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PROCESS INNOVATION: HOLISTIC SCENARIOS TO REDUCE TOTAL LEAD TIME

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Rezumat. *Globalizarea piețelor necesită o dezvoltare continuă a scenariilor holistice de afaceri cu scopul de a asigura flexibilitatea acceptabilă pentru a satisface clienții. Îmbunătățirea continuă a lanțurilor de distribuție presupune îmbunătățirea continuă a lead-time-ului și a fluxului de materiale și produse, a stocurilor de materiale și de produse finite și creșterea la maximum a numărului de furnizori. Contribuția studiului nostru constă în prezentarea de scenarii holistice pentru îmbunătățirea și inovarea lead-time-ului total prin implementarea politicii lanțului de distribuție.*

Abstract. *The globalization of markets requires continuous development of business holistic scenarios to ensure acceptable flexibility to satisfy customers. Continuous improvement of supply chain supposes continuous improvement of materials and products lead time and flow, material stocks and finished products stocks and increasing the number of suppliers close by as possible. The contribution of our study is to present holistic scenarios of total lead time improvement and innovation by implementing supply chain policy.*

Keywords: process innovation, supply chain policy, supply lead time, production lead time, delivery lead time

1. Introduction

With the increase in global competitiveness, one of the objectives of manufacturing companies is to continuously improve the creativity of employees in order to continuously meet customers demands [1, 2]. The continuous improvement of human creativity [3] supports the development of innovative strategies [4] which refer to the creation of new products [2], new materials [5], new processes [6] and new technologies [7], better or more efficient or using ideas easy to put into practice [8]. In most cases, the effects of innovation are manifested by reducing the scrap ratio and the man/hour, by reducing the number of breakdowns and Mean Time To Repair (MTTR) duration [9], cost reduction [10, 11], minor stops/ idling elimination and rework reduction [8] . In order to achieve these desired effects, the innovation activities are typically focused on two main areas, namely: *continuous improvement of total lead time [12] and*

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continuous improvement of costs [13]. In order to safely deliver in accordance with customer requirements, the continuous optimization of material and products lead time and flow and the continuous optimization of material stocks and finished products stocks require a continuous process innovation in companies by boosting the creativity of all people to ensure an acceptable synchronization level of processes to market signals [14].

This article gives an overview of the importance of process innovation using holistic development scenarios for continuous reduction of total lead time by reviewing the literature, through open discussions with creative leaders from multinational manufacturing companies in Romania and by structuring the practical experience of the authors over the years. The issue of this article is to continuously improve total lead time by innovating the processes of manufacturing companies that require the development of holistic scenarios [15] for the improvement and innovation of supply lead time [16], production lead time and for delivery lead time [17], according to supply chain policy [18], such as compliance with customer requirements to maximize the On Time In Full - OTIF for the finished products delivery, to reduce the production constraints, to optimize finished products stocks, to reduce the changes to the production plan, to optimize parts stocks, to optimize raw materials stocks, etc. [19]. This paper does not refer to product, materials and technology innovation [7].

2. Theoretical framework

Liker [20] thinks that : *"People are responsible for innovation – it does not come from computers or from lean. It comes from individual imagination and persistence"*. Thus, creativity and innovation go hand in hand, and a decisive role is played by the *"contextual behavior of managers" [21]*. Martens, addressing creativity at work, believes that: *"Creativity is the ability to produce work that is both new and valuable"[1]*. According to Martens, creativity is a process in four phases:*"(1) Preparation. Investigation of the problem in all directions. This phase is characterized by gathering data and information for the process. (2) Incubation. Unconsciously thinking about the problem, implicit cognitive process, primarily individual. (3) Illumination. The appearance of "the happy idea" together with the psychological events that immediately preceded and accompanied that appearance. This is the moment in a creative process where a "flash" occurs and the winning concept cuts across consciousness. (4) Verification. The validity of the idea is tested and the idea itself is reduced to exact form. Are goals and values met?"[22]*

In order to continuously adapt to market messages, especially messages from customers [23], through creativity and innovation [24], production companies, like any other organization, are forced to make continuous changes at the level of

products and especially processes [6], but rarely at the level of technology [7]. In this context of continuous change, Holloway [25] believes that: *"innovation is defined as changes to a process or product that can be incremental (small or subtle change to an existing material or method) or radical (paradigm shifts in technology or outlook), all with the eventual goal of solving a problem".* In the context of production systems [24], changes can be made in small steps (*kaizen* [26], continuous improvement [20] or incremental innovation in small steps [20]) or in larger steps (*kaikaku* [27] or radical innovation [28]).

