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A Study on Data Gathering based on Agent for APC in FA

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Abstract

This paper presents a data gathering for Advanced Process Control (APC) in FA (Factory Automation). It is important that the gathered data in FA to control all the processing, to be a predictive maintenance of equipments and manage products. We gathered the entire data of all in FA through Equipment Engineering System (EES) and analyzed that to control a processing, predict the next processing and manage the various things for the enhancement of productivity, overall equipment efficiency, product yield and quality. And we enabled APC to operate micro process control by gathering data from the process control system not only in the current process in real time but also in past process through back-tracking of products [1, 5]. So, we control micro process based on the acquired data using simulating functionality using APC. This simulation produces the outcome of the data analysis and the operation of micro process control that leads to reduce errors. The proposed the data gathering system based on agent brings an efficient management of micro process control in automated processing. It is optimized in the semi-conductor and the flat panel display (FPD) industry.

1. Introduction

It is need to manage the applications in factory automations that decision making, process control, predictive maintenance and managing of equipments and the various devices. It is very important that process control based on engineering data analysis (EDA) to be manufactured product in automated processing. Process control not only enhances productivity, product yield and quality but guarantees enterprise as well. Hence many enterprises used the method of Statistical Process Control (SPC) to reduce errors occurring in automated process. The process steps of SPC are as follows: first, it defines tolerance value based on measured value in past process per each process; second, they measure a product metrology when each process fulfills its own function; third, they compare the result of the measurement with the values defined in the first step; finally, they decide whether the process is acceptable or not—whether or not there are errors. If it is decided to be unacceptable, they rework from the beginning instead of moving into forward process.

Nowadays, such manufacturing process has been replaced with the Advanced Process Control (APC) system. APC is a Process Control System(PCS) such as run-to-run(R2R) control, fault detection(FD), fault classification(FC), fault prediction(FP), statistical process control(SPC), etc. [1]. The system provides automatic adjustment function of feed-forward, feed-back, and micro control data to reduce errors occurring in automated process control system.

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Our APC uses neural networks based on back-propagation to reduce errors. Back-propagation is learning algorithms based on 'Supervised Learning' used in multiplayer that needs 'Input value' and 'Output value' to optimize data. These algorithms produce 'Result' that not only calculates 'Input value' but also calculates and refreshes the weight of neural network to reduce proportional errors made a difference between 'Output value' and 'Result.' To support this APC, therefore, data should be gathered in real time. The metrological parameter's data occurred in past process should also be gathered. Data here means the entire data that is occurred in the whole process of product manufacturing [5]. The proposed data gathering system based on agent can gather the entire data in the whole process in real-time and result in an efficient management of APC by enabling APC to control automated processing. The system is optimized in the semi-conductor and FPD industries.

The structure of this paper is as follows: section 2 presents MES and EES, section 3 describes the data for gathering in EES, section 4 examines scenario and gathering data by agent, and analyzes gathered data and finally presents conclusion.

2. MES and EES

There is a manufacturing execution system (MES) that has collected data occurred in equipment. The data is large scale of binary raw data and is occurred in real-time. MES is used at companies to measure and control critical production activities. Other functions of MES solutions may include equipment tracking, product genealogy, labor tracking, inventory management, costing, electronic signature capture, defect and resolution monitoring, performance indicator monitoring and alarming and other various reporting solutions. It is, however, difficult to integrate data and use various applications that MES is dependent on equipment as shown in figure 1.

Consequently, many companies find a new paradigm that is effective for managing equipment, applying various applications based on the integration data on occurring in equipment. This is called Equipment Engineering System (EES) shown as figure 2. EES enhances productivity, product yield and quality all of which remove obstacle through gathering and analysis of status value in producing. This provides an integrated environment to develop and operate various applications. Especially this is optimized in semi-conductor and TFT/LCD industries because of the vast variety of equipment and application. The use of this system will increase the uptime and enable their combined performance to exceed that of a stand-alone tool [3, 4, 8].

