

Productivity Improvement in Semiconductor Subcontracting Company Using Simulation Modeling

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Abstract

The study aims to improve the existing production output of a semiconductor industry through simulation modeling. The study covers the front line process of back end semiconductor subcontracting firm. The focus is on the first step of the process which is the die attach. During observation, there were significant occurrences of unscheduled machine downtime which resulted in the interruption of production process. The machine downtimes were caused by man-machine interaction. The study shows that Frame Error in Input Bin and Frame Error in Output Bin in the die attach section contributes to the machine downtime. The simulation output revealed that there was an increase of throughput by 15, 600 production units per day, if the current situation of having an unscheduled machine downtime will be eliminated.

There should be an alarm for the machines when supplies were not refilled. The man-machine ratio must be reviewed to determine if the machine assignment per operator is efficient. Lastly, the layout of the section should be reviewed so that operator can better observe and monitor the many machines he is handling.

Keywords: Simulation Modelling, Die Attach Process, Semiconductor Process

1 INTRODUCTION

There is a strong presence of outsourcing as evident from the recent information of the database of a world leading provider of company profiles and country reports, which roughly estimated that there are 1,480 firms that engaged in outsourcing worldwide. Majority (i.e. 25%) of these firms are positioned as the highest earner at an annual revenue of 2,000 US\$M and above [1].

This phenomena was supported by the longitudinal study of Beugelsdijk,S., Pedersen,T., Petersen,B. (2009)over the two decades which indicates that the multinational companies continuously inclined to invest in several parts of the world especially in developing countries[2].This progression corroborates with the recent data about manufacturing outsourcing activities (also called contract manufacturing), in which in 2001, it was estimated to have worth \$120 billion and has been the fastest growing sector among manufacturing industries with a yearly growth rate of more than 80% between 1996 and 2000 [3].Hence, It becomes necessary to look into the manufacturing process of a subcontracting/outsourcing firm and improve their productivity in order to become more competitive

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2 PROCEDURES

Simulation is an appropriate quantitative tool that could generate several scenarios which can reflect the dynamic characteristic of an investigated system.Simulation is the “imitation of a real world process or system over time” [4]. The study use descriptive research that primarily relies on observation as a means of collecting data [5]. The study will also employ experimental research. Experimental research is defined as isolating and controlling the relevant conditions which determines the events investigated and identifies the effects when the conditions are manipulated[6].

3 RESULTS AND DISCUSSIONS

The study relies on direct observation as a means of collecting data. The study covers the front line process of back end semiconductor subcontracting firm. The focus is on the first step of the process which is the die attach.

The case study company is a subcontracting firm of a Multinational Companies that sells integrated circuits and electronic parts all over the world. The case study company conducts assembly and tests of various semiconductor products such as Radio Frequency Identification Device (RFID), Opto Modules, etc. with monthly capacity of up to 3 million units. The case study company is now in 3 decades of doing semiconductor business.

3.1 Die Attach Process Description

Die attach is the first process and is considered as critical since the downstream relies on the output of this process. The manufacturing plant. Cause and Effect Diagram in Die Attach Process the die attach working table.

The operator then fills empty magazines with 20 strips each. The operator will then loads two magazine in the loading bin of the die attach machine. Then machine will run to process the input part. The machine will automatically load the processed strips into empty magazines in the post process bin. The operator unloads the magazines with the processed part and takes one strip for inspection, which will take 25 seconds. If the sample parts are good, then the operator will transport it to the curing trolley. When 40 magazines (8 lots) have accumulated at the curing trolley, curing process is The direct observation of the manufacturing operation in the case study company was conducted for three consecutive days. Then after a week, another one day was spent for direct observation in the manufacturing process particularly the die attached section so as to validate the data gathered and the simulation results.

During the observation and as confirmed by the operators and supervisor there are downtimes of the die attach machines. Machine downtime is the time during which a machine cannot be operated because of breakdown. To be able to determine the causes of machine downtime a Pareto analysis was conducted.