Based on workplace creativity approach of Martens [21], one may need a holistic approach to improvements and innovations. The holistic approach to improvement was analyzed from the perspective of *production systems* [29] and from the perspective of *continuous improvement process during the daily operations* [30], but not in terms of *total lead time* in order to improve productivity, quality and costs.

3. The conceptual model of total lead time

Synchronizing production processes to the takt time required by the customer and to the required supply rate needs a stabilization and a continuous improvement of *total lead time* with minimal flexibility cost. **(see Figure 1)**. Fulfilling the two basic principles of the continuous improvement philosophy, respectively the *continuous flow* [20] and the *one piece flow* [12] requires the creation of a synchronized system to use all resources and processes within manufacturing companies and further on to customers and suppliers, or until the customers of the production company's customers, or until the suppliers of the production company's suppliers.
In order to meet delivery promises to customers in terms of delivery times, and of quality level and especially of costs reflected in the price, it is necessary to continuously know the composition of *total lead time* through standardization, continuous improvement and continuous innovation of composing processes.

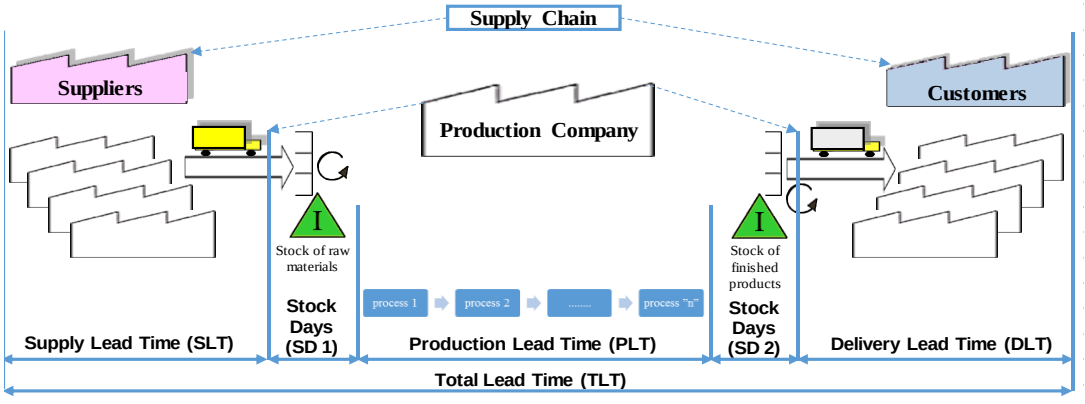

Fig. 1: total lead time.

Based on the previous figure, to collect data and analyze the *total lead time* the following measurements are needed:

a) Supply Lead Time (SLT) or raw material and components lead time (days):

$$SLT = SILT + SPLT + STLT \quad (1)$$

Where: SLT = Supply Lead Time (days); SILT = Suppliers Informational Lead Time (days); SPLT = Suppliers Production Lead Time (days); STLT = Suppliers Transport Lead Time (days).

