Proceedings in MANUFACTURING SYSTEMS

Proceedings in Manufacturing Systems, Volume 18, Issue 4, 2023, 137-142 ISSN 2067-9238

USING SOFTWARE AND MATHEMATICAL METHODS TO OPTIMISE A BOTTLING FLOW

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Abstract: *Automating processes has emerged as a significant global trend within the bottling industry, with a rising number of companies now focusing on this aspect. The present study conducted a simulation to optimise a bottling flow using the WITNESS Horizon software. The main objective of increasing the profit was achieved by optimising the bottling flow by modifying working times and implementing two new bottling lines. In addition, another efficient method was presented, which was solved using Kuhn's algorithm to optimise the proposed flow. The system designed in the present study was compared to other systems in the bottling industry market. The research found that the system proposed in this paper was the most efficient as it could complete a whole cycle of bottling and packing ten boxes in a shorter time than the other systems.*

Keywords: *automation, bottling flow, simulation, algorithm, optimisation.*

1. INTRODUCTION

The general structure of a production flow consists of more than one type of system, the most important ones being: supply, transportation, transfer, packaging, labelling, palletising and storing systems.

As detailed in the paper, the bottling production flow consists of the following components: the bottling and fastening system for bottle caps, the labelling system, the belt conveyor transportation system, the storing system, and human operators.

In this case, the transportation systems are the conveyors, which take and move the bottles towards the areas where different procedures will take place (bottling, labelling, capping, palletising, wrapping, etc.) [1].

The purpose of the transfer system is to transfer the products to different stages within the bottling flow.

The storage spaces are used to store the raw materials utilised during the production flow and temporarily store the finished products.

The human operators are meant to oversee and intervene during the production flow processes if needed [1].

A bottling flow will be simulated using WITNESS Horizon to optimise the flow and achieve the highest number of finished products in the shortest amount of time.

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2. COMPARATIVE ANALYSIS OF FLOW CHOICES PROVIDED BY COMPANIES WORKING IN THE FIELD

The Shemesh Automation sparkling water bottling line is fully automatic and offers a complete filling, cap fastening, labelling and sealing process using state-of-the-art systems. This line is a complete solution that carries out the sparkling water bottling process with minimal loss.

The scheme ensures a higher effectiveness for the systems used and is meant to bottle 3000 bottles per hour [2].

The cap fixing system is designed to offer effective and precise cover for a wide array of products. The machine is built to screw caps and is fully automated for maximum efficiency.

The sealing system provides a new perspective on the quality of the sealing process and allows the making of a completely sealed product with no scraps caused by the process.

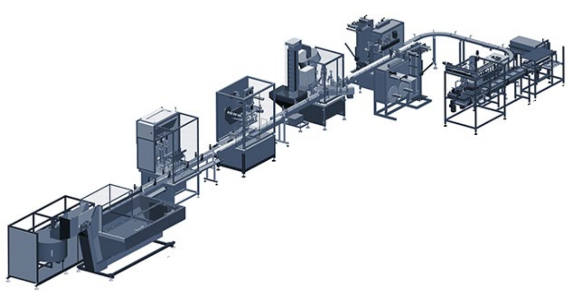

Fig. 1. Shemesh Automation bottling line [2].

The labelling system has the perfect solution for applying different types of labels on a wide range of container shapes. This machinery is capable of applying any type of self-adhesive label. The system ensures that every label will be placed in exactly the same place on each bottle. Production never stops replacing an old labelling tape with a new one because it keeps on rolling labels as the old tape connects to the new one in order to have no breaks.

The conveyor is designed to carry both filled and empty bottles. It is equipped with an adjustable side rail for guidance, making the machine compatible with different types of bottles. It can also be adjusted in height [2].

The Krones sparkling water bottling line has an increased productivity of over 15.000 bottles per hour with a controlled filling level, and it is designed to maintain a low cost of energy and resources [3].

The bottling line is used for different types and sizes of bottles and is one of the best-performing systems when it comes to the filling method.

The Krones filling system bottles drinks with high precision while ensuring a high-quality filling process.

The cap fixing system processes a large number of caps that are fastened on bottles using a manufacturing device that is more productive.

The labelling system consists of three main components and seven types of labelling stations. It is effective and reliable equipment that allows for increased productivity.

