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Evaluation of Yogurt Production Line Simulation Using Arena Software

Kawthar A. Mohammed Hasan* **Ali H. Kadhum****
Ameer H. Morad***

**, **Department of Automated Manufacturing Engineering/ Al-Khwarizmi Engineering College/ University of Baghdad/ Iraq*
****Department of Information and Communication Engineering / Al-Khwarizmi Engineering College/ University of Baghdad/ Iraq*
*Email: kawthar.abd.alhameed@gmail.com
**Email: kadhumali59@yahoo.com
***Email: ameer_morad@yahoo.com

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Abstract

The main purpose of the paper is to identify the controllability of an existing production system; yogurt production line in Abu Ghraib Dairy Factory which has several machines of food processing and packing that has been studied. Through the starting of analysis, instability in production has been found in the factory. The analysis is built depending on experimental observation and data collection for different processing time of the machines, and statistical analysis has been conducted to model the production system. Arena Software is applied for simulating and analyzing the current state of the production system, and results are expanded to improve the system production and efficiency. Research method is applied to contribute in knowing and expecting the future running of the system to enhance the controllability of the system production and improve the production system and machine efficiency. Moreover, build an experimental model in Arena in order to simulate the system in term of production and process. First step is to collect the statistical data required for analysis in terms of input and output data for analysis. Second, is to track the production problem in term of process bottleneck in order to improve the utilization of the system. Third is to validate the model in order to overcome the product demand of the system uncontrollability. Through the result analysis of waiting time and production rate, it is clearly shown that system is stable with a need to resetting the capacity as a chance for the improvement, regarding to resources utilization. Re-planning resources capacity positively enhances the production and profitability of the system. The validation percent of the experimental results of output products and actual number of products is about 98%.

Keywords: *Arena simulation, evaluation of manufacturing system, Yogurt production line.*

1. Introduction

Simulation is a powerful tool to evaluate and improve of actual production line systems without disturbing its operation by builds a simulation model using computer. Running the model for long and short times experiments to tracks if there is any occurrence of problems or bottlenecks during running of the processes. Also simulation helps the managers to make proper decision for controllability of product line steps.

Arena is discrete event simulation and automation software expanded by Systems Modeling and obtained by Rockwell Automation in 2000. Arena simulation modeling software used to solve several types of problems such as layout problems, analysis of the production line, cycle time. improve the production efficiency.

production line balance, workers and machine performance.

Arena software can be used in modeling and simulation of flexible system for electrical machine assembly, M. Bruqi et al. [1] used Arena to model an electrical machine assembly and they include design, analytical and optimization tasks of complex production systems, computer architecture, and gain good results. W. R. Nyembaa and C. Mbohwab [2] attempted to develop an effective system for the materials flow of multi product furniture assembling factory through modelling and simulation, also provide the demand at an appropriate time and a minimal cost. R. Mathur et al. [3] studied the production of utensils and the impact of the location of the machines in a plant and employee's amenities on the efficiency of the production. also attempted to improve the factory layout through using Arena simulation. M. S. Eryilmaza et al. [4] studied shoe manufacturing that was analyzed and modeled in Arena and specific production policy was implemented and developed for the shoe making company. R. P. Nithin et al. [5] studied a manufacturing planning for a PVC sheets of cooling towers and aimed to raise the productivity, the simulation study was determined by Arena software and was designed using CAD package. Lopez et al. [6] conducted in the area of gynecological surgery a time study program, to indicate the current level of capacity and enhance the programming time so as to respond to demand immediately. The system was analyzed by waiting lines and used Arena simulation to estimate suggestions for enhancing and optimizing time of the surgeries. Neubauer and Stewart [7] aimed to improve service quality and decreasing the costs as they found it is difficult to make the transition from the simple model to modeling and simulating actual processes on the computer, suggestions were made to others who may want to utilize Arena software to bring the process modeling into the Public Affairs and Administration curriculum. R. Mathur et al. [8] obtained arrangement, order of the facilities and the efficient locations. The industry of utensils was a typical example of a work-flow shop that based production system. Also they pursued to explore and improve the current factory layout by making an attempt to imitate the current and the proposed factory layouts by using Arena software. Faisal et al. [9] aimed to understand the attitude of a system or estimating strategies for the operation of the system, Arena was used to comprehend the standing layout and the utilization of each station was optimized. Muralidaran and Sandeep [10] studied basically the analysis of an existent layout in a pump manufacturing industry. They analyzed the factory layout of manufacturing system, and an attempt has been made to mimic the existing layout of the industry by using the Arena software. Stopper and Stuja [11] presented in Arena a two different solutions for cycle time improvement based on a flexible manufacturing cell for treating cover parts. Marsudi and Shafeek [12] aimed to imitate the production process of a metal stamping industry and to estimate the utilization of the production line by using Arena simulation software.

