THE USE OF DISCRETE EVENT SIMULATION TECHNIQUES TO OPTIMIZE A PROPOSED FACTORY LAYOUT

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submitted in part fulfilment of the requirement for the degree of M ENG. in the Department of MECHANICAL ENGINEERING in the Faculty of ENGINEERING at the University of Durban - Westville.

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PROPOSAL OF THESIS

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   LAYOUT
7. MOTIVATION:

The manufacturing and packing capacity of a large company is being increased to meet expected sales demands. The company currently has seven packing machines which pack either of two products in any one of five packs varying from 150g to 5Kg. Once packed, each product/pack combination must be treated as a discrete entity.The product exits the packing machines in cases which are then automatically palletised. Six pallets are loaded onto a mini - train which is towed to the warehouse with a manually driven tow tractor. The company intends to increase the number of packing machines to eleven over a four year period. It is also intended to replace the mini - trains by automatic guided vehicles (AGVs). This would require a redesign of the warehouse.

The products to be packed are in powder form. The difficulty in ensuring free flow of the powders and consistent loading of the packs results in frequent stoppages of the packing machines. Due to the random nature of these stoppages it is almost impossible to predict the performance of these machines by conventional calculations. As the investment in handling equipment will cost several million Rand, it is in the interest of the factory that necessary and sufficient equipment be installed to ensure optimum use of all resources while satisfying market demands.

The purpose of this project is to establish whether discrete event simulation techniques can be used to simulate, on computer, the packing, palletising and warehousing departments of the factory. The simulation should be verified on the existing system and then be used to analyze various alternatives on the new system to assist in decision making on the expansion of the palletising system and to determine the optimum number of AGVs required. Since the object of the study is to increase the throughput of the factory at minimum capital cost, the results of the simulation will be used to optimize the equipment installed.

This is a specialized application to a particular factory and has not been researched by others. It requires the application of a computer simulation technique previously not used in this specific application.The technique requires substantial research and experimentation to ensure that the model simulates correctly the performance of the installed system.

8. Methodology

Workstudy methods will be used to obtain information on the existing factory. Although the equipment is automatic, the processes are complex and machinery requires periodic adjustment to ensure performance to specification. This causes random interruptions to the production process. This information will be used to prepare a computer model of the existing system.

The accuracy of the model will then be tested by inputting into the simulation, actual packing speeds, and run and stop durations for a number of shifts and comparing the simulated results to that which occurred in the factory during those shifts. Once the model is shown to reasonably represent the existing system, modifications will be made to test various alternatives of the new system to evaluate whether equipment selected is optimal.

Additional alternatives to be investigated will include variations to pallet size and packing height and alternative means of transporting products to the warehouse.

The output from the simulation of the palletising system will be the input into the warehouse. The warehouse will then be redesigned to accommodate AGVs. A simulation of the warehouse will then be done to determine the optimum number of AGVs required. A final report will then be prepared and submitted.

9. Provisional Structure of the Report

A. Executive Summary

Summary of the main aspects of the project, findings and recommendations.

B. Main Report

1. Introduction (Problem Statement)
2. The Existing System
3. Simulation of the existing system
4. Model verification
5. The Proposed System
6. Simulation of the proposed system
7. Analysis of alternatives
8. Warehouse Design
9. Simulation of the Warehouse
10. Recommendations
11. Conclusion
12. Appendices

10 Registration at other Universities

This is a specialized application to a particular factory. Similar work in other factories would not be applicable to these particular circumstances. This project is not registered at another university.

11 Funding

No funding is required from the university as this project is fully supported by the factory who will provide the financial support for the purchase of computer software, travelling expenses etc.

M.Gokal	Prof. A M Guthrie
(candidate)	(intended supervisor)

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SYNOPSIS

This project has proved conclusively that discrete event simulation techniques can be used to simulate, on computer, a complex stochastic materials handling system. The packing, automatic palletising and warehousing departments of a large powders manufacturing factory was used as an example to investigate the capabilities of computer simulation.

The company intends to increase the number of packing machines from seven to eleven, and has embarked on productivity improvement projects that aims to increase the average packing efficiency from the current 50%, to 60% with a long term goal of 70%. Due to the stochastic nature of the run and stop durations of the packing machines, it was impossible to predict the effect of the increased throughput on the palletising system by conventional means.

The system was modelled on computer using the SIMAN simulation language. Extensive research was initially carried out in order to determine the operating parameters of the system. The generation of cases from the packing machines in the program was verified against actual production runs.

Various alternatives were analyzed to assist in decision making on the expansion of the palletising system in order to accommodate the increased throughput expected from the packing floor. The simulation was therefore used to increase the capacity of the automatic palletising system at minimal cost while meeting demands from the packing floor. It was established that the only capital expenditure required would be about R500 000 to increase the capacity of a palletiser and to provide a pallet conveyor to transport 40% of the pallets to direct despatch.

1. INTRODUCTION

The manufacturing and packing capacity of a large company is being increased to meet expected sales demands. The company currently has seven packing machines which pack either of two products in any one of five packs varying from 150g to 5Kg. Once packed, each product/pack combination is treated as a discrete entity. The product exits the packing machines in cases which are then automatically palletised. Six pallets are loaded onto a mini - train which is towed to the warehouse with a manually driven tow tractor. The company intends to increase the number of packing machines to eleven over a four year period. It is also proposed to replace the mini - trains by automatic guided vehicles (AGVs).

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The simulation will be used to analyze various alternatives on the new system to assist in decision making on the expansion of the palletising system and to determine the optimum number of AGVs required. Since the object of the study is to increase the throughput of the factory at minimum capital cost, the results of the simulation will be used to optimize the equipment installed.

2. THE EXISTING SYSTEM

The characteristics of the existing system was determined using standard work study techniques and by discussions with the suppliers of the equipment. This was done by the researcher over a 15 week period from June 1987 to June 1989. Most of the investigation was performed over two and three week periods, during the researcher's winter and summer holidays.

A block diagram of the existing system is shown in figure 1. There are 7 packing machines. The products are filled into cartons and packed into cases at the packing machines. Once five cases have accumulated at the end of the packing machines they are discharged onto one of two "warehouse" conveyors. The cases are identified at the case recognition system installed on the "warehouse" conveyors and directed to the respective case accumulation conveyors.

Cases not identified by the system are directed to the carousel where they are manually palletised. The pallets are block stacked and loaded onto mini - trains using fork trucks. The mini - trains transport the pallets to the warehouse.

There are 9 case accumulation conveyors. Each conveyor is dedicated to a single product. Products with a high throughput rate are allocated to two conveyors.

The cases are palletised on automatic palletisers and the pallets are sent to pallet accumulation conveyors. There are 2 automatic palletisers and 9 pallet accumulation conveyors. Each pallet accumulation conveyor is dedicated to a single product. Once 6 pallets have accumulated on a conveyor they are discharged to the mini - train loader. These 6 pallets are transferred individually, using a transfer car, to the mini - train. The mini - train transports the pallets to the warehouse.

FIGURE 1 : BLOCK DIAGRAM - EXISTING SYSTEM

AUTOMATIC PALLETISING SYSTEM
EXISTING CONFIGURATION

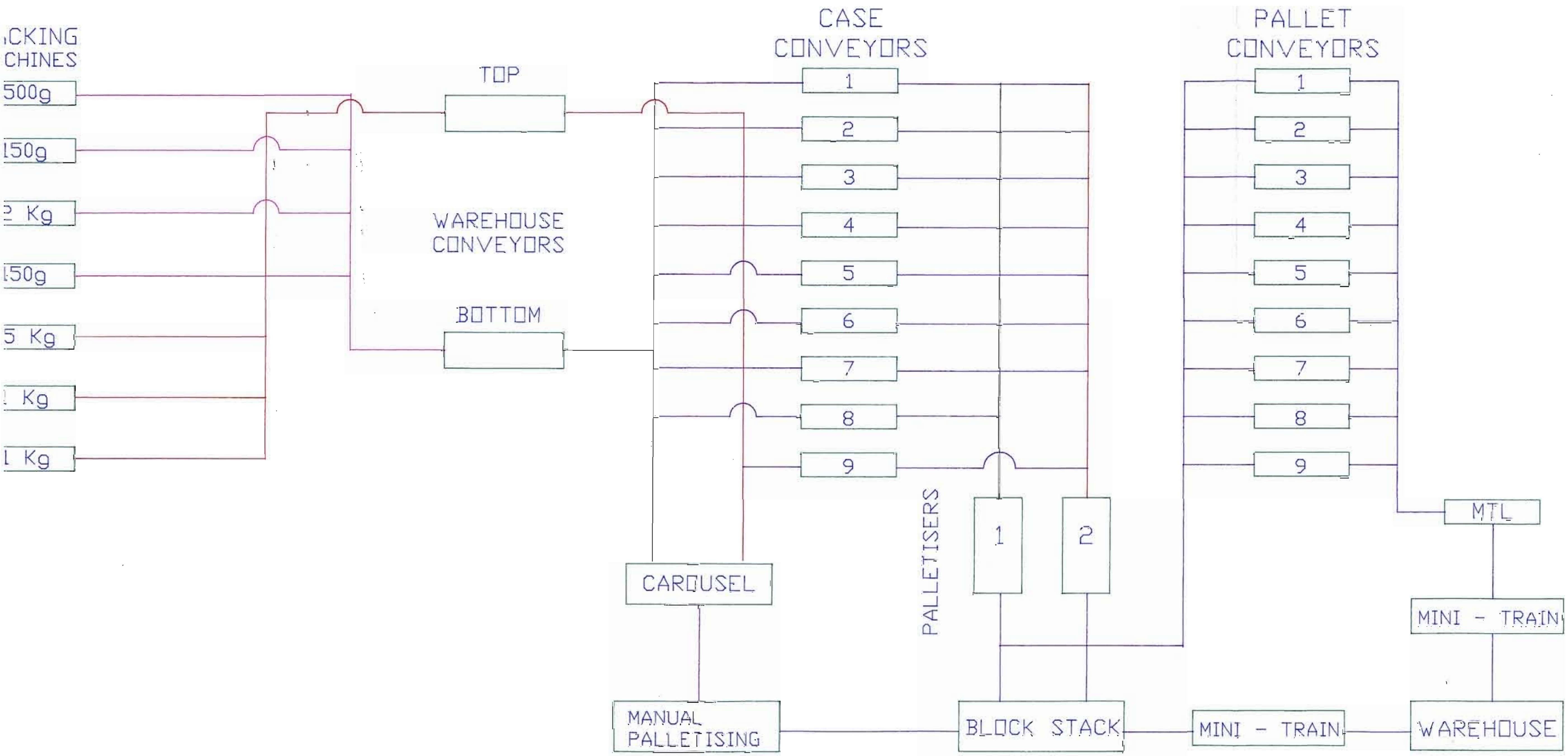


Fig 1 : Block Diagram - Existing System

2.1 The Packing Floor

The packing floor has seven packing machines. The products are packed in 5 pack sizes viz. 150g, 500g, 1Kg, 2Kg and 5Kg. In order to simplify the tables and the writing of the simulation program it was decided to code the pack sizes as follows:

A : 150g ; B : 500g ; C : 1Kg ; D : 2Kg ; E : 5Kg.

11 : Product 1 ; 22 : Product 2

The packing speeds, pack sizes, cases per pallet etc. are shown in table 1 below.

M/C No.	PROD	CTNS/MIN	CTN/CC	CC/MIN	CC/PALL
1	B11	210	36	5.83	40
2	A11	285	72	3.96	40
3	D11	100	8	12.5	28
4	A11	270	72	3.75	40
5	E11	20	4	5.00	21
6	C11	160	18	8.89	20
7	C11	160	18	8.89	20

CTNS - CARTONS ; CC - CASES ; PALL - PALLETS

TABLE 1 : CURRENT PACKING FLOOR PARAMETERS

A study of the run and stop durations of the packing machines was carried out. The results, presented in the form of a frequency distribution, are in appendix I.

The 150g line runs at an average efficiency of 75%. The average efficiency of the other machines is 50%.

2.2 Case Accumulation Conveyors

There are nine case accumulation conveyors. The cases are transported from the packing machines to the case accumulation conveyors via two "warehouse" conveyors. Each case accumulation conveyor is dedicated to a particular product/pack combination. Products with a high throughput rate are designated to two conveyors. The cases reside on the accumulation conveyors until sufficient cases for a full pallet load have accumulated. The cases are then released to an available palletiser. There is an additional accumulation of 5 cases on the take up conveyors at the end of each packing machine. If an accumulation conveyor is full, the corresponding packing machine stops.

The lengths of each of the conveyors together with the available accumulation per pack size is shown in the table 2.

		MAXIMUM AVAILABLE ACCUMULATION (CASES)				
CONV.	CONV.	PACK SIZE (CASE LENGTH m)				
NO.	LENGTH(m)	A(.406)	B(.493)	C(.580)	D(.488)	E(.513
1	23.70	63	53	45	53	51
2	19.20	52	43	38	44	42
3	19.64	53	44	38	45	43
4	19.82	53	45	39	45	43
5	24.52	65	54	47	55	52
6	24.52	65	54	47	55	52
7	20.03	54	45	39	46	44
8	24.37	65	54	47	54	52
9	24.37	65	54	47	54	52

<u>Note</u> : The buffer of 5 cases at the end of the packing machines is added to the number of cases on the case accumulation conveyors to give the maximum accumulation available per pack size.

TABLE 2 : CASE ACCUMULATION CONVEYOR CAPACITY

2.3 Automatic Palletisers

There are two automatic palletisers which draw cases from the nine case accumulation conveyors. The palletising times vary between different pack sizes depending on the number of cases per pallet and the number of layers. The palletising time for the various pack sizes are shown in table 3 below.

Pack Size	Palletising Time (secs.)
150g (A)	59.2
500g (B)	47.8
1Kg (C)	41.1
2Kg (D)	51.5
5Kg (E)	44.5

TABLE 3 : AUTOMATIC PALLETISER CAPACITY

The run and stop patterns for the automatic palletisers is shown in appendix I.

The efficiency of the palletisers is 95%.

2.4 Pallet Accumulation Conveyors

There are nine pallet accumulation conveyors each with a capacity of twelve pallets. Each conveyor is dedicated to a single product. Once six pallets have accumulated on the conveyor they are discharged to the MTL when it becomes available. If a pallet accumulation conveyor is full, additional corresponding pallets are removed using fork trucks. The pallets are stacked and later loaded onto mini - trains using fork trucks.

2.5 Mini - Train Loader (MTL)

The nine pallet accumulation conveyors discharge onto a single pallet conveyor which transports the pallets to the MTL. Batches of six pallets are transported via this conveyor to the MTL. The pallets are transferred to the mini - train using a transfer car which indexes consecutively to each of the six pallets on the MTL. The transfer car returns to the start position while the pallets load onto the transfer conveyor. The cycle then repeats itself.

A study of the operation of the MTL revealed the following:

i) The cycle time is 2.9 minutes

ii) MTL delays are caused by stuck pallets, repairs to case flaps and mini - train delays.

iii) The efficiency of the MTL is 66%

The mini - train consists of six coaches and is drawn by a small electrically driven tractor which is manually controlled. Mini - train delays occur when there are no mini - trains available to load the pallets or when a loaded train cannot be removed because the driver has un - hitched the coaches and is busy elsewhere in the warehouse.

During periods of MTL delays the 6 pallets reside on the transfer conveyor and the pallet accumulation conveyors are prevented from discharging. If any of these conveyors reach their full capacity, the corresponding pallets are removed from the palletisers by fork trucks.

The run and stop patterns for the MTL are shown in appendix I.

3. THE PROPOSED SYSTEM

A block diagram of the proposed system is shown in figure 2. The number of packing machines will be increased to eleven. In order to increase the throughput of the packing floor, the company intends to increase the packing speeds of the new as well as the existing machines. Table 4 below gives the new packing speeds per machine, the cartons per case, and the cases per pallet for 1.6m and 2.1m pallet load heights. The 2.1m pallet load height has an extra layer of cases.

It is not possible at the moment to predict the capacities of the various sections of the automatic palletising system. Various alternatives are being considered and these are presented in chapter 4.

MACHINE NUMBER	PRODUCT	PACK SPEED (ctns/min)	CARTONS PER CASE	PACK SPEED (cases/min)	CASES/PALLET 1.6m	CASES/PALLET 2.1m
1	B11	210	36	5.83	24	32
2	A11	285	72	3.96	40	50
3	D11	100	8	12.5	28	42
4	A11	270	72	3.75	40	50
5	B22	250	36	6.94	24	32
6	C11	160	18	8.89	20	30
7	C11	160	18	8.89	20	30
8	B22	240	36	6.67	24	32
9	C22	160	18	8.89	20	30
10	A22	280	72	3.89	40	50
11	E11	20	4	5.00	21	28

A:150g ; B:500g ; C:1Kg ; D:2Kg ; E:5Kg

11: PRODUCT 1 ; 22: PRODUCT 2

TABLE 4 PROPOSED PACKING FLOOR PARAMETERS

FIGURE 2 : BLOCK DIAGRAM - PROPOSED SYSTEM

AUTOMATIC PALLETISING SYSTEM
PROPOSED CONFIGURATION

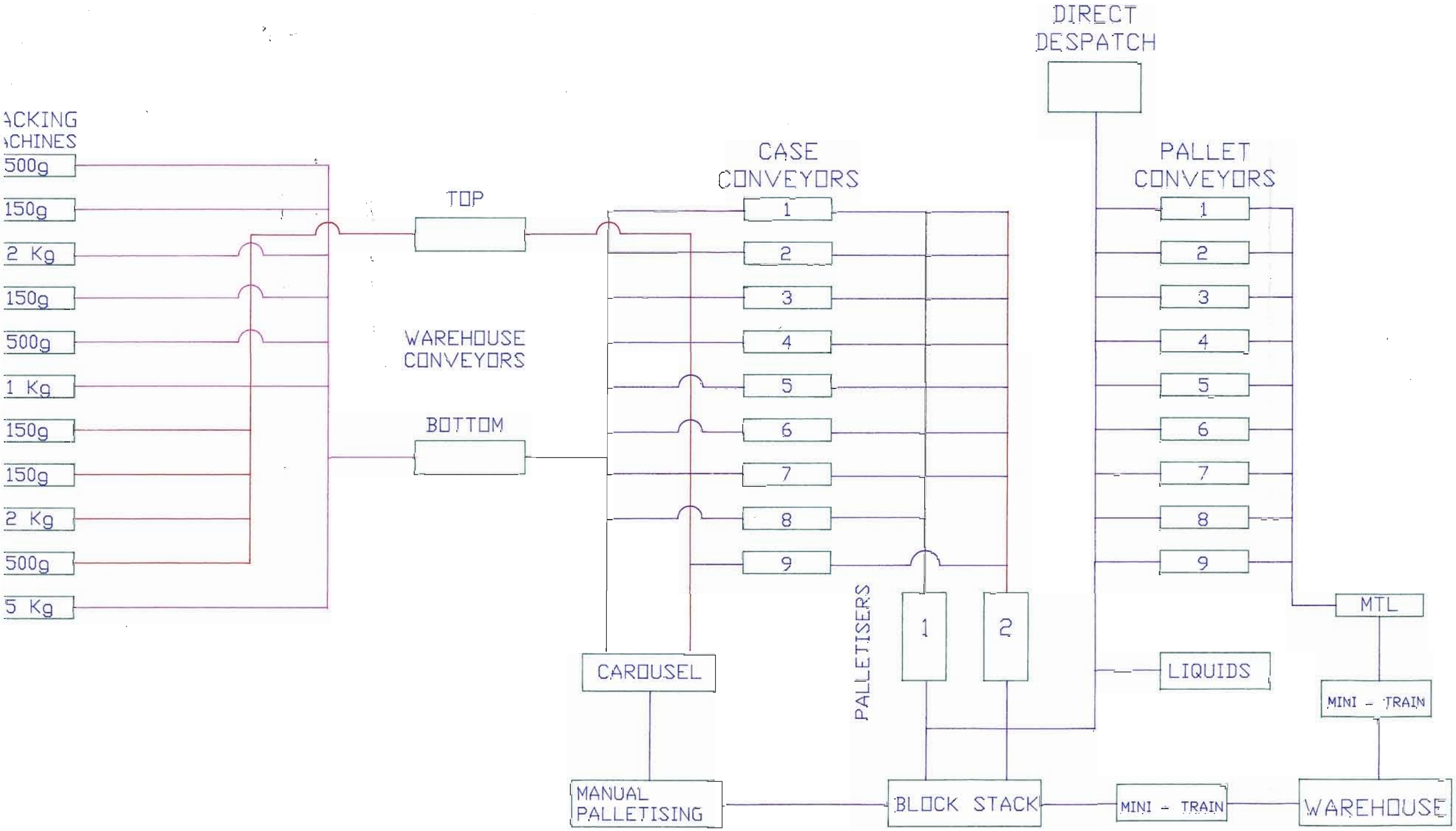


Fig 2 : Block Diagram - Proposed System

4 ALTERNATIVES

4.1 Packing Efficiency

Due to the complexity of the palletising system and the high capital cost involved, it is necessary to analyze all alternatives in order to optimize the equipment installed. This would eliminate the unnecessary expenditure involved in over design of the system while having sufficient capacity to meet predicted demands.

The packing machines stop for a number of reasons. The most common stop causes are carton jam, sticky powder, mass control problems, dirty glue rollers, carton guides out of alignment, dirty conveyors and case sealer breakdown. The current average packing efficiency is 50%. The company however, is involved in a number of productivity improvement projects and envisage increasing this efficiency to 60% in the short term, with a long term goal of 70%. It is therefore essential to investigate the effects of both the 60% and 70% packing efficiencies on the various configurations of the palletising system.

4.2 Pallet Load Height

The average pallet load height is currently 1.6m. The products are transported to other distribution warehouses in the country via road vehicles. With the 1.6m high pallet loads, a large space exists between the top of the pallet and the roof of the vehicle. Due to the high transportation costs and the expected increases in these costs in the future, massive savings could be realized by utilizing this space. This could be achieved by manually packing cases over the pallets in the vehicle or increasing the load height on the pallets. The manual packing of cases is not desirable as this is labour intensive and would increase the time required to load the vehicle. Investigations show that a 2.1m pallet height would adequately utilize the space in the vehicle eliminating totally the need to manually pack cases above the pallets. A 2.1m pallet load height can be achieved by palletising an additional layer of cases on the pallets. This can be easily accomplish by making slight modifications to the palletisers and re - programming the programmable logic controllers (PLCs).

Due to the increase in the number of cases per pallet, more case accumulation would be required, thereby reducing the buffer time available on the accumulation conveyors after a full pallet load of cases has accumulated. This could result in more frequent stops of the packing machines due to case accumulation overflow. It is therefore necessary to determine the effect of the increased pallet load height on the automatic palletising system.

4.3 Direct Despatch

All products, once palletised, are currently sent to the pallet accumulation conveyors from where they are transported via mini - trains to the warehouse. In order to reduce the working capital tied up in stock, serious consideration is being given to despatching 40% of the production directly from the palletisers. It is envisaged that these pallets will travel via a pallet conveyor to the despatch holding area directly from the palletisers (see figure 2). This means that only 60% of the pallets enter the pallet accumulation conveyors. This alternative will have a tremendous impact on the capacity constraints of the mini - train loader. It is possible that this will eliminate the need to invest large amounts of capital to increase the capacity of this section of the system.

Liquids products are manufactured, packed and palletised in the building alongside the powders factory. The liquids pallets are currently transported directly to the warehouse and do not affect the powders palletising system. With the direct despatch alternative, 40% of the liquids pallets must also be sent to direct despatch. These pallets will be introduced into the system downstream of the palletisers before the pallet accumulation conveyors and will be transported to direct despatch via the same pallet conveyor used to transport the powders pallets (see figure 2). Although the liquids pallets will not affect the palletising system, it must be included in the investigation to determine the total number of pallets entering the direct despatch area, and the rate at which these pallets pass the check point.

4.4 Automatic Guided Vehicles

One of the main causes of capacity constraints on the mini - train loader is mini - train delays resulting from no mini - trains or no driver. The mini - train loader is unavailable while experiencing mini - train delays resulting in pallet accumulation overflow. The possibility of using automatic guided vehicles (AGVs) to tow the mini - train coaches to the warehouse is being investigated. The use of AGVs would result in a reduction of the delays caused by mini - trains thereby reducing the occurrences of pallet accumulation overflow.

4.5 Automatic Palletisers

There are currently two automatic palletisers, each with a rated capacity of 35 cases per minute. It is possible to increase the capacity of the palletisers to 56 cases per minute by modifying them to palletise on two layers simultaneously.

Three alternatives with the palletisers are to be considered. These are:

i) Use the two palletisers as existing.

ii) Keep one palletiser as existing and modify the other to the increased capacity of 56 cases per minute.

iii) Install a third palletiser rated at 35 cases per minute.

5. SIMULATION

5.1 Introduction

In a highly industrialized and capitalised industry poor decisions could be very costly. There is therefore a need for procedures and techniques to assist the Industrial Engineer in decision making. A number of techniques have been developed, most of which use the concept of building a model of the system under investigation. Due to the random components of many systems it is extremely difficult to accurately model these systems using conventional mathematical models.

Computer simulation is probably one of the only techniques capable of effectively modelling large random systems such as the automatic palletising system described in the chapters above. It is one of the most powerful techniques available for improving productivity through effective analysis, design and operation of complex processes and systems.

Many powerful and flexible simulation languages have been developed which enhance the feasibility of using simulation over other modelling techniques. One such language is the SIMAN simulation language.(Kruger)[1]

5.2 Simulation Modelling

Simulation modelling assumes that a physical system can be described in terms acceptable to a computing system. If a system can be characterized by a set of variables, with each combination of variable values representing a unique state or condition of the system, then manipulation of the variable values simulates movement of the system from state to state. Simulation can therefore be summarized as the representation of the dynamic behaviour of the system by moving it from state to state in accordance with well defined operating rules.

Within this context, a simulation model is a mathematical - logical representation of a system which can be exercised in an experimental fashion on a digital computer. Thus, a simulation model may be considered as a laboratory version of an existing or proposed real world system.(Pritsker)[2]

The two views most often employed for the development of simulation models of industrial systems are:

i) The "fixed time increment" approach for building continuous models, and

ii) The "next event" approach for building discrete models.

5.3 Continuous Simulation

The continuous simulation approach is usually employed in situations where the state variables of the system are perceived to change continuously with respect to time and a fixed increment time advance mechanism is appropriate. In figure 3 below, the basic concepts of the continuous simulation approach is illustrated.(Kruger)[1]

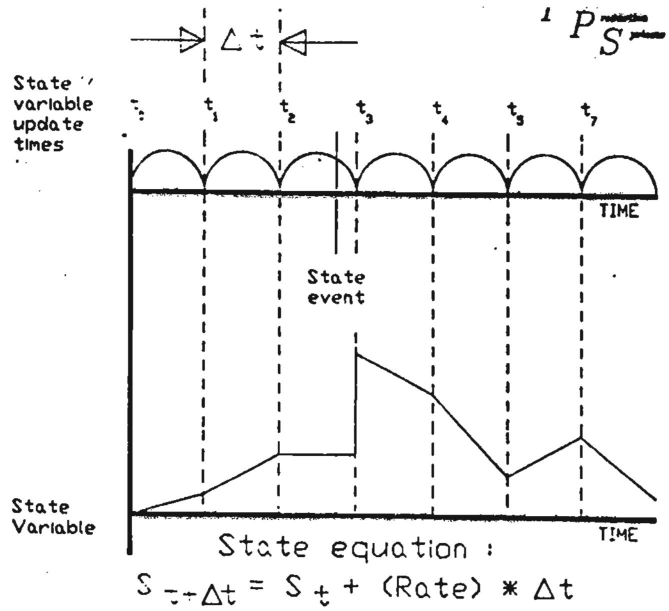


FIGURE 3 : CONTINUOUS SIMULATION APPROACH

5.4 Discrete Event Simulation

A discrete event simulation approach is appropriate when the state variables of the system change in a discrete and possibly stochastic way. One alternative for simulating such systems is known as the next event approach and the basic principles are illustrated in figure 4.(Kruger)[1]

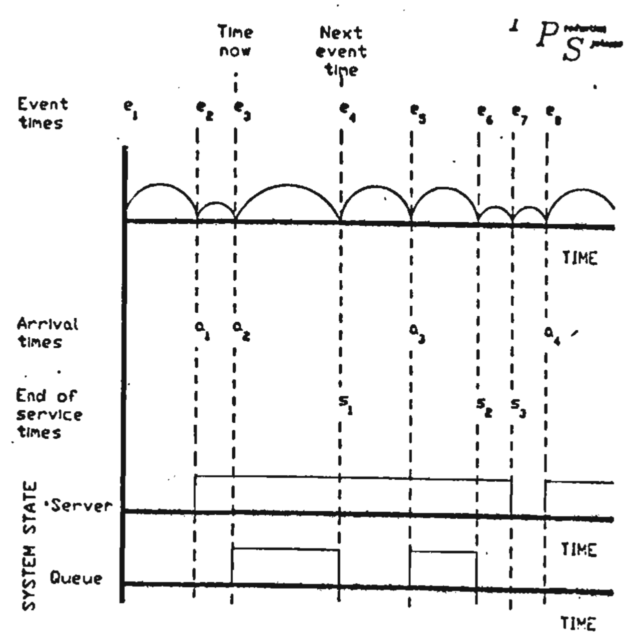


FIGURE 4 : THE NEXT EVENT DISCRETE APPROACH

As the name suggests, discrete event simulation logically follows the sequence of events programmed, and records what happens at queues, resources, transporters etc. Elapsed time between events are recorded as the simulation progresses. When the total planned simulation time is equaled or exceeded or when a certain event occurs (eg. production target reached) the process is stopped and the results are printed out.

As the automatic palletising system in this project is event controlled (cases will be palletised only when a sufficient number has accumulated for a full pallet load), discrete event simulation was used to model the system.

5.5 Stochastic Modelling

In either the continuous or discrete event simulation systems the processes could be stochastic or a combination of both deterministic and stochastic. Certain variables (eg. machine run and stop durations) have statistical properties of some empirical distribution. As these distributions are empirical and do not fit into any of the standard statistical distributions, the Monte Carlo simulated sampling technique was used to draw samples from the actual empirical distribution.

The process involved here is to initially determine the empirical distribution of the variable being sampled. This is achieved by analyzing the system and recording the empirical data. (For example a stop watch was used to record the run and stop durations of the packing machines in this factory

and the data presented in two frequency distribution tables - see appendix I). The frequency distribution is then converted to a cumulative probability distribution. The cumulative distribution is entered into the program with the sets of the cumulative probability and it's corresponding value separated by a comma (see line 54 in the experiment file in section 6.4). The computer generates a random number between 0 and 1 and selects the value corresponding to this number in the table. A convenient and effective source of random numbers is required for this purpose and the family of linear congruential generators is the most widely used technique.
The Monte Carlo simulated sampling technique described above was used in this project and is referred to as the discrete probability distribution in the SIMAN simulation language. This language has nine different random number generators.

5.6 Simulation Languages

High level special purpose simulation languages such as GPSS and SIMSCRIPT have been available on mainframe computers for a number of years. Recently, other languages such as SIMAN and SLAM have been developed.
With the ever increasing availability of low cost powerful micro computers, versions of most of the simulation languages that were originally developed for mainframe machines have been modified to run on micro computers, and other simulation systems were developed specifically for the micro computer environment.

These languages provide extensive modelling capabilities and various kinds of support software to meet user needs.
Examples of support software are: animation, file editors and output processors.
Some of the simulation languages available for use on micro computers are: GEMSII, GPSS/PC, MAST, SIMAN PC, SIMSCRIPT PC and SLAM PC. The first three of these languages can simulate using only the discrete event simulation approach, while the last three can simulate in both the discrete event and continuous approaches.
The prices range from R3000 to R12000 depending on whether any support software is purchased.
The SIMAN simulation language was used in this project for the following reasons:

i) The programme is written in two files - Model and Experiment files. The Model file simulates the system while the Experiment file contains the variables. The advantage is that various alternatives can be tested by making changes to the experiment file only, the model file remains unchanged.

ii) The language was readily available as the company purchased the SIMAN package prior to the researcher's involvement in this project.

iii) SIMAN is widely used in South Africa, and a number of people are competent in it's use. This provides a source of expertise in the language and people can be consulted to assist in solving complex simulation situations.

5.7 The SIMAN Simulation Language

SIMAN is a combined discrete continuous simulation analysis language for modelling general systems. It is a FORTRAN based simulation language which can run on mini - and 16 bit - micro computers as well as large computers.

The language is designed to allow the programme to be entered in two files viz. the system model and the experimental frame. The system model defines the static and dynamic characteristic of the system. The experimental frame defines the experimental conditions under which the model is run to generate specific output data. By separating the model structure and the experimental frame into two distinct elements, different simulation experiments can be run by changing only the experimental frame. The system model remains the same. The model and experimental files are linked using the SIMAN linker to produce a program file on which the simulation is run. The simulation program generates an output file which records the model state transitions as they occur in simulated time.(Pegden)[3]

To simulate all the alternatives of the proposed automatic palletising system, six model programs were written, one for each of the three palletiser alternatives and modifications on each of these three to allow for the 1.6m and 2.1m pallet heights. Each model was run on four different experiment files viz.:

i) All pallets via MTL for 60% packing efficiency,

ii) All pallets via MTL for 70% packing efficiency,

iii) 40% of pallets to direct despatch for 60% packing efficiency, and

iv) 40% of pallets to direct despatch for 70% packing efficiency.

