Changes in the Manufacturing Process of a Logging Company Aiming at Increasing Production Volume

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***Abstract*--Small-sized logging companies in Brazil mostly have poor production structure and low production volume, and their survival largely depends on the search for improvement in their manufacturing processes. The aim of this study was to propose changes in the productive process of wooden trusses of a small business in order to obtain an increase in production. All information related to the current production process was raised. A system assessment model was created with the ProModel software, and the results showed that the current production line has a very low use of equipment and resources. Taking into account all alternatives evaluated, an increase in trusses production was obtained by considering three devices, called woodcutters, and nine operators, i.e. an increase of 170% in production. An economic feasibility analysis of the relative investment was carried out, and its results showed that it is viable to invest in two woodcutters (one already exists in production) and hire three more operators. The computer simulation proved to be a great tool to assist decision making in the production line of logging companies.**

I. INTRODUCTION

To the extent that the world market becomes dynamic and turbulent , many companies are not prepared for this requirement and will suffer serious consequences , but to stay in the market companies need to respond faster to market dynamics and have quick responses to customer needs . It is essential to the creation of new production strategies in order to exploit the maximum production capacity [9].

When considering new investments and resources, there are many questions as what is the best layout of the studied line, as have the highest productivity, flexibility and quality of the line always with least amount of resources possible. Usually the answers to these questions are given by employees or groups with experience, are often little quantitative and qualitative decisions, or who consider static mathematical models, it does not address the dynamics of the system, often led astray [6].

The timber industry in general, especially the processing lumber, constantly uses this wrong model to design their production lines or new projects and when installed finds the misuse of resources, generating waste, low productivity and high costs, many often lead to the organization of bankruptcy [5].

The modeling of a system is based on an assessment of an individual on the real system, a model difficult to address all the details of the system, because however clever, experienced and with the greatest amount of technological artifacts used where plenty of detail to represent reality completely. So for [13], a model is an external and explicit representation of the reality seen by the person you want to use that model to understand, change, manage and control part of that reality.

Typically for simulation study are used mathematical models which are developed with the aid of simulation software. Mathematical models are classified between deterministic (when internal and external variables have fixed values) or stochastic (at least one internal or external variable is probabilistic); static (time is not taken into account) or dynamic (the time variation of the interaction with the variables is taken into account). Typically simulation models are stochastic and dynamic [12].

The simulation is a tool to evaluate the performance of a system existing or proposed in various configurations or settings and for prolonged periods of time. It is used in the analysis of a system prior to deployment to verify whether the proposed or modified system actually meets the desired requests [12]. With the simulation can advance to check whether one proposed layout system or actually produce the expected results, with the advantage of low cost compared with the cost demobilization after the mounting has been proposed. For [3], a benefit of computer simulation is the graphical design view or system studied in static and dynamic way, which contributes a lot for analysis, with more detailed data and charts.

The aim of this study was to propose changes in the production process of a small timber industry, leading to an increase in production volume.

II. LITERATURE REVIEW

Simulation

The simulation involves the generation of an artificial history of the system to be analyzed, make observations and inferences the operating characteristics of the system being represented [2].

According [3], the simulation process follows the scientific method, so, formulates hypotheses, preparing the experiment, tests the hypotheses by experiment and validates the hypotheses through the obtained results.

Also for [3], the simulation does not replace the work of human interpretation, but provides results for more elaborate analyzes of the system dynamics, thereby enabling a deeper and more comprehensive interpretation of the studied system.

Because to its versatility and flexibility, the simulation is widely used in technical and research activities operations [11].

According [11], some of the many simulation application areas are: computer systems, manufacturing systems, businesses, government entities, ecology, environment, society and behavior, life sciences, etc.

Besides the strong contribution in improving the issues of manufacture, the simulation can be a very useful tool in the service area, and the main applications are: evaluation of staff at service providers companies, improving procedures, health, patient scheduling, patient flow between departments, mutual use of services, logistical issues of services, storage and handling of components and materials, management of finished goods inventory, order processing, maintenance in the process without affecting the operational capacity of the service, logistics related environmental cleaning and waste handling.