The packaging system is automated and can handle a wide range of bottle sizes. One perk of the automated system is that it allows great flexibility regarding bottles' shapes and sizes.

The palletising system is efficient and allows fully automated loading and emptying of pallets.

The conveyor system is flexible in handling different types of bottles and maintains a constant flow, with a high enough speed and a buffer zone that is mandatory for every filling line. It is also highly effective in handling products, making very little noise and consuming little energy. The exit area is also very versatile in terms of product types, as it is equipped with high-accuracy sensors that provide smart production management.

The solutions provided by the two companies working in the bottling domain have increased productivity and can be used as templates for the devised model.

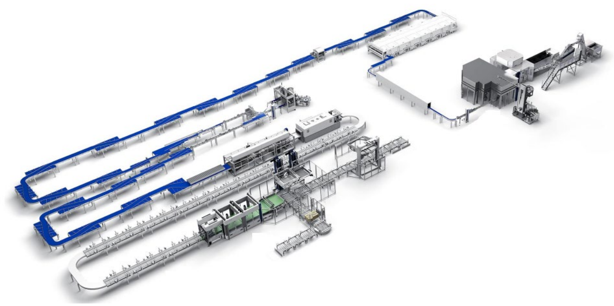

Fig. 2. Krones bottling line [3].

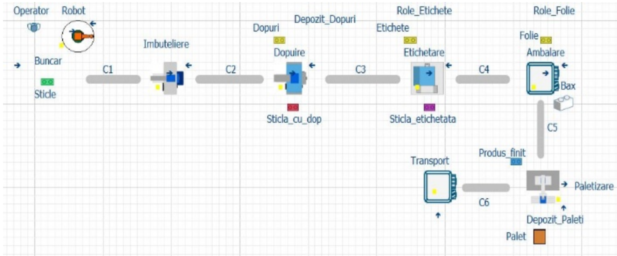

Fig. 3. Depicting the flow components in Witness [4].

3. SIMULATING THE PROPOSED BOTTLING FLOW USING THE WITNESS HORIZON

The following components were integrated within the simulated bottling flow: buffers, conveyors (C1, C2, C3, C4, C5, C6), the bottling system, the cap fixing system, the labelling system, the packing system, and the palletising system (Fig. 3).

Simulations have been made for the following types of bottles: 0.5 litres, 1.0 litres, 1.5 litres, 2.0 litres, and 2.5 litres PETs. The results in the paper at hand are presented for the most favourable case, which is bottling in 1.5 litre PET bottles.

Empty 1.5 litres PET bottles are taken from the buffer using a robot and transferred to the conveyor(C1) which transports them to the bottling system. After sterilisation and filling, the bottles exit the conveyor(C2) and are carried to the cap fixing system. After screwing the caps, the bottles are unloaded to the conveyor(C3) and moved to the labelling system. After applying labels, the bottles are taken by the conveyor(C4) and transported to the packing-in-cases system. The cases are picked up by the conveyor (C5) and taken to the palletising system. After finishing the palletising and wrapping processes, the pallets are moved to the deposit using the forklift.

3.1. Initial simulation and costs

The modelled systems were simulated for 5 working days (5 days x 8 hours x 60 minutes = 2400 minutes) to make a diagnosis and identify the bottlenecks (Fig. 4).

At the end of the 5-day simulation, the productivity report shown in Fig. 5 was achieved. By reviewing this report, it can be observed that 4.801 1.5-litre bottles were bottled, grouped in 794 cases, and positioned on 12 pallets, with 64 cases on each pallet.

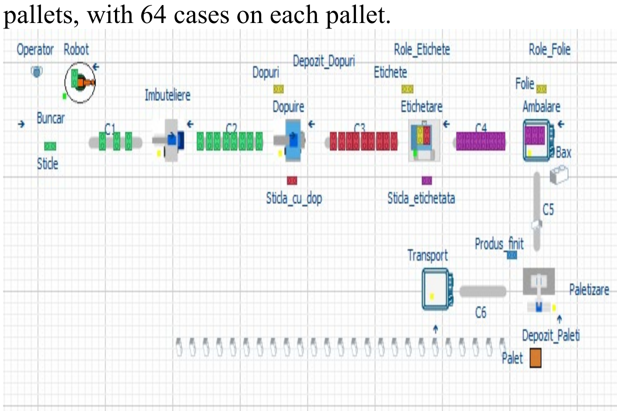

Fig. 4. Simulating the initial flow in order to identify the bottlenecks.

