

Designing a production system

When designing a production system, one must take into consideration the big picture. On top of understanding the resources the system is made of, we must comprehend the trade off and relationship between different resources in the value transformation process. In other words, we must be able to describe the process of production. In everyday usage, a 'process' means any activity that proceeds in a certain way. On the other hand, a **production process** describes the order, in which production resources are used, and which resources one must combine to reach the desired goal. In manufacturing, different stages are happening either consecutively, where A needs to be done before B, or in parallel, where the order of A and B has no significance - however, both need to be done before C. When the order, dependence and the estimated time of each stage are known, the theoretical flow time can be counted. One also gets to know the bottleneck of the production process. Next off, we can proceed to examining the workflows of production.

Flow Unit

In production, the object of the transformation is called the flow unit. Meaning that the object, which state is being transformed, flows through the processing phases. In production of goods, the flow unit is a tangible object. If the object is a singular entity, like part of a machine or piece of furniture, the process is called discrete manufacturing. On the other hand, if the object is not easily identifiable, like in oil processing or beer brewing, it means we are talking about process manufacturing. Instead, in service production, the object of transformation is often the customer, for example a patient in a hospital or a customer in a hair salon. The object can also be property of the customer like a car in carwash or a customer case, such as a lawsuit. In some cases it can be easier to look at multiple flow units, all of which combined produce the customer value. For example in a lunch restaurant, we can consider the flow unit to be food, but we might as well think of the customer as the flow unit, or the tray on which the customer takes the food.

Configuration of the workstation

We still need to define a few more concepts for designing the production process. The resource executing the production function is referred to as a workstation. The workstation may be immovable, like a lathe in a workshop, or movable, like a plumber and his/her toolbox. Before a workstation may execute a production function (e.g. lathe a piece of metal or fix a pipe), one must make a configuration for the workstation. While making the configuration, the workstation (and possibly the product itself) are being prepared for the function needed to produce the product. As a part of the configuration, in some production systems one must find out what the workstation should do to the product on hand. If there is no variation in the production system, this part of the configuration is quite trivial, because the workstation does the same transformation to all products.

However, in some cases finding out what to do may be a big part or even the whole production function. One example of that kind of situation is the work of a plumber that tries to figure out where the leak is. When it's clear what should be done, the needed settings may be done to the production resource so that it can make the right transformation to the product. For example, the right blade is assembled to the lathe, the settings of the machine are modified and the piece coming for lathing is attached to the lathe. To the same extent, plumber cuts the waterflow in the pipe, prepares the place for fixing and possibly gets some special equipment. Production includes also preparation/maintenance that doesn't necessarily relate to any specific product, but still may affect the configuration and execution of a product. A few examples of this kind of cases are general tidiness, cleaning and the order of the tools and lubrication of the production machines. If the configuration is expensive and time-consuming, it may be tempting to increase the amount of repetitions between the configurations. This divides the costs of configuration to greater quantities of products, but it means also standardization of the product.

Waiting time in production

What happens between the workstations is obviously an important part of the production process. When the workstation has completed one stage in its process, the flow unit may move on to the next station. Even though on a convoyeur belt the flow unit moves directly to the next station, in many production systems the shift doesn't happen instantly. Instead, it's more convenient to wait that the workstation produces a certain number (ie. one box) of its products before moving on. Additionally, the wait can also be a consequence of the next workstation being occupied with producing some other type of product. Any production process, where a flow unit is waiting for its next production stage, is considered unfinished.

If the flow unit is waiting for a box to be filled up, the waiting time might be counted in minutes. On the other hand, sometimes a flow unit might sit for months in storage, before the next stage is ready to receive it. Unfinished production ties down real capital, which is bad. On the flipside, unfinished products sitting in the storage also work as a buffer for the production system, leading to improved capacity utilization - especially in the case of the storage preceding the system's bottleneck. This will in turn improve the utilization rate of the capital tied to production. Except for some systems in the field of process industry, the flow unit is rarely in a continuous movement, never having to wait for the next stage. This means that in almost all the production systems, the actual flow time is longer than the theoretical. Shortening the flow time is central to lots of improvement philosophies and - methods.

