“Proposal of Improvement of the Production Process of roll-up doors of the Metalworking Company Hialuvid, applying tools of the Lean Manufacturing Methodology”

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Abstract.

The present investigation was developed in the metalworking company HIALUVID, which presents as main problem the delay in the delivery of the finished product (rolling doors) to the customer, generating complaints and nonconformities.

For this reason, the need arises to make a proposal for improvement in its production process, which allows to reduce the delivery time of the product to its customers and to guarantee its efficiency and productivity, through the use of tools of the Lean Manufacturing methodology.

In order to develop this improvement proposal, the following tools were used: Lean Manufacturing 9'S, SMED, TPM, KANBAN, which provided the following possible results: total production process time would improve by 6.10%, value added time by 2.13% The 315 minute talk time of 24 doors a month, would increase one minute more ie 316 minutes but to produce 26 doors per month, giving an improvement of 7.4%, and mainly, the delivery time would decrease 590 to 554 minutes, with a reduction of 6.10%, all these results lead to faster and more efficient deliveries to the customer .

Keywords

Feasibility study, financial administration, Economic risk, Internal Rate of Return, Net Present Value, Cost benefit ratio, payback period.

1. Introduction

Since ancient times man has worked metals, developing materials and tools, which have marked the progress of peoples. (Iici, 2012). The Metal-mechanic sector has become one of the main economic activities of the world. (Guerrero, 2012).

The international trade of Metalworking products exceeds 4,000 billion dollars, representing more than 30% of the world total. Within this industry, almost 40% corresponds to the capital goods sector, 20% to the automotive industry and another to the electronic components and electrical appliances sector, the rest completing the other metal-mechanical sectors. (INEC), 2013). In this sense, the most important exporting economies are the countries of the European Union (Germany, France, Italy), China, the United States, Japan and Southeast Asian countries (Mainly South Korea). (Burgos, 2010)

In Latin America, the countries with the greatest influence are Brazil, Argentina, Chile and Colombia. For 2012, the ECLAC (Economic Commission for Latin America and the Caribbean) forecast a growth of 3.7% in the metallurgical industry in the whole region including the Americas Latin America and the Caribbean, (Institute for Industrial Technology and Services Development (IDITS), 2011)

In Ecuador, the metal-mechanic industry constitutes a fundamental pillar in the country's production chain. In this way, its transversality is justified with the food, textile and clothing sectors, lumber, construction, etc. (Institute of Promotion of Exports and Investments [PROECUADOR], 2013)

According to the National Institute of Statistics and Censuses (INEC, 2011), this sector has 65% of employment generation. The Metal-mechanics sector accounts for 14% of GDP and has had an annual average growth of 7% from 2000 to 2011. An important indicator of this sector is the Productive Chain, which results in intermediate steel consumption is 65%, higher than the manufacturing industry with 59%. (Banegas, 2014)

2. Materials and Methods

Taking into account the analysis of the Lean Manufacturing methodology and its various approaches; It details the procedure that is used to make the proposal of improvement of the process. This procedure consists of 4 phases:

Phase 1: Collection and Search

To get an overview of the Lean Manufacturing system and develop its methodology, the first step was to carry out relevant scientific and technical research on its philosophy, tools, applications, objectives, benefits; Which provided information necessary to start the investigative work.

Phase 2: Analysis of the productive system

For the development of this phase, an initial diagnosis was made of the metalworking company HIALUVID concerning the process of production of rolling doors, employee activities, supply of materials and supplies, sale of the finished product, machines and tools, etc .; To determine the areas in which improvements are required in terms of order, cleanliness, timely deliveries and the seven classic waste in an industry.

For this purpose, field observation, interviews with the manager, workers and clients were taken as a basis to know their degree of satisfaction with regard to rolling doors manufactured by the company. These investigative instruments provided important data and information for the development of this project and the use of quality management tools of which we highlight:

• **Value Stream Mapping (VSM):** This graphic technique allowed us to visualize the whole process in detail and understand the flow of information and materials necessary for the rolling doors to reach the customer, with this technique we identified activities that do not add value to the process to later initiate the necessary activities to eliminate them.

• **Process Diagram:** It is the graphic representation of the process which provides a visual description of the activities involved in the production process of rolling doors, showing the sequential relationship between them, the number of steps in the process, which facilitates the understanding of each activity.

