Simulation and Lean Principles: A Case Study in a Public Service in Brazil

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Abstract: Through the application of simulation and lean manufacturing principles, this paper aims to highlight the features and operation of a system of providing public services in Brazil, which brings together, in one single place, a call to various services of a public nature, thus presenting a proposal for improvements of the services offered, specifically the process of renewal of driver's license. The results obtained in this study showed that the process of renewal of driver's licenses currently offered by Poupatempo system is a process which has already implemented improvements since its structure, but there are still opportunities to be applied to make it more efficient. The study showed that the lean manufacturing principles in conjunction with the simulation can be applied without any restrictions in processes of providing public services and contribute positively to the identification of process improvements.

Keywords: Lean Manufacturing; VSM; Value Stream Mapping; Simulation; Public Service System; Improvement; Queuing theory; Service sector.

1. Introduction

The Lean Manufacturing philosophy, often called Lean Production, emerged as a management system whose purpose is to develop processes and procedures through continuous reduction of waste in all its phases, such as inventory excess between workstations and higher waiting time. The objectives of Lean Manufacturing are the quality and flexibility of the process, enhancing their capacity to compete in an increasingly demanding and globalized scenario. Basically, it is a TPS (Toyota Production System) upgraded with the introduction of new practices and tools, such as customer service and value chain [1]. Among the tools of Lean, VSM applied in this study, is characterized by obtaining all activities (value added or not) that are required to manufacture a product (or a group of products that use the same resources) through the main flow, starting with the raw material and ending in the customer [2]. The VSM creates a common basis for a productive process, facilitating decision making to improve the value stream [3].

Notes that despite several methodologies have been used in studies of production Just in time (JIT), the simulation has attracted the attention of many researchers and practitioners [4]. Many simulation studies have been reported in the Lean Manufacturing field, where it is also observed that the simulation is more prevalent in manufacturing than in services [5]. The system of providing service analyzed in this research is characterized by being an innovative model of providing public service, which had its implementation in 1996 by the Government of the State of São Paulo. The model is named as Poupatempo, this being a call centre that brings together under one roof various government agencies of different spheres of government (federal, state, municipal and
judiciary), the private sector, the utilities, associations and other entities, among the main objectives of this system are offering to the population of different types of services quickly and efficiently and provide quality service, saving time and effort of citizens in needed services [6]. Among the services provided by the most sought after by people Poupatempo are the system of issuing identity cards, vehicle licensing, renewal of driving license and work permits issuance.

This case study aims, through the application of simulation and lean manufacturing principles, identify characteristics and performance of a system for the provision of public services in Brazil, enabling an improvement proposal in the renewal of driver's license process performed by Poupatempo system. The structure of this paper is organized as follows: Section 1 - Introduction; Section 2 - Research Methodology; Section 3 - Literature review; Section 4 - Case Study; Section 5 - Conclusions and future opportunities.

2. Methodological Procedures

The classification of this research is characterized as a case study. A case study is an empirical research that investigates a contemporary phenomenon in depth and in its real life context, especially when the boundaries between phenomenon and context are not clearly evident [7]. Figure 1 shows the steps for the development of this research.

Step 1 – Process description: aims to identify the characteristics of the analyzed process, considering this analysis the concepts of lean manufacturing.

Step 2 – Mapping process through the application of VSM (Value Stream Mapping): VSM development as a way of mapping the service current process.

Step 3 – Process simulation: by collecting data in the process, the data will be simulated.

Step 4 – Validation of Simulation: the simulation results should be analyzed and compared with the information obtained during the data collection performed in step 3 of this research.

Step 5 – Improvements proposal: with the simulation results the lean manufacturing practices should be evaluated for the elaboration of improvements proposal to the current system.

Step 6 – Results and discussion: discussion of the proposed improvements in step 5 of this research.

3. Lean Manufacturing Principles, Simulation and Providing Service System

As mentioned by Womack and Jones [8] lean thinking is a way to specify value, line up in the best sequence the actions that create value, perform these activities without interruption whenever someone requests them and achievable them each time more effectively. Lean thinking is lean because it is a way to do more with less and less - less human effort, less equipment, less time and less space - while at the same time, approaching more and more to offer customers exactly they desire.

