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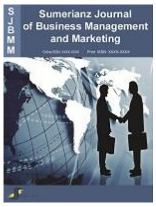

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Optimization of Manufacturing Flows

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Abstract

The design of manufacturing flows is directly related to the design of the products, their construction and technological peculiarities and the size of their production series. The design of manufacturing flows is made for enterprises or production units along with the design of the enterprise and, for existing enterprises, on the occasion of the study of modernization or development of different production units. The optimum design of manufacturing flows requires the creation of appropriate conditions for the constructive and technological realization of the products. Thus, in the design of the various products, the manufacturing flow must be designed so that they can be processed in the superior conditions by using the type constructions for different parts or semi-products, unifying and typing the parts. On the basis of these conditions, the technological design of the manufacturing process is carried out, providing for the concrete forms of the technological process under the conditions of the organization of the manufacturing flow.

Keywords: Design of the products; Manufacturing flows; Optimized production technology; Production management; Kanban system.

1. Introduction. General Notions Defined In Production Management

The problem of production can be made in the following terms:

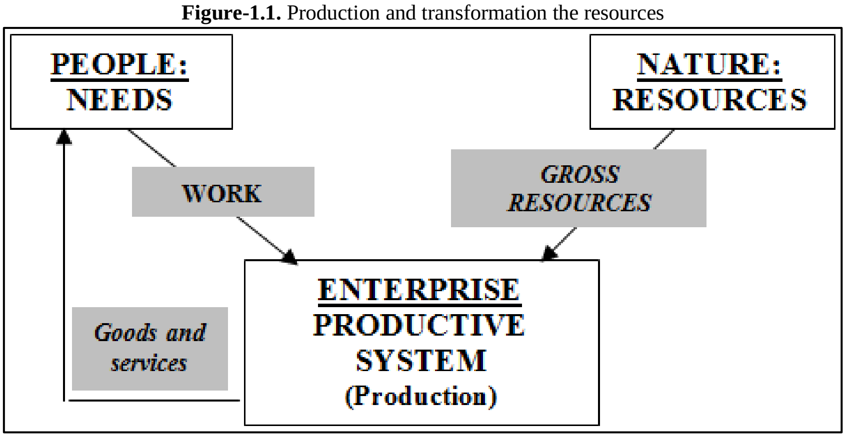
• There are, on the one hand, a set of human NEEDs, which are multiple and of varying intensity, and must be satisfied for people to live;

• On the other hand, is NATURE, where natural resources are found, easier or harder to exploit.

Natural resources in their gross state, are, for the most part, less useable than humans. It is necessary to apply an effort, that is, to intervene to WORK to transform these raw resources into economic goods, in useful things to satisfy the human needs.

As a result, it can be said that *production* is the transformation of resources within a productive system, with the objective of creating material goods and/or services. This aspect can be seen as shown in Figure 1.1.

Figure-1.1. Production and transformation the resources



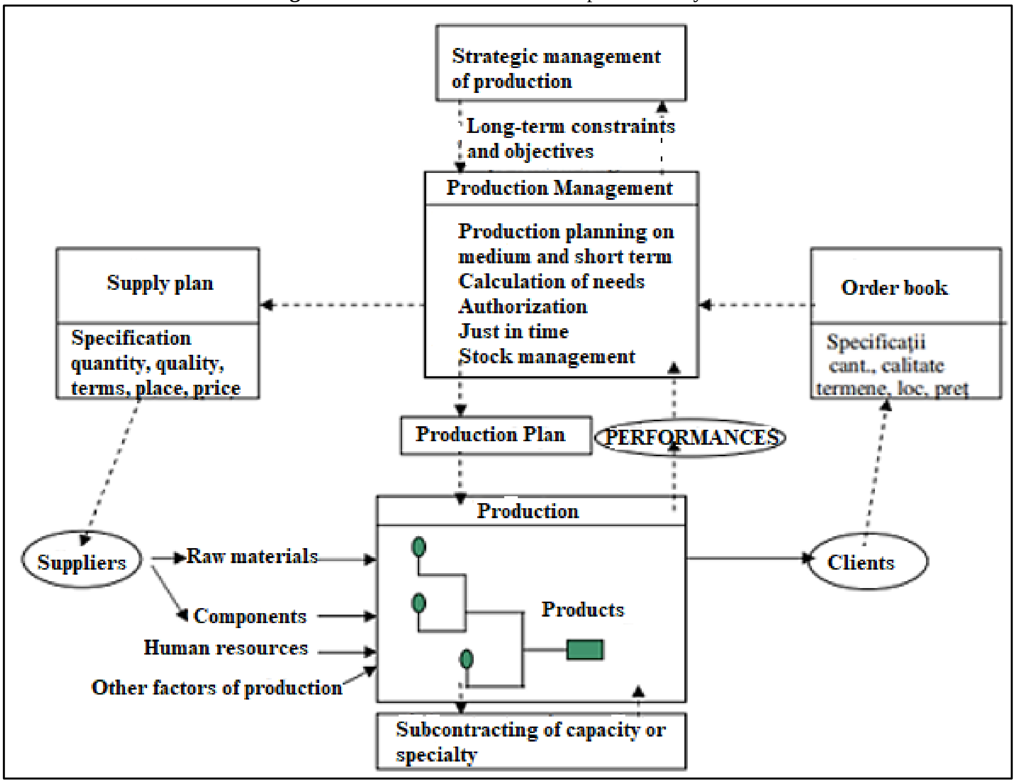
Managerial issues and concerns related to production are of strategic and operational nature. The strategic aspects of production are the subject of production management, and operational and tactical aspects are the responsibility of the operational management of production or production management.

