

# The impact of integrating a good level of service into an inflexible sytem

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## Abstract

At present, the level of service in manufacturing industries has brought about more commitments to satisfy customers with faster deliveries and a larger variety of product quality aspects. For this reason, industries need their material processing systems to respond effectively and self-adapt to market needs. In turn, this may generate high expenses when trying to offer a good level of service in a non-flexible manufacturing system. This investigation will show the case of a Colombian industry with little flexibility and an ease factor analysis $f_{ij}$, according to a variety of products that could be processed by the production line in a fast way.

*Key words*

Flexibility, Service level, Ease factor, Automation, Inventory.

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## 1. Introduction

The continuing growth in market demand in terms of when, how much, and where customers or markets want their products, as well as the possible combination of demands, has encouraged production systems to look for appropriate technologies for timely and efficient processing. In trying to harmonize the companies with this level of service in stochastic environments, a commitment to effectiveness rather than efficiency has emerged when they do not possess the required flexibility. This paper is aimed at showing the results of a study on the consequences of inflexibility in a production system. Additionally, the paper examines and analyzes the associated ease factor [1], which provides an adequate examination of the behavior of the production system versus flexibility. This paper is divided into two parts. The first sections will review the literature regarding aspects such as the components of a service level, stocktaking as a buffer between demand and supply uncertainties, and finally the role of flexibility as a technology [1]. In the second part of the paper, an ease-factor analysis is made for a real case study. Finally, the paper describes the importance of future analysis for other companies and provides concluding remarks with the highlights of the research.

## 2. Service level

Customers receive the offers of a whole company in terms of price, quality, speed and service, and respond in accordance with their preferences for the product or the lack of it, compared to other products of the same kind [2]. This suggests that a company that offers a good level of service has a competitive advantage. Customer service is a rather broad term that may include many elements, for this reason the term requires citing some definitions. We start with a definition that states that the customer service, when used effectively, is a key variable that can have a major impact on creating demand and maintain customer loyalty [3]. For other experts on customer service, the term specifically addresses the chain of activities aimed at satisfying sales, which generally begin with the entry of the order, and end with the delivery of products to customers, continuing in some cases as a either a service or equipment maintenance benefits, or other technical services [4]. Finally we have established the following definition for many companies: customer service is the speed and reliability through which the items ordered by customers can be made available [5]. The latter concept is the one that more closely represents the goal of this research.

For a better approach to the definition of customer service within this research, we may establish the kind of items or activities that constitute the time in which the transaction occurs between the supplier and the customer [6]. The pre-transaction elements set the right environment for good customer service. Within these activities of pre-transaction the flexibility of the system is generated. This will be the most important part of the process and it allows a client to create his or her own preferences since it allows knowing the time in which their products will be delivered, once one or more orders of various products have been properly generated. Followed by pre-transaction elements are the elements of transaction, where product-delivery activities are generated. It is at that point where more factors coexist due to the high degree of uncertainty involved in the materials conversion system. The solution posed by most companies to absorb the activities of supply and demand is the generation of inventory levels, which will control the deviation from the forecasts of actual demand data. Finally, we have the elements of the post transaction, representing the set of services necessary to maintain the product in the field. These services are presented after the sale of the product.

## 3. Setting inventory levels

Inventories are defined as an amount of goods and services under the control of a company, saved for some time to meet future demand [7]. The inventory is a "buffer" between two processes, namely supply and demand. The process contributes to supplying goods inventory as the demand consumes the same inventory. This is necessary because of the differences in rates and times between supply and demand [8]. For these reasons, it is justifiable to maintain an inventory together with regular accumulation of products. Assemblies and materials through a prolonged period of time may ensure the attention of a very uncertain future demand or may serve a seasonal demand pattern with a very strong peak value. This ensures that production systems do not collapse in a period of time and maintains a regular production pace that behaves efficiently by not moving all the company's resources to meet such demands.

Unfortunately the inventory does not add value to the system conversion of materials since these are created to comply with an immediate demand. This is directly related to the level of service you want to offer, but taking the wrong way can cause overruns [8].

One inappropriate way of managing inventory is to generate excessive levels, with the aim to cover flaws or weaknesses within the system of production. Let us start looking at these problems from the perspective of the production chain.

