GASP IV SIMULATION MODEL FOR THE COMPOSITES AND BONDING PRODUCTION FACILITY

Darrell W. Starks

ABSTRACT

This article describes the operation of the composites and bonding production facility of McDonnell Aircraft Company in St. Louis. It explains why a simulation of this area was needed, gives an overview of the simulation, and describes how the industrial engineers use the results of the simulation.

INTRODUCTION

The MCAIR composites and bonding production facility has the responsibility of producing aircraft parts requiring structural composites of high-strength fibers such as graphite or boron in a suitable matrix material, such as epoxy. This manufacturing process requires expensive tooling and a high level of quality control. The operating costs and the costs of resources is therefore proportionally higher then other conventional operations. Conventional methods were used in projecting the resource requirements in light of an increasing production rate for MCAIR aircraft. A means of validating these projected resource requirements, such as tooling, manpower, autoclave, and other equipment capacity, was needed since the operations are so dynamic and interdependent.

In order to provide MCAIR Industrial Engineers with a more effective means of evaluating present and future operations at their facility, a bond shop simulation model was developed. The approach taken in developing the model consisted of four primary steps. First, the most significant operations at the facility were clearly defined. Next, a level of detail was found which would provide the needed realism yet not burden the model with extraneous information. The model was then programmed using the GASP IV simulation language, and finally, the model was validated by comparing output results with current operations at the facility.

BOND SHOP OPERATIONS

The MCAIR composites and bonding production facility is a unique job shop type operation since both fabrication and assembly processes occur during the completion of a part. The facility uses resources of workers, work stations, tooling, and specialized equipment to produce aircraft assemblies. Figures 1 and 2 show the chemical cleaning work station and the DNC honeycomb machining center. Figure 3 shows one of the many tooling jigs. Work orders to begin fabrication of the various parts enter the system on a regularly scheduled basis. A part progresses through its required work stations according to

Bond Shop Operations (Continued)

its production diagram which is a listing of the work stations in the order through which the part flows. Figure 4 illustrates the flow of a typical part through the bonding facility. When all resources are needed, the part looks first for tooling, then facility, and finally workers. There are times when all resources are not needed and times when a part must wait in a queue to capture the resource. The resource is retained until it is not needed for the next operation. At any given time there exists within the facility a specific number of each type of tooling and a specific number of workers in each of seven different job classifications.

There are certain time constraints associated with the parts as they move from one facility to the next. In some cases, a subsequent process, not necessarily the next one, must be either started or completed within a set time limit from entering or exiting the lead facility. Once the work at this facility begins or ends, the time limit is deleted. However, if the limit expires prior to the subsequent activity, the part must be returned to the facility where the limit originated, and begin at this point again in its production process. For example, for the graphite material the time from the beginning of the laser cutting process, at which time the graphite is removed from the freezer, until autoclave curing begins must be less then 480 hours.

The simulation logic for most work stations is the same in that a part enters, remains for a specific cycle time, and then leaves. Certain work stations, however, operate uniquely, thus requiring special attention when building the model. These special work stations are the autoclave (Figure 5), cure oven, nondestructive testing (NDT), and the work station area where completed subassemblies are merged with subassemblies still in process. For parts to enter the autoclave, the parts must be grouped based on pressure and temperature while most parts entering the oven do so in groups of two having equal cycle time. The NDT work stations, of which there are four, are unique in that the flow through these work stations can occur in any order.

The bond shop operates on a three shift basis where the workers are available 22 1/2 hours per day. Some work stations, such as the autoclave and cure ovens, operate 24 hours a day. A manufacturing calendar is used to schedule weekends, holidays, and Saturday overtime. The level of available tooling and/or the available workers may also vary with time.

MODEL DEFINITION AND DESCRIPTION

The simulation model is a deterministic, discrete event, digital simulation program. All activities occur in a nonrandom manner according to a predetermined manufacturing calendar. Work orders enter the system on a regularly scheduled basis and all service times for parts at facilities are constants as specified by each part group's production diagram. It is a discrete model in that all events occur at specified points in simulated time.

GASP IV is used to produce a simulation which is a dynamic portrayal of the bond shop assembly area over time. The model is comprised of plant

Model Definition and Description (Continued)

operations, resource definitions, and management logic for the bond shop. In addition to the FORTRAN subroutines which reflect the logic of the bond shop, there is data which the user is required to furnish. The manufacturing day calendar is input in order to establish a time frame. A part group production diagram is used to describe the flow of a part through the facilities for each part group. In addition to the precedence relationships, this diagram gives the cycle time, manpower required, tools used and limits occurring at each facility. Data describing each facility, its capacity, and shift availability is input as well as manpower and tooling quantities available. The autoclave load descriptions which determine the combinations of tools to go into the autoclave and their priorities are also input.

From this simulation a large amount of statistical data is generated, including the part group condition, queue statistics, and facility and tool statistics. The part group condition section describes the number of parts entered and the number completed which enables the shop management to determine if the desired production requirements will have been met. This section also gives the average time in the system for each part group which allows the management to determine an average cycle time for each part group.