Simulation is used before the system change, or rather, of building a new system, to reduce the chances of disability to meet the specifications to eliminate unforeseen bottlenecks to avoid lack or resources left over and to optimize performance system [12].

According [8], mapping the process data analysis and computer simulation reduces the risk of inefficiency improvement proposals for the manufacturing operations. The authors conducted a study to see improvements in the cutting process of sheets of paper at a pulp and paper industry in Thailand, they used the mapping process, data analysis and computer simulation and managed more efficient results for decision making.

According [7], the main reason for the development of a simulation model or any other method of modeling is that it is an inexpensive way to obtain significant results when the costs, risks and logistics of handling the real system of interest are prohibited.

The simulation is a tool that allows for economic and financial analysis of investments in projects involving new equipment and projects [1]. The estimated costs with the use of computer simulation on a project are between 1% and 3 % of the total project cost.

One of the difficulties of the economic justification of the simulation is the fact generally not able to assess what the savings generated in the project, achieving obtain this value only at the end of the project [1].

With the simulation has a lower cost compared with the cost of performing the direct trials, involving large sums of money, equipment and people, and that is not always achieved the expected results.

According [10], when information is needed regarding not yet implemented systems or information about changes to models already in operation, the simulation is the alternative that offers the best cost / benefit for obtaining such information.

In a system or project where there is the application of simulation the design phase has a higher cost in relation to a study without applying the system, this, because, it is precisely at this stage that one can plan for a more optimized system and consequently in step implementation and operation do you get the expected reduction in costs [4].

Second [8], the combination of the procedure of mapping and computer simulation is beneficial, especially because it reduces the risk of ineffective redesigned manufacturing operation.

III. RESEARCH DEVELOPMENT

The survey was conducted on a small business, founded in 2000 and located in Arujá - SP. The company currently has a factory area of approximately 6000 square meters, has 70 employees and an annual turnover of approximately R$ 3.6 million.

The system studied in this research was the wooden trusses manufacturing process that meets both the construction sites as the roofs of residential structures. The trusses are scaled according to a specific project or customer request and are assembled at the factory, sent later ready for the works that will be mounted on buildings, the mounting work is usually performed by technicians of the company or the customer themselves.

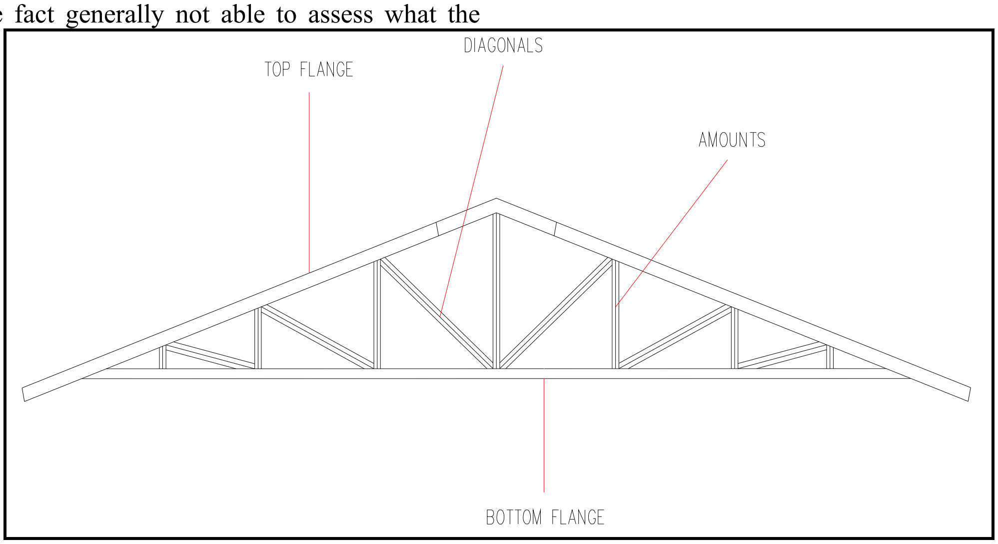

Figure 1 – Wood trusses model

The decision to conduct the study on the wooden trusses manufacturing line was mainly due to lack of in-depth and accurate study of the best use of available resources and the fact that the production line meets the two products manufactured by the company (construction sites and residential roofs).