This work focused on evaluating an improving in existing yogurt production line; Abu Ghraib Dairy Factory in Iraq which has several machines of food processing and packing. Arena Software is applied for simulating and analyzing the current state of the production system, and results are expanded to improve the system production and efficiency.

2. Simulation Methodology

2.1. Real-World System Production

The system production is a FILL SEAL 4L which is an automatic filling/thermo sealing machine (shown in Fig.1.) manufactured by means of the most modern construction methods and made of high quality materials such as stainless steel and anodized aluminum duly treated against the corrosion.

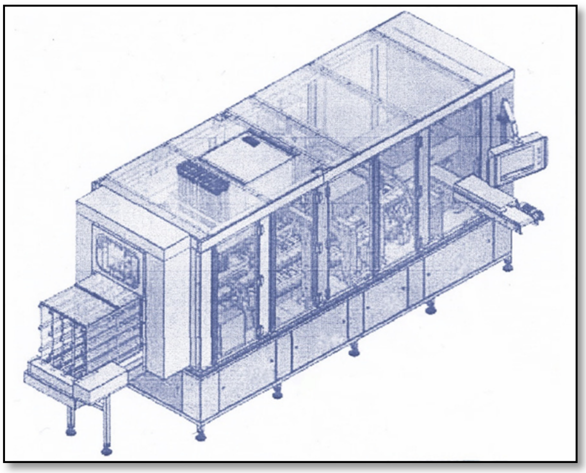

Fig. 1. FILL SEAL 4L Production machine.

The machine consists of the following:

1. Basement: The base represents the machine body and all parts are installed on it such

pneumatic and electric members. To access the base, it is necessary to remove the side covers by means of the endowed keys.
2. Cups Denester: The cup denester is the first operative station. Its function is to denest and to transfer the cups from the store into the cup holder. Two forks with double section. being driven by a pneumatic cylinder, make the separation of a container from the pile.
3. Dosing Station: After being destacked, the cups are filled by means of a volumetric doser endowed with a dosing regulator. On the doser there is a hopper for containing the product. The doser is entirely made of AISI 316 stainless steel and it is formed of a cylinder inside which there is a special sucking-pumping piston and of pneumatic dispenser which keep in sucking phase the product is brought from the hopper to the suction chamber.
4. Sealing Station: The sealing station performs the most important task of the packaging cycle. In fact, the sealing efficiency depends on the correct working of this station (on the quality of the employed materials and on the compatibility of the cup with the thermo sealing lid too) and vouches on a good preservation of product. The sealing station thermo seals the lids on the containers.
5. Ejection Station: It is the last station of the normal packaging cycle and makes the ejection of container from the machine. This station is usually formed by 3 main parts: the elevator, the pusher, and the carrying ejection conveyor with continuous operation.
6. Control Panel: The control panel is the interface that allows the operator to set the parameters of the machine and check for proper operation. the control panel consist of start button, stop button, emergency button, reset button and touch screen panel.

2.2. Real-World System Modelling

The time has been calculated manually of each process (in seconds) 30 times. After calculating the data, the real-world process is simulated and modeled in Arena software. Figure (2) represent the model for all the processes in Arena.