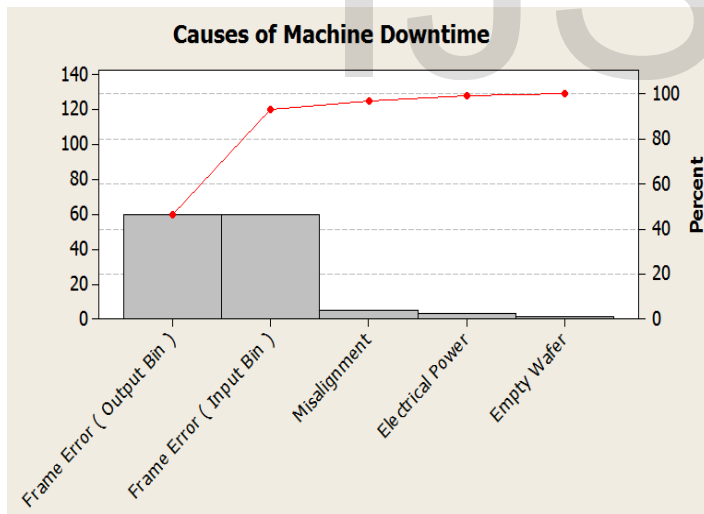


Figure 1 – Pareto Chart for Causes of Machine Downtime

The above figure shows the number of occurrences of the different causes of downtime based on direct observation. Frame error in Input Bin Magazine and Frame error in Output Bin Magazine contribute most to the problem of machine downtime in the die attach. In the 12 hours operation, there is usually 60 times occurrence of these machine downtime. The other causes of downtimes of the machines are misalignment, electrical problem, and empty wafer for the photo and integrated circuit pads but occurs in few times only.

The way in which the machine could stop running was because of the machine detects there is no frame in the input bin magazine. This means that it will stop running because the machine does not have input supply to be processed. And the cause of it is that operator did not refill/reload the input materials. In other words, the machines are usually down or idle when the operator is not able to load magazines or supply (i.e. frame error (input bin)). There is no alarm in the machine that operator could be informed about the need to refill again the frame. Hence, it leads to interruption of operations in the die attach. This occurs for about 60 times per shift (i.e. 12 hours). Every machine downtime in the loading part (i.e. frame supply error) could last on the average of .75 minutes with standard deviation of 0.54 mins.

Another instance when machine stops' running is when operator was not able to unload the processed parts which was cased in the magazine. It occurs 60 times as well in the 12 hours operation. Although machine has an alarm in the frame roller which is the unloading part of the machine, the downtime has an average of 0.62 minutes with standard deviation of 0.312 minutes. Furthermore, upon knowing the causes of machine downtime, the time to process each elemental activities in the die attach was gathered through time and motion study.

In Table 1, there are 6 elemental activities in the die attached. Instead of using an average time for the 10 cycle observations, the study used probability distribution to capture accurately the performance of the system. The 10 observed time of each element were inputted to the stat: fit which determines the appropriate probability distribution which will then inputted in the simulation model. It will be noted that element description no.7 and no.8 are the downtime of the machine which was discussed earlier.

3.2 Simulation Modeling

The processing time for each element description was collected from one lot or one batch. One lot is equivalent to one magazine. One magazine has 40 strips. One strip has 20 integrated circuits. The study was conducted for 3 days and another 1 day for the validation of the data gathered. The processing times which become the simulation syntax as shown table 1 were used in simulating the existing process. Figure 2 shows the simulation model of the existing process in die attach section. The result of the simulation was shown in table 2. Two scenarios were applied in the simulation model, scenario 1 is the existing process which includes the observed machine downtimes. Scenario 2 in the simulation model does not include machine downtimes (i.e. frame error (input bin) and frame error (Output Bin)).