The trusses can be produced with pine or eucalyptus woods. It was considered to carry out this work the production of eucalyptus for the greatest distortion in the finished parts and therefore higher production time.

In figure 1 is shown a model of a wood trusses, object of this research study.

IV. MANUFACTURING PROCESS

The company has a single production line to meet the construction sites sector and structures for residential roofs. The elements of the trusses go through the same machines and what differs are the dimensions, type of wood and shape of the trusses (flat or triangular).

The process under study consists of five machines; the industry operates with six employees and one shift of eight hours of work per day.

The wood trusses have four elements which in spite of being produced on the same line passing through different paths. The four elements that make up a trellis are: top flange, bottom flange, amounts and diagonals.

The process is fueled by wood packages provided in a place called stock timber, which are usually all in the same width measurements, thickness and length. The machines and their operations are described below:

The wood cutter equipment is a circular saw which performs straight cuts on top of the woods, that equipment parts are cut in desired sizes.

The press "C" is a hydraulic press which connects the connecting elements to two pieces of wood. It is usually used for mounting the upper and lower flanges.

The circular saw is a device that has a turntable until 180º, widely used in cutting degree of the amounts.

Pneumatic circular saw is a device developed by the company, it has two mountain ranges that perform two simultaneous cuts on the edge of the wood, and this equipment is used in the production of the diagonals.

Finally, the roller press, it is a table, which has two rolls, one upper and another lower, and connecting the connection elements to the nodes of trusses composed of the four elements.

After assembly, the trusses are taken from the press roller with the help of a hoist and stored in a place called stock trusses and wait until loading.

After the description of the overall process flow, defined the inspection, operation, transportation, storage and waiting. With this information it was possible to mount the flowchart mapping wooden trusses manufacturing process, shown in figure 2.

For truss manufacturing line sought to measure all activities through the realization of time. The information of each equipment processing time and its set time was obtained by timing the production line, since the devices have manual operation and some were developed by the company, as is the case of wood cutter equipment and pneumatic circular saw.

Since the amount of manpower and layout of the production line was obtained with supervisors and heads of industry, or even analyzed in locu.

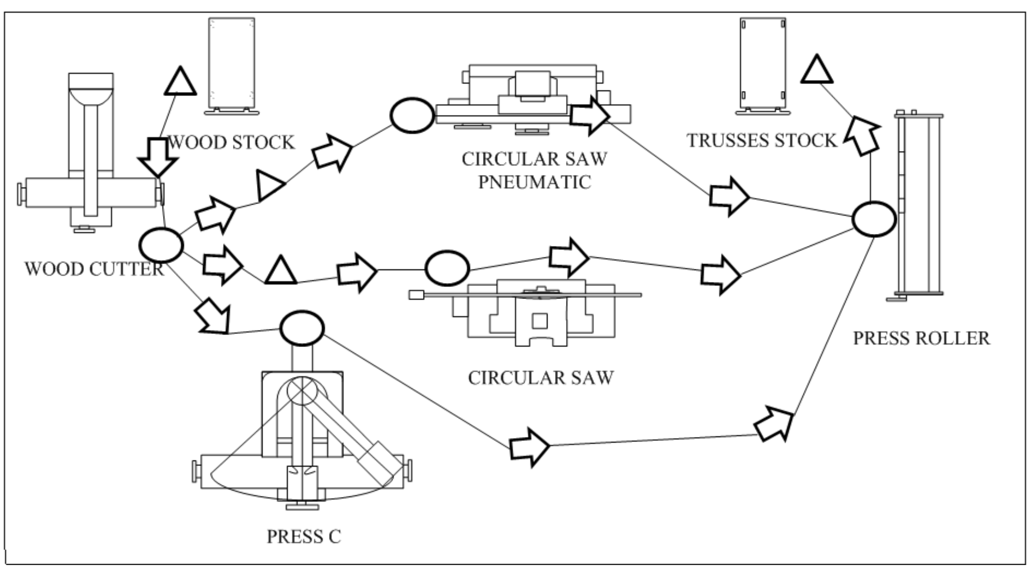

Figure 2 - Flowchart mapping wood trusses manufacturing line

The information manpower handling time, stand and manual carving, were obtained by timing the current trusses production line, being these activities usually used by the company.