Production management or operational management of production deals with solving the current production problems, which occur at tactical and operational level in the short and medium term, such as: production planning, gross and net needs calculation, production planning, inventory management, etc.

Thus, we can define production management as the set of administrative activities related to forecasting, planning, programming, launching and tracking of production (Moldovan, 2000).

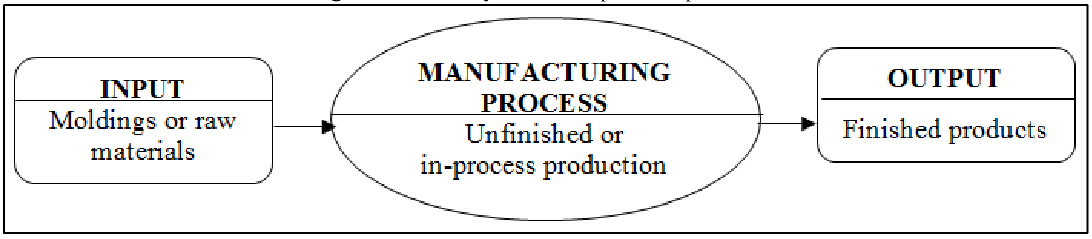
In an environment characterized by a high level of competitiveness, inventory management appears to be a necessity to ensure continuity of business activities, whose performance is directly infuenced by optimal inventory management. Figure 1.2 shows the general architecture of a production system.

Figure-1.2 General architecture of a production system



Inventories are the physical quantities of materials, products or goods needed for each phase of the operating cycle (supply, production, sales) to ensure the continuous and rhythmical operation of the exploitation activity.
The inventory theory has emerged from the need to ensure rhythmical supply and minimum spending on raw material and material inventories and current consumption inventories in the production process, and on the other hand inventories of finished products and consumer goods in the sale of goods (Bășanu and Pricop, 2004).
Production uses and generates inventories, and to optimize the production process, their management is *interdependent*, hence the concept of Production and Inventory Management. A representation of the inventory in the different phases of the production process is presented in Figure 1.3.

Figure-1.3 Inventory in different phases of production



Production management uses a number of terms assigned to each parts used in the manufacturing process. We list and define the terms most frequently used.

The *product* is a very broad concept of good material or service that can be sold to consumers.

The *part* is a monoblock solid body made of a certain material (simple or complex) and bounded by certain geometrical elements: surfaces, curves/edges, dots.

The *assembly* is a reunion of functionally interdependent parts that form a technical system with a well-defined role.

The *article* is a specific notion of production management. The article definition is the following: two objects are defined by the same article if they are interchangeable from the point of view of the user of this article. The use of the article notion allows easy exploitation of the enterprise information system, but requires coding. Thus, each article in the enterprise will be associated with a reference code that will allow the article to be clearly identified and knowledge of some of its features in the case of certain coding systems. Due to the transformations that take place within the production system, the following types of items can be encountered, as appropriate: materials, semi-finished products, components and products.

The *material* is an article that is bought by the enterprise and which is the subject to transformations in the production process.

By *semi-finished product* we understand an article type part or assembly that is an optimal input to the production process in terms of shapes and sizes.

By *component* we understand an article type part or assembly that is purchased by the enterprise and which is assembled within the enterprise without being subjected to other transformations.

By *product* we understand an article type part, subassembly (intermediate products) and final product (finished product) that is sold to consumers.

The *batch* designates a group (quantity) of homogeneous items (semi-finished products, parts, etc.) subject to the same set of actions that take place between two events in the production process.

