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Using the INJET System in the EPS Injection Industry

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Abstract**—** *The aim of this research is to demonstrate the improvements and gains that the expanded polypropylene company (EPS) obtained with the use of the mes-idw injet system in the machines, to obtain levels of productivity compatible with the resources of the company. By analyzing the data and facts collected in the company's process flow, it was possible to identify improvement in the operations performed. The productive control has contributed to the company's productivity with excellence. According to the bibliography based on data collected in the company, it was possible to identify actions that are satisfactory. Based on the needs evidenced in the company and the necessary measures that were taken through the implementation of the INJET system, it is feasible the improvements that were applied, with which it increased the continuous production performance and the total quality of its products..*

Keywords**— Production management, monitoring system, quality, improvement tools.**

I. INTRODUCTION

Production management encompasses all processes related to production in a company that works with manufacturing, where the competitive environment is becoming more and more disputed, making it always a search for improvements in productive resources, with quality and the lowest possible cost.

There are several definitions for the term quality, which makes a definitive concept impossible for the idea of what it is. The truth is that it has come to stay, whether at work, at home, in the production of goods or in the provision of services, quality is present in all areas of our lives.

The thermo technique is a company focused on the production of solutions, integrated in the supply chain, producing the own raw material and products developed with the best performance in the market. It is considered a leader in the Brazilian packaging market for industrial products, and consolidates with ample growth and evolution, as the largest manufacturing industry of EPS-Styrofoam Expanded (Styrofoam) in South America.

The MES-IDW INJET (manufacturing execution system) system is a monitoring system that provides managers with information about each machine in the production process: a case study at the company Termotécnica da Amazônia Ltda.

The general objective of the research is to demonstrate what improvements and gains in the quality of the products and services that the company Termotécnica obtained with the use of the system in the production line. In order to contextualize, the specific objectives were created: to demonstrate the improvement of productivity and time that the organization obtained with the use of the system; verify the vulnerability of the system; to describe the efficiency of the machines that the company had with the implementation of the monitoring system.

Methodologically, this study adopted the type of field research within the production area, where the system is applied and developed based on the questionnaire done in all sectors that compose the company's portfolio.

The study is therefore justified if factory floor information is not handled properly, a number of problems can occur in production management, so the INJET system plays a key role within the company, it streamlines the process of data collection, emitting accurate reports on production design and machine shutdown reports, giving an extensive view throughout the productive process, thus aiding in decisions and the total quality of the products.

It has relevance for the companies, due to the fact that in the productive process that is the greater possibilities of losses and, also, the greater of gain. In this way, the evolution of the machine monitoring system is

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fundamental to promote the identification of these losses, as companies seek to excel in the market through productivity and quality, and using an efficient and innovative system to facilitate the data collection of the production. Society is the most benefited by this feature, because it increases the quality of products, reducing production time, thereby reducing waste and, consequently, the final price passed on to customers will be lower.

For the academics of quality and production management, it has relevance because they have gained knowledge, added values and a better understanding for a good strategy in the globalized and competitive market.

II. THEORETICAL REFERENCE

Will be presented in this item, the conceptual elements on industrial production, technology, INJET system, INJET architecture, Quality Management, Quality Tools, Management Systems and KAIZEN.

2.1 INDUSTRIAL PRODUCTION

What we know as industry, developed from the Industrial Revolution, which began in the eighteenth century in England. The bourgeoisie sought greater profit, lower cost and accelerated production, so it sought an alternative to improve the production of goods, because in the middle ages, the way of production was handmade [1].

In today's globalized world, companies seek to increase their competitiveness, either by reducing costs, improving the product or adding value to the customer's product, to differentiate themselves from the competition [2].

The revolution brought the production method more efficient, the products are produced quickly, with the help of machines, thus, prices became more affordable, but also with the evolution of machines came unemployment, because, with the use of machines , human labor was no longer necessary [3]. No organization survives unless it produces something that society needs, at the price it is willing to pay. Each organization defines its systemic model because it depends on the marketed product and the production capacity.

The assembly line and the standardization of the equipment used in the production gave rise to uniform products, unlike craft products which could hardly be reproduced equally [4].

Production within the factory requires a lot of technology and investment to be economically profitable, the traditional production line is subjected to a series of rationalization and optimization methods; study of time and methods to better seize the workforce. According to [5], abundant capital provided innovations, making the mechanization of manufacturing organizations result in increased production and cost reduction.