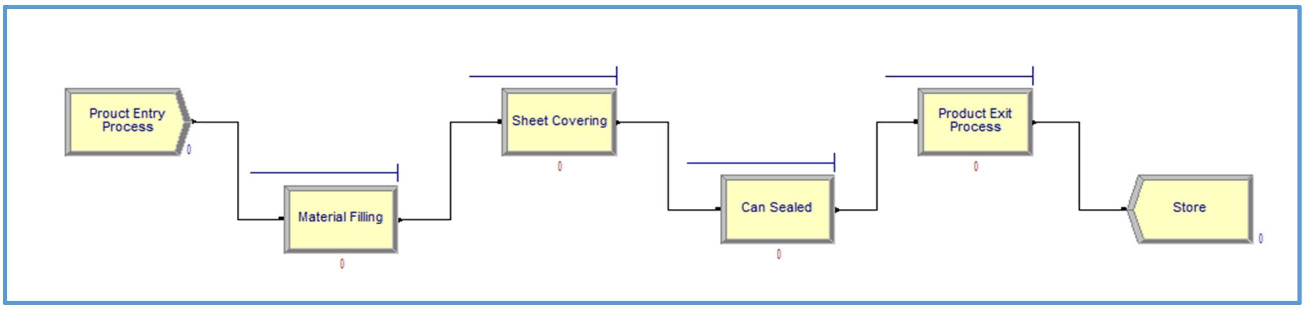

Fig. 2. Arena model of the processes.

The Arena model in this work consists of the following processes:
1. Product Entry Process.
2. Material Filling
3. Sheet Covering
4. Can Sealing
5. Product Exit Process

By using input analyzer in Arena, the distribution diagram is obtained for each process. Figure (3), (4), (5), (6), and (7) show the distribution diagram for product entry process, material filling, sheet covering, can sealing, and product exit process respectively. and data analysis for this process.

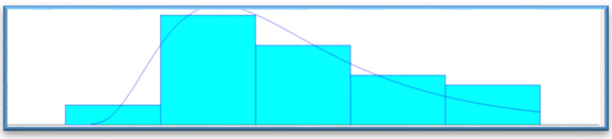

Fig. 3. Distribution diagram for product entry process.

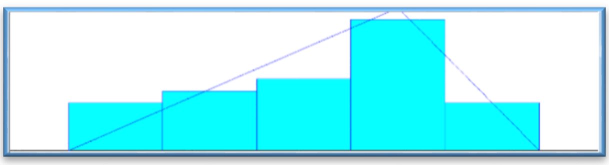

Fig. 4. Distribution diagram for material filling process.

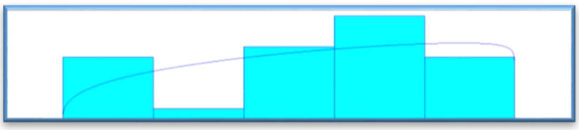

Fig. 5. Distribution diagram for sheet covering process.

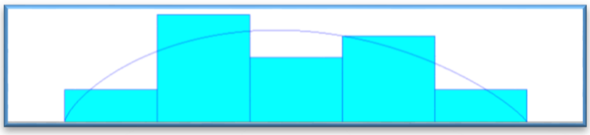

Fig. 6. Distribution diagram for can sealing process.

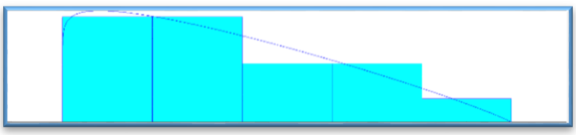

Fig. 7. Distribution diagram for product exit process.

3. Results and Discussion

3.1. Input Results Analysis

The production line model has been modified to mimics the actual system based on production rate. Table (1) illustrates designed plan of the system to run the production, the data that used to compare with the simulation model outcomes and analyzing improvement chances.

