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Design of a model for the correct reporting of unproductive times in production lines

Diseño de un modelo para el correcto reporteo de tiempos improductivos en líneas de producción

REYES-OLÁN, Claudia†*, PINILLA-RODRÍGUEZ, Juan Antonio, POZOS-TEXON, Felipe de Jesús, GASCA-CABALLERO, Carlos Javier and ROSALES-LASNIBAT, René Valdemar

Universidad Cristóbal Colón

ID 1st Author: *Claudia, Reyes-Olán* / **ORC ID:** 0009-0008-7531-5425, **CVU CONAHCYT ID**: 1301950

ID 1st Co-author: *Juan Antonio, Pinilla-Rodríguez* / **ORC ID**: 0009-0008-2930-9825, **CVU CONAHCYT ID**: 1297440

ID 2nd Co-author: *Felipe de Jesús, Pozos-Texon* / **ORC ID**: 0009-0004-1580-3479, **CVU CONAHCYT ID**: 538145

ID 3rd Co-author: *Carlos Javier, Gasca-Caballero* / **ORC ID**: 0009-0009-3039-7858, **CVU CONAHCYT ID**: 496327

ID 4th Co-author: *René Valdemar, Rosales-Lasnibat* / **ORC ID**: 0009-0005-5437-6681

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Abstract

The research carried out was conducted in a metal-mechanical company, where there were reporting problems from the operational staff, as well as productivity indicators that did not allow for the reliable analysis of the root cause of unproductive times, preventing continuous improvement in the production area. Therefore, a model had to be defined to prevent certain events that affected productivity. The research conducted was quantitative in nature since the hypotheses proposed were tested through data collection, based on numerical measurement and statistical analysis to establish patterns of behavior and test theories. Data collection focused primarily on the most frequently used unproductive time codes according to the stipulations in the quality management system. Additionally, productivity calculations were made comparing deductive codes with non-deductive ones to have a reference. The collected data was analyzed using descriptive statistics to obtain actions and reach the conclusion of the desired model to implement in the production area.

Statistical analysis, Quality, reliability, Root cause, Deductibility, Indicators, Production lines, Productivity, Reporting, Quality management system, Downtime

Resumen

La investigación desarrollada se realizó en una empresa de giro metal mecánico; en donde se presentaban problemas de reporteo de parte del personal operativo, además de indicadores de productividad que no permitían analizar la causa raíz de los tiempos improductivos de manera confiable que evitaba la mejora continua en el área de producción, por lo que se tuvo que definir un modelo que evitara que ciertos eventos que afectaban la productividad. La investigación realizada fue de tipo cuantitativo, ya que a través de la recolección de datos se probaron las hipótesis planteadas con base en la medición numérica y el análisis estadístico, para establecer patrones de comportamientos y probar teorías. La recolección de datos se enfocó principalmente en las claves de tiempo improductivo que se utilizaban con mayor frecuencia de acuerdo con lo estipulado en el sistema de gestión de la calidad, aunado al cálculo de productividad con comparativos de claves deducibles de las que no lo eran, para estar en la posibilidad de tener una referencia. Los datos recabados se analizaron mediante estadística descriptiva para la obtención de acciones y llegar a la conclusión del modelo que se quería lograr para implementar en el área de producción.

Análisis estadístico, Calidad, Confiabilidad, Causa Raíz, Deducibilidad, Indicadores, Líneas de producción, Productividad, Reporteo, Sistema de gestión de la calidad, Tiempos improductivos

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*Correspondence to Author (e-mail: claudiar@ucc.mx)
† Researcher contributing as first author.

Introduction

The objective of companies is profitability; behind this concept are recognized other no less important concepts such as quality and productivity (Evans & Lindsay, 2020), but through whom is the achievement of the objectives set in an organization achieved? The answer would be: through the different areas and departments that make up the organization and, in turn, the human factor, which is the one that must make the right decisions, establish work methods and ensure that everyone is aware and convinced of the role they play and how they contribute to the achievement of goals and results.

