Definition of Inventory Management Policy of Semi-finished Goods in a Tobacco Industry

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Abstract

This paper presents a case study about inventory management of semi finished goods at a tobacco firm in Brazil. A new inventory management policy was developed. The results reveal that safety inventory size is limited by the storage capacity. It´s suggested a feasibility study to enhance storage capacity.

Keywords: 1) Inventory Management, 2) Safety Stock 3) Storage Capacity

Introduction

Inventory management, according to Ritzman and Krajewski (2004), is a concern of huge importance to managers in companies of all sizes and kinds. By one mean, there's a pressure for small stocks, since it represents an investment of financial resources in goods, and also several maintenance costs related to storage, handling, taxes, insurance, loss, and so on. On the other hand, there's the pressure for big stock to ensure a good service to the client, reducing potential delays in order deliveries due to lack of finished goods and also to optimize the costs related to purchase orders, batch and payment to providers. Thus, the challenge faced by inventory managers consists in determining the appropriate stock levels, making this pressure compatible, reducing costs without impact in the service quality.

The objective of this paper is to describe the policy definition process of semi-finished goods stocks in a large cigarette manufacturing company located in the state of Minas Gerais, Brazil. It's intended to describe the situation of the company before the policy definition, and also the aspects that motivated its beginning; describe the process and actions developed in the project and describe the results achieved in the observed period.

Theoretical Framework

The concept of Stock is defined by Corrêa and Corrêa (2006), as gathering of material resources between specific stages of the transformation process, which fundamental property is to provide independence to these production stages. The authors differ (input) material stocks from finished products stocks and its functions: the input stocks are used to regulate the differences between the provider's supply rate and the demand in the production process,
while product stocks are used to regulate the differences between production rates and market demands.

Bowersox and Closs (2007) define stock policy as norms concerning what to buy or produce and when and how much should be produced. It's also included in the policy the decisions about positioning and allocation of stocks in factories and distribution centers. Another component of the stock policy, according to Bowersox and Closs (2007), is the management strategy, which may include interdependence between stocks in distribution centers, which incurs in central management with better coordination and communication or an independent management in each distribution center.

Reposition time, or response Lead Time is defined by Fleury, Wanke and Figueiredo (2008) as the response time between the order placement and the answer from the final client, or subsequent process, in case of semi-finished goods. According to Slack et al. (2002), Lead Time, just like the demand, isn't completely predictable and has variability in function of external factors not controlled by the operation - the uncertainties - which may result in delayed deliveries. The quality of the Customer Service, according to Bowersox and Closs (2007), is an objective set by the high management, which is compounded by performance goals which the stock function must be able to accomplish. This level may be determined in terms lost cycle time, percentage of responded quantities or a combination of these two goals. The cycle of activities comprehend the period between the delivery of client's orders and the receiving of the ordered merchandise. Since the percentage of responded quantities is the percentage of required quantities which is responded promptly in each time (BOWERSOX et al., 2007).

The safety stock, according to Dias (2010) is the minimum amount that should be in the inventory, destined to cover eventual delays in the re-supply, with the objective of ensure the uninterrupted and efficient functioning of the productive process, without the risk of lacking. When there's a predictable re-supply time, but there's variability in the predicted consume, Wanke (2010) proposes the traditional and precise mathematical model (as seen in Equation 1). The service factor may be obtained consulting the Table 1.

\[
ES = k \times \sigma D \times \sqrt{TR}
\]

Equation (1)

Where:

ES = Safety stock
K = Service factor
\(\sigma\) = Standard Deviation
TR = Response Time