• **Diagram Cause - Effect:** This technique establishes what are the possible causes that generate an unwanted effect or problems within the production process of rolling doors. This tool was used to provide solutions to the problems found in the production process, whether machinery and equipment, economic resources, environment, people, management, materials and methods.

• Flow Diagram: It is a technique to visualize the process graphically, using symbols lines and connectors, indicating the sequence that carries this process, in addition to the interactions between each of the subprocesses.

Phase 3: Improvement Proposal

This phase was aimed at finding the solution to the problem raised where we chose between the wide range of techniques and tools that groups lean manufacturing. This proposal had a rigorous and systematic approach to decide what solution had to be adopted to solve the problems encountered. This will require the following steps:

Stage 1: Prior Awareness.- A previous awareness was made with all the members of the metalworking company about the benefits that the implementation of the tools of the Lean Manufacturing philosophy in the company will bring.

Stage 2: Development of the proposal.-At this stage, the tools that will be used for the implementation of the Lean philosophy were determined, after having performed the initial diagnosis of the company.

Phase 4: Analysis of results

In order to determine the results that would be obtained in case the improvement proposal is implemented, the following analyzes by Indicators or Measures of performance will be necessary:

• By Lean Manufacturing Tools (9'S, SMED, TPM, VSM)

• By Production Indicators

3. Results

The application of the described procedure is detailed below. To carry out an analysis of the results of this proposed improvement it is necessary to perform the following calculations:

Results Flow Diagrams and VSM

As can be seen in the following table, the results of the times obtained by studying the different diagrams of each process and the VSM for the production of rolling doors are as follows:

Table 1: Results Flow Diagrams and VSM

N°	Process	Total Time (min)	Value Adding	Time that does not

			Time (min)	add Value (min)
1	Abastecimiento	320	-	-
2	Flejado	140	110	30
3	Elab. del eje	19	12	7
4	Elab. de ángulo y canal antigata	16	11	5
5	Elab. de la base	13	11	2
6	Elab. de orejas	4	3.5	0.5
7	Elab. de rieles y banderas	13	9	4
8	Elab. de taparollo	7	6	1
9	Armado e Instalación	58	25	33
TOTAL		**590**	**187.5**	**82.5**

Production Calculations

Calculations were made of total production times, per unit, labor cost, installed production capacity, current production capacity, to determine the current situation of the company.

Total Production Time

It is the time used for each operation of the process of elaboration of rolling doors.

Production time per unit = T. Add value + T. Do not add value

Production time per unit = 187.5 + 82.5 min
Production time per unit = 270 min / roll-up door

270 minutes were used to make a roll-up door, ie 6480 minutes or 108 hours were used for the production of 24 roll-up doors per month.

Total Production Time = T. Supply + T. Production
Total Production Time = 7680 min + 6480 min
Total Production Time = 14160 min

That is to say that the total time to elaborate 24 doors to the month is of 14160 min, 236 hours or 29.5 days, where the supply time and the production time are added.

Productivity

It is the relation between the quantity of products obtained by a productive system and the resources used to obtain such production. It can also be defined as the relationship between the results and the time taken to obtain them: the shorter the time it takes to obtain the desired result, the more productive the system is. (Gutiérrez, P., 2010).

Current Productivity

It refers to the efficient use of resources (inputs) when producing goods and / or services (products). Productivity in terms of employees is synonymous with performance. In a systematic approach we say that something or someone is productive with a quantity of resources (Inputs) in a given period of time and obtains the maximum of products. (Gutiérrez, P., 2010).

Table 2: Productivity Data

Data Collected	
Working days per month	20
Hours of work per day	8
Hours of work per month	160
Number of roll-up doors	24
Cycle time (minutes / roll-up door)	270
Total production time (minutes)	14160
Total production time (hours)	236
N ° of workers	2

General Productivity

Productivity is calculated taking into account the input time used for the production of 24 rolling doors and the total production time.

Productivity = (Units Produced) / (Total Time)

Productivity = (24 rolling doors) / (236 hours)

Productivity = 0.20 (rolling doors) / hour

Production capacity

It is the production potential or maximum production volume that a company can achieve over a given period of time, taking into account all available resources such as: production equipment, facilities, human resources, technology, experience / knowledge, etc. (Gutiérrez, P., 2010).

