MANAGING SHORT CYCLE TIME MANUFACTURING WITH WITNESS SIMULATION SOFTWARE

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ABSTRACT: Various approaches and techniques have been adopted for reducing cycle time. They can be classified into the following four categories:

1. To establish inter-relationships among critical processes, e.g. pull-type manufacturing;
2. To rationalise the process layout; e.g. cellular layout;
3. To control product mix and product volume released into production lines;
4. To schedule operations at critical processes, e.g. bottleneck-based scheduling;
5. To simplify and integrate processes, e.g. reduce number of operations in process flow.

Each of them has merits and weakness. For a company, it would be very risky to implement any technique without going through a detail analysis and evaluation. Manufacturing simulation provides an effective way for a company to evaluate impact of introducing a new policy or layout on productivity. The paper discusses how WITNESS, the simulation software, can be used to help companies shorten cycle time.

KEYWORDS: Simulation, Cycle Time, Manufacturing

1. INTRODUCTION

A major concern in the manufacturing industry is the manufacturing cycle time. Delivery performance, together with quality and service are crucial to the company's success and survival in the marketplace. New technology, automation, capital investment are the common methods used to achieve better delivery performance. This paper, however, describes the management techniques that drive for short cycle time with the existing facility. The techniques are based on the authors' consulting experiences over the last several years in the south east Asia.

The barrier that prevent the management from adopting a new technique is the unknown consequences. Any method will have its pros and cons. Traditional methods such as pilot implementation is risky and costly; static calculation like spreadsheet is not able to analyse the dynamic behaviours such as work-in-process (WIP), setup, product mix. Computer simulation, however, models the real life system dynamically, and is able to run what-if scenarios quickly and more accurately. The application of simulation saved million of dollars in the United States, Japan and Europe[2]. With the rapid economical progress, the simulation technology is getting more and more acceptance in this region.

The information flow of simulation is illustrated in Figure 1. The dynamic characteristics of production, e.g. process flow, processing times, setup requirement, labour, control rules, breakdown, shift, loading schedule, etc. are modelled in the computer. When simulation model is run, the system status will change (e.g. part is processed, material is moved from one station to next) as in real life with the system built-in clock. Typical reports by simulation include throughput, manufacturing cycle time, equipment utilization, WIP levels at various stages. By changing the input parameters, one can study the impact on the production performance.

WITNESS is the leading simulation software from AT&T ISTEL. As the fourth generation simulation software[3] and the only visual interactive simulation software[1] available, WITNESS is a very powerful, yet highly user friendly package running on Windows, OS/2 or UNIX. Models can be changed at any point during the model building or running phases. A combination of physical and logical objects enables WITNESS to model very complicated manufacturing and business processes. So far more than 3,000 systems installed worldwide, including almost 70 installations in the south east Asia.

This paper describes how the WITNESS simulation software was used to analyse the what-if of various management techniques and help companies shorten cycle time. These management techniques can be classified into five broaden categories:

- To establish inter-relationships among critical processes, e.g. pull-type manufacturing;
- To rationalise the process layout; e.g. cellular layout;
- To control product mix and product volume released into production lines;
- To schedule operations at critical processes, e.g. bottleneck-based scheduling;
- To simplify and integrate processes, e.g. reduce number of operations in process flow.

2. TO ESTABLISH INTER-RELATIONSHIP AMONG CRITICAL PROCESSES

A general guideline of this technique is: operation at upstream bottleneck is controlled by WIP level at downstream bottleneck, and loading is controlled by WIP level at the first bottleneck.

Assume that a line consists of a series of machines, products flow from left to right, and machine No. 2 and No. 5 are bottlenecks (Figure 2). If WIP in front of machine No. 5 exceeds maximum level, machine No. 2 will stop working. Before WIP in front of machine No. 5 drops below the minimum level, machine No. 2 must resume work, otherwise it may cause machine No. 5 unnecessary idling. Similarly, if WIP in front of No. 2 exceeds maximum level, stop loading. Before WIP in front of No. 2 drops below the minimum level, loading must be resumed.

This concept resembles the Just-In-Time, but in a more loose form, in the sense that it does not control every operation and would be much easier to be implemented from a environment without any WIP control mechanism. Experiences show that controlling WIP in front of bottlenecks can reduce cycle time by 10% - 40%.

However, the triggering mechanism (i.e. maximum and minimum level of WIP in front of bottlenecks) must be carefully designed. If the minimum WIP level in front of a bottleneck machine is designed to be too low, it may lead to extra machine idle time when any upstream machine breaks down, thus causing drop in throughput.

Here, WITNESS serves two purposes. First, it can be used to forecast potential bottlenecks with respect to the production demand and expected material loading plan. Secondly, WITNESS is an excellent tool to establish the triggering mechanism, as it takes into consideration the fluctuations of processing times, randomness of machine breakdown, unexpected material shortage, and so on.

3. TO RATIONALIZE THE PROCESS LAYOUT

Re-layout is common at shop floor. For example, several machines in a group looked after by a single operator may be re-oriented to reduce the operator's walking distance. Production lines may be re-structured as U-Shape to improve visibility between the beginning and end of the line. More drastically, the large production process may be re-layout from function-based flow to product-based cellular layout based on Group Technology (Figure 3).