This resulted in a total of 24 output files.

6 PROGRAM VERIFICATION

Before the actual model and experimental files were written it was necessary to verify the results of a simulation in order to ensure that the program simulated correctly the performance of the system. This was achieved by inputting into the simulation, actual packing speeds, and run and stop durations for a number of shifts and comparing the simulated results to the actual production. The model and experimental listing used in the verification process is in appendix II. The production in the main simulation program was generated in the same manner as in the verification program. The results of the verification experiments are summarized in table 5. The input parameters used are in appendix III. During the verification process, ten simulations were run per packing machine. The input parameters used in each run were the same, but a different set of random numbers were used. The simulated production (in cases) per packing machine is tabulated below. The mean of the ten simulation runs was calculated and is presented as a percentage of the actual production for comparison purposes.

SIMULATED PRODUCTION PER PACKING MACHINE

RUN	LINE3	LINE2	LINE6	LINE7	LINE1	LINE5
	2Kg	150g	1Kg	1Kg	500g	5Kg
1	3014	1498	995	1268	1522	705
2	2324	1443	1063	1285	1837	571
3	2570	1598	1152	1781	1776	677
4	2780	1330	1476	1164	1612	657
5	2588	1531	1031	1000	1476	628
6	2556	1461	1273	1128	1546	640
7	2942	1409	1158	1253	1550	744
8	2958	1596	1043	1462	1556	645
9	2824	1455	1068	1250	1758	672
10	2558	1437	1059	1341	1519	638
MEAN	2711	1476	1132	1293	1597	658
ACTUAL	3062	1654	1245	1556	1810	637
PERCENT	89	89	91	83	88	103

TABLE 5 : SUMMARY OF VERIFICATION EXPERIMENTS

From the above table it is clear that the simulation represents reasonably accurately the performance of the actual system.

7 SIMULATION PARAMETERS

The parameters used in the simulation are given in tables 6 and 7. The run and stop durations of the packing machines for 60% and 70% efficiency are in appendices IV and V respectively. These run and stop durations were determined by using the existing patterns as a base. A separate simulation was used to generate these patterns. This was achieved by a trial and error method over a number of simulation runs in which the frequencies of larger run durations were increased, the frequencies of shorter run durations decreased and the frequencies of longer stop durations decreased. The cases were generated in this simulation in the same manner as in the main programme, using the same random number generators and starting seeds.

It is envisaged that the run and stop patterns of the palletisers will remain unchanged.

The case accumulation conveyors were selected so as to equally distribute the cases as far as possible in the conveyors. This was achieved by calculating the available buffer in a conveyor after one pallet load of cases had accumulated. Appendix VI shows the tables used in calculating the available buffer. The case accumulation conveyor allocation was made within the physical constraints of the palletising systems. Appendix VII and figure 2 show these constraints.

The palletisers were selected so as to equally distribute the work load between them. Appendix VIII shows the palletiser selection for the three alternatives.

In the alternative where 40% of the pallets are sent to direct despatch, 40% of production from the liquids plant must also be accommodated. The calculation of the arrival times of the liquids pallets for the 60% and 70% efficiency is in appendix IX.

In tables 6 and 7 the products are coded as follows:

A : 150g ; B : 500g ; C : 1Kg ; D : 2Kg ; E :5Kg

11 : Product 1 ; 22 : Product 2 CC : cases

! Palletiser rated at : 35cc/min

* Palletiser rated at : 56cc/min

M/C No.	PRODUCT	SPEED MIN/CC	CASES/PALLET 1.6m	CASES/PALLET 2.1m	CASE CONVEYOR NO.	CASE CONVEYOR CAPACITY
1	B11	0.17	24	32	1	53
2	A11	0.25	40	50	6	65
3	D11	0.08	28	42	5	55
4	A11	0.27	40	50	6	65
5	B22	0.14	24	32	-	--
6	C11	0.11	20	30	8	47
7	C22	0.11	20	30	3	38
8	B22	0.15	24	32	4	45
9	C22	0.11	20	30	7	39
10	A22	0.26	40	50	9	65
11	E11	0.20	21	28	2	42

TABLE 6 : SIMULATION PARAMETERS - PACKING SPEED

M/C No.	PRODUCT	PALLETISING TIME (Mins) !1.6m	!2.1m	*1.6m	*2.1m
1	B11	0.80	1.07	0.50	0.67
2	A11	0.99	1.24	0.62	0.78
3	D11	0.86	1.29	0.54	0.81
4	A11	0.99	1.24	0.62	0.78
5	B22	0.80	1.07	0.50	0.67
6	C11	0.69	1.04	0.43	0.65
7	C22	0.69	1.04	0.43	0.65
8	B22	0.80	1.07	0.50	0.67
9	C22	0.69	1.04	0.43	0.65
10	A22	0.99	1.24	0.62	0.78
11	E11	0.74	0.99	0.46	0.62

TABLE 7 : SIMULATION PARAMETERS - PALLETISING TIME

The pallet conveyor has a capacity of 12 pallets. The MTL has a cycle time of 2.9 minutes for 6 pallets.

Ten packing lines are run at a time. Usually either the 500g (line 5) or the 5Kg (line 11) machine is run. The worst case ie. the 5Kg machine (line11) running, is simulated.

8 CODING

Due to the large number of simulation runs, a system of coding was used to keep track of the files. The three palletiser configurations were called alternatives A, B, and C. A is the existing configuration with 2 palletisers rated at 35cc/min. In alternative B one of the existing palletisers is upgraded to operate at 56cc/min. Alternative C has 3 palletisers each rated at 35cc/min.

All file names commence with APS (Automatic Palletising System). The first digit after APS in both the model and experiment files indicate the palletiser configuration ie. 1 for A, 2 for B and 3 for C. In the model file, the next digit 1 or 2 indicates the pallet height used, 1 for 1.6m and 2 for 2.1m. For example, the model file APS32 is the model of the system using three palletisers and 2.1m pallet height.

In the experiment file, the last two digits (60 or 70) indicate the packing efficiency, 60% or 70%. An experiment file APS370 would therefore be used when simulating the system with 3 palletisers and 70% packing efficiency.

The output file has 4 digits after the APS. The first 2 indicate the palletiser configuration and the pallet height. The last 2 represents the packing efficiency. If a D appears after the 4 digits, 40% of the pallets were sent to direct despatch. If the D is absent all pallets were removed via the MTL. An output file APS3270D is the result of the simulation of the system with 3 palletisers, 2.1m pallet height, 70% packing efficiency and 40% pallets to direct despatch.

Table 7 lists the 24 simulation files.

MODEL FILES	EXPMT FILES	OUTPUT FILES
APS11	APS160	APS1160
APS12	APS160	APS1260
APS11	APS170	APS1170
APS12	APS170	APS1270
APS21	APS260	APS2160
APS22	APS260	APS2260
APS21	APS270	APS2170
APS22	APS270	APS2270
APS31	APS360	APS3160
APS32	APS360	APS3260
APS31	APS370	APS3170
APS32	APS370	APS3270
APS11	APS160D	APS1160D
APS12	APS160D	APS1260D
APS11	APS170D	APS1170D
APS12	APS170D	APS1270D
APS21	APS260D	APS2160D
APS22	APS260D	APS2260D
APS21	APS270D	APS2170D
APS22	APS270D	APS2270D
APS31	APS360D	APS3160D
APS32	APS360D	APS3260D
APS31	APS370D	APS3170D
APS32	APS370D	APS3270D

TABLE 8 : SUMMARY OF SIMULATION FILES

9. SIMULATION OF THE PROPOSED SYSTEM

9.1 The Model File

The system shown in figure 2 was simulated using the SIMAN simulation language. The model files were kept as general as possible so as to accommodate many alternatives in one program. The different alternatives were activated from the experiment file. The option of sending pallets to direct despatch and the changes in packing efficiency was included in the same model file. Different model files were written to accommodate the three palletiser configurations, and the 1.6m and 2.1m pallet load heights. This resulted in six model files being written. These files were coded as described above. These files are:

i) APS11 - 2 palletisers rated at 35 cases per minute each
- 1.6m pallet load height

ii) APS12 - 2 palletisers rated at 35 cases per minute each
- 2.1m pallet load height

iii) APS21 - Palletiser 1 rated at 35 cases per minute
- Palletiser 2 rated at 56 cases per minute
- 1.6m pallet load height

iv) APS22 - Palletiser 1 rated at 35 cases per minute
- Palletiser 2 rated at 56 cases per minute
- 2.1m pallet load height

v) APS31 - 3 palletisers rated at 35 cases per minute each
- 1.6m pallet load height

vi) APS32 - 3 palletisers rated at 35 cases per minute each
- 2.1m pallet load height

The model of the alternative using the two existing palletisers and 1.6m pallet height (APS11) is shown below. The other five models are in appendices X to XIV.

MODEL FILE

```
BEGIN,1,1,YES,AUTOPALL,YES;
;AUTO PALLETISING SYS. - MODEL FILE "APS11.MOD" M. GOKAL
;1.6m PALLETS
; TWO PALLETISERS : 35cc/min each
;
         CREATE,1;
START1   ASSIGN:X(1)=ED(1);            Machine 1 packing speed
         DELAY:ED(2);                  run time duration
         ASSIGN:X(1)=ED(3);
         DELAY:ED(3):NEXT(START1);     stop time duration
         CREATE,1:X(1);                machine 1 (B11)
         COUNT:1,1;                    count production
         ASSIGN:A(1)=1;                case conveyor number
         ASSIGN:A(2)=24;               cases per pallet
         ASSIGN:A(3)=53;               case conveyor capacity
         ASSIGN:A(4)=0.80;             palletising time
         ASSIGN:A(5)=21:NEXT(BR1);     combined for palletiser
;
         CREATE,1;
START2   ASSIGN:X(2)=ED(4);            machine 2 packing speed
         DELAY:ED(5);                  run time duration
         ASSIGN:X(2)=ED(6);
         DELAY:ED(6):NEXT(START2);     stop time duration
```

```
                CREATE,1:X(2);                  machine 2 (A11)
                COUNT:2,1;                      count production
                ASSIGN:A(1)=6;                  case conveyor number
                ASSIGN:A(2)=40;                 cases per pallet
                ASSIGN:A(3)=65;                 case conveyor capacity
                ASSIGN:A(4)=0.99;               palletising time
                ASSIGN:A(5)=26:NEXT(BR2);       combined for palletiser
;
                CREATE,1;
START3          ASSIGN:X(3)=ED(7);              machine 3 packing speed
                DELAY:ED(8);                    run time duration
                ASSIGN:X(3)=ED(9);
                DELAY:ED(9):NEXT(START3);       stop time duration
                CREATE,1:X(3);                  machine 3 (D11)
                COUNT:3,1;                      count production
                ASSIGN:A(1)=5;                  case conveyor number
                ASSIGN:A(2)=28;                 cases per pallet
                ASSIGN:A(3)=55;                 case conveyor capacity
                ASSIGN:A(4)=0.86;               palletising time
                ASSIGN:A(5)=25:NEXT(BR3);       combined for palletiser
;
                CREATE,1;
START4          ASSIGN:X(4)=ED(10);             machine 4 packing speed
                DELAY:ED(11);                   run time duration
                ASSIGN:X(4)=ED(12);
                DELAY:ED(12):NEXT(START4);      stop time duration
;
                CREATE,1:X(4);                  machine 4 (A11)
```

```
                 COUNT:4,1;                      count production
                 ASSIGN:A(1)=6;                  case conveyor number
                 ASSIGN:A(2)=40;                 cases per pallet
                 ASSIGN:A(3)=65;                 case conveyor capacity
                 ASSIGN:A(4)=0.99;               palletising time
                 ASSIGN:A(5)=26:NEXT(BR4);       combined for palletiser
     ;
                 CREATE,1;
     START5      ASSIGN:X(5)=ED(13);             machine 5 packing speed
                 DELAY:ED(14);                   run time duration
                 ASSIGN:X(5)=ED(15);
                 DELAY:ED(15):NEXT(START5);      stop time duration
                 CREATE,1:X(5);                  machine 5 (B22)
                 COUNT:5,1;                      count production
                 ASSIGN:A(1)=4;                  case conveyor number
                 ASSIGN:A(2)=24;                 cases per pallet
                 ASSIGN:A(3)=45;                 case conveyor capacity
                 ASSIGN:A(4)=0.80;               palletising time
                 ASSIGN:A(5)=24:NEXT(BR5);       combined for palletiser
     ;
                 CREATE,1;
     START6      ASSIGN:X(6)=ED(16);             machine 6 packing speed
                 DELAY:ED(17);                   run time duration
                 ASSIGN:X(6)=ED(18);
                 DELAY:ED(18):NEXT(START6);      stop time duration
                 CREATE,1:X(6);                  machine 6 (C11)
                 COUNT:6,1;                      count production
```

```
              ASSIGN:A(1)=8;                  case conveyor number
              ASSIGN:A(2)=20;                 cases per pallet
              ASSIGN:A(3)=47;                 case conveyor capacity
              ASSIGN:A(4)=0.69;               palletising time
              ASSIGN:A(5)=28:NEXT(BR6);       combined for palletiser
;
              CREATE,1;
START7        ASSIGN:X(7)=ED(19);             machine 7 packing speed
              DELAY:ED(20);                   run time duration
              ASSIGN:X(7)=ED(21);
              DELAY:ED(21):NEXT(START7);      stop time duration
              CREATE,1:X(7);                  machine 7 (C22)
              COUNT:7,1;                      count production
              ASSIGN:A(1)=3;                  case conveyor number
              ASSIGN:A(2)=20;                 cases per pallet
              ASSIGN:A(3)=38;                 case conveyor capacity
              ASSIGN:A(4)=0.69;               palletising time
              ASSIGN:A(5)=23:NEXT(BR7);       combined for palletiser
;
              CREATE,1;
START8        ASSIGN:X(8)=ED(22);             machine 8 packing speed
              DELAY:ED(23);                   run time duration
              ASSIGN:X(8)=ED(24);
              DELAY:ED(24):NEXT(START8);      stop time duration
              CREATE,1:X(8);                  machine 8 (B22)
              COUNT:8,1;                      count production
              ASSIGN:A(1)=4;                  case conveyor number
              ASSIGN:A(2)=24;                 cases per pallet
```

```
                ASSIGN:A(3)=45;                 case conveyor capacity
                ASSIGN:A(4)=0.80;               palletising time
                ASSIGN:A(5)=24:NEXT(BR8);       combined for palletiser
    ;
                CREATE,1;
    START9      ASSIGN:X(9)=ED(25);             machine 9 packing speed
                DELAY:ED(26);                   run time duration
                ASSIGN:X(9)=ED(27);
                DELAY:ED(27):NEXT(START9);      stop time duration
                CREATE,1:X(9);                  machine 9 (C22)
                COUNT:9,1;                      count production
                ASSIGN:A(1)=7;                  case conveyor number
                ASSIGN:A(2)=20;                 cases per pallet
                ASSIGN:A(3)=39;                 case conveyor capacity
                ASSIGN:A(4)=0.69;               palletising time
                ASSIGN:A(5)=27:NEXT(BR9);       combined for palletiser
    ;
                CREATE,1;
    START10     ASSIGN:X(10)=ED(28);            machine 10 packing speec
                DELAY:ED(29);                   run time duration
                ASSIGN:X(10)=ED(30);
                DELAY:ED(30):NEXT(START10);stop time duration
                CREATE,1:X(10);                 machine 10 (A22)
                COUNT:10,1;                     count production
                ASSIGN:A(1)=9;                  case conveyor number
                ASSIGN:A(2)=40;                 cases per pallet
                ASSIGN:A(3)=65;                 case conveyor capacity
                ASSIGN:A(4)=0.99;               palletising time
```

```
              ASSIGN:A(5)=29:NEXT(BR10); combined for palletiser
;
              CREATE,1;
START11       ASSIGN:X(11)=ED(31);       machine 11 packing spee
              DELAY:ED(32);              run time duration
              ASSIGN:X(11)=ED(33);
              DELAY:ED(33):NEXT(START11);stop time duration
              CREATE,1:X(11);            machine 11 (E11)
              COUNT:11,1;                count production
              ASSIGN:A(1)=2;             case conveyor number
              ASSIGN:A(2)=21;            cases per pallet
              ASSIGN:A(3)=42;            case conveyor capacity
              ASSIGN:A(4)=0.74;          palletising time
              ASSIGN:A(5)=22:NEXT(BR11); combined for palletiser
;
BR1           BRANCH,1:
                IF,NQ(A(5)).LT.2,Q1:
                IF,NQ(A(5)).EQ.2.AND.NQ(A(1)).LT.:
                   (A(3)-(2*A(2))),Q1:
                ELSE,FULL1;
BR2           BRANCH,1:
                 IF,NQ(A(5)).EQ.0,Q6:
                 IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q6:
                 ELSE,FULL2;
BR3           BRANCH,1:
                 IF,NQ(A(5)).EQ.0,Q5:
                 IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q5:
                 ELSE,FULL3;
```

```
BR4       BRANCH,1:
               IF,NQ(A(5)).EQ.0,Q6:
               IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q6
               ELSE,FULL4;
BR5       BRANCH,1:
               IF,NQ(A(5)).EQ.0,Q4:
               IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q4
               ELSE,FULL5;
BR6       BRANCH,1:
             IF,NQ(A(5)).LT.2,Q8:
             IF,NQ(A(5)).EQ.2.AND.NQ(A(1)).LT.:
                  (A(3)-(2*A(2))),Q8:
                  ELSE,FULL6;
BR7       BRANCH,1:
               IF,NQ(A(5)).EQ.0,Q3:
               IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q3:
               ELSE,FULL7;
BR8       BRANCH,1:
               IF,NQ(A(5)).EQ.0,Q4:
               IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q4
               ELSE,FULL8;
BR9       BRANCH,1:
               IF,NQ(A(5)).EQ.0,Q7:
               IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q7
               ELSE,FULL9;
BR10      BRANCH,1:
               IF,NQ(A(5)).EQ.0,Q9:
               IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q9
```

```
                       ELSE,FULL10;
        BR11      BRANCH,1:
                     IF,NQ(A(5)).LT.2,Q2:
                     IF,NQ(A(5)).EQ.2.AND.NQ(A(1)).LT.:
                        (A(3)-(2*A(2))),Q2:
                     ELSE,FULL11;
        ;
        FULL1     COUNT:12,1:DISPOSE;
        FULL2     COUNT:13,1:DISPOSE;
        FULL3     COUNT:14,1:DISPOSE;
        FULL4     COUNT:15,1:DISPOSE;
        FULL5     COUNT:16,1:DISPOSE;
        FULL6     COUNT:17,1:DISPOSE;
        FULL7     COUNT:18,1:DISPOSE;
        FULL8     COUNT:19,1:DISPOSE;
        FULL9     COUNT:20,1:DISPOSE;
        FULL10    COUNT:21,1:DISPOSE;
        FULL11    COUNT:22,1:DISPOSE;
        ;
        Q1        QUEUE,1;
                  COMBINE:A(2),FIRST:NEXT(P1);
        Q2        QUEUE,2;
                  COMBINE:A(2),FIRST:NEXT(P2);
        Q3        QUEUE,3;
                  COMBINE:A(2),FIRST:NEXT(P3);
        Q4        QUEUE,4;
                  COMBINE:A(2),FIRST:NEXT(P4);
        Q5        QUEUE,5;
```

```
             COMBINE:A(2),FIRST:NEXT(P5);
Q6           QUEUE,6;
             COMBINE:A(2),FIRST:NEXT(P6);
Q7           QUEUE,7;
             COMBINE:A(2),FIRST:NEXT(P7);
Q8           QUEUE,8;
             COMBINE:A(2),FIRST:NEXT(P8);
Q9           QUEUE,9;
             COMBINE:A(2),FIRST:NEXT(P9);
;
             CREATE,1;
PAL1         DELAY:ED(34);
             QUEUE,40;
             SEIZE:PALL1;
             DELAY:ED(35);
             RELEASE:PALL1:NEXT(PAL1);
;
             CREATE,1;
PAL2         DELAY:ED(36);
             QUEUE,41;
             SEIZE:PALL2;
             DELAY:ED(37);
             RELEASE:PALL2:NEXT(PAL2);
;
P1           QUEUE,21:DETACH;
P4           QUEUE,24:DETACH;
P6           QUEUE,26:DETACH;
P7           QUEUE,27:DETACH;
P8           QUEUE,28:DETACH;
```

```
              QPICK,CYC:P1:P4:P6:P7:P8;
              SEIZE:PALL1;
              DELAY:A(4);
              RELEASE:PALL1;
              TALLY:1,BET(12);
              BRANCH,1:
                 WITH,ED(41),DD1:
                 WITH,ED(42),BR12;
;
BR12          TALLY:4,BET(15);
              BRANCH,1:
                 IF,A(1).EQ.1.AND.NQ(31).EQ.2,FT1:
                 IF,A(1).EQ.1.AND.NQ(31).LT.2,Q11:
                 IF,A(1).EQ.4.AND.NQ(34).EQ.2,FT4:
                 IF,A(1).EQ.4.AND.NQ(34).LT.2,Q14:
                 IF,A(1).EQ.6.AND.NQ(36).EQ.2,FT6:
                 IF,A(1).EQ.6.AND.NQ(36).LT.2,Q16:
                 IF,A(1).EQ.7.AND.NQ(37).EQ.2,FT7:
                 IF,A(1).EQ.7.AND.NQ(37).LT.2,Q17:
                 IF,A(1).EQ.8.AND.NQ(38).EQ.2,FT8:
                 IF,A(1).EQ.8.AND.NQ(38).LT.2,Q18;
;
P2            QUEUE,22:DETACH;
P3            QUEUE,23:DETACH;
P5            QUEUE,25:DETACH;
P9            QUEUE,29:DETACH;
              QPICK,CYC:P2:P3:P5:P9;
              SEIZE:PALL2;
              DELAY:A(4);
```

```
              RELEASE:PALL2;
              TALLY:2,BET(13);
;
              BRANCH,1:
                 WITH,ED(41),DD2:
                 WITH,ED(42),BR13;
;
BR13          TALLY:6,BET(16);
              BRANCH,1:
                 IF,A(1).EQ.2.AND.NQ(32).EQ.2,FT2:
                 IF,A(1).EQ.2.AND.NQ(32).LT.2,Q12:
                 IF,A(1).EQ.3.AND.NQ(33).EQ.2,FT3:
                 IF,A(1).EQ.3.AND.NQ(33).LT.2,Q13:
                 IF,A(1).EQ.5.AND.NQ(35).EQ.2,FT5:
                 IF,A(1).EQ.5.AND.NQ(35).LT.2,Q15:
                 IF,A(1).EQ.9.AND.NQ(39).EQ.2,FT9:
                 IF,A(1).EQ.9.AND.NQ(39).LT.2,Q19;
;
FT1           COUNT:23,1:DISPOSE;
FT2           COUNT:24,1:DISPOSE;
FT3           COUNT:25,1:DISPOSE;
FT4           COUNT:26,1:DISPOSE;
FT5           COUNT:27,1:DISPOSE;
FT6           COUNT:28,1:DISPOSE;
FT7           COUNT:29,1:DISPOSE;
FT8           COUNT:30,1:DISPOSE;
FT9           COUNT:31,1:DISPOSE;
;
Q11           QUEUE,11;
```

```
                COMBINE:6,FIRST:NEXT(Q31);
      Q12       QUEUE,12;
                COMBINE:6,FIRST:NEXT(Q32);
      Q13       QUEUE,13;
                COMBINE:6,FIRST:NEXT(Q33);
      Q14       QUEUE,14;
                COMBINE:6,FIRST:NEXT(Q34);
      Q15       QUEUE,15;
                COMBINE:6,FIRST:NEXT(Q35);
      Q16       QUEUE,16;
                COMBINE:6,FIRST:NEXT(Q36);
      Q17       QUEUE,17;
                COMBINE:6,FIRST:NEXT(Q37);
      Q18       QUEUE,18;
                COMBINE:6,FIRST:NEXT(Q38);
      Q19       QUEUE,19;
                COMBINE:6,FIRST:NEXT(Q39);
      ;
                CREATE,1;
      MTL1      DELAY:ED(38);
                QUEUE,42;
                SEIZE:MTL1;
                DELAY:ED(39);
                RELEASE:MTL1:NEXT(MTL1);
      ;
      Q31       QUEUE,31:DETACH;
      Q32       QUEUE,32:DETACH;
      Q33       QUEUE,33:DETACH;
      Q34       QUEUE,34:DETACH;
```

```
Q35     QUEUE,35:DETACH;
Q36     QUEUE,36:DETACH;
Q37     QUEUE,37:DETACH;
Q38     QUEUE,38:DETACH;
Q39     QUEUE,39:DETACH;
        QPICK,CYC:Q31:Q32:Q33:Q34:Q35:Q36:Q37:Q38:Q39;
        SEIZE:MTL1;
        DELAY:ED(40);
        RELEASE:MTL1;
        TALLY:3,BET(14):DISPOSE;
;
        CREATE,1:ED(43):NEXT(DD3);  Liquids production
;
DD1     TALLY:5,BET(17):NEXT(Q50);
DD2     TALLY:7,BET(18):NEXT(Q50);
DD3     TALLY:8,BET(19):NEXT(Q50);
Q50     QUEUE,50;
        COMBINE:8,FIRST;
        TALLY:9,BET(20);
        QUEUE,51;
        SEIZE:FTRUCK;
        DELAY:ED(44);
        RELEASE:FTRUCK;
        COUNT:32,8:DISPOSE;
END;
```

9.2 The Experiment File

Two experiment files were written, one for 60% packing efficiency and the other for 70% packing efficiency. The same experiment files were used for the 1.6m and 2.1m pallet load heights. The direct despatch alternative was accommodated by setting the percentage of pallets sent to direct despatch to zero in the experiment file. This concept is explained in greater detail in section 9.3.6.

The experiment file used when simulating the 2 palletisers as existing, 1.6m (or 2.1m) pallet height, 60% packing efficiency and 40% of pallets sent to direct despatch is shown below. The experiment file for 70% packing efficiency is presented in appendix XV.

EXPERIMENT FILE

```
BEGIN,1,1,YES,NO;
;AUTO PALLETISING SYST - EXPMT. FILE "APS160.EXP" M.GOKAL
PROJECT,AUTO PALLETISING,MG,8/12/89;
DISCRETE,800,5,83;
SEEDS:1,1453,YES:2,2547,YES:3,3364,YES:4,4645,YES:
      5,5772,YES:6,6981,YES:7,7486,YES:8,8593,YES:
      9,9900,YES:10,10000,YES;
DISTRIBUTIONS:1,CO(1):                ! packing speed m/c1
              2,DP(2,1):              ! m/c1 run duration
              3,DP(3,1):              ! m/c1 stop duration
              4,CO(4):                ! packing speed m/c2
              5,DP(5,2):              ! m/c2 run duration
              6,DP(6,2):              ! m/c2 stop duration
```

```
7,CO(7):           ! packing speed m/c3
8,DP(8,3):         ! m/c3 run duration
9,DP(9,3):         ! m/c3 stop duration
10,CO(10):         ! packing speed m/c4
11,DP(11,4):       ! m/c4 run duration
12,DP(12,4):       ! m/c4 stop duration
13,CO(13):         ! packing speed m/c5
14,DP(14,5):       ! m/c5 run duration
15,DP(15,5):       ! m/c5 stop duration
16,CO(16):         ! packing speed m/c6
17,DP(17,6):       ! m/c6 run duration
18,DP(18,6):       ! m/c6 stop duration
19,CO(19):         ! packing speed m/c7
20,DP(20,7):       ! m/c7 run duration
21,DP(21,7):       ! m/c7 stop duration
22,CO(22):         ! packing speed m/c8
23,DP(23,8):       ! m/c8 run duration
24,DP(24,8):       ! m/c8 stop duration
25,CO(25):         ! packing speed m/c9
26,DP(26,9):       ! m/c9 run duration
27,DP(27,9):       ! m/c9 stop duration
28,CO(28):         ! packing speed m/c10
29,DP(29,1):       ! m/c10 run duration
30,DP(30,1):       ! m/c10 stop duration
31,CO(31):         ! packing speed m/c11
32,DP(32,2):       ! m/c11 run duration
33,DP(33,2):       ! m/c11 stop duration
34,DP(34,10):      ! palletiser1 running
```

```
                  35,DP(35,10):         ! palletiser1 stopped
                  36,DP(36,10):         ! palletiser2 running
                  37,DP(37,10):         ! palletiser2 stopped
                  38,DP(38,10):         ! MTL running
                  39,DP(39,10):         ! MTL waiting for  MT
                  40,CO(40):            ! MTL operating speed
                  41,CO(41):            ! % from PALS to DD
                  42,CO(42):            ! % from PALS to MTL
                  43,CO(43):            ! pallets from LIQ (TBC)
                  44,CO(44);            ! ftruck oper. spd in DD
PARAMETERS:1,.17:
               2,.01,35,.05,30,.12,25,.18,20,.22,15,.30,10:
                 .50,5,1,1:
               3,.01,43,.02,20,.03,15,.08,10,.50,5,1,1:
               4,.25:
               5,.03,59,.08,30,.15,25,.18,20,.25,15,.40,10:
                 .55,5,1,1:
               6,.15,10,.26,5,1,1:
               7,.08:
               8,.05,30,.08,25,.15,20,.20,15,.25,10,.50,5,1,1:
               9,.01,30,.02,15,.10,10,.35,5,1,1:
               10,.27:
               11,.01,59,.03,30,.05,25,.10,20,.30,15,.40,10:
                 .57,5,1,1:
               12,.11,10,.26,5,1,1:
               13,5000:
               14,.01,35,.07,30,.12,25,.20,20,.25,15,.30,10:
                 .50,5,1,1:
```

```
15,.01,43,.02,20,.05,15,.12,10,.50,5,1,1:
16,.11:
17,.05,41,.30,30,.35,25,.37,20,.40,15:
    .50,10,.60,5,1,1:
18,.01,40,.02,30,.05,25,:
    .10,15,.20,10,.50,5,1,1:
19,.11:
20,.01,41,.08,30,.15,25,.27,20,.40,15:
    .50,10,.60,5,1,1:
21,.01,50,.02,30,.05,25,:
    .10,15,.25,10,.40,5,1,1:
22,.15:
23,.01,35,.20,30,.30,25,.40,20,.47,15:
    .55,10,.60,5,1,1:
24,.02,20,.05,25,.10,15,.30,10,.40,5,1,1:
25,.11:
26,.01,41,.25,30,.30,25,.35,20,.40,15:
    .50,10,.60,5,1,1:
27,.01,50,.02,40,.06,30,.09,25,.15,15:
    .25,10,.60,5,1,1:
28,.26:
29,.03,59,.10,30,.15,25,.18,20,.30,15:
    .40,10,.57,5,1,1:
30,.11,10,.26,5,1,1:
31,.20:
32,.02,50,.13,30,.20,25,:
    .42,15,.52,10,.90,5,1,1:
33,.02,20,.05,15,.25,10,.60,5,1,1:
```

```
                34,.5,45,.8,30,1,15:
                35,.4,2,.6,1,1,.5:
                36,.5,45,.8,30,1,15:
                37,.4,2,.6,1,1,.5:
                38,.25,15,.70,10,1,5:
                39,.10,10,.70,5,1,1:
                40,2.9:
                41,0.4:
                42,0.6:
                43,9.26:
                44,16;
;
COUNTERS:1,MC1 PRODUCTION:
         2,MC2 PRODUCTION:
         3,MC3 PRODUCTION:
         4,MC4 PRODUCTION:
         5,MC5 PRODUCTION:
         6,MC6 PRODUCTION:
         7,MC7 PRODUCTION:
         8,MC8 PRODUCTION:
         9,MC9 PRODUCTION:
         10,MC10 PRODUCTION:
         11,MC11 PRODUCTION:
         12,MC1 CC CNV OFLOW:
         13,MC2 CC CNV OFLOW:
         14,MC3 CC CNV OFLOW:
         15,MC4 CC CNV OFLOW:
         16,MC5 CC CNV OFLOW:
```

```
            17,MC6 CC CNV OFLOW:
            18,MC7 CC CNV OFLOW:
            19,MC8 CC CNV OFLOW:
            20,MC9 CC CNV OFLOW:
            21,MC10 C CNV OFLOW:
            22,MC11 C CNV OFLOW:
            23,PAL CNV1 OFLOW:
            24,PAL CNV2 OFLOW:
            25,PAL CNV3 OFLOW:
            26,PAL CNV4 OFLOW:
            27,PAL CNV5 OFLOW:
            28,PAL CNV6 OFLOW:
            29,PAL CNV7 OFLOW:
            30,PAL CNV8 OFLOW:
            31,PAL CNV9 OFLOW:
            32,PALLETS TO DD;
;
RESOURCES:1,PALL1:2,PALL2:3,MTL1:4,FTRUCK;
TALLIES:1,EXIT RATE PAL1:2,EXIT RATE PAL2:
           3,EXIT RATE MTL1:4,FROM PAL1 TO MTL:
           5,FROM PAL1 TO DD:6,FROM PAL2 TO MTL:
           7,FROM PAL2 TO DD:8,FROM LIQ. TO DD:
           9,EX RATE P10 8pp;
DSTAT:1,NR(1),PALL1 UTIL:2,NR(2),PALL2 UTIL:
         3,NR(3),MTL UTIL: 4,NQ(51),DIRECT DESP Q;
REPLICATE,1,0,460;
END;
```

9.3 Description : Model and Experiment files

9.3.1 Definitions

The command statements in the SIMAN model files are referred to as blocks. The names given to the blocks are meaningful. Some of the blocks used in the model file are:

- CREATE - creates an entity
- ASSIGN - assigns values to variables
- DELAY - delays an entity
- COUNT - counts the number of entities passing through this block
- BRANCH - branches entities to other subroutines in the programme depending on the conditional statements in that particular branch block.
- QUEUE - holds entities in a queue
- COMBINE - combines entities residing in a queue
- SEIZE - seizes a resource. The resource is not available for the period indicated in the DELAY block following the SEIZE block.
- RELEASE - releases the resource after the period of the delay has elapsed.
- QPICK - picks entities from a set of queues indicated in the QPICK block.
- TALLY - records the time between successive entities passing through the TALLY block.
- DISPOSE - is a block modifier used to dispose (kill) an entity. Once an entity passes through a block with a DISPOSE modifier attached to it, the entity is removed from the simulation.

