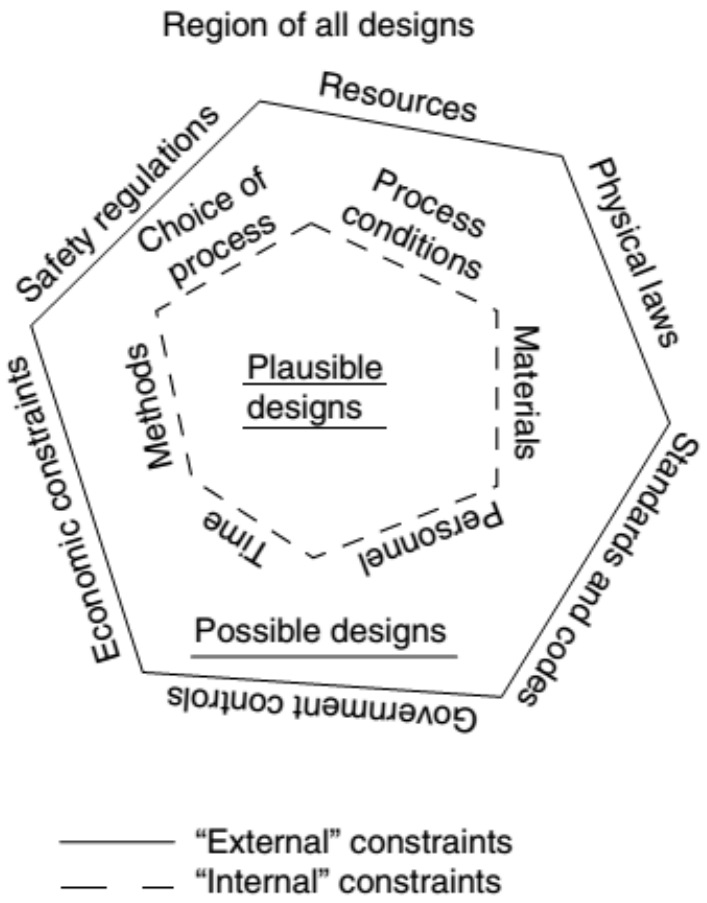
Cont.

- The engineering part of a design project involves basically the development of the process flowsheet, the material and energy balances, and the sizing of the process equipment
- In addition, the following essential components of the process plant should be considered: plant location, utilities, plant layout, buildings (architectural and civil engineering), plant operation and control, health and safety, waste disposal, personnel, and legal requirements

Cont.

- When considering possible ways of achieving the objective, the designer will be constrained by many factors, which will narrow down

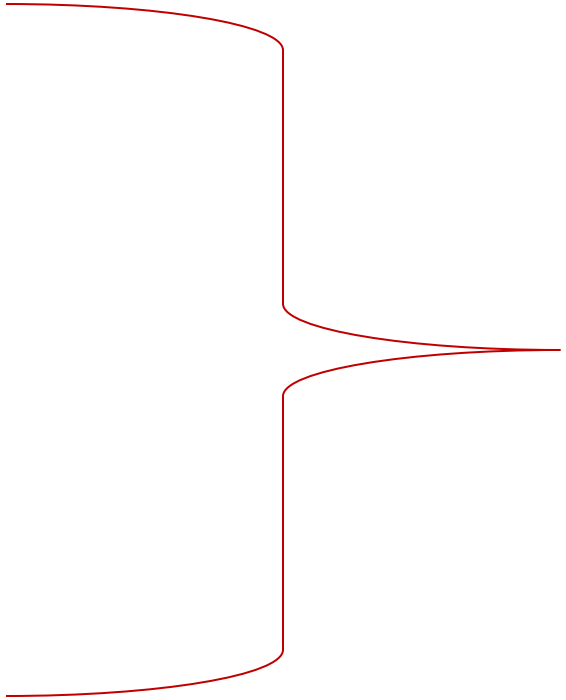
the number of possible designs



Coulson and Richardson, (2005)

Cont.