Description of the problema

The problem of study began with a deficient reporting of unproductive times on the part of the production operators, since, through time, personnel from other areas at the staff level, had realized that this was not objective and most of the time, it was used for the convenience of manufacturing supervisors to present productivity indicators within the established parameters without facing the problems that commonly occurred in the production line.

In the same way, in the unproductive time table that was registered in the quality management system, there were keys that allowed deducting time from the total working hours.

A problem derived from what was mentioned in the previous paragraph is that the processes could not be optimized with statistical data based on criteria that were not correctly based and that presented deficiencies in their application, which did not contribute to the continuous improvement of the productive process.

The main problem to be eradicated through the implementation of a methodology was to get the operating personnel (both operators and supervisors) to change their way of thinking and to properly report the problems that arose during their work shift in order to improve the process and contribute to the profitability of the business.

The company where the research was carried out belongs to an international group where the indicators must be compared under the same criteria, in order to be able to benchmark and solve problems that affect the production lines globally.

Objectives

To determine if the current way of reporting unproductive times is correct, and also if it contributed to the decision making and strategic planning of the company. This being the general objective of the research.

In particular, the following objectives were proposed: to determine the deficiencies of the method that was being used at that time, as well as to investigate the causes of why production supervisors avoided reporting real problems, as well as productivity indicators out of context, and finally, to define a correct model for reporting unproductive times in order to have reliable productivity indicators for accurate and adequate decision making.

Justification

The definition of a downtime reporting model in the production lines was necessary, since it had been detected that the problems reported to the maintenance and engineering areas were not congruent with the productivity indicators reported by the different entities within the company.

The ideology of the production personnel was to obtain a certain productivity index, since this way, their performance was evaluated, which was completely detrimental to the company because the root causes that caused the problems or that the process was not optimized were not attacked.

By establishing a well-defined model, we wanted to contribute to the productivity and awareness of the operating personnel, with the objective of developing a continuous improvement process that would allow achieving the objectives and that each area would be responsible for the failures and errors that could occur (Robbins & Coulter, 2018).

Hypotheses and research questions

Among the hypotheses that could be obtained according to what was observed and to the previous knowledge in this research topic were: Process problems that occurred in the production lines were continuously reported with deductible keys to avoid off-target productivity indicators. More experienced and therefore older personnel used deductible nonproductive time keys more frequently.

At production reports with completely true data, the actions taken were more accurate (since the problem was known) and improved the process.

Some of the questions that were defined to study the problem were:

What were the reasons for production supervisors to manipulate the information stated in the production reports?

What was the impact of not having a defined model for the proper reporting of non-productive time?

By what percentage would productivity indicators be affected if deductible downtime keys were eliminated?

What was the disadvantage of reporting work shifts less than the actual work time?

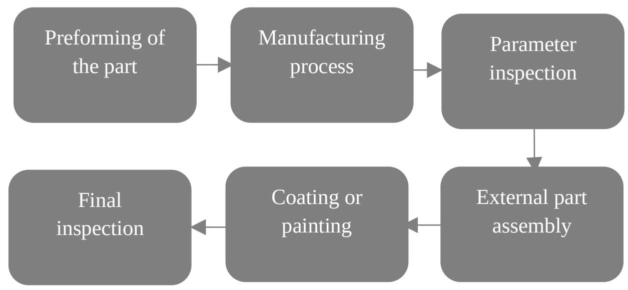
How could personnel safety be affected by continuing to report incorrectly?

Could machining and machinery problems be minimized on all production lines if they were reported, even if they only occurred in a particular area?

Process flow on production lines

A process flow structure refers to the way a factory or industry organizes the flow of material using one or more technologies (Freivalds & Niebel, 2014). Hayes and Wheelwright (1984) have identified four main structures in process flow: job shop, batch shop, assembly line or assembly line, and continuous flow.