The statements used in the experiment file are referred to as elements. Some of the elements used in this simulation are:

PROJECT	- used to label the SIMAN output file
DISCRETE	- sets the maximum number of concurrent entities in the system, the maximum number of attributes associated with any entity, and the maximum number of files (queues, counters, tallies etc) in the system. This information is used by the programme to allocate the necessary amount of memory required to run the simulation.
SEEDS	- SIMAN has ten random number generators. A different starting seed can be allocated to each of these generators.
DISTRIBUTIONS	- sets the distribution type to the random sample, references the parameter element and specifies the random number stream.
PARAMETERS	- defines the parameters associated with the random variables.
COUNTERS	- identifies the counters specified in the model file.
RESOURCES	- specifies the resources referenced by the model file.
TALLIES	- identifies the tallies specified in the model file.
DSTAT	- obtains time - persistent statistics on variables.
REPLICATE	- specifies the number of simulation runs, the beginning time of the run and the duration of the simulation run.(Pegden)[3]

9.3.2 The Packing Floor

The entities created in this simulation are cases. The simulation time is in minutes.

The set of commands from lines 6 to 142 in the model file simulates the packing floor. The technique used to simulate the first packing machine (lines 6 to 17 in the model file) is described below. Production from the other packing machines is generated in the same manner.

Cases are generated at line 11 of the model file at a rate specified in the global variable X(1). A dummy entity is initially created in line 6 of the model file. This entity is used to set the packing speed, and to start and stop the packing machine according to the randomly selected run and stop durations presented in the experiment file. In line 7 of the model file the dummy entity is also assigned the global variable X(1), which is set to the value ED(1). This references the experiment distribution 1 (line 8) in the experiment file which sets the statistical distribution (in this case a constant "CO (1)"). The value of the constant is read from the corresponding parameter set number, under "parameters" in line 52 of the experiment file. The parameter set number is indicated by the value in brackets in the experiment distribution. Therefore the value 0.17 which appears in parameter set 1 is assigned to the global variable X(1). Machine 1 will then create entities (cases), at line 11 in the model file, at a rate of 1 every 0.17 minutes. This is equivalent to a packing speed of 5.9 cases per minute.

The dummy variable is delayed in line 8 of the model file. The duration of this delay is obtained from the experiment distribution 2 which sets the statistical distribution, the parameter set number and the random number stream. In this case, the distribution is a discrete probability distribution (similar to Monte Carlo sampling) which selects values from parameter set 2 using a random number generated from stream 1 indicated in the seeds element in line 5 in the experiment file.

The dummy entity is delayed by this duration and the value of the global variable X(1) is maintained at 0.17 minutes. This simulates the run duration of the packing machine. After the run duration has elapsed the global variable X(1) is assigned a randomly selected value (in line 9 in the model file) from the next parameter set in the experiment file in the same manner as described above. The value of the global variable X(1) in the CREATE block (line 11) is changed to this new value and would not create any cases during this period. The dummy entity is delayed for the same period thereby simulating the stop duration of the packing machine. Once this period has elapsed the dummy variable is looped back to line 7 which resets the value of the global variable X(1) to 0.17 minutes - the packing speed. The process then repeats itself.

Once a case is created it is counted at the COUNT block in line 12 and is recorded as production from machine 1 in line 110 in the experiment file. It is then assigned a number of values (using the ASSIGN block) which it carries with it throughout the simulation. In lines 13 to 16 of the model file, the case accumulation conveyor number (which is also used to identify the product), the number of cases per pallet, the case accumulation conveyor capacity, and the palletising time is assigned to the entity. The ASSIGN block in line 17 assigns an imaginary conveyor in which full pallet loads of cases reside while waiting for an available palletiser. The case is then sent to the subroutine marked BR1 which simulates the case accumulation conveyors.

The process described for machine 1 in lines 6 to 17 is repeated for the other 10 machines using the corresponding values in the experiment distributions and parameter sets in the experiment file.

Since machine 5 is not running for the purposes of this simulation, the global variable X(5) = ED(13) is set to 5000 minutes. As the time between successive creations of cases is larger than the duration of the simulation run, no production will be generated for this machine.

9.3.3 Case Accumulation Conveyors

The case accumulation conveyors are simulated between lines 150 to 227 in the model file. The technique used to simulate the case accumulation conveyors involves queuing the cases at a QUEUE block. A different QUEUE block is used for each case accumulation conveyor. There are therefore nine queues (labelled Q1 to Q9) representing the nine case accumulation conveyors.

Once sufficient cases for a full pallet load have accumulated at a particular QUEUE block, the cases are combined into a single entity (pallet) using the COMBINE block. Once combined, the entity (pallet load) is sent to another QUEUE block (conveyor) where it waits for the palletiser. There are nine such QUEUE blocks, labelled P1 to P9. In the real situation this conveyor does not exist. The cases reside on the case accumulation conveyor and a full pallet load of cases is drawn into the palletiser when it becomes available.

The COMBINE block is used in the simulation because the RESOURCE (palletiser) can draw only one entity at a time from a queue. The cases must therefore be "palletised" prior to them entering the palletiser.

The COMBINE block combines the cases into a single entity immediately a sufficient pallet load of cases has accumulated, irrespective of whether the palletiser is available or not. The combined entity is then removed from the queue. This poses a problem with the simulation as it affects the accumulation capacity on the queue. If the cases are removed from the queue and not palletised the capacity of the queue (conveyor) is effectively increased by the number of cases per pallet. The case conveyor capacity must therefore be decreased by one pallet load of cases if there is an entity in the imaginary queue. Once this entity is removed by the palletiser the capacity of the case conveyor must be increased to it's original value.

This problem was overcome as follows:
When an entity arrives at the BRANCH block the condition of the imaginary queue is checked first. If the number of entities in this queue is less than one the case is sent to the accumulation conveyor. If an entity is present in the imaginary queue a check is made on the conveyor queue. If the number of cases in the conveyor queue is less than the difference between the conveyor capacity and the number of cases per pallet, the case is sent to the accumulation conveyor. If both conditions fail the conveyor is full, and the case is sent to a COUNT block labelled FULL. The case is counted and recorded as production loss due to machine stoppage resulting from full case accumulation conveyors. Once counted, the case is removed from the system using the DISPOSE modifier attached to the COUNT block.
This technique is valid if the case conveyor capacity is less than twice the number of cases per pallet.In the instance where the case conveyor capacity is more than double the number of cases per pallet (but less than 3 times the capacity), the first condition at the BRANCH block checks if the number of entities in the imaginary queue is less than 2. If this is true the case is sent to the accumulation conveyor. If there are 2 entities in the imaginary queue, a check is performed on the accumulation conveyor. If the number of cases on this conveyor is less than the difference between the conveyor capacity and twice the cases per pallet, the case is sent to the case conveyor. If both conditions fail the conveyor is full.

9.3.4 Automatic Palletising

The technique used to model palletiser 1 is described below. The other palletisers were modelled in the same manner.

Once a pallet load has accumulated in the case accumulation conveyor the cases are·ready for palletising. This is indicated by a combined entity residing in the imaginary queues labelled P1 to P9 (lines 243 to 24739 and lines 270 to 273). The palletiser scans the queues labelled in the QPICK block (line 248) and draws a combined entity from the first full queue it encounters. The palletiser is then unavailable for the duration of the palletising time. This is modelled by using the SEIZE and DELAY blocks (lines 249 to 250). The palletising time is the value of the attribute A(4) assigned to that entity when it was created. Once the duration of the palletising time has elapsed the palletiser is released using the RELEASE block (line 251). It then scans the queues in a cyclic manner from the last queue from which it drew a pallet load.

Once released, the pallet is sent to a BRANCH block (line 253) which directs it to either direct despatch (DD) or to a pallet accumulation conveyor. The number of pallets and the exit rate from the palletiser is recorded using the TALLY block (line 252).

The palletiser stoppage is modelled by creating a dummy entity (line 236) which waits in a queue for the period when the palletiser is running. The run duration is selected in a random manner from the corresponding experiment distribution and parameter set. Once this period has expired the dummy entity seizes the palletiser and delays it for the period selected from the distribution of stop durations. The palletiser is then released for normal operation and the dummy entity is looped to the queue where it resides for the period of the next run duration.

9.3.5 Pallet Accumulation Conveyors

Upon leaving the palletiser the pallet is sent to the subroutine BR12 (line 257) where it is identified using the identification number assigned to it when it was created. Once identified it is sent to it's pallet accumulation conveyor modelled as queues labelled Q11 to Q19 (lines 305 to 321). The pallet resides in this queue until six pallets have accumulated. They are then combined and sent to an imaginary queue labelled Q31 to Q39 (lines 331 to 339) where they wait for the mini - train loader.

If the pallet accumulation conveyor is full the pallet is directed to counters labelled FT1 to FT9 (lines 295 to 303) where it is counted and disposed. This is recorded as pallet accumulation overflow and is the number of pallets that are removed from the system by the fork trucks due to pallet accumulation conveyors being full.

9.3.6 Mini - Train Loader

Once six pallets have accumulated in the pallet accumulation conveyor the pallets are ready to be transferred to the mini - train using the mini - train loader. This is indicated by a combined entity residing in the imaginary queues labelled Q31 to Q39 (lines 331 to 339). The MTL scans the queues indicated in the QPICK block (line 340) and draws a combined entity from the first full queue it encounters, in the same manner as the palletisers. The run and stop durations of the MTL are modelled by introducing a dummy entity (line 324) which seizes and releases the MTL for the durations indicated in the corresponding parameter sets in the same manner as with the palletisers. The number of 6 pallet loads and the exit rate from the MTL is recorded using the TALLY block (line 344).

9.3.7 Liquids Production

In the alternative where 40% of the pallets are sent to direct despatch, production from the adjoining liquids plant must be accommodated. This is achieved by creating pallets at line 346 of the model file at a rate described in the corresponding parameter set. In the alternative where no pallets are sent to direct despatch, this value is set to 5000 minutes. As this time is larger than the duration of the simulation run, no pallets will be created. Once created, the liquids pallets are sent to direct despatch (DD3).

9.3.8 Direct Despatch

The arrival rate of pallets to direct despatch from the two palletisers and from the liquids plant are recorded at the three TALLY blocks labelled DD1, DD2 and DD3 (lines 348 to 351). These pallets are sent to the direct despatch pallet accumulation conveyor modelled as a queue labelled Q50 (line 351).

Once eight pallets have accumulated they are combined into a group using the COMBINE block (line 352). These groups are tallied at the TALLY block, in line 353, which records the number and rate at which groups of 8 pallets pass the check point, P10. (Eight pallets are grouped because the documentation at the check point can accommodate eight pallets at a time. The document is called a P10 document.) After passing the check point the pallets are removed from the conveyor using a fork truck. These pallets are counted and removed from the system using the DISPOSE modifier attached to the COUNT block.

10. SIMULATION OUTPUT

There are twenty four output files from the simulation runs. These files are presented in appendices XVI to XXXIX. The file APS1160D.OPT is presented here for explanation. This is the alternative using the two existing palletisers, 1.6m pallet height and 60% packing efficiency with 40% of the pallets going to direct despatch.

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.021	.572	.689	3.981	450
2	EXIT RATE PAL2	1.282	.904	.690	8.260	357
3	EXIT RATE MTL1	6.113	5.201	2.899	25.070	74
4	FROM PAL1 TO MTL	1.683	1.365	.689	11.751	273
5	FROM PAL1 TO DD	2.584	2.421	.690	16.510	177
6	FROM PAL2 TO MTL	2.256	1.832	.690	11.470	203
7	FROM PAL2 TO DD	2.937	2.923	.690	22.611	154
8	FROM LIQ. TO DD	6.836	.847	.000	6.940	67
9	EX RATE P10 8PP	9.142	2.937	4.692	15.980	49

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.791	.406	.000	1.000	460
2	PALL2 UTIL	.646	.478	.000	1.000	460
3	MTL UTIL	.760	.426	.000	1.000	460
4	DIRECT DESP Q	11.021	6.139	.000	21.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	4	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	0	Infinite

Counters

15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	153	Infinite
18	MC7 CC CNV OFLOW	12	Infinite
19	MC8 CC CNV OFLOW	0	Infinite
20	MC9 CC CNV OFLOW	214	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	224	Infinite

10.1 Tally Variables

The TALLY block in the model file records the value of a specified variable identified by the corresponding TALLIES element in the experiment file and displays the statistics in the TALLY VARIABLES in the output file. The output is interpreted as the exit rate, as the TALLIES block records the time between successive entities passing through it. The TALLIES block also keeps a record of the number of entities passing through it.

The mean time between successive pallets on the palletiser are 1.02 and 1.28 minutes respectively for palletisers 1 and 2. The minimum value for both palletisers is 0.69 minutes. Of the 450 pallets palletised on palletiser 1, 273 were sent to the mini - train loader while 177 were sent to direct despatch. Sixty seven pallets arrived from the liquids plant to direct despatch. A total of 49 P10 documents were issued at direct despatch. This accounts for 392 (49 * 8) pallets which were sent to direct despatch. The remaining 6 pallets (398 - 192) were still on the conveyor waiting to be processed when the simulation ended. The operator in the direct despatch department must process a P10 document on average of once every 9.1 minutes. The mini - trains made 116 loads.

10.2 Discrete Change Variables

The discrete change variable is the output which results from requests using the DSTAT element in the experiment file. The DSTAT element is used to obtain time - persistent statistics on variables. In this model the utilization of the palletisers and the MTL is recorded and statistics on the direct despatch queue is maintained. The utilization of the palletisers in this alternative are 79% and 65%. The MTL has a 76% utilization.

10.3 Counters

The COUNTERS block in the model file keeps records of the number of entities passing through it. It is identified by the COUNTERS element in the experiment file.

Counters 1 to 11 record the number of cases produced during the shift. The same random streams were used in the 24 runs so as to ensure identical production between alternatives. The simulated production for 60% and 70% packing efficiency is tabulated in appendix XXXX.

Counters 12 to 22 give the production loss in cases experienced by each packing machine due to stoppages resulting from full case accumulation conveyors.

Counters 23 to 31 give the number of pallets per product type removed from the pallet accumulation conveyors due to full pallet accumulation conveyors.

Counter 32 reflects the number of pallets removed from the direct despatch conveyor.

10.4 Summary of Output

The summary of the outputs for the four alternatives of the three different palletiser configurations for the 60% and 70% packing efficiencies are in appendices XXXXI to XXXXVI. These summaries are further summarized into two tables, one for each of the packing efficiencies. These are presented in tables 9 and 10.

10.4.1 Case Accumulation Conveyers

Case accumulation overflow decreases with increasing palletiser capacity. However there is no substantial difference between enhancing the capacity of one of the palletisers to purchasing an additional palletiser (alternatives B and C). Changing from 1.6m pallet height to 2.1m pallet height increases the case accumulation overflow. This is expected due to the smaller buffer available because of the larger number of cases per pallet. From the summary of the simulation results in appendices XXXXI to XXXXVI, 90% of the overflow occurs on conveyors 6 and 9 with conveyor 7 becoming critical with the 2.1m pallets and higher packing efficiencies. The overflow is negligible when using increased palletising capacity, except with alternative B with 2.1m pallets and 70% packing efficiency with the bulk of the overflow coming from conveyor 7. Sending 40% of the pallets to direct despatch does not affect the case accumulation conveyors.

Summary of Simulation Results - 60% Efficiency

POWDERS PACKED : 1.6m Pallet Height - 828 Pallets
2.1m Pallet Height - 582 Pallets

	All Pallets Removed Via. MTL					
	1.6m Pallets			2.1m Pallets		
	A	B	C	A	B	C
Powders Palletised	811	825	826	559	577	578
Case acc. overflow	320	43	0	698	112	114
Pallet acc. overflow	48	120	122	0	0	0
No. of M T loads	116	108	105	87	91	90
UTILIZATION (%)						
Palletiser 1	79	68	51	78	67	51
Palletiser 2	64	50	51	63	50	50
Palletiser 3	-	-	48	-	-	47
Mini - Train Loader	98	98	98	81	88	84

	40% Of Pallets Sent to Direct Despatch					
	1.6m Pallets			2.1m Pallets		
	A	B	C	A	B	C
Powders Palletised	807	826	825	561	576	577
Case acc. overflow	383	36	10	622	154	101
Pallet acc. overflow	0	0	0	0	0	0
No. of M T loads	74	81	75	52	53	54
Pallets to DD(Pdr&Liq)	398	379	414	275	280	274
Exit Rate DD (min/8pal)	9.1	9.7	8.9	13.4	13.1	13.4
UTILIZATION (%)						
Palletiser 1	79	69	52	78	67	50
Palletiser 2	65	51	50	63	50	51
Palletiser 3	-	-	47	-	-	48
Mini - Train Loader	76	81	76	64	69	65

TABLE 9 : SUMMARY OF SIMULATION OUTPUT - 60% EFFICIENCY

Summary of Simulation Results - 70% Efficiency

POWDERS PACKED : 1.6m Pallet Height - 953 Pallets

2.1m Pallet Height - 670 Pallets

All Pallets Removed Via. MTL

	1.6m Pallets			2.1m Pallets		
	A	B	C	A	B	C
Powders Palletised	925	951	952	639	661	665
Case acc. overflow	567	41	10	921	225	80
Pallet acc. overflow	142	192	230	2	5	0
No. of M T loads	118	114	108	101	103	106
UTILIZATION (%)						
Palletiser 1	89	77	57	88	76	57
Palletiser 2	73	57	58	72	57	58
Palletiser 3	-	-	54	-	-	54
Mini - Train Loader	98	98	98	91	91	93

40% Of Pallets Sent to Direct Despatch

	1.6m Pallets			2.1m Pallets		
	A	B	C	A	B	C
Powders Palletised	924	951	952	637	661	665
Case acc. overflow	568	44	4	963	207	89
Pallet acc. overflow	2	0	0	0	0	0
No. of M T loads	83	83	87	62	66	64
Pallets to DD(Pdr&Liq)	453	488	471	289	302	314
Exit Rate DD (min/8pal)	8.1	7.5	7.8	12.7	12.2	11.7
UTILIZATION (%)						
Palletiser 1	89	77	58	87	77	56
Palletiser 2	73	56	58	72	55	59
Palletiser 3	-	-	55	-	-	56
Mini - Train Loader	83	81	82	66	71	70

TABLE 10 : SUMMARY OF SIMULATION OUTPUT - 70% EFFICIENCY

10.4.2 <u>Automatic Palletisers</u>

High case accumulation overflow is indicative of insufficient palletiser capacity. Changing the pallet height from 1.6m to 2.1m does not affect the palletiser utilization. As expected, the palletiser utilization decreased with increasing palletiser capacity. The palletiser utilization for alternative "C" (3 palletisers) is low, indicating excess palletiser capacity. This is also reflected in the marginal difference in case accumulation overflow with alternative "B". The palletisers are not affected by sending pallets to direct despatch.

10.4.3 <u>Pallet Accumulation</u>

Pallet accumulation overflow increases with increasing palletiser capacity. On average 88% of the overflow occurs on conveyors 3, 5, 7 and 8 with the 1.6m pallets and all production going to the MTL. The overflow drops to a negligible amount when using 2.1m pallets or when 40% of pallets are sent to direct despatch.

10.4.4 <u>Mini - Train Loader</u>

Pallet accumulation overflow is indicative of low MTL capacity. The MTL is under capacity (89% utilization) when palletising to 1.6m pallets. MTL utilization decreases with the 2.1m pallets or with 40% of pallets going to direct despatch. The MTL has sufficient capacity for these alternatives.

11 RECOMMENDATIONS

11.1 Case Accumulation Conveyors and Palletisers

From the summary of the output (tables 9 and 10) it is obvious that the palletiser capacity should be increased to reduce the case accumulation overflow. However it is not necessary to install a third palletiser, but to utilize the much cheaper option of increasing the capacity of one of the existing palletisers. This can be achieved by installing a second palletising platform, thereby palletising two layers simultaneously. The palletising capacity would increase from 35cc/min to 56cc/min.

A new palletiser, installed and commissioned, costs in excess of R500 000 while the modification of the existing palletiser would cost only R50 000. The modification can be done over a weekend with no loss to production.

A additional palletiser would utilize more floor space in an already congested environment. The high expenditure involved in installing a third palletiser would result in under utilization of the palletisers without a significant reduction in case accumulation overflow (tables 9 and 10).

It is therefore recommended that the rated capacity of palletiser 2 be increased to 56cc/min by installing a second palletising platform. This together with palletiser 1 as existing would adequately meet the throughput from the packing floor at both the 60% and 70% packing efficiencies.

With the 1.6m pallet load height and 70% packing efficiency the system experienced a case accumulation overflow of only 41 cases (1.5 pallets). Case accumulation overflow is an indication of insufficient palletiser capacity. If the recommendation for the palletisers is implemented, it will not be necessary to increase the accumulation capacity of the case accumulation conveyors in this case.

With the 2.1m pallet load height, the overflow was 225 cases or 6 pallets. The bulk of these cases came from machines 3 and 7 ie. products D11 and C22 and case conveyor numbers 5 and 3 respectively. (See table 6 and appendix XXIII). Installing a third palletiser would reduce this overflow to 80 cases (table 10). This alternative is however not recommended as the extra cost involved cannot be justified against the marginal reduction in case accumulation overflow. If the company decides to palletise to a height of 2.1m in order to realize savings in distribution costs, it is recommended that the accumulation capacity of conveyors 3 and 5 be increased. This can be achieved at a cost of about R10 000 (R5 000 per conveyor).

It had originally been planned to increase the capacity of all conveyors at a cost of R45 000 as shown in the buffer calculation in appendix VI. Thus the simulation has revealed a potential saving of R35 000.

11.2 <u>Pallet Accumulation Conveyors and MTL</u>

The MTL will be under capacity when palletising to the 1.6m pallet load height. This would result in severe pallet accumulation overflow (see tables 9 and 10). The investment required to adequately increase the MTL capacity will be in excess of R1.2 million. However, sending 40% of the pallets to direct despatch eliminates all capacity constraints in the MTL. This has the added advantage of reducing the storage requirements in the warehouse and eliminates the double handling of the pallets. It is therefore recommended that a pallet conveyor be installed to transport 40% of the pallets to direct despatch. These pallets will not enter the pallet accumulation conveyors but will pass on to the new conveyor which will transport the pallets to the direct despatch area situated alongside the palletising floor. It is envisaged that this conveyor together with the logic controllers will cost R200 000 to install and commission. If 2.1m pallets are used, the throughput in terms of pallets per minute decreases due to the larger number of cases on the pallet. Pallet accumulation overflow for this alternative is negligible indicating sufficient MTL capacity. Therefore, if the company decides to use 2.1m pallet load heights it will not be necessary to make any improvements to the pallet accumulation conveyors or the MTL.

12. WAREHOUSE DESIGN

12.1 Existing Layout : Mini - Trains

The warehouse acts as a storage and distribution depot for a number of factories on and off site. Powders pallets are brought in directly from the automatic palletisers with mini - trains. Other pallets arrive via road vehicle or tractor drawn trailer. These pallets are deposited under the canopy outside the warehouse and brought in using mini - trains.

The full mini - trains are un - hitched from the tow tractor in the vicinity of the area where that product is stored. The pallets are removed from the mini - train with fork trucks and block stacked. The empty train remains idle in the aisle until removed by a passing tractor. The current layout of the warehouse is shown in figure 5.

12.2 Proposed Layout : AGV

The use of mini - trains in the warehouse has proved to be very inefficient. This is a result of delays caused by no available mini - train, no driver or no tow tractor. This has severe implications on the automatic palletising. Due to these delays the MTL cannot operate, resulting in severe pallet accumulation overflow.

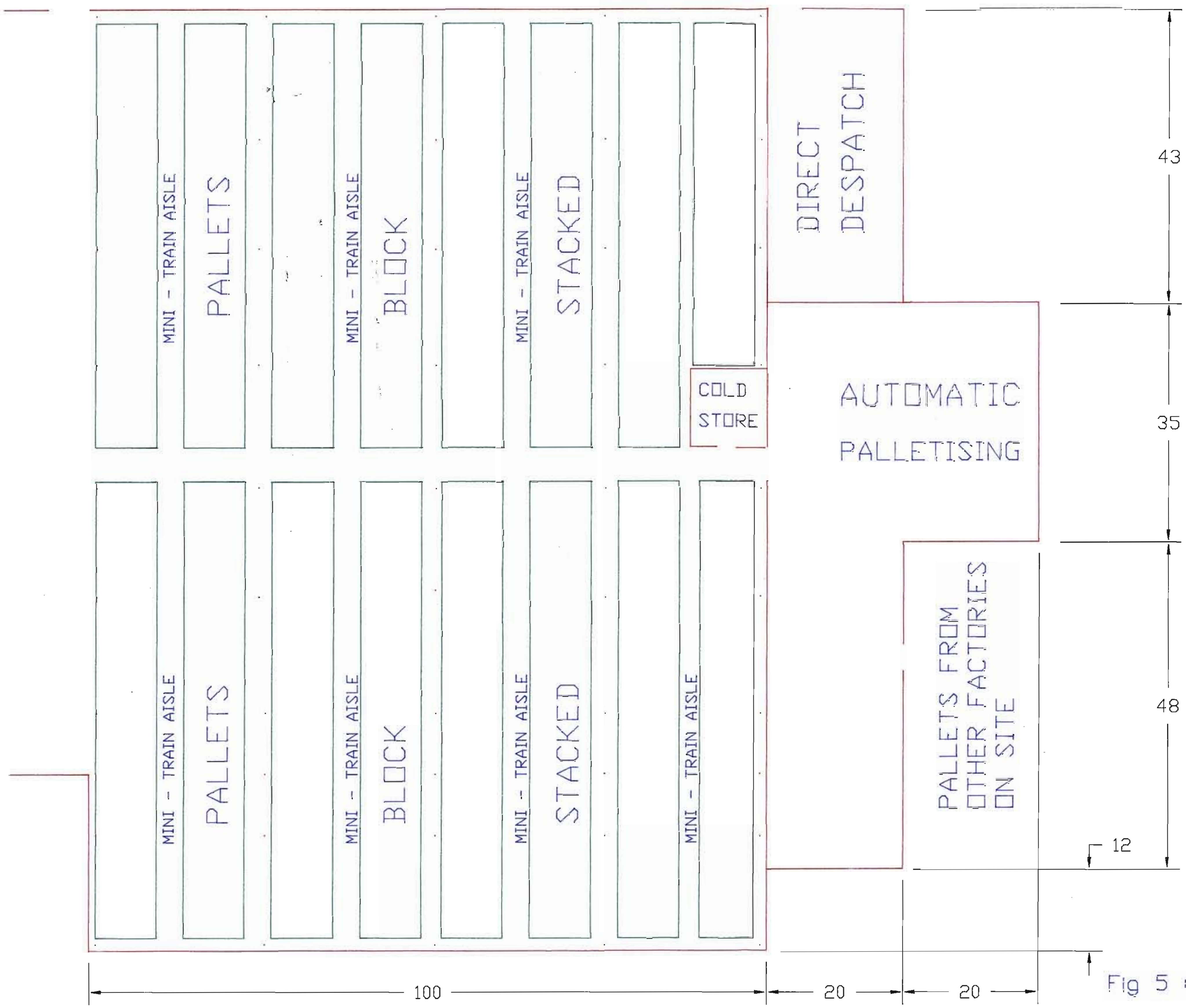
It was therefore decided to investigate the possibility of using automatic guided vehicles (AGVs) to transport the pallets to the warehouse. An AGV is a computer controlled vehicle. The computer communicates with the AGV via signals from a wire embedded in the floor of the warehouse.The AGV follows the wire to a destination requested by the computer. This requires the redesign of the layout of the warehouse to accommodate the AGV's. The proposed layout is shown in figure 6. The AGV will transport 6 pallets in the same manner as the mini - train but will automatically deposit the pallets at pallet conveyors (pick and deposit stations) in the warehouse. The AGV with the train will return immediately to a holding area near the MTL. The fork truck will pick the pallets from the conveyor and block stack in the usual manner. Separate lanes have therefore been provided for the AGV's and the fork truck.

Although the AGV's would be used initially for powders products only, the warehouse layout presented here is for complete AGV usage. Usually about a third of the warehouse is used for powders products. This section can initially be converted for use with AGVs and the rest of the changes could be phased in later.

In the final layout pick and deposit stations for AGVs will be provided in the canopy area outside the warehouse. The pallets will be transported and deposited in the warehouse in the same manner as with the powders pallets. Initially pallets will be removed from the warehouse using fork trucks or mini - trains as is the existing method. With the new layout it will be possible to remove the pallets with the AGVs. All that will be required are pick and deposit stations which will be loaded by fork truck from the block stacks. An empty AGV will then automatically load and transport the pallets to the despatch area.

FIGURE 5 : WAREHOUSE LAYOUT - EXISTING

WAREHOUSE : EXISTING LAYOUT



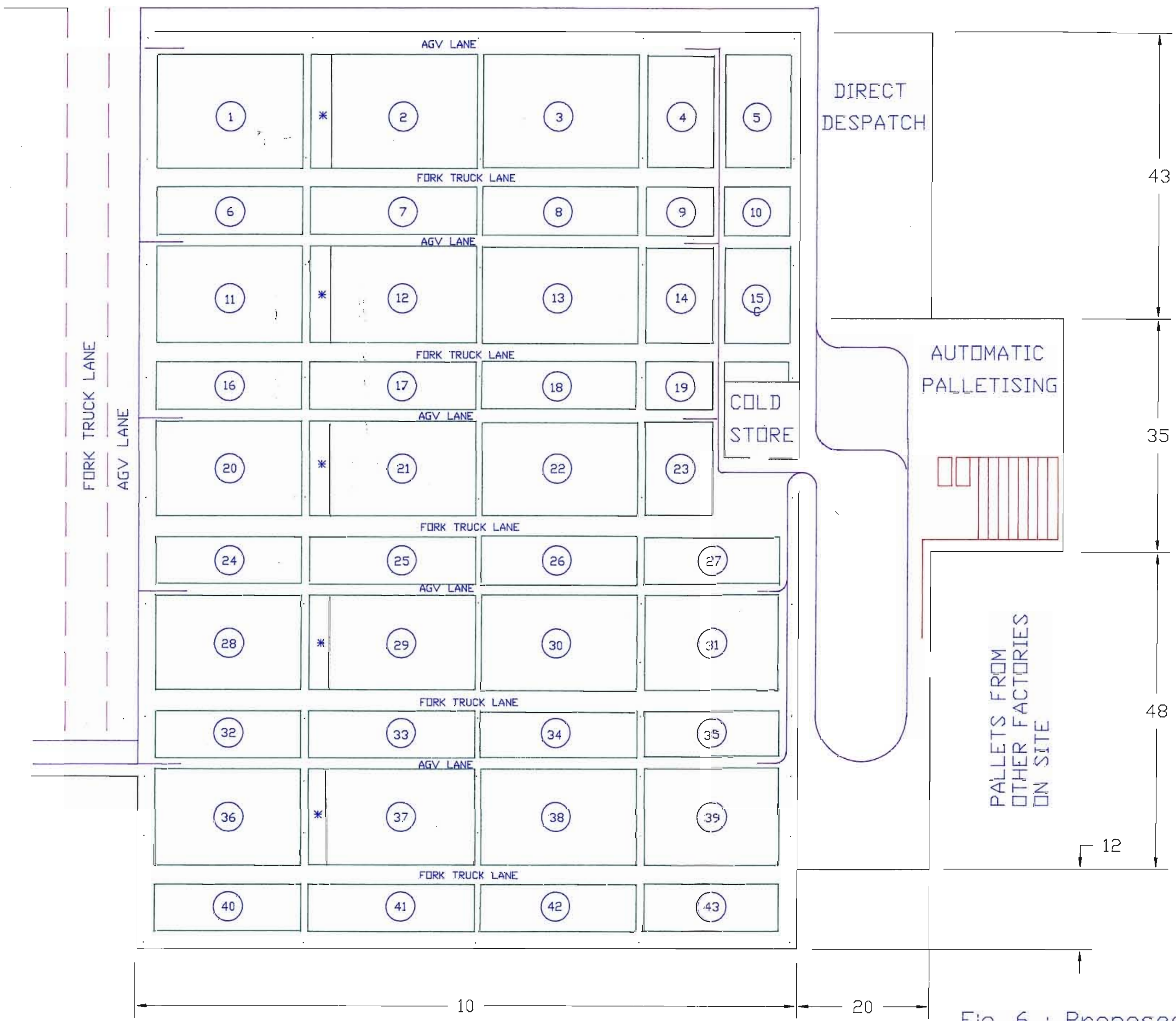
PALLET STORAGE AREA 9117 sq m
7597 PALLET POSITIONS

DIMENSIONS IN METERS

SCALE : 1:650

Fig 5 : Warehouse Layout - Existing

FIGURE 6 : WAREHOUSE LAYOUT - PROPOSED



PALLET STORAGE AREA (sq.m)

1	369.6
2	420.0
3	386.4
4	168.0
5	180.0
6	158.4
7	180.0
8	72.0
9	72.0
10	72.0
11	316.8
12	360.0
13	331.2
14	144.0
14	144.0
16	158.4
17	180.0
18	165.6
19	72.0
20	316.8
21	360.0
22	331.2
23	108.0
24	158.4
25	180.0
26	165.6
27	144.0
28	316.8
29	360.0
30	331.2
31	288.0
32	158.4
33	180.0
34	165.6
35	144.0
36	316.8
37	360.0
38	331.2
39	288.0
40	158.4
41	180.0
42	165.6
43	144.0
TOTAL	9696

8080 PALLET POSITIONS

* - AGV DEPOSIT STATION (GRAVITY ROLLER)
AGV AISLES 1.6m WIDE
FORK TRUCK AISLES 3m WIDE

DIMENSIONS IN METERS

SCALE : 1:650

Fig. 6 : Proposed Warehouse Layout (AGVs)

13 AGV SIMULATION

13.1 Introduction

Due to the randomness of the output from the palletising system a simulation program was written to determine the number of AGVs required to transport the powders pallets to the warehouse. The simulation was run for the alternative with two palletisers, with enhanced capacity on the second palletiser, 1.6m pallet height, 70% packing efficiency and all pallets removed via the MTL.