<table>
<thead>
<tr>
<th>Service Level (%)</th>
<th>K Factor</th>
<th>Service Level (%)</th>
<th>K Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>0.05</td>
<td>80</td>
<td>0.84</td>
</tr>
<tr>
<td>55</td>
<td>0.13</td>
<td>85</td>
<td>1.04</td>
</tr>
<tr>
<td>60</td>
<td>0.25</td>
<td>90</td>
<td>1.28</td>
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<tr>
<td>65</td>
<td>0.39</td>
<td>95</td>
<td>1.64</td>
</tr>
<tr>
<td>70</td>
<td>0.52</td>
<td>99</td>
<td>2.33</td>
</tr>
<tr>
<td>75</td>
<td>0.67</td>
<td>99.9</td>
<td>3.09</td>
</tr>
</tbody>
</table>


The capacity is defined by Chase et al. (2006) as the amount of output that a system is capable of attaining under a specific period of time. According to Slack et al. (2002, p. 344) "the definition of capacity in an operation is the maximum level of value activity added in a determined period of time which the process may perform under normal operating conditions". According to Chase et al. (2006), the objective of strategic management of
capacity consists in determining the total capacity level for capacity of intensive capital resources - facilities, equipments and the total size of the workforce in order to support the long term competitive strategy of the company. The strategic management of capacity involves the investment decision that must combine the capacities and resources to a preview of long term demand.

**Methodology**

This is a descriptive study with qualitative approach, produced as a case study, which is, according to Severino (2007), a research focused in the study of a particular case, considered representative in a set of analog cases. Case study is a research method that often uses qualitative data, collected from real events, with the purpose to explain, explore or describe the phenomena inserted in its own context. To elaborate this case study of the Company X, the most used techniques were the direct observation in the company, consulting the project records and company's internal documents which were specific to the case presented. Gerring (2004) maintains that the application of the case study for tests or confirming theories is limited. Bennet (2004) affirms that case studies have low representativeness because it's not possible to turn it in general cases and the poor possibility to evaluate the relation between cause and effect between the variables.

**Case Presentation**

Company X is a large cigarette factory located in the state of Minas Gerais, Brazil. Company X works in the whole cycle of the product, starting from the production and processing of the tobacco until the manufacture and distribution of cigarettes. Aside from the tobacco processing until the own production and distribution of cigarettes destined to the national market, the integrated production system in the company produces tobacco for export purpose. The given finished product, the cigarette, is composed by two main semi-finished goods (SFG): filter and tobacco blend, besides other raw materials, such as paper, stickers and packing materials. The project to define a stock policy which was the study subject in this article was developed to the semi-finished good Blend. Due to the huge difference between products, the productive processes and the supply forms, the same concepts and methodology couldn't be applied to the semi-finished good Filter, which has an independent management.

**a. Diagnosis of the situation found**

The planning of the semi-finished good "Blend" was informal, based only in the knowledge and experience of the production analyst in charge of programming during nine years. No specific methodology was used for the calculus of safety stock and there were no records of the real response capacity. In front of a situation with many stops in the production process of the cigarettes due to lack of adequate Blend stocks, the need for a formal planning was raised, with methodological basis, which gave form to the project of Definition of Inventory management Policy of Semi-Finished Goods, object of study in this article. Among the several causes that may cause the engines to stop, the highlights are: parts breakage, electrical failure, lack of raw materials, lack of semi-finished goods, lack of workforce, corrective maintenance, lack of energy supply input, and so on.

The intelligence and manufacture area keeps an archive named Production Follow-up, which contains records of planned volume and daily produced volume for each production module, by the cigarette Stock Keeping Units (SKU). This archive also has commentaries
that register the motives for engine stops and the impact in the volume of lost produce. The volume loss is calculated based in the data of time during the stop registered in the Makers overseeing system. In company X, this calculus is made based in the concept of Zero Based Loss Analysis (ZBLA), in which the lost production volume is calculated over the nominal capacity of the engine and not over the planned volume over the effective capacity.

Picture 1 shows the monthly volume of cigarette loss due to engine stops in the Secondary Manufacturing Department (SMD) caused by lack of blends. February was an uncommon month, because there was a change in the primary process that caused stops in the occasion of switching blends. In May, when the volume of cigarettes lost in SMD increased due to lack of blend, it was raised the need of a formal safety stock planning in the Cut Rag Department (CRD).

