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Lean Manufacturing tools in the industries of Tundama

Herramientas Lean Manufacturing en las industrias de Tundama

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Key words: Improvement, Lean Manufacturing, Management, Process
Palabras clave: Mejora, Lean Manufacturing, Gestión, Proceso

ABSTRACT

With the advantages brought by the implementation of tools and philosophies for the improvement of business productivity, in the following investigation, carried out in the province of Tundama between 2016-2017, 13 of the most representative companies of the province registered in the local Chamber of Commerce were analyzed. This province is made up of the municipalities of Belen, Buzbanza, Cerinza, Corrales, Floresta, Paipa, Santa Rosa de Viterbo, Tutaza and the capital municipality of Duitama, which has an area of 2232km2 and has in the region of 200.000 inhabitants. It is located in one of the most important industrial corridors in Colombia. The methodology used in this study begins with the design of the data collection instrument (opinion survey), where a pilot test was carried out in three companies with the purpose of validating the questions and analyzing the language convenience and use. Following this, ten companies were selected to conduct the survey, in order to determine the level of awareness of Lean Manufacturing tools. The objective of implementing one or various of these tools is to achieve continuing improvements in any type of organization, thereby eliminating unproductive activities. After a survey analysis, the current panorama of the region was established in relation to the status of Lean tools. The result of this will, by way of future investigations and projects, allow for the design and implementation of a methodology which facilitates its adoption at the organizations' core, possibly to improve the productivity of the industrial corridor in the Tundama province.

RESUMEN

Con las ventajas aportadas por la implementación de herramientas y filosofías para la mejora de la productividad empresarial, en la siguiente investigación, realizada en la provincia de Tundama entre 2016-2017, 13 de las empresas más representativas de la provincia se registraron en la Cámara local de Se analizaron los comercios. Esta provincia está compuesta por los municipios de Belén, Buzbanza, Cerinza, Corrales, Floresta, Paipa, Santa Rosa de Viterbo, Tutaza y el municipio capital de Duitama, que tiene un área de 2232 km2 y tiene una región de 200.000 habitantes. Está ubicado en uno de los corredores industriales más importantes de Colombia. La metodología utilizada en este estudio comienza con el diseño del instrumento de recolección de datos (encuesta de opinión), donde se llevó a cabo una prueba piloto en tres compañías con el propósito de validar las preguntas y analizar la conveniencia y uso del idioma. A continuación, se seleccionaron diez empresas para realizar la encuesta, a fin de determinar el nivel de conocimiento de las herramientas de Lean Manufacturing. El objetivo de implementar una o varias de estas herramientas es lograr mejoras continuas en cualquier tipo de organización, eliminando así

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las actividades improductivas. Después de un análisis de la encuesta, se estableció el panorama actual de la región en relación con el estado de las herramientas Lean. El resultado de esto, a través de futuras investigaciones y proyectos, permitirá el diseño y la implementación de una metodología que facilite su adopción en el núcleo de las organizaciones, posiblemente para mejorar la productividad del corredor industrial en la provincia de Tundama.

INTRODUCTION

In the last decade, the Colombian economy has attempted to engage in an expansionist dynamic of its markets, establishing free trade deals with other countries such as Mexico, the United States and Chile, among others, this engagement creating a globalized business environment which is more accentuated every day. From this perspective, small and medium businesses which are the majority in the county, must get involved in the changes and trends used by international companies with which Colombia establishes commercial nexus, most importantly in what is referred to as management and operational effectivity practices. This environment demands great efforts to be made for growth, the improvement of the quality of products and processes, as well as productivity and thereby competitivity. The ability to reduce operational costs and reduce lead times with the aim of improving brand positioning and market reputation represents the challenge that such organizations should take on if they want to remain economically active (Lopez, Avila & Mendez, 2011).