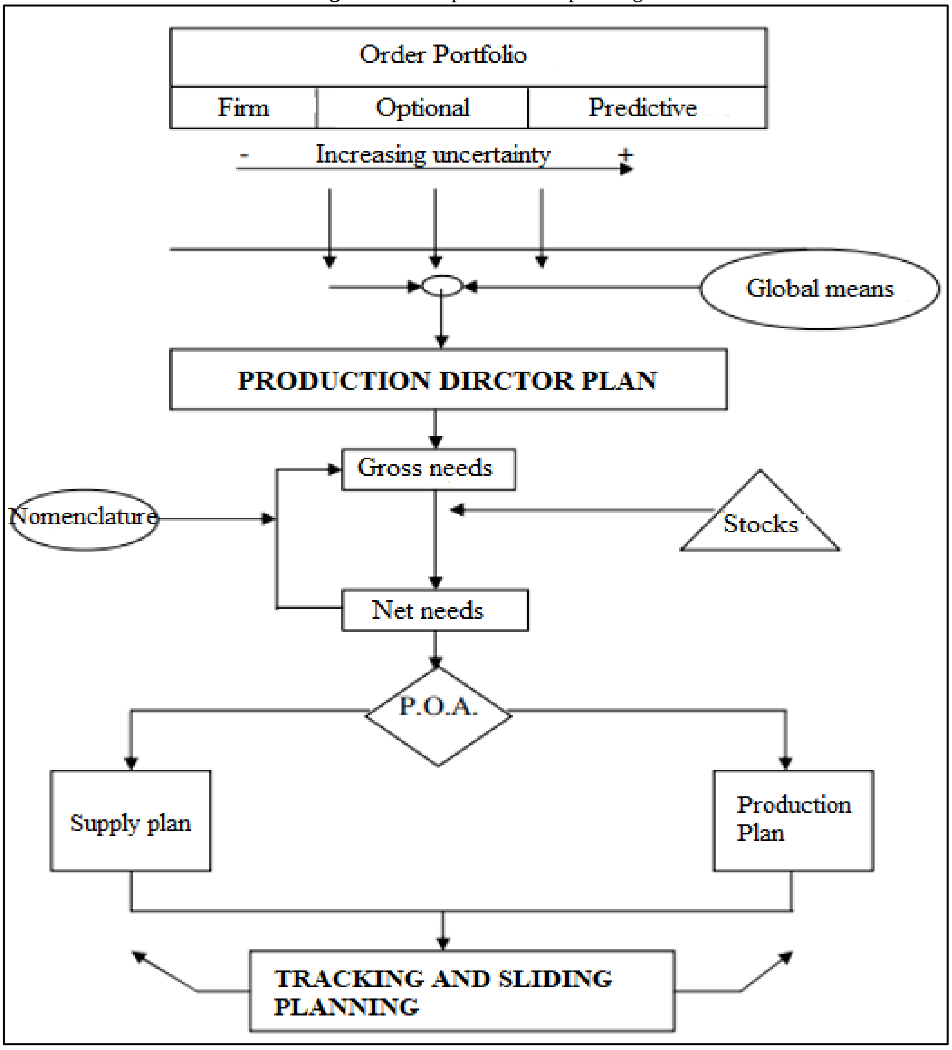
The *technological process* represents the chronological sequence of technological operations that are performed by a part (sub-assembly/product) in which the operation takes place, if necessary, modify the shape, structure and/or chemical composition of the semi-finished product (work items) input.

2. Methods. Methods of Production Management

2.1. Push Stream Management

Evoluţia producţiei şi a mediului a condus, în mod firesc, şi la evoluţia metodelor şi tehnicilor de gestiune a activităţilor de producţie. Producţia de masă se caracterizează printr-o puternică standardizare a produselor care amplifică problema complexităţii suprapunerii fluxurilor de producţie. Calculul nevoilor de componente a fost dezvoltat pentru a rezolva această problemă şi pentru a permite gestiunea strategică a acestui tip de producţie. Figura 2.1 prezintă arhitectura generală a planificării pe baza calculului necesarului de componente. Evolution of production and the environment has naturally led to the evolution of methods and techniques of management of production activities. Mass production is characterized by a strong standardization of products that amplifies the complexity of overlapping production flows. Component needs calculation has been developed to address this issue and to allow strategic management of this type of production. Figure 2.1 shows the general architecture of planning based on the component needs calculation.

Figure-2.1 Component needs planning



This method of management, called MRP (Material Requirements Planning), was developed in the 1960s.

The planning principle is simple because it consists, from the order book, to the decomposition of orders into assemblies, subassemblies, components, raw materials.

Existing inventories will be taken into account in order to avoid unnecessary production. The starting point for mass production planning is the order book.

The production master plan corresponds to an adjustment of the order book according to the overall production capacity in the medium term.

The calculation of gross and net needs takes into account the structure of the products and the available inventories.

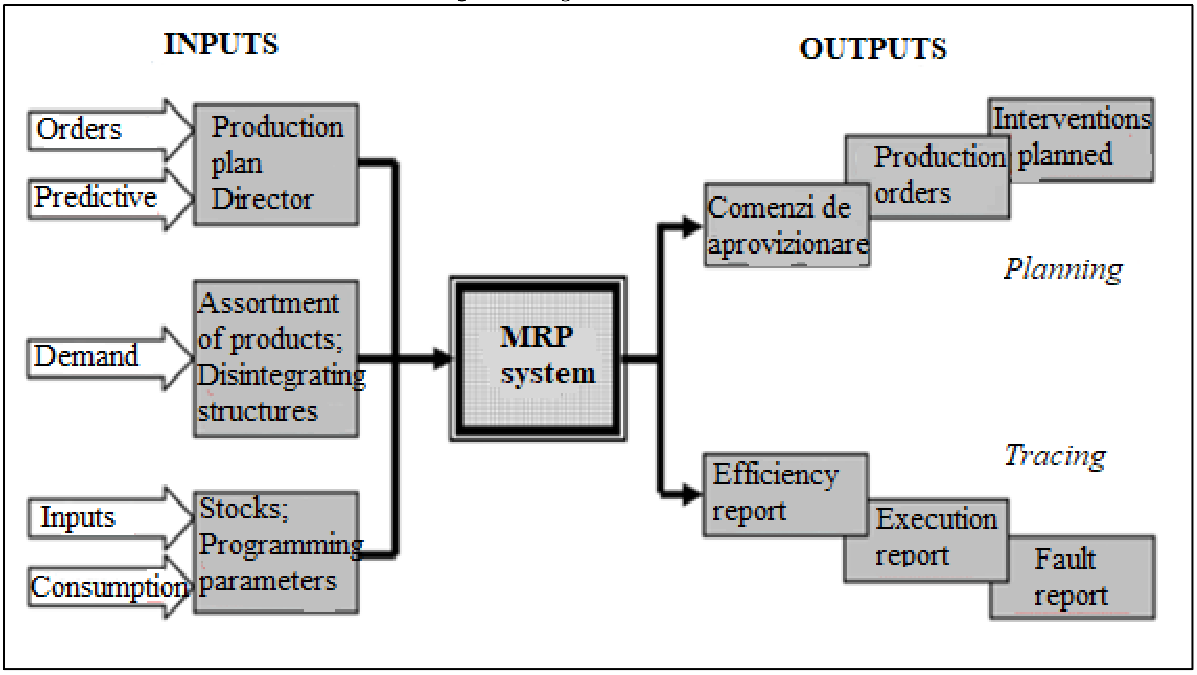
Among the most used methods in calculating needs in mass production we mention: OPT method, MRP 2, JIT, Kanban.