Name	No. Entered	No. Shipped	No. Scrapped	No. Assembled	No. Rejected	W.I.P.	Avg W.I.P.	Avg Time	Sigma Rating
Dopuri	12000	0.000	0.000	4789.000	0.000	7211.000	3611.282	722.256	6.000
Etichete	12000	0.000	0.000	4779.000	0.000	7221.000	3621.335	724.267	6.000
Folie	12000	0.000	0.000	794.000	0.000	11206.000	5606.507	1121.301	6.000
Palet	4801	0.000	0.000	12.000	0.000	4789.000	2394.848	1197.175	6.000
Sticla_cu...	4789	0.000	0.000	4779.000	0.000	10.000	10.053	5.038	6.000
Sticla_etic...	4779	0.000	0.000	4764.000	0.000	15.000	15.209	7.638	6.000
Sticle	4801	0.000	0.000	4789.000	0.000	12.000	11.282	5.640	6.000
Bax	794	0.000	0.000	768.000	0.000	26.000	32.262	97.516	6.000
Produs_finit	12	12.000	0.000	0.000	0.000	0.000	0.028	5.500	6.000

Fig. 5. Product report.

The analysis of the report on loading the production systems within the flow, presented in Figs. 6 and 7, shows that the palletising system has a very low loading, being inactive for 98% of the time.

Furthermore, following the analysis of the report for loading conveyors, shown in Figs. 8 and 9, it can be observed that the working time for conveyor 6 is very little, accounting for 2.5% in relation to the functioning time of the flow components. These flaws are going to be fixed as a result of adapting and optimising the flow [5].

Reports on product quantity, loading the systems in the flow and production costs were produced after simulating the initial flow.

Further, the goal is to optimise the bottling flow by improving productivity, loading the flow systems as much as possible in relation to the maximum capacity, without bottlenecks in other areas of the flow, and achieving the lowest possible production costs considering the entry benchmarks [6].

Name	% Idle	% Busy	% Filling	% Emptying	% Blocked	% Cycle Wait Labor
Imbuteliere	82.011	17.989	0.000	0.000	0.000	0.000
Dopuire	80.046	19.954	0.000	0.000	0.000	0.000
Etichetare	0.425	99.575	0.000	0.000	0.000	0.000
Ambalare	83.458	16.542	0.000	0.000	0.000	0.000
Paletizare	98.500	1.500	0.000	0.000	0.000	0.000
Transport	99.750	0.250	0.000	0.000	0.000	0.000
Robot	80.000	20.000	0.000	0.000	0.000	0.000

Fig. 6. Production systems report.

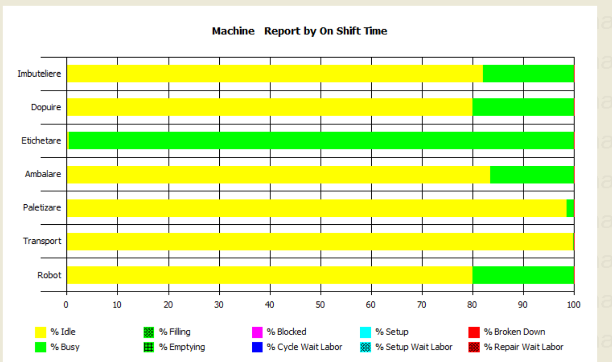

Fig. 7. Production systems chart.

Name	% Empty	% Move	% Blocked	% Queue	% Broken Down	Now On	Total On	Avg Size	Avg Time
C1	0.004	99.996	0.000	0.000	0.000	3	4800	3.513	1.756
C2	0.083	99.917	0.000	0.000	0.000	8	4797	7.190	3.597
C3	0.237	78.515	0.000	21.247	0.000	9	4789	9.057	4.539
C4	0.445	94.263	0.000	5.292	0.000	12	4779	11.701	5.876
C5	33.841	66.142	0.000	0.017	0.000	1	794	0.661	1.999
C6	97.500	2.500	0.000	0.000	0.000	0	12	0.025	5.000

Fig. 8. Conveyor transport systems report.