Coinciding with the above, the business and academic world have developed a series of tools that over the years have been demonstrated to support organizations in improving their productivity, above all in technical areas, production plants and in human resource departments. This set of tools are grouped under the philosophy of lean manufacturing (lm), the beginnings of which were seen in 1950's japan, a country that, after the attacks in Hiroshima and Nagasaki and with a scarcity of natural resources and space, began a trend that eliminates waste with the slogan of "zero defects, zero inventories, zero delays and zero disregard for people". According to Sipper (1998), production philosophy passed from "push" to "pull": sell first, then produce. This means that flow adjusts to demand allowing for the reduction of inventories through the "just in time" system. All this is combined with the underlying satisfaction of the clients, increase in the added value of the products, the participation of the employees in improvement processes and the rise in profits for investors (Sipper & Bulfin, 1998). In the last five years, the Boyaca department and especially the industrial corridor where the Tundama province is located, a lag in terms of development,

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economic growth and business competitiveness has been shown in comparison with other regions of the country. In the (Sarria, Fonseca & Bocanegra, 2017) study, it is mentioned that developing countries such as Colombia need the adoption and use of new management tools, including the Lean philosophy since its adoption and use by organizations has been shown to strengthen and boost their operations. The importance of this study is highlighted since the analysis under this approach applied to the Boyaca organizations is not documented.

Within the methodology of the present work is the design of the survey, allowing to characterize and diagnose the current state of the companies in this region to identify the problems that reduce productivity to companies. In the study by (Velez et al., 2008), these problems are related to Management Systems and Human Resources, and the most commonly used tools in the country are highlighted. These tools are also documented in the study by (Espejo & Moyano, 2007).

This paper aims to provide an overview of the knowledge and possible adoption of these techniques and tools in companies in the industrial sector of Tundama province and which are registered in the chamber of commerce of the city of Duitama. The initiative is based on the document "Plan Estratégico Departamental de Ciencia, Tecnología e Innovación – PEDCTI" (Provincial Science, Technology and Innovation Strategic Plan), where the question arises as to how productive units adopt and develop better forms of production that would enable them to be more efficient and competitive. As such, it becomes necessary to transform productive factors urgently and profoundly, and initiatives or studies that emerge from the academic world play an important role in this process.

THEORETICAL FRAMEWORK

To support the present study and the results of the documentary review, the following set of tools was found within those most representative, and made up of Lean Manufacturing and all those production tools or practices and their complementary parts. Initially Lean Manufacturing (LM) is defined as the set of techniques developed by Toyota after World War II. These techniques help to improve and optimize the operational processes of organizations, independent of their size (Womack, Jones, and Roos 1992). All of these techniques were included in what was initially known as "Just in Time" or TPS (Toyota System Production), which was contributed to by authors including Shigeo Shingo, Edward Deming, Juran and Crosby.

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At first, this set of techniques became known as a tool for reducing inventories, without explaining that it is a tool for the reduction of waste including: inventories, times, defective products, transport, storage, machinery and even people. LM's goal is to reduce costs, improve production, increase system efficiency, increase production, improve supplier and vendor relationships, and stabilize work, thereby satisfying both employees and customers. In LM, a series of tools are proposed in which their use allows the proposed organizational objectives to be reached. In this sense, it is not a question of applying all the tools together or one by one, but rather it is a question of remembering that the improvement of the parts does not imply the improvement of the whole, in as much as the cause-effect relationship is directed towards a specific purpose. Among the most important or the most used in the industry are:

Andon or *"visual aid"*: Signaling systems that allows for the delivery of the right order or service at exactly the right time (Hirano, 2011).

Kaizen or *5 S's*: This is a series of techniques used to improve work areas (Gemba or workshop floor), for the purpose of facilitating the flow of materials and people, allowing a company to correctly locate material inputs etc. (Shaikh et al. 2015).

Kamban: In general terms and as shown in work (Gross & McInnis, 2003), this tool is utilized to facilitate the signaling of the flow of materials, information and products which may be in process or finished.

