Productivity in a refrigeration company with emphasis on quality improvement
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Abstract
In this article it was studied the implementation of improvements carried out in an air conditioning company whose process happens on the production line of evaporator Units (inside the Split product), specifically in the "Run test" post where you perform the product test performance. Observing the production processes of the company in under study it was possible to detect some faulty procedures, for example, the products need to undergo performance tests (Test Run).

Key words: Productivity, Efficiency, Quality, Safety

INTRODUCTION
With the advancement of technology, there is great competition between companies and increasingly competition to impose speed and quality. This encourages companies to improve their processes and train their employees. According to Moura and Banzato (1996) it is natural in any branch due to the need and requirement of quality for customers, smaller Lead time because while reducing the volume of orders the competitiveness increases. So any idea to mitigate time or device to assist in agility and increase safety in the process should be put in place or at least tested.

Thus, it can be understood that the study of production and productivity is significant, even though it is still not being used in some enterprises, deserves attention and should be suitable for the same. Also according to Peinaldo and Graeml (2007) the most complex tasks, or more difficult to perform need more time in order to have a good level of productivity and quality. The more qualifications and training an employee can have, the better its performance in the execution of their tasks.

In a globalized and competitive world, only the companies that can reduce their production costs stay. Expand productivity means increasing profits and reduce costs by continuously improving the quality of products. The consumer requires that, increasingly, the industries are agile, reliable and have quality in their products. This makes companies look for new tools and techniques to plan and manage production.

PROCUTION LINE
The production line of a company is partly operational which can be regarded as a form of mass production, several workers can be found side by side and/or end to end facing a conveyor belt so that the product can pass by all of them, such line may be called live line, but there are also other types of production line, work is carried out with the help of specialized machines sequentially.

The production line according to Duarte (2009) is called the chain of production, it constitutes the integrated set of personnel, machinery, equipment, accessories and raw materials in systemic and sequential operation that, according to a production process, carries out planned operations, constant and repetitively.

PRODUCTIVITY
According to Contador (1994), productivity is the relationship between the results of production and productive resources applied to it and is measured at three levels: The operation, the company and the nation. At the operating level, it reflects the Taylorist concept of increasing the productive capacity of the resources involved in an operation. At the level of the whole company, it reflects the relationship between

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revenues and total costs called value-added tax by Campos (1989), and includes the entire production chain, from suppliers to customers. In the nation's level it reflects the concept of per capita income. It is noteworthy that companies need to constantly improve their productivity, quality and efficiency, and for this to occur it is required a good structuring, easy communication and enhancement of the human environment. Under this thinking, some companies have adopted and resuited quality techniques, burning lines of non-competitive products, introduction of more efficient production flow, among other processes that make them more competitive.

PRODUCT QUALITY
Quality are aspects of a product or service that allow you to meet needs (Longenecker, Moore, Petty, 1997), according to Miranda (1994) organizations need to generate products and services able to meet the demands of their end users - consumers in all aspects. When speaking of a production process it is important to highlight the need to ensure the quality of products to the best satisfaction of the supplier and also the end consumer, thus the quantity of products that reach the authorized service may fall notably because the same will be with quality guaranteed. Product quality is noticed when the product is in perfect condition, has no flaw, and when it is noted that it is working as planned.

MES SYSTEM
Berti (2010), used the MES system (Manufacturing Execution System, or System Manufacturing Execution), a company in the white goods sector with global operations. The factory where the work was performed is the largest refrigeration products factory in Latin America and the largest belonging to the group worldwide. Where refrigerators, freezers (horizontal and vertical) and dryers are manufactured.

MES
The MES term - Manufacturing Execution Systems, or Execution System Manufacturing was established in 1990 by Bruce Richardson of Advance Manufacturing Research (AMR). According to MacClellan, (1997) the MES is an online integrated computerized system, which includes all methods and tools necessary to carry out production. The MES is usually a specific system for each type of manufacturing system, corresponding to the border between the provisional plans and their implementation. The MES fulfills two roles: One is to control the production, that is, consider what was actually produced and how it was produced and allows comparisons with what was planned so that, in case of not coincidence, it allows the corrective trigger actions. The other role is to release the production orders, and the concern of detailing the programming decision to produce the schedule set by the MRP, ie ensure that the plane defined by the MRP is accomplished.