![Volume of Lost Cigarettes Due to Lack of Tobacco](image)

**Picture 1: Chart Volume of lost cigarettes due to lack of tobacco.**

Source: Produced by the authors

Towards the given data, the proposal was to create a new formal policy of semi-finished goods fit for a cigarette company. This policy should meet the characteristics and limitations of the factory and the stock planning should be able to ensure that the demand can be responded in a satisfactory customer service level, with the smallest budget possible locked in stocks.

b. Changes in the Production Process

Previously, all blends processed in the Primary Manufacturing Department (PMD) passed through two leaf processing leaf lines: half of the batch passed through the regular leaf line and the other half through the roasting leaf line. However, the blends with roasted "notes" that indeed passes through the roasting chamber were just a few SKUs of cigarette, that have sporadic productions.

With the objective of reducing costs, in the beginning of 2014, the product development team started a development project for the recipes in order to migrate the blends that didn't need to pass through the roasting chamber for processing in single line, the regular leaf line. Doing so, it would be possible to reduce the manufacture costs to operate both lines and the costs with energy input to maintain two lines working. The challenge consisted in changing the recipe of the blends and ensure that there wouldn't be any loss in its visual, smoke, chemical and physical characteristics, which are the signature of each cigarette brand, so that the customer wouldn't notice the change. In March, 5th 2014 the migration was concluded. Afterwards, fundamental variables for the calculation of safety stock were changed: the production time of the single line blends increased and the weight of the batches was altered.
That said, the first steps to define the stock policy were: review the average weight of the batches, review the lead time in the primary process and revising the storage capacity of the CRD.

c. Review of the Average weight of batches

Called ‘Savings Project’ in the PMD, another action to reduce costs in the primary process that was implemented in composing the new single line blend recipes was the increase of the fill power - the blends occupied more room in the cigarette, thus, the cigarette kept the same size, but with a smaller amount of tobacco. In the Value for Money blends, it was increased the percentage of addition of Stems. In Premium blends, it was increased the addition percentage of a tobacco leaf called DIET (Dry Iced Expanded Tobacco), which is the tobacco leaf expanded with dry ice (CO2) which has 60% greater fill power than the non-expanded tobacco leaf. Being so, the batches became lighter but used more room space in the warehouse. The deviance in the average weight of the batches was measured after three months of single line production, based on the scale history recorded in the automation system from CRD. The average weight found was 7.200kg, 300kg less than the average in the previous blends, which was 7.500kg.

d. Lead Time review

After implementing the changes in the production process, to be used as a goal to internal productivity indicators, a conference was made to ensure all the necessary conditions to produce the blend: verifying the available workforce, adjustment of the humidity and temperature set points and the supply of tobacco and energy inputs. Also it was made the follow up and timing of production from beginning to the end of a roasting batch and a single line batch. The ideal times found was:

- Start of the roasting leaf line: 02h00min
- Start of the regular leaf line: 01h00min

For many reasons, there are deviations in lead time. Events as briefing meetings with the workforce at the beginning of each workday; electrical problems after deep cleaning; errors in the supply of tobacco; lack of energy input, and so on. These factors impact the time of production and delivering the blend to SMD.

The roasting leaf line production had a great deviation towards the expected due to the fact that the leaf line stays stopped during many days and, being so, the start and warming of the chambers become more critical. The deviation in lead time was measured three months after the single line production. The average time of real lead time found was:

- Start of the roasting leaf line: 04h10min
- Start of the normal leaf line: 01h45min

e. CRD capacity Review

The nominal storage capacity of bins in the CRD is 1404 positions in the shelves. Initially, 1400 bins were acquired, however, with the passing time, some of those were damaged and became inappropriate for use, being discarded. Currently, the total of functional bins is 1347, and one of these is reserved to be used as tare for the CRD scales, not being used for storing
tobacco. It was known that, during the informal planning, each bin could store average 210kg of blends. Thus, the total CRD capacity would be 282.870 kg of blends.

