A Decision Support System for Production Planning in Tyre Balancing Machines

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Abstract

This project is a case study developed in a real industrial context of a company in the automotive industry dedicated to tyre manufacturing. The high quantity of items associated with a limited production capacity in the balancing section leads to a significant increase in production planning activity complexity. The allocation of products to the balancing machines is done daily by workers who use only spreadsheets, taking a significant part of their day in a time-consuming and complex activity. To evaluate the usage of the installed capacity of the machines and to minimise the setups in the equipment, a Decision Support System (DSS) based on optimisation models is developed. Having as input the items that need to be tested, the DSS suggests an optimal configuration of the equipment that will minimise the setups and guarantee that all tyres are tested, facilitating the daily routine of production planners. This article describes the problem, the mathematical model of linear programming that is the basis of the DSS. It presents the results obtained after testing the system in a real context.

Keywords

planning, tyre manufacturing, DSS.

1. Introduction

The automobile sector plays a significant role in the global economy. The search for competitiveness advantages from companies in this sector leads to a continuous focus on increasing productivity and efficiency. The search for efficiency is particularly relevant in the tyre manufacturing industry, whose profitability depends on cost-efficient operations as tyres are largely considered a commodity.

This project was developed in a tyre manufacturing company whose production process can be divided into five main stages. The process begins with the Blending of raw materials in mixers that produce a compound stored at the end of the stage. In the next stage, Preparation, different tyre components are manufactured to be assembled in the next stage, Construction. It is then followed by Vulcanisation, where the tyre acquires its final appearance and characteristics when vulcanised in a mould at a high temperature and pressure, specific for each tyre. Finally, the tyre goes to Final Inspection. A visual inspection is performed at this stage, followed by tests on uniformity machines and balancing machines. Balancing is a test that measures the mass distribution in the tyre. In the company, only those tyres whose customers request it undergo this last test.

The Balancing section consists of a group of parallel balancing machines on which a rim is mounted to enable the tyre to be balanced during operation. Each rim allows the fitting of three different tyre sizes. Thus, each machine can test tyres of three different consecutive sizes. There is a limited number of available rims of each size. The balancing cycle time depends on the size of the tyre. Any machine can receive any rim, and the machines are considered identical. Each tyre type has two parameters that determine whether it can be tested on a given rim: the size and the width.

The large volume of items leads to increased difficulty in the production planning activity, especially when the workload and equipment capacity is very similar. In situations like the one described, it is necessary to ensure that the downtime of the machines is minimised, in particular, to have efficient planning of rim setups. Currently, planning the tyre balancing process is done only with the support of spreadsheets and simple calculations. Thus, decisions are made based on the empirical knowledge of the planning workers. This results in overwork for the workers that need to spend at least 60 minutes planning the production of the balancing section.

In this work, a decision support system that verifies if the production capacity for a certain period is sufficient for the workload and determines the rim allocation to machines that minimises the number of setups to be executed and ensures the testing of all tyres is introduced. The decision support system will also reduce the time required in the production planning activity.

The remainder of this paper is organised as followed. Section 2 contains a review of relevant literature. Section 3 describes the problem addressed. Section 4 describes the mathematical programming model solution used in the DSS. Section 5 reports the computational results of the mathematical model. Section 6 describes the DSS, and Section 7 reports the computational results.

2. Literature Review

Definition of Decision Support System

Even though we are used to terms such as Decision Support and Decision Support System, these concepts are not defined in a simple way. Different authors have been creating various definitions which makes it harder to come up with one general definition for these concepts. The Decision Support Systems are usually associated with complex computer programs and related with information systems, but these tools do not need to be complex to be useful to support the decision-making process (Nizetic et al., 2007).

For Dous et al. (2018) a DSS is a specific class of computerized information system that supports decision-making activities by performing tasks that help the decision makers collect useful information from data, documents, personal knowledge and business models. In many situations this type of tools were used as a complement of decision-making processes, but they have been more and more used as an integrated part of business processes and information systems. Nowadays, DSS are used in a wide range of applications from agriculture and crop planning to health, business, and environment, working alongside with decision-makers and enhancing their decisions (Mir & Quadri, 2009).

According to (Nizetic et al., 2007) and his analysis of different definitions, a Decision Support System can be a simple system that shows requested information to the user or a system able to treat and help in complex decision-making processes. The author puts in evidence the large number of systems that fit into this broad spectrum of systems, which leads to a need of defining characteristics that help in distinguish a DSS from an information system.

