CONTENT UNIT 2

PRODUCTION PROCESS BASICS

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2 Basics production process

2.1 The introduction

The topic

Whoever says "industrial car production" must also say "production process". After all, the production of a modern car requires a large number of technical resources and employees. The production process determines how these two elements are organised to transform raw material into the desired finished state - or, more simply, how the cars are built at the end of the day in the factory.

To design the production process as sensibly as possible for a production line (for example, so that as many variants of a vehicle as possible can be produced in a single production line without interruption) there are two important starting points. One is process planning, the other is resource planning - this applies to all manufacturing industrial companies.

Especially in the automotive industry, the so-called "lean production" is gaining ground - a particularly systematised and integrated method of making the production process as efficient as possible.

As you can see, the design of a production process is, in a sense, the efficiency backbone of any factory, which must be comprehensively planned and implemented. The production process is also in close contact with other processes of a company (such as human resources management, logistics, research and development and other elements) and together with the work process and the business process of an industrial company forms the core of the so-called process chain.

In this learning unit, we, therefore, deal with the most important basics of the production process. You will learn:

- important elements and instruments around work and process planning
- planning strategies and planning methods
- coding and numbering
- the tasks of scheduling
- how the lead time is made up
- the most important terms of capacity and materials management
- methods and goals around material planning as well as working time organization
- the objectives of capacity management
- material requirements planning
- the basics of working and operating time organisation

- the principles of Lean production and associated tools
- the basics of the value chain and how to fundamentally reduce waste along it
- how the KANBAN system works

2.2 Work and process planning

Work and process planning is nothing more than the **design, documentation, control, and improvement of a production process**, i.e., the extent to which personnel, material, operating resources and our plant can be used as productively as possible to achieve the corporate goal. To meet delivery deadlines or minimize throughput times, for example, there are various process planning strategies and methods.

It is important to plan each process according to four criteria:

- With **uniformity** (i.e., processes that are as standardized or proven as possible), you create reliability, traceability, and reproducibility in the company.
- The correct **sequence of** elements in the process is essential to avoid downtime and time losses along the production line.
- An adequate **definition of the goals of** a process is important, not only division-specific but also cross-divisional.
- With **cross-divisional thinking,** you achieve a coherent system with fewer interfaces and correspondingly less coordination effort.

Hint

The pillars of any process are the employees. It is therefore essential that they are understood as part of the process of planning. **Clear and transparent communication** is important here, not only about tasks and areas of responsibility but also about goals and key figures.

The better the staff **understands the background of process planning** (and the changes it entails), the more likely they are to **accept it.** Discussing processes with staff is also a good way to increase **motivation** (staff feel involved) and identify possible **weaknesses in** the plan that have not yet been considered.

Let us now take a closer look at **two of the most important planning strategies** or methods. First, a planning strategy is the principles and procedures for effective planning of order processing in the company.

Practical Relevance

Over time, of course, many more planning strategies have developed, most of which follow the principle of uniformity - this means that **depending on the field of application or the problem, there is probably already a suitable planning strategy** - practically!

Here are some examples of terms for orientation: process or sequence planning, process-oriented work planning, bottleneck planning, just-in-time, just-in-sequence, kanban, load-oriented order release, zero-defect production, group organization, out-/insourcing etc.

Let's take **process and sequence planning as** a first example. This is used to optimize the operational sequence of orders (i.e. the order in which orders are processed). Depending on the priority target value (for example, efficient use of resources versus adherence to schedules), orders are ranked according to the following rules:

- **Earliest Due Date:** The job with the least remaining processing time is processed first.
- **Highest Value**: The order with the highest added value is processed first.
- **First-Come, First-Serve rule**: The order received first is processed first (also referred to as the first-come-first-serve principle).
- **Shortest Processing Time**: The order with the shortest order processing time is processed first.