Aiming to measure the impact of implementing the single line production in the CRD storage capacity, it was verified that the average net weight of the bins by type of blend, based on the scale data captured by the automation. The average value found was 180kg. Being so, the real CRD capacity after the single line is 242.460kg of blends.

f. Shelf Life

Shelf life, or expiration date of the blends, is the time that a given batch may be kept in inventory before becoming inadequate for usage. It is defined according to the addition of some specific products in the primary process. Most of the blends are good through 90 days. Only 6 from the 24 SKU's had the addition of cocoa and had the expiration date set in 30 days. The volume of cigarettes produced in SMD is according to the demand, and can be smaller than the blend batches. Some of these blends may not be totally consumed in production and surpass the CRD expiration date. In this case, the expired blends may be added in a new batch with 5% of its original weight, thus they are not discarded and still occupy room in the CRD.

g. Test blends and blocked batches

Some blend produces are destined to testing. These blends are used to produce cigarettes that won't become a finished good destined to the market, but samples to the product developing area. Eventually, operation flaws will happen and the batches will be produced without following the given specifications, for example: problems with low or high humidity, smaller or greater addition of stems than expected, number of cuts by inch greater or smaller, and other problems that may occur during the operation. If the batch quality wasn't compromised, which means, if there were no contamination in it, the test batches and the blocked batches due to operational failure also may become addition, respecting the specified addition percentage. So, these remain in the stock, occupying bins. All these situations are part of the daily primary process, thus, the availability of bins to store blends for direct consuming in SMD is compromised.

h. Total of Unavailable Bins

Expired, blocked or test batches are a part of the primary process routine. The addition of these blends is made inside the CRD, turning the bin in a Tobacco Supplying System (TSS) dedicated to adding, which has a suction system to send the blend to the production line, in the threads before entering the last cylinder in the process. So, during three months a research was made about the average number of unavailable bins, which means, occupied by one of these three types of blends that will not be used directly in the production of cigarettes, as we can see in Table 2:
<table>
<thead>
<tr>
<th>Month</th>
<th>Average of Bins with Test Blends</th>
<th>Average of Bins with Expired Blends</th>
<th>Average of Bins with Blocked Blends</th>
<th>Total of Unavailable Bins</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>93</td>
<td>169</td>
<td>0</td>
<td>261</td>
</tr>
<tr>
<td>June</td>
<td>48</td>
<td>208</td>
<td>8</td>
<td>263</td>
</tr>
<tr>
<td>July</td>
<td>35</td>
<td>178</td>
<td>79</td>
<td>292</td>
</tr>
<tr>
<td>General Total</td>
<td>65</td>
<td>186</td>
<td>14</td>
<td>272</td>
</tr>
</tbody>
</table>

Table 2: Average amount of occupied bins per day
Source: Produced by the authors

Thus, from the 1347 bins, averagely 272 bins will be available, with 1075 remaining for storage of blends to SMD loading, which are equivalent to 193.500Kg, which means that in the total CRD capacity, only 80% can be considered available for usage.

i. Need of empty bins in the beginning of production

The primary process operates only in the first and second production turns, during the third turn, the process is stopped for maintenance and cleaning of the machinery. In the meantime, the secondary process is operating in all three turns, consuming blends constantly. This implies that the PMD needs to produce in two turns the total blend amount needed to produce three turns in the SMD. Being so, the production volume of blends in the primary is greater than the blend volume consumed by SMD, so the occupation of bins during PMD production is faster than the liberation of bins for unloading a new batch.

