Zeeni Trading Agency: Toward's efficiency

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***Abstract*— Our Final Year Project focuses on improving the efficiency of the Zeeni's Trading Agency. This Lebanese company produces a variety of products ranging from personal care products to boats. It even produces its own machines for the production lines of these products. We decided to help the company improve the production and the overall business by exploring and studying many different aspects of its operations. Our focus will be on a new production line created to produce "AmbiPur" floor cleaners. When we watched how this line operates, we directly noticed a huge need for improvement and therefore set our first objective as to improve the production line efficiency of "AmbiPur" floor cleaners. In addition to that, the company manages three different warehouses, and stocks a lot of inventory, raw material, chemical products, packaging boxes, etc. To help them ensure an efficient, safe and cost-effective warehouse, we decided to work on optimizing the main warehouse which is the second floor for storing finished goods.**

Using a time study, we were able to document the standard method used, list and divide the processes into elements and get the standard time of the operation. In addition to that, we simulated the process using the Arena software in order to find a way to reduce the time wasted in the production line. Based on the results obtained, the updated model will replace two elements (capping and wiping) by one automated machine which will reduce the number of working days, workers needed and labor costs.

Concerning the warehouse optimization, the team is currently aiming to find the optimal layout that will minimize the objective function set and eventually reduce the cost and time of handling the products.

Keywords—time study, Arena simulation, warehouse optimization, efficiency, production line

I. INTRODUCTION

Industrialization has played an important role in improving the economic conditions of various countries [1]. In fact, it is well-known that countries with a strong industrial sector have shown the most economic growth, highest living standards and a good national income [1]. In Lebanon, the industrial sector contributes to only 8% of the country's gross domestic product (GDP) [2]. However, the Lebanese industrial sector is expected to grow and witness increasing investments with the current development of the oil and gas sector and the planned construction of various industrial zones [2].

With the hopes of developing and improving this sector, we decided to work with Zeenni's Trading Agency: a Lebanese manufacturing company that produces a large variety of products. Our goal is mainly to contribute to sustainable changes and increased profits for this business by improving its efficiency. We decided to cover many aspects of this company's operations: from our first visit we were able to identify a newly introduced production line, the "AmbiPur" production line as a line in need of much improvement. Most of it was manual, the standard time was long for such a simple process and we also witnessed a lot of irregular elements. We were also very enthusiastic to improve their main warehouse which is a focal point in their operations especially after noticing how disorganized and in need of improvement it is.

From there, we set out our main objectives:

- Improve the production line efficiency of "AmbiPur" floor cleaners in order to increase profits coming in from this line.
- Optimizing the main warehouse of this manufacturing facility and presenting a new and improved layout in order to minimize time wasting and provide ease of circulation.

II. BACKGROUND

After several visits to Zeeni's Trading Agency, and in order to be able to achieve an increase in efficiency, we decided to focus on two main aspects of the manufacturing facility, which are the production line efficiency of the AmbiPur floor detergent and the improvement of their main warehouse. Several studies have investigated the positive effects of applying time studies when working on production lines in manufacturing facilities. Time studies help increase the efficiency of production lines and have been used for all manufacturing and service sectors as a scientific approach. They aim at examining the way an activity is being carried out, simplifying or modifying the method of operation to reduce unnecessary or excess work and setting up a time standard for performing that activity [3].Moreover, time studies aim to eliminate unnecessary work and design the most effective methods and procedures while providing methods of measuring work to determine a performance index for an individual or group of workers, department or entire plant [4]. While working on the production line of AmbiPur, we recorded many cycles and were able to break down the job into elements in order to get to accurate times to be able to simulate the process using Arena. When it comes to the main warehouse of the facility, we noticed a lot of inefficiencies, jobs that threatened the safety of the workers, as well as idle times. Aiming to optimize worker productivity while not exceeding ergonomic thresholds by modeling a box conveying task in Jack, a simulation tool, and solving for the optimal design using a genetic algorithm [2]. For each solution that was generated by the genetic algorithm procedure, the main program redesigned the workplace and simulated the work process. The data was then were extracted from Jack and the objective function score was calculated resulting in design with 105% higher productivity [2]. This is something that we could try to mimic in our project in order to achieve some similar results. We are looking to find the combination that will minimize our distance objective function in order to see the best options of product placements in the warehouse to ensure working efficiently and minimizing unnecessary operations that waste time [5]. This has shown to be effective in ensuring ease of circulation in the targeted space.

