

**DEVELOPMENT AND ANALYSIS OF A SOAP BATCH PROCESS
USING ARENA SIMULATION TOOL**

By

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DISSERTATION

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



Melissa Loo Ragai

ABSTRACT

The objective of this project is to design and build a model of a batch process and model and simulate, and conduct a performance analysis using ARENA simulation tool. The scope of this project is to focus on a soap batch process that produces products of different flavours. It will involve mixing of different kinds of composition of chemicals to produce different flavour of liquid soaps. Its aim is so that through the analysis, efficiency of the plant would be conducted; process time and also the queue time from one batch to another. Thus, not only will it be reliable, but its availability and efficiency may increase. This report focuses on these sections: Background Study, Problem Statement, Objectives and Scope, Literature Review, Methodology and results and discussion. The procedures taken include data gathering, model building, simulation and analysis. To improve the understanding of the ARENA simulation tool, further research needs to be done to familiarize with the use of the software. Besides that, studies on the principles and theories on how to simulate a model are crucial to achieve a working simulation. Once the analysis has been done, the results will be analyzed in a report form.

ACKNOWLEDGEMENT

Firstly, I would like to firstly thank God Almighty that through Him all things were made possible for this project. Next, I would like to express my heartfelt gratitude to my late supervisor Dr. Muhammad Asif Sadiq and Dr. Nordin Saad who took the responsibility to continue to guide and assist me. Their continuous support and guidance throughout this whole project was much appreciated. Their ideas and general approach with respect to this project were very useful and encouraging despite other commitments and packed schedules. Lastly, I would also like to express my gratitude and special thanks to my family members and close friends who have continuously given me encouragement and the moral support to never give up till the very end.

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LIST OF ABBREVIATIONS

| | |
|-----------------|--|
| USA | United States of America |
| Arena PE | Arena Professional Edition |
| BASIP | Batch Simulation Package software package |
| MES | Manufacturing Execution Software |
| VBA | Visual Basic |

CHAPTER 1

INTRODUCTION

1.1 Background Study

In USA and European countries, simulation has helped decision makers to make the best decisions in their company although many still do depend on their experiences and intuition. The advantage of a simulator is that they are able to provide users with the practical feedback while simulating an option. Designers and engineers have the ease of comparing the alternative designs without actually building the systems. Through this, a thorough study can be made.

Another advantage of a simulation is the level of detail that can be obtained from it. Simulation is particularly advantageous when the complexity or operational variability of the systems under study renders the application of purely analytical models impossible [1, 2].

Simulation enables designers to study a problem of the simulated environment in a several levels of abstraction. By approaching a system in this manner, designers are able to understand the behaviors and interactions of the high level abstraction. Thus, it equips them to counteract with the complexity of the overall system and may then be able to verify and perform evaluation on the lower level components [3]. The system may be built on the “top-down” technique.

1.2 Problem Statement

Arising competitions and also globalization market economics have caused many companies to be advance in terms of their company's efficiency, production and also the technology. There has always been a pressure of producing products which are good in quality, yet less in production cost. Adding with the recent increase of the fuel price globally, the value of products and cost of living has increased dramatically. Thus, this adds on more pressures and also challenges for companies to overcome. It is not only time consuming but also costly to explore the various ideas and projects for the best solution. Simulation has been the next best option to identify the means to improve the companies' need.

1.3 Objectives

The objectives of the project are:

- To design and build a model of a batch process
- To model and simulate, and conduct a performance analysis

1.4 Scope of Study

The scope of this project is to focus on a formation of soap batch process. It will involve mixing of different kinds of composition of chemicals to produce different flavours or scented liquid soaps. Its aim is so that through the analysis, efficiency of the plant would be conducted; process time and units produced per day. Thus, not only will it be reliable, but its availability and efficiency may increase. This feasibility of this project is that it can be done within the period of 1 year (2 semesters) as long as the data gathered and information is sufficient.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are many kinds of Simulation tools available for example Arena, AutoMod, ProModel and Simul8. Research has covered other Companies using Arena and applying it in their own research and project. The purpose of this research is to see how wide companies have used the application of Arena which has so much to offer on different kinds of systems and also the different kinds of editions for Arena itself.

2.2 Simulation Language for Manufacturing System

A case study has been done by Silva, Ramos and Vilarinho [4] about using Arena simulation for manufacturing of chest freezers reengineering. The study was required to increase its throughput and overall productivity to determine its limitations and problems. The relevant performance measures allowed them to identify a set of operational constraints to the manufacturing system performance. First of all, the authors studied the process of manufacturing the chest freezers and the area of the manufacturing site. It was found that between the pre-drying and the post-drying department, the post-drying area was underused and changes were needed. One could easily use an analytical technique for balancing the assembly line in the post-drying department, but the operational variability induced to the manufacturing system, as a whole, by the operations performed in the pre-drying

department, renders the optimization of the manufacturing system performance impossible to achieve by analytical techniques [4].

Authors were able to collect large amounts of historical data related to the processing times involved in the manufacturing process. This allowed fittings of proper distributions of data. Thus, the distributions and its parameters were selected using the Arena's software module Input Analyzer [5]. After simulation was done and the results were obtained, the authors were able to suggest modifications. With the changes done, manufacturing system operation would be smoother and the workloads in both departments are evenly distributed.

Another research was found, presented by John Moore with the title, Production Line Simulation- A valuable tool for Process Improvement [6]. Roeslein & Associates, Incorporation wanted to design engineering solutions for their Metal Container Manufacturing, Beer & Beverage Filling and Food Packaging. Their aim was to control the quality of their products and also its consistency. The company's goal was to profit ideally by knowing the outcome before someone else does and realistically have proper investments of time and money.

The author explains that in the production improvement cycle, there are 4 main stages. The cycle is as shown below:

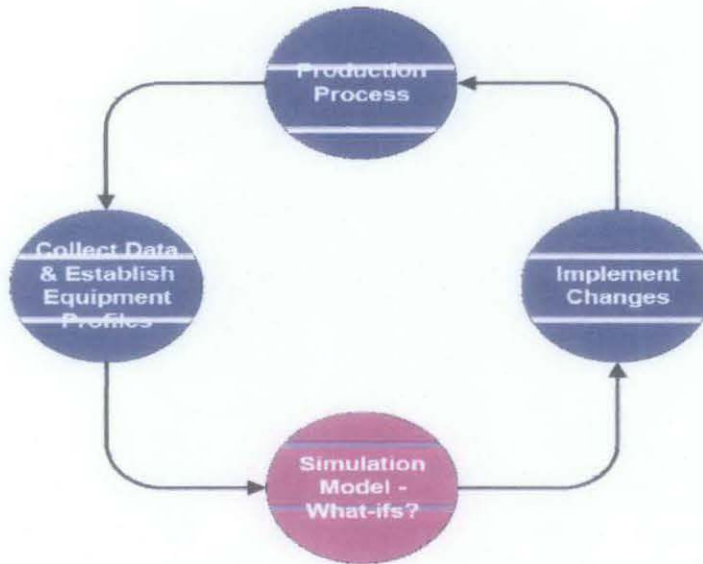


Figure 1: Production Improvement Cycle, [6]

Exact data's of the real environment were needed to simulate the model. The typical data that were collected were the up time (%), down time (%), rated speed, mechanical observations, data analysis and more. The analysis' scope was to develop What-If models and also validate the base case against the production with additional line observation. The What-If scenarios were developed for the layout constraints of the process, bottleneck issues, unbalanced line controls, improper procedures and for customer requests for a revised layout.

Rockwell Arena Modeling Software, Packaging Edition was used and it uses Simon language-based application to model process flow systems. Both discrete events and continuous process were involved and the simulation lasted for 1 to 2 days which was equal to 30 days of production in reality. The author quotes that long-term analysis can identify subtle but large causes of efficiency [6]. Indeed Moore agrees that line simulation identifies the current and maximum throughput potential, equipment layout advantages and constraints, line control constrains, and

also the equipment's capabilities. Simulation reduces risk and cost and it is a low cost way to predict measurable changes to the process line [6].

2.3 Modeling using ARENA

There are many kinds of editions for Arena suite of products for the purpose of modeling, simulation, and optimization highlighting product architecture and technology features. For this project, I would be using the Arena Professional Edition. From the article about the Arena product family written by Bapat, [7] it writes that Arena Professional Edition enhances Arena Standard Edition (Arena SE) with the capability to craft custom simulation objects that mirror components of the real system. The Arena template has a whole collection of modules that provides general features for modeling all types of applications like resources, queuing, process logic and system data. It is proven that Arena effectively models combined discrete/continuous system, for example chemical production through its built-in continuous modeling capabilities. Its SIMAN simulation language provides a powerful foundation for modeling complex systems and a fast simulation engine for efficient analysis of design alternatives. Simulation models have the flexibility to be created from "top-down" adding detail at a lower level of hierarchy as a project progresses or bottom up by combining individual submodels into a complete system model.

Control logic and MES software implementations in the Arena allows the user to slow down the simulation model to run in a real time to provide human timescale system responses. Thus, it makes it possible to test a wide variety of scenarios that would otherwise take an excessively long time to accomplish when working with the real system [7]. Thus, it is proven that Rockwell Software customers uses Arena PE do exploit simulation more effectively because they can build complete, self-contained templates and deliver it to others in the enterprise. Model construction can be made to match closely elements of the real system not

only terminologically but also in the important aspects of model logic, collection of performance measures, and animation. Indeed Rockwell Software has continually risen up and lead in providing cutting-edge tools to address the changing environment in a simulation use.

2.4 Simulation Language for Processes with continuous and discrete systems

According to the report by Marcelo, Luiz and Daniel [8], it is proven that Arena is able to simulate processes which combine continuous and discrete simulation components. They have built a simulation model of the logistics of the San Lorenzo refinery of PETROBRAS ENERGIA (Argentina) using refinery templates in Arena. Templates allows user to pack an important amount of logic, animation and data in a single object which is transparent to the user [8]. Using refinery template allows an organization to successfully model very complex refinery process and logistics. Also, the model is user friendly where people with just a basic training in simulation can use and modify the process definition, operation logic and test different plant configurations. Thus reduce the time needed to build a model.

Arena can also simulate for high-speed combined continuous and discrete food industry manufacturing processes. In the report by A.M. Huda and C.A Chung [9], the transformation of a product from a fluid state into distinct packages requires systems that are modeled both continuously and discretely with respect to time. Certain systems which are more complex requires continuous event or combined discrete and continuous event simulation to develop valid models [9]. Indeed food processing industry is unique where the system must first be modeled with a continuous event approach and then later with a discrete event approach. For a combine system, the continuous variable must be carefully designed to maintain a balance between continuous and discrete part because the continuous variable is monitored as it passes a threshold value which in may trigger a discrete change.

The state of a system changes with time for a continuous model. This change is represented by a state equation which is affected by the changing of the derivative of the state system. We need to be aware that the integration process to solve the differential equations in the continuous component can present problems when the time advance involved is not carefully specified. It should not be too large as it may result in a negative state variable value. Another issue arises is how combined models (continuous and discrete) affects one another. Pritsker states that this can occur in three ways [10]. First way is that a continuous state variable achieving a threshold value may cause a discrete event to occur. Then, a discrete event can affect the value of a continuous state variable. Next, the relationship governing a continuous state variable can be changed at a particular time due to the discrete event [9].

During simulation especially for a combined system, the selection of experimental factors is vital. It becomes more complicated because the analyst has a choice to select continuous related factors, discrete related factors or both types. The authors concluded that modelers for a combined system should expect to encounter unique data collection- continuous to continuous component, continuous to discrete component, discrete to continuous component, and factor selection modeling and analysis issues [9].

2.5 Simulation Language for Batch Process

According to the report by M. Fritz, A. Liefeldt and S. Engell with the title “Recipe-driven batch process: Event handling in Hybrid System Simulation”, recipe-driven chemical processes can be simulated both in the continuous and in the discrete-event domain with its own specific advantages and limitations. The report was based on the simulation done by Batch Simulation Package software package (BASIP). Discrete batches of material are transformed in a series of steps of finite duration which is also known as a batch mode. A recipe is usually defined

by a sequential function chart that consists of steps and transitions with concurrency [11].

2.6 Ways to produce Soap

There are 2 types of ways to produce soap. The first system starts from raw materials which involve oil or tallow and soda. The whole process may include the saponification plant, the dryer vacuum plant and also the soap finishing line. The other system would be the finishing lines starting from soap noodles (pellets). Soap finishing is the transformation of soap noodles into formulated stamped soap bars [12]. The process of soap finishing includes pre-refining, mixing, refining and extrusion, stamping and packaging. In this project, it will be similar to the second system of producing soap.

CHAPTER 3

METHODOLOGY

3.1 Schematic flow process of the project:

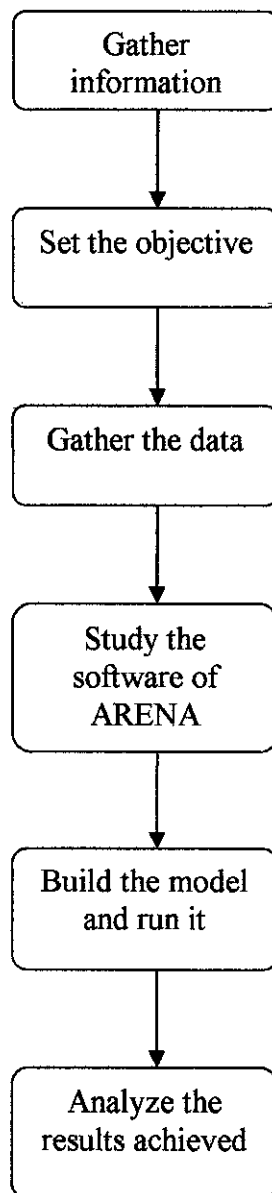


Figure 2: Flow process of project

First of all, more information about the Rockwell Arena Simulation Tool is needed to start of the project. Besides that, understanding the general principles of running a simulation are required to be aware of the functions and also the different kinds of simulation environments (for example: discrete-event simulation). Then, determine the objective of the project.

Then, datas are gathered to learn how to simulate batch processes using ARENA software. When the data has been collected, it is important to understand the process flow of the simulation. With the basic knowledge of the simulation software, it would be easier to apply and build the model. Exact settings and data's are needed to obtain the results which are reasonable with the real model. After running the simulation, the results should be analyzed to better understand the behavior and problems occurred. Thus, suggestions could be made.

3.2 Main flow process of the simulation

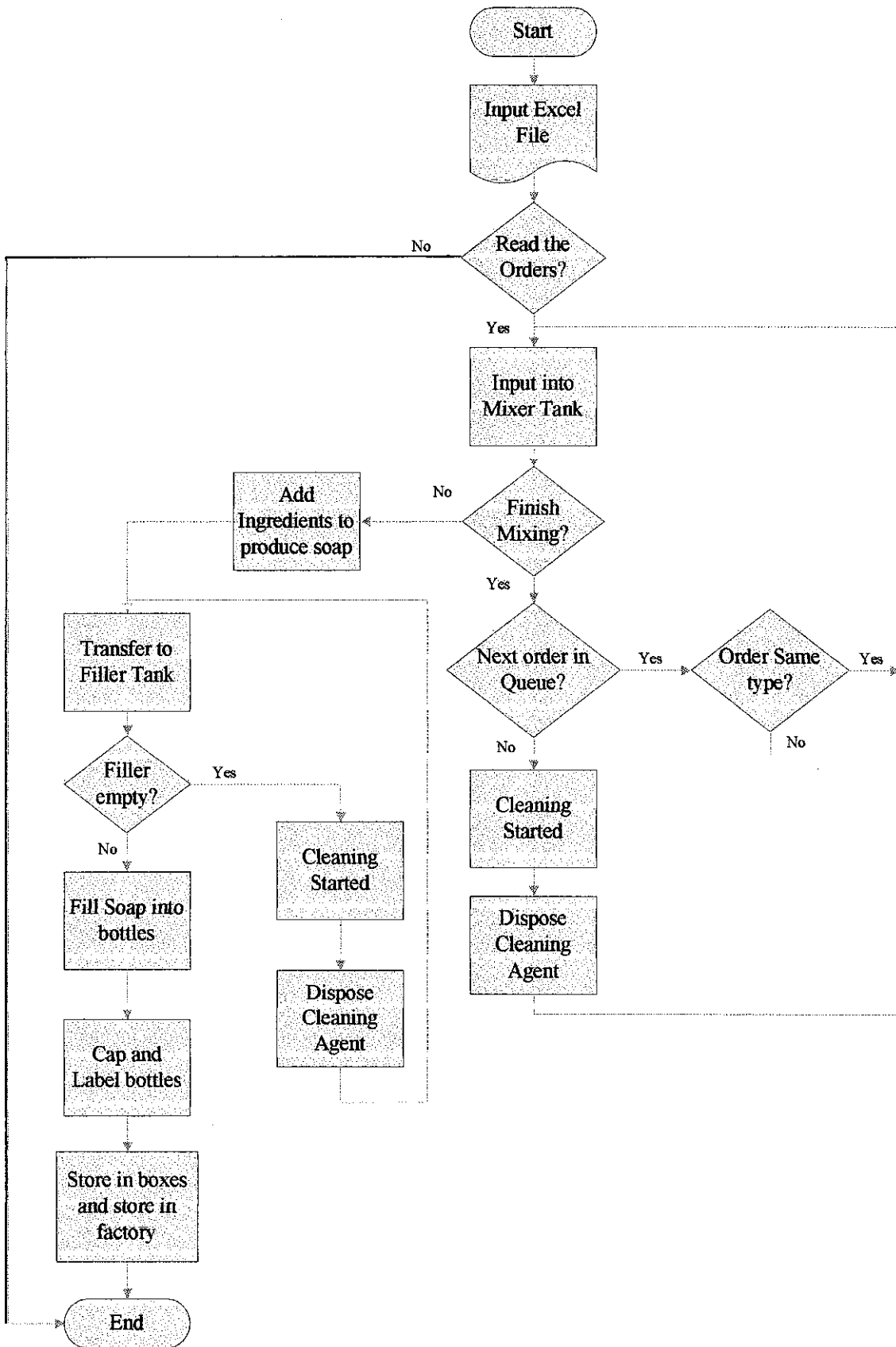


Figure 3: Main flow of the simulation

When the button “Run” is pressed, then the simulation will start. It will read the excel file which contains the order of the soap from the customers. The details will be discussed further in the result section of this report. Then the products to prepare the soap will enter the mixer tank. When the mixing is done, it will be sent to the filler tank to be filled up into bottles, capped, labeled and then stored in boxes and to the factory.

Whenever the filler tank is empty, it will start cleaning the tank using the cleaning agent. Other than that, when the mixing has been completed and the next order (flavour) in queue is not the same flavour as the previous one, it will clean the tank. This is to avoid any contamination of different flavours.

3.3 Basic skills of ARENA software building and simulation model

There are a few simulation concepts in the Arena that we need to understand first. *Modules* are the flowchart and data objects that define the process to be simulated. All information required to simulate a process is stored in modules. *Entities* represent the objects moving through the system. Each entity has its own characteristics, referred to as *attributes*. The purpose of a *queue* is to provide a waiting space for entities whose movement through the model has been suspended due to the system status (e.g. busy). There are 2 types of queues used by Arena. Individual queues have a symbolic name, a ranking rule and a specific capacity. Internal queues provide a basic first-in, first-out container for entities at a particular activity (module), but do not provide animation, statistics or ranking mechanisms.

Resources are stationary elements of a system that can be allocated to entities. They have a specified capacity at any point in time and a set of states (e.g. busy, idle, inactive) that they transition between during a simulation run. Resources

may be represented as people, machines or even space in a storage area. *Storages* are a second type of passive construct for containing entities. An entity may undergo a series of activities while in a storage, however must explicitly specify its departure from the storage. The movement of entities through a series of processes or activities may be captured in a single table called a *sequence*, which defines the series of stations to be visited by the entity. A sequence contains an ordered set of steps, each defining a station to be visited and, optionally, data to be used when the entity performs the activity at the sequence step.

Conveyors are devices that move entities from one station to another in a single direction. *Transporters* on the other hand are a type of device that moves entities through the system. They can be represented as fork trucks or delivery vehicles. Information such as the transporter's speed and travel distances between stations are required.

3.4 From the Example in Arena Simulation Tool

The figure below shows the example of the super soap batch process. There are 3 kinds of fluids, water, active and fragrance which will be mixed inside the mixer tank. Super Soap produces 4 types of scented liquid soap-Apple, Lemon, Peach and Strawberry. The filler and mixer are cleaned in between orders of different products. The filler is required to fill the bottles and then it'll be capped and packed into boxes.

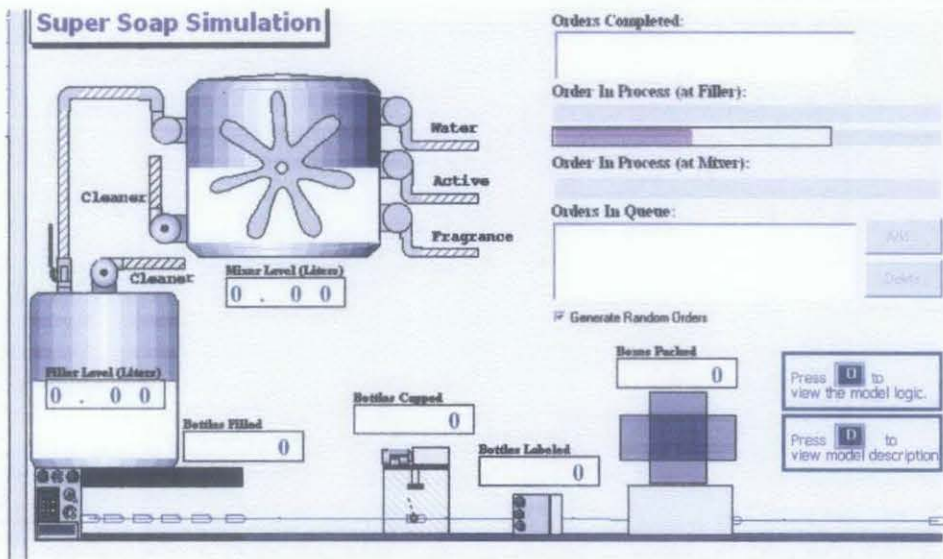


Figure 4: Super Soap Simulation, [13]

CHAPTER 4

RESULT AND DISCUSSION

4.1 Experimentation/Modelling

For this project, it will be a modified version of the example found in the ARENA simulation software. The design of the Soap Batch process plant will also produce 4 flavours or scented liquid soaps- Apple, Lemon, Peach and Strawberry. However, the orders of the different kinds of soap will be as scheduled in an Excel file where customers can determine the orders. The example is as shown in Table 1 and it will be simulated for a day's production.

Table 1: Customer's Order

| Flavour | BottleSize (Liters) | Boxes |
|----------------|--------------------------------|--------------|
| Apple | 1.18 | 877 |
| Lemon | 1.18 | 837 |
| Strawberry | 1.18 | 940 |
| Peach | 1.18 | 907 |

So far, all the logics and block diagrams have been created. This includes mixing and batch logic, filler animation, filler logic, labeler logic, labeler animation, capper logic and also the packing logic. The Visual basic codes (VBA) will be shown in the Appendices.

4.1.1 Submodels

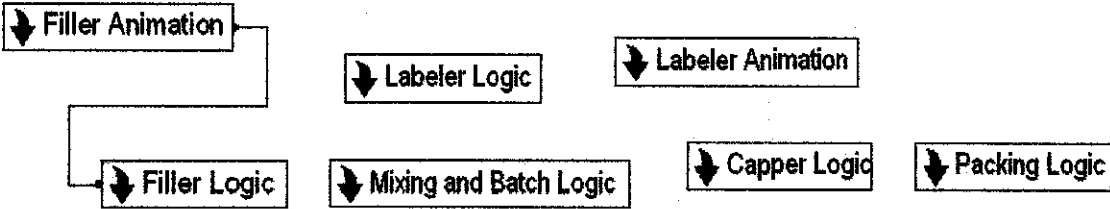


Figure 5: Submodels

Figure 5 shows the submodels that are required to build the simulation. The different processes that are involved are the filler tank which fills the soap into bottles, labeler of the bottles, mixing and batching of the soap, putting on caps on individual bottles of and also the packing of the soap into its boxes.

