CAPACITY ANALYSIS OF AN APPLIANCE TESTING PROCESS

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ABSTRACT

The application of simulation is illustrated in a real life study dealing with plant capacity and resource management. This paper indicates the steps taken in the construction of the simulation model. First the objectives of the study are determined, then the simulation model is designed. The designed model is verified by comparing its elements with that of the actual system. The model is validated by using past data to check if it is able to simulate dynamic system behaviour. Finally, the simulation model is used as an analysis tool. These analysis were used to assist managers in capacity planning and resource utilization sutdies.

INTRODUCTION

In a hearing before the subcommittee on economic statistics of the Joint Economic Committee, Senator William Proxmire cautioned about the ills of mismanagement of production capacity and disproportionate allocation of the nations resources.(6) Management Science has provided tools which assist managers to efficiently manage production capacity and resources. In this paper an application of simulation and mathematical programming is illustrated in a real life study dealing with plant capacity and resource management.

The study is made of the range test and repair areas in the range plant at the General Electric Appliance Park in Louisville, Kentucky. All ranges produced must pass through this area for quality control inspection. Capacity constraints in this area effect the quality of the ranges and the production flow of the total manufacturing system. The objectives of the study were as follows:

1. To determine the present utilizations of personnel and equipment on the range test and repair lines.
2. To determine if the present capacity in these areas was sufficient to meet the projected demand for ranges in the future years.
3. To investigate procedures for improving capacity.
4. To determine an optimal product mix for the range plant.

The first three objectives were met by a simulation analysis of the system, the last through simulation and mathematical programming.

The capacity of the system is defined in terms of the number of units that could be produced per year. It is a relatively simple matter to determine the capacity of a single piece of equipment in the manufacture of any particular product. However, if a total manufacturing system is considered, with the interactive effects of several pieces of equipment, products, personnel etc. then the task becomes complex.(1) Owing to this reason simulation was adopted for capacity analysis. The modelling of the interactions within the system was done through simulation, this enabled the analysis of the systems capacity.

SIMULATION MODEL DESIGN

In developing the simulation model for capacity planning it was found helpful to start with an area layout as shown in Figure 1. Line 1 and line 2 are low volume lines testing 'custom' and 'deluxe' ranges and line 3 is a high volume line testing standard ranges. Three transportation elevators (E1, E2, E3,...see Figure 1) bring the finished ranges to the test area. Custom ranges are loaded on line 1 from elevator E1. From here a custom range moves along the conveyor to (STN1). From STN1 the range is transferred on to Queue 1. Operator 1 (OPR1) removes the range from Queue 1 and tests it for several attributes. Rejects are sent down repair line 1 to the repair areas where a worker repairs the ranges and sets them on a conveyor which merges with line 2 and the process is repeated. This flow is indicated by arrows in Figure 1. The non-defective ranges go through the ground test areas which are high potential tests that test for any leakage or shorts. The defectives from

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this area are repaired on repair line 3 and the ground test is repeated. The custom ranges then pass through the Q.C. audit stations to the packing area. Here they are packed and sent to the warehouse. The deluxe ranges are loaded on the conveyor from elevator E2. Owing to their low annual production they are merged with line 1 at STN1 and from there they flow on the same lines as the custom ranges as indicated in Figure 1. The standard ranges are placed on the high volume line (Line 3) from the elevator E3. The production of standard ranges is about three times that of custom and deluxe ranges. Operators 2 and 3 (OPR2 & OPR3,...see Figure 1) inspect these ranges. The nondefective ranges go through the ground test and packing areas to the warehouse as indicated. The defective ranges are sent on repair line 2 to the repair area where they are repaired by the repairman and transferred back onto line 3. This flow is represented in Figure 1.

The operations and processes in the range test and repair areas were translated into a process flow chart. This chart was constructed using the designated symbols of the simulation programming language GESIMTEL (GEneral SIMulation via TELetype). The chart was of invaluable assistance in verifying the model and in constructing the program. (See Figure 2)

The annual production volumes and the process rates are indicated in Tables 1 and 2. For 1976 and 1977 the production volumes are based on known data for 1978 and 1979 the production volumes are projected figures. This data was used as input data for the program.

