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Optimization the Prodution of Solar Collectors

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Abstract

This work proposes the implementation of a decision support tool to analyze and optimize a manufacturing process of photovoltaic systems for electricity generation. This is a cooperative effort with the company WS Energia, producing innovative PV systems, which provided the case study and led to its development.

Initially, a framework of the problem is defined and the process under study is defined. The main objective is to increase current production capacity to improve the flexibility to respond to an increasing number of customer orders.

The simulation models are chosen as the tool to support the most appropriate decision, and the Arena software is chosen to solve the problem.

We developed a simulation model using the presented methodology for its development. We studied two scenarios: a scenario for the current production process, and an alternative scenario with optimized production process.

The scenario was analyzed for the current production process from which we obtain decisions formulation, based on the use of a methodology for evaluating the results of the simulation model that allowed us to identify the bottleneck operations in order to obtain the best scenario for achieving goals. The results show that when changes are implemented, the bottleneck effect of the process is relieved, critical situations are minimized and the gain made in production capacity is considerable.

Keywords: Prodution, optimization, simulation model development methodology, outcome evaluation method, bottleneck, simulation models.

1. Introduction

Increasingly, companies face significant and growing challenges resulting from competition imposed by the globalization of product markets and production factors.

To meet these requirements, it is essential that processes are capable, able to adapt quickly to innovation and change in the product spectrum, and for rapid product delivery to customers.

In this context, the realization of this work is located. The main objective of the work presented in this paper seeks to contribute to improving the production process of an innovative product, through the study of the production process and present alternative proposals aimed at its optimum. In this sense, the space where the production takes place is analyzed with particular emphasis.

This work involves the use of two methodologies: methodology development tool that is chosen to solve the problem and the methodology for evaluating the results.

The chosen tool was the simulation models, and methodology of model development comprises the following steps: problem formulation, conceptualization and data collection, implementation, verification, validation, testing, implementation, documentation and presentation of results.

The methodology for evaluating the results have in mind the definition of an effective strategy to increase the production capacity of the process, and based on data provided by the model. This methodology encompasses identifying the main bottlenecks in accordance with the time of execution of operations and the time lost in the process.

2. Case-study

WS Energia is a company located in Taguspark - Science and Technology Park in Oeiras. This company provides the photovoltaic market innovative and technologically advanced products by making its production. One such product is DoubleSun technology that was developed and patented by the company with the aim of significantly increasing the efficiency of conventional photovoltaic systems.

DoubleSun Technology the subject of this paper, it is an innovative technology, created in the department of research and development of WS Energia. This technology, called DoubleSun, consists of two reflective mirrors and plans which, when incorporated into solar concentrators, basically doubling the sunlight reaching the PV modules by increasing the incident radiation. The modules receive radiation in two ways, the direct and one reflected by mirrors, thus producing more energy compared with conventional solar modules, which naturally translates into a gain in energy efficiency, economic and also ecological preservation.

With the growth of the business, the current production of mirrors (Technology DoubleSun) is not enough to meet orders, becoming necessary to improve the performance of their production process. Reducing the time of some operations of the production process can be achieved by introducing some measures to optimize production.

3. The simulation

A critical research was conducted on the possible approaches to the problem. Given all the possibilities, Simulation Models emerged as the most appropriate approach to the problem, coupled with the fact that the decision support tool with greater balance in risk-cost. The most important benefits of simulation models are (Law and Kelton, 2000):

a) permit the study of real-world systems with stochastic elements that can not be described by mathematical models;
b) allowing the identification and analysis of bottlenecks to be performed;
c) making it possible to simulate the implementation of new features, new settings options, etc. that can be explored and compared, allowing for sensitivity analysis of the type "What if ...."
d) allowing the modeler to manipulate the scale of time, and can simulate long periods in a short time;
e) allowing the identification of problems arising from poorly designed specifications avoiding the construction or modification not requiring investments in this way doomed to failure.

In the simulation process, you must perform a set of steps in order to validate the model as an accurate representation of reality, and from there establish credible and reliable. Given the diversity of proposals in the literature on what steps it was decided to adapt to the problem the proposal by Banks (1998).