Characteristics of a Decision Support System

In the same way that there is no consensus about the definition of DSS, Nizetic et al., (2007) explains that it is also difficult to establish a set of elements that could be used to characterize this type of systems. By looking into different proposals from other authors, it is possible to say that a Decision Support System is developed to help and support the decision maker using data and models, providing the complementary information that a person might need to make a decision and having as main objective the improvement of the effectiveness of a decision. According to Dous et al., (2018) in order to generate alternative solutions, the DSS can make analysis, deductions, projections, optimization, simulation etc., by using linear programming, integer programing, goal programming, network models and statistical models.

Types of Decision Support Systems

There are different criteria that can be used to categorize DSS, but the most used is the assistance mode, according to which these systems can be categorized in five types: communications driven DSS, data driven DSS, document driven

DSS, knowledge driven DSS and model driven DSS (Power, 2014). The first type mentioned above is used to improve the communication and the collaboration between users to facilitate the dialogue and the sharing of ideas needed in a decision-making process of a group of people. The second type, document driven DSS, are mostly used to get stored information and support the decision by providing files or documents from databases, webpages, or other type of place that stores information. The data driven DSS are slightly different from the previous ones in the way how the data is processed. This type of DSS supports the decision-maker by analyzing the data from databases and by extracting information from the analyzed data. More than data, the user will be provided with information about the data that can be useful to decide. The knowledge driven DSS are focused on a specific area and can help the user decide and understand problems under that domain. Finally, the model driven DSS have in their core decision and optimization models that use analytic tools to find and suggest solutions and alternatives. This type of systems uses parameters and variables defined by the user, but generally there is no need to use large databases.

In Figure 1, the differences between a model driven DSS and a knowledge driven DSS are schematized.

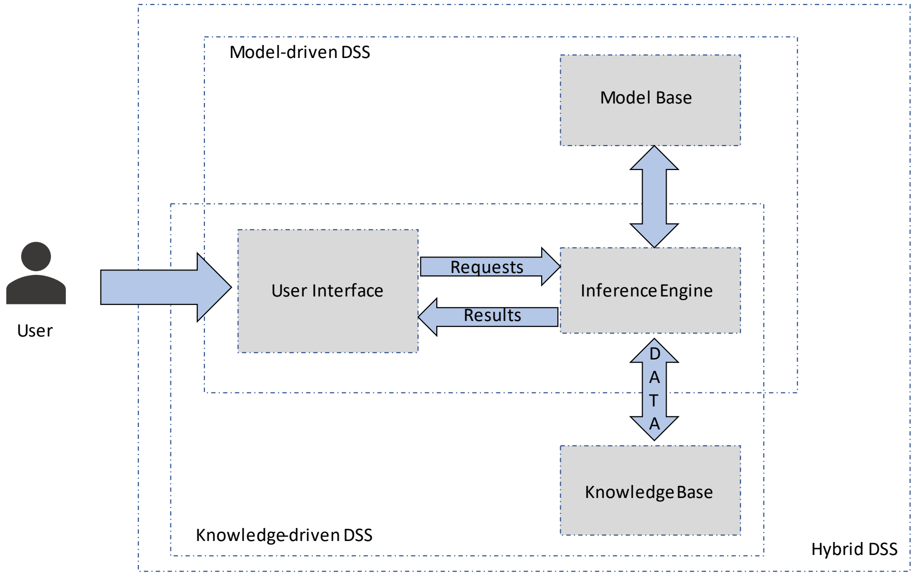


Figure 1. “Assign” Button and Parameter Counting Functions.

As it can be seen, a DSS has at least five elements: the user (person who uses the system), the user interface (part of the system that communicates with the user), the Inference Engine (part of the system that makes the conclusions), the Knowledge base (database that contain all the information and data needed) and the Model Base (optimization models that perform the decision-making process). The User enters the requirements through the interface and are sent to the Inference Engine to be processed. The Inference Engine sends and receives data from and to Knowledge and Model bases, and after getting a solution, it sends the Results back to the User.

On a model driven DSS the main actor is the Model Base that searches for optimal solutions and executes all the decision-making process. On a knowledge driven DSS is the Inference Engine that performs the decision process, but the main actor is the Knowledge Base from which all the information is extracted. Some more complex DSS integrate both Model and Knowledge Bases resulting in Hybrid DSS. The DSS developed in this project can be considered a Model Base DSS, since it has a linear programming model as main element to obtain and suggest solutions to support the decision.