Thus, as noted by Shingo [9], 80 percent of the lean is about eliminating waste and on the balance of the system. Waste, often called "muda", in Japanese, is composed of seven common types of waste: overproduction, unnecessary movement, overstock, excess transportation, rejections / rework, waiting, and super processing [10]. Apparently, the elimination of these wastes seems simple and straightforward, but their identification is often difficult in most organizations [11].
To help processes improvement based on lean thinking, one of the widely used tools is the VSM (Value Stream Mapping). This tool creates a portrait of the current state of a production system and will emphasize improvement proposals to compose the future state map. Taylor [12] states that the value stream map is a very effective method to summarize, present and communicate the main features of a process within an organization.

Singh and Sharma [13] implemented the VSM in an organization in India and obtained a reduction of 92.58 percent on-time delivery, 2.17 percent in processing time, from 97.1 percent reduction in WIP (Work in Process) and 26.08 percent reduction of manpower. Chowdary and George [14] conducted a case study at a pharmaceutical company using the VSM. The tool helped to reduce delivery times, cycle times and inventories in the manufacturing process. The company was able to reduce the storage space and production people at 38 percent and 50 percent respectively.

3.1 Simulation

The simulation is a reliable tool to evaluate and analyze the plan of a new system or make necessary corrections in the current system and also suggest the needs for revision of current control system and operational functions. Simulation applies a method to present information obtained from the construction of a model based on the observation of the workflow on the current situation and other related variables [15; 16; 17; 18; 19]. Simulation is an approved tool for accuracy, decision making based on evidence and provides excellent outputs in assessments and complicated and uncertain planning systems such as health system [20]. Narasimhan et al. [21] introduced a new approach known as the “simulation aided by VSM” and illustrated a case study showing the successful application of the VSM approach in an environment of a global engine manufacturer test. Similarly, Gurumurthy and Kodali [5] presented a simulation along the practice of VSM during the design of lean manufacturing systems using a case study of an organization. Simulation studies were performed for different scenarios, such as "before the Lean Manufacturing" (current state VSM) and "after Lean Manufacturing" (future state VSM). It was found that the organization of the case study can achieve significant improvement in performance and can meet the growing demand without additional resources.
3.2 Poupatempo Model: A providing service system in Brazil

This providing service model was implemented in Brazil in 1996 by the State Government of São Paulo and emerged from a partnership between government and companies. Currently has several service units installed by the state and in the period from 1997 to 2002 have been assisted more than 39.7 million people, considering the seven units in operation during this period [6]. The Poupatempo is an innovative model that has as main objectives the reduction of waiting times and services to the population due to the rationalization, bureaucracy and simplification of flows due to the fact of concentrating in one place several types of services to the population. It is worth mentioning that this concept of public attendance also innovated compared to previous practices of Public Administration to: handing over of certain types of documents on the same day or at the most 48 hours before this period ranged from 30 to 60 days; least cost to the customer, not being required to pay a third party satisfies the applicable forms, this step is performed online during the service in the system. The processes computerization of Poupatempo is an advantage to the model as it allows greater flexibility in the delivery of this service [22].

After implementing the model, some improvements were made in their processes aiming to respond more effectively and efficiently their customers, among the changes made to the following projects: provision of information material for users explaining the functioning of the system; information guide customer through call centre and scheduling services via internet; training and qualification of team work, annual refresher with all employees seeking to standardize service; screening and referral services by multitasking attendants; appropriate lay out every care situation and established visual communication [6]. Actually the Poupatempo in the country is a reference model in Customer Service, being accepted and well ranked by population.

4. Case Study

This case study development occurred in accordance with the methodological steps defined in section 2 of this research. The first step was to identify the features of analyzed process, considering this analysis the concepts of lean manufacturing.

The Poupatempo system offers several types of services to the population, including the most popular are: issuing identity cards, vehicle licensing, renewal of driving license and issuance of work permits. For this research service analyzed was the renewal of driver's license (in Brazil named CNH).