The field of study for this research is the production line which refers to an assembly line or assembly line; where the production of parts moves from one workstation to another in a controlled rate, following the sequence necessary to manufacture the product. When other in-line processes are employed along with assembly, it is commonly referred to as a production line (Freivalds & Niebel, 2014), as exemplified in Figure 1:



Graph 1 Production Procedure
Source: Own Elaboration

Current model of non-productive time reporting

The fundamental purpose of work measurement is to establish time standards for a job. These are necessary for four reasons:

a) To schedule work and allocate capacity. All scheduling methods require an estimate of how much time is needed to do the work that has been planned.

b) To provide the basis for a target in order to motivate workers and measure their performance. Measured standards are particularly important when production-based incentive plans are employed.

c) To bid for and win new contracts and evaluate the performance of existing contracts. Questions such as: Can we do it? and How are we performing? Assume the existence of standards.

d) To provide benchmarks for improvement. In addition to internal evaluation, benchmarking teams regularly compare work standards in their company with similar work in other organizations.

Table 1 of non-productive times shows the following classification differentiated by numbers and letters:

Password	Concept	Example
I	Raw material supply.	Lack of prepared material.
II	Obstructed flow.	Material without the correct temperature, empty line or full line.
III	Machine failure.	Controls, sensors, failures in the main machine elements.
IV	Auxiliary equipment failure.	Hoist, cranes, lack of fluids.
V	Personal activities.	Training, meetings, absenteeism, delayed transportation of personnel.

Table 1 Non-productive times
Source: Own Elaboration

Productivity indicators

As stated at the beginning of this research, the main problem was that the measurement of work in the production lines was not reliable, due to the productivity calculation model that could be manipulated and have deductible type unproductive time keys.

According to Jacobs and Chase (2019), standard time is obtained by adding normal time and tolerances for personal needs; unavoidable delays in work (due to failures or breakdowns), as well as worker fatigue (physical or mental).

The equation representing the above statement is defined as:

Standard time = Normal time + (Tolerances x Normal time) (1).

Normal time = Observed performance time per unit x Performance index (2)

In the production lines where this research was carried out, the cycle time to determine productivity is calculated in the same way as the normal time. The productivity indicator is defined as follows (see table 2):

Indicator	Calculation
Productivity	Total Efficiency Index
Formula	Theoretical time / Time worked in a work shift. Theoretical time = Parts accepted per cycle time.
Unit of measure	Percentage.
Range	From 0 to 100%.
Objective	Measure operational effectiveness over a time interval.
Results	The total efficiency index shows the performance of a production line. If the data is not correct, the indicator will give a false picture.

Table 2 Productivity indicator
Source: Own Elaboration

Manufacturing data management system

The model to be developed must be compatible with a manufacturing data management system. Currently with Industry 4.0, manufacturing and production processes are based on database technology. Companies keep this information on finished goods, raw materials and inventories, and goods in transit that can be used in supply chain management. The manufacturing process employs numerous supplier, work progress, product component, quality, and cost databases (Laudon & Laudon, 2016).

The electronic recording of production batches or data, enables manufacturing completely free of paper reports. On the other hand, it optimizes production, because it reduces workload and increases accuracy, improves batch release time and reduces manufacturing errors.

A manufacturing data management system has the following characteristics: reduction in work in process, cycle times, product in process, overtime and order issuance and, on the other hand, increases throughput, timely deliveries and customer satisfaction.

Training and awareness

The implementation of a data management system requires the involvement of several areas and departments of a company, mainly in this case (Laudon & Laudon, 2016):

Production: It will use a new reporting model and a technological system for real-time capture of stoppages or unproductive times.

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Information technology: To adapt the current system and install the necessary communication networks and execute software updates.

Maintenance: To repair and support equipment.

Purchasing: To establish contracts, warranties and supplier scope.

At this point, it was necessary to train, educate, raise awareness and break paradigms of all participants and users of the project to change the traditional way of working to the new reporting model to calculate the productivity indexes of the production lines.

Type of research

The research project that was developed required a quantitative type of research, since in order to define the non-productive time reporting model we could count on indicators or statistics, which provided data such as scores or numerical values. Additionally, we also relied on qualitative research as it is a type of formative research that offers specialized techniques to obtain in-depth answers about what people think and what their feelings are. This allowed program managers to better understand the attitudes, beliefs, motives and behaviors of a given population.