4.1.2 Mixing and Batch Logic

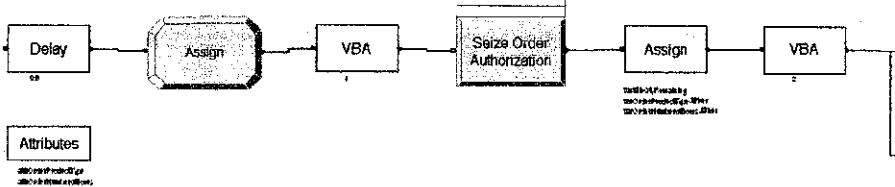


Figure 6: Mixing and Batch Logic

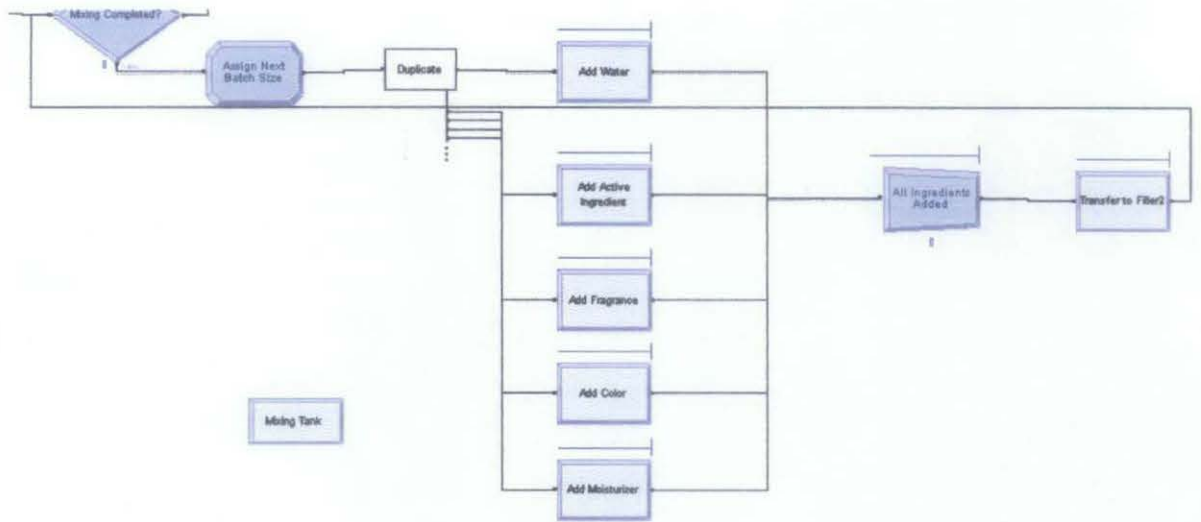


Figure 7: Mixing and Batch Logic

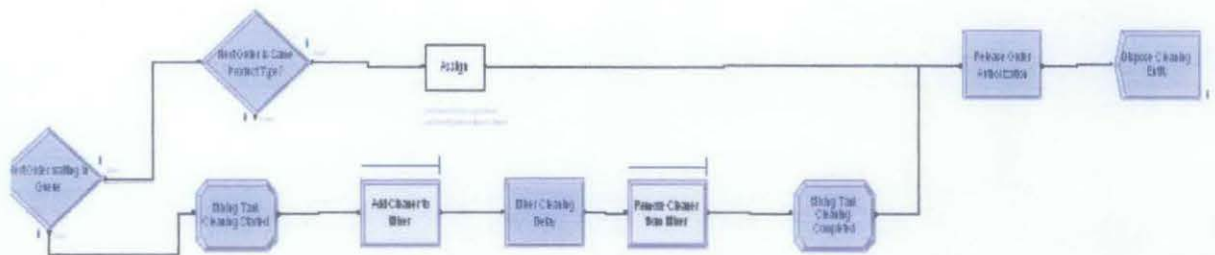


Figure 8: Mixing and Batch Logic

As shown in Figure 6,7 and 8, the logic shows that the orders from the Excel file will be inputted into the program in Arena. It seizes the order and then enters to the logic where the mixing is done. If the mixing has been completed, the mixer will be cleaned first before the next batch of liquid soap for a different flavour is mixed. If the flavour is still the same, the cleaning process will not be done.

4.1.3 Filler Animation

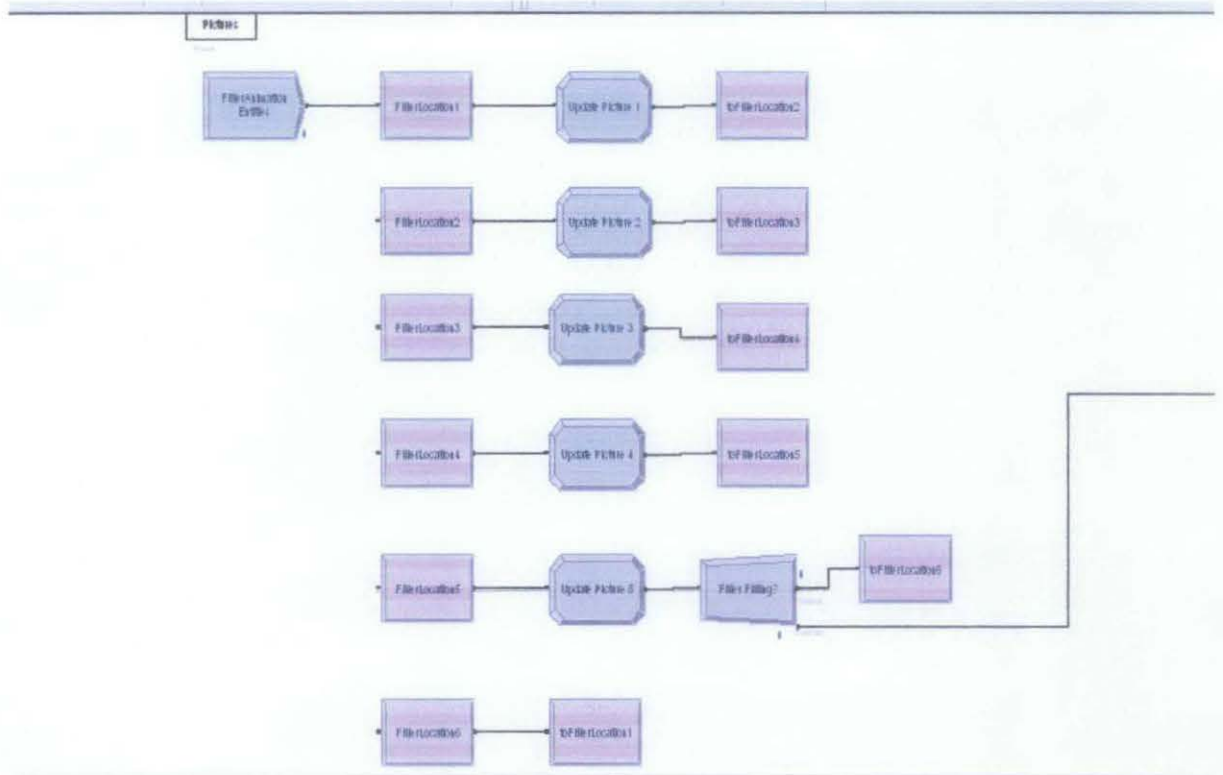


Figure 9: Filler Animation Logic

In Figure 9, the block logic is required to change the picture of the animation for filler tank depending on the different situations.

4.1.4 Filler Logic

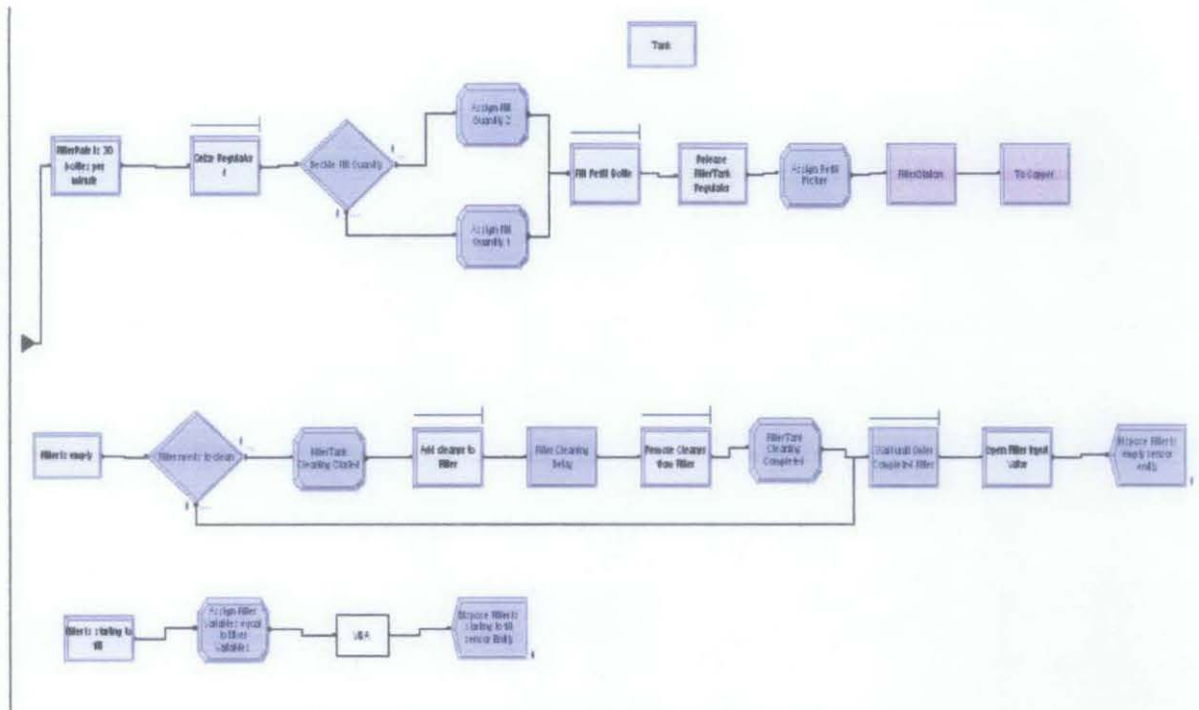


Figure 10: Filler Logic

Figure 10 shows how the filler tank works. It fills up the soap from the tank into empty bottles. When the filler is filled with a different kind of flavour of soap, the cleaning process will take place to avoid any contamination of flavours. After the filling process, the bottles of soap will be send to the capper station where it will be capped.

4.2.5 Capper Logic

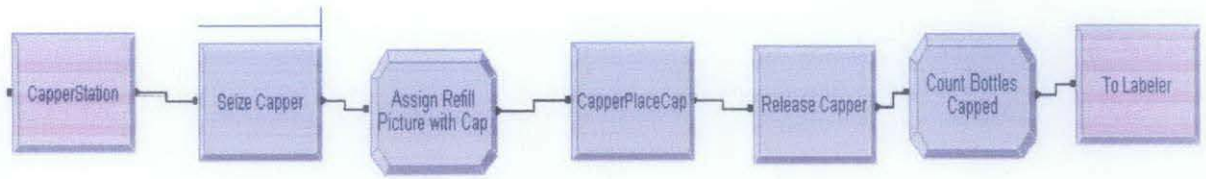


Figure 11: Capper Logic

The capper logic as shown in Figure 11 is to ensure that the bottles will be capped and then send to the labeler for labeling.

4.1.6 Labeler Logic



Figure 12: Labeler Logic

The labeler logic in Figure 12 ensures that the bottles are labeled according to the correct flavour then it is send to the packing station to be packed into boxes.

4.1.7 Labeler Animation

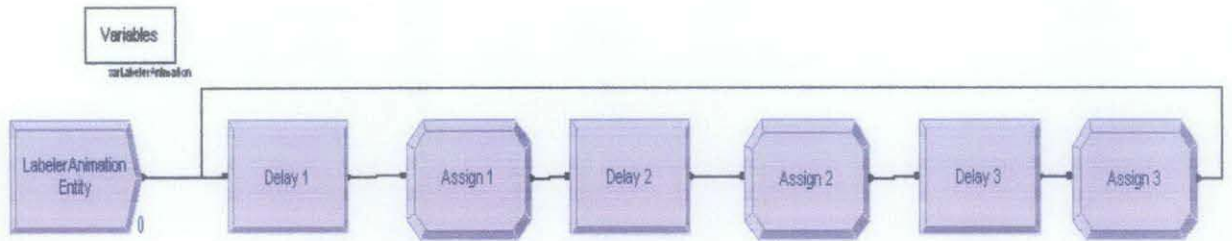


Figure 13: Labeler Animation Logic

Figure 13 of the labeler animation is to ensure that the picture of the labeler animation changes according to the different situation.

4.1.8 Packing logic

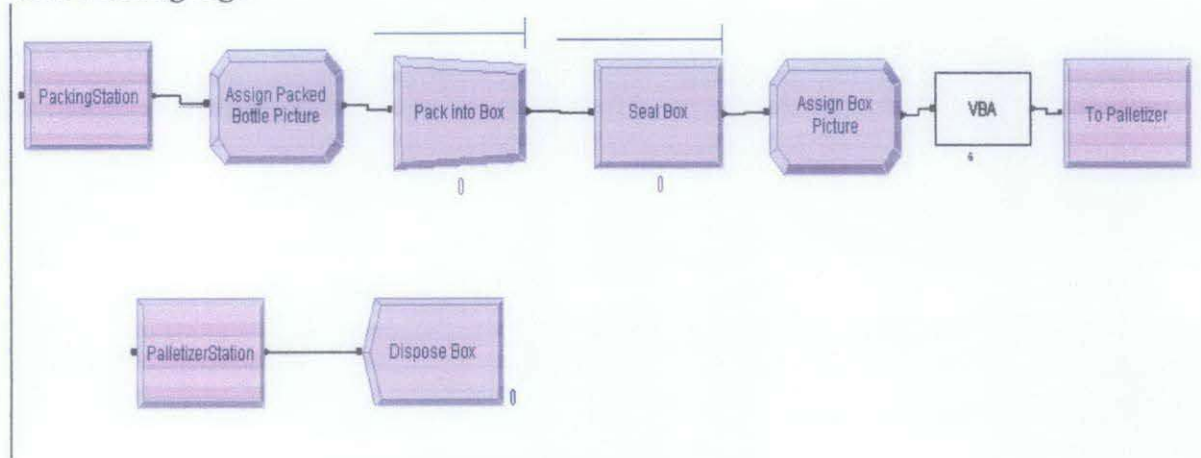


Figure 14: Packing Logic

The packing logic as shown in Figure 14 is to make sure that the bottles will be packed into boxes, sealed and then send to the palletizer where the boxes will be stored and then delivered to customers.

4.1.9 Full Animation

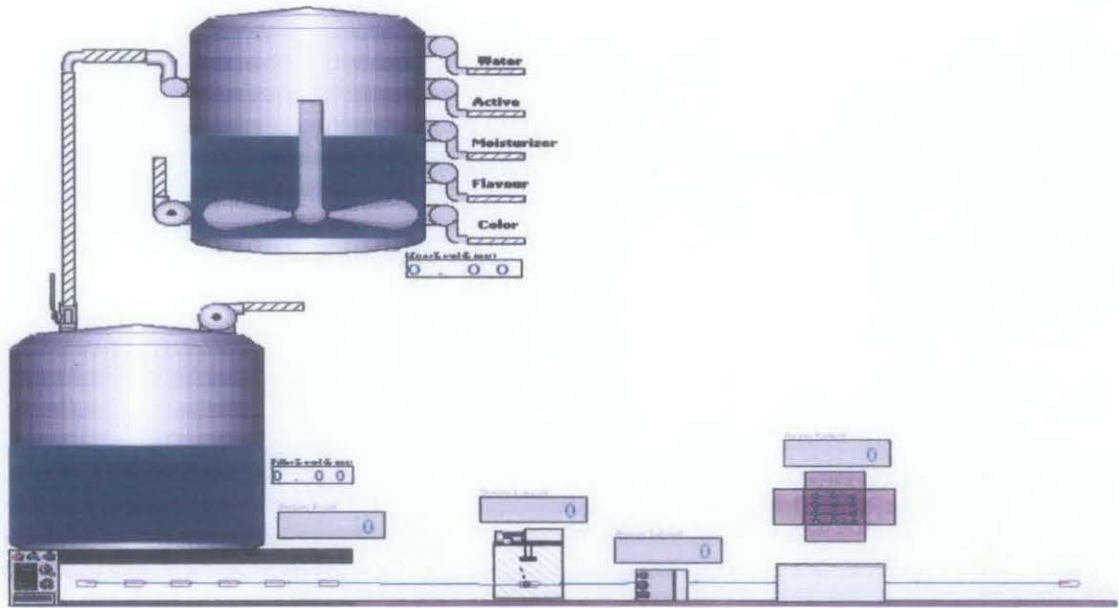


Figure 15: Full animation

The full animation is as shown in Figure 15. Each flavours that enter the mixer tank, different colors has been assigned to them - Apple (Green), Peach(Orange), Strawberry (Pink), Lemon(Yellow).

4.2 Simulation Results

After simulating the process to run for a day which is 1440 minutes, the results will report on the entities (bottles), process time (seal boxes), queue time, resources (tanks and stations) and tanks.

4.2.1 Entity

Entity in this case is referring to the bottles that are transferred within the process when the simulation is running. The results are shown in Table 2. The waiting time is 2.2 minutes for a bottle where there is a delay at a process also known as a queue. The transfer time to refill the bottle on the conveyor is 5.52 minutes. Value added time is the accumulated time when an entity incurs a delay at a value added process which is 0.43 minutes. The number of bottles entering the process to be filled when the simulation is running is 46202 bottles and the 46176 bottles exiting the system.

Table 2: Entity Results

| | Minutes |
|-------------------------------|----------------|
| Waiting Time | 2.2 |
| Transfer Time (Refill Bottle) | 5.52 |
| Value Added Time | 0.43 |
| | Value |
| Refill Bottle (Number in) | 46202 |
| Refill Bottle (Number out) | 46176 |

4.2.2 Process

The process in this case is the sealing of boxes when the simulation is running. Each box contains 12 bottles and after that, the sealed box will be sent for storage. As shown in Table 3, the average total time per box is 0.03 minutes while the accumulated total time for the process is 118.4 minutes on average.

Table 3: Process Time

| | Average (Minutes) |
|------------------------|--------------------------|
| Total Time per Entity | 0.03 |
| Accumulated Total Time | 118.4 |
| | Value |
| Number Out | 3552 |
| Number In | 3552 |

4.2.3 Queues

The queue time for the simulation is as shown below in Table 4. For the bottles to be packed into boxes, the queue is 0.18 minutes. For the process to read the order list, it takes 92.93 minutes and to wait until the order is completed at the filler tank, it takes 0.5 minutes. The queue for the order to be completed is 3.4 minutes. In Figure 16, the queue time is similar except for seize order authorization.queue that spiked up to 92.93minutes.

Number waiting column is the section where it reports the number of entities waiting in each queue. The number of bottles waiting in line to be packed is 5.43 and the seize order queue is 1.84. For the wait until order has completed, it has 0.06 in queue. As shown in Figure 16, the number waiting in queue are almost similar.

Table 4: Queue Time

| | Time (Minutes) | Number Waiting |
|---|----------------|----------------|
| All Ingredients Added.Queue | 0.00 | 0.00 |
| Pack Into Box.Queue | 0.18 | 5.43 |
| Seal Box.Queue | 0.00 | 0.00 |
| Seize Capper2.Queue | 0.00 | 0.00 |
| Seize Filler2Tank Regulator.Queue | 0.00 | 0.00 |
| Seize OrderAuthorization.Queue | 92.93 | 1.84 |
| Wait Until Order Completed Filler.Queue | 0.50 | 0.00 |
| Wait Until Order Completed.Queue | 3.40 | 0.06 |

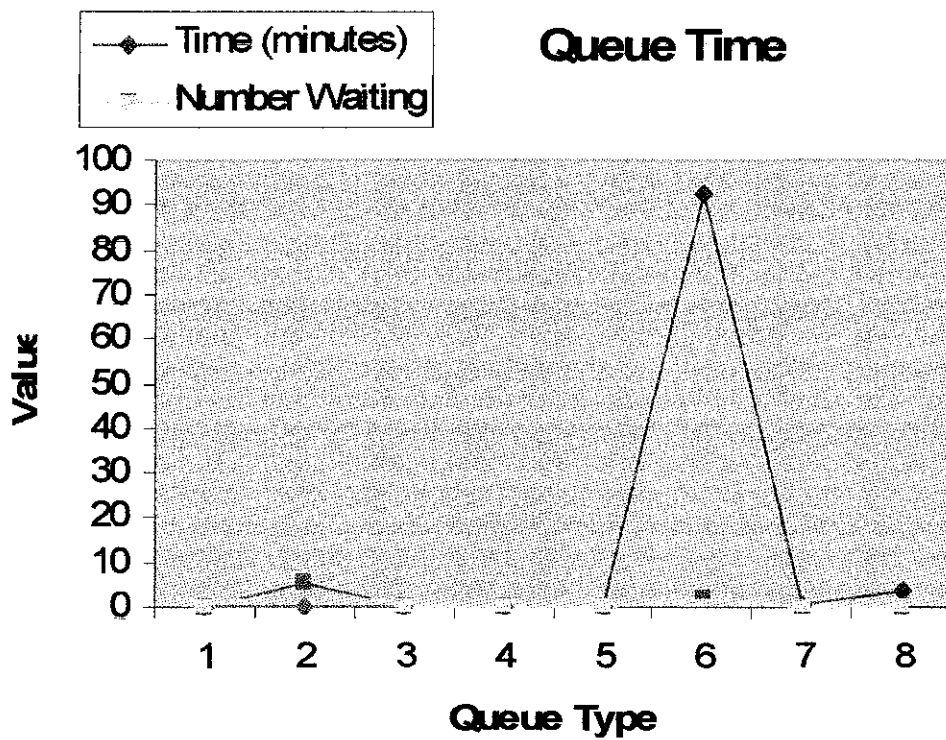


Figure 16: Queue Time

4.2.4 Resources

In this section, the resources refer to the stations and machines. The results are as shown in Table 5. Instantaneous utilization reports the statistics on the resource's utilization at any instant time. Thus, 0.49 means that it was busy for 49% of the time during the simulation; 1.00 means 100% and 0.08 means 8% of the time during the simulation. Number busy column reports the number of busy resource units which is similar to instantaneous utilization. Number scheduled section reports the number of scheduled resource units which is 100% for all three sections. Number seized at the capper station would be 42639 bottles (as mentioned earlier), 27 orders read and 3552 boxes packed. Scheduled utilization reports the cumulative average utilization over the time period that the resource was actually scheduled in the system.

Table 5: Resources Results

| | Inst Util | Num Busy | Num Sched | Num Seized | Sched Util |
|---------------|------------------|-----------------|------------------|-------------------|-------------------|
| Capper2 | 0.49 | 0.49 | 1.00 | 42639.00 | 0.49 |
| OrderAuthoriz | 1.00 | 1.00 | 1.00 | 27.00 | 1.00 |
| Packing | 0.08 | 0.08 | 1.00 | 3552.00 | 0.08 |

4.2.5 Tanks

The tank level results are shown in Table 6. The average level for the filler tank is 92.04 and the total quantity added into the tank is 51606.64 and quantity removed is 51506.64. The average level for the mixing tank is 211.42 and the total quantity added into the tank is 57310.48 and quantity removed is 57306.64.

Table 6: Tank Level

| | Level | Total Quantity Added | Total Quantity Removed |
|-------------|--------------|-----------------------------|-------------------------------|
| Filler2Tank | 92.04 | 51606.64 | 51506.64 |
| MixingTank | 211.42 | 57310.48 | 57306.64 |

4.3 More Simulation Results

In this section, 3 more simulation results will be shown to compare the results with the first simulation results.