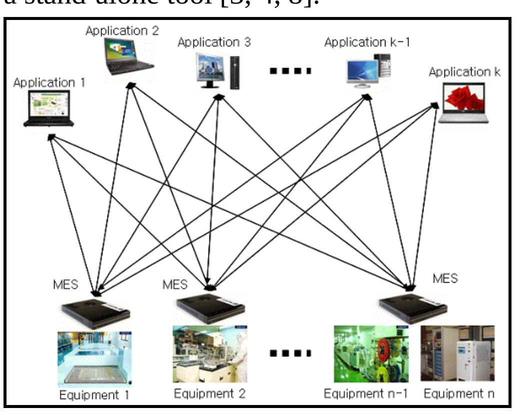

Figure 1: Infrastructure of manufactured engineering system (MES)

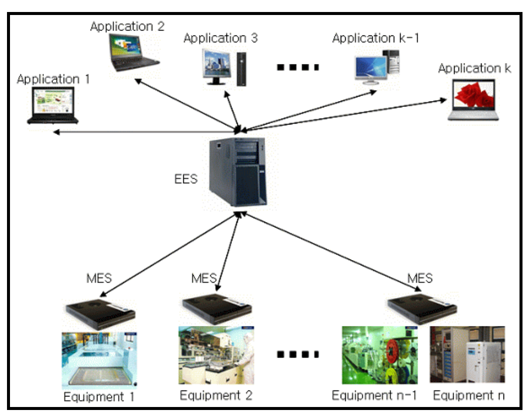

Figure 2: Infrastructure of equipment engineering system (EES)

EES serves the various applications which are a part of processing control, predictive maintenance, recipe management and others. It is important that analysis after gathering data on each equipment and processing through EES. APC on EES uses agent to gather the entire data of all processing, equipments and products.

3. Gathered Data by Agent in EES

The data gathering agent is based on the EES infrastructure. The agents gather data for simulation of APC. EES, a system concept, is intended to contribute to more efficient manufacturing, enabling closer collaboration between the equipment suppliers and device makers. That is composed of the components that are able to do fail-over, switch-over, logging and monitoring. And that uses the various interfaces of communication which are equipment interface such as SECS/GEM, EDA, TDI, etc and legacy interface such as TIB/RV, CORBA, JMS, COM/DCOM, between EES and equipments. EE data should directly describe equipment capability, activities such as process behavior [6].

There are many factors to have influence on productivity, overall equipment efficiency, product yield and quality. The list of factors is shown in table 1. Factors are classified into several categories. Location is the set of product in equipment and Thickness is the state of product thickness. Shape is the state of product shape. Energy is the state of given energy in equipment and Gas is the state of given gas in equipment. It is need that trace and analyze the relation of influence in occurred an error on processing of products. It has to overload all data of entire processing to find that. So we gather and analyze that data for reducing an error on processing used simulator based on neural networks.

Table 1: The lists of factors in equipments

Category	**Factor**	**Description**
Location	Offset	Over length from zero point
	Rotation	Over rotation angle from zero point
	Gradient	A gradient status to be lean on horizontal line
Thickness	Size	Over thick or under thin
	Flat	Flat status or rough status
Critical Dimension	Part Etch	Entire etch or a part etch
Shape	Dimension	2 dimension or 3 dimension
	Shape	Shape of product (circle, square, etc.)
Energy	Temperature	Given temperature
	Span	Span holding out temperature
Gas	Type	Type of injection gas in equipment
	Amount	Amount of gas
	Strength	Injection strength of gas
Etc.	Etc.	Etc.

Figure 2 shows the infrastructure of EES and the step of gathering data occurred in equipments. The gathered data is dispatched to application via EES. After it is processed and analyzed that data in each application, its results are transferred to EES. Then EES dispatches that to each MES.

The extracted data lists are as follows: Product Data, Process Data, Equipment Data and etc. shown in figure 3. That shows the relation of data items, the catalogue of all data gathered in whole process. That data include the parameter data which influences productivity, product yield and quality. There are five items that extract control parameters in EES. They exert influence on productivity, product yield and quality. There is a vast volume of data occurred in each process. Thus we have classified data into certain items by their relation to each other.

- ‘All Process’ is data occurring in the current process and equipment.
- ‘Ideal Parameter’ is a set of parameters that exert influence on productivity, product yield and quality, occurring in the current process and equipment.
- ‘Ideal Parameter Expand Data’ is a set of sum value ideal parameter’s and information of all the past process and equipment.
- ‘Metrological Parameter’ is a set of metrological parameters that exert influence on productivity, product yield and quality, occurring in all the past process and equipment.
- ‘Metrological Parameter Expand Data’ is a set of sum value metrological parameter’s and information of all the past process and equipment.

