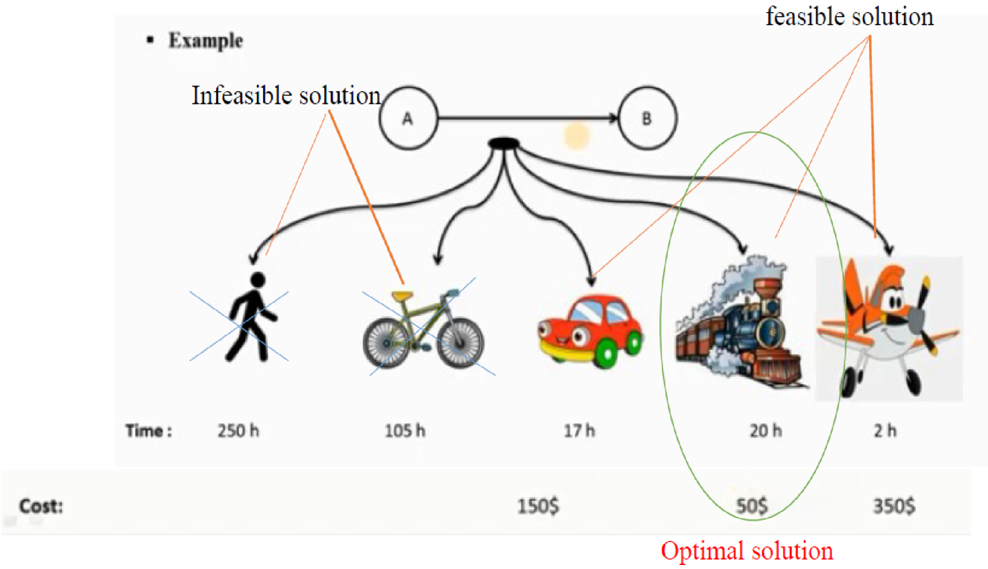
Al-Mustaqbal University / College of Engineering & Technology
Department of Chemical Engineering and Petroleum Industries
Class (4)
Subject (Optimization) / Code (CES.R. 424)
Lecturer (Asst. Prof. Dr. Fawzi Al-Qaessi)
2nd term – Lecture No.1 - Itroduction

Introduction

- Finding the best solution among set of all feasible solutions.
- Deals with the problem of minimizing or maximizing a function with several variables subject to some constrains.
- Every, almost daily, solves optimisation problems in formal ways by using mental models.
- Optimisation plays a central rule in operation research, managing science and engineering.



1- Time 20 h

2- objective : min cost

Why optimize

- Best design
- solving for the number of pipes in a piping network that result in minimal pressure drop
- solving for the size of an engine block that results in the best combination of speed and efficiency (using some weighting on each of these metrics its importance)
- Lowest cost
- Find the combination of truck routs to transport a set amount of raw material between points that results in the lowest total cost (labour, truck maintained fuel)
- Highest efficiency
- Maximising the efficiency of a power production system by finding the right combination of inputs (flow rate, temperatures, pressure,..)
- In Chemical Engineering
- Utilize resource/energy/utility in the most efficiency way.
- Reduce waste generation; minimize the environmental impact.
- Determine the most desirable operating conditions; safe operation
- Meet product specification; maximize profit.
- deciding on the most effective allocation of limited resources
- choosing control variables that will cause a system to behave as desired.

- Some objectives in optimisation problems may be:
  - minimise cost
  - Maximise the profit
  - planning production
  - increase process efficiency

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What is mean optimization?

- Optimization is an act, process or methodology of making something (system, design or decision) as fully perfect, functional and effective as possible to achieve optimum solution.
- A collective process of finding the best conditions required to achieve the best results from a given situation.
- It is one of the major quantitive tools in the machinery of decision-making. A wide variety of problems in the design, construction, operation and analysis of chemical plants can be resolved by optimization.

Some other important definitions:

- Optimum value: it is a technical term including quantities measurements and mathematical analysis to determine the best setting (maximum or minimum) of a dependent variables.
- Optimization procedure: it is the process of determining the optimum value (maximum or minimum) of some criterion function.
- Optimization problem: is the specification of the variables that need to be optimized.