User Interface

The User Interface is a very important component of any DSS, especially in systems which performance depends on the communication with the user. A simple and intuitive interface is a key factor to the success of an efficient communication between the user and, consequently, resulting in good solutions or alternatives presented to the decision-maker.

According to Nizetic et al. (2007), the UI should be divided in two parts: the first in which the user defines the requests and give inputs to the system, and the second in which in system presents the results to the user. The entry of requirements should be designed to facilitate the process for the user and avoiding the inconsistency of people. In the same way, the presentation of the results should be simple and objective, making it easier for the user to take conclusions about the results. A user-friendly interface has using visual elements, graphic representations, images, clear designs In a DSS the user-friendly interface should facilitate interaction with the system, both in data entry and in the interpretation of results by using visual elements such as graphics representations, diagrams or images.

3. Problem description

3.1. The Balancing Test

Balancing is a production process operation whose objective is to test and measure mass distribution across the tyre. This test is performed along the longitudinal axis, and a static or dynamic balancing can be obtained. In the first case, there is an irregular distribution of mass in a way that is symmetrical to the axis, which can be caused by overlapping seams. In the second case, there is an uneven distribution of mass in a way that is asymmetrical to the dividing line of the tyre, which for example, can be caused by differences in material thickness.

It is mandatory that 21" and 22" size tyres and tyres whose customer requires this operation pass through this stage in the company. The balancing test can be done to all tyres from one reference or by sampling only a part of them, which means that only some tyres of a given reference are sent for this test.

The width is a parameter relating to the space between the two sides of the rim that holds the tyre during testing (Figure 2). Two numbers express this parameter: the minimum Gap (tight rim) and the maximum Gap (open rim).

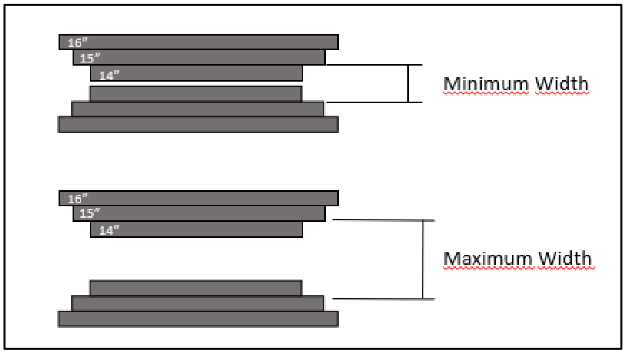


Figure 2. Minimum and maximum width representation

Each machine can test tyres of three consecutive sizes, for example, 14", 15", and 16" tyres. Each rim has three sizes that are not combinable, and there is a limited set of 14 rims available. Table 1 shows all available rims and their openings per size.

Table 1. Rim Inventory for Balancing Machines

Rim Type	Quantity	Minimum Width			Maximum Width		
14/15/16	1	2	3,5	5	7	8,5	10
15/16/17	2	3	4,5	6	8	9,5	11
16/17/18	2	4,5	6	7,5	9,5	11	12,5
17/18/19	2	5,5	7	8,5	10,5	12	13,5
18/19/20	3	4,5	6	7,5	9,5	11	12,5
19/20/21	2	5	6,5	8	10	11,5	13
20/21/22	1	7	8,5	10	12	13,5	15
20/21/22	1	5,5	7	8,5	10,5	12	13,5

Once the test has been executed, the tyre is automatically conveyed to its storage destination. When it is an item whose balancing is done by sampling, only a small part of the tyres is sent to the balancing machines. When the pre-established number of tyres to be tested is reached, this item is no longer supplied to the equipment.

The rim is changed according to the production need's, and there is no set frequency for this, meaning that each rim remains in the equipment until there is another need for change. However, if there is a large accumulation of a certain size of the tyre (due to a breakdown, for instance), a rim size with lower production is changed for the one that needs to be compensated.

The setup time is 30 minutes, and it is independent of rim size and machine. Every day in the third shift, some machine parameters are adjusted, which takes 15 minutes per machine. Besides the preventive maintenance that is performed every eight weeks, specific calibrations are done every three months.

Table 2 presents the average cycle times on the balancing machines by tyre size. Since these are considered identical machines, it is assumed that the cycle time is the same for each rim regardless of which machine the operation is occurring on.

Table 2. Cycle Time per rim size.