SMED Quick Change Method: This tool is used to reduce model change times or machine or production line set-up times for units of time under two digits, whether in hours, minutes or seconds (Socconini, 2008).

Total Productive Maintenance or *TPM*: This is a method used to maximize the availability of manufacturing equipment and machinery, avoiding unexpected failures and possible defects generated (Nakajima 2007).

Total Quality Approach: In addition to the ISO 9001 or SGC system it is very important that there is a total quality culture with a focus on creating value for the customer or client.

Zero Quality Control Method: This consists of replacing a visual inspection at the end of the work for several, distributed along the production line with the aim of reducing defect levels to parts per million.

Manufacturing cells: These are used to reduce processing times and resource use, having to do with performing operations under the 'just in time' philosophy.

Manufacturing waste (MUDA): This is defined by everything that is not the minimum amount of equipment, materials, supplies, parts, locations and times of machines or workers, which are absolutely essential to add value to the product or service. The seven classifications for waste are described below (Barón & Rivera 2014).

Overproduction: Of all types of waste, this is the most significant and depends mostly on

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those responsible for strategic and tactical decision making. Overproduction refers to scheduling the use of resources at a time and in quantities that are really not required to satisfy the consumer.

Stock: Its prolonged and excessive upkeep is detrimental. It is divided into raw material, in process and finished product. It generates storage and handling costs, leads to obsolescence, defects and a "feeling" of low capacity.

Transportation: This can be the displacement of various "elements", be it materials, finished product, people or tools. During that period of time the organization is not modifying the form or substance characteristics of the product for which the customer is willing to pay.

Unnecessary movements: Workplace layouts are sometimes ineffective, forcing the staff to carry out movements that are not natural for the limbs, obliging them to bend down to pick up a substance or tool and, among other activities, to bend and stretch, thereby putting their health at risk and generating an unproductive environment (Hirano, 2011). A disorganized workplace leads to this kind of waste, for example, when necessary elements are mixed with those that are not, several actions being needed to find what is required (Rajadell & Garriga, 2005).

Wait times: This represents the event that, at any given time, resources that should keep moving through the production process, do not do so. For example, when a unit leaves a work center and must be there a period of time for it to be processed (Liker, 2004). This generates unnecessary costs and can make idle people lazy and lead them to underperform when they eventually go back to their task. Wait times are due to poor leveling of workloads, failures in programming or in equipment and the absence of 5S.

Unnecessary Processes: Made up of activities that exist because of the design of inefficient or weak processes, or because of the presence of defects. For example, the reprocessing of a part, after inefficient quality control of the supplier (Browning & Sanders, 2012).

Defects: This refers to accepting, producing or sending products that do not meet customer specifications, either internal or external. In turn, this generates unnecessary processes. The costs of this lack of quality include a waste of valuable time and a detrimental effect, not only on the productive or economic aspect, but even on customer satisfaction, be that internal or external (Sipper & Bulfin, 1998).

Poka Yoke (Error-Proof): This is a mechanism that helps to prevent errors before they occur, or failing that, it highlights the error so that the operator corrects it in time.

All the aforementioned tools are but a sample of all those found in the literature. However, a special recommendation is made that, it is presumed, guarantees the correct adoption of these tools, initially being the correct documentation or design of processes that aids the personnel or human resources of the organization in carrying out the operations that are

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documented, thereby cementing the standardization of operations.

Furthermore, the authors that were consulted insist on the need to establish measurable parameters that facilitate the evaluation of the course and performance of the production process in all its stages, also acting as a way to maintain continuous improvement with the premise that "that which is not measured cannot be controlled and if it is not controlled it cannot be improved" (Najar & Álvarez, 2007); (Arbeláez & Alberto, 2006).

METHODOLOGY

Initially a context is developed evidencing a need to analyze the production processes of the companies under study. In this case, we can say that in Colombia, for example, Small and Medium Enterprises (SME) represent more than 90% of economic units and concentrate around 60% of employment (Montoya, Montoya and Castellanos 2010).

