

Proposal for the automation of the shipping process of automotive parts and improvement the quality management process in the warehouse of Toyota de Venezuela C.A

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July 2011

Abstract

The main objective of this work is to make a proposal to improve the dispatch operation of the TDV's warehouse, having as main objective to reduce errors and costs and to increase quality and service level.

During the analysis it was concluded that the errors done by the operators during the operation are based, in a high percentage, in the comparison of the spare parts' numbers and in the counting of the spare parts. Also it was analyzed that some aspects of the operation, like "credit notes", "picking notes" and picking labels, can be reduced or eliminated of the operation.

Using these aspects, were developed the new processes that will be used during the dispatch's operation. These processes use a barcode scanner as tool to reduce the errors done when reading spare parts' numbers and counting the spare parts. These processes are a picking process, a checking process and a classification process.

Also, analyzing the warehouse denials it was noticed that there is not a clear reason why these errors are happening. To try to solve this situation it was suggested a system called "data collection system" that will allow to collect the data about the misallocated spare parts with the objective of improve the inventory.

For the application of these processes it was suggested a schedule with a final estimated duration of 53 weeks.

Finally, for all these to be applied, there were suggested quality policies that will help to sustain the changes through time and to facilitate its implementation.

Key words: Quality, barcode, processes improvement, automation.

Introduction

The automotive industry is a challenging and competitive industry. Any advantage that can be obtained in any stage of the supply chain will help the company to better serve the customers and increase benefits.

One of the areas of the supply chain where companies may obtain a strategic advantage is the warehouses.

That is why Toyota de Venezuela C.A (TDV) is trying to improve the operation in their warehouse to reduce costs and improve the quality of the process.

Company profile

The TDV's warehouse of spare parts is located in Caracas. This warehouse receives the spare parts that are sent to Venezuela (from Japan, Brazil, USA and other countries), store them and sent them to the 66 dealers in the country. (Toyota de Venezuela C.A, 2011).

For the dispatch of spare parts, the warehouse works with 10 routes¹ per day. The dispatch is divided in 6 processes:

- Closing of the orders received from the dealers.
- Printing of bills and picking labels that will be used to pick spare parts.

¹ Route: Time frame in which the items are picked and packed for a group of dealers.

- The work is distributed for the picking and packing process.
- Picking of the spare parts that will be sent in the route.
- Classification of the spare parts.
- Packing of the spare parts by dealer.

1. TDV's types of errors

The dispatch operation is subjected to the mistakes that can be committed by the operators. For instance, in the picking process the operators may pick up the wrong item or the wrong amount, these errors are called mispicking.

They may not find the item they are looking for, this error is considered denial.

Finally, it is possible that one of these errors filters through to the dealer, in which case it would be considered misshipping.

2. Proposal made by TDV

The errors described before are situations that the warehouse must reduce so the operation can be the most smooth and efficient as possible.

Another issue the management wants to eliminate is an administrative process called "credit notes". After a dealer orders an item, this one is billed automatically to the dealer but if the item is not found in the warehouse is necessary to register the shortage of this item because it is already billed. In this situation the warehouse is wasting the time of the operator that has to introduce the credit note to be sent the next day to the dealer. This task does not add any value to the process because those items that are registered as credit notes are not sent later, that part of the order is cancelled and is only sent if the dealer asks for it again.

With these issues in mind, the warehouse management wants to automate their dispatch process using a barcode scanner to reduce the errors committed by the employees, to modify the processes to eliminate the "credit notes" and use the scanner to improve the task of data collection.

Tools for process analysis

For the analysis of the data in this work, it will be used Pareto charts and cause-effect diagrams.

1. Cause-effect diagram

A cause-effect diagram is a simple graphic method to represent a chain of causes and effect, to classify the causes and organize the relations between them (Evans & Lindsay, 2008).

The use of this diagram will be to allow classify the different causes that produce the errors in groups, to look for similarities that allow solve them in conjunction.

2. Pareto chart

The Pareto chart is a bar's graphic, where the bars are organized from left to right from the highest value to the lowest; in the left side the "x" axis contains the amounts measures and in the right side the "y" axis measures the percentage. From the top of the first bar is created a line that accumulates the percentage of the bars, arriving to the last bar marking the 100%.

This chart will allow establish which of the causes have the higher effect in the errors evaluated.