4.3.1 One flavour and lesser liters

The flavour that is chosen for this simulation is Apple with 0.708 liters per bottle. The results are similar for the queue time and resource results. The only difference would be the entity, processes and tank results. In Table 7, the entity for number in and number out has increased from the first results which are 46202 and 46176 each. As shown in Table 8, the total time per entity and accumulated total time are similar. The number of boxes in and out of the system however are 3581 each. The tank level for total quantity added and removed has reduced. The results are as shown in Table 9.

Table 7: Entity results

| | Minutes |
|-------------------------------|----------------|
| Waiting Time | 2.2 |
| Transfer Time (Refill Bottle) | 5.52 |
| Value Added Time | 0.43 |
| | Value |
| Refill Bottle (Number in) | 46202 |
| Refill Bottle (Number out) | 46176 |

Table 8: Process Time

| | Average (Minutes) |
|------------------------|--------------------------|
| Total Time per Entity | 0.03 |
| Accumulated Total Time | 118.4 |
| | Value |
| Number Out | 3581 |
| Number In | 3581 |

Table 9: Tank Level

| | Level | Total Quantity Added | Total Quantity Removed |
|-------------|--------|----------------------|------------------------|
| Filler2Tank | 96.03 | 30539.04 | 30439.04 |
| MixingTank | 225.53 | 30619.58 | 30539.04 |

4.3.2 Customer's orders are reduced by 25%

The customer's orders are reduced by 25% of the original data as shown in Table 1. The liters per bottle are reduced to 0.708 liters. After simulating the orders, it is shown in Table 10 and 11 that the number of bottles and boxes produced has decreased. In Table 12, the resources are not as busy. Besides that, in Table 13 it shows that the tank level has also decreased. However, for the queue time, it is similar and there are not many changes.

Table 10: Entity results

| | Minutes |
|-------------------------------|----------------|
| Waiting Time | 2.2 |
| Transfer Time (Refill Bottle) | 5.52 |
| Value Added Time | 0.43 |
| | Value |
| Refill Bottle (Number in) | 41618 |
| Refill Bottle (Number out) | 41613 |

Table 11: Process Time

| | Average (Minutes) |
|------------------------|--------------------------|
| Total Time per Entity | 0.03 |
| Accumulated Total Time | 106.70 |
| | Value |
| Number Out | 3201 |
| Number In | 3201 |

Table 12: Resources Results

| | Inst Util | Num Busy | Num Sched | Num Seized | Sched Util |
|---------------|------------------|-----------------|------------------|-------------------|-------------------|
| Capper2 | 0.44 | 0.44 | 1.00 | 38412 | 0.44 |
| OrderAuthoriz | 0.90 | 0.90 | 1.00 | 24 | 0.90 |
| Packing | 0.07 | 0.07 | 1.00 | 3201 | 0.07 |

Table 13: Tank Level

| | Level | Total Quantity Added | Total Quantity Removed |
|-------------|--------------|-----------------------------|-------------------------------|
| Filler2Tank | 84.37 | 28995.70 | 28995.70 |
| MixingTank | 193.29 | 36195.70 | 36195.70 |

4.3.2 Customer's orders are reduced by 50%

In the last simulation, the customer's orders are reduced by 50% from the orders shown in Table 1. The liters per bottle are now 0.708 liters. As shown in Table 14 and 15, the number of boxes and bottles produced has decreased by half. In Table 16, it shows that the resources are not as busy. Besides that, the tank level as shown in Table 17 shows that it decreased by half. However, for the queue time, it is similar and there are not many changes.

Table 14: Entity results

| | Minutes |
|-------------------------------|----------------|
| Waiting Time | 2.2 |
| Transfer Time (Refill Bottle) | 5.52 |
| Value Added Time | 0.43 |
| | Value |
| Refill Bottle (Number in) | 23106 |
| Refill Bottle (Number out) | 23101 |

Table 15: Process Time

| | Average (Minutes) |
|------------------------|--------------------------|
| Total Time per Entity | 0.03 |
| Accumulated Total Time | 59.23 |
| | Value |
| Number Out | 1777 |
| Number In | 1777 |

Table 16: Resources Results

| | Inst Util | Num Busy | Num Sched | Num Seized | Sched Util |
|---------------|------------------|-----------------|------------------|-------------------|-------------------|
| Capper2 | 0.25 | 0.25 | 1.00 | 21324 | 0.25 |
| OrderAuthoriz | 0.50 | 0.50 | 1.00 | 16 | 0.50 |
| Packing | 0.04 | 0.04 | 1.00 | 1777 | 0.04 |

Table 17: Tank Level

| | Level | Total Quantity Added | Total Quantity Removed |
|-------------|--------------|-----------------------------|-------------------------------|
| Filler2Tank | 46.52 | 16397.39 | 16397.39 |
| MixingTank | 108.06 | 21597.39 | 21597.39 |

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As a conclusion, if the simulation is done for only one flavour of soap and when the liters per bottle decreases, there will be more boxes and bottles in production. When the orders and the liters per bottles are reduced, the production of boxes and bottles will decrease too. Other than that, the resources (machines/stations) will not be as busy.

Indeed it is challenging to be able to simulate a batch process from a plant. From this study, companies will be able to work more efficiently and effectively through simulation software similar to ARENA.

5.2 Recommendation

There are a few recommendations that can be made. One of them would be to conduct further studies on similar and more complicated batch processes for example the food processing industry. The second recommendations would be to explore the continuous processes like the natural gas and petroleum industry.

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APPENDICES

APPENDIX I

LOGIC VBA CODES


```

Private Sub cmdAddOrder_Click()
    frmAddOrder.Show vbnonmodal
End Sub
Private Sub cmdDeleteOrder_Click()
    With ActiveModel.SIMAN
        .QueueRemoveEntity .QueueEntityLocationAtRank(1stOrdersInQueue.ListIndex + 1, .SymbolNumber("Seize
OrderAuthorization.Queue")), .SymbolNumber("Seize Order Authorization.Queue")
    End With
    1stOrdersInQueue.RemoveItem 1stOrdersInQueue.ListIndex
    1stOrdersInQueue.ListIndex = -1
    cmdDeleteOrder.Enabled = False
End Sub
Private Sub 1stOrdersInQueue_Click()
    If (1stOrdersInQueue.ListCount > 0) Then
        cmdDeleteOrder.Enabled = True
    End If
End Sub
Private Sub ModelLogic_DocumentOpen()
    Call ClearControls
End Sub
Private Sub ModelLogic_RunBeginSimulation()

'chkGenerateRandomOrders.Enabled = False
Set ISIMAN = ThisDocument.Model.SIMAN

'Open Excel spreadsheet to read values from
Set oExcelApp = CreateObject("Excel.Application")
oExcelApp.Visible = True
Set oWorkbook = oExcelApp.Workbooks.Open("Soapy.xls")
Set oWorksheet = oWorkbook.ActiveSheet
Set oExcelAppRange = oWorksheet.Range("A2:B2:C2")

g_Flavour = ISIMAN.SymbolNumber("attrOrderProductType")
g_BottleSize = ISIMAN.SymbolNumber("attrOrderBottleSize")
g_Boxes = ISIMAN.SymbolNumber("attrOrderNumberOfBoxes")

End Sub
Private Sub ModelLogic_RunEnd()
    Call ClearControls
End Sub
Private Sub VBA_Block_12_Fire()
    If (1stOrdersInQueue.ListCount = 0) And (lblOrderInProgress.Caption = "") Then
        lblAddMessage.Caption = "Click the Add button to simulate an order."
    End If
End Sub
Private Sub VBA_Block_13_Fire()
    lblAddMessage.Caption = ""
End Sub
Private Sub VBA_Block_15_Fire()

```

```

Dim i As Integer
If (chkGenerateRandomOrders.value = True) Then
    'Generate random orders
    For i = 1 To 2 - lstOrdersInQueue.ListCount
        Call GenerateRandomOrder
    Next
End If
End Sub
Private Sub GenerateRandomOrder()
Dim lngEntityNumber As Long
Dim intFragrance As Integer
Dim dblBottleSize As Double
Dim intNumberOfBoxes As Integer
With ActiveModel.SIMAN
    lngEntityNumber = .EntityCreate
    intFragrance = Int(.SampleUniform(1, 4.9999, 10))
    .EntityAttribute(lngEntityNumber, .SymbolNumber("attrOrderProductType")) = intFragrance
    dblBottleSize = .SampleUniform(0, 1, 10)
    If (dblBottleSize <= 0.5) Then
        dblBottleSize = 0.708
    Else
        dblBottleSize = 1.18
    End If
    .EntityAttribute(lngEntityNumber, .SymbolNumber("attrOrderBottleSize")) = dblBottleSize
    lngNumberOfBoxes = Int(.SampleUniform(10, 30, 10))
    .EntityAttribute(lngEntityNumber, .SymbolNumber("attrOrderNumberOfBoxes")) = lngNumberOfBoxes
    .EntitySendToBlockLabel lngEntityNumber, 0, "StartOrder"
End With
End Sub
Private Sub VBA_Block_4_Fire()
'Remove from "In Queue" List
lstOrdersInQueue.RemoveItem 0
End Sub
Private Sub VBA_Block_18_Fire()
'Set "Order In Process" Fields
Dim intProductType As Long
Dim strProductType As String
Dim strBottleSize As String
Dim strNumberBoxes As String
With ActiveModel.SIMAN
    intProductType = .VariableValue(.SymbolNumber("varOrderProductType.Filler"), 0, 0)
    Select Case intProductType
    Case 1
        strProductType = "Apple"
    Case 2
        strProductType = "Lemon"
    Case 3
        strProductType = "Peach"
    Case 4

```

```

    strProductType = "Strawberry"
End Select
strBottleSize = .VariableValue(.SymbolNumber("varOrderBottleSize.Filler"), 0, 0) & " Liters"
strNumberBoxes = .VariableValue(.SymbolNumber("varOrderNumberOfBoxes.Filler"), 0, 0) & " Boxes"
lblOrderInProgress.Caption = strProductType & "," & strBottleSize & "," & strNumberBoxes
Call UpdateOrderCompletedPercentage
End With
End Sub

```

```

Private Sub VBA_Block_21_Fire()
'Set "Order In Process Mixer" Fields
Dim intProductType As Long
Dim strProductType As String
Dim strBottleSize As String
Dim strNumberBoxes As String
With ActiveModel.SIMAN
    intProductType = .VariableValue(.SymbolNumber("varOrderProductType.Mixer"), 0, 0)
    Select Case intProductType
    Case 1
        strProductType = "Apple"
    Case 2
        strProductType = "Lemon"
    Case 3
        strProductType = "Peach"
    Case 4
        strProductType = "Strawberry"
    End Select
    strBottleSize = .VariableValue(.SymbolNumber("varOrderBottleSize.Mixer"), 0, 0) & " Liters"
    strNumberBoxes = .VariableValue(.SymbolNumber("varOrderNumberOfBoxes.Mixer"), 0, 0) & " Boxes"
    lblOrderInProgressMixer.Caption = strProductType & "," & strBottleSize & "," & strNumberBoxes
    'Remove from "In Queue" List
    lstOrdersInQueue.RemoveItem 0
End With
End Sub

```

```

Private Sub VBA_Block_22_Fire()
lblOrderInProgressMixer.Caption = ""
End Sub

```

```

Private Sub VBA_Block_5_Fire()
Dim strDateTime As String
Dim dblCurrentTime As Double
With ActiveModel.SIMAN
    'Add the order to the "Orders Completed" list
    dblCurrentTime = .RunCurrentTime
    strDateTime = .CalendarDayOfMonth(dblCurrentTime) & "/" & .CalendarMonth(dblCurrentTime) & "/" &
.CalendarYear(dblCurrentTime)

```

```

    strDateTime = strDateTime & " " & .CalendarHour(dblCurrentTime) & ":" & .CalendarMinute(dblCurrentTime) & ":" &
.CalendarSecond(dblCurrentTime)
    lstOrdersCompleted.AddItem strDateTime & " " & lblOrderInProgress.Caption
    'Clear the "Order In Process" label
    lblOrderInProgress.Caption = ""
    lblOrderCompletedPercentage.Caption = ""
End With
End Sub
Private Sub VBA_Block_7_Fire()
Dim intProductType As Long
Dim strProductType As String
With ActiveModel.SIMAN
    'Add the order to the "Orders In Queue" list
    intProductType = .AttributeValue(.ActiveEntity, .SymbolNumber("attrOrderProductType"), 0, 0)
    Select Case intProductType
    Case 1
        strProductType = "Apple"
    Case 2
        strProductType = "Lemon"
    Case 3
        strProductType = "Peach"
    Case 4
        strProductType = "Strawberry"
    End Select
    lstOrdersInQueue.AddItem strProductType & ", " & .AttributeValue(.ActiveEntity,
.SymbolNumber("attrOrderBottleSize"), 0, 0) & " Liters," & .AttributeValue(.ActiveEntity,
.SymbolNumber("attrOrderNumberOfBoxes"), 0, 0) & " Boxes"
End With
End Sub
Private Sub ClearControls()
lblOrderInProgress.Caption = ""
lblOrderInProgressMixer.Caption = ""
lstOrdersCompleted.Clear
lstOrdersInQueue.Clear
cmdAddOrder.Enabled = False
cmdDeleteOrder.Enabled = False
lblOrderCompletedPercentage.Caption = ""
lblAddMessage.Caption = ""
lblAddMessage.Enabled = True
lblAddMessage.BackColor = RGB(242, 242, 242)
chkGenerateRandomOrders.Enabled = False
chkGenerateRandomOrders.BackColor = RGB(242, 242, 242)
lblOrderInProgressMixer.FontSize = 10
End Sub
Private Sub VBA_Block_8_Fire()
Call UpdateOrderCompletedPercentage
End Sub
Private Sub UpdateOrderCompletedPercentage()
Dim lngOrderSize As Long

```

```
Dim lngOrdersCompleted As Long
lngOrderSize =
ActiveModel.SIMAN.VariableValue(ActiveModel.SIMAN.SymbolNumber("varOrderNumberOfBoxes.Filler"), 0, 0)
lngOrdersCompleted = ActiveModel.SIMAN.VariableValue(ActiveModel.SIMAN.SymbolNumber("varBoxesPacked"), 0,
0)
lblOrderCompletedPercentage.Caption = CLng((lngOrdersCompleted / lngOrderSize) * 100) & "% Completed"
End Sub
```

APPENDIX II

GANTT CHART

First semester:

| | Activity | Week | | | | | | | | | | | | | |
|---|--|------|---|---|---|---|---|---|---|---|----|----|----|----|----|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 1 | Briefing from Coordinators and Meet Supervisor | ■ | | | | | | | | | | | | | |
| 2 | Obtain simulation software | | ■ | ■ | | | | | | | | | | | |
| 3 | Contact Engineers and perform data gathering | | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | |
| 4 | Understand and familiarize with the software | | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | |
| 5 | Submission of Preliminary report | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 6 | Research and familiarize with the data collected | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 7 | Submission of Progress report | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 8 | Submission of draft report | | | | | | | | | | | | ■ | ■ | ■ |
| 9 | Submission of Interim report | | | | | | | | | | | | | | ■ |

Second semester

| | Activity | Week | | | | | | | | | | | | | |
|----|---|------|---|---|---|---|---|---|---|---|----|----|----|----|----|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 1 | Project work continue. - Determine the codes and logic | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 2 | Submission of Progress Report 1 | | | | ● | | | | | | | | | | |
| 3 | Determine the Equation and Variables | | | | ■ | ■ | ■ | ■ | ■ | | | | | | |
| 4 | Submission of Progress Report 2 | | | | | | | ● | | | | | | | |
| 5 | Preparing the Animation | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 6 | Analyzing the simulation | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 7 | Seminar (Compulsory) | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ |
| 8 | Poster Exhibition | | | | | | | | | | ● | | | | |
| 9 | Submission of Dissertation (soft bound) | | | | | | | | | | | | ● | | |
| 10 | Oral Presentation | | | | | | | | | | | | | ● | |
| 11 | Submission of Project Dissertation (hard bound) | | | | | | | | | | | | | | ● |

APPENDIX III

SIMULATION RESULTS

Gap Batch Process

Days: 1 Time Units: Minutes

Key Performance Indicators

| | |
|------------|---------|
| Item | Average |
| Number Out | 3,631 |

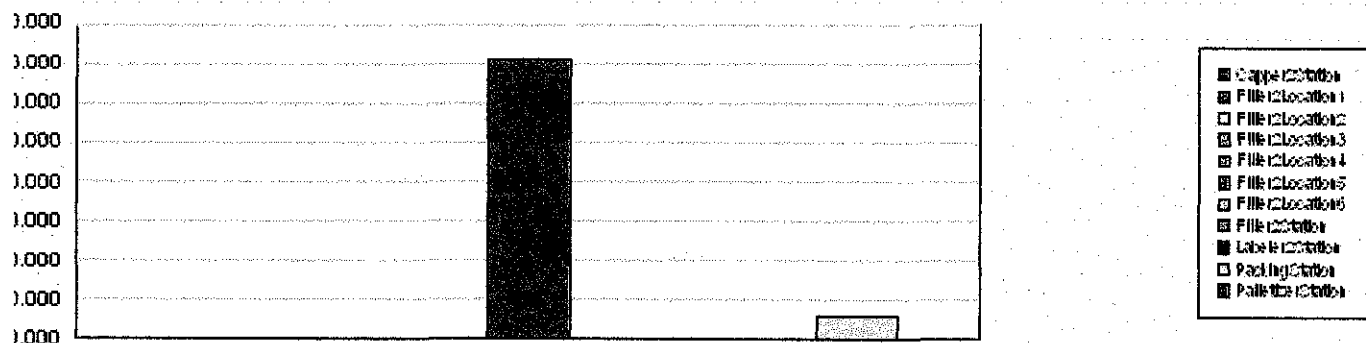
oap Batch Process

rs: 1 Time Units: Minutes

Area (Level 000)

ulated Time

| Activity | Value |
|----------|---------|
| ation | 0.00 |
| ion1 | 0.00 |
| ion2 | 0.00 |
| ion3 | 0.00 |
| ion4 | 0.00 |
| ion5 | 1421.47 |
| ion6 | 0.00 |
| on | 0.00 |
| ation | 0.00 |
| tion | 118.40 |
| ation | 0.00 |



| Activity | Value |
|----------|-------|
| tion | 0.00 |
| ion1 | 0.00 |
| ion2 | 0.00 |
| ion3 | 0.00 |
| ion4 | 0.00 |
| ion5 | 0.00 |
| ion6 | 0.00 |
| on | 0.00 |
| tion | 0.00 |
| ion | 0.00 |
| ation | 0.00 |

oap Batch Process

rs: 1 Time Units: Minutes

Area (Level 000)

ulated Time

ansfer Time

Value

| | |
|-------|------|
| ation | 0.00 |
| tion1 | 0.00 |
| tion2 | 0.00 |
| tion3 | 0.00 |
| tion4 | 0.00 |
| tion5 | 0.00 |
| tion6 | 0.00 |
| on | 0.00 |
| ation | 0.00 |
| tion | 0.00 |
| ation | 0.00 |

ait Time

Value

| | |
|-------|------------|
| ation | 0.00 |
| tion1 | 0.00 |
| tion2 | 0.00 |
| tion3 | 0.00 |
| tion4 | 0.00 |
| tion5 | 0.00000000 |
| tion6 | 0.00 |
| on | 0.00 |
| ation | 0.00 |
| tion | 7814.40 |
| ation | 0.00 |

oap Batch Process

rs: 1 Time Units: Minutes

Area (Level 000)

ulated Time

| her Time | Value |
|----------|--------|
| ation | 710.63 |
| tion1 | 0.00 |
| tion2 | 0.00 |
| tion3 | 0.00 |
| tion4 | 0.00 |
| tion5 | 0.00 |
| tion6 | 0.00 |
| on | 0.00 |
| ation | 0.00 |
| rtion | 0.00 |
| lation | 0.00 |

Map Batch Process

is: 1 Time Units: Minutes

Area (Level 000)

ulated Time

| im Time | Value |
|---------|---------|
| ation | 710.63 |
| ion1 | 0.00 |
| ion2 | 0.00 |
| ion3 | 0.00 |
| ion4 | 0.00 |
| ion5 | 1421.47 |
| ion6 | 0.00 |
| on | 0.00 |
| ation | 0.00 |
| tion | 7932.80 |
| ation | 0.00 |

oap Batch Process

ns: 1 Time Units: Minutes

| | Average | Half Width | Minimum Value | Maximum Value |
|-----|-----------------|---------------------|---------------|---------------|
| | 0.4333 | (Correlated) | 0.4333 | 0.4333 |
| | Average | Half Width | Minimum Value | Maximum Value |
| | 0.00 | 0.000000000 | 0.00 | 0.00 |
| | Average | Half Width | Minimum Value | Maximum Value |
| | 2.2000 | 0.000000000 | 2.2000 | 2.2000 |
| ime | Average | Half Width | Minimum Value | Maximum Value |
| | 5.5167 | (Correlated) | 5.5167 | 5.5167 |
| e | Average | Half Width | Minimum Value | Maximum Value |
| | 0.2000 | (Correlated) | 0.2000 | 0.2000 |
| | Average | Half Width | Minimum Value | Maximum Value |
| | 1.0167 | 0.000000000 | 1.0167 | 1.0167 |
| | Value | | | |
| | 3.0000 | | | |
| | 46202.00 | | | |

oap Batch Process

ns: 1 Time Units: Minutes

Out

Value
1.0000
46176.00

| Average | Half Width | Minimum Value | Maximum Value |
|---------|----------------|---------------|---------------|
| 1.9999 | (Insufficient) | 0.00 | 2.0000 |
| 30.0413 | 0.141582461 | 0.00 | 37.0000 |

oap Batch Process

19: 1 Time Units: Minutes

er Entity

| Per Entity | Average | Half Width | Minimum Value | Maximum Value |
|------------|------------|--------------|---------------|---------------|
| | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |

| Per Entity | Average | Half Width | Minimum Value | Maximum Value |
|------------|---------|------------|---------------|---------------|
| | 0.00 | 0.00000000 | 0.00 | 0.00 |

| Per Entity | Average | Half Width | Minimum Value | Maximum Value |
|------------|------------|--------------|---------------|---------------|
| | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |

ulated Time

| Time | Value |
|------|--------|
| | 118.40 |

| ait Time | Value |
|----------|-------|
| | 0.00 |

| | Value |
|--|---------|
| | 3552.00 |

| ut | Value |
|----|---------|
| | 3552.00 |

Gap Batch Process

Days: 1 Time Units: Minutes

| Queue Name | Average | Half Width | Minimum Value | Maximum Value |
|---------------------------|-------------|----------------|---------------|---------------|
| Items Added.Queue | 0.00 | 0.000000000 | 0.00 | 0.00 |
| Box.Queue | 0.1833 | (Correlated) | 0.00 | 0.3667 |
| Queue | 0.00 | 0.000000000 | 0.00 | 0.00 |
| Server2.Queue | 0.00 | 0.000000000 | 0.00 | 0.00 |
| 2Tank Queue | 0.000000000 | (Correlated) | 0.00 | 0.000000000 |
| ServerAuthorization.Queue | 92.9304 | (Insufficient) | 0.00 | 282.44 |
| Order Completed | 0.5000 | (Insufficient) | 0.5000 | 0.5000 |
| Order Queue | 3.3973 | (Insufficient) | 3.3249 | 5.2081 |

| Queue Name | Average | Half Width | Minimum Value | Maximum Value |
|---------------------------|-------------|----------------|---------------|---------------|
| Items Added.Queue | 0.00 | (Insufficient) | 0.00 | 3.0000 |
| Box.Queue | 5.4270 | 0.031831601 | 0.00 | 12.0000 |
| Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| Server2.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| 2Tank Queue | 0.000000000 | (Correlated) | 0.00 | 1.0000 |
| ServerAuthorization.Queue | 1.8380 | (Insufficient) | 0.00 | 6.0000 |
| Order Completed | 0.00451389 | (Insufficient) | 0.00 | 1.0000 |
| Order Queue | 0.06133998 | (Insufficient) | 0.00 | 1.0000 |

