

WITNESS HELPS BUSINESS PROCESS RE-ENGINEERING (BPR) IN A MANUFACTURING CONTEXT

Patrick Tung
*National Semiconductor, PO Box 312, Batu Berendam Free Trade Zone,
75350 Malacca, Malaysia*

and

Dr Wang Ming, Dr George Sun
*CIMTEK Pte Ltd, SISIR Building, #01-65, 1 Science Park Drive,
Singapore 0511*

ABSTRACT

National Semiconductor (NS) in Malacca, Malaysia, is a Semiconductor Assembly and Test Plant. It has gone through a series of re-engineering of the Manufacturing Operations. Simulation was used to study the change of a major Package process from function-based flow to product-based cellular line. This paper describes the re-engineering of the Manufacturing process and the simulation project that helped the understanding of the process, the evaluation of improvement suggestions and capital savings. The simulation project was divided into two stages: study of the first cell and the inter-cell relationship. The results presented here include performance measurement, bottleneck identification, and others.

1. Introduction

With decades of innovation, expansion, acquisition, improvement and growth, National Semiconductor (NS) has become one of the world's largest supplier of semiconductors, specializing in Analog-intensive, Communications-intensive and Personal systems. The number of employees had hit 30,000 worldwide in the early nineties. After a re-organization of the Corporate to drive for better service, higher efficiency, higher profit margin and focused products, its employees have been reduced to about 23,000 but total sales and profit increased. In 1993, NS enjoys a total revenue of US\$2.0 billion, with a net profit of US\$130 million.

The Manufacturing site of NS at Malacca, Malaysia, is a semiconductor assembly and test plant. Its products is focused on analog chips, such as SO, TO, Mold Dip. As one of the few Multi-National Companies set-up in Malacca in the early seventies, the Plant just celebrated the 20th anniversary.

Since late 1993, the Plant has gone through a series of re-engineering of the Manufacturing Operations. One project was to change a major Package process from function-based flow to product-based cellular line. Facing the unknown of the new changes, simulation was used to run the future process on computer. This paper describes the re-engineering of the process and the simulation project.

2. Business Process Re-Engineering

In "Re-engineering the Corporation"[1], Business Process Re-engineering (BPR) is defined as a "fundamental rethinking and radical redesign of business processes to achieve dramatic improvements...". As one step to respond to the fierce competition in Semiconductor industry, a major Package process in NS Malacca went through a re-structuring from function-based to product-based layout. In the original process structure, a product type

may be processed by any equipment in the functional area (Figure 1). Each functional area is responsible for the output, utilization and work-in-progress in its own area. In the re-designed structure, equipment for the similar product types which may be of different functions are grouped into cells. Each cell is responsible for the output, utilization and work-in-progress in its own cell (Figure 2).

Many advantages have been claimed for the product-based cellular layout[2]: i). Machine changeovers between batches are simplified, thereby increasing capacity; ii). Variability of tasks is reduced, and training periods for workers are shortened; iii). More direct routes through production allow faster shipment; iv). Parts spend less time waiting, in-process inventory is reduced; v). With less part variability, workers are more specifically trained, quality control is improved; vi). With more direct routes and with reduction of materials-handling, production planning and control are simpler; vii). As a result of reduced part variety and similarity of tooling within cells, automation of cells is much simplified.

On the other hand, the product-based cellular layout may have problems if not handled carefully. For example, some equipment may not be fully utilized if the demand for the product mix in a cell changes. Some lots may lose control when they are transported between cells in order to balance equipment utilization. To maximize the advantages and minimize the potential problems of the cellular structure, a simulation project was conducted prior to the re-structuring of the processes.

3. The Simulation Project

A barrier to the Business Process Re-engineering (BPR) is the uncertainty and risk involved in the radical re-design and re-structuring of the processes. Computer simulation, with its detailed information capture, dynamic analysis and graphical animation by a model, can accurately predict the process of future and greatly reduce risk.

The management in NS placed a lot of emphasis on the simulation project. Because it is a new technology, a careful and progressive approach was adopted as: i). Understanding the

technology; ii). Selecting the software system; iii) Training; iv). Study of the first Cell; v). Study of the inter-cell relationship.

The management attended seminars on computer simulation and sit in the demonstration by various vendors. After a series of internal discussions and meetings with vendors, it was decided that the selection of the simulation software be based on four broaden criteria:

- Meeting the application requirement
- User-friendly
- Common Platform, including the hardware requirement and software environment
- Local support, both the software and the simulation project

Vendors of several simulation software were invited to demonstrate the use of software by simulating the original process in the Plant. Through the exercise, it was better understood how simulation could be applied in the Plant, what could be delivered by simulation, and what would be the constraints. More confidence was gained. Furthermore, it helped understand whether the software product meet NS requirement, the user-friendliness, the platform requirement and the local support.