Processes in TDV's warehouses

1. Picking

This is the process in which the operators go through the warehouse looking for the items that the dealers asked.

In this process the key aspect is that the operator has to go to the right location, take the right spare part and take the correct amount. In the process applied currently, the operator must do all these activities manually.

The errors here are produced because sometimes in one location a spare part is misplaced and this is wrongly picked as the spare part that was ordered.

Also, sometimes, the operator doesn't pick the amount of spare parts that were asked by the dealer.

2. Classification

This is the process in which the items that were picked by the operators are distributed according to the dealer that they are going to be sent to.

The classification process is mainly a buffer to distribute what has been picked to the operators that will be in charge of checking and packing the spare parts. This process is mainly based on checking the dealer code number to put the spare parts in front of the right checker.

3. Checking and packing

This process is the one where the spare parts are put in boxes to be sent to the dealer. Each operator is assigned to one dealer, so he checks and packs all the spare parts to be sent.

The main errors that are committed in this process are: that the operator checks a part number but he is actually sending a spare part with another part number and that the operator may check certain amount of the item but he is sending a different amount.

Processes in Toyota Caetano Portugal (TCP)

1. Picking

The advantages of the method used by TCP are mainly in the use of the scanner as main tool to make the picking process, reducing the influence of the operator in the performance of the process. They use the scanner to compare the part numbers of the item. In case of any mistakes the scanner gives an alarm to the operator and shows a message in the screen to notify the mistake.

Also, TCP has two interesting procedures that are worth to evaluate: the first is that they use few picking labels. The idea applied in TCP is that they do not print a picking label for every item, they have that information in the system and the scanner only reaches for it when the operator scans the barcode of the work assignment.

The second procedure TCP has is what they name as "transferring" a spare part from the location to the box where they are picking the spare parts. This procedure allows track the spare parts from the location to the dealer, keeping with this a record that allows analyze in what stage of the process the errors are made.

2. Check/sort

In the warehouse of TCP they make the picking process according to the geographical areas the spare parts are going to be sent. After

the spare parts are picked they check and pack the items following this same scheme.

In their operation they make the classification and the packing at the same time, using plastic boxes for all the packing. With this method they reduce the possibility of having a lost item between processes. Also, this methodology reduces the amount of persons that interact with each spare part, reducing the possibility of errors.

Key errors indicators (KEI)

1. Mispicking

Here, we have the mispicking data from TDV and TCP, from the year 2010 expressed in ppm², to compare the level of error and analyze the processes.

Types of errors	TDV	TCP
Less quantity	64	57
Excess quantity	24	6
Wrong part number	173	16
Missing item	42	3
Other	1	0

When we make a Pareto chart using this data (in ppm) about the mispicking errors in TDV, we obtain the one showed in figure 1.

This chart shows that the main error committed by the operators is when a wrong spare part is picked and sent to the dealer. This must be considered as the main aspect to be evaluated at the moment of studying and improving the processes.

Also, we can see that a lot of the errors are related with quantity issues.

With this in mind, in our approach to analyze the processes we must take in account the need of keeping a better control of the quantities and of the part numbers.

² Ppm: Parts per million.

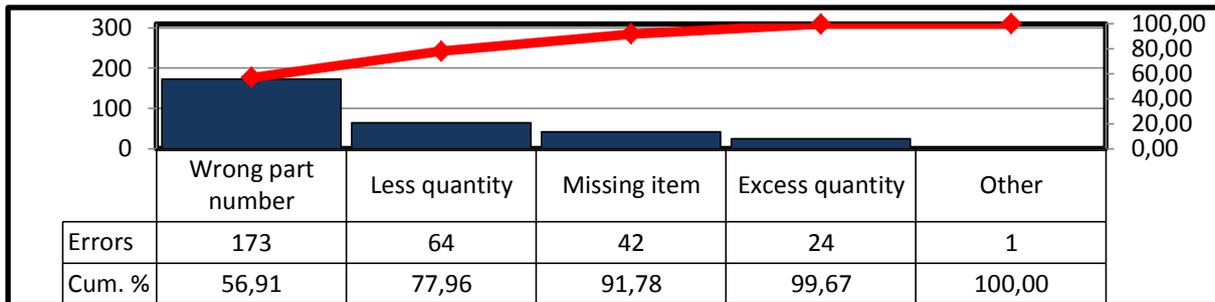


Figure 1 Pareto chart of mispicking from TDV in year 2010.

