PROCESS OPERABILITY
Why Operability?

Is design complete when we have a solution for the base case material and energy balances?

What could go wrong with a plant design that satisfied the M&E balances correctly for the base case?

It could be unsafe, unreliable, be unable to satisfy production quantity or quality changes – and many more deficiencies!

We have a base case design but is it operable? Will it function for years in many situations?

A concise definition of operability*

Process operability

Ensuring that the plant has the capacity and flexibility to achieve a range of operating conditions safely, reliably, profitably and with good dynamic performance and product quality.

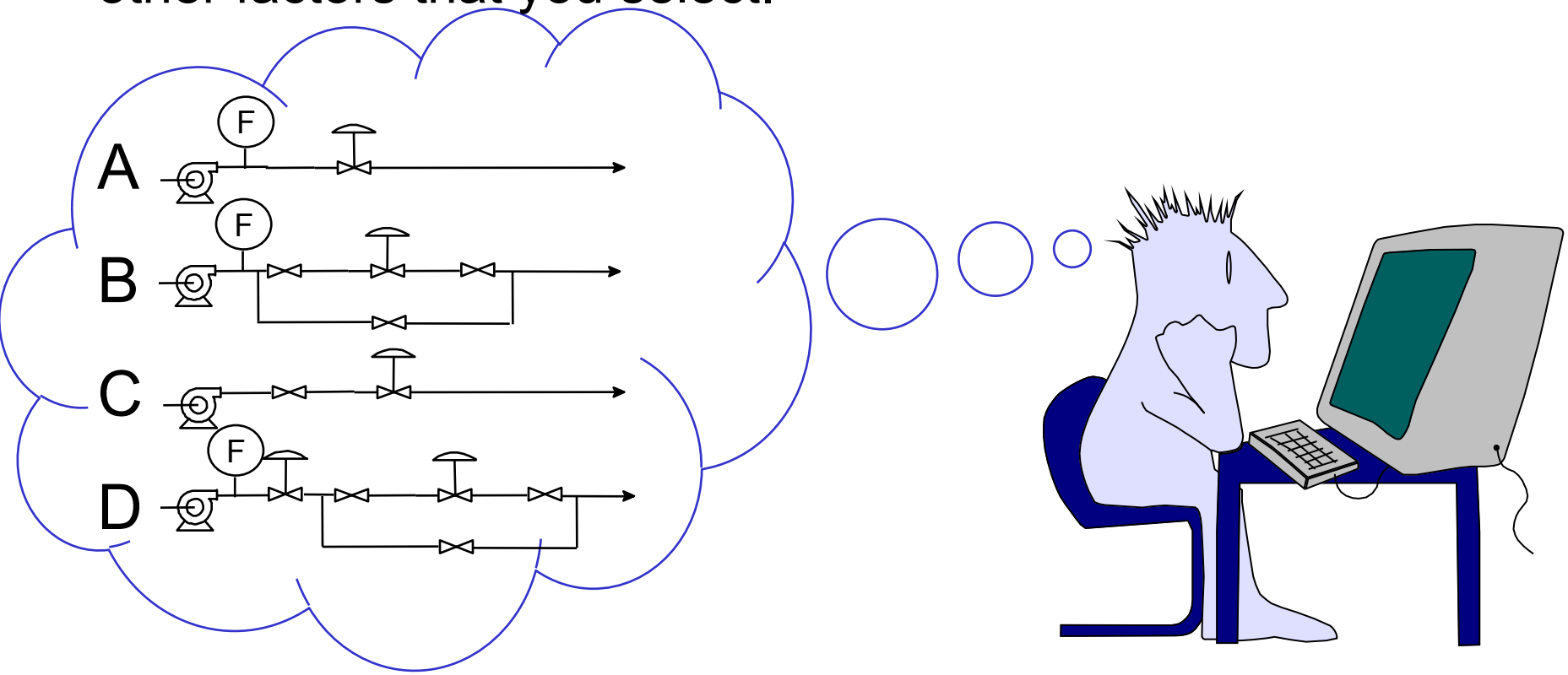
Some engineers prefer the term "Robust Design". The two terms have the same general meaning.

* Useful for concise description but not enough detail to guide engineering decisions.

Class workshop

We need to regulate the flow, but how complex should the equipment be?

Rank designs for simplicity, cost, reliability, flexibility and other factors that you select.