All services offered by this system operate nine hours per day from Monday to Friday and on Saturdays for 6 hours. The process is characterized by the fact that the services offered are allocated in one physical space, thus avoiding the user to move to different places. The physical arrangement of Poupatempo system as a whole is classified as cell layout due to the fact that different services are grouped into different physical space, as Figure 2.
Figure 2: Poupatempo Layout

The configuration of the layout of the renewal of the driving license process is classified as layout by product, due to the fact that workstations are allocated and defined by the sequence of operation, as Figure 3.

Figure 3: Driving License Process Layout

The daily demand for this service offered can reach up to 72 users each hour (defined by 12 users every ten minutes). The station number 1 is the operation of screening the documents, where documents required for the process of renewing a driver's license will be analyzed. The station number 2 performs the procedures of user identification, such as collecting digital and photography. After station 2 the user is routed to the station 3, in which medical examinations are performed. Then the user should refer to the payment of mandatory fee, allocated in the station number 4, it is worth noting that this last one is a shared cell with several other types of services provided by Poupatempo. The final step of renewing a driver's license occurs in the station number 5 where the user takes delivery of proof of payment, thus completing the operation.

Table 1: Operations Description

<table>
<thead>
<tr>
<th>Station</th>
<th>Operation Description</th>
<th>Number of attendants</th>
<th>Cycle time</th>
<th>Operation takt time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Screening documentation</td>
<td>4</td>
<td>338.07s</td>
<td>84s</td>
</tr>
<tr>
<td>2</td>
<td>Identification</td>
<td>3</td>
<td>261.41s</td>
<td>87s</td>
</tr>
<tr>
<td>3</td>
<td>Medical Examination</td>
<td>2</td>
<td>253.34s</td>
<td>126s</td>
</tr>
<tr>
<td>4</td>
<td>Fee Payment</td>
<td>4</td>
<td>97.17s</td>
<td>24s</td>
</tr>
<tr>
<td>5</td>
<td>Proof Delivery</td>
<td>1</td>
<td>86.63s</td>
<td>86s</td>
</tr>
</tbody>
</table>
Each operation works with a number of attendants and different cycle times, thus resulting in a specific takt time for each operation, the details can be seen in Table 1.

The scheduling process of the services offered by Poupatempo for best user comfort, resulting in an improvement made after the implementation of the service is conducted through the site, allowing better management of service. For the development of step 2, as Figure 1 of this case study, we applied the VSM tool to improve understanding of the process analyzed. The model shown in Figure 4 was constructed through a data collection taken at one of the service units of Poupatempo.

![Image of VSM Current State](image.png)

Figure 4: VSM Current State

It is observed that the PCE (Process Cycle Efficiency) factor used to verify the efficiency of the production system mapped - which gives the ratio between the sum of adding value activities (AV) with the sum of non-adding value activities (NAV) - corresponds to 8.8%.

In step 3 of the research, the simulation of the renewal of the driving license process was applied through simulation software, information concerning the data collection performed at one of the Poupatempo service units were entered into the system for analysis of process. For this to materialize steps were necessary:

Step 1 – Understanding the Process: This step was important to the analysis of process steps to meet the queuing system, the number of attendants, the system of arrivals and service users. The application of the VSM tool contributed to this first analysis, since the process was already drawn.

Step 2 – Data Collection: Quantitative data of arrival times and service were collected, a sample consisting of 30 measurements were recorded.

Step 3 – Tabulation and analysis of data: The data relating to service and arrival time were summarized in a spreadsheet and analyzed with the objective of identifying special causes and average service time.

Step 4 – Simulation: Performing the previous steps, it was possible the application of simulation in the process, where the data were inserted in the simulation software and some parameters used in the model validation, as shown in Figure 5. The necessary parameterization for simulation consisted basically in:
i. Inserting calendar: it was necessary to use the calendar definition of working time system;

ii. Arrivals system: during the data collection it was observed that every ten minutes six people on average arrived, so it was necessary to insert this data into the system.