Table 1 - Existing Process in Die Attach with time study

No.	Element Description	Simulation Syntax	Remarks
1	Loading of magazines(photos)	WAIT n(0.12, 0.0283279) min	Operative Working
2	Attaching of photos	WAIT 5.46 min	Machine working
3	Inspection of incoming Ics	WAIT n(0.3165, .0176840)	Operative Working
3	Loading of magazines(IC)	WAIT n(0.366, 0.0602833)min	Operative Working
4	Attaching of IC	WAIT 5.29 min	Machine working
5	Change magazine, fill up travel card,put code and locks	Move for n(.064133,0.0900190) min	Operative Working
6	Put magazine to trolley	Move for n(0.150667,.0290508)min	Operative Working
7	Frame Error(Input Bin Magazine)	Wait n(0.75 , 0.554) min	Delay
8	FrameError(Output Bin Magazine)	Wait n(0.63 , 0.312) min	Delay

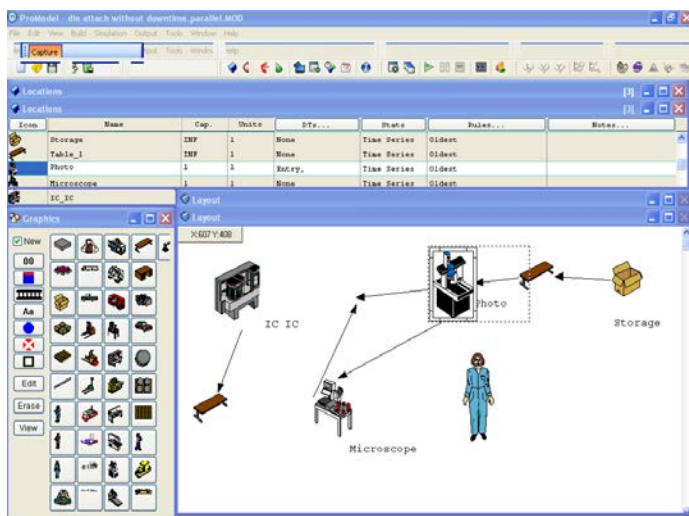


Figure 2 - Simulation model of the existing process in die attach

A simulation model was presented based on the process description of die attach. In order to transform the gath-

ered data into a simulation modeling 4 basic modeling construct takes place.

The first step is to identify the locations. This involves the presentation of machines, conveyors, workstations, etc. in the areas of investigation. In the case study company, two highly automated machines are involved which are one unit of Photo Machine, one unit of IC IC machine and other equipment such as one unit of microscope, one area for storage and one working table. One operator is assigned to work on this process. Table 2 is the simulation text for locations which also incorporates the observed machine downtime for the two machines.

The second step in simulation modeling is to identify the Entities. The entity in the model is named as raw materials.

The third step is to identify when the raw materials arrived. It was set to arrive every 5 minutes, meaning materials are assumed to be available in all time.

The Last step in simulation modelling is to identify the processes. This includes defining the routing of parts through the system and to specify what operations are performed for each part at each location. Table 3 shows the simulation text for Processing, the move logic was done by an operator. This is called resources. The simulation was run in 8 hours with 2 replications.

The simulation was also run by two scenarios. The first scenario is the existing conditions of the company which have an unscheduled downtime due to machine breakdown as discussed earlier. The second scenario is the proposed scenario where the unscheduled downtime should be eliminated.

Table 2 - Simulation text for Locations with observed Machine Downtime (Existing Scenario)

```

Time Units:           Minutes
Distance Units:      Feet

*****
*                      Locations                      *
*****

Name      Cap Units Stats      Rules      Cost
-----
Storage   INF 1      Time Series Oldest, ,
Table_1   INF 1      Time Series Oldest, ,
Photo     1 1      Time Series Oldest, , First
Microscope 1 1      Time Series Oldest, ,
IC_IC     1 1      Time Series Oldest, , First
Setup_table_2 INF 1      Time Series Oldest, ,

*****
*                      Clock downtimes for Locations          *
*****

Loc      Frequency  First Time  Priority  Scheduled Disable Logic
-----
Photo    1           1           99       No        No        WAIT n(0.75,0.554 ) min
IC_IC    1           1           99       No        No        WAIT n(0.63, .312) MIN
    
```

Table 3 – Simulation text for Processing

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*****
* Processing *
*****

Process Routing

Entity Location Operation Blk Output Destination Rule Move Logic
-----
Raw_Material Storage 1 Raw_Material Table_1 FIRST 1
Raw_Material Table_1 WAIT n(0.12, 0.0283279)min
1 Raw_Material Photo FIRST 1 MOVE WITH Operator THEN FREE