Two cases were tested, the first using one AGV and the other using 2 AGVs. The output file for the model with two AGVs is presented below for discussion. The model and experiment files are in appendicies XXXXVII and XXXXVIII respectively. The output file when using a single AGV is in appendix XXXXIX.

13.2 Description : Model and Experiment Files

In the AGV simulation, the system was modelled downstream from the palletisers to the warehouse. In this model an entity is a pallet and the simulation time is in minutes. The exit rate from the two palletisers in the palletising system simulation was used as the input rate, in minutes per pallet, into the AGV simulation.

Pallets were therefore created using two CREATE blocks, each block representing a palletiser. These pallets were then directed to the nine pallet accumulation conveyors. As it was not possible to identify the product arriving from the palletisers, the pallets were directed to the various pallet accumulation conveyors at the ratio of their actual packing speeds in pallets per minute.

The pallets were accumulated in the accumulation conveyors and combined and transferred to the AGV loader in the same manner as described in the simulation of the palletising system. The mini - train loader was now referred to as the AGV loader. A reduced pallet transfer time was used as no mini - train delays would occur.

Currently, the top third of the warehouse is used for powders products. As this area is serviced by two AGV aisles (see figure 6), two deposit stations were modelled in the simulation. These stations are numbered 2 and 3, station 1 being the AGV loader. Once loaded, the AGV transports the pallets to either station 2 or 3, deposits the pallets and returns to the AGV loader. The station number to which the product is to be sent was assigned to the pallet when it was created. The distance between stations was specified in the DISTANCES element in the experiment file. The travelling time was automatically calculated using the AGV speed specified in the TRANSPORTERS element.

In an efficient system, a load of six pallets, once accumulated, should be discharged immediately to the AGV loader and transferred to the AGV. To check for this, a hypothetical buffer queue (identified as no AGV in the program) was modelled into the simulation at a point after the AGV loader. Once six pallets had accumulated on a conveyor, they were combined and sent to the AGV loader. If an AGV was available the pallets passed directly through the queue to be transferred to the AGV. If an AGV was not available, the pallets waited in the buffer queue until an AGV arrived.

Statistics on this queue was requested using the DSTAT element in the experiment file. If no statistics were recorded on this queue, there were sufficient AGVs and the AGV loader experienced no delays due to insufficient number of AGVs. Any other value is an indication of the degree to which the AGV system was under capacity.

13.3 AGV Output File

The simulation was run for one shift and the output was recorded in the output file. In the simulation with two AGVs the average utilization was 85% per AGV and the buffer queue had no pallets. No statistics in the buffer queue indicates that two AGVs are adequate to transport powders pallets to the warehouse. This does not indicate whether this is the optimum number of AGVs required. Using 3 or more AGVs would show the same statistics in the buffer queue.

The 85% utilization per AGV when using 2 vehicles indicates that the two AGVs are adequately utilized and the system is not over designed. Since the buffer queue was empty, this is the optimum number of AGVs required.

With one AGV the utilization was 98% and the buffer queue had 66 AGV loads at the end of the simualtion run. This means that one AGV is not adequate to transport the powders products to the warehouse.

Using three AGVs would show a low utilization per AGV. This would involve unnecessary expenditure resulting from over specifying the system.

Output File : AGV Simulation

SIMAN Summary Report

Run Number 1 of 1

Project: AGV

Analyst: MG

Date : 8/17/1989

Run ended at time : .4600E+03

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	NO AGV	.000	.000	.000	.000	460
2	AGV UTIL	1.691	.540	.000	2.000	460

Counters

Number	Identifier	Count	Limit
1	EXIT PALL1	487	Infinite
2	EXIT PALL2	490	Infinite
3	FROM P1 TO CON11	97	Infinite
4	FROM P2 TO CON12	99	Infinite
5	FROM P1 TO CON13	135	Infinite
6	FROM P1 TO CON14	107	Infinite
7	FROM P2 TO CON15	140	Infinite
8	FROM P2 TO CON16	66	Infinite
9	FROM P2 TO CON17	145	Infinite
10	FROM P1 TO CON18	148	Infinite
11	FROM P2 TO CON19	40	Infinite

14. Conclusion

This project has proved conclusively that discrete event simulation techniques can be used to simulate on computer the packing, palletising and warehousing departments of a factory. The simulation is especially useful in modelling complex process controlled systems which contain many sources of random variables.

The accuracy of the output depends largely on the accuracy of the input parameters. In most instances this requires extensive analysis of the characteristics of the system to be modelled.

Once modelled a number of alternatives can be investigated without physically installing expensive capital equipment. This was highlighted clearly in the choice of increasing the automatic palletiser capacity, where it was proved that a modification to one of the existing palletisers would meet the demands of the packing floor, compared to installing an additional palletiser. A new palletiser costs R500 000 while the modification would cost R50 000. This saving of R450 000 can be directly related to the effective use of simulation modelling as a tool to assist in decision making.

With the 1.6m pallet load height the simulation showed that the alternative of sending 40% of the pallets to direct despatch eliminates all capacity constraints at the MTL and the pallet accumulation conveyors. This resulted in a saving of over R1 million in increasing the capacity of the MTL. It would also not be necessary to convert to an AGV system eliminating a further additional expenditure of R2 million.

The effect of increasing the pallet height on the system was also determined without actually doing so. Although it was predicted that this would have a negative impact on the case accumulation conveyors, the simulation showed that the capacity of just two of the conveyors should be increased. This can be achieved at a cost of R10 000 compared to R45 000 if the capacity of all the conveyors was increased as initially envisaged. The simulation showed clearly that the MTL and the pallet accumulation conveyors had sufficient capacity to accommodate the reduced throughput of pallets resulting from the larger number of cases in the higher pallet load. It would therefore not be necessary to invest over R3 million in increasing the capacity of the MTL and converting to an AGV system.

From the recommendations in chapter 10, the only capital investment required would be to modify the palletiser and to provide a pallet conveyor to direct despatch. It is envisaged that this investment would be less than R200 000, which is much less than the initially predicted investment of over R3 000 000.

The cost involved in researching the characteristics of the automatic palletising system and developing the simulation model was offset many times over by the savings achieved as a result of developing an optimal system. The model will always be available to test other alternatives in the future with little added expenditure. Continuous monitoring of the system characteristics and updating of the values in the parameter sets will result in increasing accuracy of the output of the simulation.

Computer simulation modelling has been successfully used here to optimize the equipment installed in a complex packing, palletising and warehousing system.

REFRENCES

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APPENDICES

APPENDIX I : CURRENT RUN AND STOP DURATIONS

150g Machine

Duration	Frequency RUN	Frequency STOP	% Occurence RUN	% Occurence STOP
0 - 1	34	60	44	74
1 - 5	13	12	17	15
5 - 10	8	9	10	11
10 - 15	9	0	12	0
15 - 20	4	0	5	0
20 - 25	4	0	5	0
25 - 30	4	0	5	0
> 30	2	0	3	0
MAX	59	6		
TOTAL	78	81	100	100

500g Machine

Duration	Frequency RUN	Frequency STOP	% Occurence RUN	% Occurence STOP
0 - 1	66	75	50	61
1 - 5	31	34	23	28
5 - 10	18	9	14	7
10 - 15	3	2	2	2
15 - 20	7	1	5	1
20 - 25	5	0	4	0
25 - 30	1	0	1	0
> 30	1	1	1	1
MAX	35	43		
TOTAL	132	122	100	100

1kg Machine

Duration	Frequency RUN	Frequency STOP	% Occurence RUN	% Occurence STOP
0 - 1	36	42	31	35
1 - 5	48	49	41	41
5 - 10	15	18	13	15
10 - 15	3	1	3	1
15 - 20	5	0	4	0
20 - 25	8	3	7	3
25 - 30	0	3	0	3
> 30	1	3	1	3
MAX	41	66		
TOTAL	116	119	100	100

APPENDIX I (CONT)

Duration	2kg Machine Frequency		% Occurence	
	RUN	STOP	RUN	STOP
0 - 1	48	103	31	70
1 - 5	69	31	45	21
5 - 10	19	10	12	7
10 - 15	10	2	7	1
15 - 20	3	0	2	0
20 - 25	2	0	1	0
25 - 30	2	0	1	0
> 30	0	2	0	1
MAX	30	40		
TOTAL	153	148	100	100

Duration	5Kg Machine Frequency		% Occurence	
	RUN	STOP	RUN	STOP
0 - 1	3	7	9	23
1 - 5	12	13	36	42
5 - 10	11	8	33	26
10 - 15	3	2	9	6
15 - 20	0	1	0	3
20 - 25	1	0	3	0
25 - 30	2	0	6	0
> 30	1	0	3	0
MAX	59	24		
TOTAL	33	31	100	100

Duration	PALLETISERS Frequency		% Occurence	
	RUN	STOP	RUN	STOP
0 - .5	0	13	0	20
.5 - 1	0	13	0	20
1 - 5	0	38	0	60
10 - 15	13	0	20	0
25 - 30	20	0	30	0
> 30	33	0	50	0
MAX	45	2		
TOTAL	66	64	100	100

Duration	MINI - TRAIN LOADER Frequency		% Occurence	
	RUN	STOP	RUN	STOP
0 - 1	0	5	0	10
1 - 4	17	21	30	40
4 - 6	0	21	0	40
6 - 10	30	5	55	10
10 - 12	8	0	15	0
TOTAL	55	52	100	100

APPENDIX II : VERIFICATION - MODEL AND EXPERIMENT FILES

MODEL FILE

```
BEGIN,1,1,YES,VERIFY,YES;
; VERIFY CASE GENERATION - MODEL FILE "VERIFY.MOD" M. GOKAL
          CREATE,1;
START     ASSIGN:X(1)=ED(1);               machine packing speed
         DELAY:ED(2);
          ASSIGN:X(1)=ED(3);
          DELAY:ED(3):NEXT(START);         stop time duration
          CREATE,1:X(1);                   packing machine
          COUNT:1,1:DISPOSE;               count production
END;
```

EXPERIMENT FILE

```
BEGIN,1,1,YES,NO;
;    VERIFY CASE GENERATION - EXPMT. FILE "VERIFY.EXP" M. GOKAL
PROJECT,VERIFY CASE PROD,MG,8/3/89;
DISCRETE,5,2,2;
SEEDS:1,1453,YES:2,2547,YES:3,3364,YES:4,4645,YES:5,5772,YES:
      6,6981,YES:7,7486,YES:8,8593,YES:9,9900,YES;
DISTRIBUTIONS:1,CO(1):                  ! m/c packing speed
              2,DP(2,3):                ! run duration
              3,DP(3,8);                  stop duration
PARAMETERS:1,2:
           2,.25,15,.70,10,1,5:
           3,.10,10,.70,5,1,1;
COUNTERS:1,CASES PRODUCED;
REPLICATE,1,0,460;
END;
```

APPENDIX III VERIFICATION : INPUT PARAMETERS

LINE1: 500g

1,.151: (239 ctns/min)

2,.03,35,.17,25,.28,20,.33,15,.47,10,.71,5,1,1:

3,.03,43,.06,20,.09,15,.23,10,.74,5,1,1;

total run time 446 mins.

run duration 273 mins

stop duration 173 mins

LINE2: 150g

1,.246: (293 ctns/min)

2,.08,60,.21,30,.34,25,.47,20,.67,15,.83,10,.96,5,1,1:

3,.32,10,1,1:

total run time 451 mins.

run duration 407 mins

stop duration 44 mins

LINE3: 2Kg

1,.073: (105 ctns/min)

2,.01,20,.05,15,.12,10,.75,5,1,1:

3,.03,40,.1,10,.42,5,1,1;

total run time 440 mins.

run duration 224 mins

stop duration 216 mins

APPENDIX III (CONT)

LINE5: 5Kg

1,.444: (9 ctns/min)

2,.03,59,.09,30,.12,25,.21,15,.54,10,.9,5,1,1:

3,.26,10,.68,5,1,1;

total run time 452 mins.

run duration 299 mins

stop duration 153 mins

LINE6: 1Kg

1,.105: (172 ctns/min)

2,.02,25,.04,20,.1,10,.62,5,1,1:

3,.02,66,.04,33,.06,25,.16,10,.70,5,1,1:

total run time 376 mins.

run duration 131 mins

stop duration 245 mins

LINE7: 1Kg

1,.137: (131 ctns/min)

2,.03,41,.07,30,.10,25,.13,20,.16,15,.46,10,.96,5,1,1:

3,.04,50,.11,15,.25,10,.89,5,1,1;

total run time 384 mins.

run duration 219 mins

stop duration 165 mins

APPENDIX IV : PACKING MACHINE - RUN AND STOP DURATION : 60%

LINE1

Duration	Frequency% RUN	STOP
0 - 1	50	50
1 - 5	20	42
5 - 10	8	5
10 - 15	4	1
15 - 20	6	1
20 - 25	7	0
25 - 30	4	0
> 30	1	1
MAX	35	43
TOTAL	100	100

LINE2

Duration	Frequency% RUN	STOP
0 - 1	45	74
1 - 5	15	11
5 - 10	15	15
10 - 15	7	0
15 - 20	3	0
20 - 25	7	0
25 - 30	5	0
> 30	3	0
MAX	59	10
TOTAL	100	100

LINE3

Duration	Frequency% RUN	STOP
0 - 1	50	65
1 - 5	25	25
5 - 10	5	8
10 - 15	5	1
15 - 20	7	0
20 - 25	3	0
25 - 30	5	1
> 30	0	0
MAX	30	30
TOTAL	100	100

APPENDIX IV (CONT)

LINE4

Duration	Frequency% RUN	STOP
0 - 1	43	74
1 - 5	17	15
5 - 10	10	11
10 - 15	20	0
15 - 20	5	0
20 - 25	2	0
25 - 30	2	0
> 30	1	0
MAX	59	10
TOTAL	100	100

LINE5

Duration	Frequency% RUN	STOP
0 - 1	50	74
1 - 5	20	15
5 - 10	5	11
10 - 15	5	0
15 - 20	8	0
20 - 25	5	0
25 - 30	6	0
> 30	1	0
MAX	35	10
TOTAL	100	100

LINE6

Duration	Frequency% RUN	STOP
0 - 1	40	50
1 - 5	10	30
5 - 10	10	10
10 - 15	3	5
15 - 20	2	0
20 - 25	5	3
25 - 30	25	1
> 30	5	1
MAX	41	40
TOTAL	100	100

LINE7

Duration	Frequency% RUN	STOP
0 - 1	40	60
1 - 5	10	15
5 - 10	10	15
10 - 15	13	5
15 - 20	12	0
20 - 25	7	3
25 - 30	7	1
> 30	1	1
MAX	41	50
TOTAL	100	100

LINE8

Duration	Frequency% RUN	STOP
0 - 1	40	60
1 - 5	5	10
5 - 10	8	20
10 - 15	7	5
15 - 20	10	2
20 - 25	10	3
25 - 30	19	0
> 30	1	0
MAX	35	20
TOTAL	100	100

LINE9

Duration	Frequency% RUN	STOP
0 - 1	40	40
1 - 5	10	35
5 - 10	10	10
10 - 15	5	6
15 - 20	5	0
20 - 25	5	3
25 - 30	24	4
> 30	1	2
MAX	41	50
TOTAL	100	100

APPENDIX IV (CONT)

LINE10

Duration	Frequency% RUN	Frequency% STOP
0 - 1	43	74
1 - 5	17	15
5 - 10	10	11
10 - 15	12	0
15 - 20	3	0
20 - 25	5	0
25 - 30	7	0
> 30	3	0
MAX	59	10
TOTAL	100	100

LINE11

Duration	Frequency% RUN	Frequency% STOP
0 - 1	10	40
1 - 5	38	35
5 - 10	10	20
10 - 15	22	3
15 - 20	0	2
20 - 25	7	0
25 - 30	11	0
> 30	2	0
MAX	50	20
TOTAL	100	100

APPENDIX V : PACKING MACHINE - RUN AND STOP DURATION : 70%

LINE1

Duration	Frequency% RUN	Frequency% STOP
0 - 1	50	60
1 - 5	10	32
5 - 10	5	5
10 - 15	7	1
15 - 20	3	1
20 - 25	5	0
25 - 30	15	1
> 30	5	0
MAX	35	30
TOTAL	100	100

LINE2

Duration	Frequency% RUN	Frequency% STOP
0 - 1	45	74
1 - 5	15	11
5 - 10	15	15
10 - 15	10	0
15 - 20	5	0
20 - 25	5	0
25 - 30	2	0
> 30	3	0
MAX	59	10
TOTAL	100	100

LINE3

Duration	Frequency% RUN	Frequency% STOP
0 - 1	50	45
1 - 5	10	45
5 - 10	5	8
10 - 15	5	1
15 - 20	5	0
20 - 25	10	0
25 - 30	5	1
> 30	10	0
MAX	35	30
TOTAL	100	100

LINE4

Duration	Frequency% RUN	STOP
0 - 1	43	74
1 - 5	17	15
5 - 10	10	11
10 - 15	20	0
15 - 20	5	0
20 - 25	2	0
25 - 30	2	0
> 30	1	0
MAX	59	10
TOTAL	100	100

LINE5

Duration	Frequency% RUN	STOP
0 - 1	50	55
1 - 5	10	33
5 - 10	5	7
10 - 15	5	3
15 - 20	10	1
20 - 25	5	0
25 - 30	5	1
> 30	10	0
MAX	40	30
TOTAL	100	100

LINE6

Duration	Frequency% RUN	STOP
0 - 1	40	60
1 - 5	10	25
5 - 10	5	5
10 - 15	2	7
15 - 20	3	0
20 - 25	5	1
25 - 30	15	2
> 30	20	0
MAX	41	30
TOTAL	100	100

APPENDIX V (CONT)

LINE7

Duration	Frequency% RUN	Frequency% STOP
0 - 1	40	60
1 - 5	10	20
5 - 10	10	10
10 - 15	10	7
15 - 20	10	0
20 - 25	10	2
25 - 30	5	1
> 30	5	0
MAX	41	30
TOTAL	100	100

LINE8

Duration	Frequency% RUN	Frequency% STOP
0 - 1	35	70
1 - 5	10	10
5 - 10	5	10
10 - 15	5	7
15 - 20	10	1
20 - 25	10	2
25 - 30	5	0
> 30	20	0
MAX	40	20
TOTAL	100	100

LINE9

Duration	Frequency% RUN	Frequency% STOP
0 - 1	40	60
1 - 5	10	20
5 - 10	3	10
10 - 15	2	6
15 - 20	3	0
20 - 25	7	3
25 - 30	10	1
> 30	25	0
MAX	41	30
TOTAL	100	100

APPENDIX V (CONT)

Duration	LINE10 Frequency% RUN	STOP
0 - 1	43	74
1 - 5	17	15
5 - 10	10	11
10 - 15	2	0
15 - 20	3	0
20 - 25	5	0
25 - 30	10	0
> 30	10	0
MAX	59	10
TOTAL	100	100

Duration	LINE11 Frequency% RUN	STOP
0 - 1	10	40
1 - 5	38	40
5 - 10	10	17
10 - 15	12	2
15 - 20	0	1
20 - 25	5	0
25 - 30	10	0
> 30	15	0
MAX	50	20
TOTAL	100	100

APPENDIX VI : BUFFER CALCULATIONS - CASE ACCUMUALTION SELECTION

BUFFER CALCULATIONS

TIME TO FILL CASE ACCUMULATION LANES (mins)

M/C No.	PROD	CASE ACCUMULATION CONVEYOR NUMBER 1	2	3	4	5	6	7	8	9
1	B11	9.0	7.3	7.5	7.7	9.2	9.2	7.7	9.2	9.2
2	A11	15.8	13.0	13.3	13.3	16.3	16.3	13.5	16.3	16.3
3	D11	4.2	3.5	3.6	3.6	4.4	4.4	3.7	4.3	4.3
4	A11	17.0	14.0	14.3	14.3	17.6	17.6	14.6	17.6	17.6
5	B22	7.4	6.0	6.2	6.3	7.6	7.6	6.3	7.6	7.6
6	C11	5.0	4.2	4.2	4.3	5.2	5.2	4.3	5.2	5.2
7	C22	5.0	4.2	4.2	4.3	5.2	5.2	4.3	5.2	5.2
8	B22	8.0	6.5	6.6	6.8	8.1	8.1	6.8	8.1	8.1
9	C22	5.0	4.2	4.2	4.3	5.2	5.2	4.3	5.4	5.2
10	A11	16.4	13.5	13.8	13.8	16.9	16.9	14.0	16.9	16.9
11	E11	5.6	4.6	4.7	4.7	5.7	5.7	4.8	5.7	5.7

BUFFER AVAILABLE AFTER ONE PALLET LOAD ACCUMULATED (mins)

1.6m PALLETS

M/C No.	PROD	CASE ACCUMULATION CONVEYOR NUMBER 1	2	3	4	5	6	7	8	9
1	B11	4.9	3.2	3.5	3.6	5.1	5.1	3.6	5.1	5.1
2	A11	5.8	3.0	3.3	3.3	6.3	6.3	3.5	6.3	6.3
3	D11	2.0	1.3	1.4	1.4	2.2	2.2	1.5	2.1	2.1
4	A11	6.2	3.2	3.5	3.5	6.8	6.8	3.8	6.8	6.8
5	B22	4.0	2.6	2.8	2.9	4.2	4.2	2.9	4.2	4.2
6	C11	2.8	2.0	2.0	2.1	3.0	3.0	2.1	3.0	3.0
7	C22	2.8	2.0	2.0	2.1	3.0	3.0	2.1	3.0	3.0
8	B22	5.4	3.9	4.0	4.2	5.5	5.5	4.2	5.5	5.5
9	C22	2.0	1.2	1.2	1.3	2.2	2.2	1.3	2.2	2.2
10	A11	6.0	3.1	3.4	3.4	6.5	6.5	3.6	6.5	6.5
11	E11	3.3	2.3	2.4	2.4	3.4	3.4	2.5	3.4	3.4

2.1m PALLETS

M/C No.	PROD	CASE ACCUMULATION CONVEYOR NUMBER 1	2	3	4	5	6	7	8	9
1	B11	3.6	1.9	2.1	2.3	3.8	3.8	2.3	3.8	3.8
2	A11	3.3	0.5	0.8	0.8	3.8	3.8	1.0	3.8	3.8
3	D11	0.8	0.1	0.2	0.2	1.0	1.0	0.3	0.9	0.9
4	A11	3.5	0.5	0.8	0.8	4.1	4.1	1.1	4.1	4.1
5	B22	2.9	1.5	1.7	1.8	3.1	3.1	1.8	3.1	3.1
6	C11	1.7	0.9	0.9	1.0	1.9	1.9	1.0	1.9	1.9
7	C22	1.7	0.9	0.9	1.0	1.9	1.9	1.0	1.9	1.9
8	B22	4.5	3.0	3.1	3.3	4.6	4.6	3.3	4.6	4.6
9	C22	0.5	0.3	0.3	0.2	0.7	0.7	0.0	0.7	0.7
10	A11	3.4	0.5	0.8	0.8	3.9	3.9	1.0	3.9	3.9
11	E11	2.5	1.5	1.6	1.6	2.6	2.6	1.7	2.6	2.6

APPENDIX VII : PHYSICAL CONSTRAINTS : PALLETISING SYSTEM

1. Packing machines to "warehouse" conveyor (top/bottom)

Conveyor	Top	Bottom	Both
Packing M/C	7, 8, 9, 10	1, 2, 3, 4, 5, 11	6

2. Warehouse conveyors to case accumulation conveyors

Warehouse conveyor	Top	Bottom	Both
Accumulation conveyor	9	1, 5, 6, 8	2, 3, 4, 7

3. Case accumulation conveyors to palletisers

Palletiser	1	2	Both
Accumulation conveyor	8	9	1, 2, 3, 4, 5, 6, 7

4. The palletising patterns of the 2Kg and 5Kg products can only be palletised on palletiser 2. All other products can be palletised on either of the palletisers.

APPENDIX VIII : PALLETISER SELECTION

1. 2 Palletisers 35cc/min each

Palletiser1

m/c no	conv no	Pall. 1.6m	Time 2.1m
6	8	0.57	0.86
1	1	0.69	0.91
2,4	6	1.14	1.43
8	4	0.69	0.91
9	7	0.57	0.86
	TOTAL	3.66	4.97

Palletiser2

m/c no	conv no	Pall. 1.6m	Time 2.1m
3	5	0.80	1.20
11	2	0.60	0.80
10	9	1.14	1.43
7	3	0.57	0.86
	TOTAL	3.11	4.29

2. 2 Palletisers Palletiser 1: 35cc/min ; Palletiser 2: 56cc/min

Palletiser1

m/c no	conv no	Pall. 1.6m	Time 2.1m
6	8	0.57	0.86
1	1	0.69	0.91
7	3	0.57	0.86
8	4	0.69	0.91
	TOTAL	2.52	3.54

Palletiser2

m/c no	conv no	Pall. 1.6m	Time 2.1m
3	5	0.50	0.75
11	2	0.38	0.50
10	9	0.71	0.89
9	7	0.36	0.54
2,4	6	0.71	0.89
	TOTAL	2.66	3.57

3. 3 Palletisers 35cc/min each

Palletiser1

m/c no	conv no	Pall. 1.6m	Time 2.1m
6	8	0.57	0.86
2,4	6	1.14	1.43
8	4	0.69	0.91
	TOTAL	2.40	3.20

Palletiser2

m/c no	conv no	Pall. 1.6m	Time 2.1m
3	5	0.80	1.20
11	2	0.60	0.80
1	1	0.69	0.91
	TOTAL	2.09	2.91

Palletiser3

m/c no	conv no	Pall. 1.6m	Time 2.1m
9	7	0.57	0.86
7	3	0.57	0.86
10	9	1.14	1.43
	TOTAL	2.28	3.15

APPENDIX IX : CALCULATION OF LIQUIDS PALLETS

LIQUIDS PRODUCTION

DIRECT DESPATCH ALTERNATIVE

40% of production sent to direct despatch

1.6m PALLETS

100% Production : 0.6 pallets/min

60% Production Efficiency : 0.6 * 0.6 = 0.36 pp/min

40% to Direct Despatch : 0.36 * 0.4 = 0.144 pp/min

TIME BETWEEN SUCCESSIVE PALLETS : 6.94 mins

70% Production Efficiency : 0.6 * 0.7 = 0.42 pp/min

40% to Direct Despatch : 0.42 * 0.4 = 0.168 pp/min

TIME BETWEEN SUCCESSIVE PALLETS : 5.95 mins

2.1m PALLETS

100% Production : 0.45 pallets/min.