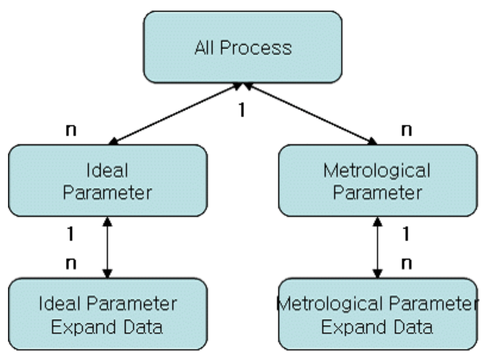

Figure 3: The relation of data items

The relation of ‘All Process’ with ‘Ideal Parameter’ and ‘Metrological Parameter’ is one to many. And the relation of ‘Ideal Parameter’ with ‘Ideal Parameter Expand Data’ is one to many and ‘Metrological Parameter’ with ‘Metrological Parameter Expand Data’ is one to many.

We brought the XML schema of gathered data by data gathering system based on that formula. Table 2 shows the XML schema of the gathered data by data gathering agent. This is based on pairs of processing and equipment, parameters of choice by processing engineers. Its functionality is described in terms of products as follows:

- A *product* is the name of product and ordering of the same product.
- A *processing* is a list of all the manufacturing process of products.

- A *process* is the information of processing in equipments.
- The *equipment* is the information of equipments on a processing of products.
- A *pType* is a type of parameter which engineers selected that of all parameters was occurred in the process. For example, *locationX* is the over length from zero X-point and *gasStrength* is the injection strength of gas.
- A *pValue* is a value type of parameters that 'ideal' is a input value in equipment before processing, 'metrological' is a measured value on inspector after processing and 'offset' is an error that metrological value is the difference of ideal value.
- A *trace* is a depth of past process that a product was processed.
- A *times* is the start time and end time of a process in equipments

Table 2: XML Schema of gathered data

```xml
<products>
  <product id="1" name="LOT001" >
    <processing id="1" >
      <process name="A1001" />
      <equipment name="GT101" />
      <parameters>
        <parameterID>
          <pType id="1" name="locationX" />

          <pType id="n" name="gasStrength" />
        </parameterID>
        <parameterValue>
          <pValue id="1" name="ideal" />
          <pValue id="2" name="metrological" />
          <pValue id="3" name="offset" />
          <pValue id="4" name="sumOffset" />
        </parameterValue>
      </parameters>
    </processing>
    <trace depth="2" />
    <times start="20070402093011" end="20070402094942" />
  </product>
</products>
```

So we could gather the entire data of all processing, products, equipments and devices by agents. And we analyzed that data for micro process control as follows: 1) Gathering the entire data in factory automation, 2) Computation the control limit (CL) value including an upper control limit (UCL) value and lower control limit (LCL), 3) Decision of the stability of process control, finally Analysis of the gathered data graph. On analyzing of the gathered data graph, we know the situation of processing and can control the processing for stability. It is classified the type of graph shown as figure 4 without others.

In the case of 'Run', we can assume the change of processing, engineer, product, setting value of equipment and so on. Second, in the case of 'Trend', we can know to be abraded a parts of equipment and changed the relative temperature and humidity. In the case of 'Cycle', we can assume an abnormal voltage of equipment on processing, the used different parts. And it may be merged the processes and have a physical and chemical phenomenon. Finally, in the case of 'Hugging the control limit', we can know the difference of material quality and managing recipes. So, we can manage the equipments, device, engineers, and control micro processing through analysis of graph.

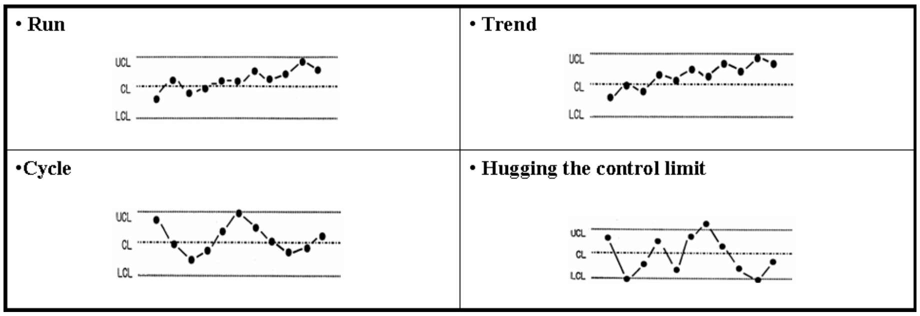

Figure 4: The type of analysis graph

4. Analysis of the Gathered Data

We have to do the steps to gather parameter data in real time. The first step is choice of parameter number and type, the second step is choice of equipment and process. The third step is decision of depth which of product's past process and the final step is decision of interval process's start time and end time. It can be schematized as follows.