METHODOLOGY
For this work, the following topics were raised:

1) With the analysis of the internal drives production process of Air Conditioners, applying a quality control during the performance testing process in a refrigeration company in the city of Manaus - AM, which is located in the Industrial Pole of Manaus.

2) At the beginning of the year 2014 it was presented the need for investment for managers of the research company through a meeting called "Review" where the problem was presented: Completing the Run test manual test which several failures that were not identified during the process were presented in the field, such as:
   1. Inverted links;
   2. Product does not switch on;
   3. Led does not work;
   4. Valve reverser does not trigger the hot/cold models;
5. Infra red emitter does not respond;
6. Board does not switch on;
7. Thermostat sensor broken.

3) For the applicability of the project, the study case developed in the company was divided into eight stages, which began in February 2014 and ending in June 2015 with the implementation, these being:
1. Presentation of the project proposal of the Company’s management for approval of investment;
2. Development of descriptive memorial for the Project sector, stating all the technical design;
3. Development of descriptive memorandum by the Occupational Safety Engineering industry, including all relevant information to the legal service;
4. Setting up of three quotes to generate comparative values and within the definition of delivery of suppliers;
5. Opening service request and approval by the entire chain managers;
6. Implementation of the project according to the scheduled proposed;
7. Test and validation;
8. Project homologation combined with the areas: Industrial Engineering, Manufacturing, Quality, Maintenance and Safety Engineering.

RESULTS AND DISCUSSION
Having as proposal the automation of the Run test where it was linked to the traceability system (MES) used by the research company. In 2014 when the tests were performed manually by the employees, and the fact that companies submit daily, weekly, fortnightly or even monthly goals, this way you can explain that during the year 2014 when the tests were performed manually by the employees they were more concerned about achieving their goal than with the quality of the products to be produced, taking the problem to the final customer.
This becomes clear when look at Figure 1, clearly showing the number of defects that were detected month by month through the Run test, which then was performed manually by the collaborator, looking at the numbers the amount of defects detected in 2014 and comparing the defects detected from the second half of the year 2015 as shown in figure 2, the implementation period of the new test concept (automatic). The evaporator production process of the company in question is divided into seven (7) lines, but the sampling improvements were used only three (3) lines.

Figure 1. Better set the defects per lines, manual process:

<table>
<thead>
<tr>
<th>LINE: EVAPORATOR 1</th>
<th>MONTHS</th>
<th>TOTAL FAILURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEFECTS (RUN TEST)</td>
<td>JAN</td>
<td>FEB</td>
</tr>
<tr>
<td>LED FAULT INITIAL</td>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td>MISSING COMPONENT</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>DAMAGED WIRE</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>POORLY FIXED WIRE</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>LOOSE WIRE</td>
<td>45</td>
<td>17</td>
</tr>
<tr>
<td>DOES NOT WORK</td>
<td>42</td>
<td>5</td>
</tr>
<tr>
<td>DEFECTS (RUN TEST)</td>
<td>TOTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LINE: EVAPORATOR 2</td>
<td>MONTHS</td>
<td>TOTAL FAILURES</td>
</tr>
<tr>
<td>DEFECTS (RUN TEST)</td>
<td>JAN</td>
<td>FEB</td>
</tr>
<tr>
<td>LED FAULT INITIAL</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>MISSING COMPONENT</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>DAMAGED WIRE</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>POORLY FIXED WIRE</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>LOOSE WIRE</td>
<td>42</td>
<td>17</td>
</tr>
<tr>
<td>DOES NOT WORK</td>
<td>42</td>
<td>5</td>
</tr>
<tr>
<td>DEFECTS (RUN TEST)</td>
<td>TOTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LINE: EVAPORATOR 3</td>
<td>MONTHS</td>
<td>TOTAL FAILURES</td>
</tr>
<tr>
<td>DEFECTS (RUN TEST)</td>
<td>JAN</td>
<td>FEB</td>
</tr>
<tr>
<td>LED FAULT INITIAL</td>
<td>42</td>
<td>7</td>
</tr>
<tr>
<td>MISSING COMPONENT</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>DAMAGED WIRE</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>POORLY FIXED WIRE</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>LOOSE WIRE</td>
<td>42</td>
<td>17</td>
</tr>
<tr>
<td>DOES NOT WORK</td>
<td>42</td>
<td>5</td>
</tr>
<tr>
<td>DEFECTS (RUN TEST)</td>
<td>TOTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Study Company data.
The manual concept of test was performed only with the indoor unit from the drives on the remote control in an interval of 30 seconds in which the following items were checked:
1. Turbine actuation;
2. Vane actuation;
3. Led actuation.