III. METHODS

1. AmbiPur Production Line Efficiency Improvement

A. Time Study

As a first step, we conducted a time study on the AmbiPur production line in order divide the process into different elements. We used the data collected to simulate the process on the Arena Simulation software.
We first started off by documenting the process: we identified the number of workers, the material and equipment needed for the process. The process is clearly illustrated in the following flowchart.

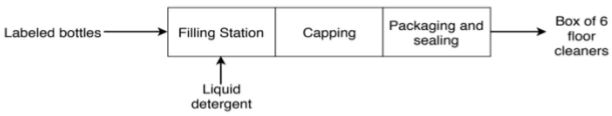

Fig. 1. Flowchart of the production line

Using the continuous timing method, we video-taped a number of cycles for the process. After analyzing the recordings, we decided to divide the process into seven regular elements and also identified two irregular elements. We were able to accurately record the times of each element by defining a starting and an ending breakpoint for each one. In order to identify the number of cycles needed, we conducted a pilot study. We used the 25 observations that we already had and computed the average and standard deviation of each element.

TABLE I TABLE REPRESENTING THE AVERAGE TIME, THE STANDARD DEVIATION, THE T VALUE AND THE NUMBER OF OBSERVATIONS NEEDED.

	1	**2**	**3**	**4**	**5**	**6**	**7**
Average	24.44	21.00	26.24	11.56	11.44	6.08	11.28
Std. Deviation	3.40	0.00	3.10	2.52	2.12	0.95	1.54
t	2.06	2.06	2.06	2.06	2.06	2.06	2.06
Number of observations	11.00	0.00	8.00	25.00	19.00	13.00	10.00

By using a confidence level of 95%, we found a t-value of 2.064. We started by computing the number of observations needed for each element using the formula:

$$n = \frac{tS}{k\bar{X}} * 2$$

The t corresponds to the t-value, S the standard deviation, $\bar{X}$ the mean of the elements and k the acceptable error fraction that we considered to be 5%. Since we were getting very large values as observation numbers, we decided to increase our k to 9% in order to get an achievable number.
For the multiple elements, we had to choose the highest value we got as our optimal number of observations. We concluded that we will use 25 cycles for each element.
We found out that the two processes that were taking up the most time and showing the highest variability were the "capping" and "placing bottles" processes.

Finally, we calculated the standard time for the process. We did this by first using the Westinghouse System Skill Rating, which is a method used to evaluate the performance of operators. It relies on four factors which are skill, effort, condition and consistency. The workers got rated D on both skills and effort, E on consistency and E on the conditions they are working in (total rating was 95%). After setting the frequency of occurrence of each element, we used the formula to get the element time (ET):

$$ET = ET_1 + \frac{f_2}{f_1}\,(ET_2) + \frac{f_3}{f_1}\,(ET_3) + \cdots + \frac{f_9}{f_1}\,(ET_9)$$

We then proceeded by multiplying the result for ET by the 95% rating to get a normal time of 11.606 seconds.
Last step was to assign an allowance using the International Labor Office Standards. The total allowance is 19: 5 for personal allowance, 4 for basic fatigue, 2 for the standing allowance, 2 for the awkward position, 5 for the atmospheric conditions, 2 for an intermittent loud noise and 1 for a medium monotony. We used the following formula to get the standard time (ST):

$$ST = Normal\ Time\ (1 + \frac{Allowance\ \%}{100})$$

We got a standard time of 135.04 seconds.