However, despite their importance, there are sources providing figures that between 60% and 90% of these companies disappear less than 5 years after beginning operations (Nieto et al., 2015). In addition to this, SMEs face several problems that impede their sustainability, among which are problems of access to markets, technological barriers, difficulties to obtain credits and difficulties in terms of internal operations. The following presents these shortcomings in their structural aspects, identified by (Velez, 2008).

Management systems: ignorance of customer needs and environmental trends, lack of strategy planning and deployment, a reactive approach to action ("putting out fires").

Processes: the scope of processes and the relationships between them is unknown. There is a large number of activities without value to the client. They present levels of productivity lower than international standards.

Human Resources: there is no awareness of the role played by the worker in the production and efficiency of the company, little or no training, scarce conditions for the worker to release their human potential.

Information: absence of reliable indicators to define objectives and goals, monitor their achievement, and make decisions based on data and facts (Velez et al., 2008).

This provides an overview where it is possible to state that only those SMEs that wish to remain in the market will be prepared to face changing markets and a horde of highly competitive new products with quality at a good price and above all, on time. This fact has led to the continuous increase of productivity becoming a key condition for any manufacturing or service industry that wants to remain competitive in the market and it is within this remit that

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the social function to be exercised by the academic world becomes a pivotal facilitator, allowing and aiding the productive community in the adoption of the latest trends in tools, techniques and management models, with continuous improvement that helps to increase and maintain competitiveness.

The designed survey is based on the methodology implementation proposed by (Sarria, Fonseca & Bocanegra, 2017), which consists of four phases (Beginning, Setup, Deployment and Tuning), which are subdivided into the following items:

- Management commitment.
- Leaders selection.
- Creation of the Implementation team.
- Value Stream Maping diagnostic.
- Human resource training focused on Lean tools.
- Creation of waste reduction indicators.
- 5s use.
- Pull system deployment.
- Use of more representative Lean Manufacturing practices (use of the Smed, TPM, Kaizen and Poka Yoke tools in customers and suppliers).

The research contemplates an exploratory descriptive methodology, in which Initially a pilot study was carried out with 3 businesses in the city of Duitama, the number and sector to which they belong were the result of a simple random sample, adjusting form and structure of the information collection tool. to select the 10 most representative companies of the region that fit the selection parameters belonging to the different economic sectors.

Phases

1. Design of the information collection instrument: In which the design of the information collection tool was carried out following the methodology described by (La Fuente and Marin 2008).
2. Validation: a test was carried out to three (3) randomly chosen companies with which the structure and content of the survey were adjusted.
3. Application of information collection instrument: which was applied to ten (10) of the ten companies most representative of the area of study and that belonged to the different economic sectors.
4. Analysis of results: through a qualitative analysis, we highlighted the most relevant results that are specified in the following section.

RESULTS

The re-written questions led to the development of the following questionnaire, made up of 13 questions geared towards determining the level of knowledge of the individuals surveyed and the possible application of said knowledge to the lean manufacturing tools within their respective businesses.

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Value Stream Mapping

1. Have you ever asked yourself why your clients prefer your products or services?

All those surveyed stated the importance of knowing the factors that set their products apart. Nevertheless, none of them have established, documented or designed a procedure that would allow them to know the preference of their clients for their products, which highlights that the entrepreneurs have not developed nor implemented value chain mapping of their products or services.

Standardization

2. Is there any document that guides the production activities within your company?

This question looks to determine if, within the enterprise, there are documents such as a manual for procedures and processes that facilitate the productive and organizational tasks. All the individuals surveyed stated that they made use of these type of documents, however the evidence points to the fact that there is no clarity regarding the differences between processes, procedures, checklists or manuals (whether for equipment, tools or even processes). The survey also highlighted that delivery notes, work orders and quotes are all included in the type of document that actually belongs to process design.

Standardization

3. Is there formal documentation within the company pertaining to production activities such as diagrams, plans and instructions, etc.?