When the client requests an order, such order enters the system. To maintain a high level of customer service; the minimum, maximum and average processing time of an order must be considered, attempting to not generate delays in the delivery of the product. When the production system cannot process an order in a timely manner, this order form disrupts the efficient flow of the system and generates dead times, which multiply in each operation of the conversion of materials and generate a summation of time delays, reflected in a total delay time for unplanned delivery. The solution includes excessive levels of inventory to avoid time delay in supplying the demand.

The next most common failure is when the system is unable to handle real-time rates in excess or missing inventory, namely the percentage of orders completed in full and the percentage of requested items arriving late. This leads to taking the same solution to maintain excessive inventory levels and avoid disagreements on the level of customer service.

Also, regarding the setup times, when the system needs reconfigured to produce variety, if setup times are too long, the only effective solution is to maintain high inventory levels of one type of product to meet demand when the system cannot cope because it is busy processing a different product.

In these three cases the problem is either the lack of properties that enable the system to support changes in activities or the processing capabilities of the system in real time [9], which generate excessive levels of inventory to try and maintain a level of service.

## 4. Flexibility as an allied technology

Flexibility could be defined as the ability of a production system to rapidly design and introduce a new product into the market, while meeting the changing patterns of product volumes necessary to provide a better product mix [8]. Flexibility may also be referred to as the availability of alternative resources to adapt to a changing environment [10].

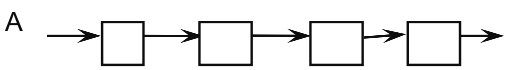
The increase in the variability of conditions in the external environment (market, economy) and also in the actual operation of the production systems has required the development of capacities to adapt to these changes. For this reason, flexibility in production systems is required to conform to the uncertainty caused by variability.

Thus the objective of flexibility is to maximize the reconfigurations in terms of time reductions not to alter the flow of materials in each operation and to provide variety.

In the ideal state of a production system, each work should begin as soon as possible and should be processed without interruption within a given processing time.

When production systems are of a dedicated product distribution type or in extreme cases, when systems do not generate discrete units (e.g. chemical industry) the total flow time of the material processed through the system equals the processing time. (See figure 1)

**Figure 1. Distribution Online or by Product**

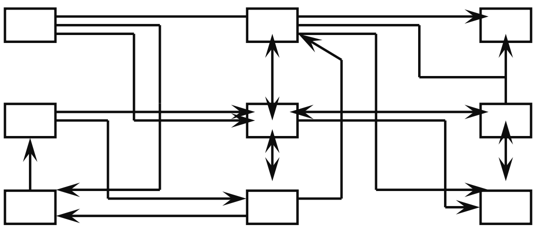



Source: own elaboration

However, when there is dependence employment that occurs when the time needed for a job depends on the work that is above a process, the time set-up must be generated; this is clarified in the following example: If product 1 needs a set of tools for processing and product 2 requires the use of other tools necessary for processing; then after processing product 1, the system needs to change the tool setup before processing product 2.

The setup time is often observed in intermittent production lines that involve a distribution process. This type of production lines exhibit particular features, namely variety and product mix are not as rigid as they are for dedicated lines. (See Figure 2)

**Figure 2. Distribution Functional or Process**



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Offering a level of service provides a competitive advantage. Flexibility efficiently reaches this goal [11] since it minimizes the time of order processing as well as the irregular demands, and also minimizes setup times by reconfiguring the system iteratively. This contributes to complying with supplies demands and coping with a high degree of uncertainty in an almost instantaneous way. For this reason it has been shown that flexibility is an important influencing factor in strategic organizational changes [12], aiming at providing maximum levels of service without the need to maintain or generate an inventory.

## 5. Real case analysis

The company is called ASENVASES Ltda. This is a metal-mechanical industry dedicated to the design, manufacture and marketing of electrolytic tinplate cans, targeted towards advertising, promotional campaigns, social expressions, food and industrial applications. To date, the company offers a wide range of products according to size, shape, finish foil and accessories.

### 5.1. Manufacturing process packaging tin

As a first step, the raw material is received and verified to comply with the required specifications. Subsequently, the materials are stored in the storage area of raw material.

