MANUFACTURING LEAD TIME DETERMINATION BY GPSS SIMULATION

MANOHAR L. ATHAVALE
International Business Machines Corporation
Endicott, New York

The manufacturing lead time allowed for a product can considerably affect the work-in-process inventory and the operations of a shop. The determination of this lead time is, therefore, one of the most important and complex problems faced in manufacturing planning. This paper describes a successful attempt at solving this problem through simulation.

INTRODUCTION

Throughout the manufacturing life of a product, a number of planning decisions have to be made. Most of these decisions, in the real world, have to be dynamic to ensure their timeliness and accuracy. One of the basic decisions pertaining to the assembly and test operations involves determination of the manufacturing lead time for the product.

Any product going through a sequence of operations takes a certain time to be completed. This completion time consists of the actual time for each operation and the waiting time before each operation. This total time for completing the product, from the start of the first operation, is defined as the manufacturing lead time for the product.

This lead time is thus used to find out "start to build" date based on the delivery date of a product. The lead time has a considerable impact on the function of the shop.

STATEMENT OF PROBLEM

The analysis of the lead time is a classical queueing problem. However, when one starts looking at more complex situations with

1. More than one shift with different manpower in shifts

2. Flexibility to move men from one station to another

3. A number of different products being manufactured through the same line

the problem becomes much too complex for any analytic solution on one hand or "engineering estimate" on the other. The decision was, therefore, made to build a simulation model to find out the manufacturing lead time.

The operations involved were essentially assembly and test type operations. The main "facility", therefore, was the manpower in the shop. Thus, the only dispatching activity involved was that of assigning a man to a new job.

The following information about the shop is required as an input data to the simulation model:

1. The routings for all products manufactured.

2. The average and the frequency distribution of operation time for each operation and for each product.

3. Production schedules for each product.

4. Men available in each shift and their skill levels.

5. The skill level required by each operation.

6. Operating rule for assigning a job to a man.

The primary reason for the development of the model was the determination of the lead time. The model was also useful in predicting the following:

1. The frequency distribution of work-in-process.

2. The average and maximum queue-length at each operation.

3. The utilization of manpower.

4. The space requirement.

DESCRIPTION OF THE MODEL

The simulation model, written in GPSS/360, consists of four different modules briefly described below.

1. Initialization: To reduce the "run in" period before reaching the steady state, all operations in the system are preloaded.

2. Order Arrival: The jobs arrive at the beginning of the day. Everyday a number of job orders, equal to the daily production rate, are created for each product. This number can be a fixed or a random number.

3. Dispatching: Dispatching module involves selecting a new job for a man when he completes one job. All the manpower in the shop is grouped into various skill levels. All the operations, likewise, have a skill requirement associated with them. When a man becomes free, he is sent to the operation within his skill level having the largest queue. However, it might not be practical to keep a man moving from one operation to another. The following feature, therefore, is incorporated into this dispatching rule:

Keep the man on the same operation if there is a job awaiting that operation and if the man has been on that operation for less than a specified length of time.

An operation is allowed to be partially completed in the shift, and then be completed by a "proper" man in the next shift. Such incomplete jobs are given higher priority in the next shift.

4. Shift Change: This routine involves releasing all the men from the previous shift and assigning a new set of manpower to the jobs. All fully or partially completed jobs are queued into the appropriate queues. The dispatching routine is then called in to assign the new men, one by one, to these jobs.

SCOPE AND LIMITATIONS OF THE MODEL

Every attempt was made to formulate the model general and flexible. As a result, it is possible with this model to simulate almost any assembly shop of the type described above. This required a considerable use of complex GPSS features. All the information like manpower in the different shifts, the skills of these men, routings for the different products, operation times with their frequency distributions, the number of hours per shift, etc., is provided in the form of various GPSS declaratives. Besides simulating the present or proposed conditions of the shop, it is therefore, possible to use the model for performing a number of special studies like:

1. Change of manpower between the shifts.

2. Cross training of manpower.

3. Change in the operating rule.

4. Two shift vs. one shift operations.

From the planning point of view, the most significant results obtainable for all these studies are:

1. Manufacturing lead time frequency distribution.

2. Space and manpower requirements.

The model however, basically remains as a planning tool and not an operating tool to find out the effect of day-to-day changes. The reasons for this limitation are as follows:

1. The inflexibility and complexity of GPSS input makes it almost impractical to run the model too frequently for making operating decisions.

2. GPSS, being a higher level programming language, is inefficient in terms of core requirement and run time.

3. GPSS is basically geared for Monte Carlo simulation with transactions internally generated by random process. A GPSS model, therefore, cannot be efficiently formulated to consider day-to-day changes in the shop.