The machines processing times were entered into the model in stochastic form, so it was necessary to survey the best theoretical probability distribution that best represents the number of times each machine behavior.

To determine distribution curve probability that best represents the collected time of each machine, we used the software Stat :: Fit the ProModel. As the p-values found in the following adhesion tests (Chi Square and Kolmogorov-Smirnov) are greater than the significance level (0.05), it was concluded that the distributions shown in table 1, are the expressions that best fit to the data collected in the system.

TABLE 1 - PROBABILITY DISTRIBUTIONS

Places	Distribution curves	Distributions
Wood cutter	Lognormal	-744+L(754, 1.82)
Press C	Pearson 5	35.7+P5(76.2, 1.9e+003)
Circular saw	Weibull	4.71+W(1.83, 2.34)
Circular saw pneumatic	Erlang	-15.+ER(21.7, 280)
Press roller	Weibull	0.989+W(8.17, 13.7)

V. MODEL CONSTRUCTION

The simulation was performed using the ProModel software, which lets you create direct model in the interface, they were inserted the information collected in the system, such as local, entities, network paths, resources, processes, arriving parameters and other important information that the model is as close to the real.

In figure 3 is represented the model of the system under study operating in ProModel software from this model experiments were performed.

VI. MODEL VALIDATION

According to [14], the validation of the simulation model is extremely important, even when models are created by copying as much detail as possible, in the end is very important to validate the model, because if you want to verify that it has an acceptable level of confidence to be able to infer answers that will be used to support decision making.

Therefore, for the assembly of the model were raised all time, process, layout, number of operators and the model was validated with the management of the company and the sector under study.

After the first simulation can be seen that the number of trusses produced in the simulation was 21 units, 5% higher than the actual production of the sector, such as demonstrating in table 2. Given the small difference was defined together with the management of the company this would be the model that would represent the truss production system and used for analysis of the experiments.

TABLE 2 - COMPARISON OF VOLUME PRODUCTION PLANNED / ACTUAL AND SIMULATED

Description	Planned / Real	Simulated	% Variation
Number of turns	1	1	0
Number of operators	6	6	0
Total production	20	21	5