The entrepreneurs surveyed stated having documents such as process and assembly plans, but nevertheless there is ignorance of the technical information pertaining to said process as well as the tools and equipment being used in it, and relating to the making of the products as well as the services being provided.

Traceability

4. Are the functions and tasks carried out by those responsible for the processes clearly identified by means of processes and procedures manuals?

Of the businesses surveyed, only three showed as having documentation related to job analysis and its respective functions, which were to be found in the organization and job description manual. Regardless, personnel in some operational jobs were unaware of the limits and functions of their positions.

Measurement

5. Does the company measure the performance of its activities?

All of the companies surveyed stated that they measured the performance of their production activities and said measurements refer to the number of products made or the number of clients attended to in a given period of time, results cross-referenced by portfolio or by invoices. This indicator refers to the result of the process and not to the prior process, which evidences that there is no rigorous, formal and systematic way to carry out partial measurements and follow up of the process before offering a final product or service. The fact that there are no partial

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measurements of the processes is evidence of the lack of knowledge of the concept of constant improvement, even when two of the business surveyed displayed, implemented and certified quality management systems.

Continuous Improvement

6. In the event of a non-conformity within the process (defects, machinery breakdown, bad quality products or prime materials) or within the service, is there a defined a path of action to avoid said non-conformity happening again?

This question sought to find out if the concept of preventative or corrective action is understood and internalized by the business, and in fact the two business that did implement the quality management system demonstrated assuredness and were able to evidence documented procedures. The other businesses behave in a reactive way, lacking of any method and only taking action when non-conformities arise at the moment of production or at the moment that service is provided.

Standardization

7. Does the company know the lead times of its products and the time spent by the operators on each job for each activity assigned?

All of the companies surveyed are unaware of their lead times, instead using estimates that are the result of the production managers' or operators' experience. Concepts such as leveling of workloads and production line balancing are unknown and there does not exist a standardization of the working times nor of the tasks carried out by the workers, neither are the positions differentiated.

Methods and Times

8. Have method analyzes been developed and measurements made to determine the workload of the operators?

Without knowing the lead times, it is impossible to answer this question, although three organizations stated that they had carried out studies to determine the work load of their operators or some such type of study. That stated, none provided evidence of the existence of said studies and were unaware of the concepts of methods and times, which are fundamental pillars to eliminate human resource related waste.

Value Stream Mapping

9. Does the company evaluate the cost of waste, whether that be time, products, raw materials, overproduction, etc.?

All of the companies surveyed, although recognizing some kind of waste inside the production process, have not designed or implemented a method that allows them to identify in the first place the waste product of their production system, much less the cost it generates.

Customer Satisfaction

10. Has the organization established measurable criteria to determine customer satisfaction with its products?

Only companies that have implemented a quality management system stated having a method for measuring customer satisfaction, although this mechanism is not always applied and is limited to

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working only when there is a complaint or grievance. The reason that these surveys are not applied, is due to the awkward feeling displayed by some of the clients at the moment the surveys are carried out.

5s

11. In the production area, are there scheduled days for the cleaning and maintenance of equipment, machines and tools used in the production activities?

Although a pleasant and orderly environment is better suited to carrying out the tasks or activities, in none of the organizations is there a defined or implemented - much less documented within the processes - preventive maintenance plan, the maintenance days evidently not being scheduled regularly but rather being the result of other types of stimuli.

Total Productive Maintenance

12. Does the company have, or is there defined, a maintenance plan for the machines, tools and equipment used in production?

Of the organizations surveyed, none have formal defined maintenance plans. However, it is more frequent to do work on the repairs derived from the lack of this type of plans, there being confusion between the concepts of preventive maintenance and corrective maintenance.

Inventory management

13. In terms of stock management, does the company have a policy that allows for the control of quantity and rotation of raw materials, inputs and finished products?