With these changes, it was necessary to create software to be able to manage production processes. According to [6], companies and professionals need continuous improvement, not to be stagnant or to be carried by the current of events to the past, because of the knowledge gap. These technological inventions have positive effects in the industries, because it is developed to aid in the decisions of the organizations and ends up becoming a competitive differential with the innovations.

2.2 INFORMATION TECHNOLOGY

Companies are turning to technologies, seeking to automate their production processes using these tools. A company without technology does not survive in the globalized world, where the search for cost reduction is constant.

The use of information technology as an organizational resource consists of its strategic use, which allows the organization to obtain a competitive advantage in relation to the competition, as well as the possibility of generating new business [7].

This system uses hardware, software, telecommunications networks, computerized data management techniques. The information age and the potential of new technologies is undeniable, however, this potential can be used positively or negatively, new technologies are of utmost importance for the survival of organizations, information technology has positive effects in the business world , since it improves the strategic and functional level, enabling companies to improve planning processes and to interact with their environment in the most productive way and making them more competitive, but it is worth emphasizing that, for the productive process to be satisfactory, employees are trained and qualified to meet the demand for information contained [8].

According to [9], many professionals, regardless of their field of activity, use the information system as a wild term, that is, it has an almost total coverage when it comes to technological solutions. The current scenario, where it is increasingly competitive, leads companies to invest in innovative programs for cost reductions, quality improvements, greater attention to consumer needs, and increasing use of information systems and technology.

A management information system is an integrated man / machine system, which provides information to support the operations, management and decision-making functions of an organization [10].

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Success and differentiation are always obtained by companies when they use the information system. System professionals are not only required to provide organizations with good software, databases and information exchange networks, it is necessary for them to know the business of the company, with a broad view of the business, main competitors and the market of the activity, only so it can develop solutions that contribute to the achievement of effective and sustainable competitive advantages.

According to [10], technological innovations and review of organizational structures will lead to the discovery of new opportunities. The path offered to organizations and people by the use of computational resources, have been very promising according to processes and communication more agile and of better quality. As the direct body of organizations becomes aware not only of the benefits of new technologies but also of risks, this system can play a much larger role than just supporting the development of new business and business processes, but also with concern about the consequences that these new technologies will add in the organizational environment.

2.3 INJET SYSTEM

The INJET system is an information tool that assists in the management of continuous improvement of the production process of machines [11]. This system is used and has been successful in management philosophies such as Lean Manufacturing with the use of Six Sigma techniques, all successful history monitored by the INJET System and registered in a database.

These new technologies have been of paramount importance to organizations, especially in the area of production.

According to [6], the companies with the greatest capacity for innovation are the most competitive, as they seek incessantly the differentiation of their products and services.

The technologies leverage levels of productivity within organizations, because these tools streamline the process and help decision making, the Injet is an indispensable tool in the production line, organizations that use this system have a differential in the level of productivity, this system is a resource with hardware and software devices that can be integrated with other organization information systems such as the Enterprise Resource Planning (ERP) system [12].

According to [13], before we implement a new process, we need to have an early idea of its possible results, either to confirm our expectations regarding the benefits sought or to identify possible side effects. The system itself does not bring capacity, that is, it provides awareness to the administrator, to the machine operator, where he can really act to improve. Where it understands and seeks more efficiency and results, this sense of achievement is the greatest gain for the organization and its employees.

The company must plan and choose carefully the purchase of software, allowing a fast and secure transaction between the management model in which it operates and what the software will provide to achieve the proposed objectives [14].

The INJET system is a tool that, well used, can bring several benefits to the productive and strategic process of a company, since there is a need to be a competitive and differentiated company in the market where it operates, thus, there is an opportunity to search solutions, where the INJET system proved to be highly adaptable to the structure of the organizations that adhered to this system, another point that was very favorable, it was the opportunity to perform a pilot with the system for later decision on its acquisition, as this system, besides reducing cost, it assists in the decision making of the organization in relation to productivity, besides making the more streamlined production line.

According to [12], with the availability of information, the flexibility in the use of available resources increases, knowing when and where they can be used, and with this, we gain competitive advantage. This system can verify the real effectiveness of the product, because it shows a different way of managing and managing the factory floor in a dynamic way, because this system has several reports that enables the continuous action where the product itself is self-marketing due to improvements and maximization of the results it offers.