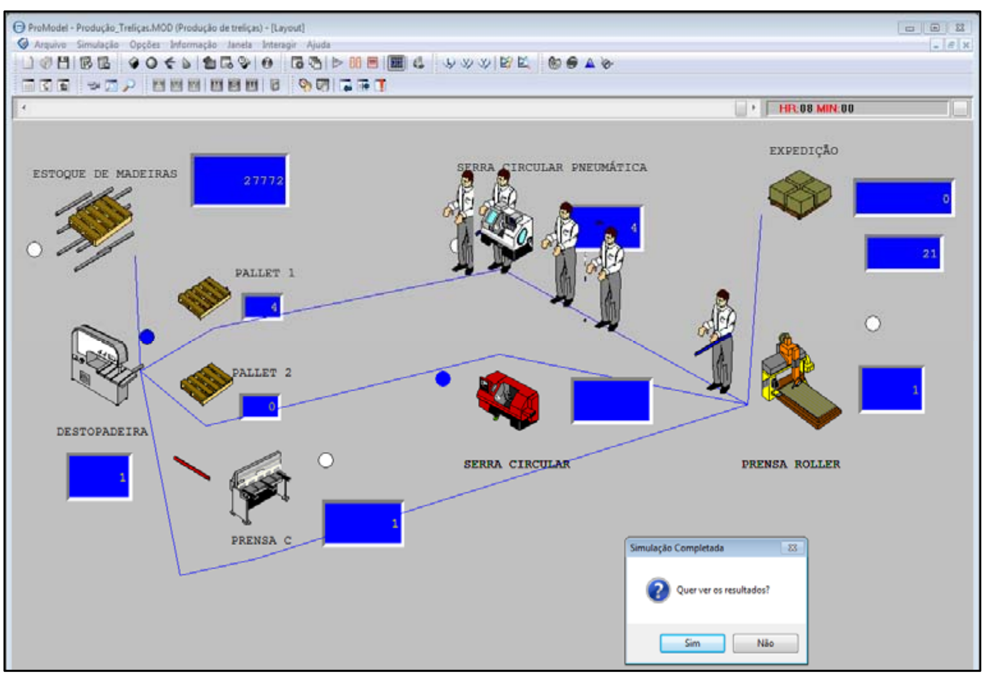

Figure 3 - Industry simulation model under study

VII. PRESENTATION AND ANALYSIS OF RESULTS

Before the main objective of this study was to evaluate the volume of production of trusses production line, it has been proposed some experiments with different scenarios to discuss improvements to the system.

A. First experiment: production volume and indicators of the current system

The simulation through the proposed model resulted in a production of 21 trusses and production of the actual system is 20 trusses.

The location for the receipt of raw materials is the only one that has a high percentage of utilization 99,81%, so it does not lack wood for the production of components, on the other hand between devices focus of this study utilization rates were: to the wood cutter equipment 27,30%, press C 43,77%, 29,49% pneumatic circular saw, circular saw 2,33% and 4,14% press roller. All rates obtained were very low indicating a large percentage of downtime of the machines. There with that much chance to improve the production of the analyzed system.

The best utilization rate was obtained by the operator 1, which was 50,95% and the lowest rate of use operator 6 was obtained which was 20,68% for the two lower rates were obtained which show that six operators may be beyond what is necessary generating an idle and unnecessary expenses.

B. Second experiment: change in the number of operators

In order to check the volume produced behavior, use of equipment and resources, there were four simulations by varying the amount of operators. The table 3 shows the volume variation produced for the four proposed scenarios.

TABLE 3 - NUMBER OF OPERATORS VERSUS PRODUCTION VOLUME

Scenarios	Trusses manufactured
Scenario 1 (3 Operators)	17
Scenario 2 (6 Operators)	21
Scenario 3 (9 Operators)	24
Scenario 4 (12 Operators)	24

The current production line under study is 21 trusses with 6 operators, with three operators increase of the increase was only 3 trusses or approximately 14% while decreasing the reduction was three operators 4 trusses or about 19%.

With the increase in the number of operators it observed an increase in the utilization rate of press C in pneumatic circular saw and press roller. By contrast there was a reduction in the operating time of wood cutter equipment and circular saw.

The average time of use of the operators was higher when they were used only three operators for the line under study is not required many operators and the greater the fewer the utilization rate and hence the more idle capacity, production costs and final cost of the product.

C. Third experiment: variation in the number of work shifts

In the third experiment it was observed the behavior of the production of lattices with increasing number of hours worked for this three simulations were performed with one shift, two and three shifts.

To perform the simulations, as the main objective of the research was the increase in production volume, the simulations were carried out with nine operators. The table 4 represents the number of trusses produced per shift.

TABLE 4 – WORK SHIFTS VERSUS PRODUCTION VOLUME

Scenarios	Trusses manufactured
Scenario 1 (1 Work shift)	24
Scenario 2 (2 Work shifts)	48
Scenario 3 (3 Work shifts)	73

The amount of trusses produced in two shifts doubled and tripled in three shifts, as expected. The percentage of use of the equipment was the same for all shifts. The percentage of average use of 9 operators was approximately 27% as well as being low there was no change between shifts.

D. Fourth experiment: variation in the amount of equipment

In the fourth experiment was checked trusses production volume behavior with the increase in the number of bottlenecks equipment, the simulation considering six operators and one shift of eight hours of work per day was found the following percentages of blocked funds, 89,35% upper and lower flange, 87,87% amounts to 90% of diagonals. The three elements come out of the same equipment that is wood cutter equipment therefore was the focus of this experiment equipment.

