SIMULATION APPLICATION IN PRINTED CIRCUIT BOARD ASSEMBLY INDUSTRY

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ABSTRACT

Many publications have been concentrated on the theoretical issues of simulation and Laboratory cases. Instead, this paper reports the use of simulation in Flextronics (S) Pte Ltd, a PCB Assembly Plant, for the improvement of their production lines.

The simulation project described in this paper had been carried out since middle 1993 after the company purchased the WITNESS software. The simulated line is a high volume medical product running on a continuous flow Assembly and Test line. Because of some physical constraints, eg. labour shortage, insufficient production equipment, high Work-In-Progress, simulation was used to help identify the main causes of these problems, and evaluate alternative solutions so as to solve existing problems and make suggestions for factory improvement. Conclusion is drawn and experiences of the project are reported by the end of this paper.

OBJECTIVE

The main objective of the simulation project initiated in the middle of 1993 was to make productivity improvement through:

(a) Reduction in Manufacturing Cycle Time (lead time)
(b) Reduction in Work-In-Progress (WIP)
(c) Increase of total Output

EXISTING PRODUCTION CONDITION

The production line under study was setup early 1993, specially catering for the ramping up of the production volume. The initial plant capacity was 120K per month.

Due to the shortage of production operators, it was not able to run 3 full shifts for all the processes. Only critical equipment, such as SMT and Final Test can maintain 3-shift, because of their long processing times and high frequency of machine breakdown.

The PCBs in this production line is fed in a single-up panel. Hence, additional material handling on the loading and unloading of boards are required for certain processes, where more than one board are required by the fixture, such as the Manual Insertion, Wave Soldering, Screen Printing, etc.

The SMT (Top side) operation in the production line cannot actually cope with the scheduled production target within normal working days. This is mainly because of the long process cycle time and poor machine performance (high frequency of breakdown). As such, running overtime on weekends and getting help from another production line become inevitable. About 1/3 of the output for this operation is supported by the other production line, with 1,000 boards being transferred to the production line under study every morning.

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Material releasing pattern for this production line is rather straightforward and simple. The kitting is carried out every two days with a quantity of 15,000 pieces at one time; and it is normally done in the morning.

The Work-In-Progress level on the line is normally very high and causing storage problems, due to a virtually unlimited WIP accumulation. The problem is particularly prominent in front of stuffing stations and after Final Test stations; this is because of the different operating shifts.

MODELING OF PCB ASSEMBLY LINE BY USING WITNESS

In July 1993, Flextronics purchased AT&T Istel's WITNESS simulation software package. The improvement of the PCB Assembly line was selected as the first simulation project to start with. The simulation project was organised into the following phases:

(1) Data collection
(2) Model building
(3) Model validation
(4) Improvement on the factory floor

Data Collection

In order to have a reasonably accurate simulation of our factory floor operations, proper data and information are needed. The most important data are; (1) process cycle times, (2) product releasing pattern, (3) equipment breakdown, (4) equipment setup times.

Since the production plant only started its operations in May 93, we can only collect two months data for this simulation project. In Flextronics environment, the relevant equipment data include:

- Process cycle times
- Machine cleaning times
- MTBF: Mean Time Between Failure
- MTTR: Mean Time To Repair

In order to limit the work-in-process in between stations, we also estimated the buffer size in front of each work stations.

Model Building

Generally, the modelling of the production line is quite simple. However, due to the continuous changing of the actual production setup, lots of model modification are required. For example, initially, all operations are only running two shifts. Because of the increasing production schedule and insufficient equipment capacity, the final test stations runs 3 shifts after 3 months of production.

The interactive modeling environment in WITNESS made the modifications fast. One can build the base model easily with all the built-in elements and features. When the model gets

complicated, the Actions provided at each element enables flexible logic to be coded with statement like IF-ELSE in the same environment.

In order to gather sufficient information, we had to involve the manufacturing engineering, quality assurance and production personnel, together we described and quantified every activity. Through these meetings, we realised that the process of building a simulation model forces us to understand exactly what is going on in the factory. This piece of information can be very valuable and is one of the side benefits of a simulation project.