Tyre Size (Inches)	Average Cycle Time (s)
14	22,22
15	22,22
16	24,43
17	20,39
18	22,56
19	23,68
20	22,48
21	21,49
22	22,53

3.2 Problem description

When the project was being carried out, the number of processed tyres in the balancing machine was increasing steadily. The growth in production was not being followed by an increase in the balancing machine's capacity. Therefore, the workers who planned the production on the balancing section needed to assess and ensure the best configuration of rims in order to test all the items scheduled. This is a situation in which the machine's available time is valuable, so it is essential to guarantee as little downtime as possible. Preventive maintenance and calibration activities are fundamental, so they cannot be avoided, unlike setup activities.

This project aimed to develop a Decision Support System to support the production planning process on the balancing machines. The system should evaluate the existing production capacity of the equipment and establish, for a time period, the optimal rim configuration that minimises the number of setups and guarantees that all items on the production plan are tested. In order to suggest a solution, the main component of the Decision Support System is an optimisation model. Thus, considering a set of rims that can be mounted on the machines and the production plan, it is necessary to develop a linear programming model whose output is the optimal rim configuration on the balancing machines.

4. Mathematical Model

This problem is formulated as an integer linear programming model to minimise the number of setups and the number of used machines.
The model has the following parameters:

n – Number of type of tyres on the production plan;
i – Number of rims;
j – Number of machines;
D_k – Tyre demand of the type k;

p_k – Unit processing time of the tyre type k;
T_k – Total processing time to all tyres of type k;
M_j – Capacity, in hours, of machine j;

C_{ki} - $\begin{cases} 1, \text{if tyre } k \text{ can be tested in rim } i; \\ 0, \text{otherwise} \end{cases}$

S_{ji} - $\begin{cases} 1, \text{if machine } j \text{ has the rim } i \text{ assembled}; \\ 0, \text{otherwise} \end{cases}$

The decision variables are:

x_{ij} - $\begin{cases} 1, \text{if rim } i \text{ is assigned to machine } j; \\ 0, \text{otherwise} \end{cases}$
y_{kij} – Production time of tyre k using rim i on machine j;
z_{ij} - $\begin{cases} 1, \text{if rim } i \text{ assigned to machine } j \text{ is changed}; \\ 0, \text{otherwise} \end{cases}$

The objective function is:

$$\text{Minimize } \sum_i \sum_j (x_{ij} + z_{ij}) \tag{1}$$

Subject to:

$$\sum_i \sum_j y_{kij} * C_{ki} \geq T_k \text{ , } \forall k \in [1 \dots n] \tag{2}$$

$$\sum_i \sum_k y_{kij} \leq M_j \text{ , } \forall j \in [1 \dots j] \tag{3}$$

$$N * x_{ij} \geq \sum_k y_{kij} \text{ , } \forall i \in [1 \dots i] \text{ , } \forall j \in [1 \dots j] \tag{4}$$

$$\sum_j x_{ij} \leq 1 \text{ , } \forall i \in [1 \dots i] \tag{5}$$

$$z_{ij} + s_{ji} \geq x_{ij} \text{ , } \forall i \in [1 \dots i] \text{ , } \forall j \in [1 \dots j] \tag{6}$$

$$\begin{aligned} & x_{ij} \in 0,1, \forall i \in [1 \dots i] \text{ , } \forall j \in [1 \dots j] \\ & z_{ij} \in 0,1, \forall i \in [1 \dots i] \text{ , } \forall j \in [1 \dots j] \end{aligned} \tag{7}$$

$$y_{kij} \geq 0 \text{ , } \forall k \in [1 \dots n] \text{ , } \forall i \in [1 \dots i] \text{ , } \forall j \in [1 \dots j] \tag{8}$$

The objective function (1) minimises the number of setups and the number of used machines. Constraints (2) ensure the demand is satisfied, meaning that all items in the production plan are tested. Constraints (3) guarantee that the capacity of the machines is not exceeded. With the constraints (4) the activation of the binary decision variables is done. A very large number, N, is used for this purpose. If the sum of the production durations of tire k using rim i on machine j is greater than zero, then this rim will be allocated to this machine. To meet the constraint, it is necessary that xij takes the value 1 so that when multiplied by N it is greater than the sum mentioned above, thus getting the decision variable activated. Constraints (5) ensure that each rim is only used in one machine. Constraints (6) assess the need of a setup, it compares the initial rim configuration of the machines and the one obtained by the model. Constraints (7) are related with binary variables and (8) relate to non-negativity conditions.