Installed production capacity

Production Capacity = (Number of units or pieces) /(Time) * Time Available

Monthly Production Capacity = 0.20 (doors) / hour * 8 hours / day * 20 days / month

Production Capacity = 32 doors / month

The expected production capacity is 32 doors a month, taking into account the eight hours a day that employees work and 20 days a month of work, concluding that the company has an installed capacity of 384 doors per year

Current Production Capacity

Production Capacity = (Number of units or pieces) / (Time) * Time Available

Monthly Production Capacity = 0.20 (doors) / hour * 7 hours / day * 20 days / month

Production Capacity = 28 doors / month

The actual production capacity is 28 doors a month, since it must be considered that the employees work seven hours a day, since one hour is used in the lunch time, which is subtracted from the available time per day. This means that the current annual capacity is 336 doors.

Lean Manufacturing Times

The calculation of Lead Time, Order Lead Time and Takt Time was carried out to determine the current situation of HIALUVID.

Lead Time Calculation

Lead Time is the time that elapses between the initiation of a request for the supply of raw material and supplies to suppliers or a factory of a certain product until the finished product is delivered to the customer. Lead time is composed of three factors: (Hernández, J., Vizán, A., 2013)

Lead Time = LT Supply + LT Production + LT Transportation

Lead Time = 320 min + 212 min + 58 min

Lead Time = 590 min

The Lead Time of the metalworking company HIALUVID is 590 minutes where the Lead Time of Supply, Lead Time of Production and Lead Time of Transport are considered, for the elaboration of each rolling door.

Order Lead Time (Olt)

Order Waiting Time (OLT) is a characteristic parameter of a logistics network. It is the time that takes place from the time an order is placed in the system (Order Entry Date) until the customer wishes the material on his site (Desired Date). (Hernández, J., Vizán, A., 2013)

% Delivered to Time = (Orders Delivered to Time) / (Orders Received)

% Delivered to Time = 43/68

% Delivered to Time = 63.23%

The level of fulfillment of orders delivered on time is 63.23% and that of non-compliance is 36.77%, the days of delay of the rolling doors in the last six months were a total of 29 days, reflecting an inadequate compliance rate.

OLT Calculation

It is the sum of the multiplications between the quantity of product delivered and the order timeout (OLT) divided by the number of orders entered into the system in the period of time that the analysis takes place in a specific location. (Cuatrecasas, 2006). In other words:

OLT = (ΣQuantity delivered * Waiting time) / (Order numbers)

OLT = (24 * 5 + 23 * 3 + 26 * 6 + 22 * 4 + 26 * 6 + 24 * 5) / 68

OLT = 10.42 days

Obtaining this number allows the company to find the volume-weighted ratio between the amount of material required for each order and the time taken for delivery. The result obtained from this operation represents the average number of days it takes since entering an order to the system and the desired day for delivery taking into account the historical data and the volumes of each order.

Calculation of Takt Time

It is the pace at which products must be completed or completed to meet the needs of demand, this time is defined by the customer and not the engineer or company policies given that this time is defined by the demand and the time available for Meet this demand, for the particular case under study this pace is the necessary to calculate it to be able to ensure that the plant will meet customer demand. (Hernández, J., Vizán, A., 2013)

Time Available: 8h = 480 min

Average working days per month: 20

Lunch Time: 1:30 h = 90 min

Break: 12 min

Real Time: T. Available - T. Lunch - Break = 480-90-12 = 378 min / day

Market / Customer Demand: 24 doors / 20 days = 1.2 door / day

Takt time = (Time Required) / (Customer Demand) = (378 min / day) / (1.2 door / day) = 315 min / door

With the data analyzed, it is possible to establish the "takt time" that expresses the rate at which the whole process moves, that is to say, at what speed the product needs to be produced to satisfy the demand of the customer. In this case you have "takt" of 315 minutes to get 1.2 doors a day. That is to say if it is not possible to elaborate 1.2 doors to the day will not be fulfilled with its demand and will be late in its shipments.

Calculation of Efficiency

It is the ability to achieve goals, with the least amount of resources possible, this involves "doing things right" without having to spend time on unnecessary activities. (Rajadell, M., Garcia, J., 2010)In the case of HIALUVID, the following efficiency calculation was performed where the following results were obtained:

Efficiency = (Time Adding Value) / ((Time Adding Value + Time That Does not Add Value)) * 100

Efficiency = 187.5 / ((187.5 + 82.5)) * 100

Efficiency = 69.44%

It means that the process of manufacturing rolling doors, is at 69.44% efficiency. There is a 30.55% waste on the resource time.