Gap Batch Process

is: 1 Time Units: Minutes

e

| ous Utilization | Average | Half Width | Minimum Value | Maximum Value |
|-----------------|------------|----------------|---------------|---------------|
| source | 0.4935 | 0.002669433 | 0.00 | 1.0000 |
| rization | 0.9992 | (Insufficient) | 0.00 | 1.0000 |
| source | 0.08222222 | 0.000495347 | 0.00 | 1.0000 |

| usy | Average | Half Width | Minimum Value | Maximum Value |
|----------|------------|----------------|---------------|---------------|
| source | 0.4935 | 0.002669433 | 0.00 | 1.0000 |
| rization | 0.9992 | (Insufficient) | 0.00 | 1.0000 |
| source | 0.08222222 | 0.000495347 | 0.00 | 1.0000 |

| cheduled | Average | Half Width | Minimum Value | Maximum Value |
|----------|---------|----------------|---------------|---------------|
| source | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| rization | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| source | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |

| Utilization | Value |
|-------------|------------|
| source | 0.4935 |
| rization | 0.9992 |
| source | 0.08222222 |

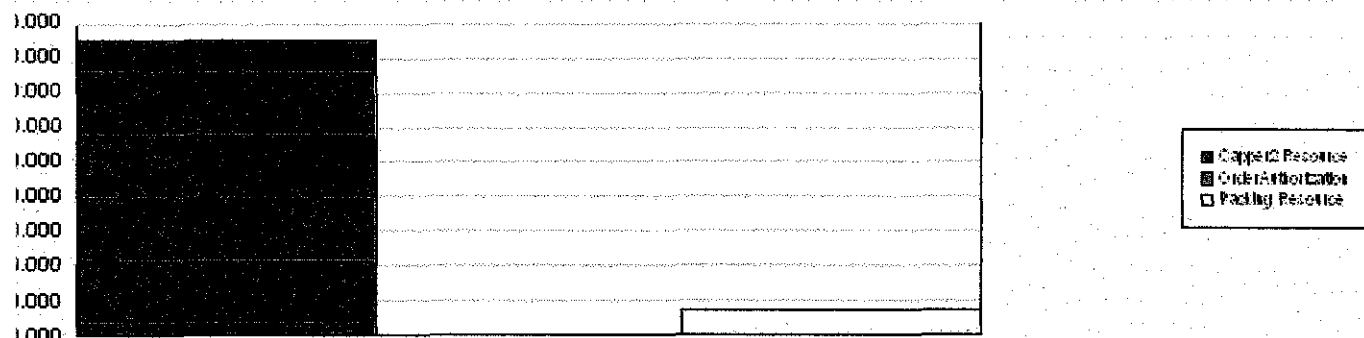
oap Batch Process

rs: 1 Time Units: Minutes

e

iber Seized

| | Value |
|---------------|----------|
| Resource | 42639.00 |
| Authorization | 27.0000 |
| Source | 3552.00 |



Entities Transferring

| | Average | Half Width | Minimum Value | Maximum Value |
|-------|---------|----------------|---------------|---------------|
| ation | 4.9353 | 0.026119271 | 0.00 | 6.0000 |
| ion1 | 0.00 | 0.000000000 | 0.00 | 1.0000 |
| ion2 | 1.0000 | 0.000000000 | 0.00 | 2.0000 |
| ion3 | 1.0000 | (Correlated) | 0.00 | 2.0000 |
| ion4 | 1.0000 | (Correlated) | 0.00 | 2.0000 |
| ion5 | 0.9999 | (Correlated) | 0.00 | 2.0000 |
| ion6 | 0.9999 | (Correlated) | 0.00 | 2.0000 |
| n | 0.00 | (Insufficient) | 0.00 | 0.00 |
| ation | 3.4543 | 0.018918551 | 0.00 | 4.0000 |
| ion | 4.9343 | 0.027867585 | 0.00 | 6.0000 |
| ation | 0.2878 | 0.001730046 | 0.00 | 1.0000 |

Map Batch Process

is: 1 Time Units: Minutes

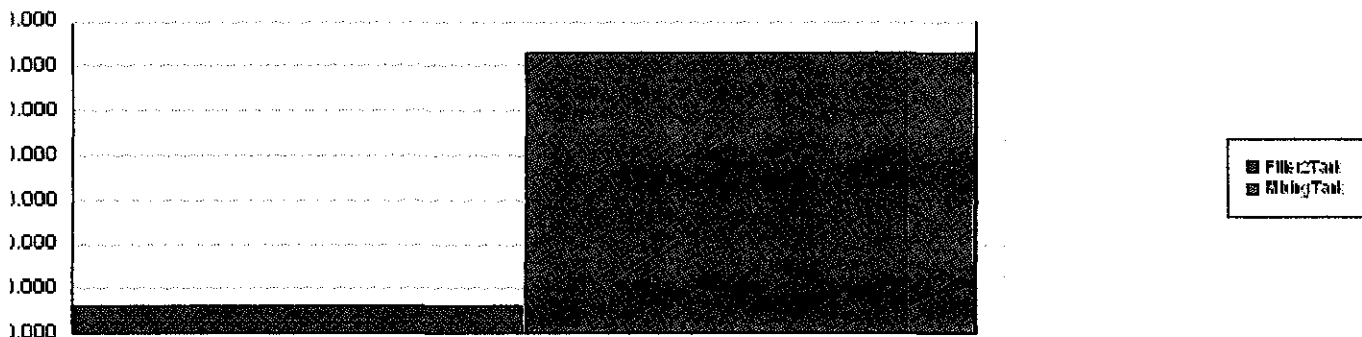
| Average | Half Width | Minimum Value | Maximum Value |
|---------|--------------|---------------|---------------|
| 92.0427 | (Correlated) | 0.00 | 100.00 |
| 211.42 | 3.09650 | 0.00 | 500.00 |

Quantity Added

Value

51606.64

57310.48



Quantity Removed

Value

51506.64

57306.64

Map Batch Process

Replications: 1

Iteration 1 Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

Detail Summary

| | NVA Time | Other Time | Total Time | Transfer Time | VA Time |
|----|----------|------------|------------|---------------|---------|
| le | 0.00 | 0.20 | 1.02 | 5.52 | 0.43 |
| | 0.00 | 0.20 | 1.02 | 5.52 | 0.43 |

| | Number In | Number Out |
|---|-----------|------------|
| | 3 | 1 |
| e | 46,202 | 46,176 |
| | 46,205 | 46,177 |

oap Batch Process

Replications: 1

ation 1 Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

1

| er | Value | | | |
|-----------|--------|----------------|------|--------|
| umber In | 3 | | | |
| umber Out | 1 | | | |
| IP | 1.9999 | (Insufficient) | 0.00 | 2.0000 |

Map Batch Process

Replications: 1

Iteration 1 Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

Bottle

| | Average | Half Width | Minimum | Maximum |
|---------------|---------|--------------|---------|---------|
| Transfer Time | 5.5167 | (Correlated) | 5.5167 | 5.5167 |
| Wait Time | 2.2000 | 0.000000000 | 2.2000 | 2.2000 |
| Total Time | 1.0167 | 0.000000000 | 1.0167 | 1.0167 |
| Setup Time | 0.4333 | (Correlated) | 0.4333 | 0.4333 |
| Other Time | 0.2000 | (Correlated) | 0.2000 | 0.2000 |
| Waste Time | 0.00 | 0.000000000 | 0.00 | 0.00 |

| | Value | | | |
|------------|---------|-------------|------|---------|
| Number In | 46,202 | | | |
| Number Out | 46,176 | | | |
| WIP | 30.0413 | 0.141582461 | 0.00 | 37.0000 |

Gap Batch Process

Replications: 1

Iteration 1

Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

Statistics Detail Summary

Statistics per Entity

| | | |
|-------------------|----------------|------------------|
| <u>Total Time</u> | <u>VA Time</u> | <u>Wait Time</u> |
| 0.03 | 0.03 | 0.00 |

Statistics per Entity

| | |
|----------------|------------------|
| <u>VA Time</u> | <u>Wait Time</u> |
| 118.40 | 0.00 |

| | |
|------------------|-------------------|
| <u>Number In</u> | <u>Number Out</u> |
| 3,552.00 | 3,552.00 |

Gap Batch Process

Replications: 1

Iteration 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units:

Minutes

DX

| per Entity | Average | Half Width | Minimum | Maximum |
|----------------------|------------|--------------|------------|------------|
| Time Per Entity | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |
| Util Time Per Entity | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |
| Wait Time Per Entity | 0 | 0.00000000 | 0 | 0 |
| Simulated Time | Value | | | |
| Sim VA Time | 118.40 | | | |
| Sim Wait Time | 0 | | | |
| | Value | | | |
| Number Out | 3,552 | | | |
| Number In | 3,552 | | | |

oap Batch Process

Replications: 1

ition 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units:

Minutes

» Detail Summary

| | <u>Waiting Time</u> |
|------------------------------------|---------------------|
| Ingredients Added.Queue | 0.00 |
| into Box.Queue | 0.18 |
| Box.Queue | 0.00 |
| Capper2.Queue | 0.00 |
| Filler2Tank Regulator.Queue | 0.00 |
| OrderAuthorization.Queue | 92.93 |
| Jntil Order Completed Filler.Queue | 0.50 |
| Jntil Order Completed.Queue | 3.40 |

| | <u>Number Waiting</u> |
|------------------------------------|-----------------------|
| Ingredients Added.Queue | 0.00 |
| into Box.Queue | 5.43 |
| Box.Queue | 0.00 |
| Capper2.Queue | 0.00 |
| Filler2Tank Regulator.Queue | 0.00 |
| OrderAuthorization.Queue | 1.84 |
| Jntil Order Completed Filler.Queue | 0.00 |
| Jntil Order Completed.Queue | 0.06 |

oap Batch Process

Replications: 1

ation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units:

Minutes

redients Added.Queue

| | Average | Half Width | Minimum | Maximum |
|--------------|---------|-------------|---------|---------|
| Waiting Time | 0 | 0.000000000 | 0 | 0 |

| | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Number Waiting | 0 | (Insufficient) | 0 | 3.0000 |

nto Box.Queue

| | Average | Half Width | Minimum | Maximum |
|--------------|---------|--------------|---------|---------|
| Waiting Time | 0.1833 | (Correlated) | 0 | 0.3667 |

| | Average | Half Width | Minimum | Maximum |
|----------------|---------|-------------|---------|---------|
| Number Waiting | 5.4270 | 0.031831601 | 0 | 12.0000 |

Box.Queue

| | Average | Half Width | Minimum | Maximum |
|--------------|---------|-------------|---------|---------|
| Waiting Time | 0 | 0.000000000 | 0 | 0 |

| | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Number Waiting | 0 | (Insufficient) | 0 | 0 |

Capper2.Queue

| | Average | Half Width | Minimum | Maximum |
|--------------|---------|-------------|---------|---------|
| Waiting Time | 0 | 0.000000000 | 0 | 0 |

| | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Number Waiting | 0 | (Insufficient) | 0 | 0 |

cap Batch Process

Replications: 1

ation 1 Start Time: **0.00** Stop Time: **1,440.00** Time Units: **Minutes**

Filler2Tank Regulator.Queue

| | Average | Half Width | Minimum | Maximum |
|--------------|------------|--------------|---------|------------|
| Waiting Time | 0.00000000 | (Correlated) | 0 | 0.00000000 |

| | Average | Half Width | Minimum | Maximum |
|----------------|------------|--------------|---------|---------|
| Number Waiting | 0.00000000 | (Correlated) | 0 | 1.0000 |

OrderAuthorization.Queue

| | Average | Half Width | Minimum | Maximum |
|--------------|---------|----------------|---------|---------|
| Waiting Time | 92.9304 | (Insufficient) | 0 | 282.44 |

| | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Number Waiting | 1.8380 | (Insufficient) | 0 | 6.0000 |

Until Order Completed Filler.Queue

| | Average | Half Width | Minimum | Maximum |
|--------------|---------|----------------|---------|---------|
| Waiting Time | 0.5000 | (Insufficient) | 0.5000 | 0.5000 |

| | Average | Half Width | Minimum | Maximum |
|----------------|------------|----------------|---------|---------|
| Number Waiting | 0.00451389 | (Insufficient) | 0 | 1.0000 |

Until Order Completed.Queue

| | Average | Half Width | Minimum | Maximum |
|--------------|---------|----------------|---------|---------|
| Waiting Time | 3.3973 | (Insufficient) | 3.3249 | 5.2081 |

| | Average | Half Width | Minimum | Maximum |
|----------------|------------|----------------|---------|---------|
| Number Waiting | 0.06133998 | (Insufficient) | 0 | 1.0000 |

Map Batch Process

Replications: 1

tion 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: **Minutes**

Resource Detail Summary

| | <u>Inst Util</u> | <u>Num Busy</u> | <u>Num Sched</u> | <u>Num Seized</u> | <u>Sched Util</u> |
|----------|------------------|-----------------|------------------|-------------------|-------------------|
| er2 | 0.49 | 0.49 | 1.00 | 42,639.00 | 0.49 |
| Authoriz | 1.00 | 1.00 | 1.00 | 27.00 | 1.00 |
| ing | 0.08 | 0.08 | 1.00 | 3,552.00 | 0.08 |

Map Batch Process

Replications: 1

Iteration 1 Start Time: 0.00 Stop Time: 1,440.00 Time Units: **Minutes**

Resource

| Resource | Value | | | |
|---------------------------|-----------|----------------|--------|--------|
| Total Number Seized | 42,639.00 | | | |
| Scheduled Utilization | 0.4935 | | | |
| Number Scheduled | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Number Busy | 0.4935 | 0.002669433 | 0 | 1.0000 |
| Instantaneous Utilization | 0.4935 | 0.002669433 | 0 | 1.0000 |

Authorization

| Resource | Value | | | |
|---------------------------|---------|----------------|--------|--------|
| Total Number Seized | 27.0000 | | | |
| Scheduled Utilization | 0.9992 | | | |
| Number Scheduled | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Number Busy | 0.9992 | (Insufficient) | 0 | 1.0000 |
| Instantaneous Utilization | 0.9992 | (Insufficient) | 0 | 1.0000 |

Resource

| Resource | Value | | | |
|---------------------------|------------|----------------|--------|--------|
| Total Number Seized | 3,552.00 | | | |
| Scheduled Utilization | 0.08222222 | | | |
| Number Scheduled | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Number Busy | 0.08222222 | 0.000495347 | 0 | 1.0000 |
| Instantaneous Utilization | 0.08222222 | 0.000495347 | 0 | 1.0000 |

Gap Batch Process

Replications: 1

Run 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: **Minutes**

Detail Summary

| | <u>Level</u> |
|-----|--------------|
| ink | 92.04 |
| ank | 211.42 |

Quantity Added

| | <u>Total Quantity Added</u> |
|-----|-----------------------------|
| ink | 51606.64 |
| ank | 57310.48 |

Quantity Removed

| | <u>Total Quantity Removed</u> |
|-----|-------------------------------|
| ink | 51506.64 |
| ank | 57306.64 |

Map Batch Process

Replications: 1

Run 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: **Minutes**

Tank

| Level | Average | Half Width | Minimum | Maximum |
|-------|----------------|---------------------|----------|---------------|
| Level | 92.0427 | (Correlated) | 0 | 100.00 |

Initial Quantity Added Value

Total Quantity Added 51,606.64

Initial Quantity Removed Value

Total Quantity Removed 51,506.64

Tank

| Level | Average | Half Width | Minimum | Maximum |
|-------|---------------|----------------|----------|---------------|
| Level | 211.42 | 3.09650 | 0 | 500.00 |

Initial Quantity Added Value

Total Quantity Added 57,310.48

Initial Quantity Removed Value

Total Quantity Removed 57,306.64

APPENDIX IV

ONE FLAVOUR AND LESSER LITERS

Soap Batch Process

ations: 1 Time Units: Minutes

Key Performance Indicators**II Entities**

Average

| | |
|----------------------|---|
| Non-Value Added Cost | 0 |
| Other Cost | 0 |
| Transfer Cost | 0 |
| Value Added Cost | 0 |
| Wait Cost | 0 |
| Total Cost | 0 |

II Resources

Average

| | |
|------------|---|
| Busy Cost | 0 |
| Idle Cost | 0 |
| Usage Cost | 0 |

| | |
|------------|---|
| Total Cost | 0 |
|------------|---|

ystem

Average

| | |
|------------|-------|
| Total Cost | 0 |
| Number Out | 3,615 |

Soap Batch Process

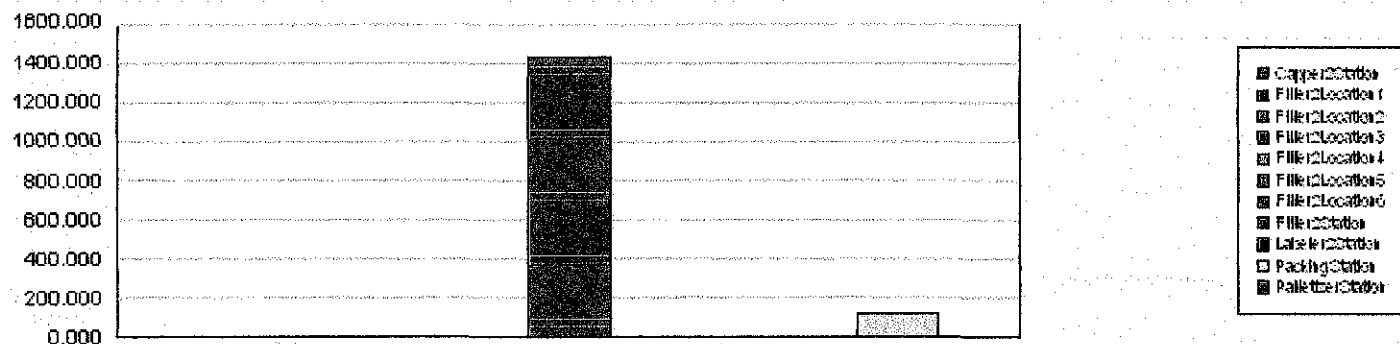
ations: 1 Time Units: Minutes

ty Area (Level 000)

Simulated Time

n VA Time

| | Value |
|-----------|---------|
| 2Station | 0.00 |
| ocation1 | 0.00 |
| ocation2 | 0.00 |
| ocation3 | 0.00 |
| ocation4 | 0.00 |
| ocation5 | 1433.10 |
| ocation6 | 0.00 |
| itation | 0.00 |
| 2Station | 0.00 |
| yStation | 119.37 |
| erStation | 0.00 |



n NVA Time

| | Value |
|-----------|-------|
| 2Station | 0.00 |
| ocation1 | 0.00 |
| ocation2 | 0.00 |
| ocation3 | 0.00 |
| ocation4 | 0.00 |
| ocation5 | 0.00 |
| ocation6 | 0.00 |
| itation | 0.00 |
| 2Station | 0.00 |
| yStation | 0.00 |
| erStation | 0.00 |

Soap Batch Process

ations: 1 Time Units: Minutes

by Area (Level 000)

Simulated Time

Transfer Time

| | Value |
|----------|-------|
| Station | 0.00 |
| ocation1 | 0.00 |
| ocation2 | 0.00 |
| ocation3 | 0.00 |
| ocation4 | 0.00 |
| ocation5 | 0.00 |
| ocation6 | 0.00 |
| ation | 0.00 |
| Station | 0.00 |
| Station | 0.00 |
| rStation | 0.00 |

Wait Time

| | Value |
|----------|------------|
| Station | 0.00 |
| ocation1 | 0.00 |
| ocation2 | 0.00 |
| ocation3 | 0.00 |
| ocation4 | 0.00 |
| ocation5 | 0.00000000 |
| ocation6 | 0.00 |
| ation | 0.00 |
| Station | 0.00 |
| Station | 7878.20 |
| rStation | 0.00 |

Soap Batch Process

ations: 1 Time Units: Minutes

ty Area (Level 000)

Simulated Time

Other Time

Value

| | |
|-----------|--------|
| 2Station | 716.45 |
| ocation1 | 0.00 |
| ocation2 | 0.00 |
| ocation3 | 0.00 |
| ocation4 | 0.00 |
| ocation5 | 0.00 |
| ocation6 | 0.00 |
| tation | 0.00 |
| 2Station | 0.00 |
| Station | 0.00 |
| erStation | 0.00 |

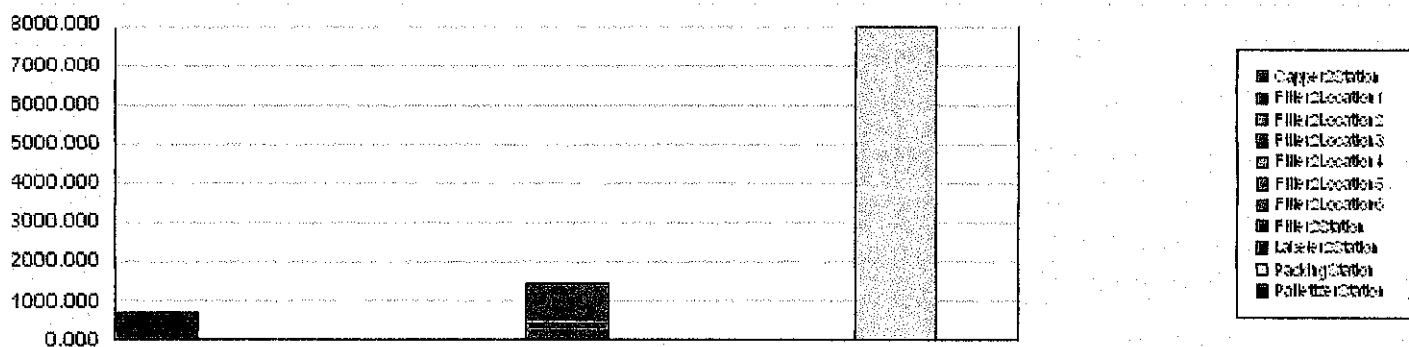
Soap Batch Process

ations: 1 Time Units: Minutes

ty Area (Level 000)

Simulated Time

| Accum Time | Value |
|------------|---------|
| 2Station | 716.45 |
| ocation1 | 0.00 |
| ocation2 | 0.00 |
| ocation3 | 0.00 |
| ocation4 | 0.00 |
| ocation5 | 1433.10 |
| ocation6 | 0.00 |
| ation | 0.00 |
| 2Station | 0.00 |
| Station | 7997.57 |
| erStation | 0.00 |



Simulated Cost

| VA Cost | Value |
|-----------|-------|
| 2Station | 0.00 |
| ocation1 | 0.00 |
| ocation2 | 0.00 |
| ocation3 | 0.00 |
| ocation4 | 0.00 |
| ocation5 | 0.00 |
| ocation6 | 0.00 |
| ation | 0.00 |
| 2Station | 0.00 |
| Station | 0.00 |
| erStation | 0.00 |

Soap Batch Process

ations: 1 Time Units: Minutes

ty Area (Level 000)

Simulated Cost

1 NVA Cost

| | Value |
|-----------|-------|
| 2Station | 0.00 |
| ocation1 | 0.00 |
| ocation2 | 0.00 |
| ocation3 | 0.00 |
| ocation4 | 0.00 |
| ocation5 | 0.00 |
| ocation6 | 0.00 |
| tation | 0.00 |
| 2Station | 0.00 |
| Station | 0.00 |
| erStation | 0.00 |

1 Transfer Cost

| | Value |
|-----------|-------|
| 2Station | 0.00 |
| ocation1 | 0.00 |
| ocation2 | 0.00 |
| ocation3 | 0.00 |
| ocation4 | 0.00 |
| ocation5 | 0.00 |
| ocation6 | 0.00 |
| tation | 0.00 |
| 2Station | 0.00 |
| Station | 0.00 |
| erStation | 0.00 |

1 Wait Cost

| | Value |
|-----------|-------|
| 2Station | 0.00 |
| ocation1 | 0.00 |
| ocation2 | 0.00 |
| ocation3 | 0.00 |
| ocation4 | 0.00 |
| ocation5 | 0.00 |
| ocation6 | 0.00 |
| ation | 0.00 |
| 2Station | 0.00 |
| Station | 0.00 |
| erStation | 0.00 |

Soap Batch Process

ations: 1 Time Units: Minutes

ty Area (Level 000)