Example

Meeting the standards set by the group was the main motivation for the company manufacturing compressors and anti-lock-braking systems. It was highlighted that the information required during the production process in the manufacturing facility changes very quickly. A system of communicating and sharing information with other than the experienced staff was required in the facility. If an employee is unsure about the quality of the component, he/she leaves it in a special area with a yellow card attached to signal for an engineer to inspect that component. For operations dealing with large variations in products, such as this company, it was identified that a cross-functional workforce was critical to balancing capacity with highly variable processing times. To increase flexibility, the company has implemented a skills matrix that includes all operations of the process and the list of operators who can perform them. This helps management to identify the right employees for the right tasks. Hourly production boards were introduced to provide production results compared to the plan. This creates a feedback system for estimated processes that allows problems to be identified in real-time and better utilizes capacities. It is easier now to identify where the components should go from one operation to another, and the distance travelled by each product was reduced.

Another planning strategy is Just-in-Time (JIT). This concerns the planning of deliveries. With JIT, these should take place as precisely as possible when the delivered resources are processed further. This has two main consequences:

- On the one hand, this planning strategy avoids storage costs and control efforts.
- On the other hand, however, one is highly dependent on the reliability of suppliers.

Hint

JIT has become more common in highly standardized industrial companies, such as the automotive industry. In some cases, companies supplying certain components have set up their operations or warehouses on the premises of their customers (e.g., automotive plants).

An important aspect in work and process planning is then, of course, time; especially about the timely completion of individual elements in the production process.

In addition, there is scheduling. This also has its strategic approaches, especially in series and mass production (such as so-called "scheduling"). Effective scheduling ensures that time schedules are adhered to and that there is no downtime within the production or waiting times outside for customers.

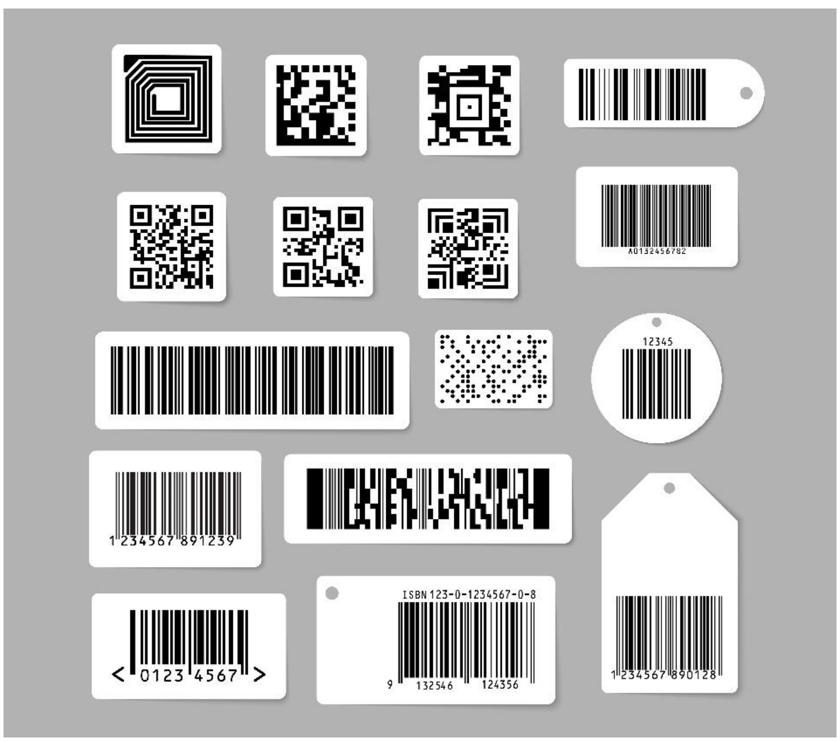
Another time-related aspect is the **lead time**. This is the duration of a process (for example, how long a certain type of model takes to roll off the assembly line). Lead time consists of scheduled and additional process steps and is an important metric for evaluating **process performance.**

Two important terms in process planning are also **numbering** and **coding.** These ensure the **exact and simple traceability of all elements in a production process**. This becomes particularly essential when model and type diversity plays a role, when batch sizes in production decrease and when the demand for quantities and quality increases in equal measure - the automotive industry is the best example of this.