Because there is no logical system, the test result was up to the developer, to test the items mentioned above and verify that the product was approved or not, with the lack of traceability in enabled test the final product reached the consumer having serious flaws.

It is noteworthy that the greatest benefit of an organization is to be recognized on the market mainly by the quality of its products and the way it treats its employees thus providing security in the work, both before and after the improvement in the form of work of the employees are adapted to the safety standards for the common good.

Figure 2. Better set the defects per lines, automatic process from July/2014:

For the test run it was necessary to create a logical system where a slave control connected to a Logic Control Programmed - PLC sends control signals to the indoor unit (evaporator), being connected to a control panel that will simulate the external unit (condenser), this communication takes place through a power cable (test cable), which when integrated to the indoor unit (evaporator) receives control signals for the operation of the product testing, simulating as if the product was working with the final consumer.

The main functions of the test in the products we previously defined based on the most common problems presented are as follows:
1. Indoor unit actuation;
2. Internal turbine actuation;
3. Vane engine of the indoor unit actuation;
4. External drive actuation;
5. External unit compressor actuation;
6. Rarefaction set from the outdoor unit actuation;
7. Reversing valve of hot/cold models actuation.

For the test to be performed in the employee production process the cooperator should be trained following the steps determined according to Figure 3 (being composed of 5 figures) representing the Labour Instruction - IT No. 00024, to the Test Run position:

**Figure 3.** (1/5) Labour Instruction - IT No. 00024, to operation at the Test Run position:

Source: Study Company data.
Figure 4. (2/5) Labour Instruction - IT No. 00024, to operation at the Test Run position:

Source: Study Company data.

Figure 5. (3/5) Labour Instruction - IT No. 00024, to operation at the Test Run position:

Study Company data.
Figure 6. (4/5) Labour Instruction - IT No. 00024, to operation at the Test Run position:

Figure 7. (5/5) Labour Instruction - IT No. 00024, to operation at the Test Run position:

Source: Study Company data.
For a better understanding of the data you can check graph 1, a comparative of defects was made between three lines of evaporator where we identified that the in the second half of 2015 after the implemented improvements to the "Run test" automatically operating the defects presented in parts per million - ppm increased significantly over the previous year with manual process. In Graph 2 we show the most significant types of defects over the same period.

**Graph 1. Statement of defect rates:**

<table>
<thead>
<tr>
<th></th>
<th>Evap 1</th>
<th>Evap 2</th>
<th>Evap 3</th>
<th>Total</th>
<th>Evap 1</th>
<th>Evap 2</th>
<th>Evap 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>295916</td>
<td>297886</td>
<td>298645</td>
<td>892447</td>
<td>186887</td>
<td>235793</td>
<td>237472</td>
<td>660152</td>
</tr>
<tr>
<td>2015</td>
<td>5809</td>
<td>4096</td>
<td>1905</td>
<td>3931</td>
<td>6319</td>
<td>6317</td>
<td>8612</td>
<td></td>
</tr>
</tbody>
</table>

Source: Study Company data.