60% Production Efficiency : 0.45 * 0.6 = 0.27 pp/min

40% to Direct Despatch : 0.27 * 0.4 = 0.108 pp/min

TIME BETWEEN SUCCESSIVE PALLETS : 9.26 mins

70% Production Efficiency : 0.45 * 0.7 = 0.315 pp/min

40% to Direct Despatch : 0.315 * 0.4 = 0.126 pp/min

TIME BETWEEN SUCCESSIVE PALLETS : 7.94 mins

APPENDIX X : Model File - APS12.MOD

2 Palletisers 35cc/min each ; 2.1m Pallet Height

```
BEGIN,1,1,YES,AUTOPALL,YES;
;   AUTO PALLETISING SYSTEM - MODEL FILE "APS12.MOD" M. GOKAL
;   ============================================================
;   2.1m PALLET HEIGHT
;   2 PALLETISERS : 35cc/min each
;
         CREATE,1;
START1   ASSIGN:X(1)=ED(1);
         DELAY:ED(2);
         ASSIGN:X(1)=ED(3);
         DELAY:ED(3):NEXT(START1);
         CREATE,1:X(1);
         COUNT:1,1;
         ASSIGN:A(1)=1;
         ASSIGN:A(2)=32;
         ASSIGN:A(3)=53;
         ASSIGN:A(4)=1.07;
         ASSIGN:A(5)=21:NEXT(BR1);
;
         CREATE,1;
START2   ASSIGN:X(2)=ED(4);
         DELAY:ED(5);
         ASSIGN:X(2)=ED(6);
         DELAY:ED(6):NEXT(START2);
         CREATE,1:X(2);
         COUNT:2,1;
         ASSIGN:A(1)=6;
         ASSIGN:A(2)=50;
         ASSIGN:A(3)=65;
         ASSIGN:A(4)=1.24;
         ASSIGN:A(5)=26:NEXT(BR2);
;
         CREATE,1;
START3   ASSIGN:X(3)=ED(7);
         DELAY:ED(8);
         ASSIGN:X(3)=ED(9);
         DELAY:ED(9):NEXT(START3);
         CREATE,1:X(3);
         COUNT:3,1;
         ASSIGN:A(1)=5;
         ASSIGN:A(2)=42;
         ASSIGN:A(3)=55;
         ASSIGN:A(4)=1.29;
         ASSIGN:A(5)=25:NEXT(BR3);
;
         CREATE,1;
START4   ASSIGN:X(4)=ED(10);
         DELAY:ED(11);
         ASSIGN:X(4)=ED(12);
         DELAY:ED(12):NEXT(START4);
         CREATE,1:X(4);
         COUNT:4,1;
         ASSIGN:A(1)=6;
         ASSIGN:A(2)=50;
         ASSIGN:A(3)=65;
```

```
          ASSIGN:A(4)=1.24;
          ASSIGN:A(5)=26:NEXT(BR4);
;
          CREATE,1;
START5    ASSIGN:X(5)=ED(13);
          DELAY:ED(14);
          ASSIGN:X(5)=ED(15);
          DELAY:ED(15):NEXT(START5);
          CREATE,1:X(5);
          COUNT:5,1;
          ASSIGN:A(1)=4;
          ASSIGN:A(2)=32;
          ASSIGN:A(3)=45;
          ASSIGN:A(4)=1.07;
          ASSIGN:A(5)=24:NEXT(BR5);
;
          CREATE,1;
START6    ASSIGN:X(6)=ED(16);
          DELAY:ED(17);
          ASSIGN:X(6)=ED(18);
          DELAY:ED(18):NEXT(START6);
          CREATE,1:X(6);
          COUNT:6,1;
          ASSIGN:A(1)=8;
          ASSIGN:A(2)=30;
          ASSIGN:A(3)=47;
          ASSIGN:A(4)=1.04;
          ASSIGN:A(5)=28:NEXT(BR6);
;
          CREATE,1;
START7    ASSIGN:X(7)=ED(19);
          DELAY:ED(20);
          ASSIGN:X(7)=ED(21);
          DELAY:ED(21):NEXT(START7);
          CREATE,1:X(7);
          COUNT:7,1;
          ASSIGN:A(1)=3;
          ASSIGN:A(2)=30;
          ASSIGN:A(3)=38;
          ASSIGN:A(4)=1.04;
          ASSIGN:A(5)=23:NEXT(BR7);
;
          CREATE,1;
START8    ASSIGN:X(8)=ED(22);
          DELAY:ED(23);
          ASSIGN:X(8)=ED(24);
          DELAY:ED(24):NEXT(START8);
          CREATE,1:X(8);
          COUNT:8,1;
          ASSIGN:A(1)=4;
          ASSIGN:A(2)=32;
          ASSIGN:A(3)=45;
          ASSIGN:A(4)=1.07;
          ASSIGN:A(5)=24:NEXT(BR8);
;
          CREATE,1;
START9    ASSIGN:X(9)=ED(25);
          DELAY:ED(26);
```

```
          ASSIGN:X(9)=ED(27);
          DELAY:ED(27):NEXT(START9);
          CREATE,1:X(9);
          COUNT:9,1;
          ASSIGN:A(1)=7;
          ASSIGN:A(2)=30;
          ASSIGN:A(3)=39;
          ASSIGN:A(4)=1.04;
          ASSIGN:A(5)=27:NEXT(BR9);
;
          CREATE,1;
START10   ASSIGN:X(10)=ED(28);
          DELAY:ED(29);
          ASSIGN:X(10)=ED(30);
          DELAY:ED(30):NEXT(START10);
          CREATE,1:X(10);
          COUNT:10,1;
          ASSIGN:A(1)=9;
          ASSIGN:A(2)=50;
          ASSIGN:A(3)=65;
          ASSIGN:A(4)=1.24;
          ASSIGN:A(5)=29:NEXT(BR10);
;
          CREATE,1;
START11   ASSIGN:X(11)=ED(31);
          DELAY:ED(32);
          ASSIGN:X(11)=ED(33);
          DELAY:ED(33):NEXT(START11);
          CREATE,1:X(11);
          COUNT:11,1;
          ASSIGN:A(1)=2;
          ASSIGN:A(2)=28;
          ASSIGN:A(3)=42;
          ASSIGN:A(4)=0.99;
          ASSIGN:A(5)=22:NEXT(BR11);
;
BR1       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q1:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q1:
             ELSE,FULL1;
BR2       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q6:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q6:
             ELSE,FULL2;
BR3       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q5:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q5:
             ELSE,FULL3;
BR4       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q6:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q6:
             ELSE,FULL4;
BR5       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q4:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q4:
             ELSE,FULL5;
BR6       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q8:
```

```
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q8:
            ELSE,FULL6;
BR7       BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q3:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q3:
            ELSE,FULL7;
BR8       BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q4:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q4:
            ELSE,FULL8;
BR9       BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q7:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q7:
            ELSE,FULL9;
BR10      BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q9:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q9:
            ELSE,FULL10;
BR11      BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q2:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q2:
            ELSE,FULL11;
;
FULL1     COUNT:12,1:DISPOSE;
FULL2     COUNT:13,1:DISPOSE;
FULL3     COUNT:14,1:DISPOSE;
FULL4     COUNT:15,1:DISPOSE;
FULL5     COUNT:16,1:DISPOSE;
FULL6     COUNT:17,1:DISPOSE;
FULL7     COUNT:18,1:DISPOSE;
FULL8     COUNT:19,1:DISPOSE;
FULL9     COUNT:20,1:DISPOSE;
FULL10    COUNT:21,1:DISPOSE;
FULL11    COUNT:22,1:DISPOSE;
;
Q1        QUEUE,1;
          COMBINE:A(2),FIRST:NEXT(P1);
Q2        QUEUE,2;
          COMBINE:A(2),FIRST:NEXT(P2);
Q3        QUEUE,3;
          COMBINE:A(2),FIRST:NEXT(P3);
Q4        QUEUE,4;
          COMBINE:A(2),FIRST:NEXT(P4);
Q5        QUEUE,5;
          COMBINE:A(2),FIRST:NEXT(P5);
Q6        QUEUE,6;
          COMBINE:A(2),FIRST:NEXT(P6);
Q7        QUEUE,7;
          COMBINE:A(2),FIRST:NEXT(P7);
Q8        QUEUE,8;
          COMBINE:A(2),FIRST:NEXT(P8);
Q9        QUEUE,9;
          COMBINE:A(2),FIRST:NEXT(P9);
;
          CREATE,1;
PAL1      DELAY:ED(34);
          QUEUE,40;
          SEIZE:PALL1;
```

```
          DELAY:ED(35);
          RELEASE:PALL1:NEXT(PAL1);
;
          CREATE,1;
PAL2      DELAY:ED(36);
          QUEUE,41;
          SEIZE:PALL2;
          DELAY:ED(37);
          RELEASE:PALL2:NEXT(PAL2);
;
P1        QUEUE,21:DETACH;
P4        QUEUE,24:DETACH;
P6        QUEUE,26:DETACH;
P7        QUEUE,27:DETACH;
P8        QUEUE,28:DETACH;
          QPICK,CYC:P1:P4:P6:P7:P8;
          SEIZE:PALL1;
          DELAY:A(4);
          RELEASE:PALL1;
          TALLY:1,BET(12);
          BRANCH,1:
             WITH,ED(41),DD1:
             WITH,ED(42),BR12;
;
BR12      TALLY:4,BET(15);
          BRANCH,1:
             IF,A(1).EQ.1.AND.NQ(31).EQ.2,FT1:
             IF,A(1).EQ.1.AND.NQ(31).LT.2,Q11:
             IF,A(1).EQ.4.AND.NQ(34).EQ.2,FT4:
             IF,A(1).EQ.4.AND.NQ(34).LT.2,Q14:
             IF,A(1).EQ.6.AND.NQ(36).EQ.2,FT6:
             IF,A(1).EQ.6.AND.NQ(36).LT.2,Q16:
             IF,A(1).EQ.7.AND.NQ(37).EQ.2,FT7:
             IF,A(1).EQ.7.AND.NQ(37).LT.2,Q17:
             IF,A(1).EQ.8.AND.NQ(38).EQ.2,FT8:
             IF,A(1).EQ.8.AND.NQ(38).LT.2,Q18;
;
P2        QUEUE,22:DETACH;
P3        QUEUE,23:DETACH;
P5        QUEUE,25:DETACH;
P9        QUEUE,29:DETACH;
          QPICK,CYC:P2:P3:P5:P9;
          SEIZE:PALL2;
          DELAY:A(4);
          RELEASE:PALL2;
          TALLY:2,BET(13);
;
          BRANCH,1:
             WITH,ED(41),DD2:
             WITH,ED(42),BR13;
;
BR13      TALLY:6,BET(16);
          BRANCH,1:
             IF,A(1).EQ.2.AND.NQ(32).EQ.2,FT2:
             IF,A(1).EQ.2.AND.NQ(32).LT.2,Q12:
             IF,A(1).EQ.3.AND.NQ(33).EQ.2,FT3:
             IF,A(1).EQ.3.AND.NQ(33).LT.2,Q13:
             IF,A(1).EQ.5.AND.NQ(35).EQ.2,FT5:
```

```
                IF,A(1).EQ.5.AND.NQ(35).LT.2,Q15:
                IF,A(1).EQ.9.AND.NQ(39).EQ.2,FT9:
                IF,A(1).EQ.9.AND.NQ(39).LT.2,Q19;
;
FT1         COUNT:23,1:DISPOSE;
FT2         COUNT:24,1:DISPOSE;
FT3         COUNT:25,1:DISPOSE;
FT4         COUNT:26,1:DISPOSE;
FT5         COUNT:27,1:DISPOSE;
FT6         COUNT:28,1:DISPOSE;
FT7         COUNT:29,1:DISPOSE;
FT8         COUNT:30,1:DISPOSE;
FT9         COUNT:31,1:DISPOSE;
;
Q11         QUEUE,11;
            COMBINE:6,FIRST:NEXT(Q31);
Q12         QUEUE,12;
            COMBINE:6,FIRST:NEXT(Q32);
Q13         QUEUE,13;
            COMBINE:6,FIRST:NEXT(Q33);
Q14         QUEUE,14;
            COMBINE:6,FIRST:NEXT(Q34);
Q15         QUEUE,15;
            COMBINE:6,FIRST:NEXT(Q35);
Q16         QUEUE,16;
            COMBINE:6,FIRST:NEXT(Q36);
Q17         QUEUE,17;
            COMBINE:6,FIRST:NEXT(Q37);
Q18         QUEUE,18;
            COMBINE:6,FIRST:NEXT(Q38);
Q19         QUEUE,19;
            COMBINE:6,FIRST:NEXT(Q39);
;
            CREATE,1;
MTL1        DELAY:ED(38);
            QUEUE,42;
            SEIZE:MTL1;
            DELAY:ED(39);
            RELEASE:MTL1:NEXT(MTL1);
;
Q31         QUEUE,31:DETACH;
Q32         QUEUE,32:DETACH;
Q33         QUEUE,33:DETACH;
Q34         QUEUE,34:DETACH;
Q35         QUEUE,35:DETACH;
Q36         QUEUE,36:DETACH;
Q37         QUEUE,37:DETACH;
Q38         QUEUE,38:DETACH;
Q39         QUEUE,39:DETACH;
            QPICK,CYC:Q31:Q32:Q33:Q34:Q35:Q36:Q37:Q38:Q39;
            SEIZE:MTL1;
            DELAY:ED(40);
            RELEASE:MTL1;
            TALLY:3,BET(14):DISPOSE;
;
            CREATE,1:ED(43):NEXT(DD3);
;
DD1         TALLY:5,BET(17):NEXT(Q50);
```

```
DD2      TALLY:7,BET(18):NEXT(Q50);
DD3      TALLY:8,BET(19):NEXT(Q50);
Q50      QUEUE,50;
         COMBINE:8,FIRST;
         TALLY:9,BET(20);
         QUEUE,51;
         SEIZE:FTRUCK;
         DELAY:ED(44);
         RELEASE:FTRUCK;
         COUNT:32,8:DISPOSE;
END;
```

APPENDIX XI : Model File - APS21.MOD

Palletiser 1 : 35cc/min ; PAlletiser 2 : 56cc/min
1.6m Pallet Height

```
BEGIN,1,1,YES,AUTOPALL,YES;
;   AUTO PALLETISING SYSTEM - MODEL FILE "APS21.MOD" M. GOKAL
;   ===========================================================
;   1.6m PALLET HEIGHT
;   PALLETISER 1 : 35 cc/min ; PALLETISER 2 : 56 cc/min
;
         CREATE,1;
START1   ASSIGN:X(1)=ED(1);
         DELAY:ED(2);
         ASSIGN:X(1)=ED(3);
         DELAY:ED(3):NEXT(START1);
         CREATE,1:X(1);
         COUNT:1,1;
         ASSIGN:A(1)=1;
         ASSIGN:A(2)=24;
         ASSIGN:A(3)=53;
         ASSIGN:A(4)=0.80;
         ASSIGN:A(5)=21:NEXT(BR1);
;
         CREATE,1;
START2   ASSIGN:X(2)=ED(4);
         DELAY:ED(5);
         ASSIGN:X(2)=ED(6);
         DELAY:ED(6):NEXT(START2);
         CREATE,1:X(2);
         COUNT:2,1;
         ASSIGN:A(1)=6;
         ASSIGN:A(2)=40;
         ASSIGN:A(3)=65;
         ASSIGN:A(4)=0.62;
         ASSIGN:A(5)=26:NEXT(BR2);
;
         CREATE,1;
START3   ASSIGN:X(3)=ED(7);
         DELAY:ED(8);
         ASSIGN:X(3)=ED(9);
         DELAY:ED(9):NEXT(START3);
         CREATE,1:X(3);
         COUNT:3,1;
         ASSIGN:A(1)=5;
         ASSIGN:A(2)=28;
         ASSIGN:A(3)=55;
         ASSIGN:A(4)=0.54;
         ASSIGN:A(5)=25:NEXT(BR3);
;
         CREATE,1;
START4   ASSIGN:X(4)=ED(10);
         DELAY:ED(11);
         ASSIGN:X(4)=ED(12);
         DELAY:ED(12):NEXT(START4);
         CREATE,1:X(4);
         COUNT:4,1;
         ASSIGN:A(1)=6;
         ASSIGN:A(2)=40;
```

```
        ASSIGN:A(3)=65;
        ASSIGN:A(4)=0.62;
        ASSIGN:A(5)=26:NEXT(BR4);
;
        CREATE,1;
START5  ASSIGN:X(5)=ED(13);
        DELAY:ED(14);
        ASSIGN:X(5)=ED(15);
        DELAY:ED(15):NEXT(START5);
        CREATE,1:X(5);
        COUNT:5,1;
        ASSIGN:A(1)=4;
        ASSIGN:A(2)=24;
        ASSIGN:A(3)=45;
        ASSIGN:A(4)=0.80;
        ASSIGN:A(5)=24:NEXT(BR5);
;
        CREATE,1;
START6  ASSIGN:X(6)=ED(16);
        DELAY:ED(17);
        ASSIGN:X(6)=ED(18);
        DELAY:ED(18):NEXT(START6);
        CREATE,1:X(6);
        COUNT:6,1;
        ASSIGN:A(1)=8;
        ASSIGN:A(2)=20;
        ASSIGN:A(3)=47;
        ASSIGN:A(4)=0.69;
        ASSIGN:A(5)=28:NEXT(BR6);
;
        CREATE,1;
START7  ASSIGN:X(7)=ED(19);
        DELAY:ED(20);
        ASSIGN:X(7)=ED(21);
        DELAY:ED(21):NEXT(START7);
        CREATE,1:X(7);
        COUNT:7,1;
        ASSIGN:A(1)=3;
        ASSIGN:A(2)=20;
        ASSIGN:A(3)=38;
        ASSIGN:A(4)=0.69;
        ASSIGN:A(5)=23:NEXT(BR7);
;
        CREATE,1;
START8  ASSIGN:X(8)=ED(22);
        DELAY:ED(23);
        ASSIGN:X(8)=ED(24);
        DELAY:ED(24):NEXT(START8);
        CREATE,1:X(8);
        COUNT:8,1;
        ASSIGN:A(1)=4;
        ASSIGN:A(2)=24;
        ASSIGN:A(3)=45;
        ASSIGN:A(4)=0.80;
        ASSIGN:A(5)=24:NEXT(BR8);
;
        CREATE,1;
START9  ASSIGN:X(9)=ED(25);
```

```
          DELAY:ED(26);
          ASSIGN:X(9)=ED(27);
          DELAY:ED(27):NEXT(START9);
          CREATE,1:X(9);
          COUNT:9,1;
          ASSIGN:A(1)=7;
          ASSIGN:A(2)=20;
          ASSIGN:A(3)=39;
          ASSIGN:A(4)=0.43;
          ASSIGN:A(5)=27:NEXT(BR9);
;
          CREATE,1;
START10   ASSIGN:X(10)=ED(28);
          DELAY:ED(29);
          ASSIGN:X(10)=ED(30);
          DELAY:ED(30):NEXT(START10);
          CREATE,1:X(10);
          COUNT:10,1;
          ASSIGN:A(1)=9;
          ASSIGN:A(2)=40;
          ASSIGN:A(3)=65;
          ASSIGN:A(4)=0.62;
          ASSIGN:A(5)=29:NEXT(BR10);
;
          CREATE,1;
START11   ASSIGN:X(11)=ED(31);
          DELAY:ED(32);
          ASSIGN:X(11)=ED(33);
          DELAY:ED(33):NEXT(START11);
          CREATE,1:X(11);
          COUNT:11,1;
          ASSIGN:A(1)=2;
          ASSIGN:A(2)=21;
          ASSIGN:A(3)=42;
          ASSIGN:A(4)=0.46;
          ASSIGN:A(5)=22:NEXT(BR11);
;
BR1       BRANCH,1:
             IF,NQ(A(5)).LT.2,Q1:
             IF,NQ(A(5)).EQ.2.AND.NQ(A(1)).LT.(A(3)-(2*A(2))),
             ELSE,FULL1;
BR2       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q6:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q6:
             ELSE,FULL2;
BR3       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q5:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q5:
             ELSE,FULL3;
BR4       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q6:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q6:
             ELSE,FULL4;
BR5       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q4:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q4:
             ELSE,FULL5;
BR6       BRANCH,1:
```

```
                IF,NQ(A(5)).LT.2,Q8:
                IF,NQ(A(5)).EQ.2.AND.NQ(A(1)).LT.(A(3)-(2*A(2))),Q8:
                ELSE,FULL6;
BR7         BRANCH,1:
                IF,NQ(A(5)).EQ.0,Q3:
                IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q3:
                ELSE,FULL7;
BR8         BRANCH,1:
                IF,NQ(A(5)).EQ.0,Q4:
                IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q4:
                ELSE,FULL8;
BR9         BRANCH,1:
                IF,NQ(A(5)).EQ.0,Q7:
                IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q7:
                ELSE,FULL9;
BR10        BRANCH,1:
                 IF,NQ(A(5)).EQ.0,Q9:
                 IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q9:
                ELSE,FULL10;
BR11        BRANCH,1:
                IF,NQ(A(5)).LT.2,Q2:
                IF,NQ(A(5)).EQ.2.AND.NQ(A(1)).LT.(A(3)-(2*A(2))),Q2:
                ELSE,FULL11;
;
FULL1       COUNT:12,1:DISPOSE;
FULL2       COUNT:13,1:DISPOSE;
FULL3       COUNT:14,1:DISPOSE;
FULL4       COUNT:15,1:DISPOSE;
FULL5       COUNT:16,1:DISPOSE;
FULL6       COUNT:17,1:DISPOSE;
FULL7       COUNT:18,1:DISPOSE;
FULL8       COUNT:19,1:DISPOSE;
FULL9       COUNT:20,1:DISPOSE;
FULL10      COUNT:21,1:DISPOSE;
FULL11      COUNT:22,1:DISPOSE;
;
Q1          QUEUE,1;
            COMBINE:A(2),FIRST:NEXT(P1);
Q2          QUEUE,2;
            COMBINE:A(2),FIRST:NEXT(P2);
Q3          QUEUE,3;
            COMBINE:A(2),FIRST:NEXT(P3);
Q4          QUEUE,4;
            COMBINE:A(2),FIRST:NEXT(P4);
Q5          QUEUE,5;
            COMBINE:A(2),FIRST:NEXT(P5);
Q6          QUEUE,6;
            COMBINE:A(2),FIRST:NEXT(P6);
Q7          QUEUE,7;
            COMBINE:A(2),FIRST:NEXT(P7);
Q8          QUEUE,8;
            COMBINE:A(2),FIRST:NEXT(P8);
Q9          QUEUE,9;
            COMBINE:A(2),FIRST:NEXT(P9);
;
            CREATE,1;
PAL1        DELAY:ED(34);
            QUEUE,40;
```

```
          SEIZE:PALL1;
          DELAY:ED(35);
          RELEASE:PALL1:NEXT(PAL1);
;
          CREATE,1;
PAL2      DELAY:ED(36);
          QUEUE,41;
          SEIZE:PALL2;
          DELAY:ED(37);
          RELEASE:PALL2:NEXT(PAL2);
;
P1        QUEUE,21:DETACH;
P3        QUEUE,23:DETACH;
P4        QUEUE,24:DETACH;
P8        QUEUE,28:DETACH;
          QPICK,CYC:P1:P3:P4:P8;
          SEIZE:PALL1;
          DELAY:A(4);
          RELEASE:PALL1;
          TALLY:1,BET(12);
          BRANCH,1:
             WITH,ED(41),DD1:
             WITH,ED(42),BR12;
;
BR12      TALLY:4,BET(15);
          BRANCH,1:
             IF,A(1).EQ.1.AND.NQ(31).EQ.2,FT1:
             IF,A(1).EQ.1.AND.NQ(31).LT.2,Q11:
             IF,A(1).EQ.3.AND.NQ(33).EQ.2,FT3:
             IF,A(1).EQ.3.AND.NQ(33).LT.2,Q13:
             IF,A(1).EQ.4.AND.NQ(34).EQ.2,FT4:
             IF,A(1).EQ.4.AND.NQ(34).LT.2,Q14:
             IF,A(1).EQ.8.AND.NQ(38).EQ.2,FT8:
             IF,A(1).EQ.8.AND.NQ(38).LT.2,Q18;
;
P2        QUEUE,22:DETACH;
P5        QUEUE,25:DETACH;
P6        QUEUE,26:DETACH;
P7        QUEUE,27:DETACH;
P9        QUEUE,29:DETACH;
          QPICK,CYC:P2:P5:P6:P7:P9;
          SEIZE:PALL2;
          DELAY:A(4);
          RELEASE:PALL2;
          TALLY:2,BET(13);
;
          BRANCH,1:
             WITH,ED(41),DD2:
             WITH,ED(42),BR13;
;
BR13      TALLY:6,BET(16);
          BRANCH,1:
             IF,A(1).EQ.2.AND.NQ(32).EQ.2,FT2:
             IF,A(1).EQ.2.AND.NQ(32).LT.2,Q12:
             IF,A(1).EQ.5.AND.NQ(35).EQ.2,FT5:
             IF,A(1).EQ.5.AND.NQ(35).LT.2,Q15:
             IF,A(1).EQ.6.AND.NQ(36).EQ.2,FT6:
             IF,A(1).EQ.6.AND.NQ(36).LT.2,Q16:
```

```
            IF,A(1).EQ.7.AND.NQ(37).EQ.2,FT7:
            IF,A(1).EQ.7.AND.NQ(37).LT.2,Q17:
            IF,A(1).EQ.9.AND.NQ(39).EQ.2,FT9:
            IF,A(1).EQ.9.AND.NQ(39).LT.2,Q19;
;
FT1       COUNT:23,1:DISPOSE;
FT2       COUNT:24,1:DISPOSE;
FT3       COUNT:25,1:DISPOSE;
FT4       COUNT:26,1:DISPOSE;
FT5       COUNT:27,1:DISPOSE;
FT6       COUNT:28,1:DISPOSE;
FT7       COUNT:29,1:DISPOSE;
FT8       COUNT:30,1:DISPOSE;
FT9       COUNT:31,1:DISPOSE;
;
Q11       QUEUE,11;
          COMBINE:6,FIRST:NEXT(Q31);
Q12       QUEUE,12;
          COMBINE:6,FIRST:NEXT(Q32);
Q13       QUEUE,13;
          COMBINE:6,FIRST:NEXT(Q33);
Q14       QUEUE,14;
          COMBINE:6,FIRST:NEXT(Q34);
Q15       QUEUE,15;
          COMBINE:6,FIRST:NEXT(Q35);
Q16       QUEUE,16;
          COMBINE:6,FIRST:NEXT(Q36);
Q17       QUEUE,17;
          COMBINE:6,FIRST:NEXT(Q37);
Q18       QUEUE,18;
          COMBINE:6,FIRST:NEXT(Q38);
Q19       QUEUE,19;
          COMBINE:6,FIRST:NEXT(Q39);
;
          CREATE,1;
MTL1      DELAY:ED(38);
          QUEUE,42;
          SEIZE:MTL1;
          DELAY:ED(39);
          RELEASE:MTL1:NEXT(MTL1);
;
Q31       QUEUE,31:DETACH;
Q32       QUEUE,32:DETACH;
Q33       QUEUE,33:DETACH;
Q34       QUEUE,34:DETACH;
Q35       QUEUE,35:DETACH;
Q36       QUEUE,36:DETACH;
Q37       QUEUE,37:DETACH;
Q38       QUEUE,38:DETACH;
Q39       QUEUE,39:DETACH;
          QPICK,CYC:Q31:Q32:Q33:Q34:Q35:Q36:Q37:Q38:Q39;
          SEIZE:MTL1;
          DELAY:ED(40);
          RELEASE:MTL1;
          TALLY:3,BET(14):DISPOSE;
;
          CREATE,1:ED(43):NEXT(DD3);
;
```

```
DD1       TALLY:5,BET(17):NEXT(Q50);
DD2       TALLY:7,BET(18):NEXT(Q50);
DD3       TALLY:8,BET(19):NEXT(Q50);
Q50       QUEUE,50;
          COMBINE:8,FIRST;
          TALLY:9,BET(20);
          QUEUE,51;
          SEIZE:FTRUCK;
          DELAY:ED(44);
          RELEASE:FTRUCK;
          COUNT:32,8:DISPOSE;
END;
```

APPENDIX XII : Model File APS22.MOD

Palletiser 1 : 35cc/min ; Plaaetiser 2 : 56cc/min
2.1m Pallet Height

```
BEGIN,1,1,YES,AUTOPALL,YES;
;    AUTO PALLETISING SYSTEM - MODEL FILE "APS22.MOD" M. GOKAL
;    ============================================================
;    2.1m PALLET HEIGHT
;    PALLETISER 1 : 35cc/min. ; PALLETISER 2 : 56cc/min.
;
         CREATE,1;
START1   ASSIGN:X(1)=ED(1);
         DELAY:ED(2);
         ASSIGN:X(1)=ED(3);
         DELAY:ED(3):NEXT(START1);
         CREATE,1:X(1);
         COUNT:1,1;
         ASSIGN:A(1)=1;
         ASSIGN:A(2)=32;
         ASSIGN:A(3)=53;
         ASSIGN:A(4)=1.07;
         ASSIGN:A(5)=21:NEXT(BR1);
;
         CREATE,1;
START2   ASSIGN:X(2)=ED(4);
         DELAY:ED(5);
         ASSIGN:X(2)=ED(6);
         DELAY:ED(6):NEXT(START2);
         CREATE,1:X(2);
         COUNT:2,1;
         ASSIGN:A(1)=6;
         ASSIGN:A(2)=50;
         ASSIGN:A(3)=65;
         ASSIGN:A(4)=0.78;
         ASSIGN:A(5)=26:NEXT(BR2);
;
         CREATE,1;
START3   ASSIGN:X(3)=ED(7);
         DELAY:ED(8);
         ASSIGN:X(3)=ED(9);
         DELAY:ED(9):NEXT(START3);
         CREATE,1:X(3);
         COUNT:3,1;
         ASSIGN:A(1)=5;
         ASSIGN:A(2)=42;
         ASSIGN:A(3)=55;
         ASSIGN:A(4)=0.81;
         ASSIGN:A(5)=25:NEXT(BR3);
;
         CREATE,1;
START4   ASSIGN:X(4)=ED(10);
         DELAY:ED(11);
         ASSIGN:X(4)=ED(12);
         DELAY:ED(12):NEXT(START4);
         CREATE,1:X(4);
         COUNT:4,1;
         ASSIGN:A(1)=6;
         ASSIGN:A(2)=50;
```

```
         ASSIGN:A(3)=65;
         ASSIGN:A(4)=0.78;
         ASSIGN:A(5)=26:NEXT(BR4);
;
         CREATE,1;
START5   ASSIGN:X(5)=ED(13);
         DELAY:ED(14);
         ASSIGN:X(5)=ED(15);
         DELAY:ED(15):NEXT(START5);
         CREATE,1:X(5);
         COUNT:5,1;
         ASSIGN:A(1)=4;
         ASSIGN:A(2)=32;
         ASSIGN:A(3)=45;
         ASSIGN:A(4)=1.07;
         ASSIGN:A(5)=24:NEXT(BR5);
;
         CREATE,1;
START6   ASSIGN:X(6)=ED(16);
         DELAY:ED(17);
         ASSIGN:X(6)=ED(18);
         DELAY:ED(18):NEXT(START6);
         CREATE,1:X(6);
         COUNT:6,1;
         ASSIGN:A(1)=8;
         ASSIGN:A(2)=30;
         ASSIGN:A(3)=47;
         ASSIGN:A(4)=1.04;
         ASSIGN:A(5)=28:NEXT(BR6);
;
         CREATE,1;
START7   ASSIGN:X(7)=ED(19);
         DELAY:ED(20);
         ASSIGN:X(7)=ED(21);
         DELAY:ED(21):NEXT(START7);
         CREATE,1:X(7);
         COUNT:7,1;
         ASSIGN:A(1)=3;
         ASSIGN:A(2)=30;
         ASSIGN:A(3)=38;
         ASSIGN:A(4)=1.04;
         ASSIGN:A(5)=23:NEXT(BR7);
;
         CREATE,1;
START8   ASSIGN:X(8)=ED(22);
         DELAY:ED(23);
         ASSIGN:X(8)=ED(24);
         DELAY:ED(24):NEXT(START8);
         CREATE,1:X(8);
         COUNT:8,1;
         ASSIGN:A(1)=4;
         ASSIGN:A(2)=32;
         ASSIGN:A(3)=45;
         ASSIGN:A(4)=1.07;
         ASSIGN:A(5)=24:NEXT(BR8);
;
         CREATE,1;
START9   ASSIGN:X(9)=ED(25);
```

```
          DELAY:ED(26);
          ASSIGN:X(9)=ED(27);
          DELAY:ED(27):NEXT(START9);
          CREATE,1:X(9);
          COUNT:9,1;
          ASSIGN:A(1)=7;
          ASSIGN:A(2)=30;
          ASSIGN:A(3)=39;
          ASSIGN:A(4)=0.65;
          ASSIGN:A(5)=27:NEXT(BR9);
;
          CREATE,1;
START10   ASSIGN:X(10)=ED(28);
          DELAY:ED(29);
          ASSIGN:X(10)=ED(30);
          DELAY:ED(30):NEXT(START10);
          CREATE,1:X(10);
          COUNT:10,1;
          ASSIGN:A(1)=9;
          ASSIGN:A(2)=50;
          ASSIGN:A(3)=65;
          ASSIGN:A(4)=0.78;
          ASSIGN:A(5)=29:NEXT(BR10);
;
          CREATE,1;
START11   ASSIGN:X(11)=ED(31);
          DELAY:ED(32);
          ASSIGN:X(11)=ED(33);
          DELAY:ED(33):NEXT(START11);
          CREATE,1:X(11);
          COUNT:11,1;
          ASSIGN:A(1)=2;
          ASSIGN:A(2)=28;
          ASSIGN:A(3)=42;
          ASSIGN:A(4)=0.62;
          ASSIGN:A(5)=22:NEXT(BR11);
;
BR1       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q1:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q1:
             ELSE,FULL1;
BR2       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q6:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q6:
             ELSE,FULL2;
BR3       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q5:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q5:
             ELSE,FULL3;
BR4       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q6:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q6:
             ELSE,FULL4;
BR5       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q4:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q4:
             ELSE,FULL5;
BR6       BRANCH,1:
```

```
            IF,NQ(A(5)).EQ.0,Q8:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q8:
            ELSE,FULL6;
BR7       BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q3:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q3:
            ELSE,FULL7;
BR8       BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q4:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q4:
            ELSE,FULL8;
BR9       BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q7:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q7:
            ELSE,FULL9;
BR10      BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q9:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q9:
            ELSE,FULL10;
BR11      BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q2:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q2:
            ELSE,FULL11;
;
FULL1     COUNT:12,1:DISPOSE;
FULL2     COUNT:13,1:DISPOSE;
FULL3     COUNT:14,1:DISPOSE;
FULL4     COUNT:15,1:DISPOSE;
FULL5     COUNT:16,1:DISPOSE;
FULL6     COUNT:17,1:DISPOSE;
FULL7     COUNT:18,1:DISPOSE;
FULL8     COUNT:19,1:DISPOSE;
FULL9     COUNT:20,1:DISPOSE;
FULL10    COUNT:21,1:DISPOSE;
FULL11    COUNT:22,1:DISPOSE;
;
Q1        QUEUE,1;
          COMBINE:A(2),FIRST:NEXT(P1);
Q2        QUEUE,2;
          COMBINE:A(2),FIRST:NEXT(P2);
Q3        QUEUE,3;
          COMBINE:A(2),FIRST:NEXT(P3);
Q4        QUEUE,4;
          COMBINE:A(2),FIRST:NEXT(P4);
Q5        QUEUE,5;
          COMBINE:A(2),FIRST:NEXT(P5);
Q6        QUEUE,6;
          COMBINE:A(2),FIRST:NEXT(P6);
Q7        QUEUE,7;
          COMBINE:A(2),FIRST:NEXT(P7);
Q8        QUEUE,8;
          COMBINE:A(2),FIRST:NEXT(P8);
Q9        QUEUE,9;
          COMBINE:A(2),FIRST:NEXT(P9);
;
          CREATE,1;
PAL1      DELAY:ED(34);
          QUEUE,40;
```

```
        SEIZE:PALL1;
        DELAY:ED(35);
        RELEASE:PALL1:NEXT(PAL1);
;
        CREATE,1;
PAL2    DELAY:ED(36);
        QUEUE,41;
        SEIZE:PALL2;
        DELAY:ED(37);
        RELEASE:PALL2:NEXT(PAL2);
;
P1      QUEUE,21:DETACH;
P3      QUEUE,23:DETACH;
P4      QUEUE,24:DETACH;
P8      QUEUE,28:DETACH;
        QPICK,CYC:P1:P3:P4:P8;
        SEIZE:PALL1;
        DELAY:A(4);
        RELEASE:PALL1;
        TALLY:1,BET(12);
        BRANCH,1:
           WITH,ED(41),DD1:
           WITH,ED(42),BR12;
;
BR12    TALLY:4,BET(15);
        BRANCH,1:
           IF,A(1).EQ.1.AND.NQ(31).EQ.2,FT1:
           IF,A(1).EQ.1.AND.NQ(31).LT.2,Q11:
           IF,A(1).EQ.3.AND.NQ(33).EQ.2,FT3:
           IF,A(1).EQ.3.AND.NQ(33).LT.2,Q13:
           IF,A(1).EQ.4.AND.NQ(34).EQ.2,FT4:
           IF,A(1).EQ.4.AND.NQ(34).LT.2,Q14:
           IF,A(1).EQ.8.AND.NQ(38).EQ.2,FT8:
           IF,A(1).EQ.8.AND.NQ(38).LT.2,Q18;
;
P2      QUEUE,22:DETACH;
P5      QUEUE,25:DETACH;
P6      QUEUE,26:DETACH;
P7      QUEUE,27:DETACH;
P9      QUEUE,29:DETACH;
        QPICK,CYC:P2:P5:P6:P7:P9;
        SEIZE:PALL2;
        DELAY:A(4);
        RELEASE:PALL2;
        TALLY:2,BET(13);
;
        BRANCH,1:
           WITH,ED(41),DD2:
           WITH,ED(42),BR13;
;
BR13    TALLY:6,BET(16);
        BRANCH,1:
           IF,A(1).EQ.2.AND.NQ(32).EQ.2,FT2:
           IF,A(1).EQ.2.AND.NQ(32).LT.2,Q12:
           IF,A(1).EQ.5.AND.NQ(35).EQ.2,FT5:
           IF,A(1).EQ.5.AND.NQ(35).LT.2,Q15:
           IF,A(1).EQ.6.AND.NQ(36).EQ.2,FT6:
           IF,A(1).EQ.6.AND.NQ(36).LT.2,Q16:
```

```
                IF,A(1).EQ.7.AND.NQ(37).EQ.2,FT7:
                IF,A(1).EQ.7.AND.NQ(37).LT.2,Q17:
                IF,A(1).EQ.9.AND.NQ(39).EQ.2,FT9:
                IF,A(1).EQ.9.AND.NQ(39).LT.2,Q19;
;
FT1         COUNT:23,1:DISPOSE;
FT2         COUNT:24,1:DISPOSE;
FT3         COUNT:25,1:DISPOSE;
FT4         COUNT:26,1:DISPOSE;
FT5         COUNT:27,1:DISPOSE;
FT6         COUNT:28,1:DISPOSE;
FT7         COUNT:29,1:DISPOSE;
FT8         COUNT:30,1:DISPOSE;
FT9         COUNT:31,1:DISPOSE;
;
Q11         QUEUE,11;
            COMBINE:6,FIRST:NEXT(Q31);
Q12         QUEUE,12;
            COMBINE:6,FIRST:NEXT(Q32);
Q13         QUEUE,13;
            COMBINE:6,FIRST:NEXT(Q33);
Q14         QUEUE,14;
            COMBINE:6,FIRST:NEXT(Q34);
Q15         QUEUE,15;
            COMBINE:6,FIRST:NEXT(Q35);
Q16         QUEUE,16;
            COMBINE:6,FIRST:NEXT(Q36);
Q17         QUEUE,17;
            COMBINE:6,FIRST:NEXT(Q37);
Q18         QUEUE,18;
            COMBINE:6,FIRST:NEXT(Q38);
Q19         QUEUE,19;
            COMBINE:6,FIRST:NEXT(Q39);
;
            CREATE,1;
MTL1        DELAY:ED(38);
            QUEUE,42;
            SEIZE:MTL1;
            DELAY:ED(39);
            RELEASE:MTL1:NEXT(MTL1);
;
Q31         QUEUE,31:DETACH;
Q32         QUEUE,32:DETACH;
Q33         QUEUE,33:DETACH;
Q34         QUEUE,34:DETACH;
Q35         QUEUE,35:DETACH;
Q36         QUEUE,36:DETACH;
Q37         QUEUE,37:DETACH;
Q38         QUEUE,38:DETACH;
Q39         QUEUE,39:DETACH;
            QPICK,CYC:Q31:Q32:Q33:Q34:Q35:Q36:Q37:Q38:Q39;
            SEIZE:MTL1;
            DELAY:ED(40);
            RELEASE:MTL1;
            TALLY:3,BET(14):DISPOSE;
;
            CREATE,1:ED(43):NEXT(DD3);
;
```

```
DD1        TALLY:5,BET(17):NEXT(Q50);
DD2        TALLY:7,BET(18):NEXT(Q50);
DD3        TALLY:8,BET(19):NEXT(Q50);
Q50        QUEUE,50;
           COMBINE:8,FIRST;
           TALLY:9,BET(20);
           QUEUE,51;
           SEIZE:FTRUCK;
           DELAY:ED(44);
           RELEASE:FTRUCK;
           COUNT:32,8:DISPOSE;
END;
```