On the other hand, the type of design had to be non-experimental, due to the fact that it is not intended to "choose or perform an action and then observe the consequences" (Hernández-Sampieri et al., 2014, p. 129). What was intended was to develop a study without deliberate manipulation of the variables and in which only the phenomena were observed in their natural environment and then analyzed.

For this research, by having a reference and being able to evaluate the result of the productivity indicator at different points in time to make inferences about the change, its causes and effects, it was determined that the design was longitudinal.

The field of study of the project was two production lines, so the longitudinal design was of the panel type. An advantage of this type of design is that it was possible to know when group and individual changes occurred.

Sampling plan

In this research process, a non-probabilistic sample was selected, due to the fact that the choice of the elements depends on the causes related to the characteristics of the research or of the person making the sample.

It was determined to select this type of sample because sometimes it is necessary to take into account particular criteria or characteristics of each area of study. For example, one production line in comparison with the other is faster because of the type of material it uses or the dimensions it processes, noting that the problems of lag and deductible keys in the faster line would not represent a reliable sample to corroborate the hypothesis of finding a relationship between these two variables.

An advantage of a non-probabilistic sample (from the quantitative view) should be mentioned, according to Hernández-Sampieri et al. (2014), it is useful for a certain study design that does not require a representativeness of elements of a population, but a careful and controlled choice of subjects with certain characteristics previously in the problem statement.

For this case study, eight production operators who are the ones who perform the reporting of unproductive time regardless of their years of experience in the position had to be sampled.

Measuring instruments

The data collection used to record data on the variables we had in mind were surveys, which were applied to the workers mentioned in the previous point, where we quantified the perceptions of the personnel in relation to how they used the unproductive time keys and the considerations they made when using them, as well as reaching a conclusion on the way operators report with different characteristics such as: age, work experience, schooling and assigned work area.

The quantitative analysis allowed us to observe the behavior of the personnel when faced with a change in the methodology of the non-productive time reporting keys.

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The databases were very useful for conducting studies that, through content analysis, were able to communicate positively, systematically and classify the elements.

Likewise, categories were assigned to a possibility of events that could occur in the production lines (unproductive times) and that were catalogued in keys, categories and groups so that the model would be reliable.

If we had been able to clearly identify the groups of downtime keys, the analysis of productivity indicators would have been more comprehensive and would have provided us with more information for proper decision making to attack and try to minimize each category.

In the table used to consult the downtime keys, there were some codes that referred to technical defects of the product such as: poor finish, roughness, vibration, stains, sharp edges, etc., but these could be caused by deficiencies in the operation (Production), machinery failure (Maintenance), lack of criteria or information (Quality) or failures in the tools and design programs (Engineering).

With the methodology to be developed, it was intended that each problem would be well identified and that each key could be assigned to a single responsible area to avoid confusion and address them properly.

If the above was implemented, the operator and production supervisor would be relieved of some responsibility, because, in the absence of a correct classification, they tried to invent or report what they thought was best, resulting in false indicators and false problems in the manufacturing process.

Characteristics of the application

The data obtained from the applicable measuring instruments were analyzed using descriptive statistics tools for each variable and frequency distributions were elaborated and represented by histograms and pie charts.

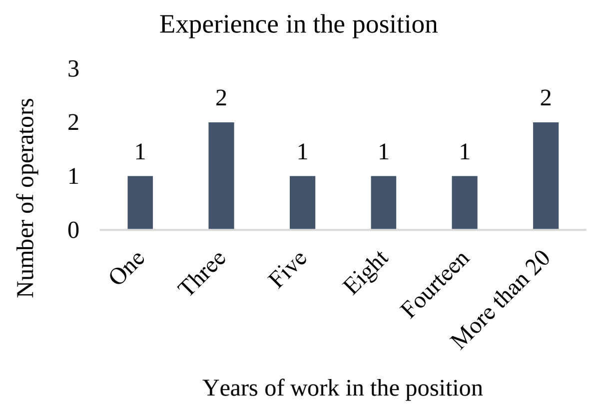
The implementation of the methodology had to be practical, homogeneous, easy to apply and unwavering; that is to say that, over time, it would not be distorted and would continue to meet the objectives that had been set at the beginning of the research.