$$Pn = \{ p_1, p_2, \cdots, p_{n-1}, p_n \},\ 1 \le n,\ Pn \text{ is a set of parameter number.}$$
$$Pt = \{ p_{t1}, p_{t2}, p_{t3} \},\ 1 \le t_i \le 3,\ Pt \text{ is a set of parameter type.}$$
$$S \text{ is paired process with equipment.}$$
$$D \text{ is a set of } S\text{'s parameter vlaue.}$$
$$Pn = \{ p_1, p_2, \cdots, p_{n-1}, p_n \},\ 1 \le n,$$
$$Pn \text{ is a set of parameter number.}$$
$$D = Pn * Pt \sum_{i=0}^{m} S^m \ (m \text{ is a depth of past process})$$

We gathered the validated data of all the selected parameters on entire processing during about 100 days in terms of 1st April to 12th July. It is the five item data of entire processing that figure 5 is shown in. Total of product's processing data is over 4 thousands, 'ideal parameters' data is over one millions and 'metrological parameters' data is over one hundred thousands. Figure 5, 6 and 7 are shown in the transition of which total amount of data on processing per one day.

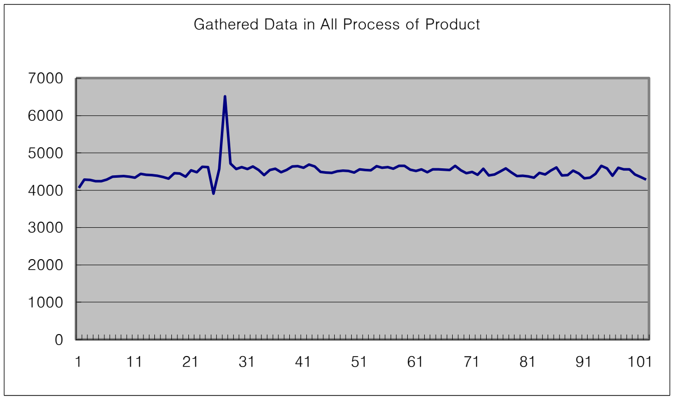

Figure 5: The gathered data on entire processing of product

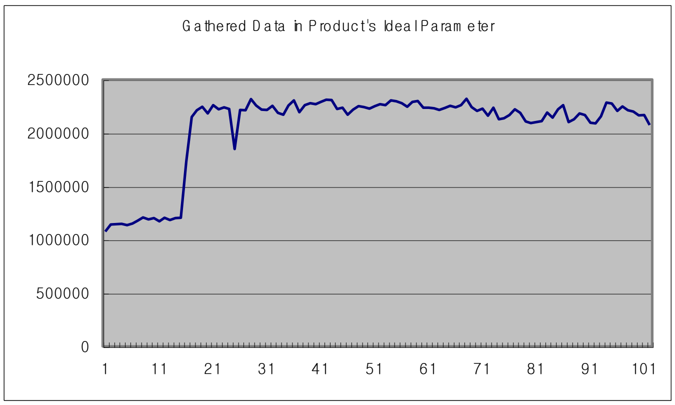

Figure 6: The gathered ideal parameter's data

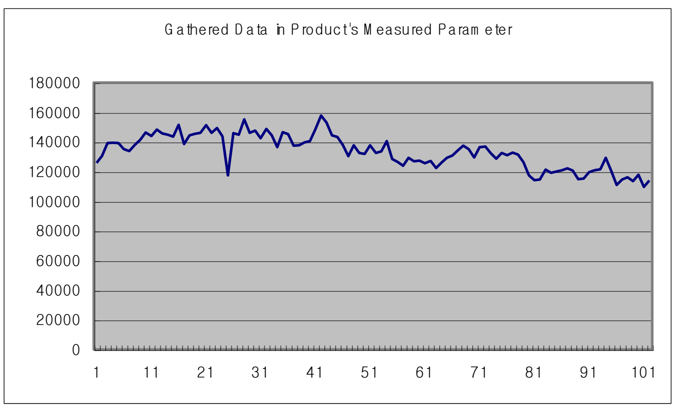

Figure 7: The gathered metrological parameter's data

Figure 5 is a graph of transition that an amount of total data in occurred on product's processing per 1 day. It came into being the drift line on 25th. We could know being of the something wrong on processing, so manage the processing and equipments to reduce an error. Then it was occurred reworks on processing because of an engineer's mistaking to manage the equipment. Figure 6 is a graph that 'ideal parameter' is gathered with a product's processing data. The