Note

Numbering is the construction of classifying or identifying combinations of digits, letters or special characters that result in individual numbers.

Coding is the encoding of these numbers. A classic example is the barcode, but also colour coding or RFIDs (Radio Frequency Identification). This is used to read out individual numbers more quickly and automatically.



There are many examples of the use of a numbering system: Invoices, article numbers, assemblies, raw materials, and services, but also processes, process steps, activities or employees can be given a number in a numbering system. What is important here is **uniqueness** (each element of a numbering system can only have one individual number) as well as **length** - the shorter and the more unique a number is, the less prone to errors the numbering system is.

2.3 Resource planning

Resource planning is the other important aspect of any production process. An important business term here is **capacity.** Let us first look at how this term is to be understood.

Example

For complex businesses in the automotive industry is vital to have strategic business process management tools like ERP software (known as Enterprise Resource Planning). ERP consists of systems and technologies that companies use to manage and integrate their core business processes (accounting, project management, procurement, supply chain operations, enterprise performance management, risk management, compliance, etc.). It helps eliminate data duplication, thereby providing data integrity. ERP consolidates the data of every department and empowers all the key decision-makers to have access to up-to-date information, edit it, manage it, and even make quick and informed decisions based on it as and when required.

Definition

The **capacity of** a company describes the quantitative maximum of a production system.

Capacity utilisation provides information about the quantity that is produced (compared to the maximum possible capacity).

The **capacity utilization rate** is the capacity utilization in per cent - for example, capacity utilization of 85 % (out of a possible 100 %).

The term **intensity is** also often used. This indicates how technical changes (for example, more material processing) or time adjustments (for example, dividing working time into shifts) can increase or also decrease capacity utilization.

Capacity management aims to achieve the highest possible or **efficient capacity utilization** - i.e. to design the process in such a way that the maximum possible quantity is efficiently achieved in a production system. The aim is not simply to produce as much as possible but to achieve a previously defined capacity as far as possible.

In this context, the capacity of any production process depends on how many personnel, machines, tools and rooms are available in a given period. These factors can in turn be assigned to three components that influence capacity utilization:

- The previously mentioned **intensity**
- The number of **machines** available (sometimes called "aggregates" in this context) and the number of **workers** available.
- the **time in** which the available machines and labour can be used

These three **components have a direct impact on capacity utilization** - for example, if the time available decreases, either the intensity or the number of machines or workers must be increased. Otherwise, a lower capacity utilization must be accepted. Accordingly, one also speaks of **plant capacity** (for the machines), **personnel capacity** and sometimes also **financial capacity** in production processes, which must be coordinated with each other.

Hint

Measuring capacity or the **degree of capacity utilization** is not at all easy, as standstill times, repairs, maintenance work, illnesses and other disruptive factors occur in production processes. Therefore, capacity measurements are only considered useful over longer periods, whereby the degree of intensity must also be kept constant over the measurement period.

Another important part of resource planning besides capacity is the **handling** of the **materials** needed and to be procured for the production processes. This means **product materials**, **auxiliary materials,** and **operating materials**.

Definition

Produce materials are materials that go directly into products and are also "consumed" in this sense (for example, in contrast to tools, which can be used again and again). These include **materials**, **raw materials**, **semi-finished products, components** and **assemblies**, but also **auxiliary materials** (such as lubricants or packaging material) and **operating materials** (such as fuel).