B. Simulation

We decided to simulate the same process with the use of the Arena Simulation software to see how we can tweak this model in order to improve efficiency and reduce the time wasted due to these two elements. Using Expert Fit and the data that we collected previously, we were able to fit the appropriate distributions for our different elements. We designed an initial model which will be running for 5 hours per day and operating for 20 working days per month.

Fig. 2. Arena simulation of the initial production line

This model will be producing 576 batches of bottles per day however waiting time during this process is approximately 0.5 hours, we are therefore wasting half an hour each day because of a certain delay.
After noticing a delay at the capping station, we came up with the idea of combining capping and wiping together. Capping and wiping will now consist of one machine that's basically a fully automated capping machine with wipers on the side; this machine will be produced in house and was estimated to cost around 6000$. This new machine will be able to process capping and wiping in around 12 seconds, a significant improvement from the combined average of approximately 37 seconds for capping and wiping. It would also require one less worker on the production line (the capping worker). Our new updated model will be replacing the capping and wiping element by one automated element and will be able to produce 735 batches per day for the same working hours in addition to a minimal negligible waiting time during the process.

2. Warehouse optimization

In order to improve the warehouse of the factory, we decided to focus on the ground floor where the finished products are stored. The products stored consist of the AmbiPur floor cleaners (available in two different sizes) as well as the Brylcream (available in 2 different colors and 3 different sizes). On the ground floor, these products either go in to be stored in the warehouse or are taken out of the warehouse for delivery. However, we noticed a lot of inefficiencies when it came to store and retrieve different products. Therefore, we decided to work on reducing products handling costs by designing a new layout, made out of departments, for the warehouse's ground floor. Each department will contain one product type. In order to do so, we started by formulating the problem as a Linear Programming model (LP). We set our objective function (z) as the cost per unit time for movement among the departments and for movement in and out of the warehouse and aim at minimizing it as much as possible. We formulated our LP as follows:

$$\min z = \sum_{i=1}^{m}\sum_{j=1}^{m} f_{ij}c_{ij}d_{ij}$$

m = number of departments
f_{ij} = flow from department i to department j (expressed in number of unit loads moved per unit time)
c_{ij} = cost of moving a unit load one distance unit from department i to department j.
d_{ij} = distance from department i to department j (Decision variable).

We set the following list of constraints that we should take into consideration when trying to find the new layout of the facility:

- The pick-up/drop off department cannot be moved
- $x_i + \frac{length\ (i)}{2} \leq 30.44$
- $y_i + \frac{width(i)}{2} \leq 28.57$
- $b_i + length_{(i)} \leq b_j$
- $c_i + width_{(i)} \leq c_j$

with (x_i, y_i) being the centroids of the rectangular department i and (b_i, c_i) being the left lower corner of the rectangular department i. The first two constraints ensure that no department lies outside of the warehouse, and the last four constraints are to make sure that we do not end up with overlapping departments.
We aim to find the layout that will give the smallest objective function and then evaluate its feasibility.

IV. RESULTS

After using 25 observations of each element of the process, we were able to compute the average time and standard deviation of each one and plot them (Figure 3). This led us to conclude that the "capping" process takes up the most time and has the highest variability. We were also able to calculate the standard time of the production line using a rating of 95% and an allowance of 21. By using Arena and merging the capping and wiping process, we were able to recalculate the new standard time of the production line (shown in Table I.). Our results showed that the new standard time is 31.46 seconds less than the initial one. So, the alternative of merging both processes is efficient since it reduces the time of the process and removes the standing allowance of the standing worker.