Table 1,
Designed plan of the system.

#	Characteristic	Value
1	Number of Processes	5
2	Number of Buffers	4
3	Number of shifts	1
4	Designed Production	5118 Products
5	Production Rate	4.22 sec.
6	Run per Shift	6 hr.
7	Run Length	21600 sec.

The input results for each process and for the buffering can be discussed as the following:

1. Processes Inputs

System processing time is a leading factor for characterizing the performance in terms of production rate and demand responsiveness. Figures (8), (9), (10), (11), and (13) show input data for the simulation model for system processes entering, filling, covering, sealing, and exiting respectively. Presented data is the experimental sample size collections for each process that planned to be 30 observations for each experiment. Collection analysis shows an expected homogeneity that can be observed depending statistical variability of the system (Mean, Standard deviation.) as following: (Entering: 4.72, 0.284), (Filling: 3.036, 0.152), (Covering: 3.42, 0.359), (Sealing: 2.60, 0.162), and (Exiting: 3.319, 0.224), all values are measured in seconds.

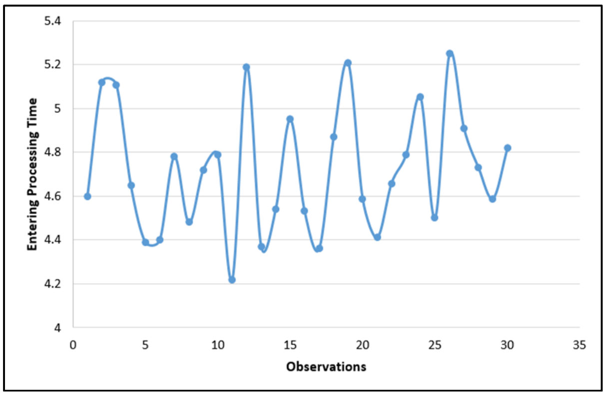

Fig. 8. Observation data for entering process.

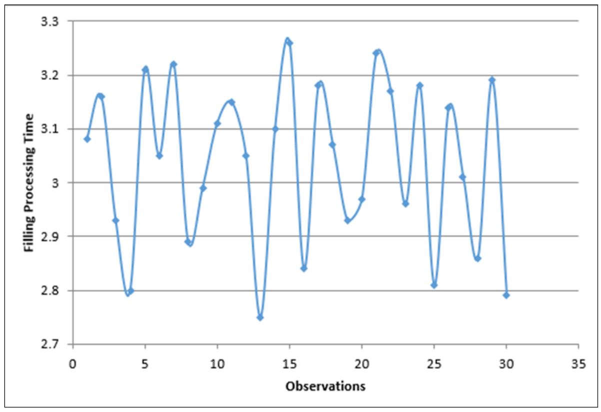

Fig. 9. Observation data for filling process.

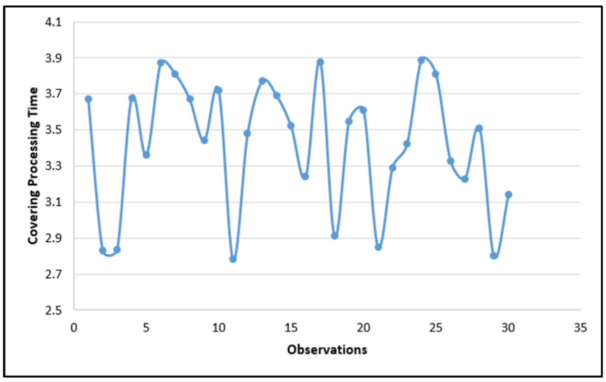

Fig. 10. Observation data for covering process.