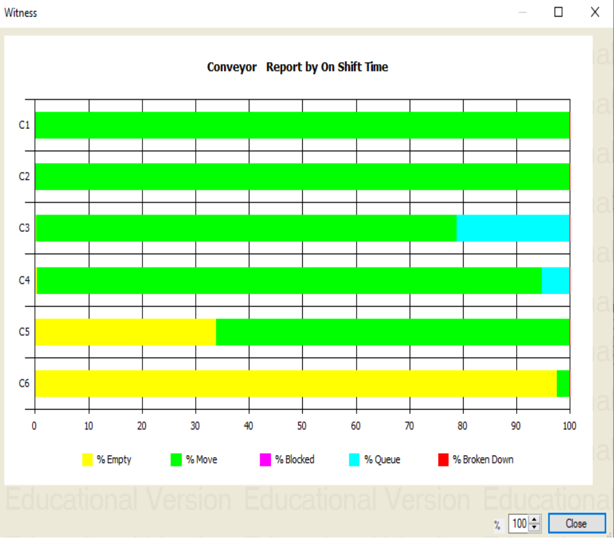

Fig. 9. Conveyor chart.

Regarding costs, after reviewing the reports derived from the simulation using the initial parametrisation, the profit resulted in $11,704.90. Considering that the profit can be increased, measures for optimising the bottling line in this sense will also be taken (Fig. 10).

3.2. Optimising the system

To meet the requirements set after simulating the initial flow, the next step was remodelling the bottling flow following the values of the initial simulation. Two more bottling lines were added to allow increasing the number of bottled, packed, and palletised bottles.

This change has taken place because, following the initial simulation, the palletising system had a much too low loading compared to the other components of the flow.

The redesigned bottling flow was reintroduced in WITNESS Horizon (Fig. 11) and properly parametrised as to achieve optimised results during the simulation [7].

A number of reports presented further below resulted from simulating and optimising the flow.

Cost, Revenue and Sustainability Reports

Revenues	Element			By Quantity	Total
	Parts			$3,000.00	$3,000.00
Total Revenue				$3,000.00	$3,000.00

Costs	Element	Fixed	By Use	By Quantity	Total
	Parts	$0.00		$4,920.00	$4,920.00
	Machines	$720.00	$0.00	$8,704.90	$9,424.90
	Labor	$360.00	$0.00		$360.00
Total Cost		$1,080.00	$0.00	$13,624.90	$14,704.90

Profits					
Profit Total					($11,704.90)

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Fig. 10. Costs report.

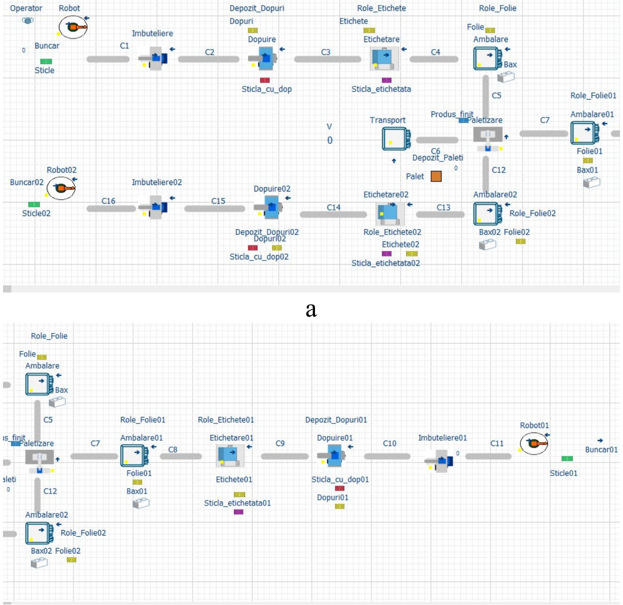
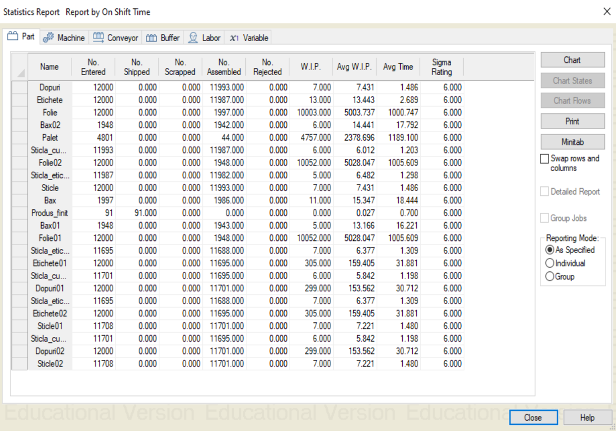
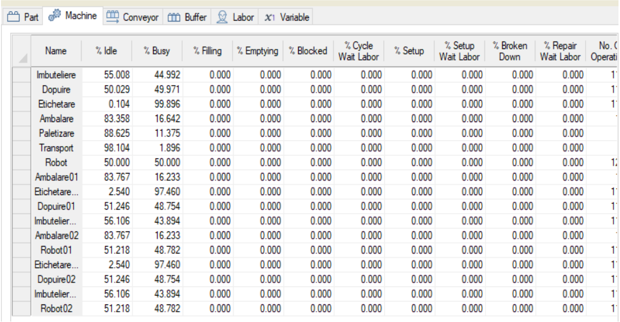