Collection, processing and analysis of information

A survey was applied to the total sample to find out their opinion of the unproductive time keys they use, how they use them and their general perception of them. The data obtained from the survey were analyzed by means of the quantitative matrix, and then a graph was made to analyze the results in a practical way.

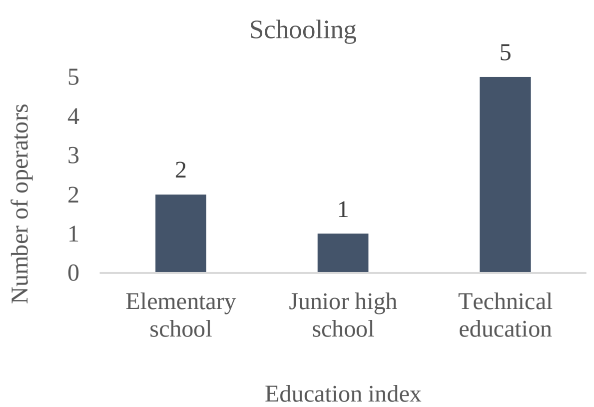
The general data are represented by the following bar graphs.

We can observe in graph 2 that most of the operators have been in the position for eight years or less, which would facilitate the application of a new reporting model.



Graph 2 Work experience
Source: Own elaboration

Another factor that will contribute to the implementation of a new methodology is that most of the operators have a technical degree, which means that they have more precise concepts about quality, productivity and continuous improvement (see Graph 3).



Graph 3 Education index
Source: Own Elaboration

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The results of the survey were as follows:

69% of the operators considered that they do not know the application of all the non-productive time keys. The conclusion is that there is a lack of a table of criteria for the use of each one of them; it also gave us the possibility to provide training to all the operators focusing on the new methodology.

Seventy-seven percent of the operators stated that there are unproductive time keys that they have never used, which made us think that certain keys do not have a specific function and their description generated confusion or was simply obsolete, because at some point they were used, but it was no longer necessary.

All the operators surveyed stated that events have occurred in which there is no downtime key defined for that situation, so it is determined that keys have been used that have not reflected the real problem, generating bad decision making by the support and service areas.

Eighty-five percent of the operators stated that deductible downtime keys have been used in stoppages of one hour or more, which made us accept our hypothesis about machine failures and machining problems that are not reported with the appropriate keys, so as not to affect the calculation of the productivity index.

Finally, the operators unanimously agreed that reporting through an electronic system would benefit them, a situation that might be surprising, since it would be thought that operators with more than ten years of experience would not accept a technological system to support their daily activities.

Non-productive time reporting methodology

The problem that was posed to be solved was that unproductive times were not reported with deductible keys that reduced the total work time to obtain fictitious productivity indicators, and that the real root cause of the problems was not found.

The existing model contained the following information (see figure 1):

- 12 key groups.
- 160 codes chosen by the production area.
- 16 deductible codes.
- 52 keys with area of responsibility.

Category	Codes	Deductible codes
Lack of material supply	10	1
Obstructed flow	18	0
Machine failure	22	0
Auxiliar equipment failure	15	1
Operational failure	8	1
Tools failure	5	0
Inspection failure	7	0
Set up	12	2
Testing	4	4
Technical failure	49	0
Personal activities	6	6
Several	4	1
Total	160	16

Figure 1 Undeclared non-productive time.
Source: Own elaboration

The proposed model considered creating groups of keys or modifying some of the existing ones according to the information available and taking into account the knowledge acquired through the experience of repetitive events occurring in the production line.

In the same way, the codes of the non-productive time keys were changed according to the name of the group to which they belong, in order to be better understood by the operator. In a historical utilization analysis, a table was made with the keys from those that were most used to those whose time was definitely not considerable (see figure 2).

