Lecture 1b

Continuous Production Plants

Introduction

Continuous simply means a production process where the raw materials are consumed in a continuous stream and a product result as a continuous outflow. Continuous processes deal with materials that are measured by weight or volume, without any discrete identity for a part of the produced material. Materials pass through different pieces of equipment, where each equipment operates in a steady-state performing one dedicated part of the complete process. The product continues to be made in an ongoing manner once the process starts.

An example of a continuous production process is shown in Figure 1. Substance A and substance B are fed to the reactor through the two inlets. The reaction A+B -> C is an exothermic reaction, and heat is produced during the reaction. The reactor therefore has a cooling jacket. The reaction is seldom perfect, which means that there will be some un-used A and B left in the tank. The mixture of product C and un-used A and B is fed to the distillation column for separation. Un-used A and B are separated out in the top of the column, and product C is separated out in the bottom of the column. The temperature of the top product is decreased so that it is transformed into liquid. This is done in the condenser. The bottom product, which has a high temperature, is lead either to a boiler or to two heat exchangers. The boiler is using the bottom product in order to pre-heat the distillation column's feed. The two heat exchangers are used to lower the temperature of the end-product C.

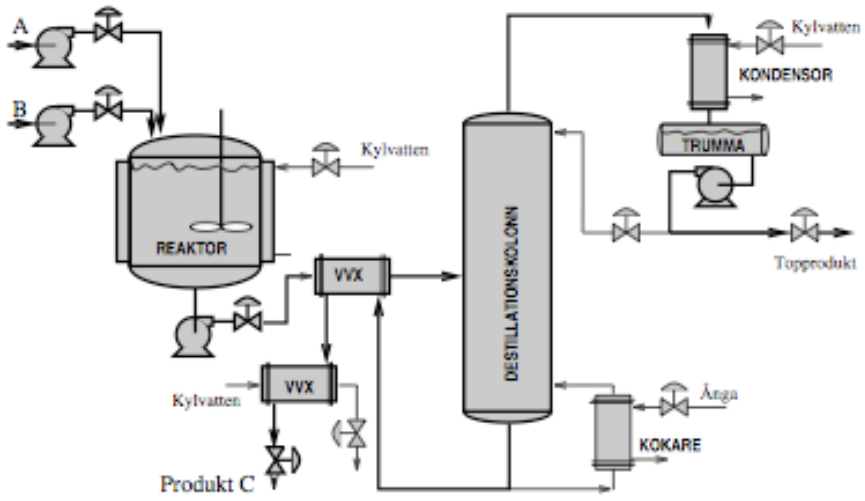


Figure 1: A process diagram of a continuous production plant.

Process and Control Design of a Continuous Production Plant

The design of the process and control system is often done in an integrated way.
Important steps (tasks) are:

1. Selection of control-parameters: chose the measured-variables and sensors
2. Selection of manipulated variables; select the actuators
3. Control structure; combine the sensors with the actuators
4. Selection of (optimal) working-point ("arbetspunkt")
5. Controller; selection of controller and tuning
6. Evaluation: economy and safety

Tasks 1, 2, and 4 are process related tasks which requires some knowledge of automatic control. Task 5 is a pure control task. Task 3 and 6 are both process and control related.

Step 1 - Selection of control-variables and sensors
There are various types of control-parameters in a plant, and various ways to measure them.

- Production rate
    - Since continuous production plants often are fluid –based, this is best measured as a flow.
- Inventory variables ("Lagervariabler")
    - Gas – pressure
    - Liquids – level
    - Solids – weight
    - Concentrations – analysis
    - Energy – temperature or pressure
- Environmental variables
    - Temperatures – temperature
    - Pressure – pressure
    - Concentrations - analysis
- Product quality
    - Physical – physical properties
    - Chemical - analysis
- Economics

In some plants, the control-variables and sensors are given and cannot be modified. In other plants (e.g., when a plant is under construction) the decision of which control-parameters and sensors that are needed, has to be taken.

In the Example of Figure 2, the control variable for production-speed is flow 4. The inventory-variables are the levels 1, 6 and 10. The environmental variables are the temperatures 3, 7 ,9 and the pressure 5. The quality is given by the concentration 2,8,11 as well as by the temperature 12.