Fig. 11. Redesigned bottling flow: *a* – optimised flow-bottling; *b* – optimised flow-packing.


Statistics Report Report by On Shift Time

Name	No. Entered	No. Shipped	No. Scrapped	No. Assembled	No. Rejected	W.I.P.	Avg W.I.P.	Avg Time	Sigma Rating
Dopuri	12000	0.000	0.000	11993.000	0.000	7.000	7.431	1.486	6.000
Etichete	12000	0.000	0.000	11987.000	0.000	13.000	13.443	2.689	6.000
Folie	12000	0.000	0.000	1997.000	0.000	10003.000	5003.737	1000.747	6.000
Bax02	1948	0.000	0.000	1942.000	0.000	6.000	14.441	17.792	6.000
Palet	4801	0.000	0.000	44.000	0.000	4757.000	2378.696	1189.100	6.000
Sticla_cu...	11993	0.000	0.000	11987.000	0.000	6.000	6.012	1.203	6.000
Folie02	12000	0.000	0.000	1948.000	0.000	10052.000	5028.047	1005.609	6.000
Sticla_etic...	11987	0.000	0.000	11982.000	0.000	5.000	6.482	1.298	6.000
Sticle	12000	0.000	0.000	11993.000	0.000	7.000	7.431	1.486	6.000
Bax	1997	0.000	0.000	1986.000	0.000	11.000	15.347	18.444	6.000
Produs_finit	91	91.000	0.000	0.000	0.000	0.000	0.027	0.700	6.000
Bax01	1948	0.000	0.000	1943.000	0.000	5.000	13.166	16.221	6.000
Folie01	12000	0.000	0.000	1948.000	0.000	10052.000	5028.047	1005.609	6.000
Sticla_etic...	11695	0.000	0.000	11688.000	0.000	7.000	6.377	1.309	6.000
Etichete01	12000	0.000	0.000	11695.000	0.000	305.000	159.405	31.881	6.000
Sticla_cu...	11701	0.000	0.000	11695.000	0.000	6.000	5.842	1.198	6.000
Dopuri01	12000	0.000	0.000	11701.000	0.000	299.000	153.562	30.712	6.000
Sticla_etic...	11695	0.000	0.000	11688.000	0.000	7.000	6.377	1.309	6.000
Etichete02	12000	0.000	0.000	11695.000	0.000	305.000	159.405	31.881	6.000
Sticle01	11708	0.000	0.000	11701.000	0.000	7.000	7.221	1.480	6.000
Sticla_cu...	11701	0.000	0.000	11695.000	0.000	6.000	5.842	1.198	6.000
Dopuri02	12000	0.000	0.000	11701.000	0.000	299.000	153.562	30.712	6.000
Sticle02	11708	0.000	0.000	11701.000	0.000	7.000	7.221	1.480	6.000

Fig. 12. Product report.