APPENDIX XIII : Model File - APS31.MOD

3 Palletisers 35cc/min each ; 1.6m Pallet Height

```
BEGIN,1,1,YES,AUTOPALL,YES;
; AUTO PALLETISING SYSTEM - MODEL FILE "APS31.MOD" M. GOKAL
; ================================================================
;    1.6m PALLET HEIGHT
;    3 PALLETISERS : 35cc/min each
;
          CREATE,1;
START1    ASSIGN:X(1)=ED(1);
          DELAY:ED(2);
          ASSIGN:X(1)=ED(3);
          DELAY:ED(3):NEXT(START1);
          CREATE,1:X(1);
          COUNT:1,1;
          ASSIGN:A(1)=1;
          ASSIGN:A(2)=24;
          ASSIGN:A(3)=53;
          ASSIGN:A(4)=0.80;
          ASSIGN:A(5)=21:NEXT(BR1);
;
          CREATE,1;
START2    ASSIGN:X(2)=ED(4);
          DELAY:ED(5);
          ASSIGN:X(2)=ED(6);
          DELAY:ED(6):NEXT(START2);
          CREATE,1:X(2);
          COUNT:2,1;
          ASSIGN:A(1)=6;
          ASSIGN:A(2)=40;
          ASSIGN:A(3)=65;
          ASSIGN:A(4)=0.99;
          ASSIGN:A(5)=26:NEXT(BR2);
;
          CREATE,1;
START3    ASSIGN:X(3)=ED(7);
          DELAY:ED(8);
          ASSIGN:X(3)=ED(9);
          DELAY:ED(9):NEXT(START3);
          CREATE,1:X(3);
          COUNT:3,1;
          ASSIGN:A(1)=5;
          ASSIGN:A(2)=28;
          ASSIGN:A(3)=55;
          ASSIGN:A(4)=0.86;
          ASSIGN:A(5)=25:NEXT(BR3);
;
          CREATE,1;
START4    ASSIGN:X(4)=ED(10);
          DELAY:ED(11);
          ASSIGN:X(4)=ED(12);
          DELAY:ED(12):NEXT(START4);
          CREATE,1:X(4);
          COUNT:4,1;
          ASSIGN:A(1)=6;
          ASSIGN:A(2)=40;
          ASSIGN:A(3)=65;
```

```
           ASSIGN:A(4)=0.99;
           ASSIGN:A(5)=26:NEXT(BR4);
;
           CREATE,1;
START5     ASSIGN:X(5)=ED(13);
           DELAY:ED(14);
           ASSIGN:X(5)=ED(15);
           DELAY:ED(15):NEXT(START5);
           CREATE,1:X(5);
           COUNT:5,1;
           ASSIGN:A(1)=4;
           ASSIGN:A(2)=24;
           ASSIGN:A(3)=45;
           ASSIGN:A(4)=0.80;
           ASSIGN:A(5)=24:NEXT(BR5);
;
           CREATE,1;
START6     ASSIGN:X(6)=ED(16);
           DELAY:ED(17);
           ASSIGN:X(6)=ED(18);
           DELAY:ED(18):NEXT(START6);
           CREATE,1:X(6);
           COUNT:6,1;
           ASSIGN:A(1)=8;
           ASSIGN:A(2)=20;
           ASSIGN:A(3)=47;
           ASSIGN:A(4)=0.69;
           ASSIGN:A(5)=28:NEXT(BR6);
;
           CREATE,1;
START7     ASSIGN:X(7)=ED(19);
           DELAY:ED(20);
           ASSIGN:X(7)=ED(21);
           DELAY:ED(21):NEXT(START7);
           CREATE,1:X(7);
           COUNT:7,1;
           ASSIGN:A(1)=3;
           ASSIGN:A(2)=20;
           ASSIGN:A(3)=38;
           ASSIGN:A(4)=0.69;
           ASSIGN:A(5)=23:NEXT(BR7);
;
           CREATE,1;
START8     ASSIGN:X(8)=ED(22);
           DELAY:ED(23);
           ASSIGN:X(8)=ED(24);
           DELAY:ED(24):NEXT(START8);
           CREATE,1:X(8);
           COUNT:8,1;
           ASSIGN:A(1)=4;
           ASSIGN:A(2)=24;
           ASSIGN:A(3)=45;
           ASSIGN:A(4)=0.80;
           ASSIGN:A(5)=24:NEXT(BR8);
;
           CREATE,1;
START9     ASSIGN:X(9)=ED(25);
           DELAY:ED(26);
```

```
          ASSIGN:X(9)=ED(27);
          DELAY:ED(27):NEXT(START9);
          CREATE,1:X(9);
          COUNT:9,1;
          ASSIGN:A(1)=7;
          ASSIGN:A(2)=20;
          ASSIGN:A(3)=39;
          ASSIGN:A(4)=0.69;
          ASSIGN:A(5)=27:NEXT(BR9);
;
          CREATE,1;
START10   ASSIGN:X(10)=ED(28);
          DELAY:ED(29);
          ASSIGN:X(10)=ED(30);
          DELAY:ED(30):NEXT(START10);
          CREATE,1:X(10);
          COUNT:10,1;
          ASSIGN:A(1)=9;
          ASSIGN:A(2)=40;
          ASSIGN:A(3)=65;
          ASSIGN:A(4)=0.99;
          ASSIGN:A(5)=29:NEXT(BR10);
;
          CREATE,1;
START11   ASSIGN:X(11)=ED(31);
          DELAY:ED(32);
          ASSIGN:X(11)=ED(33);
          DELAY:ED(33):NEXT(START11);
          CREATE,1:X(11);
          COUNT:11,1;
          ASSIGN:A(1)=2;
          ASSIGN:A(2)=21;
          ASSIGN:A(3)=42;
          ASSIGN:A(4)=0.74;
          ASSIGN:A(5)=22:NEXT(BR11);
;
BR1       BRANCH,1:
             IF,NQ(A(5)).LT.2,Q1:
             IF,NQ(A(5)).EQ.2.AND.NQ(A(1)).LT.(A(3)-(2*A(2))),
             ELSE,FULL1;
BR2       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q6:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q6:
             ELSE,FULL2;
BR3       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q5:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q5:
             ELSE,FULL3;
BR4       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q6:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q6:
             ELSE,FULL4;
BR5       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q4:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q4:
             ELSE,FULL5;
BR6       BRANCH,1:
             IF,NQ(A(5)).LT.2,Q8:
```

```
                 IF,NQ(A(5)).EQ.2.AND.NQ(A(1)).LT.(A(3)-(2*A(2))),Q8:
                 ELSE,FULL6;
BR7           BRANCH,1:
                 IF,NQ(A(5)).EQ.0,Q3:
                 IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q3:
                 ELSE,FULL7;
BR8           BRANCH,1:
                 IF,NQ(A(5)).EQ.0,Q4:
                 IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q4:
                 ELSE,FULL8;
BR9           BRANCH,1:
                 IF,NQ(A(5)).EQ.0,Q7:
                 IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q7:
                 ELSE,FULL9;
BR10          BRANCH,1:
                 IF,NQ(A(5)).EQ.0,Q9:
                 IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q9:
                 ELSE,FULL10;
BR11          BRANCH,1:
                 IF,NQ(A(5)).LT.2,Q2:
                 IF,NQ(A(5)).EQ.2.AND.NQ(A(1)).LT.(A(3)-(2*A(2))),Q2:
                 ELSE,FULL11;
;
FULL1         COUNT:12,1:DISPOSE;
FULL2         COUNT:13,1:DISPOSE;
FULL3         COUNT:14,1:DISPOSE;
FULL4         COUNT:15,1:DISPOSE;
FULL5         COUNT:16,1:DISPOSE;
FULL6         COUNT:17,1:DISPOSE;
FULL7         COUNT:18,1:DISPOSE;
FULL8         COUNT:19,1:DISPOSE;
FULL9         COUNT:20,1:DISPOSE;
FULL10        COUNT:21,1:DISPOSE;
FULL11        COUNT:22,1:DISPOSE;
;
Q1            QUEUE,1;
              COMBINE:A(2),FIRST:NEXT(P1);
Q2            QUEUE,2;
              COMBINE:A(2),FIRST:NEXT(P2);
Q3            QUEUE,3;
              COMBINE:A(2),FIRST:NEXT(P3);
Q4            QUEUE,4;
              COMBINE:A(2),FIRST:NEXT(P4);
Q5            QUEUE,5;
              COMBINE:A(2),FIRST:NEXT(P5);
Q6            QUEUE,6;
              COMBINE:A(2),FIRST:NEXT(P6);
Q7            QUEUE,7;
              COMBINE:A(2),FIRST:NEXT(P7);
Q8            QUEUE,8;
              COMBINE:A(2),FIRST:NEXT(P8);
Q9            QUEUE,9;
              COMBINE:A(2),FIRST:NEXT(P9);
;
              CREATE,1;
PAL1          DELAY:ED(34);
              QUEUE,40;
              SEIZE:PALL1;
```

```
          DELAY:ED(35);
          RELEASE:PALL1:NEXT(PAL1);
;
          CREATE,1;
PAL2      DELAY:ED(36);
          QUEUE,41;
          SEIZE:PALL2;
          DELAY:ED(37);
          RELEASE:PALL2:NEXT(PAL2);
;
          CREATE,1;
PAL3      DELAY:ED(38);
          QUEUE,42;
          SEIZE:PALL3;
          DELAY:ED(39);
          RELEASE:PALL3:NEXT(PAL3);
;
P4        QUEUE,24:DETACH;
P6        QUEUE,26:DETACH;
P8        QUEUE,28:DETACH;
          QPICK,CYC:P4:P6:P8;
          SEIZE:PALL1;
          DELAY:A(4);
          RELEASE:PALL1;
          TALLY:1,BET(12);
          BRANCH,1:
             WITH,ED(43),DD1:
             WITH,ED(44),BR12;
;
BR12      TALLY:5,BET(15);
          BRANCH,1:
             IF,A(1).EQ.4.AND.NQ(34).EQ.2,FT4:
             IF,A(1).EQ.4.AND.NQ(34).LT.2,Q14:
             IF,A(1).EQ.6.AND.NQ(36).EQ.2,FT6:
             IF,A(1).EQ.6.AND.NQ(36).LT.2,Q16:
             IF,A(1).EQ.8.AND.NQ(38).EQ.2,FT8:
             IF,A(1).EQ.8.AND.NQ(38).LT.2,Q18;
;
P1        QUEUE,21:DETACH;
P2        QUEUE,22:DETACH;
P5        QUEUE,25:DETACH;
          QPICK,CYC:P1:P2:P5;
          SEIZE:PALL2;
          DELAY:A(4);
          RELEASE:PALL2;
          TALLY:2,BET(13);
;
          BRANCH,1:
             WITH,ED(43),DD2:
             WITH,ED(44),BR13;
;
BR13      TALLY:7,BET(16);
          BRANCH,1:
             IF,A(1).EQ.1.AND.NQ(31).EQ.2,FT1:
             IF,A(1).EQ.1.AND.NQ(31).LT.2,Q11:
             IF,A(1).EQ.2.AND.NQ(32).EQ.2,FT2:
             IF,A(1).EQ.2.AND.NQ(32).LT.2,Q12:
             IF,A(1).EQ.5.AND.NQ(35).EQ.2,FT5:
```

```
              IF,A(1).EQ.5.AND.NQ(35).LT.2,Q15;
;
P3         QUEUE,23:DETACH;
P7         QUEUE,27:DETACH;
P9         QUEUE,29:DETACH;
           QPICK,CYC:P3:P7:P9;
           SEIZE:PALL3;
           DELAY:A(4);
           RELEASE:PALL3;
           TALLY:3,BET(21);
;
           BRANCH,1:
              WITH,ED(43),DD3:
              WITH,ED(44),BR14;
;
BR14       TALLY:9,BET(22);
           BRANCH,1:
              IF,A(1).EQ.3.AND.NQ(33).EQ.2,FT3:
              IF,A(1).EQ.3.AND.NQ(33).LT.2,Q13:
              IF,A(1).EQ.7.AND.NQ(37).EQ.2,FT7:
              IF,A(1).EQ.7.AND.NQ(37).LT.2,Q17:
              IF,A(1).EQ.9.AND.NQ(39).EQ.2,FT9:
              IF,A(1).EQ.9.AND.NQ(39).LT.2,Q19;
;
FT1        COUNT:23,1:DISPOSE;
FT2        COUNT:24,1:DISPOSE;
FT3        COUNT:25,1:DISPOSE;
FT4        COUNT:26,1:DISPOSE;
FT5        COUNT:27,1:DISPOSE;
FT6        COUNT:28,1:DISPOSE;
FT7        COUNT:29,1:DISPOSE;
FT8        COUNT:30,1:DISPOSE;
FT9        COUNT:31,1:DISPOSE;
;
Q11        QUEUE,11;
           COMBINE:6,FIRST:NEXT(Q31);
Q12        QUEUE,12;
           COMBINE:6,FIRST:NEXT(Q32);
Q13        QUEUE,13;
           COMBINE:6,FIRST:NEXT(Q33);
Q14        QUEUE,14;
           COMBINE:6,FIRST:NEXT(Q34);
Q15        QUEUE,15;
           COMBINE:6,FIRST:NEXT(Q35);
Q16        QUEUE,16;
           COMBINE:6,FIRST:NEXT(Q36);
Q17        QUEUE,17;
           COMBINE:6,FIRST:NEXT(Q37);
Q18        QUEUE,18;
           COMBINE:6,FIRST:NEXT(Q38);
Q19        QUEUE,19;
           COMBINE:6,FIRST:NEXT(Q39);
;
           CREATE,1;
MTL1       DELAY:ED(40);
           QUEUE,43;
           SEIZE:MTL1;
           DELAY:ED(41);
```

```
          RELEASE:MTL1:NEXT(MTL1);
;
Q31       QUEUE,31:DETACH;
Q32       QUEUE,32:DETACH;
Q33       QUEUE,33:DETACH;
Q34       QUEUE,34:DETACH;
Q35       QUEUE,35:DETACH;
Q36       QUEUE,36:DETACH;
Q37       QUEUE,37:DETACH;
Q38       QUEUE,38:DETACH;
Q39       QUEUE,39:DETACH;
          QPICK,CYC:Q31:Q32:Q33:Q34:Q35:Q36:Q37:Q38:Q39;
          SEIZE:MTL1;
          DELAY:ED(42);
          RELEASE:MTL1;
          TALLY:4,BET(14):DISPOSE;
;
          CREATE,1:ED(45):NEXT(DD4);
;
DD1       TALLY:6,BET(17):NEXT(Q50);
DD2       TALLY:8,BET(18):NEXT(Q50);
DD3       TALLY:10,BET(23):NEXT(Q50);
DD4       TALLY:11,BET(19):NEXT(Q50);
Q50       QUEUE,50;
          COMBINE:8,FIRST;
          TALLY:12,BET(20);
          QUEUE,51;
          SEIZE:FTRUCK;
          DELAY:ED(44);
          RELEASE:FTRUCK;
          COUNT:32,8:DISPOSE;
END;
```

APPENDIX XIV : Model File - APS32.MOD

3 Palletisers 35cc/min each ; 2.1m Pallet Height

```
BEGIN,1,1,YES,AUTOPALL,YES;
; AUTO PALLETISING SYSTEM - MODEL FILE "APS32.MOD" M. GOKAL
; ================================================================
;    2.1m PALLET HEIGHT
;    3 PALLETISERS : 35cc/min each
;
          CREATE,1;
START1    ASSIGN:X(1)=ED(1);
          DELAY:ED(2);
          ASSIGN:X(1)=ED(3);
          DELAY:ED(3):NEXT(START1);
          CREATE,1:X(1);
          COUNT:1,1;
          ASSIGN:A(1)=1;
          ASSIGN:A(2)=32;
          ASSIGN:A(3)=53;
          ASSIGN:A(4)=1.07;
          ASSIGN:A(5)=21:NEXT(BR1);
;
          CREATE,1;
START2    ASSIGN:X(2)=ED(4);
          DELAY:ED(5);
          ASSIGN:X(2)=ED(6);
          DELAY:ED(6):NEXT(START2);
          CREATE,1:X(2);
          COUNT:2,1;
          ASSIGN:A(1)=6;
          ASSIGN:A(2)=50;
          ASSIGN:A(3)=65;
          ASSIGN:A(4)=1.24;
          ASSIGN:A(5)=26:NEXT(BR2);
;
          CREATE,1;
START3    ASSIGN:X(3)=ED(7);
          DELAY:ED(8);
          ASSIGN:X(3)=ED(9);
          DELAY:ED(9):NEXT(START3);
          CREATE,1:X(3);
          COUNT:3,1;
          ASSIGN:A(1)=5;
          ASSIGN:A(2)=42;
          ASSIGN:A(3)=55;
          ASSIGN:A(4)=1.29;
          ASSIGN:A(5)=25:NEXT(BR3);
;
          CREATE,1;
START4    ASSIGN:X(4)=ED(10);
          DELAY:ED(11);
          ASSIGN:X(4)=ED(12);
          DELAY:ED(12):NEXT(START4);
          CREATE,1:X(4);
          COUNT:4,1;
          ASSIGN:A(1)=6;
          ASSIGN:A(2)=50;
          ASSIGN:A(3)=65;
```

```
          ASSIGN:A(4)=1.24;
          ASSIGN:A(5)=26:NEXT(BR4);
;
          CREATE,1;
START5    ASSIGN:X(5)=ED(13);
          DELAY:ED(14);
          ASSIGN:X(5)=ED(15);
          DELAY:ED(15):NEXT(START5);
          CREATE,1:X(5);
          COUNT:5,1;
          ASSIGN:A(1)=4;
          ASSIGN:A(2)=32;
          ASSIGN:A(3)=45;
          ASSIGN:A(4)=1.07;
          ASSIGN:A(5)=24:NEXT(BR5);
;
          CREATE,1;
START6    ASSIGN:X(6)=ED(16);
          DELAY:ED(17);
          ASSIGN:X(6)=ED(18);
          DELAY:ED(18):NEXT(START6);
          CREATE,1:X(6);
          COUNT:6,1;
          ASSIGN:A(1)=8;
          ASSIGN:A(2)=30;
          ASSIGN:A(3)=47;
          ASSIGN:A(4)=1.04;
          ASSIGN:A(5)=28:NEXT(BR6);
;
          CREATE,1;
START7    ASSIGN:X(7)=ED(19);
          DELAY:ED(20);
          ASSIGN:X(7)=ED(21);
          DELAY:ED(21):NEXT(START7);
          CREATE,1:X(7);
          COUNT:7,1;
          ASSIGN:A(1)=3;
          ASSIGN:A(2)=30;
          ASSIGN:A(3)=38;
          ASSIGN:A(4)=1.04;
          ASSIGN:A(5)=23:NEXT(BR7);
;
          CREATE,1;
START8    ASSIGN:X(8)=ED(22);
          DELAY:ED(23);
          ASSIGN:X(8)=ED(24);
          DELAY:ED(24):NEXT(START8);
          CREATE,1:X(8);
          COUNT:8,1;
          ASSIGN:A(1)=4;
          ASSIGN:A(2)=32;
          ASSIGN:A(3)=45;
          ASSIGN:A(4)=1.07;
          ASSIGN:A(5)=24:NEXT(BR8);
;
          CREATE,1;
START9    ASSIGN:X(9)=ED(25);
          DELAY:ED(26);
```

```
          ASSIGN:X(9)=ED(27);
          DELAY:ED(27):NEXT(START9);
          CREATE,1:X(9);
          COUNT:9,1;
          ASSIGN:A(1)=7;
          ASSIGN:A(2)=30;
          ASSIGN:A(3)=39;
          ASSIGN:A(4)=1.04;
          ASSIGN:A(5)=27:NEXT(BR9);
;
          CREATE,1;
START10   ASSIGN:X(10)=ED(28);
          DELAY:ED(29);
          ASSIGN:X(10)=ED(30);
          DELAY:ED(30):NEXT(START10);
          CREATE,1:X(10);
          COUNT:10,1;
          ASSIGN:A(1)=9;
          ASSIGN:A(2)=50;
          ASSIGN:A(3)=65;
          ASSIGN:A(4)=1.24;
          ASSIGN:A(5)=29:NEXT(BR10);
;
          CREATE,1;
START11   ASSIGN:X(11)=ED(31);
          DELAY:ED(32);
          ASSIGN:X(11)=ED(33);
          DELAY:ED(33):NEXT(START11);
          CREATE,1:X(11);
          COUNT:11,1;
          ASSIGN:A(1)=2;
          ASSIGN:A(2)=28;
          ASSIGN:A(3)=42;
          ASSIGN:A(4)=0.99;
          ASSIGN:A(5)=22:NEXT(BR11);
;
BR1       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q1:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q1:
             ELSE,FULL1;
BR2       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q6:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q6:
             ELSE,FULL2;
BR3       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q5:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q5:
             ELSE,FULL3;
BR4       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q6:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q6:
             ELSE,FULL4;
BR5       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q4:
             IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q4:
             ELSE,FULL5;
BR6       BRANCH,1:
             IF,NQ(A(5)).EQ.0,Q8:
```

```
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q8:
            ELSE,FULL6;
BR7       BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q3:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q3:
            ELSE,FULL7;
BR8       BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q4:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q4:
            ELSE,FULL8;
BR9       BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q7:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q7:
            ELSE,FULL9;
BR10      BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q9:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q9:
            ELSE,FULL10;
BR11      BRANCH,1:
            IF,NQ(A(5)).EQ.0,Q2:
            IF,NQ(A(5)).EQ.1.AND.NQ(A(1)).LT.(A(3)-A(2)),Q2:
            ELSE,FULL11;
;
FULL1     COUNT:12,1:DISPOSE;
FULL2     COUNT:13,1:DISPOSE;
FULL3     COUNT:14,1:DISPOSE;
FULL4     COUNT:15,1:DISPOSE;
FULL5     COUNT:16,1:DISPOSE;
FULL6     COUNT:17,1:DISPOSE;
FULL7     COUNT:18,1:DISPOSE;
FULL8     COUNT:19,1:DISPOSE;
FULL9     COUNT:20,1:DISPOSE;
FULL10    COUNT:21,1:DISPOSE;
FULL11    COUNT:22,1:DISPOSE;
;
Q1        QUEUE,1;
          COMBINE:A(2),FIRST:NEXT(P1);
Q2        QUEUE,2;
          COMBINE:A(2),FIRST:NEXT(P2);
Q3        QUEUE,3;
          COMBINE:A(2),FIRST:NEXT(P3);
Q4        QUEUE,4;
          COMBINE:A(2),FIRST:NEXT(P4);
Q5        QUEUE,5;
          COMBINE:A(2),FIRST:NEXT(P5);
Q6        QUEUE,6;
          COMBINE:A(2),FIRST:NEXT(P6);
Q7        QUEUE,7;
          COMBINE:A(2),FIRST:NEXT(P7);
Q8        QUEUE,8;
          COMBINE:A(2),FIRST:NEXT(P8);
Q9        QUEUE,9;
          COMBINE:A(2),FIRST:NEXT(P9);
;
          CREATE,1;
PAL1      DELAY:ED(34);
          QUEUE,40;
          SEIZE:PALL1;
```

```
          DELAY:ED(35);
          RELEASE:PALL1:NEXT(PAL1);
;
          CREATE,1;
PAL2      DELAY:ED(36);
          QUEUE,41;
          SEIZE:PALL2;
          DELAY:ED(37);
          RELEASE:PALL2:NEXT(PAL2);
;
          CREATE,1;
PAL3      DELAY:ED(38);
          QUEUE,42;
          SEIZE:PALL3;
          DELAY:ED(39);
          RELEASE:PALL3:NEXT(PAL3);
;
P4        QUEUE,24:DETACH;
P6        QUEUE,26:DETACH;
P8        QUEUE,28:DETACH;
          QPICK,CYC:P4:P6:P8;
          SEIZE:PALL1;
          DELAY:A(4);
          RELEASE:PALL1;
          TALLY:1,BET(12);
          BRANCH,1:
             WITH,ED(43),DD1:
             WITH,ED(44),BR12;
;
BR12      TALLY:5,BET(15);
          BRANCH,1:
             IF,A(1).EQ.4.AND.NQ(34).EQ.2,FT4:
             IF,A(1).EQ.4.AND.NQ(34).LT.2,Q14:
             IF,A(1).EQ.6.AND.NQ(36).EQ.2,FT6:
             IF,A(1).EQ.6.AND.NQ(36).LT.2,Q16:
             IF,A(1).EQ.8.AND.NQ(38).EQ.2,FT8:
             IF,A(1).EQ.8.AND.NQ(38).LT.2,Q18;
;
P1        QUEUE,21:DETACH;
P2        QUEUE,22:DETACH;
P5        QUEUE,25:DETACH;
          QPICK,CYC:P1:P2:P5;
          SEIZE:PALL2;
          DELAY:A(4);
          RELEASE:PALL2;
          TALLY:2,BET(13);
;
          BRANCH,1:
             WITH,ED(43),DD2:
             WITH,ED(44),BR13;
;
BR13      TALLY:7,BET(16);
          BRANCH,1:
             IF,A(1).EQ.1.AND.NQ(31).EQ.2,FT1:
             IF,A(1).EQ.1.AND.NQ(31).LT.2,Q11:
             IF,A(1).EQ.2.AND.NQ(32).EQ.2,FT2:
             IF,A(1).EQ.2.AND.NQ(32).LT.2,Q12:
             IF,A(1).EQ.5.AND.NQ(35).EQ.2,FT5:
```

```
            IF,A(1).EQ.5.AND.NQ(35).LT.2,Q15;
;
P3         QUEUE,23:DETACH;
P7         QUEUE,27:DETACH;
P9         QUEUE,29:DETACH;
           QPICK,CYC:P3:P7:P9;
           SEIZE:PALL3;
           DELAY:A(4);
           RELEASE:PALL3;
           TALLY:3,BET(21);
;
           BRANCH,1:
              WITH,ED(43),DD3:
              WITH,ED(44),BR14;
;
BR14       TALLY:9,BET(22);
           BRANCH,1:
              IF,A(1).EQ.3.AND.NQ(33).EQ.2,FT3:
              IF,A(1).EQ.3.AND.NQ(33).LT.2,Q13:
              IF,A(1).EQ.7.AND.NQ(37).EQ.2,FT7:
              IF,A(1).EQ.7.AND.NQ(37).LT.2,Q17:
              IF,A(1).EQ.9.AND.NQ(39).EQ.2,FT9:
              IF,A(1).EQ.9.AND.NQ(39).LT.2,Q19;
;
FT1        COUNT:23,1:DISPOSE;
FT2        COUNT:24,1:DISPOSE;
FT3        COUNT:25,1:DISPOSE;
FT4        COUNT:26,1:DISPOSE;
FT5        COUNT:27,1:DISPOSE;
FT6        COUNT:28,1:DISPOSE;
FT7        COUNT:29,1:DISPOSE;
FT8        COUNT:30,1:DISPOSE;
FT9        COUNT:31,1:DISPOSE;
;
Q11        QUEUE,11;
           COMBINE:6,FIRST:NEXT(Q31);
Q12        QUEUE,12;
           COMBINE:6,FIRST:NEXT(Q32);
Q13        QUEUE,13;
           COMBINE:6,FIRST:NEXT(Q33);
Q14        QUEUE,14;
           COMBINE:6,FIRST:NEXT(Q34);
Q15        QUEUE,15;
           COMBINE:6,FIRST:NEXT(Q35);
Q16        QUEUE,16;
           COMBINE:6,FIRST:NEXT(Q36);
Q17        QUEUE,17;
           COMBINE:6,FIRST:NEXT(Q37);
Q18        QUEUE,18;
           COMBINE:6,FIRST:NEXT(Q38);
Q19        QUEUE,19;
           COMBINE:6,FIRST:NEXT(Q39);
;
           CREATE,1;
MTL1       DELAY:ED(40);
           QUEUE,43;
           SEIZE:MTL1;
           DELAY:ED(41);
```

```
          RELEASE:MTL1:NEXT(MTL1);
;
Q31       QUEUE,31:DETACH;
Q32       QUEUE,32:DETACH;
Q33       QUEUE,33:DETACH;
Q34       QUEUE,34:DETACH;
Q35       QUEUE,35:DETACH;
Q36       QUEUE,36:DETACH;
Q37       QUEUE,37:DETACH;
Q38       QUEUE,38:DETACH;
Q39       QUEUE,39:DETACH;
          QPICK,CYC:Q31:Q32:Q33:Q34:Q35:Q36:Q37:Q38:Q39;
          SEIZE:MTL1;
          DELAY:ED(42);
          RELEASE:MTL1;
          TALLY:4,BET(14):DISPOSE;
;
          CREATE,1:ED(45):NEXT(DD4);
;
DD1       TALLY:6,BET(17):NEXT(Q50);
DD2       TALLY:8,BET(18):NEXT(Q50);
DD3       TALLY:10,BET(23):NEXT(Q50);
DD4       TALLY:11,BET(19):NEXT(Q50);
Q50       QUEUE,50;
          COMBINE:8,FIRST;
          TALLY:12,BET(20);
          QUEUE,51;
          SEIZE:FTRUCK;
          DELAY:ED(44);
          RELEASE:FTRUCK;
          COUNT:32,8:DISPOSE;
END;
```