Raw_Material Photo WAIT 5.46 min 1 Raw_Material Microscope 0.830000 1 MOVE WITH Operator THEN FREE
Raw_Material IC_IC 0.970000 MOVE WITH Operator THEN FREE

Raw_Material Microscope WAIT n(0.3165, .0176840)
1 Raw_Material IC_IC FIRST 1 MOVE FOR .45 MIN

Raw_Material IC_IC WAIT 5.29 min 1 Raw_Material Setup_table_2 FIRST 1 MOVE WITH Operator THEN FREE
Raw_Material Setup_table_2 1 Raw_Material EXIT FIRST 1 MOVE FOR .22 MIN
    
```

3.3 Simulation Results

The results of simulation are seen in figure 3 and figure 4. Table 4 also summarizes the important performance measure of the process.



Figure 3 - Simulation Results in Scenario 1 (With machine downtime)

The existing process (Scenario 1) resulted to an output of 54.5 lots or magazines which are equivalent to 130,800 integrated circuits or production units per day (UPD) for die attach section. This simulation result provides a valid representation of the case study company because the resulted number of exits (or production output) falls within the current capacity of the case study company.

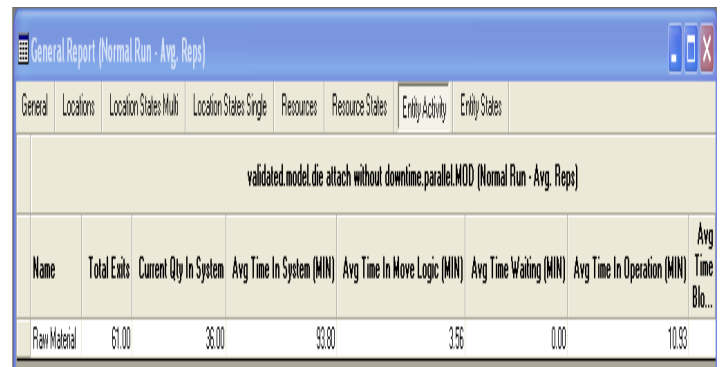


Figure 4 - Simulation Results in Scenario 2 (Without machine downtime)

Table 4 – Simulation model results with present and proposed scenarios

	Machine % operation	Total Exits	Equivalent UPD
Existing			
Photo	64.01	54.5	130800
IC IC	60.675		
Proposed			
Photo	71.7	61	146400
IC IC	68.095		
Difference		7.5	15600

Moreover, the machine percent operation or utilization for this scenario are 64.01 % for photo machines and 60.675 % machine operation in IC IC machine.

On the other hand, the proposed scenario (Scenario 2) where the unscheduled machine downtime was eliminated the output is 71.7 lots or equivalent to 146,400 integrated circuits or production units per day.

This resulted to an increase output by 15,600 production units per day. The machine percent operation or utilization are 71.7 % for Photo machine and 68.095% for IC IC machines. Clearly we could see that there is a significant difference in the production output if unscheduled downtime is eliminated. Even if it seems that the machine downtime caused by the operator not able to load and unload the magazines into the machine occurs in a very short span of time which has average of 30 seconds it still affects the production outputs and other productivity measurement such as machine utilization.

4 CONCLUSION

The machine downtimes were caused by man-machine interaction. The study shows that Frame Error in Input Bin and Frame Error in Output Bin in the die attach section contributes to the machine downtime. There is an increase of throughput by 15,600 production units per day if the current situation of having an unscheduled

machine downtime will be eliminated.

The study shows how simulation modeling provides opportunity to trace the causes of inefficiencies of the process and measure the production losses. Moreover, simulation has a feature that provides the use of probability distribution function of the processing time, which in effect provides a true representative of the performance of a system.

There should be an alarm for the machines when supply was not refilled. The man-machine ratio must be reviewed if the machine assignment per operator is efficient. Lastly, the layout of the section should be reviewed so that operator can better observe and monitor the many machines he is handling.

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