The Application of Computer Simulation Techniques to Glassware Production

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ABSTRACT

Rising costs, changing product mix, and expanding technology have left engineers with a perplexing problem; how should we design and run the manufacturing system of the early 1980's? This was indeed the question posed for the production of a well known brand name of glassware. Rising production costs were eating away at profits and changing product mix was contributing to the problem through a reduction in productivity efficiencies. Further, expanding technology developed new processes that somehow had to be efficiently added to the manufacturing process.

This paper describes how simulation was used to identify the key variables which were used to determine the best operating strategy and equipment design. In addition, and more importantly, a synopsis is presented explaining why simulation was chosen as the analysis technique (along with its advantages and disadvantages) and the problems encountered throughout the analysis.

SYSTEM DESCRIPTION

The system analyzed begins with a forming operation that is capable of forming as many as one-half of the different product types at any point in time. After forming, the ware is either sent directly to the Finishing Department to be decorated or it is put in storage to be decorated at a later time.

The Finishing Department puts a decoration on and fires it into the glass. The ware is then packed and shipped.

The Finishing Department has the capability of decorating ware that is coming directly from the Forming Department or from storage. The speeds of the decorating equipment is dependent upon the decoration type and the product type. In addition, the capacity of the firing kiln also plays a role in determining decorating speeds. The decoration types being used are determined from a production schedule.

MODEL DESIGN

At the start of the model development, a small task force -- comprised of both the model developers and its future users, developed a list of important capabilities that had to be designed into the model. First, the model had to be developed in such a way that almost any engineer could use it. In addition, the processes being modeled and any underlying assumptions, as well as the model's use, had to be easily communicated.

Secondly, it had to be highly flexible. Because of rapidly changing process technologies flexibility had to be built in to allow the user to change production parameters easily. In addition, the capability to add or delete manufacturing process steps, both forming and finishing, on an individual basis was felt to be necessary to guard against premature obsolescence.

Thirdly, the model had to have a mechanism whereby the user could account for every piece of glassware started. It had to be able to tell the user how many pieces

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went through each process step, how many were rejected at the various inspection stations, and how many were completed. This accountability makes it possible to determine production costs for the various scenarios tested with the model. In addition, it can be used to analyze material handling systems, if so desired.

WHY SIMULATION

The approach taken to analyze the system was to collect production performance data and analyze it (including marketing forecasts and engineering estimates of equipment changes) to determine the best operating strategy for the early 1980's.

While collecting the data it was found that the process was so dynamic that by the time any thorough analysis was complete the input data would be obsolete. Equipment changes to accommodate the rapid advance in decorating technology were occuring faster than they could be incorporated into the analysis. To further compound the problem, product mix was changing to meet consumer demands. The changing product mix and decorating technology, and management's desire to be able to alter the operating strategy accordingly, dictated that the analysis be easily reproduced.

Due to the complexity of the system and the desire for repeatability it was determined that simulation would be the best analysis tool to use.

CHOOSING A SIMULATION LANGUAGE

In choosing a simulating language one objective was set forth -- choose the language which minimizes the work necessary in developing the model, but still gives enough flexibility to meet the design criteria. To this end, A. Alan B. Pritsker's Q-GERT Analysis Program (1) was chosen.

Q-GERT's network philosophy contributed a method for graphically displaying the model. This graphical display greatly enhanced the communicability of the model. Also, Q-GERT has a mechanism built into it that automatically keeps track of the number of pieces going through each process step, thus meeting the accountability criterion.

Although Q-GERT is more rigid than some of the other languages available (GASP-IV, SIMSCRIPT, SLAM, etc.), it provided enough flexibility to meet the needs of the analysis. Any sacrifices that were made to flexibility were more than compensated for with the gains in communicability and accountability.

A side benefit of Q-GERT is its built-in trace mechanism. This trace mechanism allows the modeler to "follow" the pieces through the network. The benefit of the trace was obtained primarily during the model debugging stage. Logic errors were easily found through use of the trace.

MODEL DESCRIPTION

The Q-GERT model proved to be quite large. The model is comprised of more than 300 Q-GERT nodes and 100 service activities. Capability was built into the model to handle as many as 40,000 pieces of glassware in the system at any one time.

The model driver is a production schedule that the user inputs. The user also inputs equipment speeds, rejection probabilities, and the initial state of the system.

The output of the model includes a status of the system at the end of the simulation run, machine utilizations, total pieces of ware produced, a count of the number of pieces going through each production step, and histograms and statistics of key variables.

PROBLEMS ENCOUNTERED

Due to the size and complexity of the model and the relatively embryonic state of our skill at using the computer as a tool to aid the engineer, many more problems were encountered than anticipated. The model size was larger than Q-GERT was designed to handle. Therefore, most of the storage array dimensions and initialization variables had to be increased to a point that made them too large for the hardware configuration of our engineering computer. To get around this problem it was decided to run the model on a machine that had up to that point been primarily used for data processing. The decision was made, neglecting the fact that this computer's support staff was geared towards the running of COBOL data processing programs rather than the FORTRAN "answer finding" programs needed. A significant amount of time was spent finding answers to loading and compiling problems that a FORTRAN knowledgeable support staff could have answered in a matter of minutes.

In addition to little support help, the decision to use the data processing computer brought with it a hardware problem. The transition link to the computer available for use was prone to frequent failures, thus, further delaying the analysis.

The complexity and size of the model made it difficult to debug. By building the model in modules this problem was alleviated. The Q-GERT trace played a large role in making this process easier.

CONCLUSIONS

The dynamic environment of the system being analyzed coupled with the need to respond quickly and easily to technology changes necessitated the use of simulation as the analysis tool. A need has been shown for a close relationship between the computer support staff and the engineers. Measures have been taken to obtain this.

REFERENCES

(1). Pritsker, A. Alan B.; Modeling and Analysis Using Q-GERT Networks, Wiley - 1977.