Figure 1: Simulation model development methodology.

Shannon (1998) classifies the simulation software in programming language, language simulation and simulators. The study revealed the simulators as the most appropriate package, because it requires less time to build the model incorporates a graphical environment and is less expensive because of the development programs of the two languages can only be done effectively in a general way of specialists or computer. The main disadvantage is less flexibility. Within the package of simulators investigated, we chose to use this work the software arena, Rockwell Software Corporation, since several studies recommend it for industrial applications and is increasingly used in business and academic studies.

4. Model development

The development of the model involves the application of the methodology of developing the simulation model.

4.1 Proposed system constitution

The constitution of the system is focused around the production operations or in Table 1.

Table 1: Assembly operations for a mirror production.

Nº Oper.	Operation
1	Placing the mirror
2	Placing of white duct tape
3	Placing the lexan
4	Placing of gray duct tape
5.A	Placing the frame A
5.B	Placing the frame B
6	Placing of red duct tape
7	Placing the holes support bar
8	Placing the eyelets support bar
9	Placing the stickers
10	Packing

The relations of precedence of operations are presented in the following diagram.

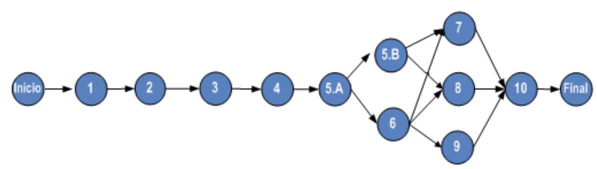

Figure 2: Precedent diagram of operations of the assembly process of mirrors.

The production of the mirrors is subject to discrete events. Although the sequence of operations can be characterized by a continuous flow, the production process are chronological events and are characterized by the production cycle. The operations have stochastic features which characterize the cycle time of production. The nature of assembly operations sequence implies that all operations are dynamic.

4.3 Data Collection

Aspects are considered relevant data. In the absence of any data, it was necessary to collect, analyze and treat all information documented. The information collected that were directly introduced into blocks built with parameters of the simulation model and used to analyze the performance of the model were the information relating to: time of production operations, auxiliary materials and operators assigned to production operations.

4. 3 Model constrution

The modeling environment of the Arena simulation blocks are constructed on the operations based on the modeling perspective-oriented event. The design of how things are for each event is as follows:

- Arrival of entities: Block start to create the model. It specified the time between arrivals of entities, which corresponds to the cycle time of production (assembly and break). Once created time between arrivals, the simulation model forward in time for the occurrence of the event. During the execution of the simulation technique is used for fixed time interval to advance the simulation model in time.

- End production of an entity: Once you complete the tasks that correspond to the execution of operations and are necessary for the model works, it is now necessary to supplement the record blocks and dispose. The block record allows you to collect statistics on production time. The dialog box is completed with the choice of time interval that allows the Arena record label as a statistical inter-arrival time of entities to the system, ie the cyclical time of production of mirrors. The last block dispose is set to demolish the entities that exit the system.

4.3 Verification and Validation

Are performed experimental simulations are interpreted and it is assumed that 10 hours is the appropriate time interval. Each production shift has a time interval of 5 hours, so it is assumed that the duration of the simulation corresponds to a day of production with two shifts.

We analyze two methods for determining the minimum number of replications of the simulation model. And it applied the following formula (Kelton, 2007):

$$n_{Rep} = \left(\frac{z_{\alpha/2}\sigma}{E} \right)^2$$

It is determined that sufficient minimum number of replicas to the model is 142.

The model works as expected, with regard to the times of production operations. The model is validated by comparing the average values of daily production capacity (over two shifts). The results indicate a deviation of less than 1% compared to the actual daily capacity, and hence the simulation model can be considered as a valid representation of the production process of the mirrors.