2.4 INJET SYSTEM ARCHITECTURE

The INJET system needs four steps for data flow to work; the first is the data application of the machine, which is based on the use of programmable logistical controllers, it can be used automatically or manually; the second is a server that is based on the client and server architecture, this collection is in the system database; the third is a master computer, it manages the receipt of data, where all information will be analyzed and processed, and the fourth step is a maintenance terminal (TM), which are computers that work the corporate network, in that computer will be monitoring in real time and also the results of the reports already made [16].

For [17], the architecture based on the business of the electronic system is a worldwide trend. This system must be well accepted within organizations, because it raises the degree of productivity, companies that already use

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this system, have reaped the fruits with the increase in profitability.

Second Technology alone is not capable of making a business more dynamic, but it can make its business models more flexible, able to adapt to the constant changes in the market.

The INJET system offers a number of analytical reports and managements that help to define improvements in the production process, taking into account the performance of machines in product performance. This technology has come to aid in the continuous process of organizations, but to achieve a good performance, it is not enough to have an efficient system, but, people qualified to operate these machines.

The INJET system goes beyond monitoring the factory floor process. For [18] this processing generates accurate information that can be presented in the form of reports and graphs that facilitate the analysis and interpretation necessary for the immediate decision making. This system controls the production in real time, the data is processed at the same time that happens the productive process.

2.5 QUALITY IN INDUSTRIAL PROCESSES

Quality is the degree of utility expected or acquired of anything, verifiable through the form and constituent elements of the same and the result of its use [19].

Quality is conceptualized by processes and methodologies, applying rules and norms in a context with company policy [20]. The implementation of the rules controls how the processes available within the company are performed so that the achievement of the organization's objectives occurs.

Usually, quality is seen as an attribute of the product or service. Broadly speaking, it refers to anything done by people, such as electrical equipment, cars, hospital services, school-provided instruction, or someone else's work, in any department, company, or institution [21].

The quality itself is characterized by the production of something, from this concept, quality serves as a measurement parameter of products and services to the needs and requirements of the final customers. In the 21st century, the quality process accompanies every stage of manufacture.

The acronym TQM stands for Total Quality Management [22]. It is a managerial philosophy, a set of practices that emphasizes continuous improvement, seeking customer needs, long-term thinking, elimination of scrap and rework, worker involvement, teamwork, new process projects, benchmarking of known best work practices), analysis and problem solving by employees, outcome measures and close relationship with suppliers [23].

When talking about Total Quality Management or Total Quality Management (TQM), reference is made to quality in a broader way, that is, encompassing several economic sectors, such as industry, commerce and services. It is a set of coordinated activities aimed at directing and controlling an organization in relation to quality, including planning, control, quality assurance and improvement [24].

TQM is an effective system for integrating efforts to develop, maintain and improve the quality of an organization's various groups, enabling production and service to be brought to the lowest levels of operation and fully meet consumer satisfaction. The search for quality to meet the needs of customers is no longer a competitive differential, but an obligation for your business to survive in the market, therefore, the use of quality tools arises.

2.6 QUALITY TOOLS AND MANAGEMENT SYSTEMS

Using the techniques and tools of quality and management helps a company win the market and have loyal customers.

Quality tools come from knowledge and, although many of these tools are used based on the ideas and opinions of the employees, that is, the work team, they can be classified for their purpose [24].

There are several tools, however, let's talk about the best-known quality tools, are the flowchart, Ishikawa diagram, check sheet, histogram, Pareto diagram, dispensing diagram, control chart, brainstorming, benchmarking, 5W2H.

The 5S and PDCA management philosophy. Together, these tools are part of a specific group of elementary statistical methods [25].

Flowchart: This tool uses graphic symbols to represent the nature and flow of process steps [26].

Ishikawa diagram: known as cause and effect diagram, fishbone or graph, its function is to identify, classify into useful categories and show the possible causes of a problem or aspect related to quality [26].

The cause and effect diagram was developed in 1953 by Professor Kaoru Ishikawa of the University of Tokyo, derived from an explanation of the relationship between a problem or the undesirable effect of the effect of the process result and the possible causes of the problem.

Benefits: It is very visual and uses a very simple format, facilitates resolution of the problem, dividing it into units easier to manage and provides a very interesting global perspective, also helps to detect the root causes and possible reasons for the variation.].

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Check Sheet: Facilitates process monitoring, providing valuable information on the most frequent deviations and global errors. Data collection is carried out based on the formulation of questions such as: where, what, who and how [27].

Histogram: The most commonly used graph to show frequency distributions or how often each different value appears in a data set.