Indicators for the evaluation of the Level of Service "NS" provided:

Cycle time delivery order: It is the time between the reception of the order and the delivery of the order To determine this, a number of samples (orders that are requested) must be obtained that meet the appropriate confidence levels and observe the time it takes to complete them (an order may consist of a single product or several products)
Cns = X + Zς

Cns = 16 +1.96 = 17.96 days

It is considered that the time of the ordering cycle - delivery of the process of elaboration of rolling doors is of 18 days. Reliability of the order-delivery cycle: In this case you can use the deviation of the duration of this cycle, you can also analyze the delay time in the delivery of the order

FC = Number of orders delivered in the period / Quantity of orders * 100

FC = 43/68 * 100

FC = 63.23%

Availability of the product or reliability of the inventory: It can be measured by evaluating the ratio of complete delivered orders and ordered orders

According to Orders

DPP = Number of completed orders delivered / Number of orders delivered * 100

DPP = 43/68 * 100

DPP = 63.23%

According to Quantities

DPC = Number of units delivered / Number of units ordered * 100

DPC = 99/145 * 100

DPC = 68.27%

The level of general service of the company is given by the multiplicative integration of selected private meters. NS = f (quantity, quality, term, cost, variety, opportunity) It translates into the reliability indicator, which responds to a multiplicative model:

$$Fs = \Pi ((1-Nf) / No)$$

Where:
Nf: Number of faults

No: TotaL

This indicator is no more than customer satisfaction, therefore its calculation is made from gathering information from customers through surveys, interviews, complaints, phone calls, mailbox; That is, look for information about customer satisfaction.

It is considered that there is an average of 12 orders per month, with this data we proceed to the calculations of the cycle and level of customer satisfaction.

Customer satisfaction cycle (CSC)

$C\_NS = \bar{X} + Z\,\sigma$
C_SC = 15.33 + 1.96 * 1.03
C_SC = 17.35 ≈ 18 days
The maximum customer satisfaction cycle is approximately 18 days with a NS of 95%.

Table 3: OLT Calculation

Month	OLT (days)	Failures (Nf)
February	10,9	1
March	7,6	1

April	13	1
May	6,7	1
June	14,18	1
July	10	1
Half	**10,40**	-

Level of service provided

NS = π (1 - Nf / OLT), term
NS = (1-6 / 10)
NS = 0.6 * 100%
NS = 60%
The level of service provided is 60% considering that it is very low.

Comparative Analysis

After the diagnosis to the company, it is necessary to carry out a comparative analysis that indicates the percentage of improvement in case of implementation.

By Lean Indicators

Table 4: Indicators Lean

INDICATORS LEAN IN HIALUVID				
N°	**Indicator**	**Frecuency**	**Whithout Lean**	**Whith Lean**
1	Maintenance control of machinery	Monthly	Eventual	Planned
2	Work areas	Daily	Not established	Signs
3	Handling tools	Daily	Inadequate	Suitable

By Production Indicators

Below is the comparative production data in case this improvement proposal is implemented.

Table 5: Production Indicators

Comparison Production Calculations and Lean Manufacturing			
Description	**Current**	**Proposed**	**Improvement (%)**
Working days per month	20	20	-
Hours of work per day	8	8	-
Hours of work per month	160	160	-
Number of roll-up doors	24	26	8.33
Cycle time minutes / rolling doors	270	238	11.85
Cycle time minutes	14160	13776.8	2.71
Cycle time hours	236	229.6	2.71
N ° of workers	2	2	-
Labor productivity (doors / hour-worker)	0.10	0.11	9.09
General Productivity (doors / hour)	0.20	0.22	14.28
Monthly production capacity	28	31	10.71
Lead Time minutes	590	554	6.10
Takt Time minutes	315	316	7.40
Efficiency	69.44%	77.31 %	7.87

4. Conclusions

To God almighty, because with my faith and hopes placed in him, today I come to fulfill this great dream.

To my family that has been my support and guide all my life, thanks to his sacrifice and delivery today I come to fulfill this professional goal.

To my dear Technical University of the North, and to all the teachers who have influenced my professional training.

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