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The optimization is interested for the engineers. Why?

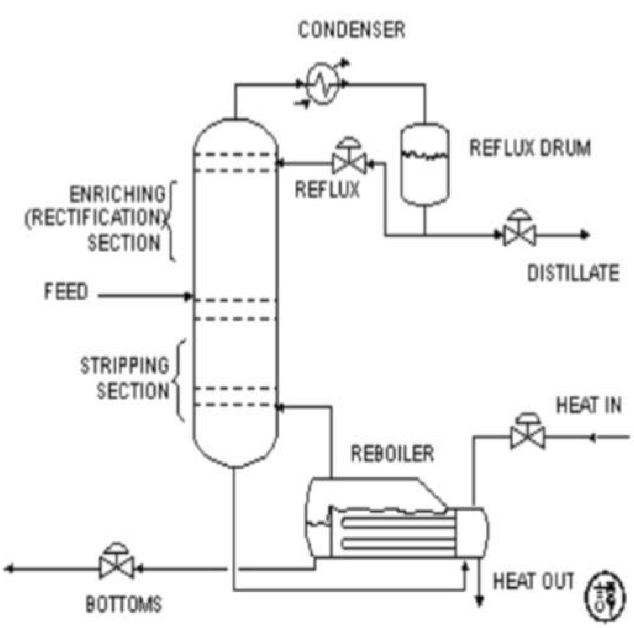
- Engineers work to improve the initial design of process and equipment.
- Engineers strive for enhancements in the operation, in order to realize:

1- Largest production.

2- Greatest profit.

3- Minimum cost (least energy usage).

Distillation column parameters' that could enhance the equipment performance (optimal condition)



- Equipment size.
- Schedule maintenance and equipment replacement.
- Design of heat exchanger network.
- Operation planning scheduling.
- Control system.
- Long time between shutdown.

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In plant operation, benefits arise from improved plant performance such as:

- Improved yields of valuable products or reduced yields of contaminations.
- Reduced energy consumption.
- Higher processing rates.
- Longer times between shutdowns.
- Reduced maintenance costs.
- Less equipment wear.
- Better staff utilization.

Example of applications of optimization:

- Determination of best sites for plant location.
- Routing of tankers for the distribution of crude and refined products.
- Pipeline sizing and layout.
- Equipment and entire plant design.
- Maintenance and equipment replacement scheduling.
- Operation of equipment, such as tubular reactors, columns, exchangers…..etc.
- Evaluation of plant data to construct a model of a process.
- Minimization of inventory charges.

- And many other ……………

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Statements of an optimization problem:

All optimization problem are stated in some standard form. You have to identify the essential elements of a given problem and translate them into a prescribed mathematical form.

- Decisions: items that need to be figured out to achieve max. efficiency.
- The ranking function: a method to make different choices of decisions.
- Rules and restrictions: specifying limitations on choices of decision values.
- Parameters: information necessary in specifying ranking function and rules.

Optimization models

Which is the mathematical representation of optimization problem to analyze or solve the optimization problem.

These models have:

1. Objective function: terms of design or decision variable and other problem or process parameters such as cost function. This function could be economical or technical. For example: economic objectives, maximize profit, minimize costs of production.
2. constraints: represent limitation on the choice of decision variables, either internal or external imposed by the designer.
3. Parameters: represent the given data.
4. Decision (design) variables: represent items that need to be determined and may involve many design variables.

Important note: there is no scope (room) for optimization, if all the design variable are fixed.

- **Example#1** **(optimal design of a can)**

Design which will hold at least 500 ml of liquid. Height = [7 12] cm, radius = [3 7] cm? what is the dimensions for the cylindrical Can use the least amount? We can minimize the material by minimize the area A!.

So, objective function:

$$A = 2\pi r^2 + 2\pi r h$$

Area of two ends — Lateral Area

Constraint:
$V = \pi r^2 h \geq 500$

Bounds (Decision variables):
$3 \geq r \leq 7$
$7 \geq h \leq 12$

- What is the dimensions for the cylindrical can use the least amount?

- we can minimize the material by reduce the area, A.