TABLE 1

ANNUAL PRODUCTION VOLUME

YEAR	LINE 1	LINE 2	LINE 3
1976	34,000	13,500	110,000
1977	45,000	17,000	135,000
1978	67,000	22,500	205,000
1979	80,000	27,000	242,000

TABLE 2

PROCESS RATES

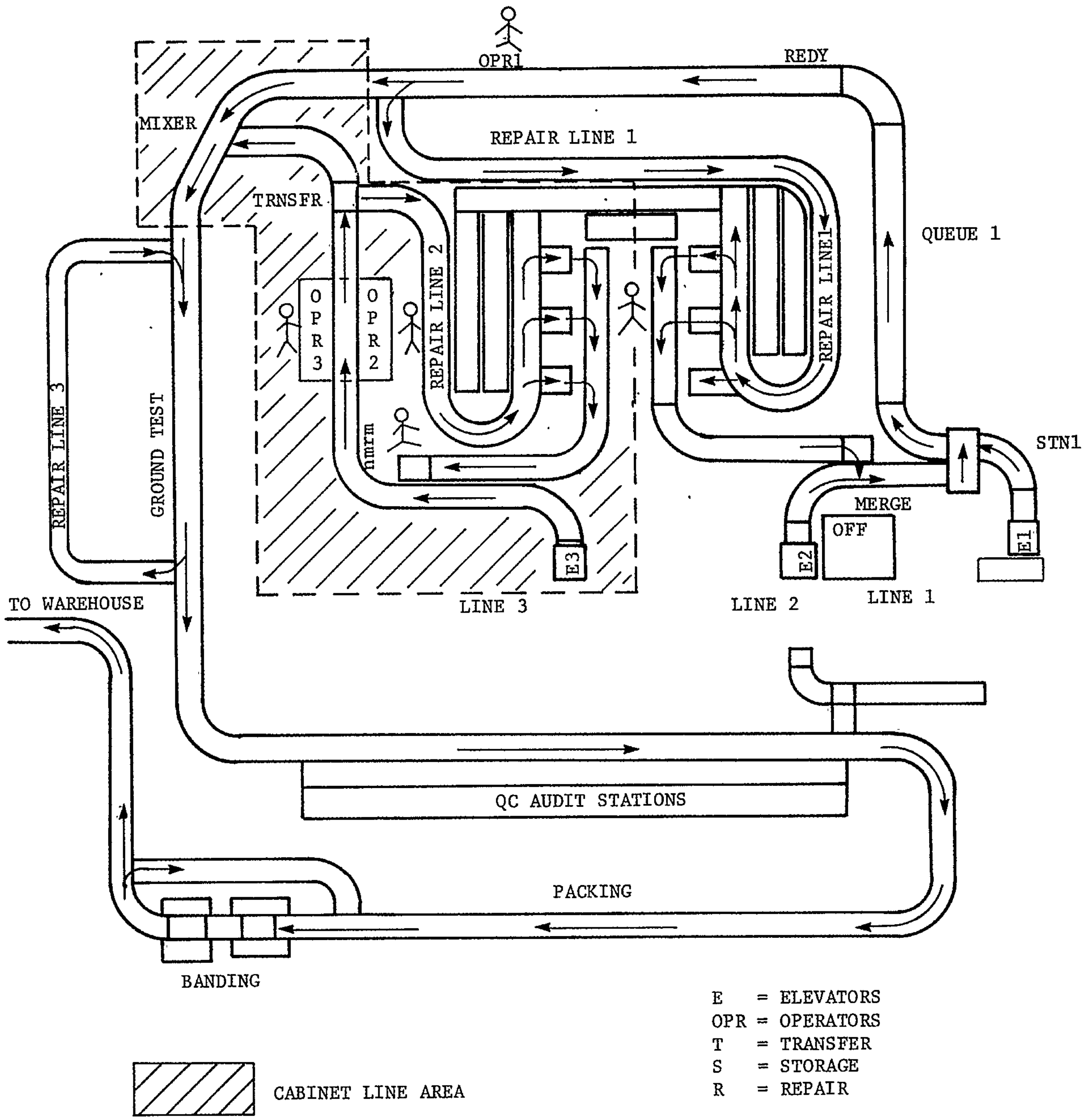
YEAR	AVG. TIME PER OPERATION					
	OPR 1	ELEC	OPR 2	OPR 3	RPR 1	RPR 2
1976	100±20		15±3	35±5	600±300	
1977	100±20		15±3	35±5	600±300	
1978	50±15	25±3	15±3	35±5	300±200	300±200
1979	50±15	25±3	15±3	8±2	300±200	300±200

