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MICROCOMPUTER MANUFACTURER FMS SIMULATION

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ABSTRACT

Apple Computer Ltd uses a flexible manufacturing system (FMS) to assemble and test several different products simultaneously. A simulation model of the system was developed to study ways to improve its efficiency. Problem areas were identified and changes were made to the computer control system to correct the problems. The simulation model was then retained as the scheduling tool.

1. INTRODUCTION

Apple Computer Ltd of Ireland uses flexible manufacturing systems (FMS) in the assembly and testing of their microcomputer products. One FMS line, in particular, can assemble several different products simultaneously. It is composed of a computer controlled, oval conveyor system that supplies assembly stations located around its periphery. Each station's operator does a set of tasks and passes her output on to a subsequent station in the assembly process. The layout of the FMS is shown in Figure 1.

The computer controller, as it was originally designed, only keeps track of what station a product goes to next in the sequence. For the production volume and product mixes Apple was normally experiencing, few problems occurred on the FMS other than an occasional short-term system breakdown. When volume increased and product mixes changed, the specification of the FMS was being approached, causing the oval conveyor to occasionally saturate with unfinished products, thus requiring expediting to correct the problem.

A simulation model of the FMS was developed in order to study, identify and correct problems before they became serious. Because of the system's complexity, the large number of different products, the flexibility of the system and the accuracy and detail of the results required, a fairly large, detailed simulation model (2,000 lines of GPSS coding) was necessary.

2. RESULTS AND CONCLUSIONS

The simulation model showed that line imbalances were causing the conveyor saturation problems. Line balancing on a FMS is no simple matter. Line imbalances on the usual, straight-line assembly line cause problems enough, but on a recirculating conveyor an imbalance can be disastrous. The imbalance on this FMS was well within reason for the level of production normally being experienced; however, when volume increased, these small imbalances were magnified.

The problem can be described more fully as follows. A "slow" station, preceded by a "faster" one, would soon have its small WIP area filled and start rejecting products from the faster station, thus causing the output of the faster station to stay on the recirculating conveyor. The bigger the imbalance the greater the loading on the conveyor. Soon this inventory on the conveyor would build to such a level as to hold-up products trying to leave each work station.

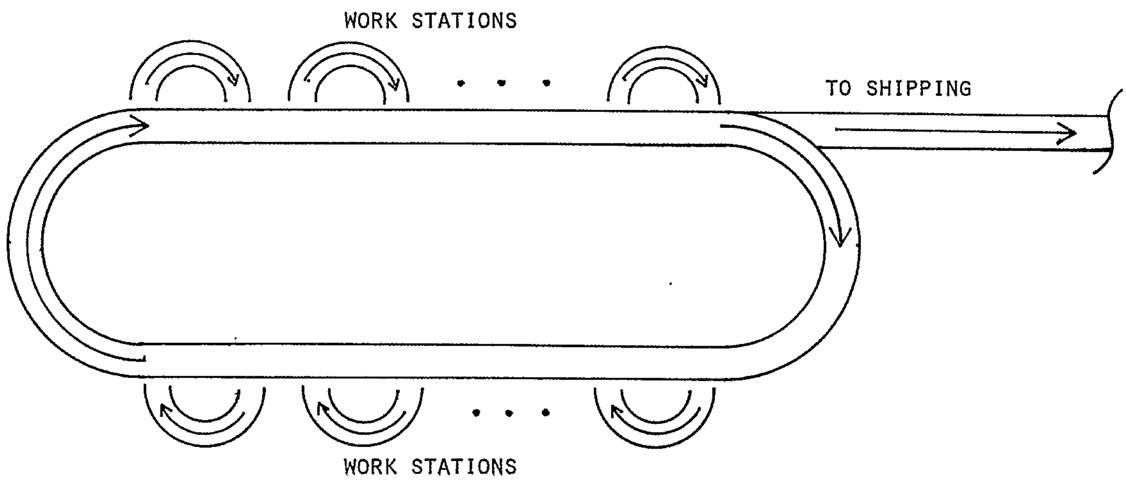

Figure 1.

Multiply this by every station where a faster operation preceded a slower one and in no time, at high volume, the conveyor would saturate.

Because the computer was not programmed to keep track of the quantity of each product at each stage of completion on the conveyor and because it was not always easy visually to discern one stage of completion from another on the conveyor, it was not clear which stations were causing the greatest problems. Some experimentation had been tried with limiting the output of certain stations, but no clear guidelines were found.

The simulation model showed which operations on which products were causing the problems. Each imbalance was analyzed to see if tasks could be reassigned to provide a closer balance - in most cases they could not be reassigned. The effect of controlling the inventory of each stage of completion of each product on the conveyor was studied next. Various maximum levels (e.g. 5, 10 and 15) for each stage of completion were imposed on the model. The results were better than had been expected. A 10% to 50% increase in throughput was experienced when compared to the present system with no expediting.

There were two problems with trying to implement the findings above. The first problem was a small one: it is difficult to sell the concept that it might be more efficient and cheaper to let workers be idle for long periods of time. The model demonstrated this to be the case beyond a shadow of doubt. The second problem was not trivial: the present computer controller was not capable of keeping track of the conveyor inventory nor of limiting the output from various stations. On the basis of the savings involved, a redesign of the computer system has been undertaken. The new controller will incorporate the conveyor inventory keeping ability and station output control, demonstrated to be so vital by the simulation model.

The simulation model will not only be maintained for future studies but is also being kept for use as an FMS scheduling tool. It has already been used to determine the efficacy of various product mixes and loadings for the present and the soon-to-be implemented system.