If the average weight of a batch is 7.200Kg and the average capacity of the bins is only 180kg, it’s obtained that each batch occupies 40 bins, in average. Since the CRD have two filling stations, it’s possible to unload two batches simultaneously. Knowing that the unloading of a blend silo takes between 50 and 60 minutes, we can say that the CRD fills 80 bins per hour. At the same time, knowing that the average production volume in SMD is 130.000 .000 cigarettes per day and that each cigarette has an average weight of 0.7 milligrams, the average amount of blend consumed daily is 91.000Kg (with 15 average batches/day). Hourly, an average 3.792Kg are consumed. Considering the average weight of the bin to be 180Kg, we can affirm that 21 bins are unoccupied each hour.

It’s concluded that, in the starting time of the PMD it’s necessary to have at least 50% of the amount of predicted bins to be occupied in that day, to avoid stops in the primary process due to lack of galleries to unload the produced batches. This means that, in average, 15 batches are produced every day and each batch occupies 40 bins, every day an average 600 bins are occupied. Thus, at least 300 empty bins are necessary in the beginning of the turn. This represents a reduction in part of the capacity to be used to create a safety stock, which is the exceeding blend stock produced (beyond the expected consume) to cover possible deviations in consume and lead time. So, from all 1075 available bins, taking 300 bins that need to be empty in the beginning of the turn, there are only 775 remaining, which correspond to 139.500Kg.

j. Mix of Blends

Currently, there are 24 kinds of different blends, but not all of them are consumed at the same time in SMD. The mix of blends to be produced by the PMD depends on the mix of cigarette brands running in the SMD. In average, 15 SKU’s of different blends run weekly. What characterizes the consume profile of each blend in SMD is if they run in Lean or Agile
modules. Lean modules are dedicated to high volume production. Thus, the blends running in these modules have constant consuming and rarely stay still in CRD stocks. The Agile modules are dedicated to low volumes in segmented production. Since a batch of Agile cigarettes isn’t necessarily a multiple of the size of blend batches, it’s frequent to have remainders of batches in stock, that are stored in CRD waiting for a new produce to be consumed.

An alternative to avoid having batch remains is negotiating the product limitations in the finish of the blend in stock. The Production Planners (PP) have autonomy to make this call when the deviation in volume of cigarettes goes between 10% more or less than the planned volume, which is the tolerance of the factory volume attendance policy, called Hit & Miss. From all 24 existing blends, 9 are destined to Lean production and 15 to Agile production. There’s a need of follow-up of the variable Mix of Blends in each planning cycle, which means, every week and analyzing the impact in availability of bins for the blends planning.

k. Deviation in the consumption in SMD

The planning in production of SMD is made based on the combination between sales predictions, the logistic distribution planning in warehouses and the availability of raw materials. Weekly, a negotiation between is made between these parts to elaborate a production plan. Any deviation in one of these plans reflects in alterations in the factory production plan.

Aside from the changes in planning, also there are deviations between programmed volume and the volume realized by the factory, due to many reasons, such as: machinery breakage; electrical failure; lack of raw materials; lack of semi-finished goods; lack of workforce; corrective maintenance; failure in the energy input supply; and many other reasons. An unexpected brand change caused by lack of raw materials, for example, means that a blend not predicted to be used is being consumed. The breakdown of a module during 24 hours means that a proportional volume of blend that was already prepared in the stock will stay unused or a batch programmed to run and need to be cut out of the programming.

Based on the Production Follow-up archive, which contains the records of planned volume and the realized volume daily of each production module, by SKU it’s possible to calculate the average daily consumption of each type of blend and also, which is the standard deviation between programmed and realized volume.

l. Calculation of Safety Stock

Based on the studies realized, it can be concluded that the deviation in the consumption of blends in SMD, which represents the demand for PMD, is greater and have a bigger impact in the management of PMD stock than the PMD lead time deviation, being considered as predictable. So, the mathematic model adopted by Company X to calculate the safety stock to PMD was the formula suggested by Wanke (2010) proposed for situations in which there’s a predictable re-supply time, but with variability in the predicted consumption (Equation 1)

\[ ES = k \times \sigma D \times \sqrt{TR} \]  

Equation (1)

1. Initially, the proposed service level was 99.9%, which gives a value of k constant of 3.09, as verified in Table 1;
2. For each SKU of blend, it was calculated the deviation in demand;
3. For each type of blend it was applied its lead time in hours, rounding the lead time of single time blends to two hours and the roasting blends to five hours.