With the objective of validations of simulation in step 3 of the research, this step 4, performed the analysis of the production system by means of statistical data obtained from the simulation software. The data provided showed that:

i. 38.95% of the time of the system refers to the operation.

ii. 61.44% of the time of the system refers to the waiting.

With the creation of graphs in software was possible to verify the efficiency of each service station, in other words, the time that each station was in operation and the time that was waiting.

Through analysis of the data presented in Figure 6, it was observed that the first station is on average 56.68% of the working time and approximately 43.32% of the time waiting. The station 2 works 60.21% and presents waiting 39.79% of the time. Longer the station 3, conducting the medical examinations in the process, working on average 81.38% and their waiting time, consists of only 18.62%. By analyzing the stations 4, it was found that there is an idle; this is represented by 83.6% of waiting time and only 16.4% of the time activity. The last service stage where it is the hand of the payment receipt, is distributed as follows: 59.19% of service time and 40.81% waiting. With this
graphical analysis offered by the software completes the validation of the simulation of the process studied.

In step 5 of the case study was analyzed the current situation of the process by means of simulation results and analysis of the VSM. After that, we identified possible improvements to be implemented by performing the balancing of operations and adequacy of layout with the following objectives:

i. Waiting time reduction.
ii. Movement flow improvement.
iii. Idle attendants reduction.

The VSM of the future situation, based on the improvements above identified was prepared, as Figure 7.

![Figure 7: VSM of Future State](image)

It is observed that the new PCE (Process Cycle Efficiency) calculated, factor of production mapped system, is corresponding to 15.3%. There is an improvement of 6.5% over the current VSM. Thus, with the balance performed obtains the following information, as shown in Table 2.

<table>
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<td>MedicalExamination</td>
<td>3</td>
<td>253.34s</td>
<td>84s</td>
</tr>
<tr>
<td>4</td>
<td>Fee Payment and Proof Delivery</td>
<td>2</td>
<td>183.80s</td>
<td>92s</td>
</tr>
</tbody>
</table>

To conclusion of this case study, step 6 is the analysis and discussion of results. According to data presented in step 1 of this study, the daily demand of the offered service can reach up to 72 users each hour (distributed in 12 users every ten minutes), but through simulation it is observed that if the arrival of this number of users occurs the system will not be able to absorb this demand unless improvements are made in the process.
From the improvements proposed in the previous step is noted that the process efficiency can be improved by applying the Lean Manufacturing principles.

Figure 8: Simulation Model – Future State

The improvements consist basically on balancing posts. As can be seen in Table 2, the new balance, the station 4 and 5 are joined, thus obtaining a new cycle time, and automatically new takt time, requiring two servers. At station 3 (medical examination), there was a need to allocate another attendant, totaling three attendants. The figure 8 illustrates the future state. This change is necessary because the previous takt time (126 seconds) to be considerably above the takt time of other operations, causing accumulate queue between stations 2 and 1 and idleness at station 4. So, get it a takt time of 84 seconds to the station 3. The Figure 9 shows the efficiency improvement.

Figure 9: Service Stations Efficiency – Future State

Considering the improvements, obtains the result:

i. Waiting time reduction: the queue time between stations 2 and 3 changed from 3654 seconds to 1596 seconds (56.3%).

ii. Movement flow improved: becoming stations 4 and 5 as a single operation, it is avoided that the users having to go to another station, improving the movement flow.

iii. Idle attendants reduction: As the station 4 had a takt time of 24 seconds compared to 126 seconds of the previous post, there were attendants of idleness. This can be improved with the unification of the last two stations, increasing the takt time and distributing the attendants adequately.
5. Conclusions

This article purpose was to identify features and operation of a system of public services in Brazil and consequently identify process improvements. As a result of this research it was observed that the process of renewal of driving license currently offered by Poupatempo system is a process which has already implemented improvements since its structure, but there are still opportunities to be applied to make it more efficient. This study demonstrated that the lean manufacturing principles jointly the simulation, can be applied without any restrictions on processes for services and contribute positively to the identification of process improvements.

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