5. Results

5.1 Outcome evaluation method

From the study presented by Roser, Nakano, and Tanaka (2003), are included in the report results of the simulation model the following techniques to identify bottlenecks in the production process:

a) The lost production time for each operation, a percentage or unit of time.

$$Bottleneck_{TmpPerOp} = \frac{Acum\ Time_{PerOp}}{Total\ Time\ Acum_{Per}} \times 100 \quad (\%)$$

b) The execution time of each operation, in percent.

$$Bottleneck_{ExcTimeOpr} = \frac{Time_{ExcOpr}}{Cycle\ Time_{Prd}} \times 100 \quad (\%)$$

5.1 Current scenario

In this section, the scenario in this analysis is the system configuration. The figures 3 and 3 provide the results of the current scenario in terms of performance bottleneck.

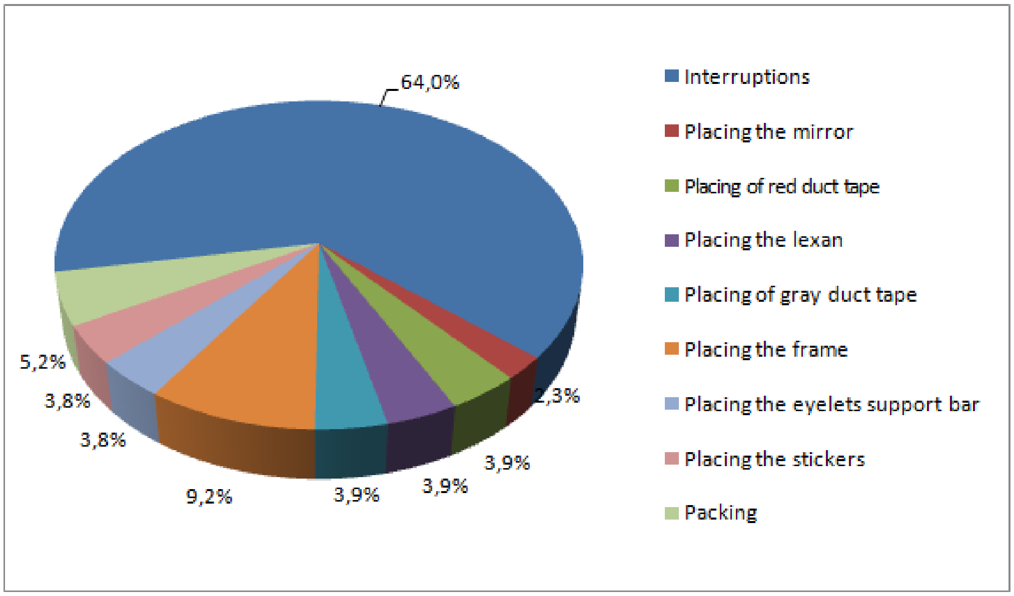

Figure 3: Current Scenario Bottleneck according to the lost time technique.