Example

General Motors (GM) is a global automotive company that produces a wide range of vehicles. To efficiently manage the production of materials, GM uses a sophisticated material planning process that involves several steps. First, GM's material planners work with product development teams to determine the required materials for each vehicle model. This includes specifying the types, quantities, and quality of materials needed for each component. Next, the material planners use this information to develop a detailed material plan that specifies the timeline for procuring and delivering the required materials. This plan takes into account factors such as lead times, transportation costs, and supplier capacity constraints. Once the material plan is in place, GM's procurement team works with suppliers to procure the required materials. The procurement team uses a variety of tools and techniques to manage the supply chain, including supplier performance monitoring, demand forecasting, and risk management. As the materials are received, they are inspected and tested to ensure that they meet GM's quality standards. The materials are then stored in GM's inventory system and released to the production line as needed. Throughout the production process, GM's material planners and production teams closely monitor the availability of materials and adjust the production schedule as needed to ensure that there are no delays or shortages. This involves ongoing communication and coordination with suppliers, transportation providers, and internal teams.

Material planning now deals with the handling of these product materials. The tasks are divided into three parts: Material requirements planning, procurement quantity planning and procurement time planning.

Material requirements planning determines how much material is needed and how the material should be procured. The **make-or-buy question is** central here - i.e., whether the required material should be purchased externally or produced internally. The demand is differentiated into three types:

- **Primary requirements** (finished products, saleable assemblies, and spare parts)
- **Secondary requirements** (raw materials, individual parts or assemblies that are necessary for the production process for primary requirements)
- **Tertiary requirements** (auxiliary materials and operating supplies, which in turn are necessary for secondary requirements)

Determining the respective demand is, of course, the decisive task in material planning - and thus also **the basis for further quantity and timing planning**. There are several methods for this in the industry:

1. **Deterministic demand determination:** Here, the demand is derived from parts lists or simply from the operating instructions (mainly for the dependent demand). For primary demand, planning is market-related - i.e. according to the company's planned sales. This type of demand determination is also called "programme-based".
2. **Stochastic determination of demand:** Here, past consumption values are used as the basis for a forecast of future consumption. Mathematical methods are used, such as exponential smoothing. This is also referred to as "consumption-based" planning.
3. **Heuristic demand assessment:** Here, the demand is subjectively estimated based on the expertise of experienced employees or consultants. This method is usually used when there is not enough data from the past (for example, for new parts to be manufactured).
4. **Rule-based requirements determination:** This is particularly in demand in the automotive industry because of the different equipment and model variants and is based on "if-then" processes. So when certain equipment is ordered, only the parts or assemblies needed for it becomes necessary.

Important

Particularly in complex production systems, such as those found in the automotive industry, **combinations of these four methods** are also often used to be able to carry out material planning as efficiently as possible.

Once the demand has been determined, the material can be ordered externally or produced in-house with the help of **procurement quantity planning** and **procurement** timing planning. Here, work is done to ensure that the right quantities are procured at the right time and are available at the necessary place.

Central to resource planning is also the organization of working or operating hours - that is, when and how employees work in a company. The organization of employees' working hours is, as we learned earlier, an essential part of capacity utilization. There are two very fancy-sounding words to know here:

- Chronometry: This concerns the duration of working time, i.e., how long a person works.
- Chronology: This concerns the distribution of working time, i.e. when a person works.

Chronometry and chronology result in the distribution of working time. This is shaped by a combination of working time models that differ chronometrically and chronologically.

In the context of industrial companies, shift work is particularly noteworthy. Here, different employees are assigned to the same workplace one after the other according to a certain schedule (chronologically) (for example, in an early shift, late shift and night shift). In this way, companies can produce for longer than the usual daily working hours.

Depending on the intensity of capacity, there are also other important working time models, such as temporary work (here employees are "borrowed" for a certain period) or the use of leapfrog staff (these are employees without a permanent job who can be deployed as needed).

Hint

Of course, familiar models such as flexitime, part-time or even newer approaches such as so-called job sharing are also possible in work and operational scheduling - here it depends primarily on the process involved and the tasks in the company. In the administrative area, shift work tends not to be necessary. In mass production processes, on the other hand, where production is to be efficient and above all constant, shift work is of course popular and effective practice.

2.4 Principles of Lean Production

Only an efficient production process is a good production process - this is something that every industrial company would agree with. A popular concept to make a production process as efficient as possible is the so-called "**lean production**".