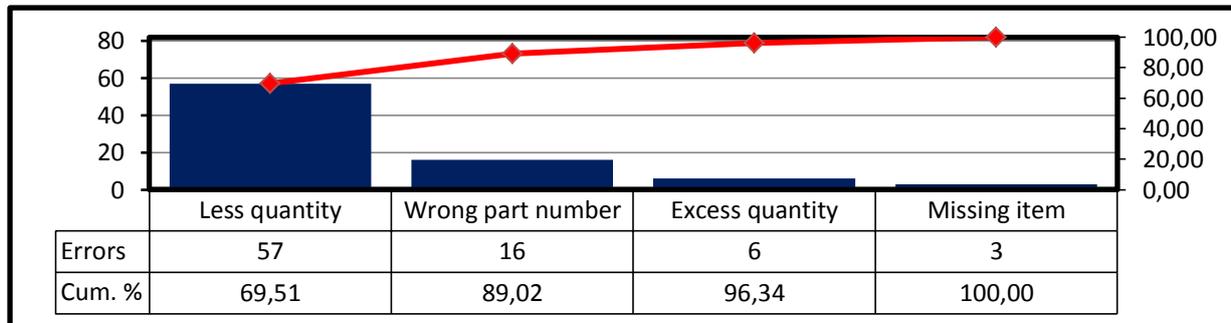


Figure 2 Pareto chart of mispicking from TCP in year 2010.

When we see these same aspects in the TCP warehouse (figure 2), we can clearly see how the errors are substantially lower in almost every aspect than the ones from TDV. There is only one case in that both amounts of errors are almost the same and that is in the “less quantity” errors. This may happen because in the picking process from TCP they use a box to pick the items, mixing them up, which may cause that some spare parts get confused with another one.

We can see that the main problem in TCP is sending less quantity than the one that was checked. This error represents a high percentage of the errors in this warehouse. We can see how the error “wrong part number” is clearly smaller, which shows that the methods used in the TCP warehouse should reduce the errors in the TDV warehouse.

2. Warehouse denial

The data provided by TDV about the warehouse denial is divided by warehouse's zones, which are:

- Zone B: Bumpers.
- Zone 1: Small sized spare parts.
- Zone F: Large sized spare parts.
- Zone 2: Medium size spare parts.

- Zone 1: Small sized spare parts.
- Zone 6: Spare parts of metal.
- Zone H/I: High locations.
- Zone 2: Medium sized spare parts.
- Zone 9: Security spare parts.
- Others: All the other locations of the warehouse.

We made a Pareto chart (figure 3) to analyze which zones of the warehouse need higher attention in the development of the new processes.

It is possible to see that the Zone B (Bumpers) is the one that represents higher errors so it is recommendable to analyze it, but the errors are highly distributed between several zones. This may suggest that the problem is not the zones but the general processes used to allocate and pick items.

New processes

The application of the new processes will be done in two stages: the first one mainly considering the improvement of quality and the second one for reducing costs.