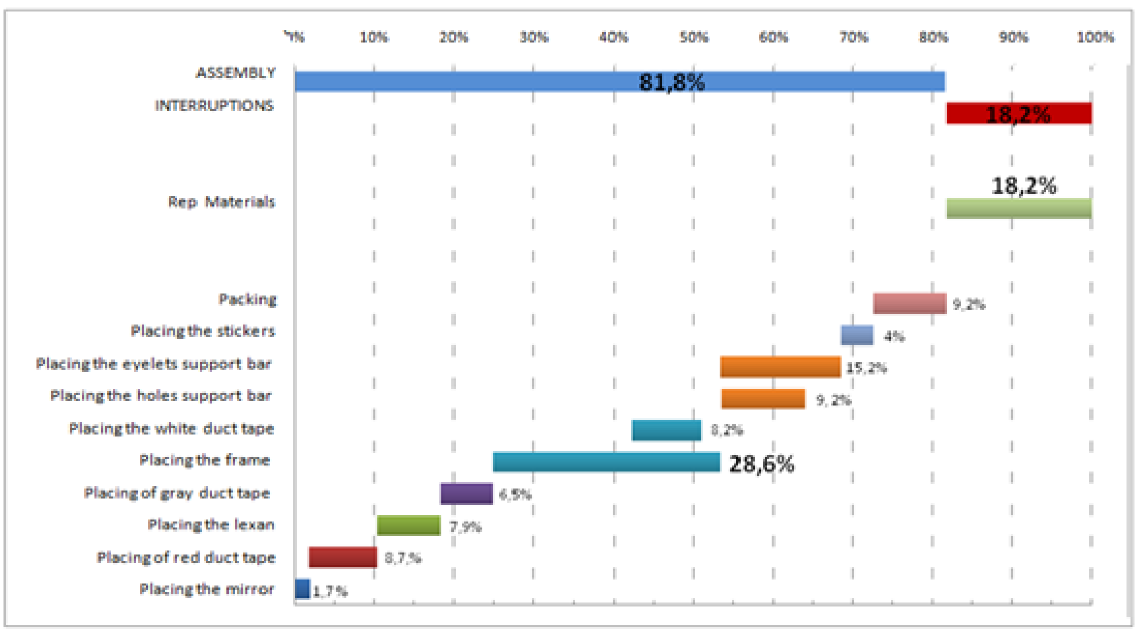

Figure 4: Current scenario bottleneck according to the execution time technique.

5.3 Alternative scenario

The figures 5 and 6 show the results of model simulation of the alternative in terms of performance bottleneck.

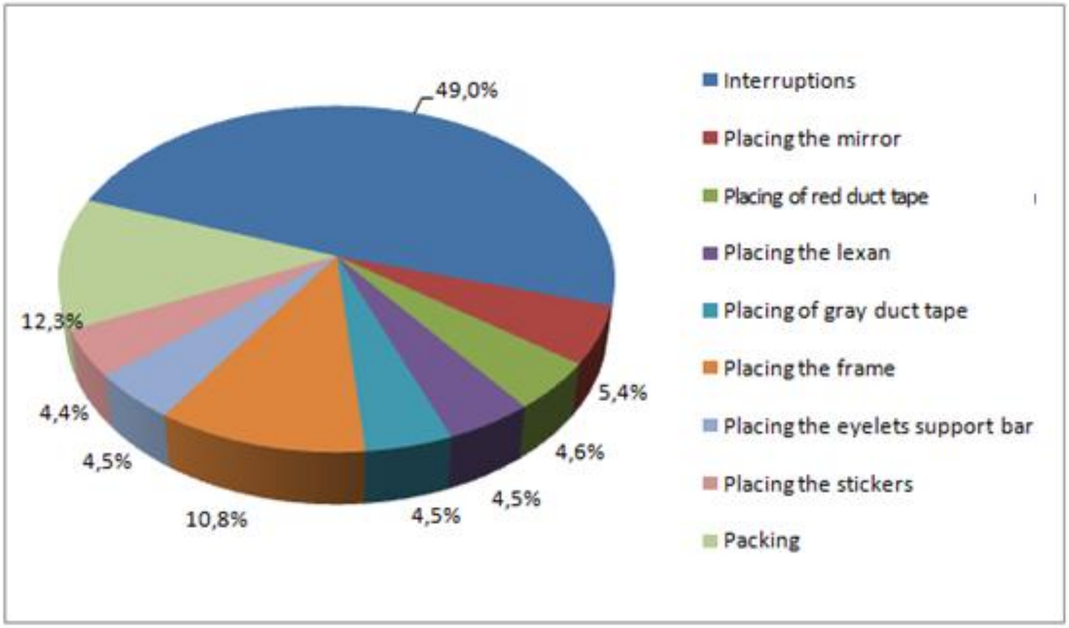

Figure 5: Alternative Scenario Bottleneck according to the lost time technique.