Simulated Cost

Other Cost

Value

| | |
|-----------|------|
| 2Station | 0.00 |
| ocation1 | 0.00 |
| ocation2 | 0.00 |
| ocation3 | 0.00 |
| ocation4 | 0.00 |
| ocation5 | 0.00 |
| ocation6 | 0.00 |
| tation | 0.00 |
| 2Station | 0.00 |
| Station | 0.00 |
| erStation | 0.00 |

Accum Cost

Value

| | |
|-----------|------|
| 2Station | 0.00 |
| ocation1 | 0.00 |
| ocation2 | 0.00 |
| ocation3 | 0.00 |
| ocation4 | 0.00 |
| ocation5 | 0.00 |
| ocation6 | 0.00 |
| tation | 0.00 |
| 2Station | 0.00 |
| Station | 0.00 |
| erStation | 0.00 |

Soap Batch Process

ations: 1 Time Units: Minutes

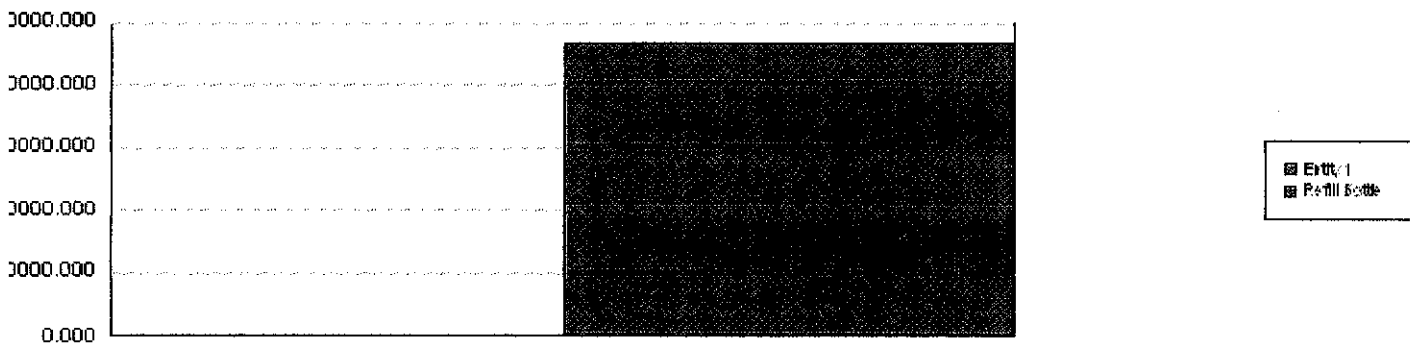
| ne | Average | Half Width | Minimum Value | Maximum Value |
|---------|---------|--------------|---------------|---------------|
| ttle | 0.4333 | 0.000000000 | 0.4333 | 0.4333 |
| ime | Average | Half Width | Minimum Value | Maximum Value |
| ttle | 0.00 | 0.000000000 | 0.00 | 0.00 |
| ime | Average | Half Width | Minimum Value | Maximum Value |
| ttle | 2.2000 | 0.000000000 | 2.2000 | 2.2000 |
| er Time | Average | Half Width | Minimum Value | Maximum Value |
| ttle | 5.5167 | (Correlated) | 5.5167 | 5.5167 |
| Time | Average | Half Width | Minimum Value | Maximum Value |
| ttle | 0.2000 | (Correlated) | 0.2000 | 0.2000 |
| ime | Average | Half Width | Minimum Value | Maximum Value |
| ttle | 1.0167 | 0.000000000 | 1.0167 | 1.0167 |
| st | Average | Half Width | Minimum Value | Maximum Value |
| ttle | 0.00 | 0.000000000 | 0.00 | 0.00 |
| ost | Average | Half Width | Minimum Value | Maximum Value |
| ttle | 0.00 | 0.000000000 | 0.00 | 0.00 |
| ost | Average | Half Width | Minimum Value | Maximum Value |
| ttle | 0.00 | 0.000000000 | 0.00 | 0.00 |
| Cost | Average | Half Width | Minimum Value | Maximum Value |
| ttle | 0.00 | 0.000000000 | 0.00 | 0.00 |
| er Cost | Average | Half Width | Minimum Value | Maximum Value |
| ttle | 0.00 | 0.000000000 | 0.00 | 0.00 |

Soap Batch Process

Iterations: 1 Time Units: Minutes

| Cost | Average | Half Width | Minimum Value | Maximum Value |
|------|---------|-------------|---------------|---------------|
| Cost | 0.00 | 0.000000000 | 0.00 | 0.00 |

| Order In | Value |
|----------|----------|
| Order In | 3.0000 |
| Order In | 46580.00 |



| Order Out | Value |
|-----------|----------|
| Order Out | 1.0000 |
| Order Out | 46553.00 |

| Cost | Average | Half Width | Minimum Value | Maximum Value |
|------|---------|----------------|---------------|---------------|
| Cost | 1.9999 | (Insufficient) | 0.00 | 2.0000 |
| Cost | 30.2462 | 0.096877646 | 0.00 | 37.0000 |

Soap Batch Process

Iterations: 1 Time Units: Minutes

SS**Time per Entity**

| Time Per Entity | Average | Half Width | Minimum Value | Maximum Value |
|-----------------|------------|--------------|---------------|---------------|
| x | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |

| Time Per Entity | Average | Half Width | Minimum Value | Maximum Value |
|-----------------|---------|------------|---------------|---------------|
| x | 0.00 | 0.00000000 | 0.00 | 0.00 |

| Time Per Entity | Average | Half Width | Minimum Value | Maximum Value |
|-----------------|------------|--------------|---------------|---------------|
| x | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |

Simulated Time

| Value | Value |
|-------|--------|
| x | 119.37 |

| Value | Value |
|-------|-------|
| x | 0.00 |

| Value | Value |
|-------|--------|
| x | 119.37 |

Cost per Entity

| Cost Per Entity | Average | Half Width | Minimum Value | Maximum Value |
|-----------------|---------|------------|---------------|---------------|
| x | 0.00 | 0.00000000 | 0.00 | 0.00 |

| Cost Per Entity | Average | Half Width | Minimum Value | Maximum Value |
|-----------------|---------|------------|---------------|---------------|
| x | 0.00 | 0.00000000 | 0.00 | 0.00 |

| Cost Per Entity | Average | Half Width | Minimum Value | Maximum Value |
|-----------------|---------|------------|---------------|---------------|
| x | 0.00 | 0.00000000 | 0.00 | 0.00 |

Simulated Cost

| Value | Value |
|-------|-------|
| x | 0.00 |

Soap Batch Process

ations: 1 Time Units: Minutes

SS

Simulated Cost

| Wait Cost | Value |
|-----------|-------|
| x | 0.00 |

| Accum Cost | Value |
|------------|-------|
| x | 0.00 |

r

| er In | Value |
|-------|---------|
| x | 3581.00 |

| er Out | Value |
|--------|---------|
| x | 3581.00 |

Soap Batch Process

ations: 1 Time Units: Minutes

| g Time | Average | Half Width | Minimum Value | Maximum Value |
|-------------------------|------------|----------------|---------------|---------------|
| redients Added.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| o Box.Queue | 0.1833 | (Correlated) | 0.00 | 0.3667 |
| x.Queue | 0.00 | 0.000000000 | 0.00 | 0.00 |
| apper2.Queue | 0.00 | 0.000000000 | 0.00 | 0.00 |
| iller2Tank | 0.00000000 | (Correlated) | 0.00 | 0.00000000 |
| or.Queue | | | | |
| rderAuthorization.Queue | 249.17 | (Insufficient) | 0.00 | 825.50 |
| til Order Completed | 0.5000 | (Insufficient) | 0.5000 | 0.5000 |
| jeue | | | | |
| til Order | 5.2081 | (Insufficient) | 5.2081 | 5.2081 |
| ted.Queue | | | | |

| g Cost | Average | Half Width | Minimum Value | Maximum Value |
|-------------------------|---------|----------------|---------------|---------------|
| redients Added.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| o Box.Queue | 0.00 | 0.000000000 | 0.00 | 0.00 |
| x.Queue | 0.00 | 0.000000000 | 0.00 | 0.00 |
| apper2.Queue | 0.00 | 0.000000000 | 0.00 | 0.00 |
| iller2Tank | 0.00 | 0.000000000 | 0.00 | 0.00 |
| or.Queue | | | | |
| rderAuthorization.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| til Order Completed | 0.00 | (Insufficient) | 0.00 | 0.00 |
| jeue | | | | |
| til Order | 0.00 | (Insufficient) | 0.00 | 0.00 |
| ted.Queue | | | | |

| er Waiting | Average | Half Width | Minimum Value | Maximum Value |
|-------------------------|------------|----------------|---------------|---------------|
| redients Added.Queue | 0.00 | (Insufficient) | 0.00 | 3.0000 |
| o Box.Queue | 5.4715 | 0.022299052 | 0.00 | 12.0000 |
| x.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| apper2.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| iller2Tank | 0.00000000 | (Correlated) | 0.00 | 1.0000 |
| or.Queue | | | | |
| rderAuthorization.Queue | 2.1026 | (Insufficient) | 0.00 | 5.0000 |
| til Order Completed | 0.00381944 | (Insufficient) | 0.00 | 1.0000 |
| jeue | | | | |
| til Order | 0.03978408 | (Insufficient) | 0.00 | 1.0000 |
| ted.Queue | | | | |

Soap Batch Process

ations: 1 Time Units: Minutes

Force

je

aneous Utilization

| | Average | Half Width | Minimum Value | Maximum Value |
|--------------|------------|----------------|---------------|---------------|
| 2 Resource | 0.4975 | 0.001768497 | 0.00 | 1.0000 |
| uthorization | 0.9998 | (Insufficient) | 0.00 | 1.0000 |
| Resource | 0.08289352 | 0.000358490 | 0.00 | 1.0000 |

er Busy

| | Average | Half Width | Minimum Value | Maximum Value |
|--------------|------------|----------------|---------------|---------------|
| 2 Resource | 0.4975 | 0.001768497 | 0.00 | 1.0000 |
| uthorization | 0.9998 | (Insufficient) | 0.00 | 1.0000 |
| Resource | 0.08289352 | 0.000358490 | 0.00 | 1.0000 |

er Scheduled

| | Average | Half Width | Minimum Value | Maximum Value |
|--------------|---------|----------------|---------------|---------------|
| 2 Resource | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| uthorization | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Resource | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |

uled Utilization

| | Value |
|--------------|------------|
| 2 Resource | 0.4975 |
| uthorization | 0.9998 |
| Resource | 0.08289352 |

Soap Batch Process

ations: 1 Time Units: Minutes

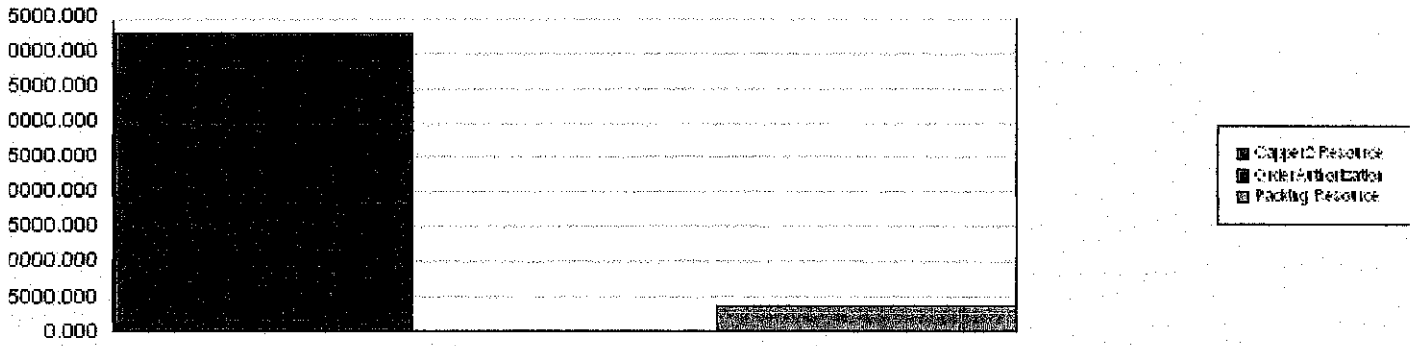
Price

je

Number Seized

Value

| | |
|--------------|----------|
| 2 Resource | 42988.00 |
| uthorization | 12.0000 |
| Resource | 3581.00 |



Cost

Value

| | |
|--------------|------|
| 2 Resource | 0.00 |
| uthorization | 0.00 |
| Resource | 0.00 |

ost

Value

| | |
|--------------|------|
| 2 Resource | 0.00 |
| uthorization | 0.00 |
| Resource | 0.00 |

Cost

Value

| | |
|--------------|------|
| 2 Resource | 0.00 |
| uthorization | 0.00 |
| Resource | 0.00 |

Soap Batch Process

Iterations: 1 Time Units: Minutes

n

r

| Entity Transferring | Average | Half Width | Minimum Value | Maximum Value |
|---------------------|---------|----------------|---------------|---------------|
| 2Station | 4.9757 | 0.016971551 | 0.00 | 6.0000 |
| ocation1 | 0.00 | 0.000000000 | 0.00 | 1.0000 |
| ocation2 | 1.0000 | 0.000000000 | 0.00 | 2.0000 |
| ocation3 | 1.0000 | (Correlated) | 0.00 | 2.0000 |
| ocation4 | 1.0000 | (Correlated) | 0.00 | 2.0000 |
| ocation5 | 0.9999 | (Correlated) | 0.00 | 2.0000 |
| ocation6 | 0.9999 | (Correlated) | 0.00 | 2.0000 |
| ation | 0.00 | (Insufficient) | 0.00 | 0.00 |
| 2Station | 3.4826 | 0.012685319 | 0.00 | 4.0000 |
| Station | 4.9747 | 0.019107574 | 0.00 | 6.0000 |
| 3rStation | 0.2901 | 0.001236360 | 0.00 | 1.0000 |

Soap Batch Process

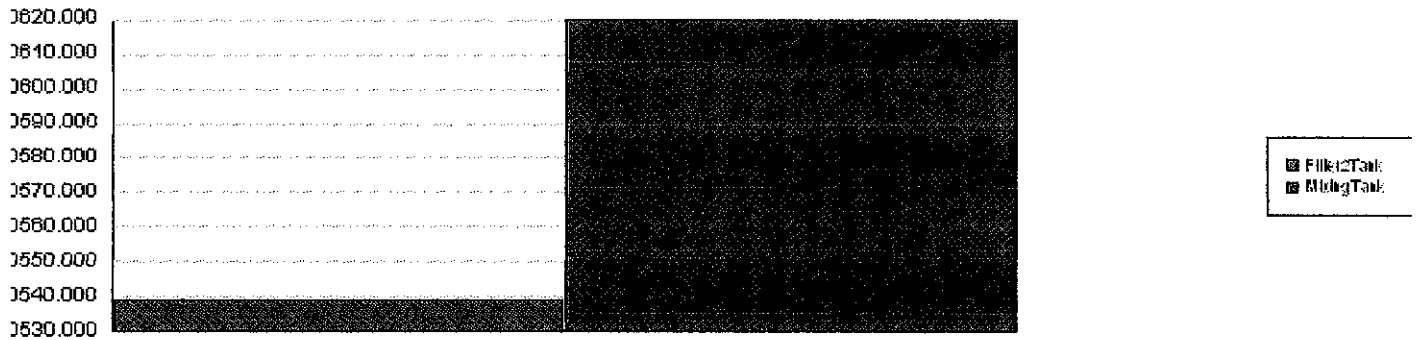
ations: 1 Time Units: Minutes

je

| | Average | Half Width | Minimum Value | Maximum Value |
|-----|---------|--------------|---------------|---------------|
| ank | 96.0279 | 1.16554 | 0.00 | 100.00 |
| ank | 225.53 | (Correlated) | 0.00 | 500.00 |

Quantity Added

| | Value |
|-----|----------|
| ank | 30539.04 |
| ank | 30619.58 |



Quantity Removed

| | Value |
|-----|----------|
| ank | 30439.04 |
| ank | 30539.04 |

Soap Batch Process

Replications: 1

lication 1

Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

Detail Summary

| | NVA Time | Other Time | Total Time | Transfer Time | VA Time |
|--------|----------|------------|------------|---------------|---------|
| Bottle | 0.00 | 0.20 | 1.02 | 5.52 | 0.43 |
| | 0.00 | 0.20 | 1.02 | 5.52 | 0.43 |

| | NVA Cost | Other Cost | Total Cost | Transfer Cost | VA Cost |
|--------|----------|------------|------------|---------------|---------|
| Bottle | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | Number In | Number Out |
|--------|-----------|------------|
| | 3 | 1 |
| bottle | 46,580 | 46,553 |
| | 46,583 | 46,554 |

Wait Time

2.20

2.20

Wait Cost

0.00

0.00

Soap Batch Process

Replications: 1

| | | | | | |
|------------------|-------------|------|------------|----------|----------------------------|
| ication 1 | Start Time: | 0.00 | Stop Time: | 1,440.00 | Time Units: Minutes |
|------------------|-------------|------|------------|----------|----------------------------|

ity 1

| Other | Value | | | |
|------------|--------|----------------|------|--------|
| Number In | 3 | | | |
| Number Out | 1 | | | |
| WIP | 1.9999 | (Insufficient) | 0.00 | 2.0000 |

Soap Batch Process

Replications: 1

Operation 1 Start Time: **0.00** Stop Time: **1,440.00** Time Units: **Minutes**

fill Bottle

| Time | Average | Half Width | Minimum | Maximum |
|---------------|---------|--------------|---------|---------|
| Total Time | 1.0167 | 0.000000000 | 1.0167 | 1.0167 |
| NVA Time | 0.00 | 0.000000000 | 0.00 | 0.00 |
| VA Time | 0.4333 | 0.000000000 | 0.4333 | 0.4333 |
| Wait Time | 2.2000 | 0.000000000 | 2.2000 | 2.2000 |
| Transfer Time | 5.5167 | (Correlated) | 5.5167 | 5.5167 |
| Other Time | 0.2000 | (Correlated) | 0.2000 | 0.2000 |

| Cost | Average | Half Width | Minimum | Maximum |
|---------------|---------|-------------|---------|---------|
| Other Cost | 0.00 | 0.000000000 | 0.00 | 0.00 |
| Total Cost | 0.00 | 0.000000000 | 0.00 | 0.00 |
| Transfer Cost | 0.00 | 0.000000000 | 0.00 | 0.00 |
| VA Cost | 0.00 | 0.000000000 | 0.00 | 0.00 |
| Wait Cost | 0.00 | 0.000000000 | 0.00 | 0.00 |
| NVA Cost | 0.00 | 0.000000000 | 0.00 | 0.00 |

| Other | Value |
|------------|---|
| Number In | 46,580 |
| WIP | 30.2462 0.096877646 0.00 37.0000 |
| Number Out | 46,553 |

Soap Batch Process

Replications: 1

ication 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units:

Minutes

Process Detail Summary

Time per Entity

| | <u>Total Time</u> | <u>VA Time</u> | <u>Wait Time</u> |
|-----|-------------------|----------------|------------------|
| Box | 0.03 | 0.03 | 0.00 |

Accumulated Time

| | <u>Total Time</u> | <u>VA Time</u> | <u>Wait Time</u> |
|-----|-------------------|----------------|------------------|
| Box | 119.37 | 119.37 | 0.00 |

Cost per Entity

| | <u>Total Cost</u> | <u>VA Cost</u> | <u>Wait Cost</u> |
|-----|-------------------|----------------|------------------|
| Box | 0.00 | 0.00 | 0.00 |

Accumulated Cost

| | <u>Total Cost</u> | <u>VA Cost</u> | <u>Wait Cost</u> |
|-----|-------------------|----------------|------------------|
| Box | 0.00 | 0.00 | 0.00 |

Inventory

| | <u>Number In</u> | <u>Number Out</u> |
|-----|------------------|-------------------|
| Box | 3,581.00 | 3,581.00 |

Soap Batch Process

Replications: 1

Simulation 1 Start Time: **0.00** Stop Time: **1,440.00** Time Units: **Minutes**

Box

| Time per Entity | Average | Half Width | Minimum | Maximum |
|-------------------------|------------|--------------|------------|------------|
| Average Time Per Entity | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |
| Total Time Per Entity | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |
| Wait Time Per Entity | 0 | 0.00000000 | 0 | 0 |

| Accumulated Time | Value |
|------------------|--------|
| Total Accum Time | 119.37 |
| Accum VA Time | 119.37 |
| Accum Wait Time | 0 |

| Cost per Entity | Average | Half Width | Minimum | Maximum |
|-------------------------|---------|------------|---------|---------|
| Wait Cost Per Entity | 0 | 0.00000000 | 0 | 0 |
| Average Cost Per Entity | 0 | 0.00000000 | 0 | 0 |
| Total Cost Per Entity | 0 | 0.00000000 | 0 | 0 |

| Accumulated Cost | Value |
|------------------|-------|
| Total Accum Cost | 0 |
| Accum Wait Cost | 0 |
| Accum VA Cost | 0 |

| Number | Value |
|------------|-------|
| Number Out | 3,581 |
| Number In | 3,581 |

Soap Batch Process

Replications: 1

ication 1

Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

ueue Detail Summary**ne**

| | <u>Waiting Time</u> |
|--|---------------------|
| Ingredients Added.Queue | 0.00 |
| ick into Box.Queue | 0.18 |
| al Box.Queue | 0.00 |
| ize Capper2.Queue | 0.00 |
| ize Filler2Tank Regulator.Queue | 0.00 |
| ize OrderAuthorization.Queue | 249.17 |
| ait Until Order Completed Filler.Queue | 0.50 |
| ait Until Order Completed.Queue | 5.21 |

st

| | <u>Waiting Cost</u> |
|--|---------------------|
| Ingredients Added.Queue | 0.00 |
| ick into Box.Queue | 0.00 |
| al Box.Queue | 0.00 |
| ize Capper2.Queue | 0.00 |
| ize Filler2Tank Regulator.Queue | 0.00 |
| ize OrderAuthorization.Queue | 0.00 |
| ait Until Order Completed Filler.Queue | 0.00 |
| ait Until Order Completed.Queue | 0.00 |

her

| | <u>Number Waiting</u> |
|--|-----------------------|
| Ingredients Added.Queue | 0.00 |
| ick into Box.Queue | 5.47 |
| al Box.Queue | 0.00 |
| ize Capper2.Queue | 0.00 |
| ize Filler2Tank Regulator.Queue | 0.00 |
| ize OrderAuthorization.Queue | 2.10 |
| ait Until Order Completed Filler.Queue | 0.00 |
| ait Until Order Completed.Queue | 0.04 |

Soap Batch Process

Replications: 1

| | | | | | |
|---------------------|-------------|-------------|------------|-----------------|----------------------------|
| Simulation 1 | Start Time: | 0.00 | Stop Time: | 1,440.00 | Time Units: Minutes |
|---------------------|-------------|-------------|------------|-----------------|----------------------------|

Ingredients Added.Queue

| Time | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Waiting Time | 0 | (Insufficient) | 0 | 0 |
| Cost | Average | Half Width | Minimum | Maximum |
| Waiting Cost | 0 | (Insufficient) | 0 | 0 |
| Other | Average | Half Width | Minimum | Maximum |
| Number Waiting | 0 | (Insufficient) | 0 | 3.0000 |

Work into Box.Queue

| Time | Average | Half Width | Minimum | Maximum |
|----------------|---------|--------------|---------|---------|
| Waiting Time | 0.1833 | (Correlated) | 0 | 0.3667 |
| Cost | Average | Half Width | Minimum | Maximum |
| Waiting Cost | 0 | 0.000000000 | 0 | 0 |
| Other | Average | Half Width | Minimum | Maximum |
| Number Waiting | 5.4715 | 0.022299052 | 0 | 12.0000 |

Final Box.Queue

| Time | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Waiting Time | 0 | 0.000000000 | 0 | 0 |
| Cost | Average | Half Width | Minimum | Maximum |
| Waiting Cost | 0 | 0.000000000 | 0 | 0 |
| Other | Average | Half Width | Minimum | Maximum |
| Number Waiting | 0 | (Insufficient) | 0 | 0 |