**Graph 1.1 Source data on comparative defects 2014-2015.**

**Source data for the graph.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Line</th>
<th>Vol.</th>
<th>ppm</th>
<th>Flaws</th>
<th>% Flaws</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>Evap 1</td>
<td>295916</td>
<td>5809</td>
<td>1719</td>
<td>0.58%</td>
</tr>
<tr>
<td></td>
<td>Evap 2</td>
<td>297886</td>
<td>4096</td>
<td>1220</td>
<td>0.41%</td>
</tr>
<tr>
<td></td>
<td>Evap 3</td>
<td>298645</td>
<td>1905</td>
<td>569</td>
<td>0.19%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>892447</td>
<td>3931</td>
<td>3508</td>
<td>0.39%</td>
</tr>
<tr>
<td>2015</td>
<td>Evap 1</td>
<td>186887</td>
<td>6319</td>
<td>1181</td>
<td>0.63%</td>
</tr>
<tr>
<td></td>
<td>Evap 2</td>
<td>235793</td>
<td>12740</td>
<td>3004</td>
<td>1.27%</td>
</tr>
<tr>
<td></td>
<td>Evap 3</td>
<td>237472</td>
<td>6317</td>
<td>1500</td>
<td>0.63%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>660152</td>
<td>8612</td>
<td>5685</td>
<td>0.86%</td>
</tr>
</tbody>
</table>

Source: Study Company data.
In the graphs 3 and 4, we can observe the "TOP 5" referring to the failures in the years 2014 and 2015, where, in 2015 we have a more consistent result because we can show a more cohesive division.

Source: Study Company data.
Graph 4. 2015 Top 5 defects.

TOP 5 - Defects 2015

Source: Study Company data.

You can visualize after the improvement in the process that the company has become more critical and strict with the quality of their products, diagnosing the problems and giving the relevant negotiations. Apart from improving efficiency as we can see in the graph 5 following.

Graph 5. Efficiency x Defects.

Efficiency x Defect

Source: Study Company data.
The company continually searches for better efficiency with the use of technologies associated with the quality process, which enables increased productivity and therefore excites their own competition, not to mention that it represents a strategic and competitive factor in the market.

With the automated process developed by MES system (Manufacturing Execution System), system that performs the traceability of the product, where to connect the product in the "Run Test" so that the system identifies the failure, reproaches and blocks product preventing the same pass for next steps of the process to be corrected and re-worked to clear the fault, this improvement brought increased productivity to the company, besides making it competitive in the market, paying attention to the quality criteria that consumers demand without forgetting the safety of employees during all assembly steps.

CONCLUSION

As described in the text, the study showed an improvement in the quality process, where we notice an excellent return in productivity without leaving worker safety aside. Automatic testing process made it possible to detect still in the company relevant problems to the evaporation unit, product produced in the research company.

This improvement is due to the implementation of the "Run test" in the second half of 2015 automatically operating defects reported in parts per million - ppm, increased significantly from the year 2014 with the manual process.

The main problem was to adapt the assembly process meeting the criteria quality. With manual achievement, the problems remained after the tests in some cases only being detected in the final consumer, hence the need for the development of automation to the test, keeping in mind the importance of always producing products in great quality levels to ensure full satisfaction of the product to the company.

It is noteworthy that the proposed objectives were achieved, since there was a significant decrease as the product defects (evaporator unit), providing flexibility in the implementation of the product performance testing, and time in identifying defects in relation to the year 2014. The cost for repair product was also reduced, since it differs to be seen in the company and to be found outside of it.

It is important that the quality is inserted in the production process to facilitate the final result of the product, keeping in mind that the earlier the problems are detected, the better to redo the process. In addition to ensuring product quality, it is worth emphasizing the importance of maintaining employee safety to operate and develop tests, the existence of compliance with occupational safety throughout the process can ensure the total satisfaction of employees to perform the work, thus increasing productivity.

In view of the current industrial scenario, organizations are faced with the increasingly fierce market looking for specific products. The industries need systems, techniques and tools that assist in the production processes in order to ensure product quality to stay in the market. So, plan and control production, goes beyond need, it is an imposition. Planning is extremely helpful allowing the company to not only set goals and productivity objectives, but also improve the production process and pay attention to the market needs.

Through the problems presented above we can understand when the company has gained ground in the competitive market, as with test automation was possible to reduce the defects of the products, than before with manual testing was not possible because it is known that ability to optimize results of an organization is proportional to the amount of problems and opportunities that it recognizes and effectively deals.

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