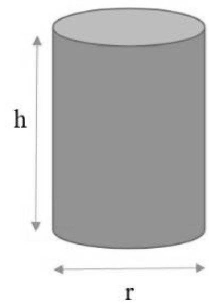

Figure 1. dimensions of can.

Example#2 (The optimal pipe diameter)

- Determination of optimal pipe diameter that uses for pumping a given amount of fluid from one point to another.

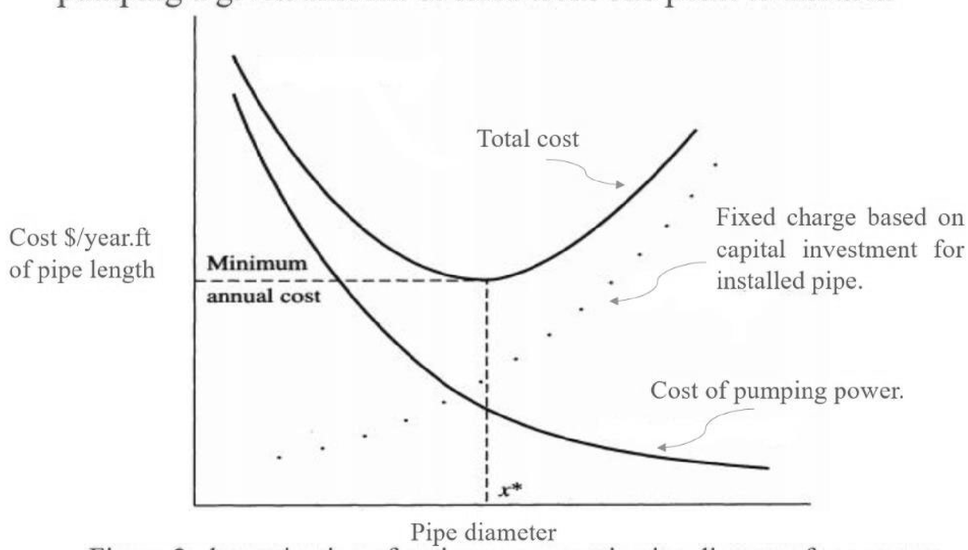

Figure 2. determination of optimum economic pipe diameter for constant mass through rates. (x^* = optimum diameter)

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Notes:

- Total cost = pumping cost + fixed cost for the installed piping system.
- Pumping cost increase with decreased size of pipe diameter, why?
- Final results that can be accomplished by using an infinite number of different pipe diameters are the same.
- The fixed charges (installed) for the pipeline become lower when smaller pipe diameters are used, why?
- The optimum economic diameter is found where the sum of the pumping costs and fixed costs for the pipeline becomes a minimum.
- Even though, the engineer must chooses the cheapest design by considering the quality of the product and the operation as well as the total cost.

Example#3 (the optimal insulation thickness)

- Additional insulation should save money through reducing heat losses.
- But, the insulation material can be expansive?
- So, we need the optimal amount of insulation.

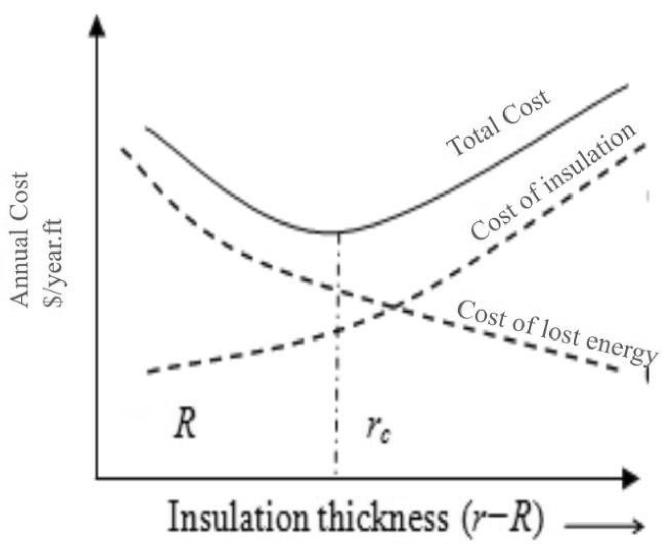

Figure 3. The effect of insulation thickness on total cost (x* = optimum thickness)