- External constraints
  - ✓ Physical law
  - ✓ Government controls
  - ✓ Economic constraints
  - ✓ Safety regulation
  - ✓ Etc.



should be identified early in the design process

External constraints are outside the designer's influence

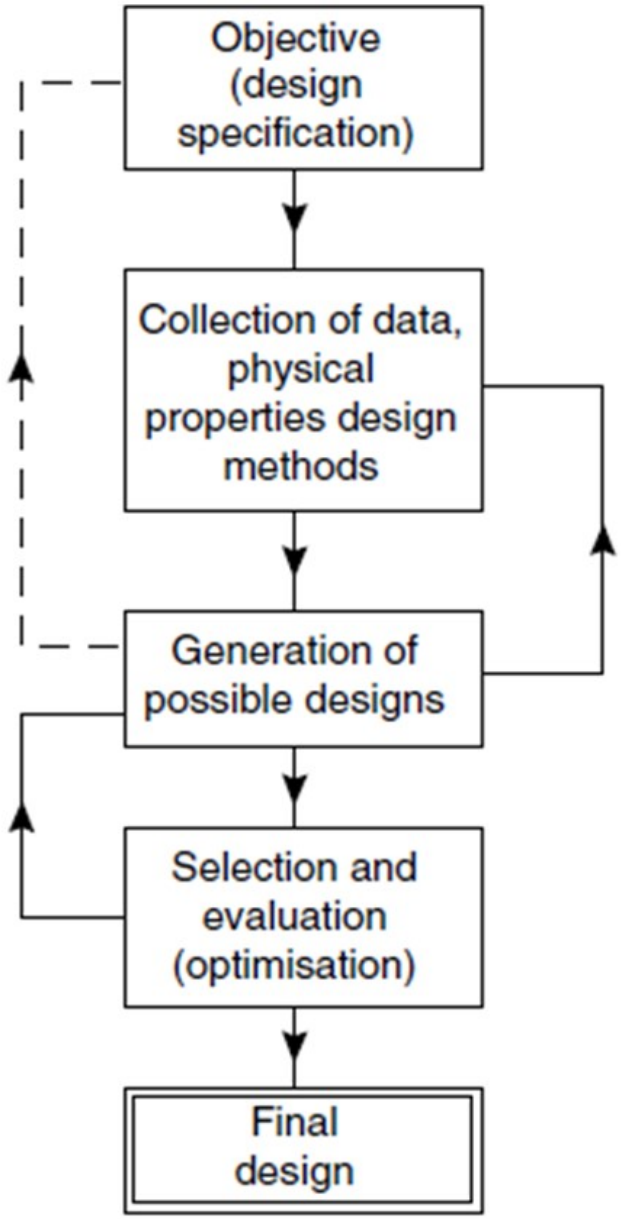
Cont.

- Internal constraints
  - ✓ Personnel
  - ✓ Time
  - ✓ Process conditions
  - ✓ Materials

Design process

The stages in the development of a design, from the initial identification of the objective to the final design

Designing and development of production processes is an iterative procedure; as the design develops, the designer will be aware of more possibilities and more constraints, and will be constantly seeking new data and ideas, and evaluating possible design solutions

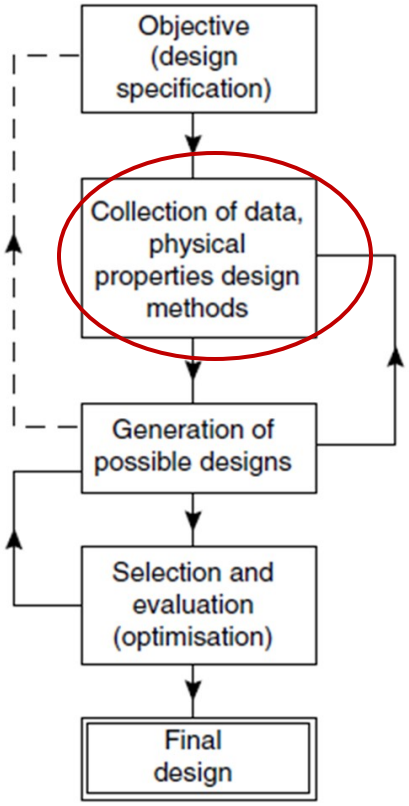


Cont.