5. Computational Results

To test the model's performance, four production plans with each item demand and the rim configuration were collected on four different days. With the collected data, it was possible to assess if the results obtained by the optimisation model is satisfactory regarding the number of setups and if the capacity is enough for the workload.
The computational tests were conducted on a portable computer Asus – X556U, with a processor Intel® Core™ i7-6500U and 8GB RAM. The operating system installed on the computer was Windows 10 Home Version 1803. The software used to run the optimisation model was IBM Ilog CPLEX Optimization Studio 12.9.
Table 3 shows the results of the tests of each considered day.

Table 3.Computational Results

Production Plan Date	Test	Number of Items	Processing Time (s)	Objective Function
4 abril	1	65	5.78	6
5 abril	2	64	6.38	6
9 abril	3	64	8.57	7
10 abril	4	64	6.18	7

The processing time results were satisfactory in all tests, with an average value of 6.73 seconds. The number of analysed products is similar on each machine because the items produced on those days were the same. The linear programming model allocates the rims to the machines based on the initial configuration. For that reason, when the value of the objective function is less than 7, fewer machines are needed than the existing ones. If the value of the objective function is equal to 7, then all machines are loaded, but the configuration of rims may or not be optimal.

As shown in Table 3, tests 1 and 2 have a final objective function value of six which means that six rims are allocated to six machines. In this case, the model finds an optimal solution in which one equipment is entirely available. The integer programming model found an advantageous optimal solution as there is available capacity for the planned production and one machine is not used. Having one equipment completely free can be useful in situations of breakdowns because it can be used to test the items that were being tested on the broken equipment. However, it can also be more interesting for the company to balance the workload between all seven machines than having machines on their maximum capacity and one machine down, meaning that workload should be levelled and distributed for all machines.

When it comes to tests 3 and 4, the final objective function value is 7, which means that all machines are used. In both tests, the results were satisfactory even though there is no production levelling on the different machines. Also, there are machines at their maximum capacity in these tests and others with some available capacity.

Therefore, the developed programming model can meet their objectives, namely, assess the capacity of the balancing section and the allocation of the articles on the production plan.

6. Practical Implementation

Decision Support System

The developed decision support system consists of three modules that interact with each other (Figure 3). The linear programming model implemented in CPLEX imports the data from a database in XLSM format and exports the solutions to a file of the same type.

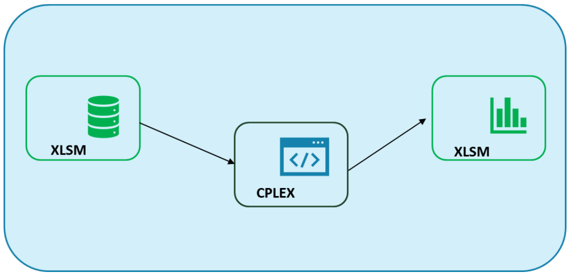


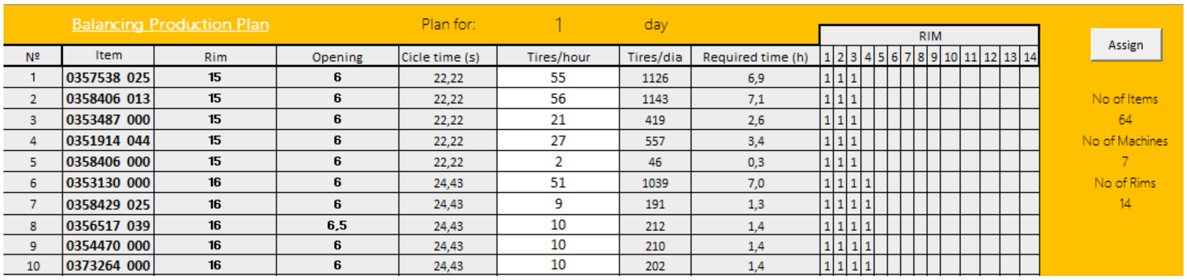
Figure 3. Decision Support System Structure.

The results obtained and treated are presented to the user through an interface also in XLSM format. One of the reasons for developing the tool in this configuration was the need to take advantage of the Excel files used in the current production planning. In addition, these are two very powerful software whose capabilities, when combined, allow to meet the needs required by the complexity of this project.

In order to facilitate data entry and reading in the tool, three separate Excel sheets were created: one for data entry and two for the presentation of the results obtained.