Due to the mix of significantly different products, the function-based process may not be efficient. For example, for PCB assembly, certain products may take longer time at auto-insertion while others are processed longer at chip placement. A mix of these two types of products on the same line mean long idle time at one equipment or another. The advantages of product-based cellular layout are: i). Reduced changeover time between batches; ii). With reduction of materials-handling, production planning and control are simpler; iii). Parts spend less time waiting, in-process inventory levels are reduced; iv). With more direct routes through production, manufacturing cycle time is stabilized and reduced.

Due to the demand fluctuations, certain equipment in a cell may not be fully utilized while in other cells the same equipment type is a bottleneck. A temporary solution is to lend this equipment for use by others. When equipment sharing between cells becomes a common practice, the cell responsibility will be lost and defeat the whole purpose of cellular layout.

Therefore the grouping of products into every cell needs to be regularly reviewed. WITNESS fits well into the evaluation of grouping criteria. Typically, WITNESS is used to study the production cell relationship, the product loading strategy, and operational procedures within a cell and between cells.

4. TO CONTROL PRODUCT MIX AND RELEASING VOLUME

How many, which type, and in what sequence should product types be loaded onto production floors appear to be a problem constantly overlooked by production management systems. The macro-level planning system, like MRP, simply plans the type and quantity to produce from the demand point of view, without checking into detail how should these products be mixed and in what sequence. On the other hand, the micro-level planning system, tend to look at every machine on which batch to process first. The WIP in front of machines are dictated by the loading, little can be done is loading is not smoothed.

A well controlled product mix and releasing volume will:

- Machine changeover times are reduced, production capacity and total throughput are increased;
- With balanced workload at different stations, the machine utilizations are increased, cycle time reduced;
- The loading matches capacity much better in regular interval, thus reducing WIP and cycle time.

A carefully designed loading strategy means planning department may have to make more effort, as planning staff of most manufacturing companies are busiest. A potential pitfall is that the general strategy may be difficult to follow when certain demand suddenly changes and cause inflexibility in issuing loading plan.

WITNESS is specially useful for designing the product mix and releasing volume strategies quantitatively. Figure 4 shows the impact of the number of product types to load per day on the throughput and cycle time. Although demand fluctuates, there are normally major products whose demand is relatively stable for a period, say, 2 months. The guidelines, therefore, must be reviewed every 2 months.

5. TO SCHEDULE OPERATIONS AT CRITICAL PROCESSES

The purpose of scheduling operations at critical process (i.e. bottleneck) is to reduce the changeover time on the bottleneck machine in order to increase the whole production line's capacity. The scheduling may be carried out at different stages of the line depending on the production conditions:

- When the line is balanced and some processes are very sensitive to setup/product conversions, sequence the products to be released based on the bottleneck machine in order to minimize setup/conversion time at the bottleneck (Figure 5).

- When the upstream processes' capacity is much greater than that of the bottleneck, sequence the WIP in front of the bottleneck in order to minimize setup/conversion times at the bottleneck (Figure 6).

Reducing the setup will increase the utilization of bottleneck machines, thus increasing the utilization of the overall production line and the total throughput. Because of less WIP in front of bottleneck, cycle time will be shortened.

Sometimes, the factors to consider for machine changeover is too many to handle statically. A typical example is the testing operation in Semiconductor Assembly and Test. When a Tester becomes available, which lot should be picked to test depends on the test type it requires, the testing temperature, handler type, load board/test plate, availability of conversion kit, downstream process capacity constraint. Furthermore, in a multiplex situation, the electronic test time and index time of the products to be hooked to different handlers should be matched such that the total testing time is minimized.

The WITNESS software is ideal in generating the schedule by considering all the operation and tooling constraints and evaluating guidelines of

- Dispatching rules to select batches to process;
- Processing rules to match different products (e.g. to test together);
- Equipment selection rules;
- Manning level.

6. TO SIMPLIFY AND INTEGRATE PROCESSES

Many automation investment is only focused on a single operation or the material handling between existing machines. In fact, a more beneficial aspect would be the reduction in material handling between operational steps by investing on machining centres that combines traditional steps into one or continuously process several steps. When operational steps are combined or linked, material handling would be simplified, WIP reduced, and cycle time be drastically shortened.

Machining centres are normally very costly. Because they are complicated and new, the risk involved in this type of investment is much greater tan upgrading one existing machine.

The large investment is best to be justified by using WITNESS. It can quantitatively demonstrate what benefits can be gained from the investment, analyse whether the fitting of the new machining centre is smooth, and identify potential problems of the automated system design. Typically, the control rules in the WITNESS model can be used as the material flow control logic in the newly installed multi-function system.

7. CONCLUSIONS

Many approaches can be adopted to the Manufacturing company for reducing cycle time, each of them has its own merits and weakness. Simulation can forecast the dynamic behaviour of the changes, obtain confidence on the benefits, justify investment, identify potential problem areas such that management can take precautions to make sure the change be a successful one. As the most flexible and user-friendly simulation software, WITNESS has been widely applied worldwide and is progressing rapidly in the south east Asia.

REFERENCES

[1] Griffin, P., W.E. Kobus, P.E. & C.E. Kutzler, A Otto Thav. "Corporate Goals and Computer Simulation: Smart-Parts and Compiled Software versus Visually Interactive and Interpretative Software".

[2] Simulation Study Group, 1992. "Simulation in U.K. Manufacturing Industry". Department of Trade and Industry, UK

[3] Wang, M.; G. Sun; D. Wang. 1993. "Manufacturing Simulation: An Effective Tool for Productivity Improvement". In *Proceedings of 3rd International Microelectronics & Systems '93 Conference*, August. Malaysia