- Objective (need)
  - ✓ The designer is creating a design to fulfill a particular need
  - ✓ In the design of a food manufacturing process, the need is the public interest for the product, the commercial opportunity, as foreseen by the sales and marketing organization
    - ❑ Market assesment required
  - ✓ Within this overall objective, the designer will recognize sub-objectives; the requirements of the various units that make up the overall process
  - ✓ A tight, well-thought-out, comprehensive, specification of the requirements defines the external constraints within which the other designers must work

Cont.

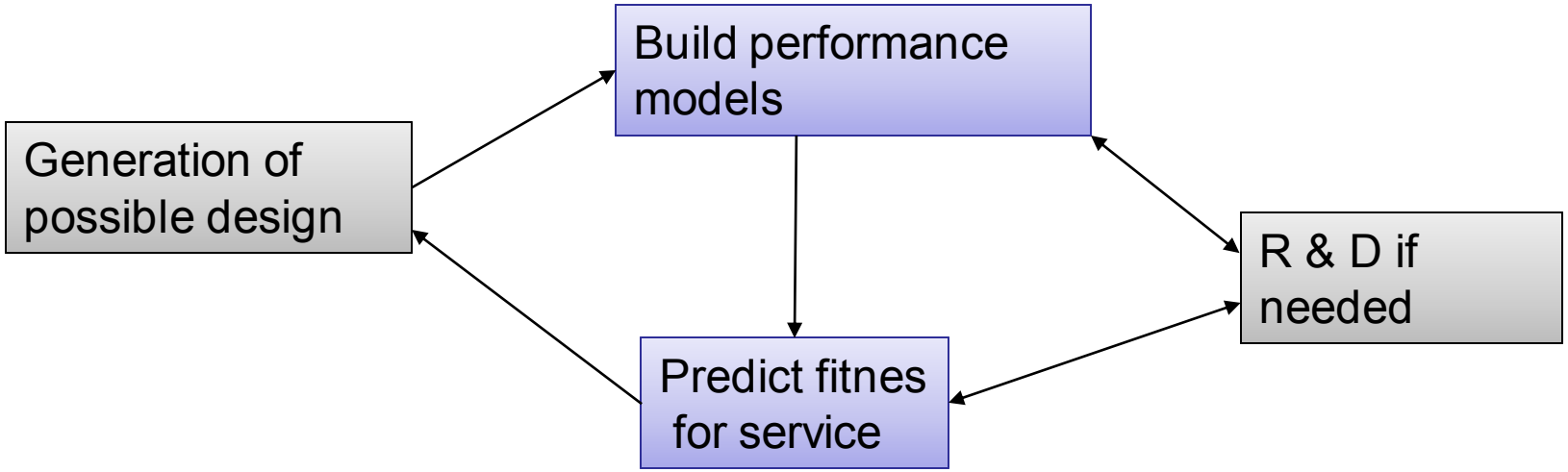
- Data collection
  - ✓ To proceed with a design, the designer must first assemble all the relevant facts and data required from:
    - possible processes
    - equipment performance
    - physical property data
  - ✓ Many design organizations will prepare a basic data manual, containing all the process “know-how” on which the design is to be based

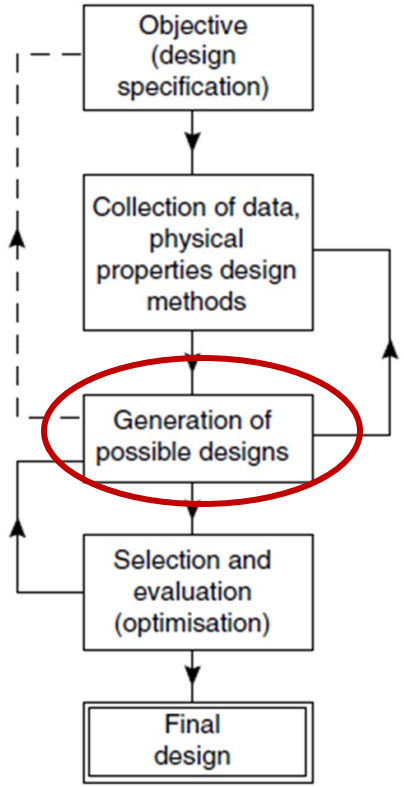


Cont.