WITNESS, a visual interactive simulation software from AT&T ISTEEL, was selected as the tool after rating a number of software using the above criteria[3]. CIMTEK Pte Ltd, the sole distributor of WITNESS in South East Asia, was engaged to help carry out the project.

4. Study of the First Cell

All the re-designed cells are similar in layout, structure and material flow, it was decided to start with one cell for detailed study. The Industrial Engineers from NS together with the consultants from CIMTEK structured the data collection format. As simulation involved a more detailed study of the process performance than the conventional capacity planning, many equipment characteristics and product features were re-organised, some dug out from various documents and programs of automated machines.

Numerous simulation experiments were carried out for statistical analysis. Historical data was compared. Meetings with I.E. and production were used to further validate the results. Several presentations were organised at different stages of the project to management, I.E., Planning, Automation, Engineering, Production for model validation, improvement suggestions and recommendations. To illustrate the concepts, only the mean values of the results are used in this paper. The project had been focused on the following:

Performance Measurement and Bottleneck Identification. The first presentation was the simulation results of production performance of the original design. It was used to identify the bottlenecks and possible improvement. In a way, the presentation served as a validation of the simulation model. The results included:

- Cycle time and Throughputs
- Number of Lots Processed by Each Process (Figure 3)
- Average WIP before Each Process (Figure 4)
- Machine Utilization (Figure 5)
- Labour Utilization

A detailed distribution of the time that Testers, i.e. the bottleneck machines, spent was presented. This was to identify the potential for improving the bottleneck's capacity. As it can be seen from Figure 6, the setup has taken more than 20%, and it matched the real production's experience. Much of the effort in the simulation project was dedicated to the reduction of Testers' setup time.

Process Layout Assessment. Secondly, simulation was used to study the material flow efficiency with the proposed process layout. It was tackled in two aspects: i) whether there was any disproportionally long material transportation time. The results showed that, on average, operators spend less than 5% of their time on transporting material from one process to another; and ii) whether transportation would affect throughput and total cycle time significantly. The difference between the simulation results from the models with material transportation and those without considering the material transportation was negligible. It was concluded that the process layout was acceptable.

Product Releasing Strategy. Two strategies were simulated on product releasing: i). The number of device types to be released per day. Figure 7 shows the results of the weekly loading plans based on 3, 4, 5, 6 and 7 types of devices to be released per day. It can be seen that the throughput drops when number of device types per day is greater than five. ii). Impact of Releasing Frequency. In the above simulations it was assumed that units of one device is continuously released at the beginning of every day. Another scenario was studied on the assumption that the units of each device are proportionally split into three shifts, and the results showed that both the throughput and cycle time deteriorated significantly. It was decided to go for the device-by-device continuous releasing strategy.

Fig. 7. Product Releasing Strategy

Lot Size Analysis. This experiment studied the impact of changing the lot size. The results showed that a fixed lot size of 5K would lead to the maximum throughput, in contrary to the belief that a small lot size would result in the best performance. Having examined the assumptions carefully, it was noticed that operating procedures and set-up time were assumed to be constant for different lot size. It became clear that the fixed and small lot size policy would not increase the throughput automatically if not properly used. The small lot size must be implemented together with the re-design of operating procedures.

Impact of Splitting Lots. Splitting lot in the Assembly area was a practice derived from some special conditions in the corporate history. This experiment examined the impact of splitting lot on the overall performance. The results showed that whether splitting lots or not would not affect the total throughput. However, the cycle time could be reduced without splitting lots. This is because the set-up times at Assembly would be reduced and more capacity made available, which in turn would reduce WIP level in Assembly and therefore the cycle time. The benefits of splitting lots only become apparent when WIP is very low and machines are idling, which was not the case in actual production.

Analysis of Testing Operations. This experiment was to identify the best product mix at Testing, by studying the overall testing time required for different Tester loading strategies. Three scenarios were studied: i).The existing practice, assuming one lot split to more than one handler; ii). Lots are randomly hooked on the handlers, assuming no lot splitting; iii). The lot loading is controlled so that a device with long Electronic test time is tested in the same Tester system with a device with short Electronic test time. The results showed a slight improvement by mixing devices with long and short Electronic test time.

Maximum Capacity Of Testing Process. As the process bottleneck, the maximum capacity of Testers would serve as a boundary for management to decide on investment of other equipment. This experiment was to study the impact of Testing WIP on the total throughput. The study was conducted by pre-determining the buffer size in front of Testers, and then changing the pre-determined buffer sizes. It was assumed that the device loading follow the same pattern as actual production, and there is no bottleneck in Assembly. The results showed that the maximum throughput could be achieved, which is about 8% higher than the Performance Measurement, if 75 to 100 lots (equivalent to 1.5 to 2 days stock) are purposefully built up in front of the testing area (Figure 8).