Soap Batch Process

Replications: 1

Simulation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units:

Minutes**Queue: Capper2.Queue**

| Time | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Waiting Time | 0 | 0.000000000 | 0 | 0 |
| Cost | Average | Half Width | Minimum | Maximum |
| Waiting Cost | 0 | 0.000000000 | 0 | 0 |
| Other | Average | Half Width | Minimum | Maximum |
| Number Waiting | 0 | (Insufficient) | 0 | 0 |

Queue: Filler2Tank Regulator.Queue

| Time | Average | Half Width | Minimum | Maximum |
|----------------|-------------|--------------|---------|-------------|
| Waiting Time | 0.000000000 | (Correlated) | 0 | 0.000000000 |
| Cost | Average | Half Width | Minimum | Maximum |
| Waiting Cost | 0 | 0.000000000 | 0 | 0 |
| Other | Average | Half Width | Minimum | Maximum |
| Number Waiting | 0.000000000 | (Correlated) | 0 | 1.0000 |

Queue: OrderAuthorization.Queue

| Time | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Waiting Time | 249.17 | (Insufficient) | 0 | 825.50 |
| Cost | Average | Half Width | Minimum | Maximum |
| Waiting Cost | 0 | (Insufficient) | 0 | 0 |
| Other | Average | Half Width | Minimum | Maximum |
| Number Waiting | 2.1026 | (Insufficient) | 0 | 5.0000 |

Soap Batch Process

Replications: 1

| | | | | | | |
|---------------------|-------------|-------------|------------|-----------------|-------------|----------------|
| Simulation 1 | Start Time: | 0.00 | Stop Time: | 1,440.00 | Time Units: | Minutes |
|---------------------|-------------|-------------|------------|-----------------|-------------|----------------|

Wait Until Order Completed Filler.Queue

| Time | Average | Half Width | Minimum | Maximum |
|----------------|------------|----------------|---------|---------|
| Waiting Time | 0.5000 | (Insufficient) | 0.5000 | 0.5000 |
| Cost | Average | Half Width | Minimum | Maximum |
| Waiting Cost | 0 | (Insufficient) | 0 | 0 |
| Other | Average | Half Width | Minimum | Maximum |
| Number Waiting | 0.00381944 | (Insufficient) | 0 | 1.0000 |

Wait Until Order Completed.Queue

| Time | Average | Half Width | Minimum | Maximum |
|----------------|------------|----------------|---------|---------|
| Waiting Time | 5.2081 | (Insufficient) | 5.2081 | 5.2081 |
| Cost | Average | Half Width | Minimum | Maximum |
| Waiting Cost | 0 | (Insufficient) | 0 | 0 |
| Other | Average | Half Width | Minimum | Maximum |
| Number Waiting | 0.03978408 | (Insufficient) | 0 | 1.0000 |

Soap Batch Process

Replications: 1

ation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: Minutes

ource Detail Summary

ge

| | <u>Inst Util</u> | <u>Num Busy</u> | <u>Num Sched</u> | <u>Num Seized</u> | <u>Sched Util</u> |
|------------|------------------|-----------------|------------------|-------------------|-------------------|
| pper2 | 0.50 | 0.50 | 1.00 | 42,988.00 | 0.50 |
| erAuthoriz | 1.00 | 1.00 | 1.00 | 12.00 | 1.00 |
| cking | 0.08 | 0.08 | 1.00 | 3,581.00 | 0.08 |

t

| | <u>Busy Cost</u> | <u>Idle Cost</u> | <u>Usage Cost</u> |
|-----------------|------------------|------------------|-------------------|
| er2 Resource | 0.00 | 0.00 | 0.00 |
| erAuthorization | 0.00 | 0.00 | 0.00 |
| ing Resource | 0.00 | 0.00 | 0.00 |

Soap Batch Process

Replications: 1

ation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: Minutes

oper2 Resource

| Usage | Average | Half Width | Minimum | Maximum |
|---------------------------|-----------|----------------|---------|---------|
| Instantaneous Utilization | 0.4975 | 0.001768497 | 0 | 1.0000 |
| Number Busy | 0.4975 | 0.001768497 | 0 | 1.0000 |
| Number Scheduled | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Total Number Seized | 42,988.00 | | | |
| Scheduled Utilization | 0.4975 | | | |

| Cost | Value |
|------------|-------|
| Usage Cost | 0 |
| Busy Cost | 0 |
| Idle Cost | 0 |

lerAuthorization

| Usage | Value | | | |
|---------------------------|---------|----------------|--------|--------|
| Total Number Seized | 12.0000 | | | |
| Instantaneous Utilization | 0.9998 | (Insufficient) | 0 | 1.0000 |
| Number Busy | 0.9998 | (Insufficient) | 0 | 1.0000 |
| Scheduled Utilization | 0.9998 | | | |
| Number Scheduled | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |

| Cost | Value |
|------------|-------|
| Busy Cost | 0 |
| Idle Cost | 0 |
| Usage Cost | 0 |

Soap Batch Process

Replications: 1

ation 1 Start Time: 0.00 Stop Time: 1,440.00 Time Units: **Minutes**

Working Resource

| Usage | Average | Half Width | Minimum | Maximum |
|---------------------------|------------|----------------|---------|---------|
| Instantaneous Utilization | 0.08289352 | 0.000358490 | 0 | 1.0000 |
| Scheduled Utilization | 0.08289352 | | | |
| Total Number Seized | 3,581.00 | | | |
| Number Busy | 0.08289352 | 0.000358490 | 0 | 1.0000 |
| Number Scheduled | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |

| Cost | Value |
|------------|-------|
| Idle Cost | 0 |
| Usage Cost | 0 |
| Busy Cost | 0 |

Soap Batch Process

Replications: 1

ation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: **Minutes**

< **Detail Summary**

el

| | <u>Level</u> |
|---------|--------------|
| 2Tank | 96.03 |
| ingTank | 225.53 |

il Quantity Added

| | <u>Total Quantity Added</u> |
|---------|-----------------------------|
| 2Tank | 30539.04 |
| ingTank | 30619.58 |

il Quantity Removed

| | <u>Total Quantity Removed</u> |
|---------|-------------------------------|
| 2Tank | 30439.04 |
| ingTank | 30539.04 |

Soap Batch Process

Replications: 1

ation 1

Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

er2Tank

| Level | Average | Half Width | Minimum | Maximum |
|-------|---------|------------|---------|---------|
| Level | 96.0279 | 1.16554 | 0 | 100.00 |

| Total Quantity Added | Value |
|----------------------|-----------|
| Total Quantity Added | 30,539.04 |

| Total Quantity Removed | Value |
|------------------------|-----------|
| Total Quantity Removed | 30,439.04 |

ingTank

| Level | Average | Half Width | Minimum | Maximum |
|-------|---------|--------------|---------|---------|
| Level | 225.53 | (Correlated) | 0 | 500.00 |

| Total Quantity Added | Value |
|----------------------|-----------|
| Total Quantity Added | 30,619.58 |

| Total Quantity Removed | Value |
|------------------------|-----------|
| Total Quantity Removed | 30,539.04 |

APPENDIX V

ORDERS REDUCED BY 25%

Soap Batch Process

ions: 1 Time Units: Minutes

Key Performance Indicators

| Item | Average |
|------------|---------|
| Number Out | 3,273 |

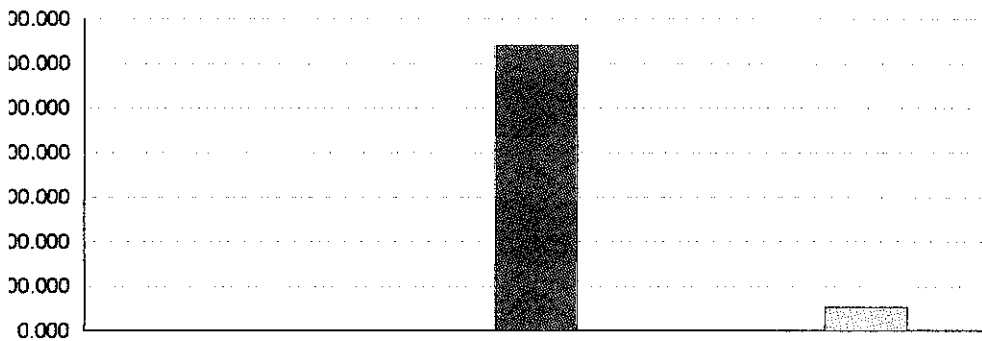
Soap Batch Process

ions: 1 Time Units: Minutes

/ Area (Level 000)

culated Time

| VA Time | Value |
|---------|---------|
| Station | 0.00 |
| ation1 | 0.00 |
| ation2 | 0.00 |
| ation3 | 0.00 |
| ation4 | 0.00 |
| ation5 | 1280.40 |
| ation6 | 0.00 |
| ion | 0.00 |
| Station | 0.00 |
| ation | 106.70 |
| Station | 0.00 |



- Capper2Station
- Filler2Location1
- Filler2Location2
- Filler2Location3
- Filler2Location4
- Filler2Location5
- Filler2Location6
- Filler2Station
- Labeler2Station
- PackingStation
- PalletizerStation

| JVA Time | Value |
|----------|-------|
| Station | 0.00 |
| ation1 | 0.00 |
| ation2 | 0.00 |
| ation3 | 0.00 |
| ation4 | 0.00 |
| ation5 | 0.00 |
| ation6 | 0.00 |
| ion | 0.00 |
| Station | 0.00 |
| ation | 0.00 |
| Station | 0.00 |

Soap Batch Process

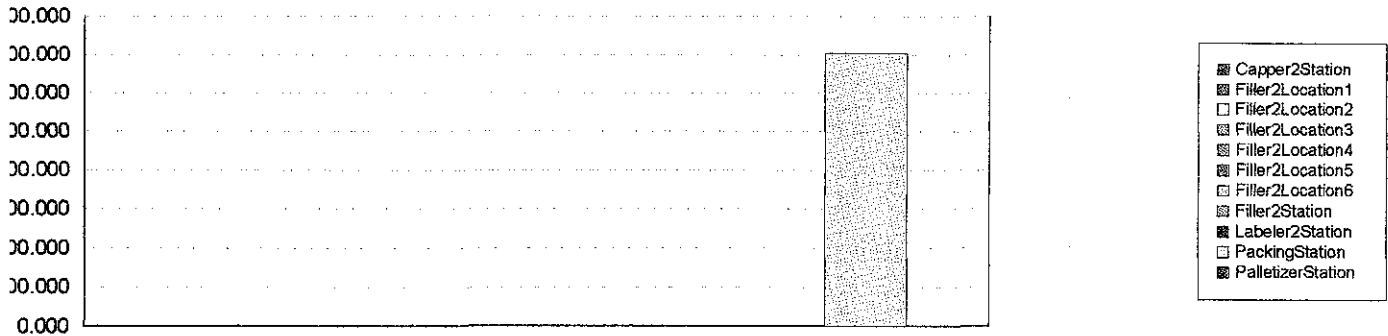
ions: 1 Time Units: Minutes

/ Area (Level 000)

culated Time

| Transfer Time | Value |
|---------------|-------|
| Station | 0.00 |
| Station1 | 0.00 |
| Station2 | 0.00 |
| Station3 | 0.00 |
| Station4 | 0.00 |
| Station5 | 0.00 |
| Station6 | 0.00 |
| Station | 0.00 |
| Station | 0.00 |
| Station | 0.00 |
| Station | 0.00 |

| Wait Time | Value |
|-----------|------------|
| Station | 0.00 |
| Station1 | 0.00 |
| Station2 | 0.00 |
| Station3 | 0.00 |
| Station4 | 0.00 |
| Station5 | 0.00000000 |
| Station6 | 0.00 |
| Station | 0.00 |
| Station | 7042.20 |
| Station | 0.00 |



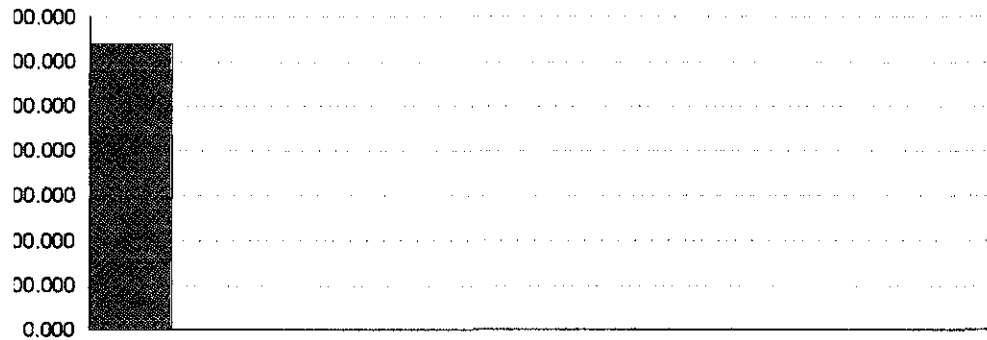
Soap Batch Process

ions: 1 Time Units: Minutes

/ Area (Level 000)

culated Time

| Other Time | Value |
|------------|--------|
| Station | 640.20 |
| ation1 | 0.00 |
| ation2 | 0.00 |
| ation3 | 0.00 |
| ation4 | 0.00 |
| ation5 | 0.00 |
| ation6 | 0.00 |
| tion | 0.00 |
| Station | 0.00 |
| tation | 0.00 |
| Station | 0.00 |



- Capper2Station
- Filler2Location1
- Filler2Location2
- Filler2Location3
- Filler2Location4
- Filler2Location5
- Filler2Location6
- Filler2Station
- Labeler2Station
- PackingStation
- PalletizerStation

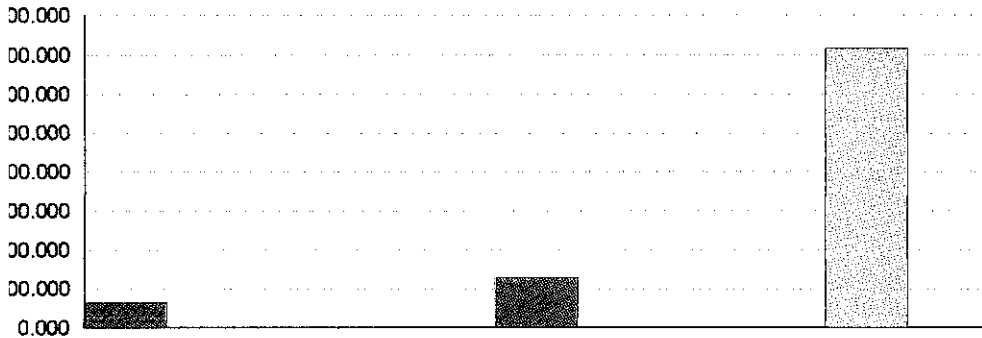
Soap Batch Process

ons: 1 Time Units: Minutes

r Area (Level 000)

nulated Time

| Station | Value |
|----------|---------|
| Station | 640.20 |
| Station1 | 0.00 |
| Station2 | 0.00 |
| Station3 | 0.00 |
| Station4 | 0.00 |
| Station5 | 1280.40 |
| Station6 | 0.00 |
| Station | 0.00 |
| Station | 7148.90 |
| Station | 0.00 |

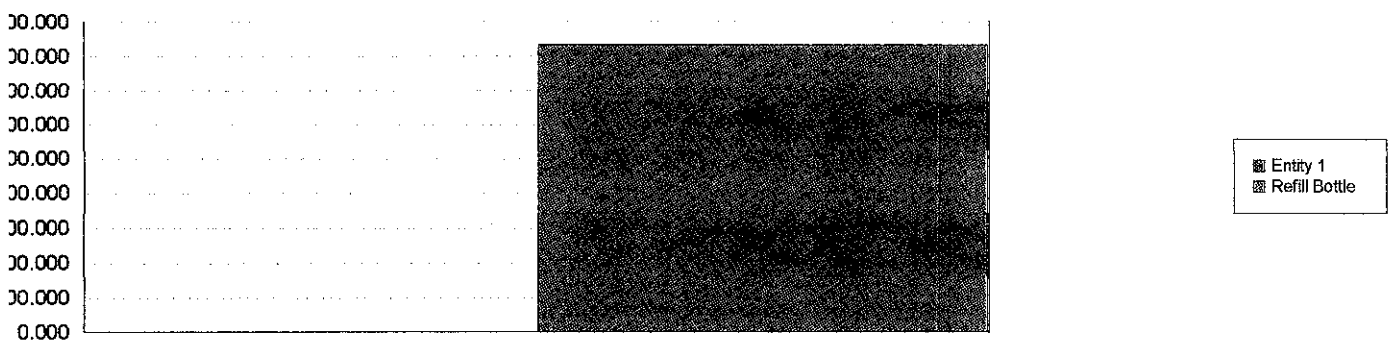


- Capper2Station
- Filler2Location1
- Filler2Location2
- Filler2Location3
- Filler2Location4
- Filler2Location5
- Filler2Location6
- Filler2Station
- Labeler2Station
- PackingStation
- PalletizerStation

Soap Batch Process

ons: 1 Time Units: Minutes

| | Average | Half Width | Minimum Value | Maximum Value |
|------|----------|--------------|---------------|---------------|
| le | 0.4333 | 0.000000000 | 0.4333 | 0.4333 |
| le | 0.00 | 0.000000000 | 0.00 | 0.00 |
| le | 2.2000 | 0.000000001 | 2.2000 | 2.2000 |
| Time | 5.5167 | (Correlated) | 5.5167 | 5.5167 |
| me | 0.2000 | (Correlated) | 0.2000 | 0.2000 |
| ne | 1.0167 | 0.000000000 | 1.0167 | 1.0167 |
| In | Value | | | |
| | 3.0000 | | | |
| le | 41618.00 | | | |



Soap Batch Process

ons: 1 Time Units: Minutes

| Out | Value | | | |
|-----|----------|----------------|---------------|---------------|
| | 1.0000 | | | |
| le | 41613.00 | | | |
| | Average | Half Width | Minimum Value | Maximum Value |
| | 1.9999 | (Insufficient) | 0.00 | 2.0000 |
| le | 27.5624 | (Correlated) | 0.00 | 37.0000 |

Soap Batch Process

ions: 1 Time Units: Minutes

s

Per Entity

| Per Entity | Average | Half Width | Minimum Value | Maximum Value |
|------------|------------|--------------|---------------|---------------|
| | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |
| Per Entity | Average | Half Width | Minimum Value | Maximum Value |
| | 0.00 | 0.00000000 | 0.00 | 0.00 |
| Per Entity | Average | Half Width | Minimum Value | Maximum Value |
| | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |

ulated Time

| | |
|-----------|---------|
| WA Time | Value |
| | 106.70 |
| Wait Time | Value |
| | 0.00 |
| In | Value |
| | 3201.00 |
| Out | Value |
| | 3201.00 |

Soap Batch Process

ions: 1 Time Units: Minutes

| Time | Average | Half Width | Minimum Value | Maximum Value |
|------------------------|------------|----------------|---------------|---------------|
| ients Added.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| Box.Queue | 0.1833 | (Correlated) | 0.00 | 0.3667 |
| Queue | 0.00 | 0.000000000 | 0.00 | 0.00 |
| oper2.Queue | 0.00 | 0.000000000 | 0.00 | 0.00 |
| er2Tank | 0.00000000 | (Correlated) | 0.00 | 0.00000000 |
| .Queue | | | | |
| lerAuthorization.Queue | 163.79 | (Insufficient) | 0.00 | 289.13 |
| Order Completed | 0.5000 | (Insufficient) | 0.5000 | 0.5000 |
| ue | | | | |
| Order | 5.2081 | (Insufficient) | 5.2081 | 5.2081 |
| d.Queue | | | | |

| Waiting | Average | Half Width | Minimum Value | Maximum Value |
|------------------------|------------|----------------|---------------|---------------|
| ients Added.Queue | 0.00 | (Insufficient) | 0.00 | 3.0000 |
| Box.Queue | 4.8904 | (Correlated) | 0.00 | 12.0000 |
| Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| oper2.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| er2Tank | 0.00000000 | (Correlated) | 0.00 | 1.0000 |
| .Queue | | | | |
| lerAuthorization.Queue | 2.7299 | (Insufficient) | 0.00 | 6.0000 |
| Order Completed | 0.00208333 | (Insufficient) | 0.00 | 1.0000 |
| ue | | | | |
| Order | 0.08680163 | (Insufficient) | 0.00 | 1.0000 |
| d.Queue | | | | |

Soap Batch Process

ions: 1 Time Units: Minutes

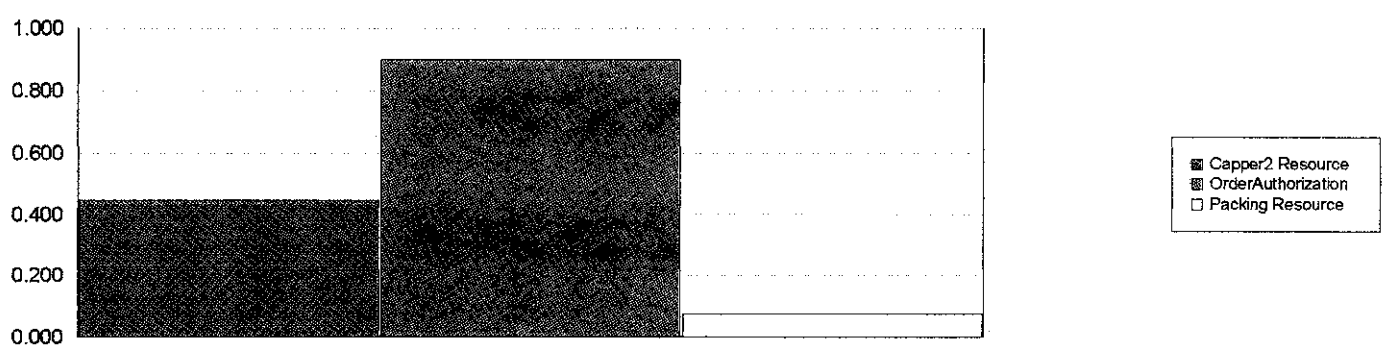
ce

| neous Utilization | Average | Half Width | Minimum Value | Maximum Value |
|-------------------|------------|----------------|---------------|---------------|
| Resource | 0.4446 | (Correlated) | 0.00 | 1.0000 |
| Authorization | 0.8987 | (Insufficient) | 0.00 | 1.0000 |
| Resource | 0.07409722 | (Correlated) | 0.00 | 1.0000 |

| Busy | Average | Half Width | Minimum Value | Maximum Value |
|---------------|------------|----------------|---------------|---------------|
| Resource | 0.4446 | (Correlated) | 0.00 | 1.0000 |
| Authorization | 0.8987 | (Insufficient) | 0.00 | 1.0000 |
| Resource | 0.07409722 | (Correlated) | 0.00 | 1.0000 |

| Scheduled | Average | Half Width | Minimum Value | Maximum Value |
|---------------|---------|----------------|---------------|---------------|
| Resource | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Authorization | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Resource | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |

| ed Utilization | Value |
|----------------|------------|
| Resource | 0.4446 |
| Authorization | 0.8987 |
| Resource | 0.07409722 |