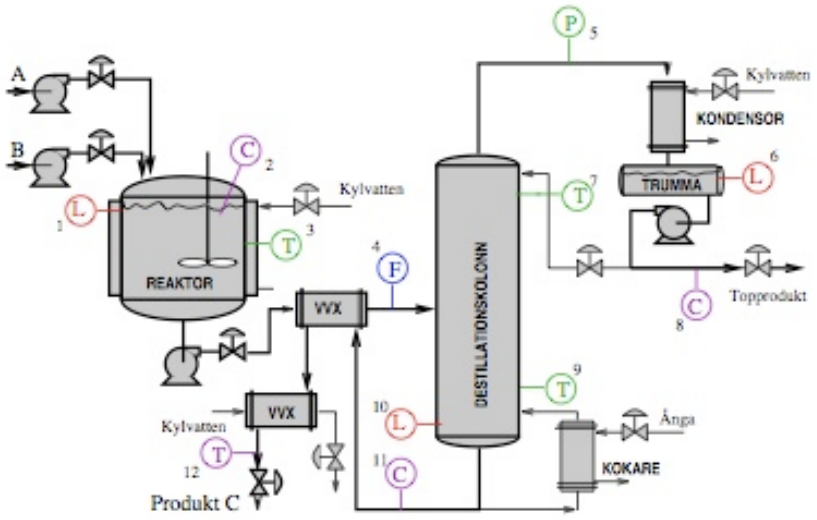


Figure 2:

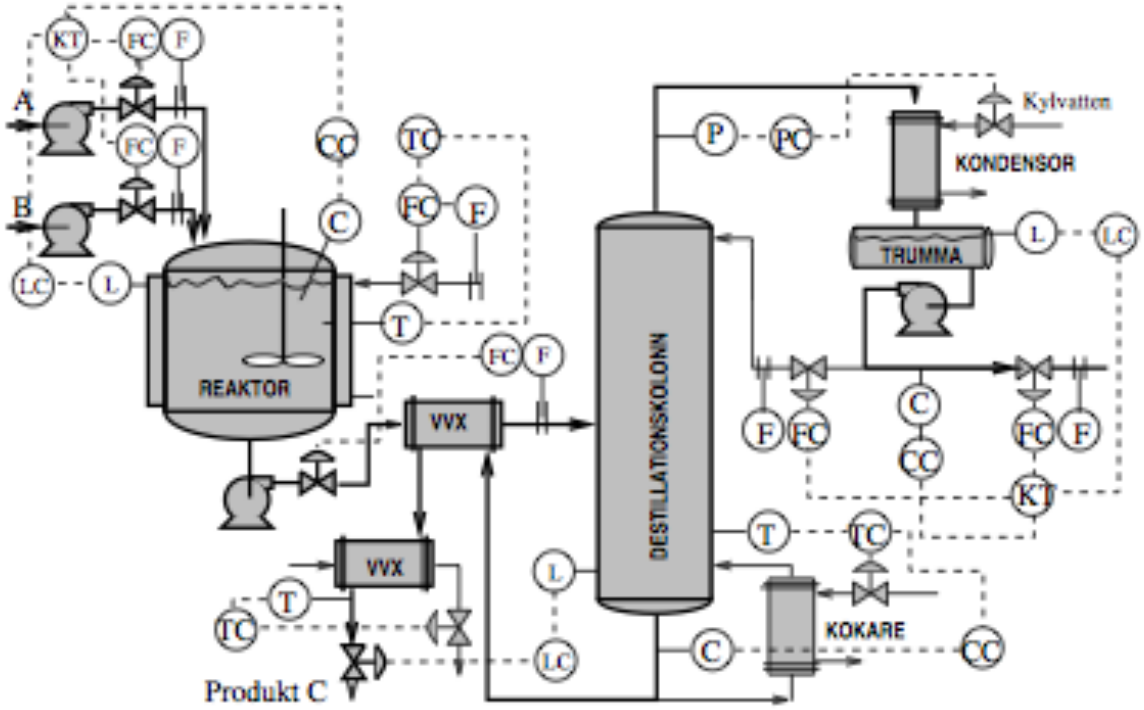
When you know what you would like to control, i.e., when you know the control-variables, you need to select sensors. There are a number of things to think of when selecting the sensors. The sensor should of course, be suitable for sensing the control-variable. The sensitivity ("känslighet") and reliability ("tillförlitlighet") are important to know. In some cases you need a very high sensitivity, whereas there might be other occasions when the sensitivity is not that important. The dynamical properties of the sensor are also important, i.e., some sensors react very slowly and others are quicker. The cost for the sensor is also a factor that needs to be taken into account.

Step2 – Selection of manipulated variables and actuators

Step 3 - Control structure

Step 4 - Selection of (optimal) working-point

Step 5 - Controller; selection of controller and tuning



Step 6 - Evaluation: economy and safety

The process and control design of a continuous production plant can be evaluated from an economical perspective, did it meet its budget, and from a safety perspective, is the plant safe enough to run?

Improvements of Continuous Production Plants

There are often control projects in a plant that aims at improving the control of the plant. When evaluating such a control project, several measures must be considered; control performance, process performance and economic performance.