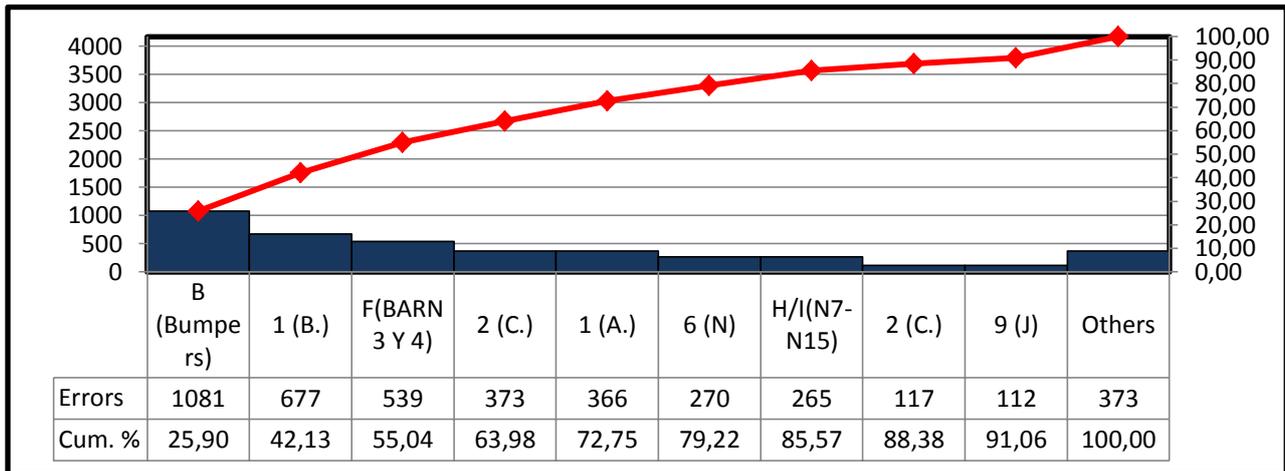


Figure 3 Pareto chart of warehouse denial from TDV in year 2010.

The first stage will include the application of the scanner in the processes of picking and checking in the warehouse with the main objective of reducing the errors. The second one will have as objective the reduction of costs by reducing at the minimum the amount of picking labels that are used during the process.

1. Picking

For the picking process the use of the scanner has the following objectives:

- To compare the spare part's number and in the picking label.
- To have a more accurate counting of the spare parts.
- To allow a simple tracking of the items.
- To prepare the information that will be used to classify and check the spare parts.
- To eliminate the "credit note" process from the picking operation.

To reach these objectives the process will use the scanner to read the part numbers to compare them in a better way. Also, at the beginning of the process the operator must introduce his own information in the scanner (through a password or a barcode) so the device identifies who is operating it and make a precise record of his development. Following this, the operator will have to scan the barcode of the trolley he is going to use for picking spare parts so the system knows in which trolley are the spare parts after the picking.

For the quantity, the method should be that always when the amount of spare parts to be picked is lower than 10 they should be all scanned.

If the amount to pick is 10 or more the operator must compare all the spare part numbers visually and introduce the amount directly on the scanner.

This must reduce significantly the amount of errors in the orders of less than 10 units. But over 9 units the scanner will only work as a comparison for the first one. This method does not improve the so much the quality, but according to the orders made in March and April of 2010 only around 3% of what is being ordered has amounts of 10 or more spare parts, so this should not affect too much the operation.

The most important change that will be done in this process will be the one that will allow eliminate the "credit notes" from the picking process. The idea here is that the billing process be done not based on what the dealer order, but based on what the operator will be able to pick.

After the operator scans the part number, he will see in the scanner the quantity he needs to pick and he will start picking it. If he does not find enough spare parts he will have to press that the picking of that item is over and then he will have to confirm it. This process will allow at the warehouse administration have the information about what is being picked up for each dealer, and use this as basis to prepare the bill that will be sent to the dealer.

At the end of this process, the system will receive the information of the items that were picked by the operator, and then they will be organized according to the dealer that they are to be sent to. Any information about an error will be stored to evaluate the performance of each operator and analyze what improvements the processes will need to reduce the errors.

2. Packing

The objectives for the new packing process are:

- To compare precisely the part numbers.
- To have an accurate counting of the spare parts packed.
- To allow a simple tracking of the items.
- To prepare the information that will be sent to the dealer.

For this process it will be used a system in which the operator will fill the box based on a list of items that he will receive in the scanner. This information will be about the amount of items and spare parts that will be necessary to pack. This information will come from the record of what each operator picked during the route and it will be updated each time that an operator finishes his cycle.

To assure that the checking of a dealer be closed in the right time, all the items picked must be packed. For this, the scanner will have a signal that will tell the operator when all the items from his dealer have been picked.

At the end of this process, the system will receive the information of the spare parts that were packed by the operator, and then the bill will be printed based on what was checked. Also, it will produce a record based on in which box each item is and the dealer. This change will also eliminate completely the necessity of the "picking notes".

3. Classification

For this process it will be needed the barcode scanner because of the elimination of most of the picking labels. The idea will be, during this process, to confirm that the spare parts that are being sent and that the amount that was picked are the same that was recorded by the operator.

This process will work in the opposite way than the packing process. The operator will scan the barcode of the trolley and he will receive the information of what it contains.

With this information he will keep scanning the barcode of each item and introducing the amount, after which he will receive the code number of the dealer who he needs to transfer the items. Then he will take them to the dealer's allocation and will scan it barcode making the transfer of the spare part from the trolley to the shelf.

Key errors indicators (KEI)

1. Service level

For taking this statistic the best method would be to compare the order of the dealer with the list that was sent to the dealers regarding the items that were packed and sent. And make a ratio between what was sent and what was ordered.