It is represented by a bar graph showing the distribution of the data. It can be considered as a snapshot of the data obtained from a process.

Pareto Diagram: The Pareto diagram shows in a bar graph which factors are most important based on the 80/20 rule which determines that 80% of the defects are concentrated in 20% of the processes [27].

Dispersion Diagram: It is used to study and identify the possible relationship between observed changes in two different sets of variables.

Letter of Control: It is a statistical tool that allows to differentiate the variations in the processes due to common causes and those that have their origin in others less normalized. This type of chart allows us to study how a process changes over time [25].

Brainstorming: means brainstorming and is a technique used to generate ideas within a group of people through interesting and creative solutions to solve the problem;

Benchmarking: A tool that compares the processes of a company with other successful companies. In the end, all ideas are analyzed [27].

5w2h: It is a tool used in the mapping and standardization of processes in the elaboration of action plans. We need to work out a framework and answer the questions: What? When? Because? At where? As? Who? How much?

Thus, this 5W2H model defines the action to be applied in the organization from the response of each of the questions made, using this tool, we can see the adequate solution of a problem, with the possibility of monitoring the execution of an action [28].].

5s: this management philosophy has five principles (Seiri, Seiton Seiso, Seiketsu, Shitsuke) - Sense of Use, Organization, Cleaning, Health or Continuous Improvement, Self-discipline, they are implanted in the organization to generate quality;

PDCA: is a management tool used in companies, made by Walter A. Shewart in the 1920s. It has the steps to plan, execute, check and act to control a process of a company [28].

2.7 KAIZEN PHILOSOPHY

Kaizen is a word of Japanese origin, which means change, it is not only a meeting with the operators to define a timely problem, it is a philosophy or culture of continuous improvement, it is a method that admits to lower costs and improve productivity , for [4], the success of the Japanese administration is based on values and discipline.

In the 1950s, the Japanese retook the concepts of the classic Taylor administration to restore their industry. Thus, the concept of kaizen arose, in Japanese it means "pure and simple change for the better", this technique aims at the good of the organization and employees in Overall, it became famous from 1990 onwards. Seeking this philosophy in organizations is improving their processes and products, to avoid wastage in the productive process.

Any unplanned action leads to wasted resources and, consequently, higher production costs and declining profit margins. The company must be thought of as a system and as such needs all parts of its gear to work in tune so that the whole system can flow [4].

Thus, assuming that time is the best indicator of competitiveness, organizations seek to implement this philosophy. Therefore, this procedure has the objective of distinguishing and eliminating the existing waste in the company, however, this practice establishes changes, to improve, something has to change, the way to accomplish, then to seek kaizen, have to be open to change in the way of working.

The increase in productivity in the Japanese system is based on discipline, on strengthening teamwork, on the use of employees' ideas, which values their self-esteem, as well as on profit sharing [4].

Applying a philosophical goal within the organization is not such an easy practice, however, we have to understand that it is possible to do better, no day should pass without some improvement being implemented, whatever it may be [19], innovation of productive systems has made an evolutionary leap for companies that have followed such developments. The changes made must be gradual and never abrupt so as not to disturb the balance of the structure.

It is natural that all methods have problems, when they arise we can analyze them, understand them and look for the best way to prevent them in the future, problems are good sources for ideas and modifications that will bring about progress, and this continuous improvement is adopted by several companies that aim to achieve ever better results, be they in the external process or in their internal processes, this improvement is achieved through

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good organizational practices and their kaizen philosophy.

III. METHODS OF PROCEDURES

The company TERMOTECNICA implemented the monitoring system after the TIS (information technology) to make several researches using the kaizen philosophy, which consists of the application of an organized form of common sense and the exercise of creativity, focusing on the individual improvement of the process. The INJET system was chosen and installed in the 30 production machines.

The prospect is very promising for the productive system; therefore, the need to look for a new technology tool was to streamline the processes, since they were previously performed manually, and checked item by item and machine per machine, making it a time-consuming service. During the development of the improvement projects, the Thermotechnics carried out a careful advisory work, aiming to transfer the necessary knowledge that will provide the organization with the maintenance and improvement of management, the company also made available tools and practices that best fit the needs of the organization and of customers. With the implementation of the system, if you had more productivity and quality of service, as will be demonstrated in the following cases.

The periods defined for data collection for benefit evaluation were the months from December to January, representing the before and after the implementation of the system. The areas involved are: production planning and production line maintenance.