ANALYSIS OF SIMULATION RUNS

Some results of the simulation runs have been summarized in Table 3. In this Table the utilizations of the operators, facilities and repairmen are indicated. From these values it can be observed that during the year 1976 (a recession year), the system was operating well within capacity. Also, in 1977 the capacity was sufficient to meet the desired production volume. A validation check with the operating data for 1976 and 1977 support these conclusions. Owing to the high utilizations of Operator 1 (OPR1), OPR3 and the repairman in 1977, these operators were given assistance through the addition of three other workers (ELEC, OPR1 and repairman 2). The utilization of personnel with these additions are indicated in Table 3 for 1978. For 1979 the simulation revealed that the facilities had reached their peak utilization and that the facilities would have to be expanded to meet the desired production levels.

The simulation analysis made management aware of impending capacity shortages early enough, enabling suitable corrective actions such as the addition of personnel and the expansion of facilities to be taken. Thus through the simulation analysis 'efficient' solutions to the capacity problem were identified. Also capacity constraints determined from the simulation analysis were used in conjunction with other constraints, such as that on energy consumption, to determine an optimal product mix for the range plant. This was done through a linear programming formulation.

FIGURE 1



OPR1
REDY
MIXER
REPAIR LINE 1
TRNSFR
QUEUE 1
O P R 3
O P R 2
REPAIR LINE 2
REPAIR LINE1
REPAIR LINE 3
GROUND TEST
STN1
MERGE
OFF
E3
E2
E1
LINE 3
LINE 2
LINE 1
TO WAREHOUSE
QC AUDIT STATIONS
PACKING
BANDING
E = ELEVATORS
OPR = OPERATORS
T = TRANSFER
S = STORAGE
R = REPAIR
CABINET LINE AREA