The Safety Stock calculation with 99% attendance level reached the approximate value of 39.000Kg, representing, averagely, 11 hours in inventory for each blend. If the average SMD consumption is 91.000Kg, the total amount of blends destined to production plus the value of the safety stock would be 130.000Kg. The actual capacity found in the CRD, after counting out all the variables that limit the amount of available bins, was 139.500Kg. Being so, the CRD occupation rate is kept the same, in average, 93%. Thus, the cases of consumption deviance way above the planned didn’t generate process stops due to lack of tobacco. On the other hand, in cases of low modular performance or non-programmed SMD stops, the CRD stock consequently increased, compromising the empty bins and occurring in PMD process stops. To achieve balance between the primary and secondary processes, the choice was to perform a 95% service level, in which the value of the constant $k= 1.64$, which results in a safety stock of approximately 20.600Kg. This new proposed amount represents approximately half the proposed safety stock tested before.

In the next two months following the implementing of the stock policy, there was a reduction in SMD stops due to lack of tobacco, and at the same time, a reduction in the impacts in the primary processes for lack of bins to store blends.

**Final Considerations**

Parting from this study, the programmer of the primary process, with the PMD management can present to the SMD management the variables that impact the processes of storing and supplying of tobacco. Given this, the main result in this research was the agreement between the areas about the 95% service level, assuming 5% of failure risk, or lack of stock of semi-finished blend. Based on the analyzed data regarding engine stops due to lack of tobacco in the months after the implementing of the safety stock, it was observed a reduction in the volume of lost cigarettes, however this didn’t eliminate the problem, since it’s not possible to perform the 100% service level. Aside from the reduction in the number of stops in the process, other results were generated to Company X based in the project **Definition of Inventory management Policy of Semi-finished Goods in a Tobacco Industry.** Among them, the highlights are: Charge description, Creation of the Bank of SFG Lack and creation of the online calculation of stock duration tool.

Based in the present study, it’s concluded that the impact in the choice of a greater level of attendance, from 95% to 99% may generate a safety stock up to twice as big. Another important conclusion in this paper is the identification of what was to Company X the main uncertainty that caused the lack of stocks was the deviance in the demand and not in the lead time. In the primary process, the restriction of CRD capacity didn’t allow the storage of the semi-finished product for more than two production days. Thus, the maintenance of the proposed safety stock, in this specific case, has an irrelevant impact on the immobilized budget for Company X. The cost of stock for a greater PMD impact are the costs related to deterioration and obsolescence, considering that the shelf life of the blends is short; there’s possibility of contamination in a stock that stays stopped for too much time and the risk of infestations of tobacco beetles. In other departments of semi-finished products, such as the FMD, in which the production can be palletized and stocked in external warehouses, it’s relevant to highlight the importance of the impact analysis in immobilized budget in maintenance costs for these stocks.

The challenge of the analyst in the programming function and production control in the Primary Process is in following and responding to the consumption deviation in the
Secondary Process, while doing the management of the production capacity in the Primary Process and storing and supplying in the CRD, acting as a mediator between the negotiating areas to achieve win-win results.

The suggestion to the company for the medium term is to invest in buying new bins to allow the complete utilization of the current total of the CRD, which are the 1404 positions in the shelves. The 57 missing bins correspond to approximately 10.300kg of increase in the capacity, representing 11% of the average daily consumption of blends. For the long term, the recommendation is an investment analysis about expansion of the capacity of storage in the CRD. In a possible scenario of increase in the production volume, or even an increase in the complexity of the variables of the productive process that may compromise the proposed attendance level, the possibility of an expansion should be analyzed, comparing the investment made with the expected return in reduction of engine stop in SMD.

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Referências