Note: it is necessary to know the maximum, minimum and average SLT value for each type of supplier (including types of transport suppliers), considering the time of year, seasonality, the size of orders, the type of product, the mix of ordered products etc.

b) Stock of raw materials – SD 1 (days)

It is necessary to know the equivalent number of production days provided by the current stock level of raw materials and materials (including the level for the *buffer stock and safety stock*).

c) Production Lead Time (PLT) or factory lead time (days):

$$PLT = IPLT + MPLT \quad (2)$$

Where: PLT = Production Lead Time (days); PILT = Informational Production Lead Time (days); MLT = Material Production Lead Time (days)

Note: it is necessary to know the maximum, minimum and average PLT value for each type of product family;

d) Stock of finished products – SD 2 (days)

It is necessary to know the equivalent number of delivery days provided by the current stock level of finished products (including for the *buffer stock and safety stock*).

e) Delivery Lead Time (DLT) or product delivery lead time (days)

$$DLT = IDLT + TDLT \quad (3)$$

Where: DLT = Delivery Lead Time (days); IDLT = Informational Delivery Lead Time (days); TDLT = Transport Delivery Lead Time (days)

Note: it is necessary to know the maximum, minimum and average DLT value for each type of clients and transport suppliers;

f) Total Lead Time (TLT) (days):

$$TLT = SLT + PLT + DLT \quad (4)$$

4) Holistic scenarios to reduce total lead time

For manufacturing companies, the continuous synchronization of production processes to external customers (takt time by types of customers; product

families) and *the stabilization and reduction of production lead time require a holistic approach of total lead time* and not just a punctual reduction of SLT, SD1, PLT, SD2 and DLT.

Based on the composition of total lead time **(see Figure 1)**, the basic scenarios for customer orders can be the following:

- ✓ **Scenario 1:** the customer places orders for finished products that are already in the finished goods warehouse (usually in the safety stock):

$$TLT = DLT \tag{5}$$

- ✓ **Scenario 2:** the customer places orders for products that are not in the finished goods warehouse, but all necessary raw materials and auxiliary materials are the warehouse of raw materials and materials of the production company:

$$TLT = DLT + PLT \tag{6}$$

- ✓ **Scenario 3:** the customer places orders for products that are not in the finished goods warehouse and not all necessary raw materials and auxiliary materials are the warehouse of raw materials and materials of the production company:

$$TLT = DLT + PLT + SLT \tag{7}$$

Even if *scenario 1* has the shortest total lead time, in accordance with the *pull-type production systems [18]*, the best scenario is *scenario 3*, with the condition that the *total lead time* is acceptable in terms of money raised, namely maintaining a minimum level of stocks. Scenario 3 can continue with different scenarios. The worst scenario is when our customer places orders for which our supplier does not have the necessary raw material in the warehouse. Each scenario should take into account the minimum, maximum and average lead time level. Depending on the historical volumes and on the planned volumes to be delivered, one will devise individual improvement plans and innovation plans of each type of total lead time, paying particular attention to SLT.

The holistic approach to reducing the total lead time for the three scenarios, requires a continuous development of *supply chain policy [19]* and hence an action plan to continuously improve and innovate both the components of total lead time (SLT, SD1, PLT, SD2 and DLT), and total lead time itself. From the holistic approach of total lead time, we are presenting a series of actions on innovation and continuous improvement for SLT, SD1, PLT, SD2 and DLT, impacting over total lead time (or impacting over the whole production system).
So the holistic direction of continuous improvement and innovation of processes for continuous reduction of total lead time could be:

- ✓ for *Delivery Lead Time (DLT)*, in order to increase the level of compliance to customer requirements could be: increasing the understanding of the exact product specifications from clients (from the first request of the client); increasing the accuracy of forecasts for supplying to customers; reducing/ eliminating the dispatch control; maximizing the *On-Time In-Full (OTIF)* for finished products delivery and increasing the load level of trucks in accordance with the stocks of finished products; increase accuracy when meeting the delivery plan etc.;
- ✓ for *Stock of finished products (SD 2)*, in order to continuously reduce the stock of finished goods: respecting the hours standards for finished products in the warehouse; making the stock of finished products according to the forecasts of customers' orders or based on orders; increasing accuracy for *buffer stock and safety stock*; increasing the score of the *5S* audit for warehouse(s) of finished products; increasing the automation when organizing the warehouse(s) of finished products; increasing the forecast accuracy for stocks in scenario 1 (TLT = DLT); keeping stick at the right level of quality etc.;
- ✓ for *Production Lead Time (PLT)*, in order to continuously reduce the unplanned production plan changes by increasing the synchronization of production processes on SLT and especially on DLT: increasing the compliance flexibility of production processes to customer requests with a minimum cost; increasing the synchronization between production processes; increasing the accuracy of the stock level next to equipment and of the planning of *Work in Process (WIP)*; eliminating all the breakdowns and reducing the *Mean Time To Repair* (*MTTR*) through a rigorous preventive maintenance planning; increasing the identifying of production processes constraints, especially for new products; increasing the number of cheap equipment which is able to achieve products according to customer specifications; increasing the number of simple design equipment; increasing the number of small batches and full implementation of the *one-piece flow production* principle; better knowing and sizing WIP in accordance with the production mix; reducing the number of operations; reducing the time of transfer between workstations; continuously improving and innovating the workplace organization design; reducing/ eliminating manual transfers between workstations etc.;
- ✓ for *Stock of raw materials (SD 1)*, in order to continuously reduce the stock of raw materials and components by successive standardization of consumption of raw materials and auxiliary materials: increasing the accuracy of current stock level; increasing the accuracy of special stock levels (raw materials, components and spare parts with high risk in case of missing or with high supply lead time); reducing the set-up time or

innovating the set-up time (no significant set-up) and the cycle time for equipment in order to continuously reduce the stock level; increasing the score of the 5S audit for warehouse(s) of finished products and components; increasing the automation when organizing the warehouse(s) of finished products and components; increasing the use level of standard parts of products (by successive innovations of product design); increasing the synchronization between the stocks of raw materials and components and SLT; keeping the stock at the right level of quality; increasing the accuracy for *bill of materials (BOM)* for every new product to be produced; increasing the accuracy for re-ordering point systems etc.;

- ✓ for *Supply Lead Time (SLT),* in order to continuously increase the synchronization level between supply lead time and production takt time: increasing the performance level of the current suppliers management but especially of the new suppliers management; reducing the supply costs; increasing the number of suppliers with an acceptable level of lead time and quality, but with a lower cost level; increasing the number of suppliers with a large production capacity in line with market volume; increasing the number of training actions with suppliers in order to continuously improve SLT; increasing the number of joint actions to improve and/ or innovate processes with suppliers in order to continuously reduce SLT etc.;

Therefore, in accordance with the first phase of creativity at work by Martens [1] (*Preparation. Investigation of the problem in all directions),* to address issues and to develop a consistent master plan for process innovation and continuous improvement over the total lead time, the production companies need to articulate rhythm and volume of customer demands with the exact location of innovation and improvement projects along the total lead time, in order to determine the types of methods, techniques and tools necessary to innovation and continuous improvement.

For example, if the annual seasonal strategy of a manufacturing company is to have about 25% of deliveries directly from stock of finished products for July-September and the rest of the year 15%, then the process innovations and improvements will be focused especially for DLT and SD 2 by continuous development of holistic scenarios.

This will be the ongoing concern for the whole company, but especially for top managers, in order not to create unnecessary opportunities for unjustified cost increases (overstock for current stocks, buffer stocks and safety stocks).

Conclusions

This paper provides a development of the *total lead time* (SLT, SD 1, PLT, SD 2, DLT, TLT) approach and a description of the different types of total lead time and the holistic approach of three scenarios for innovation and continuous improvement of processes in production companies. A first conclusion of our work relates to scenario 1 which, although having the shortest total lead time and being able to help meeting customer need to achieve short time deliveries, needs to be continuously monitored in order not to get in a position to take over storage and unjustified increases of associated costs. A second conclusion relates to the need for development of holistic actions of innovation and continuous improvement in order to continuously increase the level of synchronization between the supply lead time and production takt time. A third conclusion relates to the need to continuously standardize the *Work in Process (WIP)* to prevent overstocks and thus increasing of total lead time.
For future research, it can be said that the development of holistic scenarios for innovation and continuous improvement of total lead time can contribute to targeting strategies in order to meet the principles of *continuous flow* and *one piece flow* and successfully implementing the Kanban technique [18].

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