The *Optimized Production Technology (OPT) method* developed in the early 1980s sought to solve the problem of limited capacities in the calculation of needs, the basic principles being:

- *balancing flows rather than capacity*, which means that production must be organized according to the critical resources; the manufacturing batches are variable and different from the transfer batches;
- *eliminating bottlenecks*; developing a production program that takes account of all constraints.

The *MRP 1 method* (1965-1970) was complemented by the *MRP 2 method* (1980-1985) that sought integration of all resource planning activities required for production. *MRP 2* sought to achieve good consistency between all the different plans developed and directly or indirectly linked to product manufacturing: sales, supply, production or financial plans. Figure 2.2 shows the logic of the MRP system.

Figure-2.2 Logic of the MRP method



2.2. Stream Flow Management

The continued development of the global economy has led to increased industry competition, the development of concepts and techniques of production management.

Increasing the complexity of the management itself and the global crisis of the early 1970s have been the premises for the emergence of a new type of production management that is responsive to the market demands.

The *Just in Time method* is a set of quantitative techniques of the production management and, more than that, a global enterprise organization solution, even a philosophy. Implementation was first done at Toyota around 1970 on the initiative of Toyota's production and vice president, Taiichi Ohno, and Professor Shigeo Shingo, the one who delivered the concepts method in the industrial and academic environment.

In essence, the logic of the JIT method is as follows: by not knowing precisely what demand to be met (short to medium term), the enterprise must organize itself and be able to react as quickly as possible to produce:

- ✓ The requested product
- ✓ At the desired time
- ✓ In the quantity requested

According to this logic, the manufacture of the products should be done on as small as individual batches (as opposed to the organization of economic batches in the MRP method, which optimized certain production costs) so that the duration between the customer's order and honoring its demand, be as small as possible. Therefore, for the implementation of the method, two major directions of action are needed:

- ✓ Proper organization of the system of production;
- ✓ Increase its reactivity.

The organization of the production system is aimed at applying technical-organizational measures that lead to a reduction in the production cycle's length of production for a part.

These measures are known as continuous improvement methods, these are two major action plans:

- ✓ Elimination of waste of any nature;
- ✓ Respect of people involved in the production process.

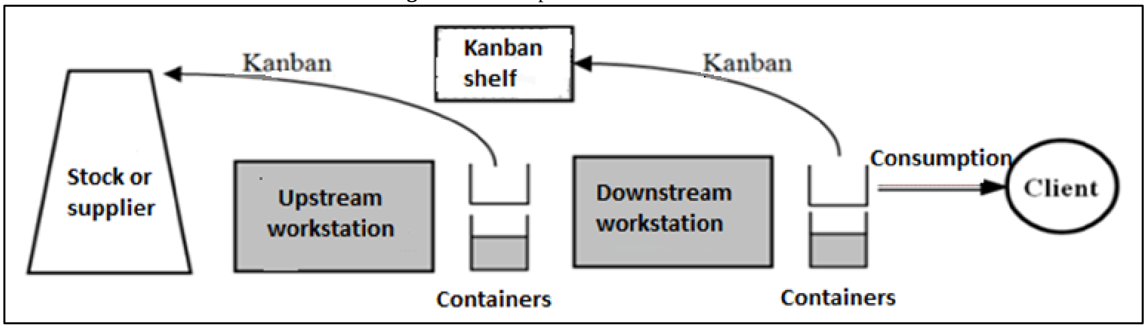
Increasing the reactivity of the production system is achieved by considering the relations between the workstations as supplier-consumer relations and the application of the consumption substitution principle: the production task of a workstation is activated by the depletion of the inventory from the downstream workstation.

The post that triggered this process is the last workstation within the System that responds to the customer's request. Therefore, at all stages of the production process, the *downstream workstation* pulls the *upstream workstation*.

Therefore, this production management system is associated with the concept of *stream flow management.*

Production scheduling and leadership is done through the Kanban method. Figure 2.3 illustrates the principle of the Kanban method (Eduard *et al.*, 2015).

Figure-2.3 Principle of the Kanban method

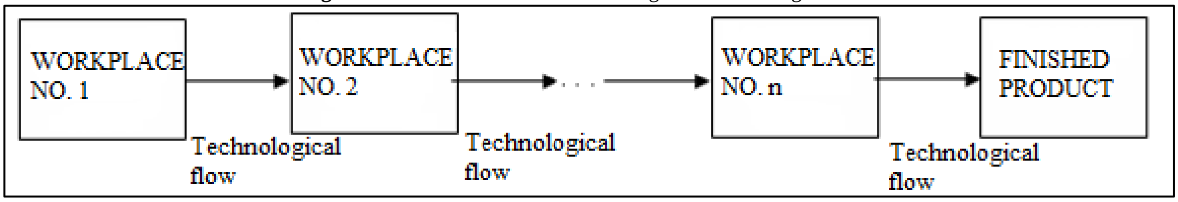


3. Results. Results in the Kanban Method

Kanban is an integrated method of Operational Management/Production Management that aims to maximize and refine the production process by assigning tag cards attached to components/ containers for optimal monitoring of the flow of materials.