Then, as a second step, staff proceeds to cut the tin shears according to the size required for packaging.

As a third step, sheets are cut and sent to the assembly section, which consists of the following sub-processes: 1. Imprinting the forms and making necessary holes for the container, mainly at the bottom and lid, 2. Rolling the sheet and join the ends, 3. Seal the can with welded seam or graph as the packing material in order to preserve the coating applied to the material; 4. Eyelashes 5. Placement of the bottom and the top is fixed. The last consists in doing the packaging; the material is ready to be dispatched to customers and is stored in the finished product area.

### 5.2. Evaluation, planning and structuring the distribution system and selling products

The process of selling products in ASENVASES Ltd. begins with the generation of a purchase order by the customer. This order processing begins with a review by the management department, which approves or rejects the processing of orders. If the project is accepted it sends a quote to the customer with the price ratio according to the products ordered. Then the process waits for the client response to continue processing the order in a twofold fashion. The first path is the review of inventories for confronting whether the product is in stock and, if so, the order is shipped to the customer immediately. The second path is to generate a production order, which takes into account the type of customer, the specifications on packaging and the delivery dates. Delivery dates agreeing with the customer's needs depends on the characteristics of the container.

### 5.3. Excess inventory

The main problem that may arise is the existence of a high level of inventory distributed throughout the plant, triggering chaos and difficulty in the flow of resources and materials through it. This situation has generated most of the floor space intended for storage of finished product inventories or sub-assemblies. As stated above, inventories are capital investments of non-added value to the productive chain and, if not managed effectively, they can generate a lot of costs or hidden flaws in the system. Moreover, the physical handling of inventory has been costly and difficult, causing space waste in many areas within the plant.

Additionally, inventory of finished goods and work in progress reduce the maneuvering space in the material processing facilities, causing delays and other unconformities associated with the people who work there.

In the case of the company, there are two factors that encourage excess inventory.

The first relates to the times used to reconfigure the system to process and offer product variety. The times associated to the line changes are huge, generating a multiplication in processing, which results in delays in supplying the demand. All this causes operational cost overruns: the inefficient use of resources associated with the transformation of materials, while neglecting the overall time for the company, generates a considerable reduction in capacity and unintended costs associated with missing space; this can be associated with low levels of service, product substitutability and low preference by the market.

The second factor refers to maintaining the level of service associated with the product mix that the system can process. The company has customers who buy a low percentage of units. Through economics of scale reference of a product in large volumes it is possible to reflect a competitive price in the market. In addition, the replenishment of this market occurs almost immediately by the decision made to keep these units in stock

### 5.3. Problem analysis

The ability of a system to quickly reconfigure and provide different products describes a system with a strong tendency to possess flexibility or flexible features. In one dimension [13] studied on the research methodology to measure the degree of flexibility in manufacturing systems [1], the following mathematical model is proposed:

$$\frac{1}{Q_m}\sum_{Np} 1-\frac{T_{Sij}}{T_p+T_{Sij}} f_j \qquad (1)$$

This model [6] relates the dimension of flexibility to product change [10], which measures the time taken by the system to process a product whit some modification, the preparation time required by the system when changing products (specifies that the system is processing a different product each time varying attributes or characteristics of functional design [1]), and the amount of products the system can produce. In this model, the time scale and its measurement are reflected in three variables; two directly (2 and 3) and one indirectly (4).

$$T_p \qquad (2)$$

$$T_{Sij} \qquad (3)$$

$$f_{ij} \qquad (4)$$

Where $T_p$ is the sum of processing times of different products in the system with its amendments and $T_{Sij}$ is the summation of the time taken to reconfigure the system to process different products with some modifications.

When we have an ideal state of flexibility, the total time taken by hard material flowing through the system of conversion is equal to the sum of the processing times for each product.