This means the **economical and time-efficient use of all production factors**, i.e. employees, materials, resources, planning and organization. Other factors are, for example, tight coordination with suppliers or rapid adaptation to market changes.

Hint

Lean production is therefore in itself a very **comprehensive concept**, but it is nevertheless actually a part of something even bigger - namely the approach of **lean management**. Lean management goes one step further and encompasses the efficiency of the entire **value chain**.

The value chain is an important term in the production economy and **represents all activities of manufacturing** - from inbound logistics, through all production processes, marketing and sales activities, to outbound logistics and service. The elements just mentioned are also called **primary activities**. These are strung together in a value chain. **Supporting activities** extend across all primary activities. These are activities that are necessary for the primary activities, such as human resources management, technology development, procurement or logistics.

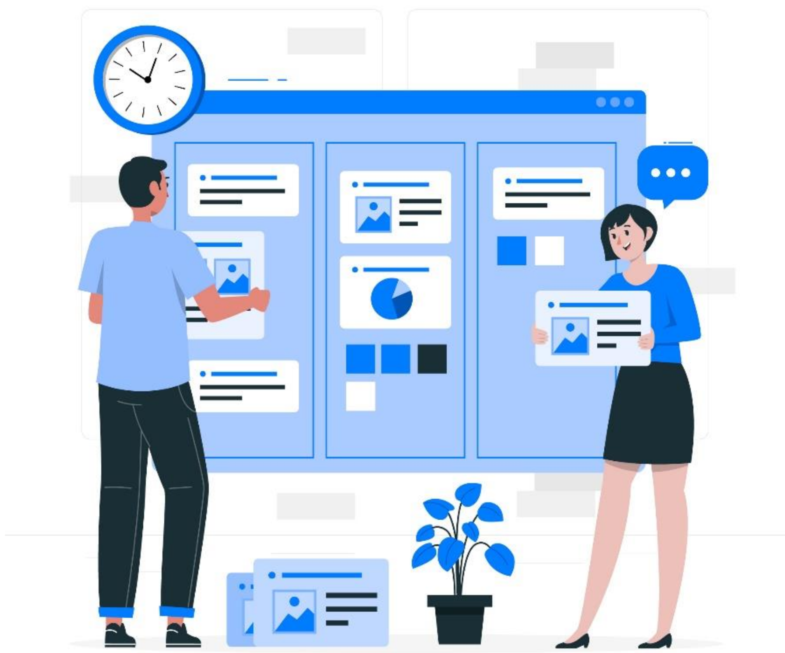
A production process is therefore a **primary activity in the value chain of** a company. The goal of lean production can now be divided into three aspects:

- **Improving productivity**: Excess inventory, underutilized capacity and lead times are to be improved.
- **Optimization of product quality**: The production process is to be checked in terms of quality, faults are to be rectified as quickly as possible, rejects are to be avoided and supplier processes are to be optimized.
- **Increasing flexibility**: Adaptable production systems are designed to reduce downtime and make capacities more flexible according to demand.

Note

Essentially, lean production (as well as other optimization concepts for production processes) is about avoiding **waste**. Waste is understood to be, for example, overproduction, standing and waiting times, long distances, complex processes, defective products, multiple data entries or also unused potential or know-how of employees.

Lean production was originally developed to avoid waste in the company. The fundamental goal was defined as **eliminating** all **non-value-adding activities within the production process**.



To avoid waste and achieve the above-mentioned goals, Lean Production now offers various **methods and tools** that are used in industrial companies:

- **Continuous improvement process**: With the involvement of the employees, small improvements in the production processes are constantly worked out and implemented in working groups.
- **Standardization**: The aim is to define the steps of repetitive processes.