TABLE II NORMAL TIME, ALLOWANCE AND STANDARD TIME OF THE INITIAL AND IMPROVED PROCESSES

	Initial process	***Improved process***
Normal Time (seconds)	111.606	87.096
Allowance (%)	21	19
Standard Time (seconds)	135.040	103.600

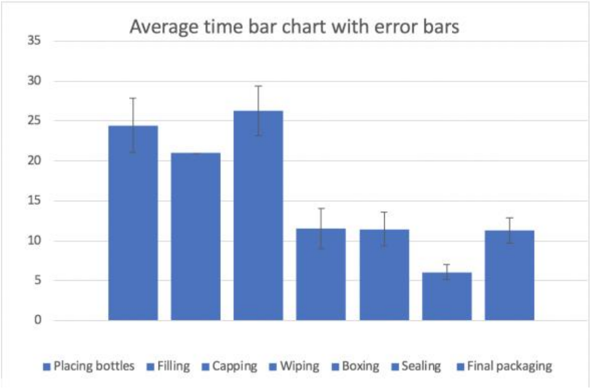

Fig. 3. Bar chart of the average times with standard deviation error bars

After combining the capping and wiping processes and simulating the new production line using Arena (shown in Figure 1), we were able to reduce their combined average from 37 to 12 seconds. In fact, the results in Table II. show that the company will be able to meet its yearly demand in fewer days and by using less workers as well as save on labor costs. Also, for an initial investment of 6 000$ (on the capping and wiping machine), the factory would be reaching break-even point in around 7 months and an increase in profits on labor savings alone for this production line will be valued at 94 800$ over 10 years.

TABLE III RESULTS OF THE MODEL BEFORE AND AFTER IMPROVEMENTS

	Before improvements	***After improvements***
Batches produced per year	138240	138240
Number of working days per year	240	188
Number of workers needed	5	4
Labor costs per year ($)	27000	16920

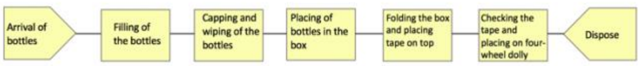

Fig. 4. Arena simulation of the production line after improvements

Concerning warehouse optimization, our aim is to analyze different options of layouts and choose the option that seems to be the most profitable and value adding over time. So, we expect the optimal layout to minimize the objective function that we set and reduce the cost of handling the products. Very few feasibility constraints are expected since the departments do not seem to be that different (there seems to be no serious consequences from any two departments being placed next to each other).

V. DISCUSSION AND CONCLUSION

In our warehouse optimization problem, the factory does have other products than the eight main products covered but were unwilling to provide us with this information due to confidentiality. We therefore worked only with the information that was provided to us.

The work in the warehouse of the factory can also be improved and made easier for the employees if an interactive system where they can check where each product is placed, and the nearest expiry date of each product, could be implemented. Such a system can prove very helpful to save time and be able to offload products with near expiry dates.

Our approach when trying to meet our objectives spanned several areas of industrial engineering, including facilities planning, lean manufacturing, simulation, as well as work measurements and methods' engineering. We also took many factors into consideration while working towards our goals, which lead to having economic, social and safety constraints when designing solutions.

For the production line covered during the previous semester, the implementation of our proposed machine would prove very profitable over time since it reduces the standard time by 30% and thus, saves the company time and money. They will be able to work for 52 less days per year and save around 100 000$ over 10 years on labor costs for this product only, meeting our objective of reducing cost and time. However, the company is reluctant to splurge on investments given the highly unstable financial situation.

Concerning our work on the ground floor of the facility's warehouse, we are still working towards finding the best possible layout to meet our objective function while taking into consideration the safety of the workers and other constraints that were previously mentioned.

Limitations for our project include disruptions such as the 2019's revolution leading to constant closure of roads and a hectic schedule during last semester. Moreover, we are also facing tough times in our present work due to the Coronavirus (COVID-19) that is affecting the whole world. The situation in Lebanon has led everyone to stay at home which in turn led to life to be put on hold for a while.

VI. REFERENCES

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