To make the simulations as the main objective of the research was the increase in production volume simulations were performed again with nine operators and one shift of eight hours of work a day.

The table 5 shows the number of trusses produced by the line with the increase in the number of wood cutter equipment.

TABLE 5 – VOLUME PRODUCTION WITH INCREASING EQUIPMENT WOOD CUTTER

Scenarios	Trusses manufactured	% Variation
Scenario 1 (1 wood cutter equipment)	24	0,0
Scenario 2 (2 wood cutters equipment)	41	70,83
Scenario 3 (3 wood cutters equipment)	54	125,0

With the system simulation with two wood cutters equipment production increased approximately 71% and with three trusses increased by 125% in volume of trusses, regarding the situation with a destopadeira nine operators.

The use of percentages increased with destopadeira increase, the most significant results were in pneumatic equipment circular saw, circular saw and roller press, with 75,33%, 60,78% and 7,27% for two wood cutters equipment, respectively, while that for three percentages equipment were 80,98% , 68,0% and 10,23% respectively.

The percentage of use of the nine operators increased with the number of wood cutter equipment added, and for one wood cutter equipment 27,23%, 48,81% to two and 68,67% to three. With the increase in the neck equipment figure rose up the trusses production number and that operators were better utilized by reducing the idle time.

E. Analysis of the Economic Feasibility - Financial and Implementation

An economic and financial feasibility analysis was performed to verify the alternatives proposed investment.

Whichever method is used for economic and financial analysis of the proposed scenario, it was found that the investment in the two wood cutter equipment and three operators is feasible. The calculation of the net present value (NPV), considering the hurdle rate (TMA) company, was greater than zero; the internal rate of return (IRR) in turn was higher than the hurdle rate (TMA); the payback period resulted below the cutoff point of the company. Observing the values obtained for the net present value (NPV) and internal rate of return (IRR) indicates that even raising the hurdle rate (TMA) to 61,17%, investment still paying off investors.

With the results obtained from the simulation of the production of all scenarios and for economic and financial analysis of investment, it is recommended the company to make the investment in two more wood cutter equipment and hire three more operators, for an increase in production volume. The return on investment is high, as the net present value (NPV) is greater than R$ 100.000,0 and the internal rate of return (IRR) is approximately six times higher than the hurdle rate (TMA) company.

VIII. CONCLUDING REMARKS

The computer simulation proved to be a great tool to assist in decision-making processes in a small business the lumber business industry, can be useful in determining the resources, equipment, production volume and visualization of the results generated by any proposed change even before making the change in locus. Another point found was that, in most cases, decisions are made based on the experience of some people involved and do not take into account the dynamics of the system.

The ProModel software presented the results and statistics very clearly, enabling rapid and simple visualization system, the movement of resources and use of equipment. To analyze the statistical distributions of process run times, the ProModel software itself has the Stat :: Fit software that suggests the setting of the main probability distributions to the data indicating the quality of these adjustments.

The results of this research were presented to the board of the company, because it is a family business, did not know the computer simulation and were very surprised with the speed of obtaining and accuracy of results. In addition, the industry leader positively evaluated the use of computer simulation to support decision-making tool; before decisions were made based on the experiences of those responsible and without considering the dynamics of the system.

The results of this research will be utilized in assembling the new production line being performed elsewhere as well; new scenarios can be evaluated using the proposed model.

The methodology used in this study can be applied to assess manufacturing processes, production lines, production capacity, utilization of resources, can be employed in the area of services, logistics and evaluation of care in health systems.

During the development and evolution of this work were emerging ideas that can be applied in future research, as follows.

Conduct a new study considering simulations with fixed operators in jobs and compare with the volume of production with multitasking employees, as shown in this study.

In this research we have not made changes to the layout; a suggestion would be to conduct a new study suggesting changes in the layout, such as reducing the distances between equipment in order to get the best productivity and the best use of equipment and resources.

ACKNOWLEDGMENTS

The authors would like to thank Centro Universitário FEI and FAPESP.

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