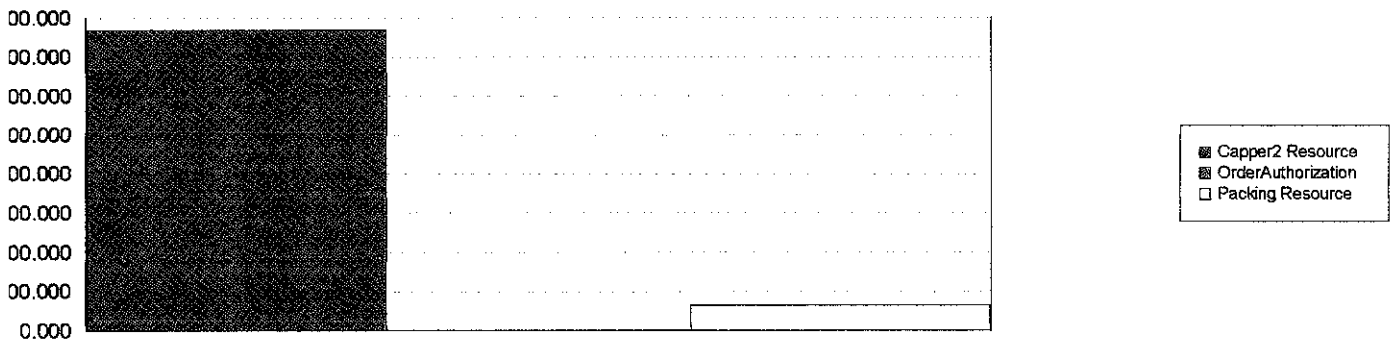


Soap Batch Process

ions: 1 Time Units: Minutes

ce

| Number Seized | Value |
|---------------|----------|
| Resource | 38412.00 |
| Authorization | 24.0000 |
| Resource | 3201.00 |



| Entities Transferring | Average | Half Width | Minimum Value | Maximum Value |
|-----------------------|---------|----------------|---------------|---------------|
| Station | 4.4458 | (Correlated) | 0.00 | 6.0000 |
| Station1 | 0.00 | 0.000000000 | 0.00 | 1.0000 |
| Station2 | 1.0000 | 0.000000000 | 0.00 | 2.0000 |
| Station3 | 1.0000 | (Correlated) | 0.00 | 2.0000 |
| Station4 | 1.0000 | (Correlated) | 0.00 | 2.0000 |
| Station5 | 0.9999 | (Correlated) | 0.00 | 2.0000 |
| Station6 | 0.9999 | (Correlated) | 0.00 | 2.0000 |
| Station | 0.00 | (Insufficient) | 0.00 | 0.00 |
| Station | 3.1121 | (Correlated) | 0.00 | 4.0000 |
| Station | 4.4458 | (Correlated) | 0.00 | 6.0000 |
| Station | 0.2593 | (Correlated) | 0.00 | 1.0000 |

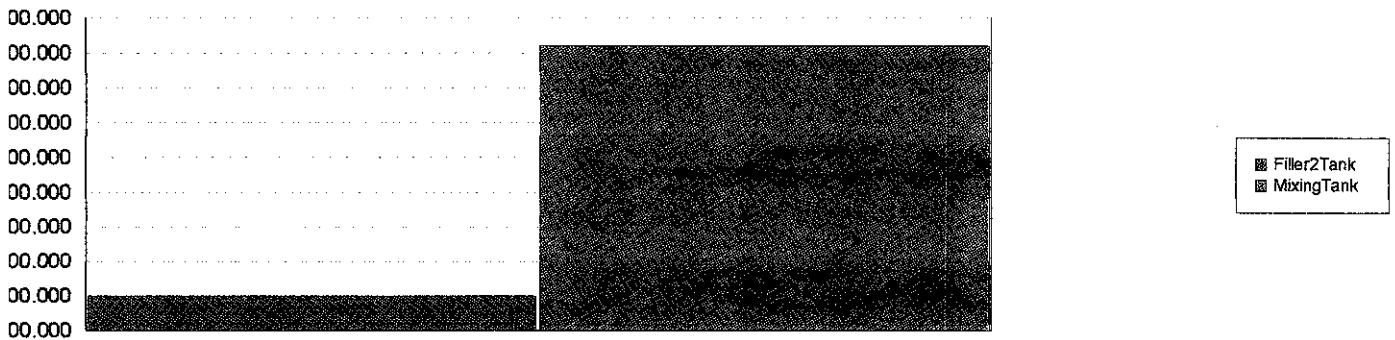
Soap Batch Process

ions: 1 Time Units: Minutes

| | Average | Half Width | Minimum Value | Maximum Value |
|----|---------|--------------|---------------|---------------|
| ik | 84.3731 | (Correlated) | 0.00 | 100.00 |
| rk | 193.29 | (Correlated) | 0.00 | 500.00 |

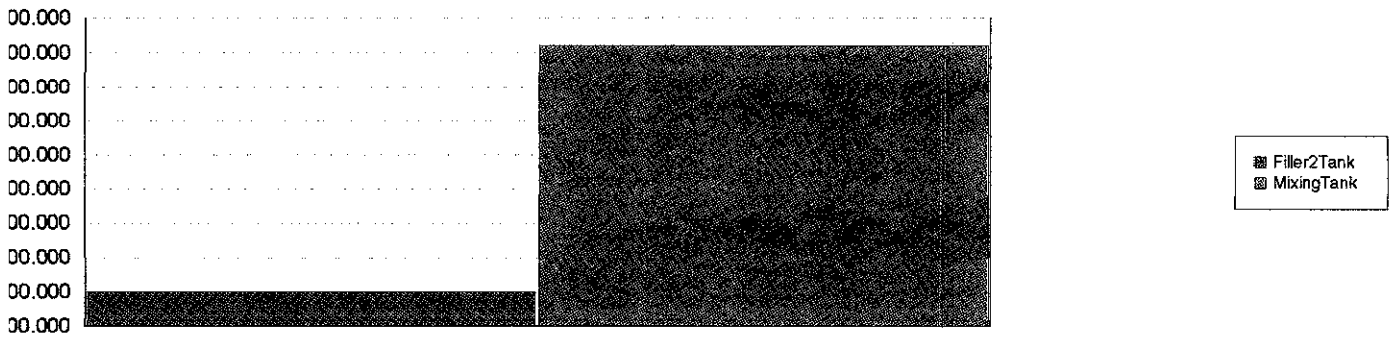
Quantity Added

| | Value |
|----|----------|
| ik | 28995.70 |
| rk | 36195.70 |



Quantity Removed

| | Value |
|----|----------|
| ik | 28995.70 |
| rk | 36195.70 |



Soap Batch Process

Replications: 1

Simulation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units:

Minutes

Detail Summary

| | NVA Time | Other Time | Total Time | Transfer Time | VA Time |
|--------|----------|------------|------------|---------------|---------|
| Entity | 0.00 | 0.20 | 1.02 | 5.52 | 0.43 |
| | 0.00 | 0.20 | 1.02 | 5.52 | 0.43 |

| | Number In | Number Out |
|--------|-----------|------------|
| Entity | 3 | 1 |
| | 41,618 | 41,613 |
| | 41,621 | 41,614 |

Vait Time

2.20

2.20

Soap Batch Process

Replications: 1

| | | | | | |
|-------------|-------------|------|------------|----------|---------------------|
| Iteration 1 | Start Time: | 0.00 | Stop Time: | 1,440.00 | Time Units: Minutes |
|-------------|-------------|------|------------|----------|---------------------|

by 1

| Parameter | Value | | | |
|------------|--------|----------------|------|--------|
| Number In | 3 | | | |
| Number Out | 1 | | | |
| MP | 1.9999 | (Insufficient) | 0.00 | 2.0000 |

Soap Batch Process

Replications: 1

Simulation 1 Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

Entity

| Entity | Average | Half Width | Minimum | Maximum |
|---------------|---------|--------------|---------|---------|
| Transfer Time | 5.5167 | (Correlated) | 5.5167 | 5.5167 |
| Wait Time | 2.2000 | 0.000000001 | 2.2000 | 2.2000 |
| Total Time | 1.0167 | 0.000000000 | 1.0167 | 1.0167 |
| Service Time | 0.4333 | 0.000000000 | 0.4333 | 0.4333 |
| Other Time | 0.2000 | (Correlated) | 0.2000 | 0.2000 |
| Setup Time | 0.00 | 0.000000000 | 0.00 | 0.00 |

| Entity | Value | Half Width | Minimum | Maximum |
|------------|---------|--------------|---------|---------|
| Number In | 41,618 | | | |
| Number Out | 41,613 | | | |
| WIP | 27.5624 | (Correlated) | 0.00 | 37.0000 |

Soap Batch Process

Replications: 1

Simulation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units:

Minutes

Process Detail Summary

per Entity

| | <u>Total Time</u> | <u>VA Time</u> | <u>Wait Time</u> |
|---|-------------------|----------------|------------------|
| x | 0.03 | 0.03 | 0.00 |

Simulated Time

| | <u>VA Time</u> | <u>Wait Time</u> |
|---|----------------|------------------|
| x | 106.70 | 0.00 |

| | <u>Number In</u> | <u>Number Out</u> |
|---|------------------|-------------------|
| x | 3,201.00 | 3,201.00 |

Soap Batch Process

Replications: 1

| | | | | | |
|--------------|-------------|------|------------|----------|---------------------|
| Simulation 1 | Start Time: | 0.00 | Stop Time: | 1,440.00 | Time Units: Minutes |
|--------------|-------------|------|------------|----------|---------------------|

| | | | | | |
|-----|--|--|--|--|--|
| Box | | | | | |
|-----|--|--|--|--|--|

| Time per Entity | Average | Half Width | Minimum | Maximum |
|-------------------------|------------|--------------|------------|------------|
| Service Time Per Entity | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |
| Total Time Per Entity | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |
| Wait Time Per Entity | 0 | 0.00000000 | 0 | 0 |

| Simulated Time | Value |
|----------------------|--------|
| cumulative VA Time | 106.70 |
| cumulative Wait Time | 0 |

| Number | Value |
|------------|-------|
| Number Out | 3,201 |
| Number In | 3,201 |

Soap Batch Process

Replications: 1

Simulation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: Minutes

Queue Detail Summary

e

| | <u>Waiting Time</u> |
|---|---------------------|
| Ingredients Added.Queue | 0.00 |
| Put into Box.Queue | 0.18 |
| Fill Box.Queue | 0.00 |
| Use Capper2.Queue | 0.00 |
| Use Filler2Tank Regulator.Queue | 0.00 |
| Use OrderAuthorization.Queue | 163.79 |
| Wait Until Order Completed Filler.Queue | 0.50 |
| Wait Until Order Completed.Queue | 5.21 |

er

| | <u>Number Waiting</u> |
|---|-----------------------|
| Ingredients Added.Queue | 0.00 |
| Put into Box.Queue | 4.89 |
| Fill Box.Queue | 0.00 |
| Use Capper2.Queue | 0.00 |
| Use Filler2Tank Regulator.Queue | 0.00 |
| Use OrderAuthorization.Queue | 2.73 |
| Wait Until Order Completed Filler.Queue | 0.00 |
| Wait Until Order Completed.Queue | 0.09 |

Soap Batch Process

Replications: 1

Simulation 1 Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

Ingredients Added.Queue

| Queue | Average | Half Width | Minimum | Maximum |
|--------------|---------|----------------|---------|---------|
| Waiting Time | 0 | (Insufficient) | 0 | 0 |

| Queue | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Number Waiting | 0 | (Insufficient) | 0 | 3.0000 |

into Box.Queue

| Queue | Average | Half Width | Minimum | Maximum |
|--------------|---------|--------------|---------|---------|
| Waiting Time | 0.1833 | (Correlated) | 0 | 0.3667 |

| Queue | Average | Half Width | Minimum | Maximum |
|----------------|---------|--------------|---------|---------|
| Number Waiting | 4.8904 | (Correlated) | 0 | 12.0000 |

Box.Queue

| Queue | Average | Half Width | Minimum | Maximum |
|--------------|---------|-------------|---------|---------|
| Waiting Time | 0 | 0.000000000 | 0 | 0 |

| Queue | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Number Waiting | 0 | (Insufficient) | 0 | 0 |

to Capper2.Queue

| Queue | Average | Half Width | Minimum | Maximum |
|--------------|---------|-------------|---------|---------|
| Waiting Time | 0 | 0.000000000 | 0 | 0 |

| Queue | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Number Waiting | 0 | (Insufficient) | 0 | 0 |

Soap Batch Process

Replications: 1

| | | | | | |
|---------------------|-------------|-------------|------------|-----------------|----------------------------|
| Simulation 1 | Start Time: | 0.00 | Stop Time: | 1,440.00 | Time Units: Minutes |
|---------------------|-------------|-------------|------------|-----------------|----------------------------|

the Filler2Tank Regulator.Queue

| Name | Average | Half Width | Minimum | Maximum |
|--------------|------------|--------------|---------|------------|
| Waiting Time | 0.00000000 | (Correlated) | 0 | 0.00000000 |

| Name | Average | Half Width | Minimum | Maximum |
|----------------|------------|--------------|---------|---------|
| Number Waiting | 0.00000000 | (Correlated) | 0 | 1.0000 |

the OrderAuthorization.Queue

| Name | Average | Half Width | Minimum | Maximum |
|--------------|---------|----------------|---------|---------|
| Waiting Time | 163.79 | (Insufficient) | 0 | 289.13 |

| Name | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Number Waiting | 2.7299 | (Insufficient) | 0 | 6.0000 |

Until Order Completed Filler.Queue

| Name | Average | Half Width | Minimum | Maximum |
|--------------|---------|----------------|---------|---------|
| Waiting Time | 0.5000 | (Insufficient) | 0.5000 | 0.5000 |

| Name | Average | Half Width | Minimum | Maximum |
|----------------|------------|----------------|---------|---------|
| Number Waiting | 0.00208333 | (Insufficient) | 0 | 1.0000 |

Until Order Completed.Queue

| Name | Average | Half Width | Minimum | Maximum |
|--------------|---------|----------------|---------|---------|
| Waiting Time | 5.2081 | (Insufficient) | 5.2081 | 5.2081 |

| Name | Average | Half Width | Minimum | Maximum |
|----------------|------------|----------------|---------|---------|
| Number Waiting | 0.08680163 | (Insufficient) | 0 | 1.0000 |

Soap Batch Process

Replications: 1

Iteration 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: Minutes

Resource Detail Summary

3

| | <u>Inst Util</u> | <u>Num Busy</u> | <u>Num Sched</u> | <u>Num Seized</u> | <u>Sched Util</u> |
|----------------|------------------|-----------------|------------------|-------------------|-------------------|
| Server2 | 0.44 | 0.44 | 1.00 | 38,412.00 | 0.44 |
| ServerAuthoriz | 0.90 | 0.90 | 1.00 | 24.00 | 0.90 |
| ServerSizing | 0.07 | 0.07 | 1.00 | 3,201.00 | 0.07 |

Soap Batch Process

Replications: 1

Simulation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: Minutes

Server2 Resource

| Age | Value | | | |
|---------------------------|-----------|----------------|--------|--------|
| Total Number Seized | 38,412.00 | | | |
| Scheduled Utilization | 0.4446 | | | |
| Number Scheduled | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Number Busy | 0.4446 | (Correlated) | 0 | 1.0000 |
| Instantaneous Utilization | 0.4446 | (Correlated) | 0 | 1.0000 |

ServerAuthorization

| Age | Value | | | |
|---------------------------|---------|----------------|--------|--------|
| Total Number Seized | 24.0000 | | | |
| Scheduled Utilization | 0.8987 | | | |
| Number Scheduled | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Number Busy | 0.8987 | (Insufficient) | 0 | 1.0000 |
| Instantaneous Utilization | 0.8987 | (Insufficient) | 0 | 1.0000 |

Shipping Resource

| Age | Value | | | |
|---------------------------|------------|----------------|--------|--------|
| Total Number Seized | 3,201.00 | | | |
| Scheduled Utilization | 0.07409722 | | | |
| Number Scheduled | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Number Busy | 0.07409722 | (Correlated) | 0 | 1.0000 |
| Instantaneous Utilization | 0.07409722 | (Correlated) | 0 | 1.0000 |

Soap Batch Process

Replications: 1

ation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: Minutes

Detail Summary

| | <u>Level</u> |
|------|--------------|
| Tank | 84.37 |
| Tank | 193.29 |

Quantity Added

| | <u>Total Quantity Added</u> |
|------|-----------------------------|
| Tank | 28995.70 |
| Tank | 36195.70 |

Quantity Removed

| | <u>Total Quantity Removed</u> |
|------|-------------------------------|
| Tank | 28995.70 |
| Tank | 36195.70 |

Soap Batch Process

Replications: 1

ation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: Minutes

2Tank

| rel | Average | Half Width | Minimum | Maximum |
|-------|---------|--------------|---------|---------|
| level | 84.3731 | (Correlated) | 0 | 100.00 |

| al Quantity Added | Value |
|----------------------|-----------|
| Total Quantity Added | 28,995.70 |

| al Quantity Removed | Value |
|------------------------|-----------|
| Total Quantity Removed | 28,995.70 |

gTank

| rel | Average | Half Width | Minimum | Maximum |
|-------|---------|--------------|---------|---------|
| level | 193.29 | (Correlated) | 0 | 500.00 |

| al Quantity Added | Value |
|----------------------|-----------|
| Total Quantity Added | 36,195.70 |

| al Quantity Removed | Value |
|------------------------|-----------|
| Total Quantity Removed | 36,195.70 |

APPENDIX VI

ORDERS REDUCED BY 50%

Soap Batch Process

Units: 1 Time Units: Minutes

Key Performance Indicators

| Item | Average |
|------------|---------|
| Number Out | 1,825 |

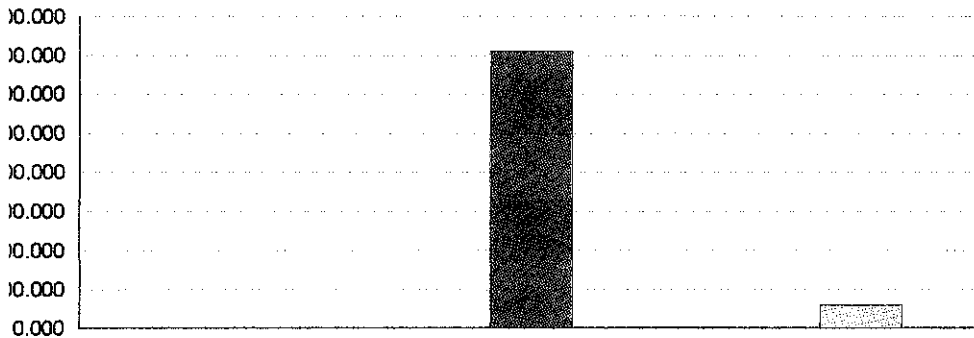
Soap Batch Process

ons: 1 Time Units: Minutes

Area (Level 000)

ulated Time

| VA Time | Value |
|---------|---------|
| tation | 0.00 |
| ation1 | 0.00 |
| ation2 | 0.00 |
| ation3 | 0.00 |
| ation4 | 0.00 |
| ation5 | 710.80 |
| ation6 | 0.00 |
| ion | 0.00 |
| tation | 0.00 |
| ation | 59.2333 |
| station | 0.00 |



- Capper2Station
- Filler2Location1
- Filler2Location2
- Filler2Location3
- Filler2Location4
- Filler2Location5
- Filler2Location6
- Filler2Station
- Labeler2Station
- PackingStation
- PalletterStation

| IVA Time | Value |
|----------|-------|
| tation | 0.00 |
| ation1 | 0.00 |
| ation2 | 0.00 |
| ation3 | 0.00 |
| ation4 | 0.00 |
| ation5 | 0.00 |
| ation6 | 0.00 |
| ion | 0.00 |
| tation | 0.00 |
| ation | 0.00 |
| station | 0.00 |

Soap Batch Process

ions: 1 Time Units: Minutes

/ Area (Level 000)

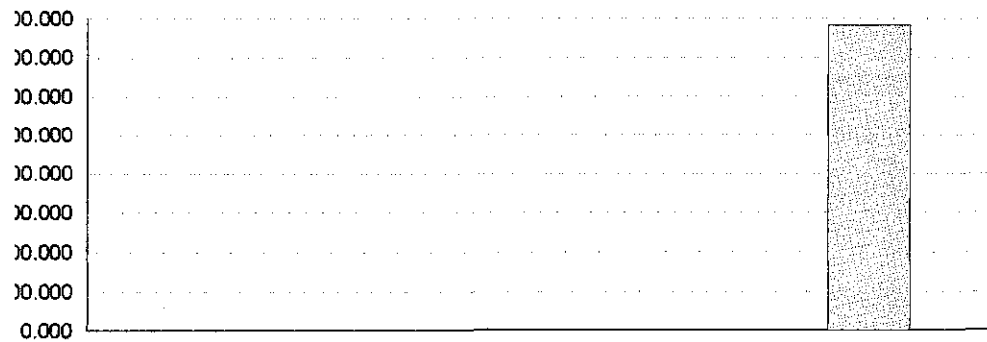
culated Time

Transfer Time

| | Value |
|----------|-------|
| Station | 0.00 |
| Station1 | 0.00 |
| Station2 | 0.00 |
| Station3 | 0.00 |
| Station4 | 0.00 |
| Station5 | 0.00 |
| Station6 | 0.00 |
| Station | 0.00 |
| Station | 0.00 |
| Station | 0.00 |

Wait Time

| | Value |
|----------|------------|
| Station | 0.00 |
| Station1 | 0.00 |
| Station2 | 0.00 |
| Station3 | 0.00 |
| Station4 | 0.00 |
| Station5 | 0.00000000 |
| Station6 | 0.00 |
| Station | 0.00 |
| Station | 3909.40 |
| Station | 0.00 |



- Capper2Station
- Filler2Location1
- Filler2Location2
- Filler2Location3
- Filler2Location4
- Filler2Location5
- Filler2Location6
- Filler2Station
- Labeler2Station
- PackingStation
- PalletizerStation

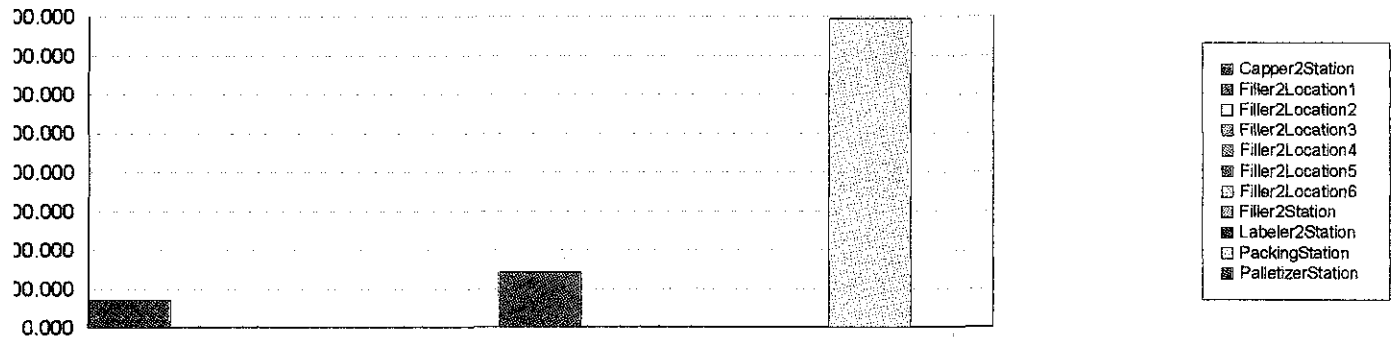
Soap Batch Process

ions: 1 Time Units: Minutes

/ Area (Level 000)

culated Time

| Station | Value |
|----------|---------|
| Station | 355.40 |
| Station1 | 0.00 |
| Station2 | 0.00 |
| Station3 | 0.00 |
| Station4 | 0.00 |
| Station5 | 710.80 |
| Station6 | 0.00 |
| Station | 0.00 |
| Station | 0.00 |
| Station | 3968.63 |
| Station | 0.00 |

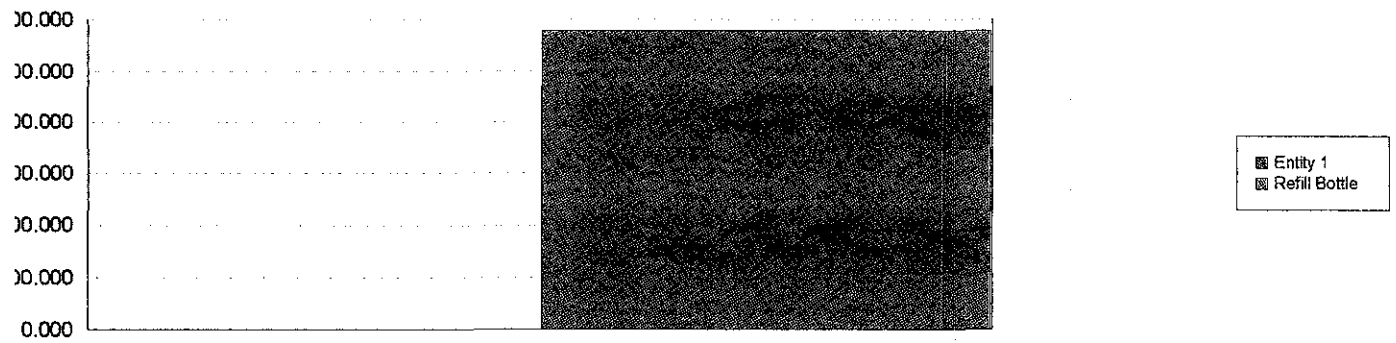


- Capper2Station
- Filler2Location1
- Filler2Location2
- Filler2Location3
- Filler2Location4
- Filler2Location5
- Filler2Location6
- Filler2Station
- Labeler2Station
- PackingStation
- PalletizerStation