Data Entry

For the data to be imported into CPLEX, a table was created in an Excel file in which the user has to enter for each of the items that have to be balanced the id, the size, the tyre opening, and the demand-hour. Additionally, the user must enter the time horizon, in days, according to which wants to evaluate the capacity. Figure 4 shows the above fields that must be entered initially.



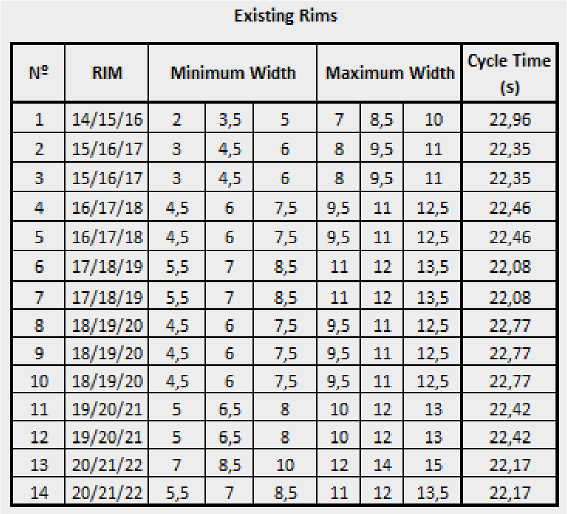
Balancing Production Plan Plan for: 1 day

								RIM													
Nº	Item	Rim	Opening	Cicle time (s)	Tires/hour	Tires/dia	Required time (h)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**0357538 025**	**15**	**6**	22,22	55	1126	6,9	1	1	1											
2	**0358406 013**	**15**	**6**	22,22	56	1143	7,1	1	1	1											
3	**0353487 000**	**15**	**6**	22,22	21	419	2,6	1	1	1											
4	**0351914 044**	**15**	**6**	22,22	27	557	3,4	1	1	1											
5	**0358406 000**	**15**	**6**	22,22	2	46	0,3	1	1	1											
6	**0353130 000**	**16**	**6**	24,43	51	1039	7,0	1	1	1	1										
7	**0358429 025**	**16**	**6**	24,43	9	191	1,3	1	1	1	1										
8	**0356517 039**	**16**	**6,5**	24,43	10	212	1,4	1	1	1	1										
9	**0354470 000**	**16**	**6**	24,43	10	210	1,4	1	1	1	1										
10	**0373264 000**	**16**	**6**	24,43	10	202	1,4	1	1	1	1										

No of Items
64
No of Machines
7
No of Rims
14

Figure 4. Data Entry Table.

In this section, there is an "Assign" button (Figure 4), which, when activated, checks for each item on which rim it can be processed, considering its size and opening. By clicking this button, the number 1 is assigned if the tyre can be processed by the rim, or 0 otherwise. The algorithm that makes this assignment was implemented in VBA using mainly multiple decision programming structures. After the items are inserted, three functions are counting the number of existing references, machines and rims, as these three parameters can change from plan to plan. Additionally, in this data entry spreadsheet, there is a table with all the existing rims, which user can edit, add, or remove rims. Each rim is characterized by a minimum and maximum width, and its cycle time (Figure 5).

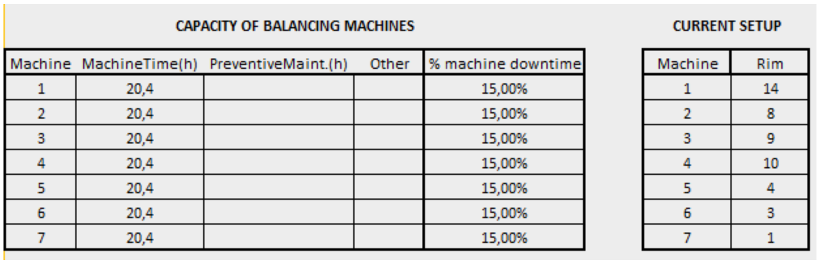


Existing Rims

Nº	RIM	Minimum Width			Maximum Width			Cycle Time (s)
1	14/15/16	2	3,5	5	7	8,5	10	22,96
2	15/16/17	3	4,5	6	8	9,5	11	22,35
3	15/16/17	3	4,5	6	8	9,5	11	22,35
4	16/17/18	4,5	6	7,5	9,5	11	12,5	22,46
5	16/17/18	4,5	6	7,5	9,5	11	12,5	22,46
6	17/18/19	5,5	7	8,5	11	12	13,5	22,08
7	17/18/19	5,5	7	8,5	11	12	13,5	22,08
8	18/19/20	4,5	6	7,5	9,5	11	12,5	22,77
9	18/19/20	4,5	6	7,5	9,5	11	12,5	22,77
10	18/19/20	4,5	6	7,5	9,5	11	12,5	22,77
11	19/20/21	5	6,5	8	10	12	13	22,42
12	19/20/21	5	6,5	8	10	12	13	22,42
13	20/21/22	7	8,5	10	12	14	15	22,17
14	20/21/22	5,5	7	8,5	11	12	13,5	22,17