- Generation of possible design solutions

  ✓ The creative part of the design process is the generation of possible solutions to the problem (ways of meeting the objective) for analysis, evaluation and selection. In this activity the designer will largely rely on previous experience, his own and that of others





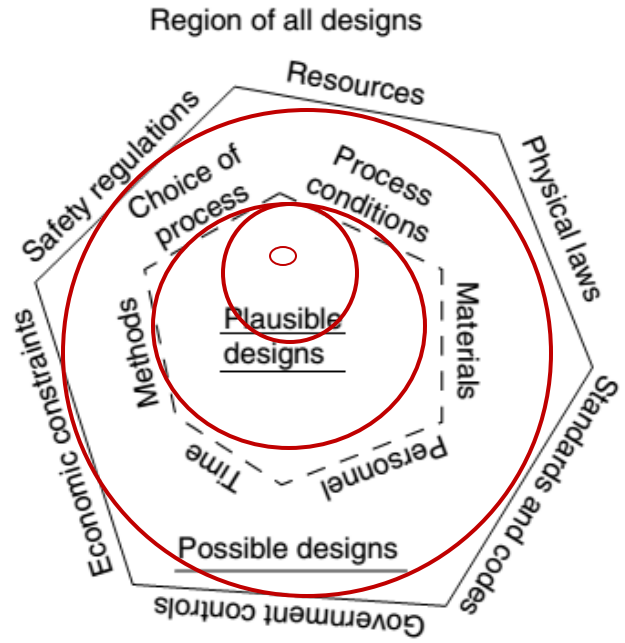
Cont.

- Sometime it is difficult to build a proto type and test which process is best
- The best way to test several design alternatives is by building a mathematical model of the process, usually in the form of computer simulations of the process, reactors, and other key equipment
- When design alternatives are suggested, they must be tested for fitness of purpose. In other words, the design engineer must determine how well each design concept meets the identified need

Cont.

- Selection
  - ✓The designer starts with the set of all possible solutions bounded by the external constraints, and by a process of progressive evaluation and selection, narrows down the range of candidates to find the “best” design for the purpose

1) Possible designs (credible)-within the external constraints.
2) Plausible designs (feasible)-within the internal constraints.
3) Probable designs- likely candidates.
4) Best design (optimum)- judged the best solution to the problem.