The flow of production

Based on the flow of production and its flow units, we can examine production processes from different viewpoints. In all of these viewpoints different challenges of production management are emphasized. First of these is the movement of flow units, based on which production systems can be categorized in following manner:

- **Job shop** includes production systems, in which the flow unit either stays in one fixed position (e.g. shipyard) or its flow is tied to a movement of a certain production resource (e.g. workshop)
- **Disconnected flow**, in which the flow units move in great numbers from one workstation to another, possibly through a storage. In the manufacturing industry this is the most common process type, and it emphasizes problems that are tied to movement of flow units: lead time of the production and inventory carrying costs.
- **Connected flow**, in which a conveyor belt moves flow units continuously from one workstation to another.
- **Continuous flow**, which is typical for the process industry.

Material flows from the perspective of variety in products

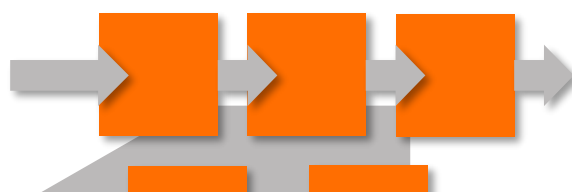
In manufacturing material flows can be viewed from the perspective of variety in products which enables the flows to form different “blueprints” or layouts.

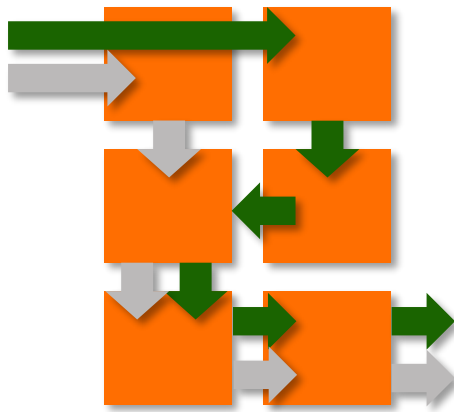
- **I-layout** describes a line production in which the material flow forms a straight line. In this layout the slowest resource defines the capacity of the production.
- **A-layout** has multiple material flows meeting at the last stage of the production which is usually the assembly. The challenge in the execution is the synchronization of the converging material flows.
- **V-layout**, in which multiple products are manufactured from the same raw materials or components. Executional challenges can be found where separate material flows are competing from the same resources. Furthermore, one can consider the combinations of the previous examples which combines the challenges as well.

Production systems from the perspective of workstations

Another way to view production processes is from the perspective of organizing the workstations. Based on this, production systems can be categorized as followed:

- **Functional Layout**, where the workstations are specialized and similar stations are aggregated. Flow units are routed from workstation to another according to the different stages.
- **Process Layout**, in which the workstations are organized according to the flow unit or product type, and the workstations required by the product type are placed in the order of the process.
- **Cell Production** is a mix between the last two: A group of different workstations are grouped into cells, in which the flow unit moves along a fixed route as smoothly as possible to go directly or via intermediate storage to the next cell. The challenge in organizing the workstations is based on the trade-off between capacity utilization and flow time.





Functional Layout

Process Layout

Level of standardization

The third way to view the production process is to look at its level of standardization. The trade-off between setting (what to do and how) and execution is very fundamental and the control of variety is an important issue with most companies.

- In a **standardized process**, the workstation has only one setting and the units flow identically through the production process in very high volume. This is very typical for companies that produce large amounts of identical copies of the same product, e.g. certain plastic parts or screws. For different types of units, the setting can be remade, but after each setting, an identical flow of units is followed.
- In a **formatted process**, the setting is done with a limited amount of predefined parameters. For example, an ATM requires several inputs from the user and the combination of said inputs determine unequivocally the final execution of the process.
- In a **routine process**, the customer and the service provider, e.g. a patient and a doctor, negotiate the setting before execution. The execution can be distributed into different subparts and -combinations, e.g. when visiting a doctor the patient can go through different examinations or operations and get prescriptions.
- In an **explorative process**, the settings and different ways of execution are decided along the way, a couple of steps at a time. The process is reviewed after every step and then the next decisions are made. This is a very typical process type in e.g. hospital emergency duty, product design and creative work. The service production improves as the process becomes routinized and the goal usually is to format the process and eventually automatize it.