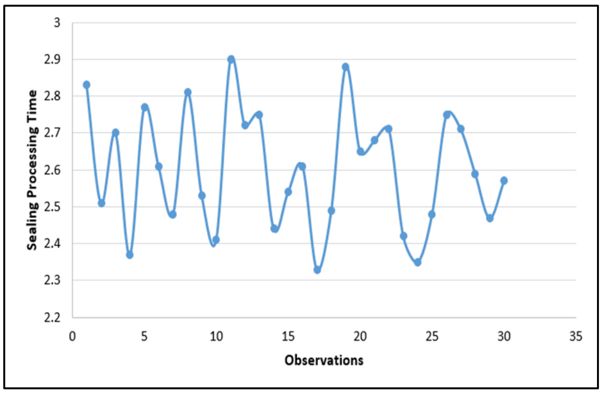

Fig. 11. Observation data for sealing process.

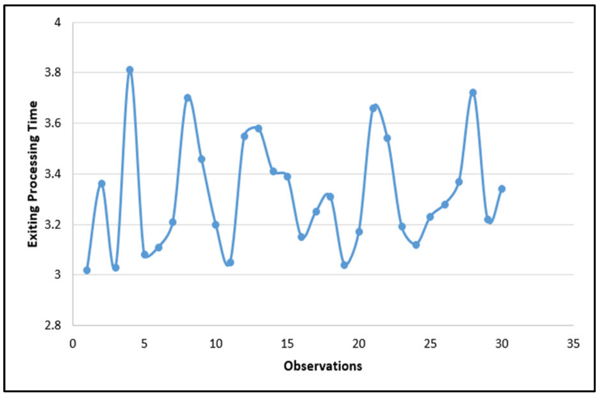

Fig. 12. Observation data for exiting process.

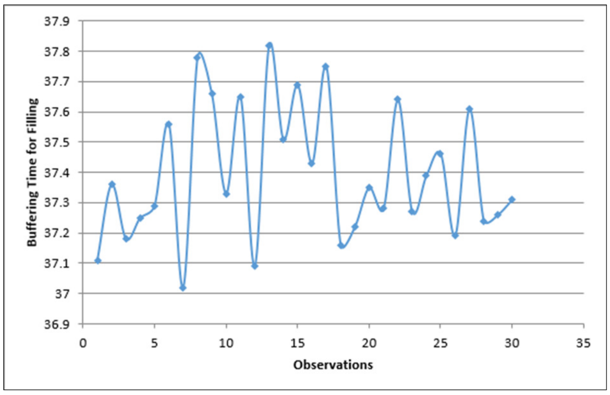

Fig. 13. Input data for buffering time of filling process.

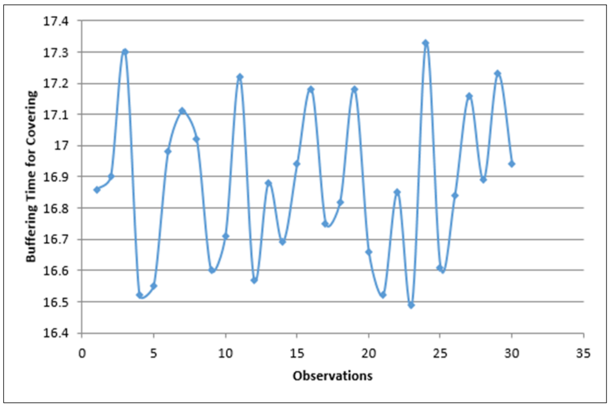

Fig. 14. Input data for buffering time of covering process.

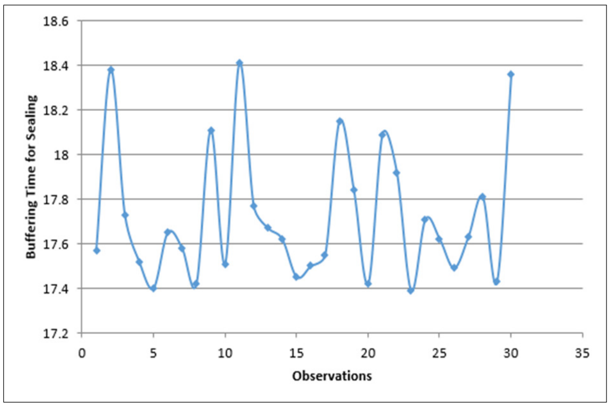

Fig. 15. Input data for buffering time of sealing process.