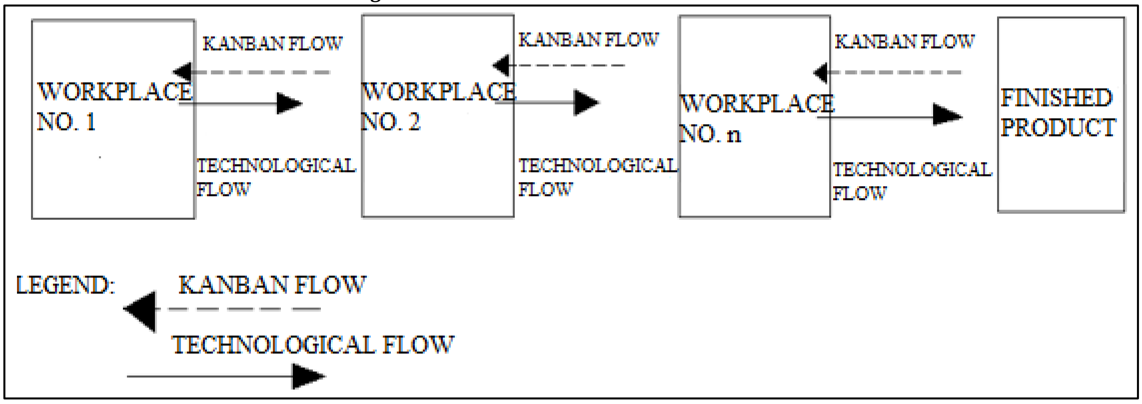
Industrial production is configured in consecutive workstation, one on the other, on the technological flow, from left to right. In this configuration, the landmarks progressively pass the production steps. Figure 3.1 shows the route of the parts according to the production flow (Rohan and Ingineria, 2004).

Figure-3.1 Route of landmarks according to the technological flow



The information flow generated by the Kanban method is carried out counter to the technological flow but simultaneously with it. In Figure 3.2, the route is set according to the information flow (Rohan and Ingineria, 2004).

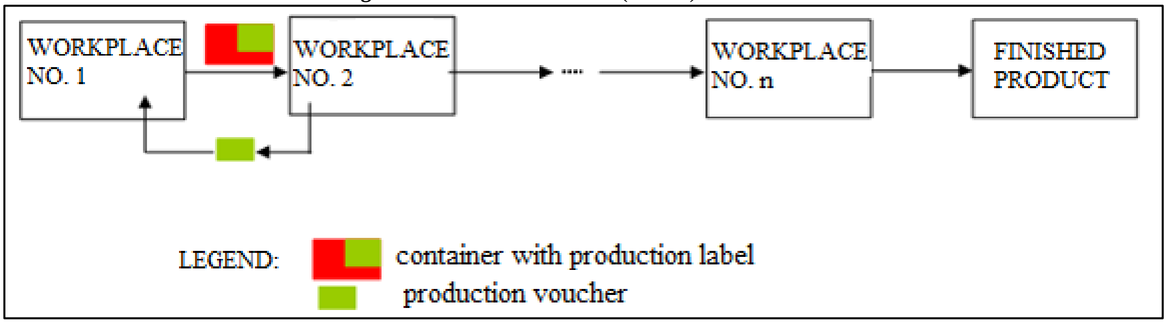
Figure-3.2 Information flow in the Kanban method



The analysis of the technological and informational flow shows that the second workstation processes the benchmarks that are being used at the first workstation. They are in a container, where the second workstation takes the *Kanban* label, which it returns to the first workstation, namely the downstream post. This label is the order or manufacturing order for the first workstation. When the first workstation - downstream - has completed the completion of the containers content, it attaches a label (a Kanban) and the container together with the label is sent to the upstream workstation.

If, from the first workstation, all Kanban are attached to the containers and sent to the second workstation, then the first workstation has interrupted production, waiting for a production order, a Kanban - for at the upstream workstation. Thus upstream production directs downstream production. Figure 3.3 shows the movement of the labels in the Kanban system.

Figure-3.3 Circulation of labels (kanban) and containers



This system of production and dissemination of information is made between all the work stations located on the technological flow, with the indication that each label is individualized. It specifies both the address of the workstation upstream and downstream, so it runs between two successive workstations. Such a tag is called *(Kanban) production label*. The use of this label implies that workplaces are consecutive on the technological flow and that there are storage rooms for containers at both workstations and between two successive jobs.