The management of stock in all the cases, responds to the immediate needs of materials and supplies, with only one company having a rigorous method of inventory control. Inventory control is associated to warehouse control by means of the Cardex tool and when it is necessary to replenish what is needed, it is according to the subjective criterion of whoever is in charge of purchases. This often generates a surplus or shortage of materials and supplies; In the following graphs, Figure 1 and Figure 2, the results of the surveys are shown, as evidenced based on the answers given in each one of the organizations.

DISCUSSION

Within this section, it is worth emphasizing that the main academic objective of this research should be to encourage entrepreneurs in the region to correctly and definitively implement the Lean Philosophy, starting with the elimination of all those activities that do not add value to the manufacturing process, to then proceed to the application of an acceptable level of flexibility of the production chains, adapting to the fluctuating demand of the region.

Many companies are at an advanced stage of documenting their processes, but

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ideally, this documentation should be followed by the leader's selection and the creation of the documentation and implementation teams who carry out the initial diagnosis based on the Value Stream Mapping for each installation. In this way, the training of human talent in this philosophy would be fully complied, which would facilitate the adoption and implementation of the 5s to continue with the other complex tools, as recommended by (Sarria, Fonseca & Bocanegra, 2017).

Finally, it is important to highlight the improvements perceived by the implementation of each of the tools or set of them, which go hand in hand in achieving significant improvements in product quality, as is the case of the company Casa Mecánica LTDA, with the implementation of 5s and Andon systems at its plant in Medellín, Colombia. (Arrieta et al., 2011).