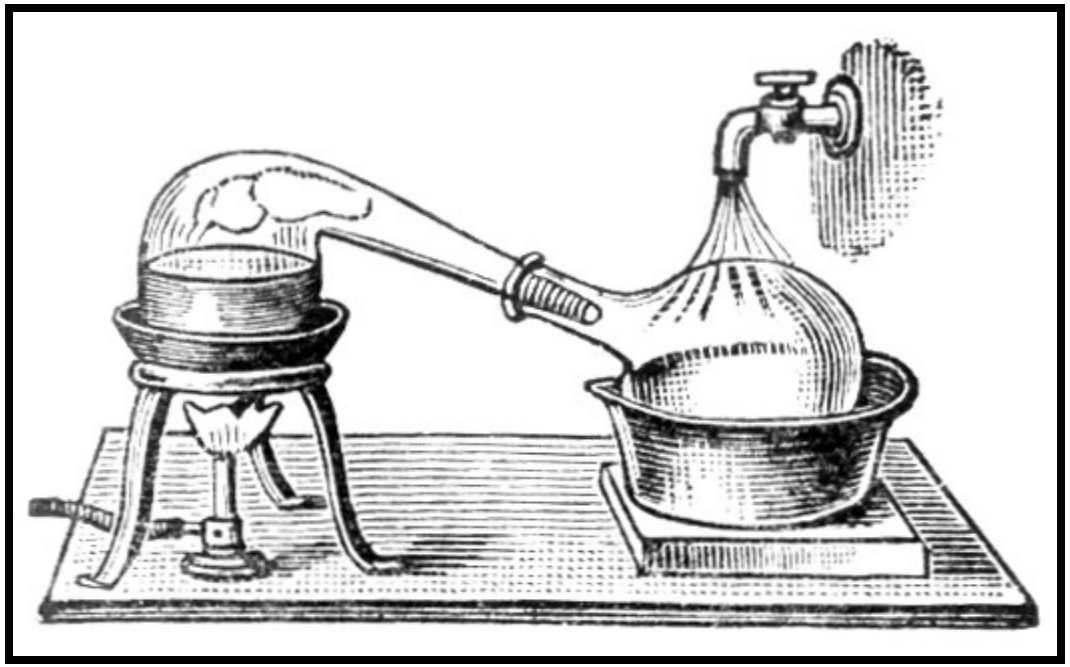


Cont.

- ✓The selection process will become more detailed and more refined as the design progresses from the area of possible to the area of probable solutions. In the early stages a coarse screening based on common sense, engineering judgement, and rough costings will usually suffice
- ✓To select the best design from the probable designs, detailed design work and costing will usually be necessary

Cont.

- ✓It is doubtful if any design is entirely novel. The antecedence of most designs can usually be easily traced
- ✓The experienced engineer will wisely prefer the tried and tested methods, rather than possibly more exciting but untried novel designs
- ✓However, whenever innovation is wanted, previous experience, through prejudice, can inhibit the generation and acceptance of new ideas



Cont.

- Design, development and commercialization of new technology is difficult and expensive
- Development of new processes inevitably requires much more interaction with researchers and collection of data from laboratories and pilot plants

Principles of Equipment Design for Food Processing Operations

- Cleanable to a Micro-biological Level
  - ✓Food equipment must be constructed and be maintainable to ensure that the equipment can be effectively and efficiently cleaned and sanitized over the lifetime of the equipment
  - ✓ The removal of all food materials is critical to prevent microorganism ingress, survival, growth and reproduction

Cont.

- Made of Compatible Materials
  - ✓ Construction materials used for equipment must be completely compatible with the product, environment, cleaning and sanitizing chemicals, and the methods of cleaning and sanitation
  - ✓ Equipment materials of construction must be inert, corrosion resistant, nonporous and nonabsorbent

Cont.

- Accessible for Inspection, Maintenance, Cleaning and Sanitation
  - ✓All parts of the equipment shall be readily accessible for inspection, maintenance, cleaning and/or sanitation

Cont.

- No Product or Liquid Collection
  - ✓Equipment shall be self-draining to assure that food product, water, or product liquid does not accumulate, pool or condense on the equipment or product zone areas

Cont.

- Hollow Areas Hermetically Sealed
  - ✓Hollow areas of equipment (e.g., frames, rollers) must be eliminated where possible or permanently sealed. Bolts, studs, mounting plates, brackets, junction boxes, name plates, end caps, sleeves and other such items must be continuously welded to the surface of the equipment and not attached via drilled and tapped holes

Cont.

- Hygienic Design of Maintenance Enclosures
  - ✓Maintenance enclosures (e.g., electrical control panels, chain guards, belt guards, gear enclosures, junction boxes, pneumatic/hydraulic enclosures) and human machine interfaces (e.g., pushbuttons, valve handles, switches, touch screens) must be designed, constructed and be maintainable to ensure food product, water, or product liquid does not penetrate into, or accumulate in or on the enclosure and interface. The physical design of the enclosures should be sloped or pitched to avoid use as a storage area

Cont.

- Hygienic Compatibility with Other Plant Systems
  - ✓ Design of equipment must ensure hygienic compatibility with other equipment and systems (e.g., electrical, hydraulics, steam, air, water)

Thank you