The queue statistics give an average waiting time at each resource where the resource may be a work station, a tool, or a particular manpower type. The average and maximum number of parts waiting at each resource is also given. These statistics are used to determine, among other items, resource overloads and number of storage racks needed at a work station.

The facility and tool statistics show capacity, average time per unit, percent utilization, and average and maximum usage. From these statistics management determines the average number of idle tools and facility or work station overload and underload.

Other statistics which are part of the output include location of parts still in work at the end of the simulation, parts waiting at each resource, autoclave loads, oven activity, and tool monitoring. Taken as a whole, the output provides a clear and descriptive picture of the bondshop assembly operation over the simulated time period.

CONCLUSION

In conclusion it should be noted that this simulation is an ongoing effort. The simulation is continually being embellished by adding new capabilities which increase the flexibility of the simulation. Overall, this simulation package is considered by the bond shop Management to be an effective and flexible instrument in their prediction of tooling, manpower, and other equipment.

REFERENCES

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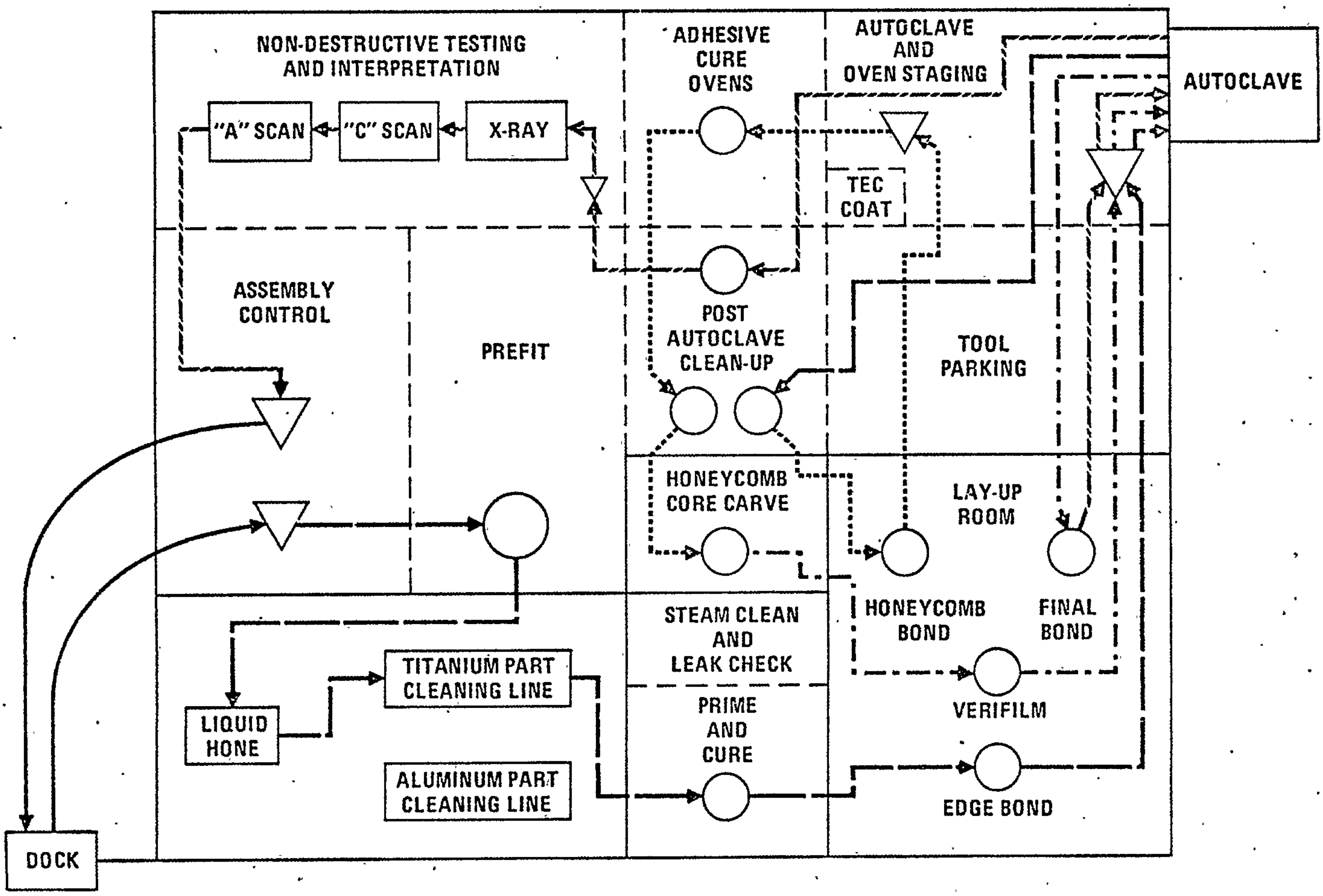

Figure 1