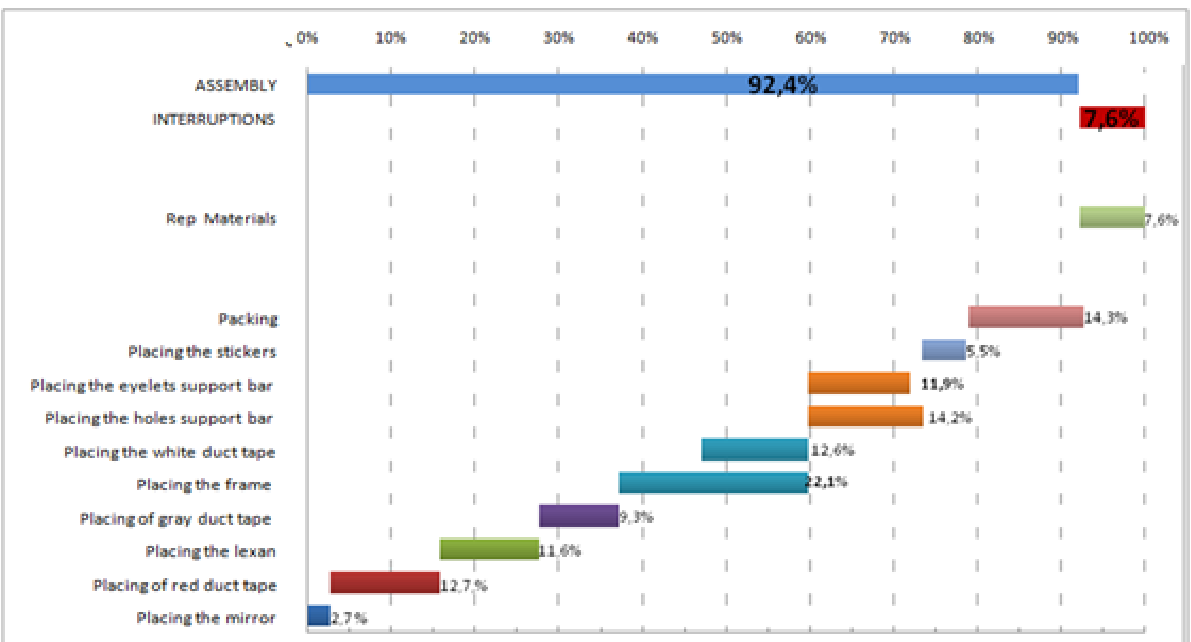

Figure 6: Alternative scenario bottleneck according to the execution time technique.

5.3 Comparation of Results

Table 8 shows the comparison of results of the simulation model of the Present Scenario and Alternative terms for the main bottlenecks more important.

Table 2: Comparison of main bottlenecks in actual and alternative scenarios.

Name	Current scenario		Alternative scenario	
	Lost Time (%)	Exec. Time (%)	Lost Time (%)	Exec. Time (%)
Op.Placing the frame	9,2	28,6	10,8	22,1
Interruptions	64	18,2	49	7,6
Total	73,2	46,8	59,8	29,7

Table 8 indicates that Operation Placement and Frame Interrupts (the two main bottlenecks most important) are the main bottlenecks for a total of approximately 73.2% of lost time and responsible for a total of about 46.8% runtime in the current scenario. The Alternative Scenario, however, presents a different result. Operation Placement and Frame Interrupts are a total of 59.8% of lost time and are responsible for a total of 29.7% of the runtime.

The results of the previous paragraph indicate clearly that the operation of placing the frame and the interruptions cease to pose an alternative scenario the bottleneck effect as important as the present scenario. These results are plotted in the figure.

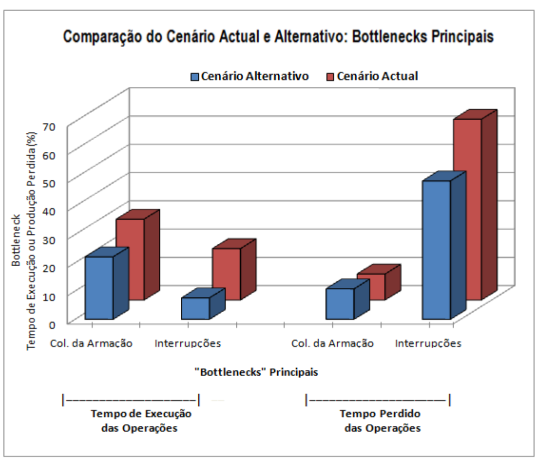

Figure 7: Comparison of Current and Alternative Scenario: main bottlenecks.