- **Zero-error principle**: Any errors that occur should not be passed on to subsequent work steps but should be rectified immediately.
- **Lean operation**: Delivering materials as promptly as possible should minimize the effort required for warehousing.
- **Orders according to the pull principle**: The production processes are carried out demand-oriented (instead of deadline-oriented according to the push principle). Important terms for this are Just-in-Time, Just-in-Sequence or also Kanban.
- **Visual management**: Processes and workflows are depicted visually. This increases the transparency of important key figures and interfaces for managers and employees.
- **Strong involvement of employees**: Employees are used as key drivers for innovative concepts and continuous process improvements and are given responsibility in this regard.

Example

A company active in remanufacturing of transmissions for passenger cars, commercial vehicles, and off-road machinery, searched for a solution related to products located in different departments: car transmissions, and steering section. The main motivation to implement lean was to satisfy the customer by reducing throughput times. They observed that operators were walking several kilometres to build one gearbox. The layout was changed to eliminate excessive movement and transportation. Managers suggested that it was people that at first seemed to be the main factor limiting the application of lean within the facility. Employees were stressed about losing their jobs if things would be completed faster. As such, communication played an important part in successfully implementing lean. For example, an 'introduction to lean' workshop was organized. Management took part in training together with employees. The workshop covered many lean concepts including waste, Kaizen, pull systems, etc. Besides the workshop, management constantly assured employees that lean is not about reducing headcount. They highlighted that if the product was cheaper, the facility will sell more, and the company will have more work and will create more jobs.

The **Kanban system** just mentioned during the pull principle is a particularly popular Lean Production tool for **inventory management** in production processes. The basic principle of Kanban is the linking of individual control loops, which always consist of a **production stage** and an **upstream material store.** The production stage independently withdraws the currently required quantities of material, which are automatically replenished by the upstream material store.

Important

Central to this are the so-called kanban **cards**, which document the withdrawal and consumption of materials along the control loops. While the material **is moved in one direction**, the withdrawal information of the corresponding kanban card is passed on to the material warehouse in the **opposite direction.**

For example, the material warehouse always has **two containers** with a certain quantity of screws. The production stage **takes one of these containers**, uses up the screws in it as needed, returns the empty container **together with the kanban card** (on which the exact consumption of screws can be seen) and takes the **second, full container** with it. The upstream material store now refills the empty container according to the **Kanban card.** This ensures a **constant flow of material according to demand.**

2.5 Summary

Save knowledge

A company's production process determines how **technology resources** and **employees** are organised to process raw materials into a desired production state. To do this as sensibly as possible, one deals with **work and process planning on the one** hand and **resource planning on the** other.

Work and process planning is about the **design**, **documentation**, **control** and **improvement of** a production process, i.e. the extent to which personnel, material, equipment and operating facilities can be used as productively as possible to achieve the corporate goal. The four criteria of **uniformity**, **sequence**, **target definition** and **interdepartmental thinking** help in this.

Depending on the area of application and the problem, there are **different planning strategies,** for example, in which order and according to which prioritisation orders are to be processed. Work and process planning also deals with optimised **scheduling** and the efficient design of **throughput times** - the main focus here is on avoiding idle times. Effective **numbering of** all elements in the production process is also a central component of process planning.

Resource planning is about the most efficient **capacity utilisation of** material, personnel and also working space. **Material planning is** used for this purpose, in which the quantity and procurement route of the necessary material is determined and defined. **Various methods of** determining requirements (for example, programme-based or consumption-based) are used for this purpose, often in combination.

The organisation of **working and operating time** is an equally important part of resource planning. This involves the duration and distribution of the working hours that employees perform. Important working time models in the automotive industry are shift work, temporary work or even jumping employees.

A particularly comprehensive production process strategy is Lean Production. The core behind this is the avoidance of waste, which results in three core goals: Improving productivity, optimising product quality and increasing flexibility. Lean Production offers several tools and methods that can be used to achieve these goals.

A popular example for industrial companies is the Kanban system. Here, control loops are formed from production stages, each with an upstream material warehouse, which in turn are linked to each other. With the help of independent material withdrawal and the use of kanban cards that document consumption, a decentralised and demand-oriented material flow is created.

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