- The control performance is often regulatory, e.g. holding a measured and/or computed quantity at its desired value. This is measured statistically and expressed as some function of deviation from target. Commonly used functions are range, maximum deviation and standard error (standard deviation).
- Process performance is a measure of how well the process meets its objectives. This could for example be production rate.
- Economic performance is measured in financial terms, e.g.., financial production rate which is expressed as Money (Euros/dollars/SEK) per production time.

Example: A chemical plant has tuned the controller that controls the PH of a tank. This has resulted in an decrease in the standard deviation from target (a control improvement). This improvement implies that more of the product produced can be classified as high-quality product. The production rate of the high-quality product will therefore increase (a process improvement). An increase in the production rate will only result in an economic improvement if there is a market for the additional product.

If there is no market for the additional product, the process improvement will not affect the economic performance.

The purpose of an improvement project is to make money, i.e. to make an economic performance improvement. In order to make an economic performance improvement, one of the following process improvements is typically achieved:

- Higher output
- Lower utility cost
- Better yield
- Fewer unwanted byproducts
- Less labor
- Better quality

Summary

In today's lecture the focus has been on Continuous Production Processes, see Figure 3.

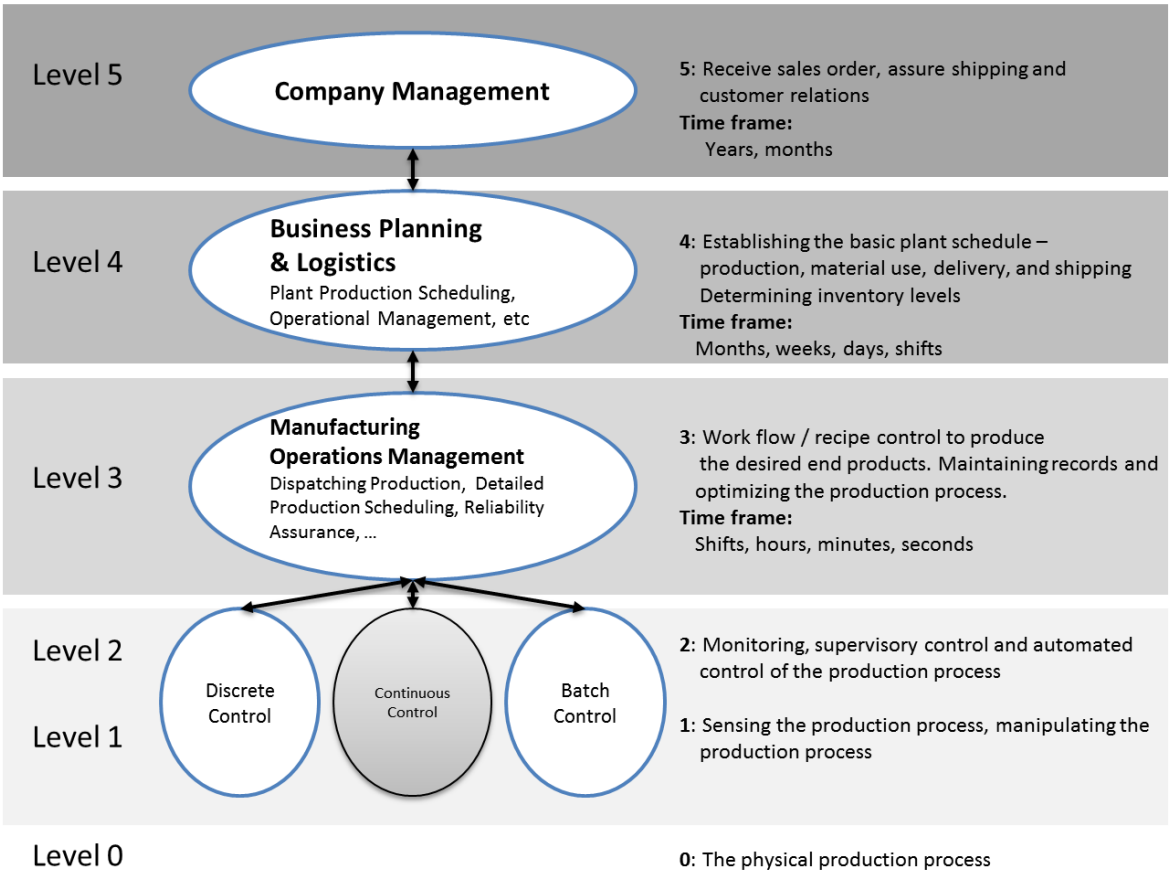


Figure 3: The continuous production process