APPENDIX XV : Experiment File - APS170.EXP

```
BEGIN,1,1,YES,NO;
; AUTO PALLETISING SYSTEM - EXPMT. FILE "APS170.EXP" M.GOKAL
; ==============================================================
;
PROJECT,AUTO PALLETISING,MG,8/12/89;
DISCRETE,800,5,83;
SEEDS:1,1453,YES:2,2547,YES:3,3364,YES:4,4645,YES:5,5772,YES:
      6,6981,YES:7,7486,YES:8,8593,YES:9,9900,YES:10,10000,YES;
DISTRIBUTIONS:1,CO(1):
              2,DP(2,1):
              3,DP(3,1):
              4,CO(4):
              5,DP(5,2):
              6,DP(6,2):
              7,CO(7):
              8,DP(8,3):
              9,DP(9,3):
              10,CO(10):
              11,DP(11,4):
              12,DP(12,4):
              13,CO(13):
              14,DP(14,5):
              15,DP(15,5):
              16,CO(16):
              17,DP(17,6):
              18,DP(18,6):
              19,CO(19):
              20,DP(20,7):
              21,DP(21,7):
              22,CO(22):
              23,DP(23,8):
              24,DP(24,8):
              25,CO(25):
              26,DP(26,9):
              27,DP(27,9):
              28,CO(28):
              29,DP(29,1):
              30,DP(30,1):
              31,CO(31):
              32,DP(32,2):
              33,DP(33,2):
              34,DP(34,10):
              35,DP(35,10):
              36,DP(36,10):
              37,DP(37,10):
              38,DP(38,10):
              39,DP(39,10):
              40,CO(40):
              41,CO(41):
              42,CO(42):
              43,CO(43):
              44,CO(44);
;
PARAMETERS:1,.17:
           2,.05,35,.20,30,.25,25,.28,20,.35,15,:
             .40,10,.50,5,1,1:
```

```
        3,.01,30,.02,20,.03,15,.08,10,.40,5,1,1:
        4,.25:
        5,.02,59,.03,35,.05,30,.10,25,.15,20,:
          .25,15,.40,10,.55,5,1,1:
        6,.15,10,.26,5,1,1:
        7,.08:
        8,.10,35,.15,30,.25,25,.30,20,.35,15,:
          .40,10,.50,5,1,1:
        9,.01,30,.02,15,.10,10,.55,5,1,1:
        10,.27:
        11,.01,59,.03,30,.05,25,.10,20,.30,15,:
           .40,10,.57,5,1,1:
        12,.11,10,.26,5,1,1:
        13,5000:
        14,.01,40,.10,35,.15,30,.20,25,.30,20,:
           .35,15,.40,10,.50,5,1,1:
        15,.01,30,.02,20,.05,15,.12,10,.45,5,1,1:
        16,.11:
        17,.05,41,.20,35,.35,30,.40,25,.43,20,:
           .45,15,.50,10,.60,5,1,1:
        18,.02,30,.03,25,.10,15,.15,10,.40,5,1,1:
        19,.11:
        20,.01,41,.05,35,.10,30,.20,25,.30,20,:
           .40,15,.50,10,.60,5,1,1:
        21,.01,30,.03,25,.10,15,.20,10,.40,5,1,1:
        22,.15:
        23,.10,40,.20,35,.25,30,.35,25,.45,20,:
           .50,15,.55,10,.65,5,1,1:
        24,.01,20,.03,25,.10,15,.20,10,.30,5,1,1:
        25,.11:
        26,.10,41,.25,35,.35,30,.42,25,.45,20,:
           .47,15,.50,10,.60,5,1,1:
        27,.01,30,.04,25,.10,15,.20,10,.40,5,1,1:
        28,.26:
        29,.03,59,.10,35,.20,30,.25,25,.28,20,:
           .30,15,.40,10,.57,5,1,1:
        30,.11,10,.26,5,1,1:
        31,.20:
        32,.05,50,.15,35,.25,30,.30,25,.42,15,:
           .52,10,.90,5,1,1:
        33,.01,20,.03,15,.20,10,.60,5,1,1:
        34,.5,45,.8,30,1,15:
        35,.4,2,.6,1,1,.5:
        36,.5,45,.8,30,1,15:
        37,.4,2,.6,1,1,.5:
        38,.25,15,.70,10,1,5:
        39,.10,10,.70,5,1,1:
        40,2.9:
        41,0.4:
        42,0.6:
        43,7.94:
        44,16;
;
COUNTERS:1,MC1 PRODUCTION:
         2,MC2 PRODUCTION:
         3,MC3 PRODUCTION:
         4,MC4 PRODUCTION:
         5,MC5 PRODUCTION:
```

```
          6,MC6 PRODUCTION:
          7,MC7 PRODUCTION:
          8,MC8 PRODUCTION:
          9,MC9 PRODUCTION:
          10,MC10 PRODUCTION:
          11,MC11 PRODUCTION:
          12,MC1 CC CNV OFLOW:
          13,MC2 CC CNV OFLOW:
          14,MC3 CC CNV OFLOW:
          15,MC4 CC CNV OFLOW:
          16,MC5 CC CNV OFLOW:
          17,MC6 CC CNV OFLOW:
          18,MC7 CC CNV OFLOW:
          19,MC8 CC CNV OFLOW:
          20,MC9 CC CNV OFLOW:
          21,MC10 C CNV OFLOW:
          22,MC11 C CNV OFLOW:
          23,PAL CNV1 OFLOW:
          24,PAL CNV2 OFLOW:
          25,PAL CNV3 OFLOW:
          26,PAL CNV4 OFLOW:
          27,PAL CNV5 OFLOW:
          28,PAL CNV6 OFLOW:
          29,PAL CNV7 OFLOW:
          30,PAL CNV8 OFLOW:
          31,PAL CNV9 OFLOW:
          32,PALLETS TO DD;
;
RESOURCES:1,PALL1:2,PALL2:3,MTL1:4,FTRUCK;
TALLIES:1,EXIT RATE PAL1:2,EXIT RATE PAL2:3,EXIT RATE MTL1:
        4,FROM PAL1 TO MTL:5,FROM PAL1 TO DD:
        6,FROM PAL2 TO MTL:7,FROM PAL2 TO DD:
        8,FROM LIQ. TO DD:9,EX RATE P10 8pp;
DSTAT:1,NR(1),PALL1 UTIL:2,NR(2),PALL2 UTIL:3,NR(3),MTL UTIL:
      4,NQ(51),DIRECT DESP Q;
REPLICATE,1,0,460;
END;
```

APPENDIX XVI : Output File - APS1160

FILE : APS1160.OPT

All Pallets via MTL

2 Palletisers 35cc/min each

1.6m Pallet Height

60% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.012	.565	.690	5.160	454
2	EXIT RATE PAL2	1.282	.894	.690	8.260	357
3	EXIT RATE MTL1	3.886	2.356	2.899	17.359	116
4	FROM PAL1 TO MTL	1.012	.565	.690	5.160	454
5	FROM PAL1 TO DD	.000	.000	.000	.000	0
6	FROM PAL2 TO MTL	1.282	.894	.690	8.260	35
7	FROM PAL2 TO DD	.000	.000	.000	.000	0
8	FROM LIQ. TO DD	.000	.000	.000	.000	1
9	EX RATE P10 8PP	.000	.000	.000	.000	0

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.793	.404	.000	1.000	460
2	PALL2 UTIL	.644	.478	.000	1.000	460
3	MTL UTIL	.975	.155	.000	1.000	460
4	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	5	Infinite
14	MC3 CC CNV OFLOW	0	Infinite
15	MC4 CC CNV OFLOW	5	Infinite
16	MC5 CC CNV OFLOW	0	Infinite

Counters

Number	Identifier	Count	Limit
17	MC6 CC CNV OFLOW	114	Infinite
18	MC7 CC CNV OFLOW	13	Infinite
19	MC8 CC CNV OFLOW	1	Infinite
20	MC9 CC CNV OFLOW	182	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	2	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	11	Infinite
26	PAL CNV4 OFLOW	2	Infinite
27	PAL CNV5 OFLOW	17	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	9	Infinite
30	PAL CNV8 OFLOW	7	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	0	Infinite

APPENDIX XVII : Output File - APS1260

FILE : APS1260.OPT

All Pallets via MTL

2 Palletisers 35cc/min each

2.1m Pallet Height

60% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.448	.788	1.039	5.799	317
2	EXIT RATE PAL2	1.893	1.227	.989	8.090	242
3	EXIT RATE MTL1	5.217	3.743	2.899	23.960	87
4	FROM PAL1 TO MTL	1.448	.788	1.039	5.799	317
5	FROM PAL1 TO DD	.000	.000	.000	.000	0
6	FROM PAL2 TO MTL	1.893	1.227	.989	8.090	242
7	FROM PAL2 TO DD	.000	.000	.000	.000	0
8	FROM LIQ. TO DD	.000	.000	.000	.000	1
9	EX RATE P10 8PP	.000	.000	.000	.000	0

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.778	.415	.000	1.000	460
2	PALL2 UTIL	.629	.482	.000	1.000	460
3	MTL UTIL	.807	.394	.000	1.000	460
4	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	6	Infinite
13	MC2 CC CNV OFLOW	14	Infinite
14	MC3 CC CNV OFLOW	104	Infinite
15	MC4 CC CNV OFLOW	13	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	192	Infinite

Counters

Number	Identifier	Count	Limit
18	MC7 CC CNV OFLOW	97	Infinite
19	MC8 CC CNV OFLOW	33	Infinite
20	MC9 CC CNV OFLOW	239	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	0	Infinite

APPENDIX XVIII : Output File - APS1170

FILE : APS1170.OPT

All Pallets via MTL

2 Palletisers 35cc/min each

1.6m Pallet Height

70% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	.887	.405	.690	3.932	518
2	EXIT RATE PAL2	1.128	.601	.690	4.200	407
3	EXIT RATE MTL1	3.844	2.247	2.899	17.359	118
4	FROM PAL1 TO MTL	.887	.405	.690	3.932	518
5	FROM PAL1 TO DD	.000	.000	.000	.000	0
6	FROM PAL2 TO MTL	1.128	.601	.690	4.200	407
7	FROM PAL2 TO DD	.000	.000	.000	.000	0
8	FROM LIQ. TO DD	.000	.000	.000	.000	1
9	EX RATE P10 8PP	.000	.000	.000	.000	0

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.892	.309	.000	1.000	460
2	PALL2 UTIL	.726	.445	.000	1.000	460
3	MTL UTIL	.979	.141	.000	1.000	460
4	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1954	Infinite
2	MC2 PRODUCTION	1431	Infinite
3	MC3 PRODUCTION	4209	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	3006	Infinite
7	MC7 PRODUCTION	2937	Infinite
8	MC8 PRODUCTION	2268	Infinite
9	MC9 PRODUCTION	3016	Infinite
10	MC10 PRODUCTION	1380	Infinite
11	MC11 PRODUCTION	1686	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	32	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	224	Infinite
18	MC7 CC CNV OFLOW	24	Infinite
19	MC8 CC CNV OFLOW	0	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	287	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	3	Infinite
24	PAL CNV2 OFLOW	1	Infinite
25	PAL CNV3 OFLOW	26	Infinite
26	PAL CNV4 OFLOW	10	Infinite
27	PAL CNV5 OFLOW	34	Infinite
28	PAL CNV6 OFLOW	2	Infinite
29	PAL CNV7 OFLOW	43	Infinite
30	PAL CNV8 OFLOW	23	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	0	Infinite

APPENDIX XIX : Output File - APS1270

FILE : APS1270.OPT

All Pallets via MTL

2 Palletisers 35cc/min each

2.1m Pallet Height

70% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Maximum Value	Number of Obs.
1	EXIT RATE PAL1	1.272	.535	1.039	4.363	361
2	EXIT RATE PAL2	1.653	.868	.989	7.008	278
3	EXIT RATE MTL1	4.549	3.101	2.899	23.960	101
4	FROM PAL1 TO MTL	1.272	.535	1.039	4.363	361
5	FROM PAL1 TO DD	.000	.000	.000	.000	0
6	FROM PAL2 TO MTL	1.653	.868	.989	7.008	278
7	FROM PAL2 TO DD	.000	.000	.000	.000	0
8	FROM LIQ. TO DD	.000	.000	.000	.000	1
9	EX RATE P10 8PP	.000	.000	.000	.000	0

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.875	.330	.000	1.000	460
2	PALL2 UTIL	.720	.448	.000	1.000	460
3	MTL UTIL	.913	.280	.000	1.000	460
4	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1954	Infinite
2	MC2 PRODUCTION	1431	Infinite
3	MC3 PRODUCTION	4209	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	3006	Infinite
7	MC7 PRODUCTION	2937	Infinite
8	MC8 PRODUCTION	2268	Infinite
9	MC9 PRODUCTION	3016	Infinite
10	MC10 PRODUCTION	1380	Infinite
11	MC11 PRODUCTION	1686	Infinite
12	MC1 CC CNV OFLOW	15	Infinite
13	MC2 CC CNV OFLOW	30	Infinite
14	MC3 CC CNV OFLOW	61	Infinite
15	MC4 CC CNV OFLOW	31	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	293	Infinite
18	MC7 CC CNV OFLOW	116	Infinite
19	MC8 CC CNV OFLOW	83	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	292	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	2	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	0	Infinite

APPENDIX XX : Output File - APS2160

FILE : APS2160.OPT

All Pallets via MTL

Palletiser1 : 35cc/min   Palletiser2 : 56cc/min

1.6m Pallet Height

60% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.129	.728	.690	7.049	406
2	EXIT RATE PAL2	1.097	.859	.429	6.847	419
3	EXIT RATE MTL1	4.191	2.799	2.899	16.419	108
4	FROM PAL1 TO MTL	1.129	.728	.690	7.049	406
5	FROM PAL1 TO DD	.000	.000	.000	.000	0
6	FROM PAL2 TO MTL	1.097	.859	.429	6.847	419
7	FROM PAL2 TO DD	.000	.000	.000	.000	0
8	FROM LIQ. TO DD	.000	.000	.000	.000	1
9	EX RATE P10 8PP	.000	.000	.000	.000	0

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.681	.465	.000	1.000	460
2	PALL2 UTIL	.502	.499	.000	1.000	460
3	MTL UTIL	.981	.134	.000	1.000	460
4	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	0	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	21	Infinite
18	MC7 CC CNV OFLOW	10	Infinite
19	MC8 CC CNV OFLOW	0	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	12	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	21	Infinite
26	PAL CNV4 OFLOW	8	Infinite
27	PAL CNV5 OFLOW	14	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	30	Infinite
30	PAL CNV8 OFLOW	47	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	0	Infinite

APPENXIX XXI : Output File - APS2260

FILE : APS2260.OPT

All Pallets via MTL

Palletiser1 : 35cc/min   Palletiser2 : 56cc/min

2.1m Pallet Height

60% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Maximum Value	Number of Obs.
1	EXIT RATE PAL1	1.626	1.003	1.039	8.889	282
2	EXIT RATE PAL2	1.554	1.181	.620	7.948	295
3	EXIT RATE MTL1	5.008	3.811	2.899	27.900	91
4	FROM PAL1 TO MTL	1.626	1.003	1.039	8.889	282
5	FROM PAL1 TO DD	.000	.000	.000	.000	0
6	FROM PAL2 TO MTL	1.554	1.181	.620	7.948	295
7	FROM PAL2 TO DD	.000	.000	.000	.000	0
8	FROM LIQ. TO DD	.000	.000	.000	.000	1
9	EX RATE P10 8PP	.000	.000	.000	.000	0

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.666	.471	.000	1.000	460
2	PALL2 UTIL	.503	.499	.000	1.000	460
3	MTL UTIL	.878	.326	.000	1.000	460
4	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	35	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	3	Infinite

Counters

Number	Identifier	Count	Limit
18	MC7 CC CNV OFLOW	27	Infinite
19	MC8 CC CNV OFLOW	16	Infinite
20	MC9 CC CNV OFLOW	31	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	0	Infinite

APPENDIX XXII : Output File - APS2170

FILE : APS2170.OPT

All Pallets via MTL

Palletiser1 : 35cc/min   Palletiser2 : 56cc/min

1.6m Pallet Height

70% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	.981	.525	.689	4.635	468
2	EXIT RATE PAL2	.952	.669	.429	6.120	483
3	EXIT RATE MTL1	3.965	2.508	2.899	16.419	114
4	FROM PAL1 TO MTL	.981	.525	.689	4.635	468
5	FROM PAL1 TO DD	.000	.000	.000	.000	0
6	FROM PAL2 TO MTL	.952	.669	.429	6.120	483
7	FROM PAL2 TO DD	.000	.000	.000	.000	0
8	FROM LIQ. TO DD	.000	.000	.000	.000	1
9	EX RATE P10 8PP	.000	.000	.000	.000	0

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PAL1 UTIL	.772	.419	.000	1.000	460
2	PAL2 UTIL	.568	.495	.000	1.000	460
3	MTL UTIL	.981	.134	.000	1.000	460
4	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1954	Infinite
2	MC2 PRODUCTION	1431	Infinite
3	MC3 PRODUCTION	4209	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	3006	Infinite
7	MC7 PRODUCTION	2937	Infinite
8	MC8 PRODUCTION	2268	Infinite
9	MC9 PRODUCTION	3016	Infinite
10	MC10 PRODUCTION	1380	Infinite
11	MC11 PRODUCTION	1686	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	2	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	8	Infinite
18	MC7 CC CNV OFLOW	25	Infinite
19	MC8 CC CNV OFLOW	0	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	6	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	19	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	42	Infinite
26	PAL CNV4 OFLOW	9	Infinite
27	PAL CNV5 OFLOW	36	Infinite
28	PAL CNV6 OFLOW	9	Infinite
29	PAL CNV7 OFLOW	48	Infinite
30	PAL CNV8 OFLOW	29	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	0	Infinite

APPENDIX XXIII : Output File - APS2270

FILE : APS2270.OPT

All Pallets via MTL

Palletiser1 : 35cc/min   Palletiser2 : 56cc/min

2.1m Pallet Height

70% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.426	.687	1.039	5.455	322
2	EXIT RATE PAL2	1.353	.879	.620	7.180	339
3	EXIT RATE MTL1	4.445	3.402	2.899	27.900	103
4	FROM PAL1 TO MTL	1.426	.687	1.039	5.455	322
5	FROM PAL1 TO DD	.000	.000	.000	.000	0
6	FROM PAL2 TO MTL	1.353	.879	.620	7.180	339
7	FROM PAL2 TO DD	.000	.000	.000	.000	0
8	FROM LIQ. TO DD	.000	.000	.000	.000	1
9	EX RATE P10 8PP	.000	.000	.000	.000	0

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PAL1 UTIL	.764	.424	.000	1.000	460
2	PAL2 UTIL	.569	.495	.000	1.000	460
3	MTL UTIL	.910	.285	.000	1.000	460
4	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1954	Infinite
2	MC2 PRODUCTION	1431	Infinite
3	MC3 PRODUCTION	4209	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	3006	Infinite
7	MC7 PRODUCTION	2937	Infinite
8	MC8 PRODUCTION	2268	Infinite
9	MC9 PRODUCTION	3016	Infinite
10	MC10 PRODUCTION	1380	Infinite
11	MC11 PRODUCTION	1686	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	55	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	37	Infinite
18	MC7 CC CNV OFLOW	104	Infinite
19	MC8 CC CNV OFLOW	4	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	25	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	1	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	4	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	0	Infinite

APPENDIX XXIV : Output File - APS3160

FILE : APS3160.OPT

All Pallets via MTL

3 Palletisers 35cc/min each

1.6m Pallet Height

60% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.653	1.181	.689	9.102	277
2	EXIT RATE PAL2	1.720	1.249	.739	8.999	265
3	EXIT RATE PAL3	1.615	1.306	.690	8.799	284
4	EXIT RATE MTL1	4.357	3.116	2.899	22.900	105
5	FROM PAL1 TO MTL	1.653	1.181	.689	9.102	277
6	FROM PAL1 TO DD	.000	.000	.000	.000	0
7	FROM PAL2 TO MTL	1.720	1.249	.739	8.999	265
8	FROM PAL2 TO DD	.000	.000	.000	.000	0
9	FROM PAL3 TO MTL	1.6150	1.300	.690	8.799	284
10	FROM PAL3 TO DD	.000	.000	.000	.000	0
11	FROM LIQ. TO DD	.000	.000	.000	.000	1
12	EX RATE P10 8PP	.000	.000	.000	.000	0

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PAL1 UTIL	.506	.499	.000	1.00000	460
2	PAL2 UTIL	.505	.499	.000	1.00000	460
3	PAL3 UTIL	.475	.499	.000	1.00000	460
4	MTL UTIL	.978	.145	.000	1.00000	460
5	DIRECT DESP Q	.000	.000	.000	.00000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	0	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	0	Infinite
18	MC7 CC CNV OFLOW	0	Infinite

Counters

Number	Identifier	Count	Limit
19	MC8 CC CNV OFLOW	0	Infinite
20	MC9 CC CNV OFLOW	0	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	2	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	34	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	35	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	27	Infinite
30	PAL CNV8 OFLOW	24	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	0	Infinite

APPENDIX XXV : Output File - APS3260

FILE APS3260.OPT

All Pallets via MTL

3 Palletisers 35cc/min each

2.1m Pallet Height

60% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	2.294	1.522	1.039	9.816	200
2	EXIT RATE PAL2	2.419	1.551	.989	8.840	188
3	EXIT RATE PAL3	2.417	1.815	1.039	12.284	190
4	EXIT RATE MTL1	5.083	3.849	2.899	23.630	90
5	FROM PAL1 TO MTL	2.294	1.522	1.039	9.816	200
6	FROM PAL1 TO DD	.000	.000	.000	.000	0
7	FROM PAL2 TO MTL	2.419	1.551	.989	8.840	188
8	FROM PAL2 TO DD	.000	.000	.000	.000	0
9	FROM PAL3 TO MTL	2.417	1.815	1.039	12.284	190
10	FROM PAL3 TO DD	.000	.000	.000	.000	0
11	FROM LIQ. TO DD	.000	.000	.000	.000	1
12	EX RATE P10 8PP	.000	.000	.000	.000	0

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PAL1 UTIL	.511	.499	.000	1.000	460
2	PAL2 UTIL	.503	.499	.000	1.000	460
3	PAL3 UTIL	.469	.499	.000	1.000	460
4	MTL UTIL	.844	.362	.000	1.000	460
5	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	1	Infinite
14	MC3 CC CNV OFLOW	10	Infinite
15	MC4 CC CNV OFLOW	10	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	0	Infinite
18	MC7 CC CNV OFLOW	28	Infinite

Counters

Number	Identifier	Count	Limit
19	MC8 CC CNV OFLOW	4	Infinite
20	MC9 CC CNV OFLOW	61	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	0	Infinite

APPENDIX XXVI : Output File - APS3170

FILE : APS3170.OPT

All Pallets via MTL

3 Palletisers : 35cc/min each

1.6m Pallet Height

70% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.471	.925	.690	6.695	312
2	EXIT RATE PAL2	1.477	1.008	.739	10.826	310
3	EXIT RATE PAL3	1.392	1.076	.690	10.761	330
4	EXIT RATE MTL1	4.251	3.115	2.899	22.900	108
5	FROM PAL1 TO MTL	1.471	.925	.690	6.695	312
6	FROM PAL1 TO DD	.000	.000	.000	.000	0
7	FROM PAL2 TO MTL	1.477	1.008	.739	10.826	310
8	FROM PAL2 TO DD	.000	.000	.000	.000	0
9	FROM PAL3 TO MTL	1.392	1.076	.690	10.761	330
10	FROM PAL3 TO DD	.000	.000	.000	.000	0
11	FROM LIQ. TO DD	.000	.000	.000	.000	1
12	EX RATE P10 8PP	.000	.000	.000	.000	0

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PAL1 UTIL	.571	.494	.000	1.000	460
2	PAL2 UTIL	.582	.493	.000	1.000	460
3	PAL3 UTIL	.538	.498	.000	1.000	460
4	MTL UTIL	.978	.145	.000	1.000	460
5	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1954	Infinite
2	MC2 PRODUCTION	1431	Infinite
3	MC3 PRODUCTION	4209	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	3006	Infinite
7	MC7 PRODUCTION	2937	Infinite
8	MC8 PRODUCTION	2268	Infinite
9	MC9 PRODUCTION	3016	Infinite
10	MC10 PRODUCTION	1380	Infinite
11	MC11 PRODUCTION	1686	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	2	Infinite
14	MC3 CC CNV OFLOW	0	Infinite
15	MC4 CC CNV OFLOW	2	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	3	Infinite
18	MC7 CC CNV OFLOW	0	Infinite

Counters

Number	Identifier	Count	Limit
19	MC8 CC CNV OFLOW	0	Infinite
20	MC9 CC CNV OFLOW	2	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	1	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	5	Infinite
25	PAL CNV3 OFLOW	27	Infinite
26	PAL CNV4 OFLOW	12	Infinite
27	PAL CNV5 OFLOW	59	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	57	Infinite
30	PAL CNV8 OFLOW	70	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	0	Infinite

APPENDIX XXVII : Output File - APS3270

FILE : APS3270.OPT

All Pallets via MTL

3 Palletisers : 35cc/min each

2.1m Pallet Height

70% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	2.046	1.241	1.039	7.369	224
2	EXIT RATE PAL2	2.088	1.288	.989	9.589	220
3	EXIT RATE PAL3	2.067	1.329	1.039	10.586	221
4	EXIT RATE MTL1	4.337	2.956	2.899	23.630	106
5	FROM PAL1 TO MTL	2.046	1.241	1.039	7.369	224
6	FROM PAL1 TO DD	.000	.000	.000	.000	0
7	FROM PAL2 TO MTL	2.088	1.288	.989	9.589	220
8	FROM PAL2 TO DD	.000	.000	.000	.000	0
9	FROM PAL3 TO MTL	2.067	1.329	1.039	10.586	221
10	FROM PAL3 TO DD	.000	.000	.000	.000	0
11	FROM LIQ. TO DD	.000	.000	.000	.000	1
12	EX RATE P10 8PP	.000	.000	.000	.000	0

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PAL1 UTIL	.569	.495	.000	1.000	460
2	PAL2 UTIL	.582	.493	.000	1.000	460
3	PAL3 UTIL	.540	.498	.000	1.000	460
4	MTL UTIL	.927	.259	.000	1.000	460
5	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1954	Infinite
2	MC2 PRODUCTION	1431	Infinite
3	MC3 PRODUCTION	4209	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	3006	Infinite
7	MC7 PRODUCTION	2937	Infinite
8	MC8 PRODUCTION	2268	Infinite
9	MC9 PRODUCTION	3016	Infinite
10	MC10 PRODUCTION	1380	Infinite
11	MC11 PRODUCTION	1686	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	15	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	0	Infinite
18	MC7 CC CNV OFLOW	21	Infinite

Counters

Number	Identifier	Count	Limit
19	MC8 CC CNV OFLOW	5	Infinite
20	MC9 CC CNV OFLOW	38	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	1	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	0	Infinite

APPENDIX XXVIII : Output File - APS1160D

FILE : APS1160D.OPT

40% Pallets to Direct Despatch

2 Palletisers : 35cc/min each

1.6m Pallet Height

60% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Maximum Value	Number of Obs.
1	EXIT RATE PAL1	1.021	.572	.689	3.981	450
2	EXIT RATE PAL2	1.282	.904	.690	8.260	357
3	EXIT RATE MTL1	6.113	5.201	2.899	25.070	74
4	FROM PAL1 TO MTL	1.683	1.365	.689	11.751	273
5	FROM PAL1 TO DD	2.584	2.421	.690	16.510	177
6	FROM PAL2 TO MTL	2.256	1.832	.690	11.470	203
7	FROM PAL2 TO DD	2.937	2.923	.690	22.611	154
8	FROM LIQ. TO DD	6.836	.847	.000	6.940	67
9	EX RATE P10 8PP	9.142	2.937	4.692	15.980	49

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.791	.406	.000	1.000	460
2	PALL2 UTIL	.646	.478	.000	1.000	460
3	MTL UTIL	.760	.426	.000	1.000	460
4	DIRECT DESP Q	11.021	6.139	.000	21.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	4	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	0	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	153	Infinite
18	MC7 CC CNV OFLOW	12	Infinite
19	MC8 CC CNV OFLOW	0	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	214	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	224	Infinite

APPRNDIX XXIX : Output File - APS1260D

FILE : APS1260D.OPT

40% Pallets to Direct Despatch

2 Palletisers : 35cc/min each

2.1m Pallet Height

60% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.443	.762	1.039	5.412	318
2	EXIT RATE PAL2	1.885	1.208	.989	8.090	243
3	EXIT RATE MTL1	8.841	7.926	2.899	47.690	52
4	FROM PAL1 TO MTL	2.372	2.277	1.039	24.052	193
5	FROM PAL1 TO DD	3.671	3.075	1.039	15.509	125
6	FROM PAL2 TO MTL	3.187	2.291	.989	12.654	143
7	FROM PAL2 TO DD	4.582	3.882	.989	16.930	100
8	FROM LIQ. TO DD	9.074	1.309	.000	9.260	50
9	EX RATE P10 8PP	13.370	3.631	6.290	21.589	34

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.778	.415	.000	1.000	460
2	PALL2 UTIL	.629	.482	.000	1.000	460
3	MTL UTIL	.643	.478	.000	1.000	460
4	DIRECT DESP Q	2.417	1.356	.000	6.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	4	Infinite
13	MC2 CC CNV OFLOW	33	Infinite
14	MC3 CC CNV OFLOW	27	Infinite
15	MC4 CC CNV OFLOW	32	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	179	Infinite
18	MC7 CC CNV OFLOW	114	Infinite
19	MC8 CC CNV OFLOW	57	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	171	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	5	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	224	Infinite

APPENDIX XXX : Output File - APS1170D

FILE : APS1170D.OPT

40% Pallets to Direct Despatch

2 Palletisers : 35cc/min each

1.6m Pallet Height

70% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	.885	.415	.690	4.984	519
2	EXIT RATE PAL2	1.135	.622	.690	4.255	405
3	EXIT RATE MTL1	5.474	4.367	2.899	24.200	83
4	FROM PAL1 TO MTL	1.516	1.126	.690	8.188	303
5	FROM PAL1 TO DD	2.123	1.659	.690	10.260	216
6	FROM PAL2 TO MTL	1.869	1.464	.690	8.830	246
7	FROM PAL2 TO DD	2.887	2.221	.690	11.440	159
8	FROM LIQ. TO DD	5.873	.673	.000	5.950	78
9	EX RATE P10 8PP	8.142	2.143	4.550	14.333	56

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Maximum Value	Time Period
1	PALL1 UTIL	.888	.315	.000	1.000	460
2	PALL2 UTIL	.730	.443	.000	1.000	460
3	MTL UTIL	.831	.374	.000	1.000	460
4	DIRECT DESP Q	14.396	7.822	.000	28.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1954	Infinite
2	MC2 PRODUCTION	1431	Infinite
3	MC3 PRODUCTION	4209	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	3006	Infinite
7	MC7 PRODUCTION	2937	Infinite
8	MC8 PRODUCTION	2268	Infinite
9	MC9 PRODUCTION	3016	Infinite
10	MC10 PRODUCTION	1380	Infinite
11	MC11 PRODUCTION	1686	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	25	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	207	Infinite
18	MC7 CC CNV OFLOW	48	Infinite
19	MC8 CC CNV OFLOW	5	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	278	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	5	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	2	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	224	Infinite

APPENDIX XXXI : Output File - APS1270D

FILE : APS1270D.OPT

40% Pallets to Direct Despatch

2 Palletisers : 35cc/min each

1.2m Pallet Height

70% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.284	.538	1.039	4.650	358
2	EXIT RATE PAL2	1.644	.890	.989	7.411	279
3	EXIT RATE MTL1	7.388	6.329	2.899	38.900	62
4	FROM PAL1 TO MTL	2.052	1.311	1.039	7.890	224
5	FROM PAL1 TO DD	3.421	2.752	1.039	14.930	134
6	FROM PAL2 TO MTL	2.514	1.988	.989	14.210	182
7	FROM PAL2 TO DD	4.731	4.156	.989	25.180	97
8	FROM LIQ. TO DD	7.803	1.042	.000	7.940	58
9	EX RATE P10 8PP	12.735	3.859	7.287	23.820	36

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.868	.337	.000	1.000	460
2	PALL2 UTIL	.717	.450	.000	1.000	460
3	MTL UTIL	.662	.472	.000	1.000	460
4	DIRECT DESP Q	3.448	2.007	.000	7.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1954	Infinite
2	MC2 PRODUCTION	1431	Infinite
3	MC3 PRODUCTION	4209	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	3006	Infinite
7	MC7 PRODUCTION	2937	Infinite
8	MC8 PRODUCTION	2268	Infinite
9	MC9 PRODUCTION	3016	Infinite
10	MC10 PRODUCTION	1380	Infinite
11	MC11 PRODUCTION	1686	Infinite
12	MC1 CC CNV OFLOW	4	Infinite
13	MC2 CC CNV OFLOW	46	Infinite
14	MC3 CC CNV OFLOW	51	Infinite
15	MC4 CC CNV OFLOW	36	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	264	Infinite
18	MC7 CC CNV OFLOW	79	Infinite
19	MC8 CC CNV OFLOW	76	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	407	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	224	Infinite