The data collection of the machines was done differently for the two cases:

• December; collected data from the minutes used in the company as a means of communication and registration;

• January; collected the production data using the Monitoring Terminal of the INJET system.

The proposed solution will demonstrate how the company excels in the quality of products and services, also gaining in productivity, profitability and profitability and thus show that, with a well-structured and qualified team, they obtain results for organization.

Because it is not enough just to seek technological innovations of the highest quality, if it does not enable its employees to perform well and work the perception of each one within the organization, they needed people to follow all evolutions within the company, so that they understand that their collaboration is of paramount importance, and also, they win out with the benefit of the system. A revolutionary vision for the current conditions of the company needs a revolutionary strategy to achieve results.

IV. ANALYSIS OF RESULTS

After all the procedures, we will show the results before the INJET system and then, with the implementation of the system, what were the losses and gains, and, based on the data collected, we will demonstrate, in the first frame, how it was without the system of monitoring.

Case 1: Through the records of all the December notebooks, Table 1 was developed, which contains productivity information and also to specify the stops.

Tab. 1: Before Monitoring

Production time	12 hours
Quantities of parts produced with quality	6770
Quantity of refuse	40
Total Available Time	677
Stop pointed	80
Stops not pointed	110

Based on the results, we analyzed the processes with the Ishikawa and 5W2H tools, as we will see below:

The Ishikawa Diagram in Figure 1 is a graphical tool used for quality management and control, identifying the problem or effect, and helps to raise the root causes of a problem, it considers all the factors that involve the execution of processes.

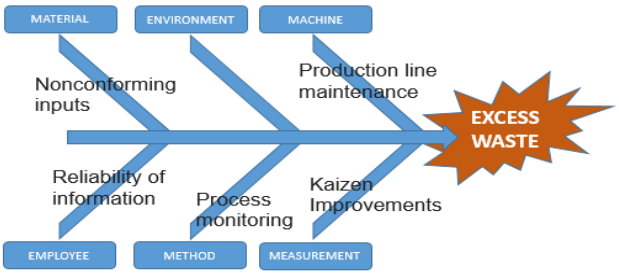

Fig. 1: Analysis of Causes and Effect

The 5W2H shown in Table 2 is a tool that can be used by any company, it has the purpose of assisting in the elaboration of action plans, such as a checklist, which gives clarity to the collaborator about his activities.

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Tab. 2: Check list 5W2H

What?	Who?	How?	Were?	Why?	How much?
Reliability of information	The managers of each sector and area	Having access only to authorized persons	In all sectors of the organization	For clarity and speed of information	No burden
Process monitoring	Supervision of production	Avoid unplanned downtime	Throughout the productive sector	Lest there be a delay in production	No burden
Maintenance in the production line	Company Maintenance Sector	Verifying the machines to avoid defects	In the production machines	Bottlenecks and line breaks	No burden
Non-compliance of inputs	Purchasing Management	Verifying that the inputs are within the normalities	Purchasing and Trading Sector	Avoid out-of-spec production	No burden
Measure work improvements through kaizem and INJET system	Directors	Verifying the best system to aid in decision making	In all sectors of production	To streamline processes and reliability	R $ 600.000.00 with maintenance

With mechanized work, time and productivity were lost, and this ended up at a loss because it would only know the total production at the end of the day. As the market is large and highly competitive, the ideal is to select situations and the paths to be followed, that is what the company did, implementing the system.

The information system is a valuable tool that helps to streamline and integrate the flow of information and knowledge within an organization, the agility of information is fast in the productive sector, thus minimizing costs and maximizing profits. With the introduction of the injet system on production machines, there has been a major change in all aspects of the organization, because the system is fast and accurate in the information.

The monitoring system has brought great benefits, such as reduced time, process optimization and productivity, more efficiency, because the system gives real-time production, organizations have been increasingly concerned about the quality of products and services, and it was what the system added to the organization, more quality and practicality in the production machines. The system is installed on the 30 production machines, one IPE for two machines, which throws the information to the master computer. As shown in figure 2.

Fig. 2: IPE model

With this system, when the equipment stops functioning, the IPÊ generates a visual alarm and starts to signal in the system as stopped equipment, having the reason of the stop as Informed Stop, this alarm is visible until the operator solves the problem and, thus, , to restart the machine, the operator must assign some cause for this stop, for this, there is a table that correlates all types of stops with a certain number.

This table gives a series of numbers that must be entered in the IP, and when this occurs, the status of the stop changes according to the information entered by the operator in the IP system.