2. Process Buffering Inputs

An automated system is required a standard size of buffering which makes storage capacity for each process is constant and basically controlled for future improvement. Collected data analysis for the system shows an expected stability can be analyzed for ignoring the buffering variability of the system (Max., Min.) as following: (For Filling: 37.82, 37.02), (For Covering: 17.33, 16.49), (For Sealing: 18.41, 17.39), and (For Exiting: 16.91, 15.69), all values are measured in seconds. In the real-world, the system has been designed for a constant capacity of product, and the observed variability is technically can be caused by the voltage fluctuations of conveyors motor. Figures (13), (14), (15), and (16) show input data description for modeling the system conveyors and buffers.

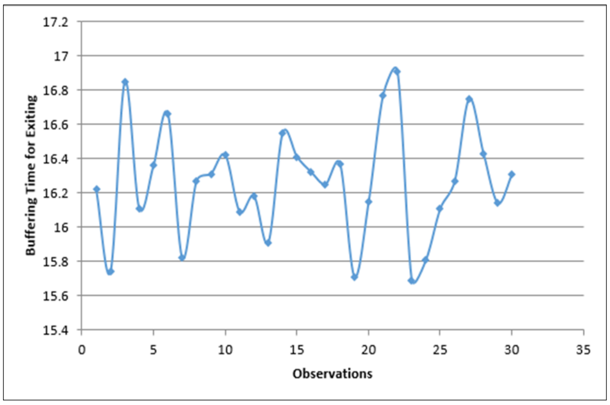

Fig. 16. Input data for buffering time of exiting process.

3.2. Outcome Results Analysis

The model of yogurt production has been running many times to get a set of experimental date for the purpose of results validity and dependability. Results analysis verifies a strong validity for improvement chances and future planning of the system. Table (2) illustrates the characteristic results of the performance and improvements that are traveling time of products in buffering for each process (waiting time), number of seized products at each buffer (waiting number), and the used capacity of system resources in producing parts (utilization). Moreover, other characters are resulted such as number of planned part (Number In), number of produced parts (Number Out), and system leading time (Total Production Time) for the analysis.

Table 2,
Characteristic results analysis.

	Filling Process	Covering Process	Sealing Process	Exiting Process	
Waiting Time	0.0	0.0	0.0	0.0	
Waiting Number	0.0	0.0	0.0	1.0	
Utilization	0.6557	0.7215	0.5500	0.7000	
Number In	4,566	Number Out	4,563	Total Time	12.5

Results analysis of the waiting time and number as zeros approves the non-need to model the buffering for each process as automated system. The production rate is closely similar to the designed production that stated in previous table (2), observed difference in the production as is related for the current running situation of the local zone due to the instability of the commitment to the business time/days. Regarding to resources utilization, it is clearly shown that system is stable with a need to resetting the capacity as a chance for the improvement. Re-planning resources capacity positively enhances the production and profitability of the system. Figure (17) visualizes utilizations distribution for each process and difference that can be used in the re-planning for improving the system.

In the research, the evolution process of the real system is done through analysis of the capacity of output products and the result shows that the system is stable with demand.

There are many difficulties arise through implementation of the research such as lack of local factories, even that the Abu Ghraib Dairy Factory is not work for full time.

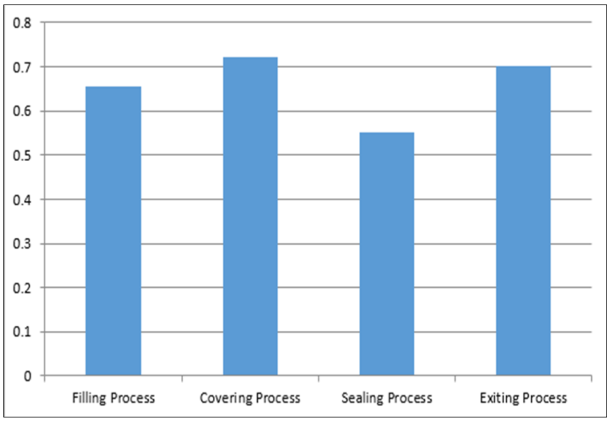

Fig. 17. Utilizations distribution for the processes.