APPENDIX XXXII : Output File - APS2160D

FILE: APS2160D.OPT

40% Pallets to Direct Despatch

Palletiser1 : 35cc/min   Palletiser2 :56cc/min

1.6m Pallet Height

60% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.127	.732	.690	7.049	407
2	EXIT RATE PAL2	1.097	.866	.429	6.981	419
3	EXIT RATE MTL1	5.657	3.731	2.899	17.420	81
4	FROM PAL1 TO MTL	1.757	1.202	.690	7.386	261
5	FROM PAL1 TO DD	3.137	2.873	.690	16.380	146
6	FROM PAL2 TO MTL	1.811	1.677	.429	11.838	253
7	FROM PAL2 TO DD	2.770	2.983	.429	16.541	166
8	FROM LIQ. TO DD	6.836	.847	.000	6.940	67
9	EX RATE P10 8PP	9.713	3.476	3.540	19.739	47

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.688	.463	.000	1.000	460
2	PALL2 UTIL	.505	.499	.000	1.000	460
3	MTL UTIL	.811	.390	.000	1.000	460
4	DIRECT DESP Q	9.275	5.398	.000	19.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	14	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	1	Infinite
18	MC7 CC CNV OFLOW	14	Infinite
19	MC8 CC CNV OFLOW	0	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	7	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	224	Infinite

APPENDIX XXXIII : Output File - APS2260D

FILE : APS2260D.OPT

40% to Direct Despatch

Palletiser1 : 35cc/min   Palletiser2 : 56cc/min

2.1m Pallet Height

60 Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.639	1.017	1.039	7.510	279
2	EXIT RATE PAL2	1.545	1.102	.620	7.559	297
3	EXIT RATE MTL1	8.574	7.563	2.899	32.030	53
4	FROM PAL1 TO MTL	2.912	2.458	1.039	15.458	156
5	FROM PAL1 TO DD	3.719	3.048	1.039	13.369	123
6	FROM PAL2 TO MTL	2.415	1.970	.620	11.281	190
7	FROM PAL2 TO DD	4.164	3.900	.620	22.340	107
8	FROM LIQ. TO DD	9.074	1.309	.000	9.260	50
9	EX RATE P10 8PP	13.070	3.528	7.179	21.960	35

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.668	.470	.000	1.000	460
2	PALL2 UTIL	.501	.500	.000	1.000	460
3	MTL UTIL	.686	.463	.000	1.000	460
4	DIRECT DESP Q	3.111	1.799	.000	7.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	6	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	20	Infinite
18	MC7 CC CNV OFLOW	81	Infinite
19	MC8 CC CNV OFLOW	37	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	10	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	224	Infinite

APPENDIX XXXIV : Output - File APS2170D

FILE : APS2170D.OPT

40% Pallets to Direct Despatch

Palletiser1 : 35cc/min   Palletiser2 : 56cc/min

1.6m Pallet Height

70% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	.981	.522	.690	4.079	468
2	EXIT RATE PAL2	.951	.660	.429	6.120	483
3	EXIT RATE MTL1	5.449	3.788	2.899	17.420	83
4	FROM PAL1 TO MTL	1.816	1.494	.690	13.958	253
5	FROM PAL1 TO DD	2.125	1.851	.690	13.057	215
6	FROM PAL2 TO MTL	1.596	1.355	.429	8.579	288
7	FROM PAL2 TO DD	2.352	2.020	.429	13.320	195
8	FROM LIQ. TO DD	5.873	.673	.000	5.950	78
9	EX RATE P10 8PP	7.520	2.059	4.380	14.750	61

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PAL1 UTIL	.773	.41874	.000	1.000	460
2	PAL2 UTIL	.562	.49610	.000	1.000	460
3	MTL UTIL	.809	.39261	.000	1.000	460
4	DIRECT DESP Q	15.685	9.29526	.000	32.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1954	Infinite
2	MC2 PRODUCTION	1431	Infinite
3	MC3 PRODUCTION	4209	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	3006	Infinite
7	MC7 PRODUCTION	2937	Infinite
8	MC8 PRODUCTION	2268	Infinite
9	MC9 PRODUCTION	3016	Infinite
10	MC10 PRODUCTION	1380	Infinite
11	MC11 PRODUCTION	1686	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	0	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	19	Infinite
18	MC7 CC CNV OFLOW	24	Infinite
19	MC8 CC CNV OFLOW	0	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	1	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	224	Infinite

APPENDIX XXXV : Output File - APS2270D

FILE : APS2270D.OPT

40% to Direct Despatch

Palletiser1 : 35cc/min   Palletiser2 : 56cc/min

2.1m Pallet Height

70% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.430	.705	1.039	4.861	321
2	EXIT RATE PAL2	1.351	.872	.620	6.950	340
3	EXIT RATE MTL1	6.904	5.631	2.899	30.850	66
4	FROM PAL1 TO MTL	2.361	1.565	1.039	10.281	194
5	FROM PAL1 TO DD	3.615	3.240	1.039	21.820	127
6	FROM PAL2 TO MTL	2.060	1.639	.620	10.999	223
7	FROM PAL2 TO DD	3.886	3.152	.620	13.809	117
8	FROM LIQ. TO DD	7.803	1.042	.000	7.940	58
9	EX RATE P10 8PP	12.206	3.092	7.370	21.820	37

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PALL1 UTIL	.766	.423	.000	1.000	460
2	PALL2 UTIL	.551	.497	.000	1.000	460
3	MTL UTIL	.707	.454	.000	1.000	460
4	DIRECT DESP Q	4.317	2.493	.000	9.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1954	Infinite
2	MC2 PRODUCTION	1431	Infinite
3	MC3 PRODUCTION	4209	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	3006	Infinite
7	MC7 PRODUCTION	2937	Infinite
8	MC8 PRODUCTION	2268	Infinite
9	MC9 PRODUCTION	3016	Infinite
10	MC10 PRODUCTION	1380	Infinite
11	MC11 PRODUCTION	1686	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	10	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	60	Infinite
18	MC7 CC CNV OFLOW	102	Infinite
19	MC8 CC CNV OFLOW	0	Infinite

Counters

Number	Identifier	Count	Limit
20	MC9 CC CNV OFLOW	35	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	224	Infinite

APPENDIX XXXVI : Output File - APS3160D

FILE : APS3160D.OPT

40% to Direct Despatch

3 Palletisers : 35cc/min each

1.6m Pallet Height

60% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.654	1.201	.690	8.772	277
2	EXIT RATE PAL2	1.720	1.272	.739	8.999	265
3	EXIT RATE PAL3	1.620	1.294	.690	9.941	283
4	EXIT RATE MTL1	6.053	4.291	2.899	19.200	75
5	FROM PAL1 TO MTL	2.712	2.441	.690	18.490	169
6	FROM PAL1 TO DD	4.201	4.007	.690	29.592	108
7	FROM PAL2 TO MTL	3.107	2.559	.739	13.303	144
8	FROM PAL2 TO DD	3.768	3.434	.739	20.417	121
9	FROM PAL3 TO MTL	2.761	2.630	.690	15.549	165
10	FROM PAL3 TO DD	3.887	3.459	.690	18.190	118
11	FROM LIQ. TO DD	6.836	.847	.000	6.940	67
12	EX RATE P10 8PP	8.857	2.539	3.950	13.880	51

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PAL1 UTIL	.515	.499	.000	1.000	460
2	PAL2 UTIL	.495	.499	.000	1.000	460
3	PAL3 UTIL	.468	.498	.000	1.000	460
4	MTL UTIL	.764	.424	.000	1.000	460
5	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	0	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	3	Infinite
18	MC7 CC CNV OFLOW	7	Infinite

Counters

Number	Identifier	Count	Limit
19	MC8 CC CNV OFLOW	0	Infinite
20	MC9 CC CNV OFLOW	0	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	408	Infinite

APPENDIX XXXVII : Output File - APS3260D

FILE : APS3260D.OPT

40% Pallets to Direct Despatch

3 Palletisers 35cc/min each

2.1m Pallet Height

60% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	2.292	1.534	1.039	8.650	200
2	EXIT RATE PAL2	2.419	1.581	.989	8.840	188
3	EXIT RATE PAL3	2.421	1.904	1.039	14.463	189
4	EXIT RATE MTL1	8.372	6.527	2.899	32.950	54
5	FROM PAL1 TO MTL	3.820	2.708	1.039	16.310	120
6	FROM PAL1 TO DD	5.702	5.876	1.039	41.340	80
7	FROM PAL2 TO MTL	4.278	4.115	.989	20.280	105
8	FROM PAL2 TO DD	5.479	4.437	.989	22.089	83
9	FROM PAL3 TO MTL	3.576	3.058	1.039	15.503	128
10	FROM PAL3 TO DD	7.461	8.650	1.039	50.029	61
11	FROM LIQ. TO DD	9.074	1.309	.000	9.260	50
12	EX RATE P10 8PP	13.376	3.643	8.609	22.778	34

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PAL1 UTIL	.501	.500	.000	1.000	460
2	PAL2 UTIL	.505	.499	.000	1.000	460
3	PAL3 UTIL	.482	.499	.000	1.000	460
4	MTL UTIL	.654	.475	.000	1.000	460
5	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1645	Infinite
2	MC2 PRODUCTION	1386	Infinite
3	MC3 PRODUCTION	3547	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	2543	Infinite
7	MC7 PRODUCTION	2621	Infinite
8	MC8 PRODUCTION	1993	Infinite
9	MC9 PRODUCTION	2485	Infinite
10	MC10 PRODUCTION	1211	Infinite
11	MC11 PRODUCTION	1514	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	3	Infinite
14	MC3 CC CNV OFLOW	8	Infinite
15	MC4 CC CNV OFLOW	3	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	0	Infinite
18	MC7 CC CNV OFLOW	61	Infinite

Counters

Number	Identifier	Count	Limit
19	MC8 CC CNV OFLOW	0	Infinite
20	MC9 CC CNV OFLOW	26	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	272	Infinite

APPENDIX XXXVIII : Output File - APS3170D

FILE : APS3170D.OPT

40% Pallets to Direct Despatch

3 Palletisers : 35cc/min each

1.6m Pallet Height

70% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	1.472	.974	.690	6.695	312
2	EXIT RATE PAL2	1.477	.994	.739	10.826	310
3	EXIT RATE PAL3	1.392	1.063	.690	10.409	330
4	EXIT RATE MTL1	5.286	3.584	2.899	18.676	87
5	FROM PAL1 TO MTL	2.524	2.281	.690	14.699	182
6	FROM PAL1 TO DD	3.522	2.828	.690	16.869	130
7	FROM PAL2 TO MTL	2.422	1.918	.739	12.266	189
8	FROM PAL2 TO DD	3.764	3.527	.739	21.345	121
9	FROM PAL3 TO MTL	2.440	2.158	.690	13.860	188
10	FROM PAL3 TO DD	3.236	2.752	.690	17.063	142
11	FROM LIQ. TO DD	5.873	.673	.000	5.950	78
12	EX RATE P10 8PP	7.817	2.345	2.810	12.611	58

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PAL1 UTIL	.576	.494	.000	1.000	460
2	PAL2 UTIL	.576	.494	.000	1.000	460
3	PAL3 UTIL	.545	.497	.000	1.000	460
4	MTL UTIL	.816	.387	.000	1.000	460
5	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1954	Infinite
2	MC2 PRODUCTION	1431	Infinite
3	MC3 PRODUCTION	4209	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	3006	Infinite
7	MC7 PRODUCTION	2937	Infinite
8	MC8 PRODUCTION	2268	Infinite
9	MC9 PRODUCTION	3016	Infinite
10	MC10 PRODUCTION	1380	Infinite
11	MC11 PRODUCTION	1686	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	0	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	0	Infinite
18	MC7 CC CNV OFLOW	3	Infinite

Counters

Number	Identifier	Count	Limit
19	MC8 CC CNV OFLOW	0	Infinite
20	MC9 CC CNV OFLOW	0	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	1	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite

APPENDIX XXXIX : Output File - APS3270D

FILE : APS3270D.OPT

40% Pallets to Direct Despatch

3 Palletisers 35cc/min each

2.1m Pallet Height

70% Packing Efficiency

SIMAN Summary Report

Run Number 1 of 1

Project: AUTO PALLETISING

Analyst: MG

Date : 8/12/1989

Run ended at time : .4600E+03

Tally Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Number of Obs.
1	EXIT RATE PAL1	2.046	1.219	1.039	7.369	224
2	EXIT RATE PAL2	2.092	1.268	.989	9.589	219
3	EXIT RATE PAL3	2.058	1.445	1.039	11.954	222
4	EXIT RATE MTL1	7.151	5.609	2.899	25.149	64
5	FROM PAL1 TO MTL	3.182	2.440	1.039	11.773	144
6	FROM PAL1 TO DD	5.716	3.847	1.039	16.147	80
7	FROM PAL2 TO MTL	3.444	2.746	.989	13.871	133
8	FROM PAL2 TO DD	5.259	4.411	.989	23.357	86
9	FROM PAL3 TO MTL	3.461	2.777	1.039	14.079	132
10	FROM PAL3 TO DD	5.059	4.398	1.039	19.008	90
11	FROM LIQ. TO DD	7.803	1.042	.000	7.940	58
12	EX RATE P10 8PP	11.675	3.303	7.741	19.243	39

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	PAL1 UTIL	.563	.495	.000	1.000	460
2	PAL2 UTIL	.587	.492	.000	1.000	460
3	PAL3 UTIL	.555	.496	.000	1.000	460
4	MTL UTIL	.704	.456	.000	1.000	460
5	DIRECT DESP Q	.000	.000	.000	.000	460

Counters

Number	Identifier	Count	Limit
1	MC1 PRODUCTION	1954	Infinite
2	MC2 PRODUCTION	1431	Infinite
3	MC3 PRODUCTION	4209	Infinite
4	MC4 PRODUCTION	1358	Infinite
5	MC5 PRODUCTION	1	Infinite
6	MC6 PRODUCTION	3006	Infinite
7	MC7 PRODUCTION	2937	Infinite
8	MC8 PRODUCTION	2268	Infinite
9	MC9 PRODUCTION	3016	Infinite
10	MC10 PRODUCTION	1380	Infinite
11	MC11 PRODUCTION	1686	Infinite
12	MC1 CC CNV OFLOW	0	Infinite
13	MC2 CC CNV OFLOW	0	Infinite
14	MC3 CC CNV OFLOW	38	Infinite
15	MC4 CC CNV OFLOW	0	Infinite
16	MC5 CC CNV OFLOW	0	Infinite
17	MC6 CC CNV OFLOW	9	Infinite
18	MC7 CC CNV OFLOW	21	Infinite

Counters

Number	Identifier	Count	Limit
19	MC8 CC CNV OFLOW	0	Infinite
20	MC9 CC CNV OFLOW	21	Infinite
21	MC10 C CNV OFLOW	0	Infinite
22	MC11 C CNV OFLOW	0	Infinite
23	PAL CNV1 OFLOW	0	Infinite
24	PAL CNV2 OFLOW	0	Infinite
25	PAL CNV3 OFLOW	0	Infinite
26	PAL CNV4 OFLOW	0	Infinite
27	PAL CNV5 OFLOW	0	Infinite
28	PAL CNV6 OFLOW	0	Infinite
29	PAL CNV7 OFLOW	0	Infinite
30	PAL CNV8 OFLOW	0	Infinite
31	PAL CNV9 OFLOW	0	Infinite
32	PALLETS TO DD	312	Infinite

APPENDIX XXXX : Simulated Production - 60% ; 70% Packing Efficiency

60% PACKING EFFICIENCY

M/C NO.	PRODUCT	CASES	1.6m PALLETS	2.1m PALLETS
1	B11	1645	68	51
2	A11	1386	34	27
3	D11	3547	126	84
4	A11	1358	33	27
5	B22	-	-	-
6	C11	2543	127	84
7	C22	2621	131	87
8	B22	1993	83	62
9	C22	2485	124	82
10	A22	1211	30	24
11	E11	1514	72	54
	TOTAL	20303	828	582

70% PACKING EFFICIENCY

M/C NO.	PRODUCT	CASES	1.6m PALLETS	2.1m PALLETS
1	B11	1954	81	61
2	A11	1431	35	28
3	D11	4209	150	100
4	A11	1358	33	27
5	B22	-	-	-
6	C11	3006	150	100
7	C22	2937	146	97
8	B22	2268	94	70
9	C22	3016	150	100
10	A22	1380	34	27
11	E11	1686	80	60
	TOTAL	23245	953	670

APPENDIX XXXXI : Summary of Output - Alternate "A" : 60%

2 Palletisers 35cc/min each

60% Packing Efficiency

Powders Production : 1.6m Pallet Height - 828 Pallets

2.1m Pallet Height - 582 Pallets

	ALL PAL TO MTL		40% PAL DD	
	1.6m	2.1m	1.6m	2.1m
Powders Palletised	811	559	807	561
Powders Pallets to MTL	811	559	476	336
Powders Pallets to DD	-	-	331	225
Liquids Pallets to DD	-	-	67	50
No. of MT Loads (6Pals)	116	87	74	52
No. of P10 DD (8Pals)	-	-	49	34
UTILIZATION (%)				
Palletiser 1	79	78	79	78
Palletiser 2	64	63	65	63
Mini - Train Loader	98	81	76	64
EXIT RATE:				
MTL 6 pallets - min	2.9	2.9	2.9	2.9
- max	17.4	24.0	25.1	47.7
- ave	3.9	5.2	6.1	8.8
P10 8 pallets - min	-	-	4.7	6.3
- max	-	-	16.0	21.6
- ave	-	-	9.1	13.4

	ALL PAL TO MTL		40% PAL DD	
	1.6m	2.1m	1.6m	2.1m
CASE ACCUMULATION OVERFLOW				
M/C 1	0	6	4	4
2	5	14	0	33
3	0	104	0	27
4	5	13	0	32
5	0	0	0	0
6	114	192	153	179
7	13	97	12	114
8	1	33	0	57
9	182	239	214	171
10	0	0	0	0
11	0	0	0	5
Total	320	698	383	622
PALLET ACCUMULATION OVERFLOW				
Prod 1	2	0	0	0
2	0	0	0	0
3	11	0	0	0
4	2	0	0	0
5	17	0	0	0
6	0	0	0	0
7	9	0	0	0
8	7	0	0	0
9	0	0	0	0
Total	48	0	0	0

APPENDIX XXXXII : Summary of Output - Alternate "B" : 60%

Palletiser1 35cc/min ; Palletiser 2 56cc/min

60% Packing Efficiency

Powders Production : 1.6m Pallet Height - 828 Pallets

2.1m Pallet Height - 582 Pallets

	ALL PAL TO MTL		40% PAL DD	
	1.6m	2.1m	1.6m	2.1m
Powders Palletised	825	577	826	576
Powders Pallets to MTL	825	577	514	346
Powders Pallets to DD	-	-	312	230
Liquids Pallets to DD	-	-	67	50
No. of MT Loads (6Pals)	108	91	81	53
No. of P10 DD (8Pals)	-	-	47	35
UTILIZATION (%)				
Palletiser 1	68	67	69	67
Palletiser 2	50	50	51	50
Mini - Train Loader	98	88	81	69
EXIT RATE:				
MTL 6 pallets - min	2.9	2.9	2.9	2.9
- max	16.4	27.9	17.4	32.0
- ave	4.2	5.0	5.7	8.6
P10 8 pallets - min	-	-	3.5	7.2
- max	-	-	19.7	22.0
- ave	-	-	9.7	13.1

	ALL PAL TO MTL		40% PAL DD	
	1.6m	2.1m	1.6m	2.1m
CASE ACCUMULATION OVERFLOW				
M/C 1	0	0	0	0
2	0	0	0	0
3	0	35	14	6
4	0	0	0	0
5	0	0	0	0
6	21	3	1	20
7	10	27	14	81
8	0	16	0	37
9	12	31	7	10
10	0	0	0	0
11	0	0	0	0
Total	43	112	36	154

PALLET ACCUMULATION OVERFLOW				
Prod 1	0	0	0	0
2	0	0	0	0
3	21	0	0	0
4	8	0	0	0
5	14	0	0	0
6	0	0	0	0
7	30	0	0	0
8	47	0	0	0
9	0	0	0	0
Total	120	0	0	0

APPENDIX XXXXIII : Summary of Output - Alternate "C" : 60%

3 Palletisers 35cc/min each

60% Packing Efficiency

Powders Production : 1.6m Pallet Height - 828 Pallets

2.1m Pallet Height - 582 Pallets

	ALL PAL TO MTL		40% PAL DD	
	1.6m	2.1m	1.6m	2.1m
Powders Palletised	826	578	825	577
Powders Pallets to MTL	826	578	478	353
Powders Pallets to DD	-	-	347	224
Liquids Pallets to DD	-	-	67	50
No. of MT Loads (6Pals)	105	90	75	54
No. of P10 DD (8Pals)	-	-	51	34
UTILIZATION (%)				
Palletiser 1	51	51	52	50
Palletiser 2	51	50	50	51
Palletiser 3	48	47	47	48
Mini - Train Loader	98	84	76	65
EXIT RATE:				
MTL 6 pallets - min	2.9	2.9	2.9	2.9
- max	22.9	23.6	19.2	33.0
- ave	4.4	5.1	6.1	8.4
P10 8 pallets - min	-	-	4.0	8.6
- max	-	-	13.9	22.8
- ave	-	-	8.9	13.4

	ALL PAL TO MTL		40% PAL DD	
	1.6m	2.1m	1.6m	2.1m
CASE ACCUMULATION OVERFLOW				
M/C 1	0	0	0	0
2	0	1	0	3
3	0	10	0	8
4	0	10	0	3
5	0	0	0	0
6	0	0	3	0
7	0	28	7	61
8	0	4	0	0
9	0	61	0	26
10	0	0	0	0
11	0	0	0	0
Total	0	114	10	101
PALLET ACCUMULATION OVERFLOW				
Prod 1	2	0	0	0
2	0	0	0	0
3	34	0	0	0
4	0	0	0	0
5	35	0	0	0
6	0	0	0	0
7	27	0	0	0
8	24	0	0	0
9	0	0	0	0
Total	122	0	0	0

APPENDIX XXXXIV : Summary of Output - Alternate "A" : 70%

2 Palletisers 35cc/min each

70% Packing Efficiency

Powders Production : 1.6m Pallet Height - 953 Pallets

2.1m Pallet Height - 670 Pallets

	ALL PAL TO MTL		40% PAL DD	
	1.6m	2.1m	1.6m	2.1m
Powders Palletised	925	639	924	637
Powders Pallets to MTL	925	639	549	406
Powders Pallets to DD	-	-	375	231
Liquids Pallets to DD	-	-	78	58
No. of MT Loads (6Pals)	118	101	83	62
No. of P10 DD (8Pals)	-	-	56	36
UTILIZATION (%)				
Palletiser 1	89	88	89	87
Palletiser 2	73	72	73	72
Mini - Train Loader	98	91	83	66
EXIT RATE:				
MTL 6 pallets - min	2.9	2.9	2.9	2.9
- max	17.4	24.0	24.2	38.9
- ave	3.8	4.5	5.5	7.4
P10 8 pallets - min	-	-	4.6	7.3
- max	-	-	14.3	23.8
- ave	-	-	8.1	12.7

	ALL PAL TO MTL		40% PAL DD	
	1.6m	2.1m	1.6m	2.1m
CASE ACCUMULATION OVERFLOW				
M/C 1	0	15	0	4
2	0	30	0	46
3	32	61	25	51
4	0	31	0	36
5	0	0	0	0
6	224	293	207	264
7	24	116	48	79
8	0	83	5	76
9	287	292	278	407
10	0	0	0	0
11	0	0	5	0
Total	567	921	568	963
PALLET ACCUMULATION OVERFLOW				
Prod 1	3	0	0	0
2	1	0	0	0
3	26	0	0	0
4	10	0	0	0
5	34	2	0	0
6	2	0	0	0
7	43	0	2	0
8	23	0	0	0
9	0	0	0	0
Total	142	2	2	0

APPENDIX XXXXV : Summary of Output - Alternate "B" : 70%

Palletiser 1 35cc/min each ; Palletiser 2 56cc/min

70% Packing Efficiency

Powders Production : 1.6m Pallet Height - 953 Pallets

2.1m Pallet Height - 670 Pallets

	ALL PAL TO MTL		40% PAL DD	
	1.6m	2.1m	1.6m	2.1m
Powders Palletised	951	661	951	661
Powders Pallets to MTL	951	661	541	417
Powders Pallets to DD	-	-	410	244
Liquids Pallets to DD	-	-	78	58
No. of MT Loads (6Pals)	114	103	83	66
No. of P10 DD (8Pals)	-	-	61	37
UTILIZATION (%)				
Palletiser 1	77	76	77	77
Palletiser 2	57	57	56	55
Mini - Train Loader	98	91	81	71
EXIT RATE:				
MTL 6 pallets - min	2.9	2.9	2.9	2.9
- max	16.4	27.9	17.4	30.9
- ave	4.0	4.4	5.4	6.9
P10 8 pallets - min	-	-	4.4	7.4
- max	-	-	14.8	21.8
- ave	-	-	7.5	12.2

	ALL PAL TO MTL		40% PAL DD	
	1.6m	2.1m	1.6m	2.1m
CASE ACCUMULATION OVERFLOW				
M/C 1	0	0	0	0
2	0	0	0	0
3	2	55	0	10
4	0	0	0	0
5	0	0	0	0
6	8	37	19	60
7	25	104	24	102
8	0	4	0	0
9	6	25	1	35
10	0	0	0	0
11	0	0	0	0
Total	41	225	44	207
PALLET ACCUMULATION OVERFLOW				
Prod 1	19	0	0	0
2	0	0	0	0
3	42	0	0	0
4	9	1	0	0
5	36	0	0	0
6	9	0	0	0
7	48	0	0	0
8	29	4	0	0
9	0	0	0	0
Total	192	5	0	0

APPENDIX XXXXVI : Summary of Output - Alternate "C" : 70%

3 Palletisers 35cc/min each

70% Packing Efficiency

Powders Production : 1.6m Pallet Height - 953 Pallets

2.1m Pallet Height - 670 Pallets

	ALL PAL TO MTL		40% PAL DD	
	1.6m	2.1m	1.6m	2.1m
Powders Palletised	952	665	952	665
Powders Pallets to MTL	952	665	559	409
Powders Pallets to DD	-	-	393	256
Liquids Pallets to DD	-	-	78	58
No. of MT Loads (6Pals)	108	106	87	64
No. of P10 DD (8Pals)	-	-	58	39
UTILIZATION (%)				
Palletiser 1	57	57	58	56
Palletiser 2	58	58	58	59
Palletiser 3	54	54	55	56
Mini - Train Loader	98	93	82	70
EXIT RATE:				
MTL 6 pallets - min	2.9	2.9	2.9	2.9
- max	22.9	23.6	18.7	25.1
- ave	4.3	4.3	5.3	7.2
P10 8 pallets - min	-	-	2.8	7.7
- max	-	-	12.6	19.2
- ave	-	-	7.8	11.7

	ALL PAL TO MTL		40% PAL DD	
	1.6m	2.1m	1.6m	2.1m
CASE ACCUMULATION OVERFLOW				
M/C 1	0	0	0	0
2	2	0	0	0
3	0	15	0	38
4	2	0	0	0
5	0	0	0	0
6	3	0	0	9
7	0	21	3	21
8	0	5	0	0
9	2	38	0	21
10	0	0	0	0
11	1	1	1	0
Total	10	80	4	89
PALLET ACCUMULATION OVERFLOW				
Prod 1	0	0	0	0
2	5	0	0	0
3	27	0	0	0
4	12	0	0	0
5	59	0	0	0
6	0	0	0	0
7	57	0	0	0
8	70	0	0	0
9	0	0	0	0
Total	230	0	0	0

APPENDIX XXXXVII : AGV Model File

```
BEGIN,1,1,YES,AGV,YES;
;     WAREHOUSE SIM : AGV - MODEL FILE "AGV.MOD" M. GOKAL
;     40% to Direct Despatch
;     Palletiser1 : 35cc/min    Palletiser2 : 56cc/min
;     1.6m Pallet Height
;     70% Packing Efficiency
;     2 P&D Stations in the Warehouse
;
         CREATE,1:ED(1);
         ASSIGN:A(1)=1;
         ASSIGN:M=2;
         COUNT:1,1;
         BRANCH:
            WITH,0.30,Q18:
            WITH,0.19,Q11:
            WITH,0.30,Q13:
            WITH,0.21,Q14;
;
         CREATE,1:ED(2);
         COUNT:2,1;
         ASSIGN:A(1)=1;
         ASSIGN:M=3;
         BRANCH:
            WITH,0.30,Q15:
            WITH,0.17,Q12:
            WITH,0.08,Q19:
            WITH,0.30,Q17:
            WITH,0.15,Q16;
```

```
;
Q11     COUNT:3,1;
        QUEUE,11;
        COMBINE:6,FIRST:NEXT(Q31);
Q12     COUNT:4,1;
        QUEUE,12;
        COMBINE:6,FIRST:NEXT(Q32);
Q13     COUNT:5,1;
        QUEUE,13;
        COMBINE:6,FIRST:NEXT(Q33);
Q14     COUNT:6,1;
        QUEUE,14;
        COMBINE:6,FIRST:NEXT(Q34);
Q15     COUNT:7,1;
        QUEUE,15;
        COMBINE:6,FIRST:NEXT(Q35);
Q16     COUNT:8,1;
        QUEUE,16;
        COMBINE:6,FIRST:NEXT(Q36);
Q17     COUNT:9,1;
        QUEUE,17;
        COMBINE:6,FIRST:NEXT(Q37);
Q18     COUNT:10,1;
        QUEUE,18;
        COMBINE:6,FIRST:NEXT(Q38);
Q19     COUNT:11,1;
        QUEUE,19;
        COMBINE:6,FIRST:NEXT(Q39);
;
```

```
Q31       QUEUE,31:DETACH;
Q32       QUEUE,32:DETACH;
Q33       QUEUE,33:DETACH;
Q34       QUEUE,34:DETACH;
Q35       QUEUE,35:DETACH;
Q36       QUEUE,36:DETACH;
Q37       QUEUE,37:DETACH;
Q38       QUEUE,38:DETACH;
Q39       QUEUE,39:DETACH;
;
          QPICK,CYC:Q31:Q32:Q33:Q34:Q35:Q36:Q37:Q38:Q39;
          SEIZE:AGVL;
          DELAY:ED(3);
          RELEASE:AGVL;
          QUEUE,40;
;
          REQUEST:AGV(SDS,1);
          TRANSPORT:AGV(A(1)),M;
          STATION,2-3;
          DELAY:ED(4);
          TRANSPORT:AGV(A(1)),1;
          STATION,1;
          FREE:AGV(A(1));
END;
```

APPENDIX XXXXVIII : AGV Experiment File

```
BEGIN,1,1,YES,NO;
; WAREHOUSE SIM. : AGV  - EXPMT. FILE "AGV.EXP" M. GOKAL
PROJECT,AGV,MG,8/17/89;
DISCRETE,500,2,50,3;
SEEDS:1,10000,YES;
DISTRIBUTIONS:1,RL(1,1):2,RL(2,1):
              3,CO(3):4,CO(4);
PARAMETERS:1,0.98,0.52:
           2,0.95,0.66:
           3,2.9:
           4,2.9;
 COUNTERS:1,EXIT PALL1:
          2,EXIT PALL2:
          3,FROM P1 TO CON11:
          4,FROM P2 TO CON12:
          5,FROM P1 TO CON13:
          6,FROM P1 TO CON14:
          7,FROM P2 TO CON15:
          8,FROM P2 TO CON16:
          9,FROM P2 TO CON17:
          10,FROM P1 TO CON18:
          11,FROM P2 TO CON19;
RESOURCES:1,AGVL;
TRANSPORTERS:1,AGV,2,1,180,1-A;
DSTAT:1,NQ(40),NO AGV:2,NT(1),AGV UTIL;
DISTANCES:1,1-3,200,200/100;
REPLICATE,1,0,460;
END;
```

APPENDIX XXXXIX : AGV Output File (1 AGV)

SIMAN Summary Report

Run Number 1 of 1

Project: AGV

Analyst: MG

Date : 8/17/1989

Run ended at time : .4600E+03

Discrete Change Variables

Number	Identifier	Average	Standard Deviation	Min. Value	Max. Value	Time Period
1	NO AGV	31.698	19.774	.000	66.000	460
2	AGV UTIL	.960	.194	.000	1.000	460

Counters

Number	Identifier	Count	Limit
1	EXIT PALL1	487	Infinite
2	EXIT PALL2	490	Infinite
3	FROM P1 TO CON11	97	Infinite
4	FROM P2 TO CON12	99	Infinite
5	FROM P1 TO CON13	135	Infinite
6	FROM P1 TO CON14	107	Infinite
7	FROM P2 TO CON15	140	Infinite
8	FROM P2 TO CON16	66	Infinite
9	FROM P2 TO CON17	145	Infinite
10	FROM P1 TO CON18	148	Infinite
11	FROM P2 TO CON19	40	Infinite