Name	% Idle	% Busy	% Filling	% Emptying	% Blocked	% Cycle Wait Labor	% Setup	% Setup Wait Labor	% Broken Down	% Repair Wait Labor	No. Operati...
Imbuteliere	55.008	44.992	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Dopuire	50.029	49.971	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Etichetare	0.104	99.896	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Ambalare	83.358	16.642	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Paletizare	88.625	11.375	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Transport	98.104	1.896	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Robot	50.000	50.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Ambalare01	83.767	16.233	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Etichetare...	2.540	97.460	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Dopuire01	51.246	48.754	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Imbutelier...	56.106	43.894	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Ambalare02	83.767	16.233	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Robot01	51.218	48.782	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Etichetare...	2.540	97.460	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Dopuire02	51.246	48.754	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Imbutelier...	56.106	43.894	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
Robot02	51.218	48.782	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]

Fig. 13. Production systems report.

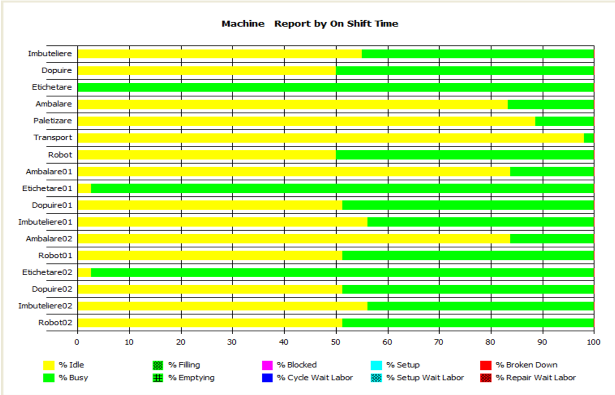
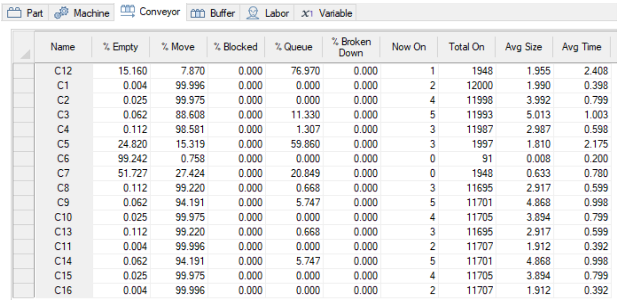


Fig. 14. Production systems chart.



Name	% Empty	% Move	% Blocked	% Queue	% Broken Down	Now On	Total On	Avg Size	Avg Time
C12	15.160	7.870	0.000	76.970	0.000	1	1948	1.955	2.408
C1	0.004	99.996	0.000	0.000	0.000	2	12000	1.990	0.398
C2	0.025	99.975	0.000	0.000	0.000	4	11998	3.992	0.799
C3	0.062	88.608	0.000	11.330	0.000	5	11993	5.013	1.003
C4	0.112	98.581	0.000	1.307	0.000	3	11987	2.987	0.598
C5	24.820	15.319	0.000	59.860	0.000	3	1997	1.810	2.175
C6	99.242	0.758	0.000	0.000	0.000	0	91	0.008	0.200
C7	51.727	27.424	0.000	20.849	0.000	0	1948	0.633	0.780
C8	0.112	99.220	0.000	0.668	0.000	3	11695	2.917	0.599
C9	0.062	94.191	0.000	5.747	0.000	5	11701	4.868	0.998
C10	0.025	99.975	0.000	0.000	0.000	4	11705	3.894	0.799
C13	0.112	99.220	0.000	0.668	0.000	3	11695	2.917	0.599
C11	0.004	99.996	0.000	0.000	0.000	2	11707	1.912	0.392
C14	0.062	94.191	0.000	5.747	0.000	5	11701	4.868	0.998
C15	0.025	99.975	0.000	0.000	0.000	4	11705	3.894	0.799
C16	0.004	99.996	0.000	0.000	0.000	2	11707	1.912	0.392

Fig. 15. Conveyor transport systems report.

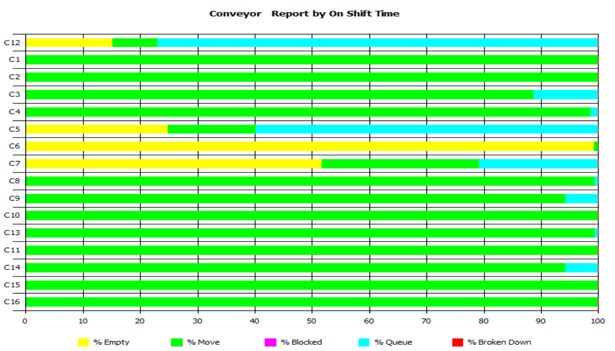


Fig. 16. Conveyor chart.