The following equations illustrate the concepts mentioned in the previous section:

$$\begin{aligned}&\sum F_t = \sum T_p\\ &F_t = T_p\\ &Then\\ &T_p = T_p\\ &1=\frac{T_p}{T_p}\end{aligned} \qquad (5)$$

When the proportion shown in equation (5) decreases, the sum of setup times $T_{Sij}$ between different products becomes non-zero (see equation 6). This creates discontinuity in the total flow time within the system, which affects the decrease in flexibility or flexible features. Then the combination of equation (5) with the relationship to the proportion of total available time is equal to:

$$1-\frac{T_{Sij}}{T_p+T_{Sij}} \quad \text{in} \quad \text{Where} \quad T_{Sij}\neq 0 \tag{6}$$

Equation (6) shows that participation has $T_{Sij}$, within the total flow time $T_p+T_{Sij}$. The larger $T_{Sij}$, in proportion to $T_p+T_{Sij}$, the more comprehensive preparations the system will use in the time available, thus resulting in a considerable reduction of the installed capacity of the system. This generates delays in delivery, low level of service and contributes to resource waste, which causes higher costs [13].

In the investigation of the model [1] that relates the dimension of flexibility in changing products, we analyzed the reconfiguration process that was provided for certain materials that allow short setup times. The fundamental reason is the degrees of facility that products give to each other so that the system is capable of processing, changing and then processing another product quickly.

This new factor, called ease factor $f_{ij}$, has an inverse relationship (See equation 7) with the sum of setup times. When the system shows an increase in $T_{Sij}$, $f_{ij}$ decreases. This is consistent, since as more cumbersome reconfigurations occur in the system while processing product $i$, more preparation time will be necessary to process a future product $j$.

$$T_{Sij}\propto\frac{1}{f_j} \quad \text{in} \quad \text{Where} \quad (0\leq f_j\leq 1) \tag{7}$$

## 6. Ease factor in the real case

For ASENVASES company Ltda., a factor analysis of Ease $f_{ij}$ allows measuring the problems that revolve around the excess inventory. This shows the impact of trying to integrate a high level of service into a system with an inflexible production line, or into a system that can be quickly reconfigured when wanting to process a variety of products.

The factor of ease is then to be analyzed:

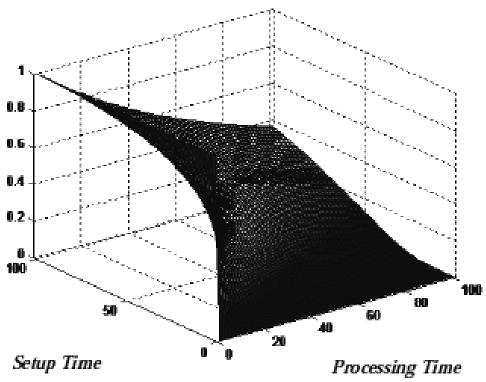
$f_j$, Corresponds to the measurement of easiness (ease factor) in the production line of ASENVASES Ltda. when moving from one product to another, which depends on the value of the constant.

$f_j$ will then be a vector of $m$ entries, calculated as follows:

$$f_j=e^{-\alpha\frac{\sum_i Sij}{t_j}} \tag{8}$$

Simulations were conducted and the following results were obtained: In figure 3, ease factor $f_{ij}$ is closely linked to the perception, as a variation of the proportion of preparation time $T_{Sij}$. Ease factor $f_{ij}$ shows how easy it is to configure the system to process a varied mix of products, that is, the ease factor $f_{ij}$ related to a large proportion of preparation time $T_{Sj}$ with respect to the total flow time $T_p + T_{Sj}$. Figure 3 also shows the difficult condition to reconfigure and offer a variety of product mix and a ratio less than or close to zero in preparation time $T_{Sj}$ with respect to the total flow time $T_p + T_{Sj}$, that is, to ease the condition to reconfigure and offer product variety mix.

**Figure 3. Behavior of Ease factor according to the setup times and processing times**




Source: own elaboration

## 7. Conclusion

In studying the case of ASENVASES company Ltda., it was observed that factor $f_{ij}$, which is the facility that supports quick reconfigurations processing for product variety, tends to zero. This is consistent with what has been described on the times to make a line change, which does not allow costly and time consuming processes, rather the production of small batches of a product variety.

This leads to the solution currently adopted, namely to build finished goods inventory in excess, to supply a good level of service by coping with customer demand with small product volumes or to serve customers that consolidate various references in small volumes.

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