Codes	% of codes reported	Code type
Personal activities	4.91%	Non deductible
Training	4.34%	Deductible
Meeting	3.37%	Deductible
Testing	3.18%	Deductible
Set up	1.36%	Non deductible
Scheduled stopped	1.31%	Deductible
Machine failure	1.01%	Deductible
More than 63 codes	0.02% - 1.00%	5 deductible codes
90 codes	0 – 0.01%	6 deductible codes

Figure 2 Keys to unproductive time
Source: Own Elaboration

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The new methodology considered the following information (see figure 3):

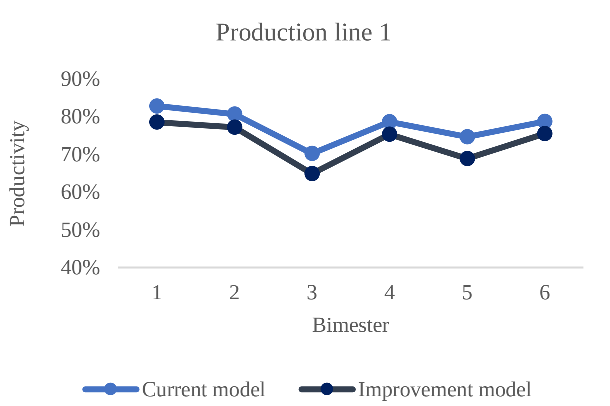
– 13 key groups.
– 90 codes chosen by the responsible area.
– 05 deductible codes.
– All keys with area of responsibility.

Category	Codes	Deductible codes
Lack of work orders	1	1
Testing	5	5
Preventive maintenance	5	5
Training	4	0
Fine tunning	6	0
5S - TPM Methodology	4	0
Personal activities	2	0
Lack of raw material	5	0
Absenteeism	3	0
Set up	9	0
Machine and operational equipment failure	30	0
Non quality process	16	0
Total	**90**	**11**

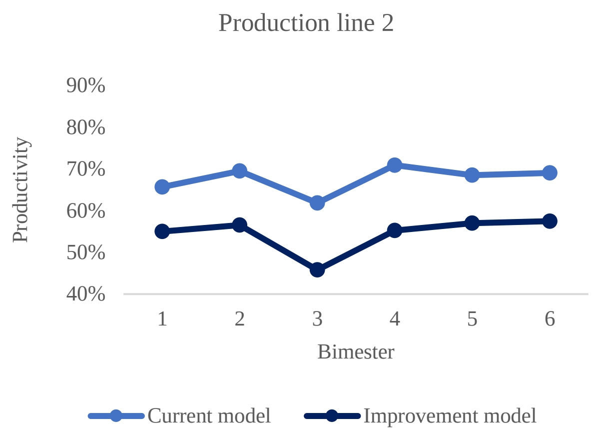
Figure 3 New methodology
Source: Own Elaboration

Results

Developing a new model that would directly affect the company's production indicators was not a simple and challenging task to achieve a paradigm shift. However, it was the beginning of a new era where the lost productivity points generated a new objective, so that in a time horizon of two years they would be recovered and would be solving real and specific problems. In graphs 4 and 5 you can see the productivity increases during one year of analysis, after implementing the improvement methodology.



Graph 4 Production line 1
Source: Own Elaboration



Graph 5 Production line 2
Source: Own Elaboration

Conclusions

After the research carried out, it was possible to conclude that process problems that took an hour or more were reported with deductible time keys so as not to affect the productivity indicator. It was also possible to confirm that the most experienced personnel reported their unproductive times in the correct way, but showed willingness to receive technological support for their daily activities.

The production supervisors reported with incorrect time keys because they felt that they did not have the support of the management or the service areas and they felt committed to deliver good indicators to the corporate.

The work area with the fastest pace in its work rhythm, the impact of the application of the new methodology only represented 5%; on the other hand, the slowest area had an impact of up to 15% less productivity in some bimonthly periods.

The activities carried out for the design of this new model made it possible to raise awareness in all the areas that were jointly responsible for the productivity indicators, working to generate strategies to reduce the impact on the production process.

After informing and training all the personnel in this new model and mainly in communicating its objective, a new project was started to select a supplier that would allow the reporting to be done in real time through automation.

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