Model Validation

Two types of validation methods were engaged on completion of the model building: "black box" validation and "white box" validation.

In Black box validation, the model as well as the production were treated as black boxes. Only the results from the model and that from the production were compared, which include:

- Work-In-Progress
- Machine/Labour Utilization
- Total Output
- Manufacturing Cycle Time

The simulation results should match the actual operation favourably (eg. the difference between the two results of total output in a month was within 2%). If the results do not match, the model as well as the data and assumptions used for simulation had to be carefully checked and revised.

In White box validation, a team consisting the simulation mode builder, Engineering Manager, Quality Assurance Engineer, and Production Manager was formed. The simulation model was run in front of the production personnel with a strong working knowledge of the factory operation. Production people were requested to validate critical logic and what-if scenario step by step, and the performance of the simulated operation was quantified and compared against that of the actual operation. A simulation specialist, Dr George Sun from CIMTEK Pte Ltd, was invited to one of this meetings.

Improvement on the Factory Floor

Once the initial model validation was completed and recognised by Engineering and Production personnel, brainstorming session had been conducted to generate suggestions for the improvement of the factory floor.

Many suggestions were generated and the following are the main ideas that could improve the production line to meet our objectives.

	Target Objectives		
Suggestions	**RMCT**	**RWIP**	**IO**
(1) Running full 3-shift for all operations	X	X	X
(2) PCBs are fed in 4-up panel	X		X
(3) Establish std WIP size between stations	X	X	

(4) Regular pulling of materials from store, ie. smaller kit size	X	X	
(5) Not require support from another production floor	X	X	

Notes: RMCT - Reduction in Manufacturing Cycle Time (lead time)
RWIP - Reduction in Work-In-Progress (WIP)
IO - Increase of total Output

4-up Panel - With the introduction of 4-up panel PCB, a reduction of station process cycle time due to elimination of loading and unloading of unnecessary fixtures/mother boards can be achieved, and this will mark a significant improvement on the process run time. The new process cycle times based on 4-up panel are re-calculated by Engineering for the purpose of evaluation.

Material Kit Size - we used the hourly output based on the bottleneck cycle time as a guideline for the material kit size. Because it would be unreasonable to request store to open 3-shift a day, we assumed material kitting to be carried out from 7am to 5pm from Monday to Friday, and 7am to 3pm on Saturdays.

Since the material handler only works 10 hours a day, we set the material kit size at 700 pieces for hourly kitting.

Standard WIP Size in between Stations - It is not possible to identify the optimum value of the WIP level in one simulation run, because the standard WIP size may affect the total output and the inventory cost. Simulation experiments have to be carried out to evaluate the impact of different WIP levels. Based on experience, we selected two sets of standard WIP sizes for our experiments.

From simulation , the expected improvement are as follows:

- Reduction in WIP cost will be more than half a million Singapore Dollars
- Reduction of Manufacturing Cycle time by 5 days
- Increase in total capacity will be more than 70K

CONCLUSION

With manufacturing simulation, the evaluation of various improvement suggestion for production lines can be carried out quickly. Many critical decisions can be made with a minimum of risk, a well understanding of every party involved, and without disruption to plant operations.

A friendly and flexible simulation software and a strong technical support from the vendor is essential to the success of a simulation project. During the project, we encountered some modelling problems and the Helpdesk of WITNESS was prompt and efficient.

The application of manufacturing simulation requires a team effort. Personnel from Engineering, Quality Assurance, Planning, Store, and Production must participate in the model validation, improvement suggestion and evaluations. It assists the model validation, reaches a common understanding of production environment, helps participants gain confidence in implementing the improvement, and stimulates more ideas for further improvement.

Enough manpower must be dedicated to simulation, in particular the first project. A simulation project involves many departments, it is very time consuming to coordinate meetings. For a detailed model of the process flow, many existing Engineering data must be pulled in, and more accurate data must be updated and collected before a validate model can be built. As a decision support tool, the brainstorming sessions for Simulation analysis demands the understanding and commitment from all participants.

With more and more industrial application of the simulation technology in this part of the World, we sincerely would like to see more users to publish and share the success and frustrations of their experiences.

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