ABSTRACT

The inconsistencies in the flow of work through a manufacturing floor in a high volume, low similarity environment make WIP (Work in Process) projections difficult for short-term decision making. How much work will be in each of our manufacturing departments tomorrow, next week or next month? We needed to answer these types of questions to do effective workload planning. The IBM facility in Owego, New York is the major supplier of circuit card assemblies (pages) for IBM's® Federal Systems Division. We manufacture many unique cards of varying demand with each card moving through many different departments and build operations. When combined with the volume of individual pages processed, a large quantity of data is generated.

We used extensively the merge capability of SAS® Software to manipulate this large amount of data. SAS Software enabled us to extract and combine data and use the result to plot a WIP projection over a three month horizon using PROC GPLOT and PROC GCHART. This paper examines our SAS Software technique to model the flow of work across the manufacturing floor, allowing us to make short-term projections for manual and automated workload planning. Our SAS Software model is an accurate forecasting tool in a complex and dynamic manufacturing environment.

Introduction and Purpose

The IBM plant in Owego, New York manufactures a large variety of circuit cards. Each type of card varies in technology and manufacturability. Thus, the manufacturing process resembles a production job shop. In such an environment, the workload is difficult to project. The Work in Process (WIP) may be heavy in one area or department during one week and light in another area. Within a short time, the reverse may be true. Because not all cards follow a common flow, projections cannot be based solely on what is in the adjacent department. The lack of knowledge of short-term workload creates a severe problem for manpower and machine allocation. Without being able to predict workload, a line becomes unbalanced as some areas are overloaded even at full capacity while other areas experience work shortages.

Long-term workload projections for capacity planning also suffer from insufficient knowledge of current WIP. Without an understanding of the flow of work through manufacturing, current demand may be understated or overstated, thus skewing future demand projection. Long-term manpower allocation, then, might be based on poor information from a long-range capacity plan.

To reduce the error in manpower allocation and long-range capacity planning, an accurate model of current Work In Process and short-term workload shifts is essential. Both Production Planning/Control and Manufacturing Planning are interested in such a model.

Basis for using SAS® Software

We decided to use SAS Software to develop the planning model for several reasons. Our Information Systems Support Group has been overloaded with work. We needed a program in place in a short time and SAS Software provided the means for us to develop the program ourselves. SAS Software has been installed at Owego for several years on the MVS/TSO Operating System. It has been used for many unique and varied applications. The SAS System is a useful tool for programming by the end-user to help alleviate the overload in our facility Information Systems Group. The SAS System is capable of handling the large amounts of data, and the output can be shown graphically using SAS procedures.

It is very important for us to be able to store the preliminary results when the program is run. The primary program costs several hundred dollars to run, thus, if we had to run this program whenever we wanted slightly different charts, it would be cost prohibitive. With SAS Software, however, we can store the data in a SAS data set format and access this data at a fraction of the cost of reading our large files. This also allows the data to be accessed by other people for different applications.

Data Collection and Assumptions

The data we analyze is stored on two large files. The first data file contains information on all 'open' orders while the other has manufacturing operation routing data about these orders. It is necessary to read both files and then merge them by order number. The merge provides us with the complete operation flow of each order in process, the current location of the order, and how long it has been at that location. The resulting dataset contains over a million observations.

There are 3 basic assumptions we use in our model:

1. All orders are released complete (no backorders).
2. If the historical cycle time for a given department is 5 days and an order has been there for 3 days, the order will be there for 2 more days.

3. The only work remaining to be done on any order are the operations after the last completed operation. Any uncompleted operations before the last completed operation are considered labor claiming errors.

These assumptions are valid based on our current business.

SAS Programming

The SAS Software model actually consists of two programs (A and B). The first Program (A) creates the database for analysis. The second Program (B) creates the charts and graphs. The separation is made for cost reasons. We often want to alter the way the data is displayed on the charts (e.g., requesting data for different departments). The database remains unchanged so we divide the model into (A) which does the database creation, and (B) which reads the data and produces the output. Program 'A' uses several values that can change monthly (e.g., historical cycle time); for these values, macro (\%LET) variables are used to make updating easier.

Program 'A' uses the routing flow data collected and analyzes all operations and departments for each order. Using the estimated hours of labor and set-up time for each of these operations and the historical cycle time data for 'wait queues', the program calculates the time before the order will reach the next operation and all following operations. The individual hours for each department and the expected time frame are compiled to give aggregates by area. The data has effectively been reduced from over a million records to less than ten thousand.

The second program, 'B', then profiles the data by department and produces output using PROC GPLOT and PROC GCHART. This output shows projected hours by department for the next six months. The hours, however, represent only the remaining work associated with orders already on the manufacturing floor. For total workload we add the hour demand associated with future releases. We retrieve this information from another series of SAS Software programs.

Program 'B' runs under batch mode and the output is normally printed on an IBM 3800 printer (Model 3). An IBM 3287 C printer is used when color print is desired.

To process individual requests of end-users, we created a 'panel' using the IBM Interactive System Productivity Facility (ISPF). The panel allows users to request WIP Data for any or all departments. While working to obtain the output, we made an interesting observation about the cost of PROC GCHART. We are using SAS System version 5.16 and it appears to cost about 10 times more to get PROC GCHART output on a 3800 printer than on a 3287. The apparent cause is in the EXCP Count. We are still trying to determine the exact cause. With PROC GPLOT and PROC GSLIDE we have not experienced this problem.

Summary

The WIP Flow Model, because of its ability to portray changes and shifts in workload, has become a useful tool. We are able to plan a shift in manpower to accommodate a shift in the workload. We can recommend the best times to take a machine down for maintenance based on the workload projections. Manufacturing can use the model to schedule training modules for maximum benefits. A measure of manufacturing performance can be assessed by amount of work in the area being measured. We are able to integrate the model with the demand projections to have a complete workload picture for demand/capacity analysis. The model is also an effective tool in making decisions to 'off-load' to or 'in-load' from a subcontractor.

We have found many advantages in our model over previous projection methods. This is the first time we have been able to use actual routing flows rather than estimates in workload projections. Our model is also able to adapt to changes as our system changes and as our workload mix changes.

Conclusion

Our SAS Software Programs provide us with a valuable WIP Model at a minimum cost. The WIP Flow Program gives us useful graphical output with SAS/Graph®. The built-in procedures of SAS Software enabled us, the end-users, to write the program ourselves. Further, the ability of SAS Software to create datasets allows any TSO user to access our output.

We have developed a useful model to project short-term workload shifts and expose possible problems. The ability to handle the massive datasets to translate the data into useful information is relevant in many applications similar to ours.

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