Soap Batch Process

ions: 1 Time Units: Minutes

| | Average | Half Width | Minimum Value | Maximum Value |
|------|----------|--------------|---------------|---------------|
| le | 0.4333 | 0.000000000 | 0.4333 | 0.4333 |
| le | 0.00 | 0.000000000 | 0.00 | 0.00 |
| le | 2.2000 | 0.000000000 | 2.2000 | 2.2000 |
| Time | 5.5167 | (Correlated) | 5.5167 | 5.5167 |
| le | 0.2000 | (Correlated) | 0.2000 | 0.2000 |
| le | 1.0167 | 0.000000000 | 1.0167 | 1.0167 |
| In | Value | | | |
| le | 3.0000 | | | |
| le | 23106.00 | | | |



Soap Batch Process

ons: 1 Time Units: Minutes

| Out | Value | | | |
|-----|----------|----------------|---------------|---------------|
| | 1.0000 | | | |
| le | 23101.00 | | | |
| | Average | Half Width | Minimum Value | Maximum Value |
| | 1.9999 | (Insufficient) | 0.00 | 2.0000 |
| le | 17.5252 | (Correlated) | 0.00 | 37.0000 |

Soap Batch Process

ons: 1 Time Units: Minutes

S

Per Entity

| Per Entity | Average | Half Width | Minimum Value | Maximum Value |
|---------------|------------|--------------|---------------|---------------|
| | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |
| ie Per Entity | Average | Half Width | Minimum Value | Maximum Value |
| | 0.00 | 0.00000000 | 0.00 | 0.00 |
| ie Per Entity | Average | Half Width | Minimum Value | Maximum Value |
| | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |

ulated Time

| | |
|-----------|---------|
| 'A Time | Value |
| | 59.2333 |
| wait Time | Value |
| | 0.00 |
| In | Value |
| | 1777.00 |
| Out | Value |
| | 1777.00 |

Soap Batch Process

ons: 1 Time Units: Minutes

| Time | Average | Half Width | Minimum Value | Maximum Value |
|-----------------------|------------|----------------|---------------|---------------|
| ents Added.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| Box.Queue | 0.1833 | (Correlated) | 0.00 | 0.3667 |
| Queue | 0.00 | 0.000000000 | 0.00 | 0.00 |
| per2.Queue | 0.00 | 0.000000000 | 0.00 | 0.00 |
| r2Tank | 0.00000000 | (Correlated) | 0.00 | 0.00000000 |
| .Queue | | | | |
| erAuthorization.Queue | 116.63 | (Insufficient) | 0.00 | 268.74 |
| Order Completed | 0.5000 | (Insufficient) | 0.5000 | 0.5000 |
| ue | | | | |
| Order | 5.2081 | (Insufficient) | 5.2081 | 5.2081 |
| l.Queue | | | | |

| Waiting | Average | Half Width | Minimum Value | Maximum Value |
|-----------------------|------------|----------------|---------------|---------------|
| ents Added.Queue | 0.00 | (Insufficient) | 0.00 | 3.0000 |
| Box.Queue | 2.7149 | (Correlated) | 0.00 | 12.0000 |
| Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| per2.Queue | 0.00 | (Insufficient) | 0.00 | 0.00 |
| r2Tank | 0.00000000 | (Correlated) | 0.00 | 1.0000 |
| Queue | | | | |
| erAuthorization.Queue | 1.2958 | (Insufficient) | 0.00 | 6.0000 |
| Order Completed | 0.00104167 | (Insufficient) | 0.00 | 1.0000 |
| je | | | | |
| Order | 0.05786775 | (Insufficient) | 0.00 | 1.0000 |
| l.Queue | | | | |

Soap Batch Process

ons: 1 Time Units: Minutes

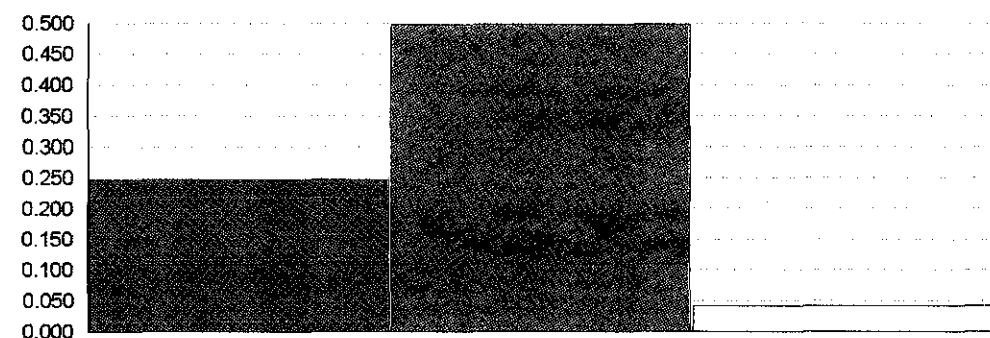
ce

| Continuous Utilization | Average | Half Width | Minimum Value | Maximum Value |
|------------------------|------------|----------------|---------------|---------------|
| Resource | 0.2468 | (Correlated) | 0.00 | 1.0000 |
| Authorization | 0.4975 | (Insufficient) | 0.00 | 1.0000 |
| Resource | 0.04113426 | (Correlated) | 0.00 | 1.0000 |

| Busy | Average | Half Width | Minimum Value | Maximum Value |
|---------------|------------|----------------|---------------|---------------|
| Resource | 0.2468 | (Correlated) | 0.00 | 1.0000 |
| Authorization | 0.4975 | (Insufficient) | 0.00 | 1.0000 |
| Resource | 0.04113426 | (Correlated) | 0.00 | 1.0000 |

| Scheduled | Average | Half Width | Minimum Value | Maximum Value |
|---------------|---------|----------------|---------------|---------------|
| Resource | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Authorization | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Resource | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |

| Used Utilization | Value |
|------------------|------------|
| Resource | 0.2468 |
| Authorization | 0.4975 |
| Resource | 0.04113426 |



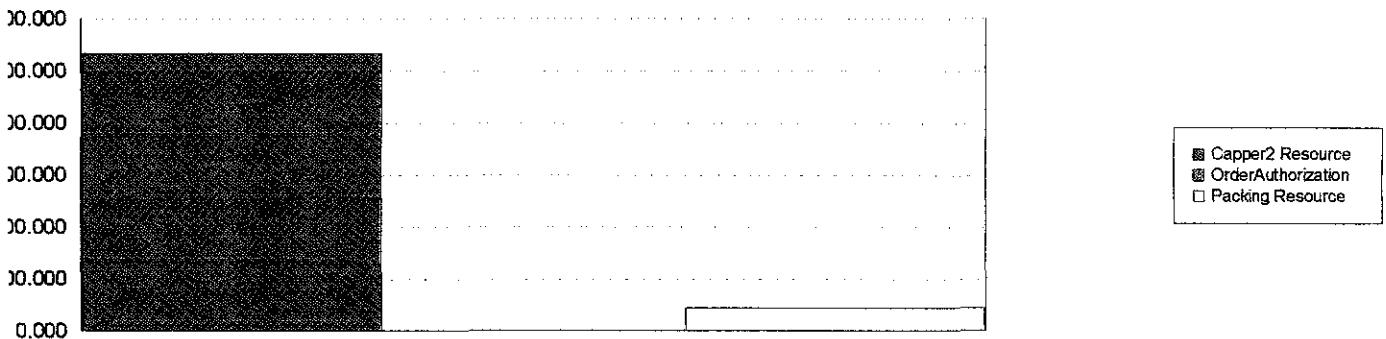
Capper2 Resource
 OrderAuthorization
 Packing Resource

Soap Batch Process

ons: 1 Time Units: Minutes

ce

| Number Seized | Value |
|---------------|----------|
| Resource | 21324.00 |
| Authorization | 16.0000 |
| Resource | 1777.00 |



| Entities Transferring | Average | Half Width | Minimum Value | Maximum Value |
|-----------------------|---------|----------------|---------------|---------------|
| tation | 2.4681 | (Correlated) | 0.00 | 6.0000 |
| ation1 | 0.00 | 0.000000000 | 0.00 | 1.0000 |
| ation2 | 1.0000 | 0.000000000 | 0.00 | 2.0000 |
| ation3 | 1.0000 | (Correlated) | 0.00 | 2.0000 |
| ation4 | 1.0000 | (Correlated) | 0.00 | 2.0000 |
| ation5 | 0.9999 | (Correlated) | 0.00 | 2.0000 |
| ation6 | 0.9999 | (Correlated) | 0.00 | 2.0000 |
| ion | 0.00 | (Insufficient) | 0.00 | 0.00 |
| tation | 1.7276 | (Correlated) | 0.00 | 4.0000 |
| ation | 2.4681 | (Correlated) | 0.00 | 6.0000 |
| station | 0.1440 | (Correlated) | 0.00 | 1.0000 |

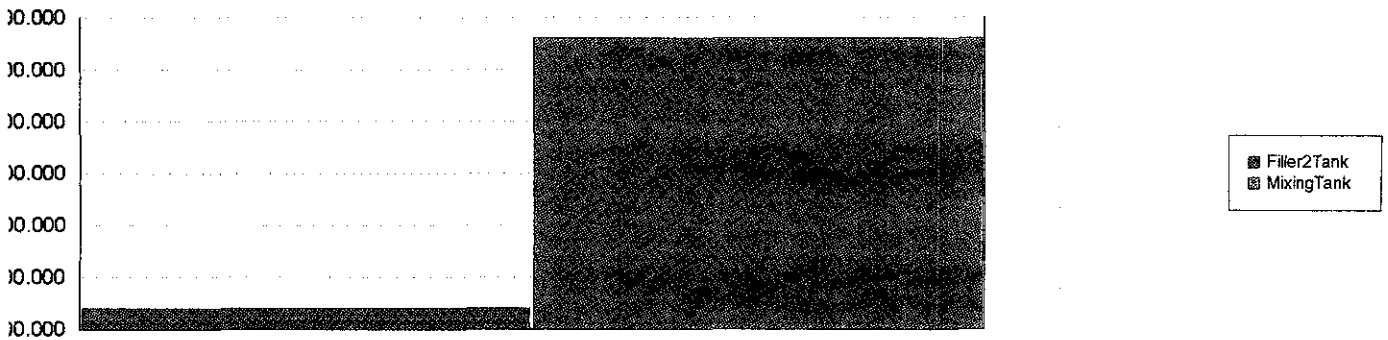
Soap Batch Process

ons: 1 Time Units: Minutes

| | Average | Half Width | Minimum Value | Maximum Value |
|----|---------|--------------|---------------|---------------|
| k | 46.5219 | (Correlated) | 0.00 | 100.00 |
| ik | 108.06 | (Correlated) | 0.00 | 500.00 |

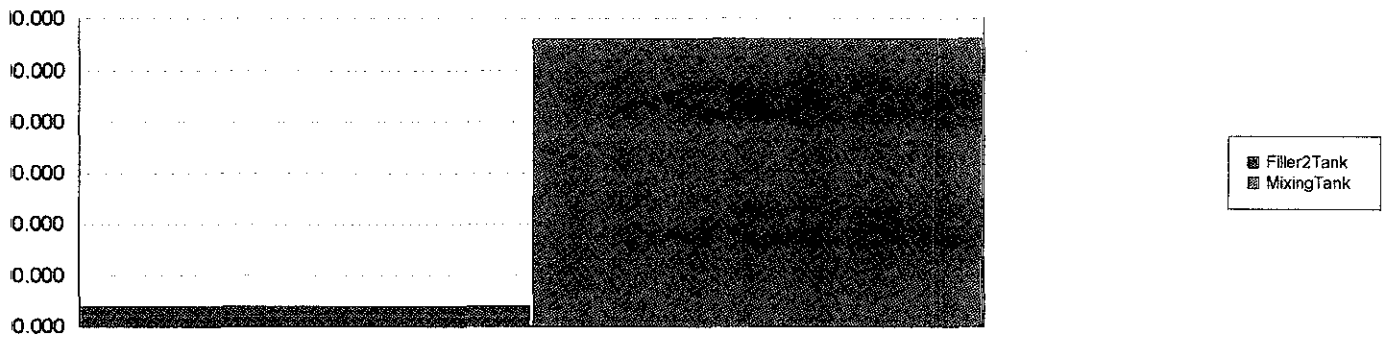
Quantity Added

| | Value |
|----|----------|
| k | 16397.39 |
| ik | 21597.39 |



Quantity Removed

| | Value |
|----|----------|
| k | 16397.39 |
| ik | 21597.39 |



Soap Batch Process

Replications: 1

Simulation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units:

Minutes

Detail Summary

| | NVA Time | Other Time | Total Time | Transfer Time | VA Time |
|--------|----------|------------|------------|---------------|---------|
| Entity | 0.00 | 0.20 | 1.02 | 5.52 | 0.43 |
| | 0.00 | 0.20 | 1.02 | 5.52 | 0.43 |

| | Number In | Number Out |
|--------|-----------|------------|
| Entity | 3 | 1 |
| | 23,106 | 23,101 |
| | 23,109 | 23,102 |

Wait Time

2.20

2.20

Soap Batch Process

Replications: 1

| | | | | | |
|-------------|-------------|------|------------|----------|---------------------|
| Iteration 1 | Start Time: | 0.00 | Stop Time: | 1,440.00 | Time Units: Minutes |
|-------------|-------------|------|------------|----------|---------------------|

/ 1

| Item | Value | | | |
|------------|--------|----------------|------|--------|
| Lumber In | 3 | | | |
| Lumber Out | 1 | | | |
| MP | 1.9999 | (Insufficient) | 0.00 | 2.0000 |

Soap Batch Process

Replications: 1

Simulation 1

Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

Bottle

| Entity | Average | Half Width | Minimum | Maximum |
|---------------|---------|--------------|---------|---------|
| Transfer Time | 5.5167 | (Correlated) | 5.5167 | 5.5167 |
| Wait Time | 2.2000 | 0.000000000 | 2.2000 | 2.2000 |
| Total Time | 1.0167 | 0.000000000 | 1.0167 | 1.0167 |
| Setup Time | 0.4333 | 0.000000000 | 0.4333 | 0.4333 |
| Other Time | 0.2000 | (Correlated) | 0.2000 | 0.2000 |
| VA Time | 0.00 | 0.000000000 | 0.00 | 0.00 |

| Entity | Value | | | |
|------------|---------|--------------|------|---------|
| Number In | 23,106 | | | |
| Number Out | 23,101 | | | |
| WIP | 17.5252 | (Correlated) | 0.00 | 37.0000 |

Soap Batch Process

Replications: 1

Iteration 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units:

Minutes

Process Detail Summary

per Entity

| | <u>Total Time</u> | <u>VA Time</u> | <u>Wait Time</u> |
|---|-------------------|----------------|------------------|
| x | 0.03 | 0.03 | 0.00 |

Simulated Time

| | <u>VA Time</u> | <u>Wait Time</u> |
|---|----------------|------------------|
| x | 59.23 | 0.00 |

| | <u>Number In</u> | <u>Number Out</u> |
|---|------------------|-------------------|
| x | 1,777.00 | 1,777.00 |

Soap Batch Process

Replications: 1

Simulation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units:

Minutes

Box

| Measure per Entity | Average | Half Width | Minimum | Maximum |
|-----------------------|------------|--------------|------------|------------|
| Time Per Entity | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |
| Total Time Per Entity | 0.03333333 | (Correlated) | 0.03333333 | 0.03333333 |
| Wait Time Per Entity | 0 | 0.00000000 | 0 | 0 |

| Accumulated Time | Value |
|------------------|---------|
| Sum VA Time | 59.2333 |
| Sum Wait Time | 0 |

| Count | Value |
|------------|-------|
| Number Out | 1,777 |
| Number In | 1,777 |

| | |
|---------------------------|-----------------|
| Soap Batch Process | Replications: 1 |
|---------------------------|-----------------|

| | | | |
|---------------------|------------------|---------------------|---------------------|
| Simulation 1 | Start Time: 0.00 | Stop Time: 1,440.00 | Time Units: Minutes |
|---------------------|------------------|---------------------|---------------------|

Queue Detail Summary

➤

| | <u>Waiting Time</u> |
|------------------------------------|---------------------|
| Ingredients Added.Queue | 0.00 |
| Into Box.Queue | 0.18 |
| Box.Queue | 0.00 |
| Cappper2.Queue | 0.00 |
| Filler2Tank Regulator.Queue | 0.00 |
| OrderAuthorization.Queue | 116.63 |
| Until Order Completed Filler.Queue | 0.50 |
| Until Order Completed.Queue | 5.21 |

➤

| | <u>Number Waiting</u> |
|------------------------------------|-----------------------|
| Ingredients Added.Queue | 0.00 |
| Into Box.Queue | 2.71 |
| Box.Queue | 0.00 |
| Cappper2.Queue | 0.00 |
| Filler2Tank Regulator.Queue | 0.00 |
| OrderAuthorization.Queue | 1.30 |
| Until Order Completed Filler.Queue | 0.00 |
| Until Order Completed.Queue | 0.06 |

Soap Batch Process

Replications: 1

Simulation 1

Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

Ingredients Added.Queue

| Queue | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Waiting Time | 0 | (Insufficient) | 0 | 0 |
| Queue | Average | Half Width | Minimum | Maximum |
| Number Waiting | 0 | (Insufficient) | 0 | 3.0000 |

Into Box.Queue

| Queue | Average | Half Width | Minimum | Maximum |
|----------------|---------|--------------|---------|---------|
| Waiting Time | 0.1833 | (Correlated) | 0 | 0.3667 |
| Queue | Average | Half Width | Minimum | Maximum |
| Number Waiting | 2.7149 | (Correlated) | 0 | 12.0000 |

Box.Queue

| Queue | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Waiting Time | 0 | 0.000000000 | 0 | 0 |
| Queue | Average | Half Width | Minimum | Maximum |
| Number Waiting | 0 | (Insufficient) | 0 | 0 |

Copper2.Queue

| Queue | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Waiting Time | 0 | 0.000000000 | 0 | 0 |
| Queue | Average | Half Width | Minimum | Maximum |
| Number Waiting | 0 | (Insufficient) | 0 | 0 |

Soap Batch Process

Replications: 1

Simulation 1 Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

Filler2Tank Regulator.Queue

| Queue | Average | Half Width | Minimum | Maximum |
|----------------|------------|--------------|---------|------------|
| Waiting Time | 0.00000000 | (Correlated) | 0 | 0.00000000 |
| Queue | Average | Half Width | Minimum | Maximum |
| Number Waiting | 0.00000000 | (Correlated) | 0 | 1.0000 |

OrderAuthorization.Queue

| Queue | Average | Half Width | Minimum | Maximum |
|----------------|---------|----------------|---------|---------|
| Waiting Time | 116.63 | (Insufficient) | 0 | 268.74 |
| Queue | Average | Half Width | Minimum | Maximum |
| Number Waiting | 1.2958 | (Insufficient) | 0 | 6.0000 |

Until Order Completed Filler.Queue

| Queue | Average | Half Width | Minimum | Maximum |
|----------------|------------|----------------|---------|---------|
| Waiting Time | 0.5000 | (Insufficient) | 0.5000 | 0.5000 |
| Queue | Average | Half Width | Minimum | Maximum |
| Number Waiting | 0.00104167 | (Insufficient) | 0 | 1.0000 |

Until Order Completed.Queue

| Queue | Average | Half Width | Minimum | Maximum |
|----------------|------------|----------------|---------|---------|
| Waiting Time | 5.2081 | (Insufficient) | 5.2081 | 5.2081 |
| Queue | Average | Half Width | Minimum | Maximum |
| Number Waiting | 0.05786775 | (Insufficient) | 0 | 1.0000 |

| | |
|---------------------------|-----------------|
| Soap Batch Process | Replications: 1 |
|---------------------------|-----------------|

| | | | |
|--------------------|------------------|---------------------|---------------------|
| Operation 1 | Start Time: 0.00 | Stop Time: 1,440.00 | Time Units: Minutes |
|--------------------|------------------|---------------------|---------------------|

Resource Detail Summary

3

| | <u>Inst Util</u> | <u>Num Busy</u> | <u>Num Sched</u> | <u>Num Seized</u> | <u>Sched Util</u> |
|----------------|------------------|-----------------|------------------|-------------------|-------------------|
| Server2 | 0.25 | 0.25 | 1.00 | 21,324.00 | 0.25 |
| ServerAuthoriz | 0.50 | 0.50 | 1.00 | 16.00 | 0.50 |
| ServerConfig | 0.04 | 0.04 | 1.00 | 1,777.00 | 0.04 |

Soap Batch Process

Replications: 1

ation 1

Start Time: 0.00 Stop Time: 1,440.00 Time Units: Minutes

er2 Resource

| age | Value | | | |
|---------------------------|-----------|----------------|--------|--------|
| Total Number Seized | 21,324.00 | | | |
| Scheduled Utilization | 0.2468 | | | |
| Number Scheduled | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Number Busy | 0.2468 | (Correlated) | 0 | 1.0000 |
| Instantaneous Utilization | 0.2468 | (Correlated) | 0 | 1.0000 |

rAuthorization

| age | Value | | | |
|---------------------------|---------|----------------|--------|--------|
| Total Number Seized | 16.0000 | | | |
| Scheduled Utilization | 0.4975 | | | |
| Number Scheduled | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Number Busy | 0.4975 | (Insufficient) | 0 | 1.0000 |
| Instantaneous Utilization | 0.4975 | (Insufficient) | 0 | 1.0000 |

ing Resource

| age | Value | | | |
|---------------------------|------------|----------------|--------|--------|
| Total Number Seized | 1,777.00 | | | |
| Scheduled Utilization | 0.04113426 | | | |
| Number Scheduled | 1.0000 | (Insufficient) | 1.0000 | 1.0000 |
| Number Busy | 0.04113426 | (Correlated) | 0 | 1.0000 |
| Instantaneous Utilization | 0.04113426 | (Correlated) | 0 | 1.0000 |

Soap Batch Process

Replications: 1

ation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: Minutes

Detail Summary

| | <u>Level</u> |
|------|--------------|
| Tank | 46.52 |
| Tank | 108.06 |

Quantity Added

| | <u>Total Quantity Added</u> |
|------|-----------------------------|
| Tank | 16397.39 |
| Tank | 21597.39 |

Quantity Removed

| | <u>Total Quantity Removed</u> |
|------|-------------------------------|
| Tank | 16397.39 |
| Tank | 21597.39 |

Soap Batch Process

Replications: 1

ation 1

Start Time:

0.00

Stop Time:

1,440.00

Time Units: **Minutes****2Tank**

| rel | Average | Half Width | Minimum | Maximum |
|-------|---------|--------------|---------|---------|
| level | 46.5219 | (Correlated) | 0 | 100.00 |

| al Quantity Added | Value |
|----------------------|-----------|
| Total Quantity Added | 16,397.39 |

| al Quantity Removed | Value |
|------------------------|-----------|
| Total Quantity Removed | 16,397.39 |

igTank

| rel | Average | Half Width | Minimum | Maximum |
|-------|---------|--------------|---------|---------|
| level | 108.06 | (Correlated) | 0 | 500.00 |

| al Quantity Added | Value |
|----------------------|-----------|
| Total Quantity Added | 21,597.39 |

| al Quantity Removed | Value |
|------------------------|-----------|
| Total Quantity Removed | 21,597.39 |