In general, below % 80 of the resources utilization is completely secured the system running for a long production term as well as proving a reasonable chance for increase the demand responsiveness of the system that makes the improvements are possible. % 0.7215 is observed at the covering process that criticizes the improvements but on the other hand makes the system planner is able to analyze the capability limits of the system for future investments.

4. Conclusion

According to the results, a simulation method help researcher to build a software model which is mimics the real system. Conducting experiments on the model allows the researchers to analyze the real system and predicates future behaviors. Arena is one of simple and professional simulation software which is used to simulate the yogurt production line. The validation of the experimental results of output products and actual number of products is closed to 98%.

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تقويم خط انتاج البان باستخدام برنامج المحاكاة أرينا

كوثر عبد الحميد محمد حسن* علي حسين كاظم أمير حسين مراد*****

**، ** قسم هندسة التصنيع المؤتمت/ كلية الهندسة الخوارزمي/ جامعة بغداد/ العراق*

**** قسم هندسة المعلومات والاتصالات/ كلية الهندسة الخوارزمي/ جامعة بغداد/ العراق*

*البريد الالكتروني: kawthar.abd.alhameed@gmail.com

**البريد الالكتروني: kadhumali59@yahoo.com

***البريد الالكتروني: ameer_morad@yahoo.com

الخلاصة

الغرض الرئيس من البحث هو تحديد قابلية التحكم في نظام انتاجي حالي؛ خط إنتاج الزبادي في مصنع أبو غريب للألبان والذي يحتوي على العديد من آلات تصنيع وتغليف المواد الغذائية التي تمت دراستها. من خلال بدء التحليل، تم العثور على عدم استقرارية في الإنتاج في المصنع كما تم تصميم التحليل بناءً على الملاحظة التجريبية وجمع البيانات لمدة زمنية مختلفة من معالجة الماكينات، وقد تم إجراء التحليل الإحصائي لنمذجة نظام الإنتاج. يتم تطبيق برنامج أرينا Arena لمحاكاة الحالة الراهنة لنظام الإنتاج وتحليلها، ويتم تفصيل النتائج لتحسين إنتاج النظام وكفاءته. تم تطبيق طريقة البحث للمساهمة في معرفة وتوقع التشغيل المستقبلي للنظام لتعزيز قابلية التحكم في إنتاج النظام وتحسين نظام الإنتاج وكفاءة الماكينة. فضلا عن ذلك، يتم بناء نموذج حقيقي للتجربة في برنامج أرينا Arena من أجل التحكم في النظام من حيث الإنتاج والعملية. الخطوة الأولى هي جمع البيانات الإحصائية المطلوبة للتحليل من حيث بيانات المدخلات والمخرجات للتحليل. الخطوة الثانية، هي تتبع مشكلة الإنتاج وعوائق العملية التي تحدث من أجل تحسين الإفادة من النظام. الخطوة الثالثة هو التحقق من صحة النموذج من أجل التغلب على الطلب على المنتج عند عدم إمكانية التحكم في النظام. من خلال تحليل نتائج وقت الانتظار ومعدل الإنتاج، يتضح بوضوح أن النظام مستقر مع الحاجة إلى إعادة تعيين القدرة بوصفها فرصةً للتحسين، فيما يتعلق باستخدام الموارد إن إعادة تخطيط قدرة الموارد تعزز بشكل إيجابي إنتاج النظام وربحيته. تبلغ نسبة التحقق من صحة النتائج التجريبية للمنتجات المخرجات والعدد الفعلي للمنتجات حوالي ٩٨٪.