It is now presented in table 8 a comparison between the final results of current and alternative scenario, the values of the lost times and implementation presented in minutes. The table also shows the ratio of lost production, and their variations (in the last line).

Table 3: Final comparison between current and alternative scenarios.

	Cumulative time of lost production (Mints/Day)	Lost time (%)	Production cycle time (Mints. /Unit)	Production capacity (Units /Day)
Current Sc.	151.9045	25.32	38.1388	(15.732) 16
Alternative Sc.	100.01 *(200,02)	16.67	24.5750	(24.415) 24 *(48)
Variations	- 51.8945 *(+48.1155)	-8.65	-13.5638	+8.683 *(32)

*(values for two assembly table)

It´s possible can see that the variation of the production capacity of mirrors between current and alternative scenario increases by about 8 (8.683) mirrors for the daily simulation model, which accounts for approximately 24 days or produced by mirrors 12 mirrors produced per shift . 8.683 The mirrors daily gains (for desk mounting) corresponds to 4.3415 mirrors that are earned in each round of 5 hours (remembering that the length of the simulation model replicates are 10 hours per day, corresponding to two production shifts) . The gain between the average production capacity of mirrors in the current and alternative scenario is about 33.3% (for desk mounting) for the simulation model.

Table 8 shows that the lost time has decreased from about 152 minutes to 100 minutes or alternatively, the time is not added value decreased from 25.32% to 16.67% on the total production time (600 minutes or 10 hours daily). The cycle time of production decreased by over 13.5 minutes, from about 38.14 minutes to 24.6 minutes.

5.2 Conclusions from the results

The results of the most important bottlenecks and other critical situations are identified in real-world scenario compared with the alternative scenario. The comparison indicates that interruptions no longer constitute a major bottleneck in time for the alternative scenario. The alternative scenario results also indicate that the time of the operation of placing the frame and the operation of bars with eyebolts settled. The transport time also showed a significant overall reduction in time.

The overall impact of these changes indicates that when these are implemented, the effect of the process bottleneck is relieved, critical situations are minimized and production capacity increases. The gain expressed in terms of production capacity is approximately 8 per shift daily mirror assembly, which represents an increase of 150% of capacity.

6. Final conclusions

This work studied the optimization and reformulation of the Production Process of Mirrors for the company's Technology DoubleSun WAS Energia. The main factor that motivated this study was the need to increase production capacity to meet an increase in orders from customers. To this end, it was considered necessary to identify the main bottlenecks of production operations and critical situations in the center of production that lead to optimization of production of the mirrors.

Through the proposed model are obtained by changing the process of decisions that allow for increased production capacity. Some of the key decisions at the level of the production process indicate: amendments to the planning of materials in order to minimize disruptions of the process; Changing the layout of the production center allowing the reduction of time of transport tasks, and adding one more a fitting station; Changes in the operation of placing the frame, through implementation of a tool that reduces the processing time to the task of placing the bars of the frame, and implementation of a dual drill to reduce the processing time of the task of bolting bars of the frame and lugs. We suggest further changes that it says are of no interest at present in its implementation, namely the addition of an operator to eliminate time from interruptions and reduce the time of the tasks of transportation, and installation of an automatic carrier in order to make production less dependent on manual transport.

Finally, given that such decisions are really hard to take by mere observation or experience, it is hoped that this study proves a useful tool for effective decision making by managers. And improvements related to the limitations of this model originated by the need to aggregate this level scheduling and control orders. Incidentally, the most important proposals are:

- Incorporate in the decision support tool control strategies that allow the optimization of management from the requisition of materials from suppliers, operators need (ie need for one or more mounting posts) according to the size of the order.
- The possible construction of the model using a specific time deliveries in order to allow also examine, in a credible way, the cost savings that would result from acceptance of orders just above a minimum number of products, contrary to the policy implemented in the company. This analysis would also stipulate how much to charge customers add in situations where this does not arise.

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