FIGURE 2

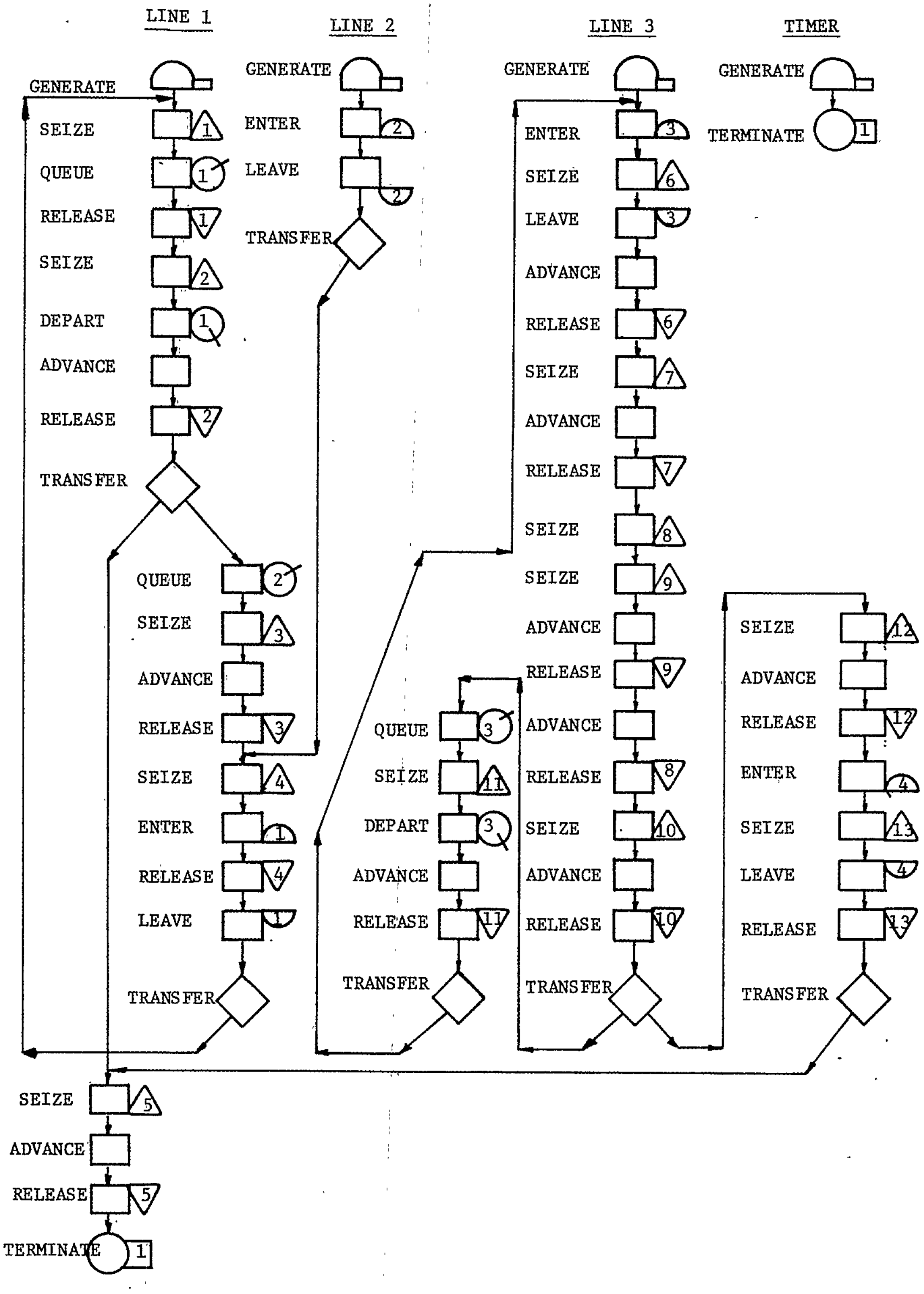

LINE 1
GENERATE
SEIZE
QUEUE
RELEASE
SEIZE
DEPART
ADVANCE
RELEASE
TRANSFER
QUEUE
SEIZE
ADVANCE
RELEASE
SEIZE
ENTER
RELEASE
LEAVE
TRANSFER
SEIZE
ADVANCE
RELEASE
TERMINATE
LINE 2
GENERATE
ENTER
LEAVE
TRANSFER
LINE 3
GENERATE
ENTER
SEIZE
LEAVE
ADVANCE
RELEASE
SEIZE
ADVANCE
RELEASE
SEIZE
SEIZE
ADVANCE
RELEASE
ADVANCE
RELEASE
SEIZE
ADVANCE
RELEASE
TRANSFER
QUEUE
SEIZE
DEPART
ADVANCE
RELEASE
TRANSFER
TIMER
GENERATE
TERMINATE
SEIZE
ADVANCE
RELEASE
ENTER
SEIZE
LEAVE
RELEASE
TRANSFER

TABLE 3

CAPACITY UTILIZATIONS (%)				
YEAR	MIXER	LINE 1	LINE 3	UNITS/ DAY
1976	45.4	73.5	48.9	653
1977	57.6	94.1	62.8	830
1978	87.0	70.2	95.8	1259
1979	95.3	83.7	99.8	1371

OPERATOR UTILIZATIONS (%)						
YEAR	OPR1	OPR2	OPR3	ELEC	RPRMAN 1	RPRMAN 2
1976	73.5	89.9	81.6	-	52.6	-
1977	94.1	73.3	83.9	-	91.8	-
1978	70.2	95.8	63.8	79.8	41.8	41.8
1979	83.7	99.8	50.2	92.9	36.8	40.4

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