Fig. 8. Maximum Capacity of Testing

5. Study of Inter-Cell Relationships

Having understood the detailed process flow in one cell, it was natural to further study the inter-cell relationships. Here the product features were categorised, and different grouping methods were studied by dozens of simulation experiments. The objective was to study the Device mix to load into each cell in order to maximize the overall throughput, utilization, and minimize WIP and cycle time. Then the Performance Measurement of all cells was reported, from which the bottleneck processes were identified. This was followed by establishing the capacity constraint for all cells. Details are as follows:

5.1 Device-Cell Relationship

Device-cell relationship refers to the guidelines on which Device types should be loaded into which cell. To achieve that, it was necessary to analyse the product features that affect manufacturing flow, which are as follows:

Testing Consideration. Each cell is associated with certain types of testing operation. The temperature setup is the most difficult, the first attempt was to assign device types to cells according to the testing temperature that the device requires, e.g. i). Devices that only require room temperature test; ii). Devices that require room and hot temperature, or room and cold temperature test; iii). Devices that require all room, hot and cold temperature test.

Handler Consideration. Each cell always uses certain types of handler. As handler is expensive and difficult to move and setup, the second attempt was to group those devices with the same requirement of handlers into the same cell.

Test Plate Consideration. Normally, lots of the same device type require the same type of test plate, a general rule was set as: The same device always goes to the same cell. For example, if one product goes to the 4th cell because of all three temperature test, then all others under the same device type would go to the 4th cell.

5.2 Performance Measurement

Similar to the study of the first cell, the results of throughput, cycle time, number of lots processed at each process, average WIP, machine utilisation and labour utilization were presented to various parties involved. From the results, it was identified that the most critical area was the functional area, where the capacity constraints (i.e. bottleneck machine) is the molding process. It was fully utilized all the time.

The second level of critical process of each cell were identified, such as the Testers at the 2nd and 3rd cell, Die Attach at the 2nd and 5th cell. The second level of critical process must be closely monitored, as their spare capacity is very small (<10%), any long machine stoppage would cause them to become major bottlenecks.

One way to relieve the workload of bottlenecks of one cell is to share the work with its neighbouring cells. In principle, it is possible to do so. In practice, however, this may cause problems in operational procedures (e.g. loose the ownership of a lot).

5.3 Capacity Constraints

With the existing equipment plan, expected releasing plan and device-cell relationship, the following constraints were established as the guidelines for Capacity Planning: Daily releasing volume per cell and Number of device types per cell to load daily.

For each cell, the quantity to load is further constrained by the standard testing capacity, i.e. the bottleneck operations. By experimenting the available quantities of the Testers, Handlers and Test Plates, the following guidelines were established: Daily capacity of each Tester type; daily capacity of each Handler type; and daily capacity of each Test plate.

To achieve the maximum output within the above constraint, it was recommended: i) Mix high volume devices with low volume devices for each cell; ii). Group the orders of the same device into one release over a time span of 2 - 3 days; iii). Balancing testing capacity requirement; vi). When the demand of high volume devices fluctuates, the device-cell relationship and capacity guidelines must be reviewed.

By studying the cell capacity in detail, it was suggested that certain processes be shared between cells and number of machines be reduced. The simulation helped identify a total of 5% reduction on the equipment investment for the proposed cellular layout.

5.4 Other Suggestions

In addition to the above simulation results, a number of suggestions were studied, and recommended to the management, they are:

Staggered break. Certain processes such as molding and Testers are almost fully utilised. To achieve the maximum throughput, it is necessary to introduce staggered break for operators at these processes in order to eliminate off-shift loss.

Control maximum and minimum buffer size. In order to control the total WIP on the line, the maximum WIP level in front of the bottleneck machines must be established; on the other hand, a minimum WIP must be built to cater for sudden machine stoppages before the bottleneck to prevent the bottleneck machine idling. This is a natural step leading towards Just-In-Time(JIT) Manufacturing.

Schedule bottleneck operations. Basically, two issues need to be addressed: i). Schedule the devices to be loaded into the assembly area to ensure that the constraints will be observed; ii). Schedule the bottlenecks in the functional area to ensure that they will evenly distribute their capacity on the cells.

6. Conclusions

Business Process Re-engineering (BPR) is about radical improvements with re-design and re-structuring of the existing processes. It promises solutions to many problems that may not be possible to tackle using the conventional methods. However, it is very risky. Simulation plays a vital role in forecasting the dynamic behaviour of the future process, stimulates ideas of improvement, identify potential problems, thus greatly reducing the risk.

Computer simulation is a decision support tool. The successful application of simulation technology in a manufacturing requires the management commitment. Like any other computer system, simulation is not a magic wand but an analysis tool. Many what-ifs can be answered, the conclusions, however, need to be reviewed as the conditions change. Simulation is a new technology in this region, it requires a constant driving force in a company to educate, organise, co-ordinate, and promote the applications.

References

- [1] Hammer, H. and J. Champy. 1994. "Reengineering the Corporation". Nicholas Brealey Publishing
- [2] Gaither, N. 1990. "Production and Operations Management - 4th ed". The Dryden Press
- [3] 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".