Based on the information, we will show, with figures, how the process was done using kaizen, ISHIKAWA and 5W2H tools.

The most important point in applying the kaizen system shown in Figure 3 is the awareness of the improvements that are to come; also an important factor in the implementation of the system, is to determine very well where the efforts of the company will be used.

Problem: Excessive waste in all processes due to machine shutdowns.

Fig. 3: Example of waste

Causes: Lack of employee attention, since the process was done every manual.

Action: Automate the processes with support of the Injet system, to streamline the production process, thus giving real-time production of each machine.

Result of the improvement: obtained a 20% gain in the production of IPS-Styrofoam expanded polyethylene.

Collected production data using INJET, we observed the efficiency of the system, there was a great change in the implantation of the Injet system, as we can observe in Table 3.

Tab. 3: After Monitoring

Production time	12 hours
Quantities of parts produced with quality	8000
Quantity of refuse	25
Total Available Time	30
Stop pointed	71
Stops not pointed	70

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Therefore, with this system it is possible to see clearly the great gain that the company had in the quality of the service in the production line.

Figure 4 demonstrates the efficiency of machine monitoring, these green colors are machines that are running without any intervention, they are 100% working in the production of polyethylene.

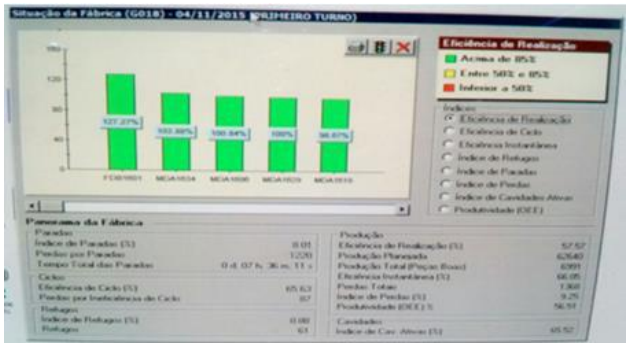

Fig. 4: Machine Monitoring

With the research, we can compare that production had a gain of 20% every three months, and with a year of implementation of the system, we can already observe the great change that occurred in the company, left the mechanical way to the computerized system, and the company has not only gained in productivity, but also in quality, agility and financial gains, thus bringing more benefits and bonuses to employees.

However, despite all the qualities of the system, the same does not work alone, it needs the assistance of trained people and good management, since the functioning of the world is based on administrative bases, so for a project to give good results , has to have a good administration, the function of INJET is not solve problems and produce more, because it is a tool of continuous process and its function is to collect data and demonstrate them in a way that the losses are visible to the collaborator, the system shows where it is to the deficiency in the production line, has to understand the necessity of using this tool and how it helps in the stability of the processes, thus will have a vast knowledge about the system.

The improvement actions, which are developed based on this information, give productivity to the company, with the help of well-trained and qualified employees to operate this system.

V. FINAL CONSIDERATIONS

Looking at the scope of production processes, it is perceived that innovation technology has come to make companies more competitive in the globalized world.

Organizations in general have attached great importance to the area where they are most profitable, which is production, where the factory floor has to be aligned as a whole. In this research, it is clear that the use of the automatic stop monitoring system contributed to the best use of productivity. The use of the INJET system resulted in a 20% improvement in representative productivity growth, since there was an increase in production, with quality without investments in new machines or labor, but there was investment in the information system.

The evolution of production management is a path with no return, old methods are being improved because of new systems that speed up decision making, and manual labor presented many problems, such as the need for time for operators to make notes operations.

The INJET system excels in quality and speed of information about the notes that are made available on the computer screen, thus facilitating the flow and management of company information. The production manager and all support staff have access to the same database information at the same time through the monitor.

With the implementation of this system, the company gains in quality, as it increased the level of production with more speed and agility in the processes of the production line, so with this system we clearly perceive the improvements that the company had with the efficiency of the monitoring, with the implementation of the system, we can already observe the great change that occurred in the company, raising its products with quality.

The monitored system has brought great benefits, such as reduced time, process optimization and productivity, and quality, more efficiency, because the system gives real-time production.

The company TERMOTECNICA, where the research was carried out, was successful with the use of the new machine monitoring technology, since, the increase of the efficiency of its production in the manufacture became more a competitive differential than its competitors, today, in the In the globalized world, companies are looking for innovations so that their products can be manufactured with less time, reducing costs, but always guaranteeing product quality.

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