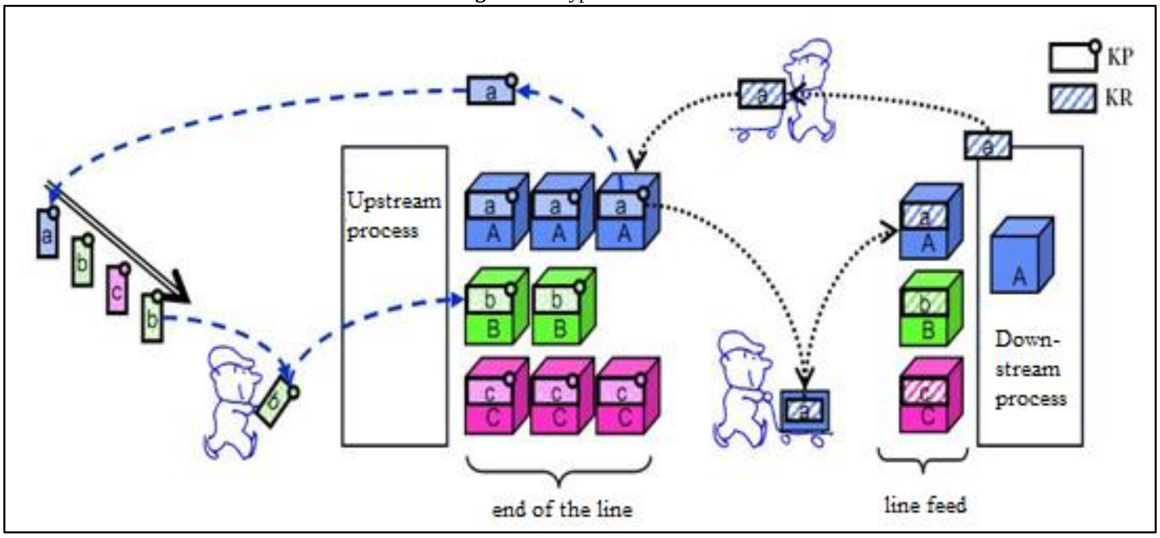
When working stations are remote from each other, in different workshops, for example, it is necessary to carry out an additional operation for the transport of containers with manufactured parts with Kanban (Dolea, 2016).

In the first place, kanban software enables monitoring and tracking of inventory, if calculates the number of labels starting from the situation without making drastic cuts, that is "calm flow of production." The commissioning of the system starts from balancing and sizing the inventories according to the consumption by the beneficiary section (Dolea, 2016).

Kanban is also a visual management tool for detecting process irregularities and eliminating overproduction.

Kanban cards have two major functions in production processes. Figure 3.4 shows Kanban flows and types.

Figure-3.4 Types of Kanban

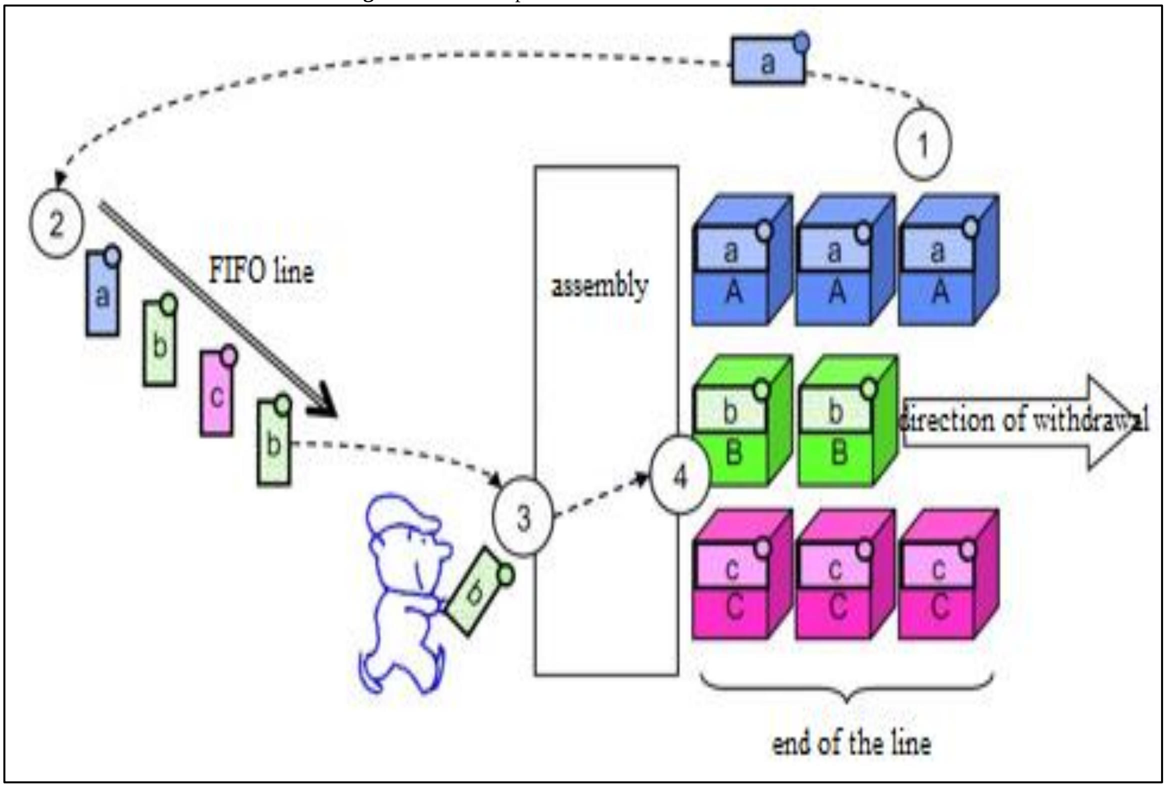


- The first function is called *Kanban production* – the process signaling to start producing the parts.
- The second is called *Kanban travel* (transportation) - warning workers to move the parts.