2. Data collection system

With the new system, where the billing process is done based on what is firstly picked by the operators, the idea of looking for the spare parts during the route is not important. But the concept of looking for the missing spare parts would be really useful for the improvement of the operation in the warehouse.

The operator in charge of looking for the spare parts will have a list with all the items he has to find. He will have to collect the information about what is the position of the item compared with its proper position, the amount that was found and who located that item.

At the moment that the operator locates an item he will have to mark it in the list he has.

With the information taken with the scanner, it will be done a new indicator called "misallocation". The formula will be:

$$\text{Misallocating from zone}_i = \frac{E}{I} * 1.000.000$$

Where:

E= Errors committed allocation in zone i

I= Items in zone i

Planning for the application of the changes

The application of the changes that are being recommended need to be done in a systematic way. If the changes are applied all together that may create failures in the processes and problems in the operation. As it was said before, the process is divided in two stages, one mainly in charge of the improvement of the quality in the processes, while the other one is mainly for reducing costs in the process. To this, we have to add the implementation of the data collection system that can be done simultaneously to the dispatch changes. The estimated time is of 53 weeks.

1. First stage

The application of the first stage will start by the checking process, because this process can be easily adapted to work with the present operation in the warehouse. This will allow evaluate it without the effects of the new picking process.

After all the operators are trained, the picking notes will be eliminated and will be given a time for the establishment of the process.

With the new checking process implemented we can pass to the next step: the picking process. After all the operators are trained, the process will be fully established by starting the printing of the bills after the checking process based on what was picked and checked.

2. Data collection system

This application is simple, because after the system's department finishes the program the operator that will be applying this system must be trained.

3. Second stage

After the data collection system is applied, the next stage is the cost reduction. In this stage we will apply the classification process in the warehouse. Finally, the picking labels are reduced and the process is fully applied.

Productivity

The use of the barcode scanner brings the possibility of collecting a large amount of data that was not possible in the past.

This data can be used for evaluating the performance of the operators and the warehouse in general. With this in mind, it is possible to apply a procedure to calculate the productivity's indicator for each operator and the warehouse in general, considering the different processes that are being done during the operation.

The new productivity indicators, by operator and for the entire warehouse will be:

- Picking productivity.
- Classification productivity.
- Sending productivity.
- General productivity of the warehouse.

Each process will be classified in 4 types of productivities: productivity by operator by zone,

productivity by operator, productivity by zone and productivity of the process. All this indicators will have as units:

$$\left[\frac{\text{items}}{\text{hour} * \text{man}} \right]$$

The formulas are:

$$POZ = \frac{\text{Items processed in the zone by the operator}}{\text{Time used to process those items}}$$

If the operator picks in different zones of the warehouse the formula is:

$$PO = \sum_{i=1}^n (POZ_i) * \left(\frac{IPZ_i}{TPI} \right)$$

Where:

n = number of zones in which the operator process items.

POZ_i = the productivity of the operator in each zone of the warehouse.

IPZ_i = number of items the operator processed by zone.

TPI = the total number of items that the operator processed.

To calculate the productivity by zone (PZ) of the warehouse the best method is to sum all the items that were processed in that zone, and divided by the time that were necessary by the operators to process them.

$$PZ = \frac{\sum_{i=1}^m \text{Items processd in the zone by operator } i}{\sum_{i=1}^m \text{Time used to process items in the zone by operator } i}$$

For the productivity in a process of the warehouse (PW), it will be used the productivity by zone (PZ) and a factor given by the ratio between the amount of items that were picked in that area, and the items that were picked in the warehouse. The formula is:

$$PW = \sum_{i=1}^n (PZ_i) * \left(\frac{IPZ_i}{TPI} \right)$$

1. General productivity of the warehouse

For the general productivity of the warehouse it will be considered two main ways. The first one is the handling productivity of the warehouse (HPW). This indicator represents the amount of spare parts that the warehouse moves during it operation. The formula for this indicator is:

$$HPW = \frac{IP + IC + IS}{TP + TC + TS}$$

Where:

IP = Items picked in the warehouse.

IC = Items classified in the warehouse.

IS = Items packed and sent in the warehouse.

TP = Time used for picking the items.

TC = Time used for classifying the items.

TS = Time used for packing and sending the items.