- *Product report*

After simulating the flow for 5 days (8 hours a day), following the report in Fig. 12, the result was 34944 bottles, 5824 cases, and 91 pallets (finished product) with 64 cases. Therefore, the production increased by 758.3% compared to the production presented in the initial flow.

- *Production systems report*

In the case of the production systems, after simulating the flow working for 5 days, the functioning time was optimised after proper redesigning and parametrising. This applies to the specific flow area for packing the bottles and palletising the cases, as shown in Figs. 13 and 14.

It is noticeable that, during the initial flow, the palletising system only worked at 1.5% of the total production time, as opposed to 11.37% after the optimisation.

- *Conveyor transport systems report*

Regarding the conveyor transport systems used in the bottling flow, the results obtained after simulating and parametrising the conveyors in compliance with the production systems are presented in Figs. 15 and 16.

- *Costs report*

The analysis of the bottling flow is even more important when considering the production costs.

After the optimisation, the results drastically changed. If the initial profit was 11,704.90$, after optimisation, the profit reached a value of 57,900.20%, resulting in an increase of 494.66% compared to the initial flow (Fig. 17).

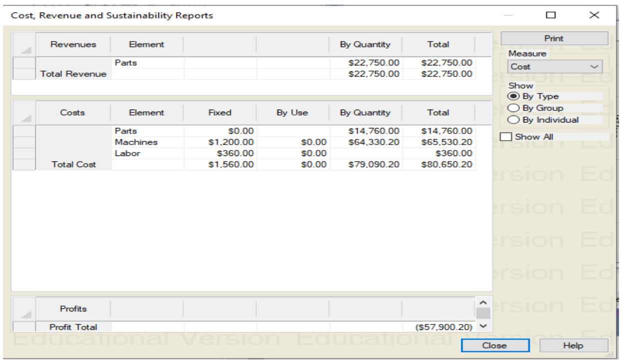


Fig. 17. Costs report.

4. SIMULATION USING THE KUHN ALGORITHM

Next up, a complementary simulation method for the intended flow was used, called the Kuhn mathematical algorithm.

Five bottling systems were compared for this stage, four of which already existed on the market and had similar characteristics and work times as presented in Table 1, respectively, the concept system offered by the authors. The data used for the concept system was taken from the reports generated following the simulation in Witness. The reports are explained in the earlier chapter for the 1.5-litre PET bottle.

Kuhn's algorithm uses the following property: the set of minimal solutions of an affect problem does not change if the same real number is added to all elements of a row or column of the cost matrix. Kuhn's algorithm is also based on the fact that a solution to the affected problem corresponds to a coupling of the bipartite graph and proceeds in several steps [9].

The following conventions are adopted for transposing the language of graph theory in matrix terms:

- A line or column is considered covered if, at a certain step, it is part of the set of marked nodes in the process of determining minimum support.
- An array element is considered circled if it is part of the coupling found up to that point.
- An element of the matrix is said to be cut if it corresponds to an edge that can be used to obtain a growth path, in a sense that will be clarified later.

Several stages will be completed respecting the previously presented conventions to validate the most efficient option for bottling, including bottling in 1.5-litre PET bottles using Kuhn's algorithm.

In this sense, the data related to the production time for the 5 bottling systems: MITSUBISHI ELECTRIC (ME), KRONES (KR), CONCEPT (CO), ACASI MACHINERY (AM), SMIGROUP (SM), in correspondence with the bottles PET of 0.5 litres; 1 litre; 1.5 litres; 2 litres and 2.5 litres was collected. Identification of the most efficient system for bottling liquid in PET containers is necessary in order to minimise the execution time of this activity.

The total time for the bottling process, stated in minutes, specific to each flow for making 10 cases of 6 bottles of every type, is represented in Table 1

Step 1. The lowest element is chosen from each line(the minor) that will t be extracted from the other elements (Table 2).

Step 2. The procedure is repeated, this time from each column, subtracting the lowest element from the other elements (Table 3).