Depending on the composition of the manufacturing batch, Kanban production is classified in Kanban production with variable batch and Kanban production with fixed batch.

Kanban production with variable production batch is used for those processes that do not require adjustments when changing the benchmark. Usually, this happens only on the assembly lines, which are flexible and can change the assembled parts without having dead time. Prioul (2010) Figure 3.5 shows how to work without a fixed production batch.

Figure-3.5 Kanban production flow without fixed batch

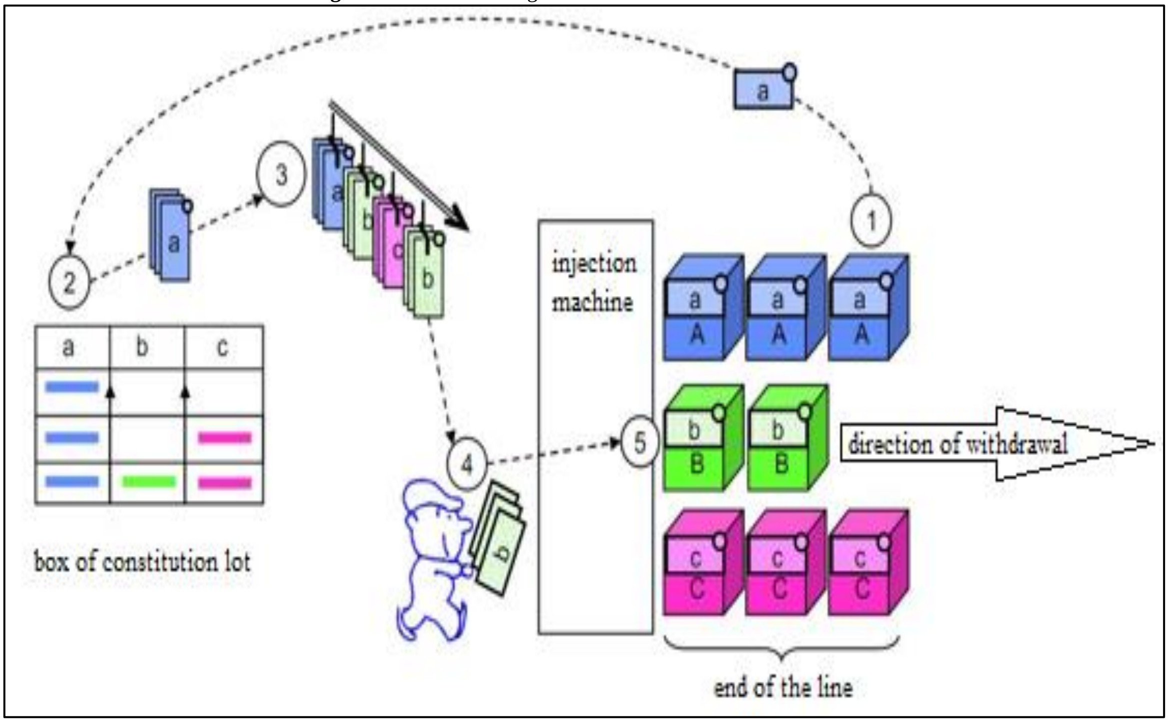


Kanban production with a fixed production batch is mainly dedicated to the production of parts that are made on machines and tools with tool change or mold. In order for these machines to be efficient and productive, they must produce a certain number of parts after a mold or tool has been changed beforehand.

This number of parts is determined by the duration of a mold and is transposed by creating a fixed batch of products to be manufactured (Prioul, 2010).

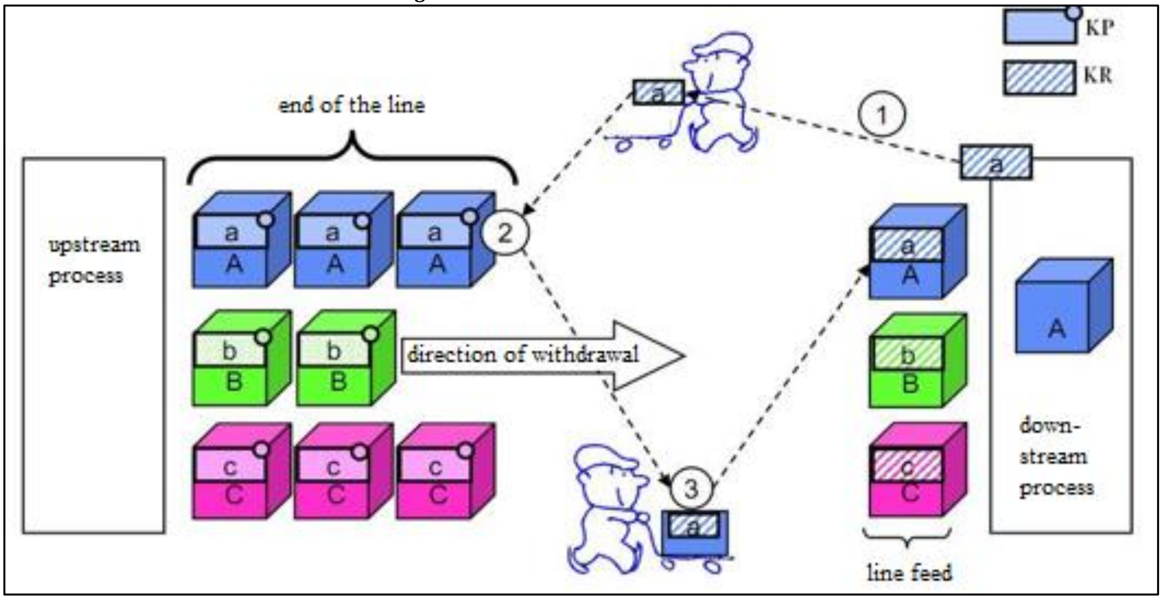
Figure 3.6 shows the production mode using a fixed batch of parts/cards.