Process operability

Roadmap for this lesson

- What will we learn in this lesson?
  - review the basic Process Design Procedure
  - Locate Operability analysis in the design procedure
  - Identify Causes of Variability in process plants
  - Introduce the Eight Operability Topics
  - Present the Learning Goals for the operability topic

Used in all future problem solving

A process design procedure

- Set goals and design specifications
- Select process technology
- Define process structure (sequence)
- Simulate the flow sheet
- Design equipment

Often performed for only 1 operating point

Construct and start up

Operate the plant over a range of conditions, including many operating points and transitions between them

Inconsistency!

Operability prevents this inconsistency!

Operability: when do we introduce it in the design procedure?

Design Procedure

- Set goals and design specifications
- Select process technology
- Define process structure (sequence)
- Simulate the flow sheet

  The flow sheet typically involves basic M&E balances, equilibrium and rate processes. It does not consider practical issues for achieving the operation.
- Design equipment

  Equipment design achieves the base case flow sheet (plus other concerns). This sets the “capacity” of the plant.

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We must define the range of operations and goals to achieve before we begin the design!

Design limited to the "base case" is not likely to be satisfactory.

We have to know where we are going before we can design!

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The design must define the range of operations to be achieved.

We can accept less than full production rate or top efficiency for extreme situations.

We must document specifications and range for operations and review with all stakeholders!

Operability: when do we introduce it in the design procedure?

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  Equipment design achieves the base case flow sheet (plus other concerns). This sets the "capacity" of the plant.

This might influence the range of operations!

For example, a fluidized bed reactor could have a smaller range of flow than a packed bed.

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This might influence the range of operations!

For example, the addition of a recycle stream might allow a wider range.

Operability: when do we introduce it in the design procedure?

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Some of the flow sheet variables, such a distillation feed location and reactor volume, influence the achievable range of operations.

Operability: when do we introduce it in the design procedure?

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- Design equipment

  Equipment design achieves the base case flow sheet (plus other concerns). This sets the "capacity" of the plant.

Equipment design has a very strong influence on the range of plant operation.

Again, satisfying the "base case" is not sufficient.

A process design procedure with operability

- Set goals and design specifications
- Select process technology
- Define process structure (sequence)
- Simulate the flowsheet
- Design equipment

Iterate as needed

Operability analysis

Construct and start up

Operate the plant over a range of conditions, including many operating points and transitions between them

Process design with operability

The design procedure should ensure that the plant is operable, that it functions "well". This requires a specification that addresses a range of conditions.

What are causes of deviation from base case conditions?

1. Changes to operations introduced by plant personnel deliberately

- We need to match production rate to sales
- We often produce multiple products and some products are made at different qualities (grades)
- We often process various feed materials

Process design with operability

The design procedure should ensure that the plant is operable, that it functions "well". This requires a specification that addresses a range of conditions.

What are causes of deviation from base case conditions?

2. Disturbances - Many "external" variables change from their assumed base case values. We refer to these as disturbances - really normal variation in the plant.

Examples are feed composition, ambient temperature, cooling water temperature, catalyst deactivation, heat exchanger fouling, etc.

Process design with operability

The design procedure should ensure that the plant is operable, that it functions "well". This requires a specification that addresses a range of conditions.

What are causes of deviation from base case conditions?

3. Mismatch in design models – Our predictions are imperfect - not useless, just contain some errors.

Examples include equilibrium, rate processes, and efficiencies. We compensate for these errors through flexibility.

If we rely on *perfect* models, the plant will not likely operate as expected.

Process design with operability

The design procedure should ensure that the plant is operable, that it functions "well". This requires a specification that addresses a range of conditions.

What are causes of deviation from base case conditions?

4. Equipment malfunction – Plants operate for months (or years) without stopping, but process equipment sometimes requires immediate maintenance.

- control valves
- heat exchangers
- motors and pumps

We need to perform some maintenance without stopping the (entire) plant, and respond safely to all faults.

Process design with operability

The design procedure should ensure that the plant is operable, that it functions "well". This requires a specification that addresses a range of conditions.

What are causes of deviation from base case conditions?

5. Human error – People make many important decisions in the plant, and inevitably, errors occur.

A single human error should not

- cause an unsafe condition

- cause environmental damage

- remain undetected (to enable fast correction)