Figure 5. Table of Existing Rims

In this same spreadsheet, as shown in Figure 6, there is a section for the user to enter information regarding the available machine time and another for the current configuration of rims on the machines. In the table "Capacity of the Balancing Machines" two fields have been created to introduce stationary machine constraints that are preventive maintenance operations or interventions of another nature.



CAPACITY OF BALANCING MACHINES

Machine	MachineTime(h)	PreventiveMaint.(h)	Other	% machine downtime
1	20,4			15,00%
2	20,4			15,00%
3	20,4			15,00%
4	20,4			15,00%
5	20,4			15,00%
6	20,4			15,00%
7	20,4			15,00%

CURRENT SETUP

Machine	Rim
1	14
2	8
3	9
4	10
5	4
6	3
7	1

Figure 6. “Capacity of Balancing Machines” and “Current Setup” Tables.

On the same spreadsheet, there is an inventory of the existing rims. This table aims to help the user enter the correct id of the rims that are placed on the machines. Thus, in the table "Current Setup" (Figure 6), the user enters the rim id that is mounted on each machine to characterise the current configuration of the equipment. Besides these parameters, the user is asked to enter the percentage of downtime, a value used to calculate the availability of the equipment.

Results Presentation

In the first Excel spreadsheet for data display, several graphs were created to provide the user with the main results. The existence of graphic and visual content makes the interpretation of the results more accessible and more intuitive. To this end, three different graphs were created. Besides the graphs, there is a top bar where the number of setups to be performed is indicated (Figure 7).

The "Balancing Occupancy" graph (Figure 7), in the form of a speedometer, shows the percentage occupancy of the balancing section, allowing us to conclude whether there is a capacity for the execution of the plan introduced.
The "Gaps" chart (Figure 7) exposes, through bars, which slack exist in each machine, i.e., the difference between the capacity and the load in each equipment.

The "Capacity VS Workload" graph (Figure 7) is a combination of a line graph and a bar graph. It is visually more perceptible to evaluate the difference between load and capacity.

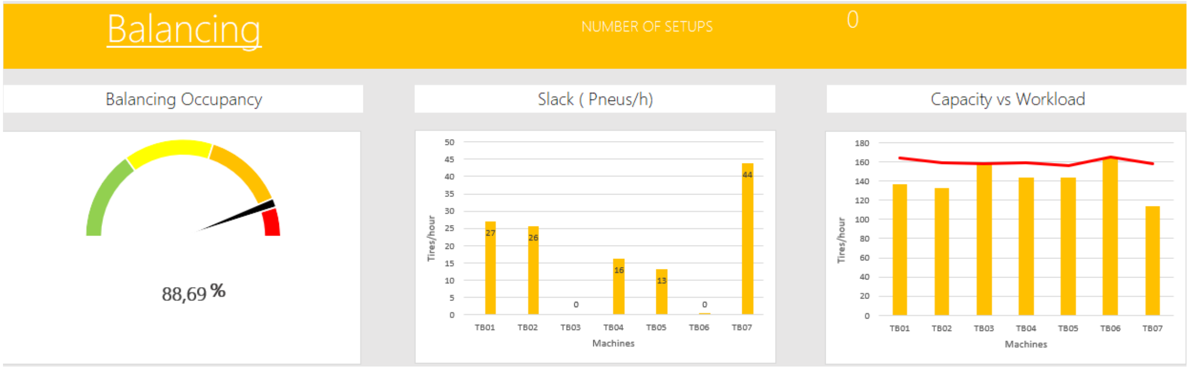
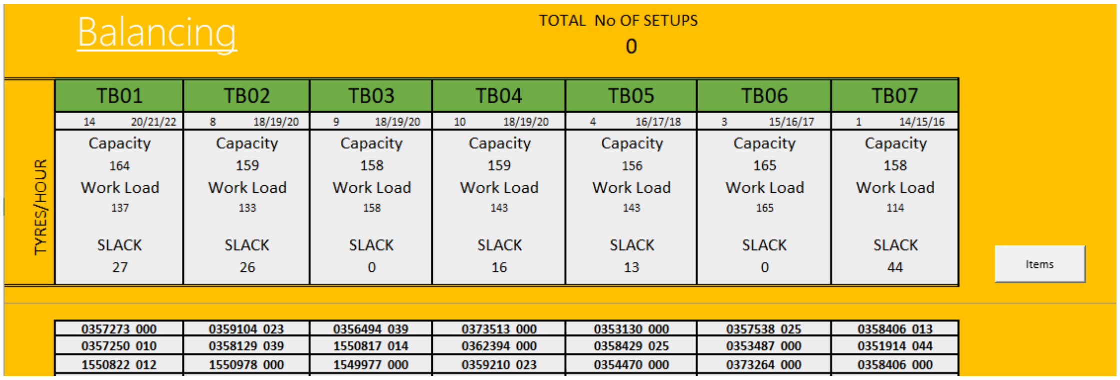