Figure-3.6 Manufacturing mode with Kanban cards fixed batch



Kanban transport (KR) *or withdrawal* is a withdrawal order of a reference. It is used between processes to order withdrawals from a subsequent process. The circulation of this type of Kanban should aim at the simultaneous transfer of the products and the corresponding information as well as the frequent transfer of the products and the band. Figure 3.7 shows the Kanban's withdrawal flow.

Figure-3.7 Outline of Kanban's withdrawal



3.1. Determining The Number of Kanban Cards

The Kanban Card is the work tool that authorizes the transfer of materials during production between successive machining operations. A kanban must contain at least the following information:

- Product data
- State of material, the quantity of products in the container
- Destination of the container

It can be also found other information like:

- Drawing of the part, number of containers in the batch
- Information on the track of the parts in the production unit
- Information on packaging and treatment of parts

A kanban production system will work in good condition if the kanban number is well established. An important number of kanban allows for fewer ruptures.

A limited number of kanban will involve weak inventory, but if the flows are too large, the risk of rupture increases.

The objective is therefore to calculate a number of labels that make the best compromise between inventory size and service quality.

The method of calculating the kanban number "N" applied to Toyota is expressed in a general manner in this way:

$$N = \frac{(T_w + T_p) \cdot (l + a)}{C} \qquad (1.1)$$

In this relationship:

- Tw is the kanban waiting time
- Tp represents the response time of the manufacturing process (between the beginning and the end of the part manufacturing, the waiting time between them)
- l indicates the number of requests in the time unit
- □□represents the sizing safety coefficient
- C is the size of the kanban associated batch (example: number of parts in a container) (Soulard, 2001).

Calculating the number of labels in circulation in the loop on a particular item is:

$$N = \frac{lot + (C \cdot Tr) + Ss}{Q} \qquad (1.2)$$

Batch size is defined by Production Manager:

Tr - Response Time (Response to Request and Delivery)

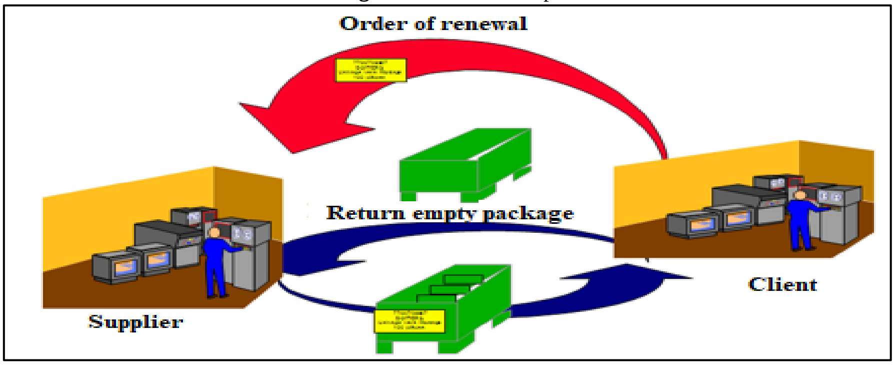
C - customer consumption

Q - the quantity specified in a container

Ss - the security inventory needed to cover unexpected production

3.2. Sizing the Kanban loop
The loop is delimited at the extremities through storage points. Downstream the storage corresponds to the storage of finished products from which the customer comes to supply. Upstream is the storage of raw parts (or intermediate products), is the reserve from which the workshop, run by the Kanban system, comes to take its needs.
All Kanban loops of different customer / supplier workshops are therefore linked via storage points.
It is very important to distinguish the storage point and the waiting point. A possible evolution, when several Kanban loops are, is to turn some storage into expectations, which allows to reduce the level of operations in progress.
Kanban loop is a label circuit of a kanban management system. This circuit is closed, the labels need not go out.
The Kanban loop is placed between the two sections, the beneficiary and executing ones, as shown in Figure 3.8.

Figure-3.8. Kanban loop



4. Conclusion
This method is currently being analyzed in detail to determine the total costs generated, and if it proves to be sustainable, it will be implemented across all product families in the production stream for factories that face similar situations.

The benefits of this method are not only to optimize the number of jobs in Kanban, with the impact of improving the entire production process in several directions:
- ✓ Improvement of the setting times for cutting machines, reduce the losses with the setting times of the different lengths for the canceled circuits;
- ✓ Improvement of operator errors, due to very small length differences and a similar Kanban root-code, operators were at increased risk of failing to read labels and sending faulty circuits to the assembly lines;
- ✓ Improvement of space for the Kanban area by effectively removing unused shelves from the production area, thus expanding the traffic lanes in the Kanban areas.

Thus, even if costs are generated by actually increasing the quantities of materials ordered, they are recovered by the savings generated by the optimization of the production process, the elimination of the scrap created due to the mistakes made by the operators in the debit zone as well as by the increase of the production capacity.

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