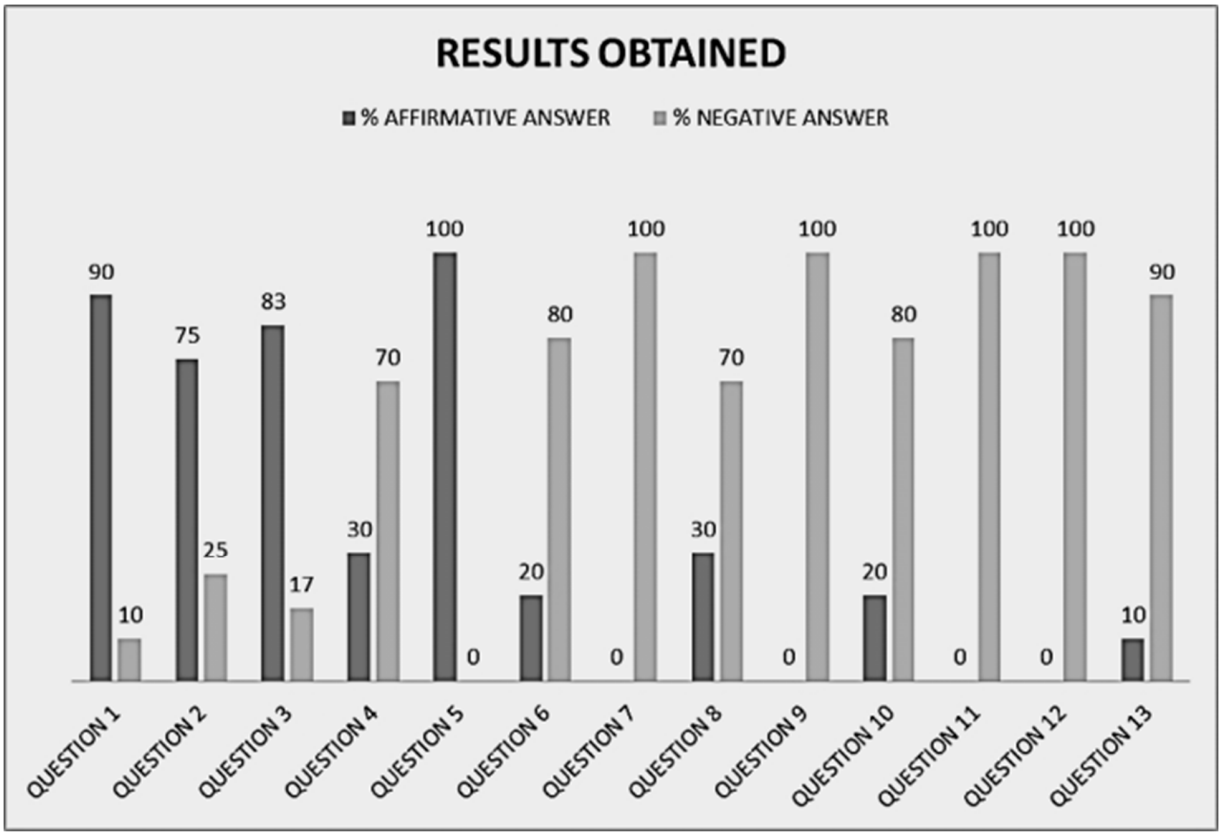

Figure 1.- Questionnaire results

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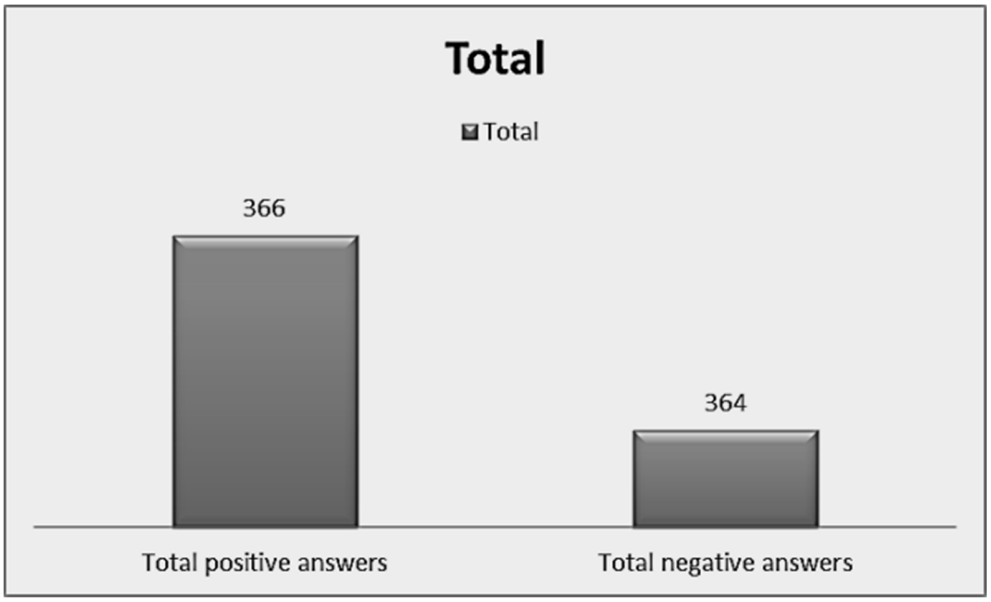

Figure 2.- Number of positive and negative answers

CONCLUSIONS

With the research carried out, there is evidence of scarce use and management of both Lean Manufacturing and continuous improvement tools concepts, so that the productivity and scarcity of new production methods is reflected in the competitiveness of the province of Boyacá, where it is necessary for companies in the region, whether small-medium or large, to develop a competitive advantage through the identification of individual strengths that lead consumers to prefer their products. It is therefore possible to start with the characterization and documentation of the processes and calculation of the of the plants' capacities, which in turn will allow to establish measurements to maintain a constant on-time delivery of orders.

From there, future studies can be generated that will be the basis for establishing indicators that highlight both individual and collective performance, leading to a better understanding of the concept of continuous improvement, complementing it with master plans of production and preventive maintenance and improving the use of resources while boosting productivity and competitiveness. This will be supported by the implementation of Lean Manufacturing tools, leading to a need to generate further studies in order to establish the appropriate methodology to apply this philosophy, based on real life cases that demonstrate the economic benefits of these tools.

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