Figure 7. “Balancing Occupancy”, “Slack” and “Capacity vs Workload” Graphs.

On the second results presentation spreadsheet, the information is displayed in greater detail. For each machine, the rim that should be allocated to it is shown as well as the machine capacity, the load and the remaining slack after the allocation of the items. Knowing the advantages of visual management, the field indicating the name of the equipment can assume two colours: green if the rim is already on the respective machine or red if a setup is required. To let the user know how many changes on the machines need to be made, the field "Total No of setups" indicates the number of rim changes to do compared to the current configuration. Figure 8 shows all the previously mentioned elements.



TOTAL No OF SETUPS
0

TYRES/HOUR	TB01	TB02	TB03	TB04	TB05	TB06	TB07
	14 20/21/22	8 18/19/20	9 18/19/20	10 18/19/20	4 16/17/18	3 15/16/17	1 14/15/16
	Capacity	Capacity	Capacity	Capacity	Capacity	Capacity	Capacity
	164	159	158	159	156	165	158
	Work Load	Work Load	Work Load	Work Load	Work Load	Work Load	Work Load
	137	133	158	143	143	165	114
	SLACK	SLACK	SLACK	SLACK	SLACK	SLACK	SLACK
	27	26	0	16	13	0	44
	0357273 000	0359104 023	0356494 039	0373513 000	0353130 000	0357538 025	0358406 013
	0357250 010	0358129 039	1550817 014	0362394 000	0358429 025	0353487 000	0351914 044
	1550822 012	1550978 000	1549977 000	0359210 023	0354470 000	0373264 000	0358406 000

Figure 8. Table of Results Presentation by Machine and "Items" Button.

Still in this spreadsheet, as shown in Figure 8, an "Articles" button allows the user to see which items were allocated to each piece of equipment. This functionality allows visualising the results of the programming model developed. This way, the user now has a base of items allocation to machines resulting from an algorithm that seeks an optimal solution. Therefore, the decision-making process in the planning of the balancing machines is simpler and better founded.

7. Conclusion

All things considered it can be concluded that the goal of developing a DSS that helps to evaluate the capacity of the balancing section was achieved. Through the developed decision support system, it is possible to assess if the production plan is feasible and also what changes need to be made to make it feasible. The linear programming model fulfills the requirement that was assigned to it.

The computational testing and evaluation of the DSS by future users were performed near the end of the project, which led to a late identification of small gaps and prevented the improvement of some aspects. Therefore, there are some future works that can be taken into consideration. As far as the linear programming model is concerned, it would be interesting to reformulate it in order to suit better the company’s context by considering consider the distribution of the workload between all the machines This means that it would be necessary to add new constrains and objectives functions to the model that would minimise the standard deviation of the remaining capacity of the equipment, preventing some equipment from being down.

Regarding the interface of the DSS, it is possible to conclude that, although it is simple, it requires some training on the part of the user in order to become familiar with the structure of the program. However, this system proved to be helpful to workers by reducing the time spent by them on the production planning activity in 25 minutes.

This project in a production context shows that decision support systems can be a very useful tool in the decision-making process, giving the decision maker the ability to evaluate different action scenarios and act in the most appropriate way. The solution here presented contemplates the use of integer programming models which are the basis of the resolution of many optimization problems in industry.

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Biographies

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