The second method that will be considered for the calculation of the warehouse productivity will have as objective allow the management have an idea about how much time will be necessary to make the items pass through all the warehouse process.

$$GPW = \frac{1}{\left(\frac{1}{PPW}\right) + \left(\frac{1}{CPW}\right) + \left(\frac{1}{SPW}\right)}$$

Quality policies

To develop better systems it is necessary to establish clear standards in the methods that will be used for the evaluation of the data. These methods should be adapted according to the different information that is being stored. And, these new methods must be adapted to the philosophy that the company is already following.

1. *General indicators vs. specific indicators*

General indicators are really useful for the analysis of the performance of the warehouse as a whole operation. This gives the bases for establishing the new objectives for the development and improvement.

But they are not adequate to solve specific problems, because they do not differentiate between factors like the operators, the zone or the moment when the errors were committed.

Currently, it is recommendable to set a secondary group for each indicator. That will allow the evaluation in a more precise way. These variables should be the evaluation of errors made by each operator; in each zone of the warehouse and the time the process was done.

With this, is strongly recommendable that the system stores all the information that is adequate to calculate the different specific indicators that the management decides to use to improve their

operation. This information should be kept at least for six months; this will allow an easy evaluation of the aspect that they decide, over time. After this period, it should be stored only the information that was considered relevant for the improvement of the operation.

2. Errors per million

The quality measures used at the present time at TDV are based on the concept of "errors by every 10.000 lines". Up to recently this measure has worked. But as we could see in the different data that was presented during this work, this base line is starting to be inadequate to evaluate the process.

The warehouse from Toyota Caetano Portugal works in a base line of "errors every 1.000.000 lines³" or ppm. This method has the advantage that allows represent in an easier manner the errors that are being made during the operation.

Based on the necessity of establishing a better base line to evaluate the quality of the warehouse, all the error evaluation measures will be established in a base of "parts per million" or ppm.

3. Checking times

All these evaluations need to be studied by the management of the warehouse. But, they cannot be checked all days.

The advice would be to establish weekly checks of the information. Having 4 main variables, checking one each week and comparing the rest with records of the previous weeks just to be sure that has not been any important unexpected change in them.

After this, it should be given a monthly report to the top management to keep them informed with the changes, and to involve them in those cases that are becoming hard to solve or that require high level decisions.

4. Training

For the proper application of a more complete quality system it is necessary to teach the operators the proper methods that need to apply. It is necessary to prepare the different training programs that will be necessary to apply for the new process work properly.

³ Lines: items

5. Documentation

One of the basis for every process to be able to be followed and improved it is to have the proper information organized in the best way possible. Having all the necessary information stored will allow the management to analyze all the different aspects they decide to consider as fast as possible.

6. Graphics

A good method to analyze the indicators is graphics. The graphics allow, rapidly, to see tendencies and to see which the key aspects are to consider. There are two main graphics that will allow evaluate the indicators. To evaluate the indicators over time the best idea is a line chart that allows see the tendency that are occurring in the process.

In the case of analyzing different aspects inside the same indicator (causes for errors, areas of the warehouse) the best graphic that should be used is a Pareto chart. With this, the graphics must be put in a board so it is seen by all the employees and they participate in the evaluation process.

Conclusions

The first analysis that was done was about the processes from TDV's warehouse. From this analysis it was concluded that the key aspect in this process is the capacity of the operator to compare spare parts' numbers and to count parts.

Also, it was done an analysis to the errors that are record in the operation. From the analysis of the mispicking errors it was concluded that the main mistakes done by the operators are to compare wrongly the spare parts' numbers and to count the amount of spare parts that are going through the process.

Also, analyzing the errors' data from TCP's warehouses it was concluded that the use of a barcode scanner as main tool in the process can significantly reduce the errors produced by the miss comparison of the spare parts.

The reduction or elimination of picking labels, "credit notes" and "picking notes" will show a

reduction in the cost of the operation of the warehouse and will improve the productivity in the process.

After the processes were developed it was concluded that applying all of them at the same time would cause disturbances if not failures in the operation, so it was proposed a schedule of the application of the processes.

Next, the quality policies that would need to be applied in the operation were considered and it was concluded that would be necessary the use of graphic material, proper documentation (e.g. manuals) and the training of the operators.

At the level of the indicators it was defined a new set of indicators.

Finally, we can conclude that the use of a barcode scanner can help to reduce the errors done in TDV's warehouse by the operators.

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