Step 3. The rows and columns are scanned one by one. On the first row, there is only one element 0, and a vertical line is drawn on column 5; on the second row, there is only one element 0, and a vertical line is drawn on column 2; on the third row, there is only one element 0 and a vertical line drawn on column 3, on the fourth row there is only one element 0, but it was previously cut, and on the fifth row there are two zeros, and we leave it be. The same procedure is done for the columns (Table 4).

Table 1

Specific time for the bottling operation

Cases type / System	ME	KR	CO	AM	SM
Cases 0.5 l	60	69	55	70	50
Cases 1.0 l	64	55	75	70	60
Cases 1.5 l	56	50	48	60	56
Cases 2.0 l	68	48	50	60	50
Cases 2.5 l	50	69	55	60	60

Table 2

Stage 1

Cases type / System	ME	KR	CO	AM	SM
Cases 0.5 l	10	19	5	20	0
Cases 1.0 l	9	0	20	15	5
Cases 1.5 l	8	2	0	12	8
Cases 2.0 l	20	0	2	12	2
Cases 2.5 l	0	19	5	10	10

Table 3

Stage 2

Cases type / System	ME	KR	CO	AM	SM
Cases 05 l	10	19	5	10	0
Cas.es 1,0 l	9	0	20	5	2
Cases 1.5 l	8	2	0	2	5
Cases 2.0 l	20	0	2	2	2
Cases 2.5 l	0	19	5	0	4

Table 4

Stage 3

Cases type / System	ME	KR	CO	AM	SM
Cases 0.5 l	10	19	5	10	0
Cases 1.0 l	9	0	20	5	2
Cases 1.5 l	8	2	0	2	5
Cases 2.0 l	20	0	2	2	2
Cases 2.5 l	0	19	5	0	4

Step 4. We checked the requirement and noticed that the number of rows (5) and repartitions (4) were not fulfilled. We are looking to obtain the maximum coupling and move on to the next stage (Table 4).

STEP 5. We search for the minor of the uncut boxes. The element will be = 2.

STEP 6. The minor of the uncut boxes, which is two, is added to the double-cut elements; it is subtracted from the uncut elements, and elements cut with one line are left unchanged. The following matrix is obtained (Table 5).

Table 5

Stages 6 and 7

Cases type / System	ME	KR	CO	AM	SM
Cases 0.5 l	8	19	5	8	0
Cases 1.0 l	7	0	20	3	2
Cases 5 l	6	2	0	0	5
Cases 2.0 l	18	0	2	0	2
Cases 2.5 l	0	21	7	0	6

STEP 7. On the first line, there is only one 0 that we circle and then cut column 5. On the second line there is also only one 0 that we circle and then cut the second column. On line 3, there are two zeros, and we leave it be. On the fourth line, there is only one 0 left, the other being previously cut. On line 5, there is also only one 0 left, the other one being previously cut, and we cut the given column. The same procedure is done with the columns. The only column that has a 0 and is left uncut is the third one. The same procedure is followed. The 0 on that column is circled, and the third row is cut with a horizontal line.

STEP 8. The condition that the number of rows (5) and the number of repartitions (5) is checked, the requirement is fulfilled in this case. We got the maximum coupling [11].

The algorithm indicates that the most lucrative bottling system is the one suggested by the authors for the 1.5-litre bottles.

5. CONCLUSION

A water bottling process was simulated using the KUHN mathematical algorithm and the WITNESS Horizon software to maximise production efficiency.

Upon optimising the workflow by adjusting the working hours and adding two more bottling lines, the proposed objective of increasing profit was achieved. During the initial parameterisation, it was noted that the palletising system was operating at only 1.5% efficiency. After optimisation, this increased to 11.37% compared to the initial flow parameterisation.

After analysing the optimised system, it was observed that production increased by 758.3% compared to the initial flow variant. This resulted in 34944 PET bottles (compared to 4801 bottles in the initial simulation), 5824 boxes (compared to 794 boxes in the initial simulation), and 91 "finished product" pallets (compared to 12 pallets in the initial simulation).

The present study used a complementary method to confirm the results obtained for the proposed flow. Specifically, four bottling systems from different companies that create a complete flow were selected. Following the selection, the systems were simulated using the method proposed by the CONCEPT authors in WITNESS Horizon. Upon completing the specific stages of the Kuhn algorithm, the bottling system configuration proposed by the authors was further validated. It was confirmed that maximum efficiency is achieved when bottling in 1.5-litre PET bottles.

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