extracted parameters data is based on the selected parameters by engineers as like table 1. The graph is shown to be made a sudden rising trendy on 15th and an even trendy after that. So we could know that engineer had applied the extended parameters related on productivity, yield and quality of products. Figure 7 is a graph that ‘metrological parameter’ is gathered with a product’s processing data. The ‘metrological parameter’ data is measured on the inspection instrument a sample within a product’s bundle on the same processing and in the same equipment. The graph is shown to be made easiness decent trendy. It was the error on a processing and in equipments continuously, but we knew that have done an effective micro control. We have omitted an analysis of the other data which are ‘ideal parameters expand data’ and ‘metrological parameters expand data’.

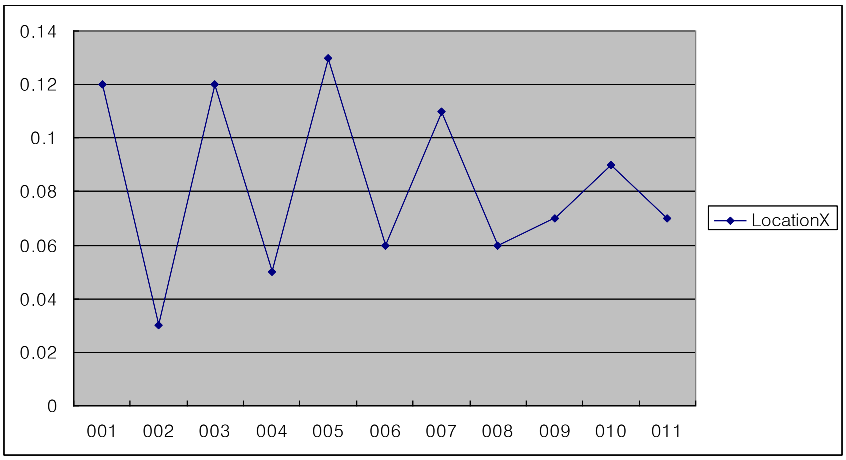

Figure 8: Trend (the analysis graph of gathered data)

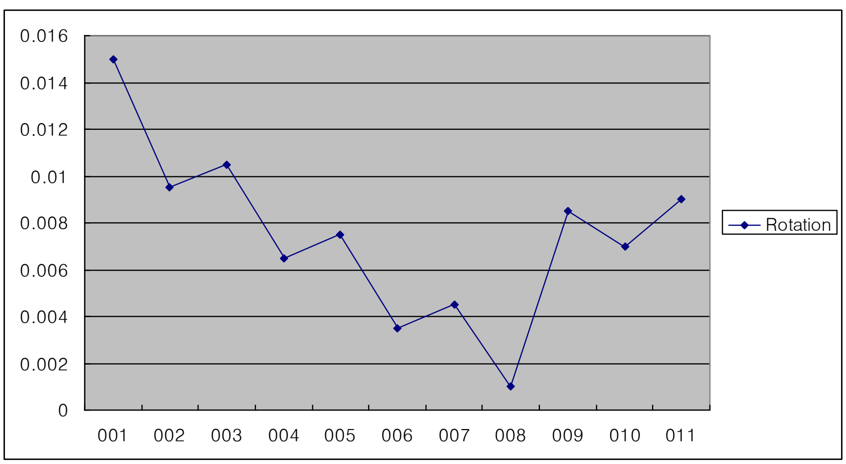

Figure 9: Hugging the control limit (the analysis graph of gathered data)

And we gathered the validated data of the selected parameters to control processing of Lots on an In-Line Equipment shown as figure 7, figure 8. It was gathered the sample data from ‘Lot001’ to ‘Lot011’ and their control limit values such as micro meter. It was ‘Trend’ graph through the analysis of the graph in figure 7 and ‘Hugging the control limit’ graph in figure 8. We know that the process was controlled on the processing of ‘Lot009’ for stability.

5. Conclusion

It is very important that process control to be manufactured product in automated process. That is increased productivity, yield and quality of product and guaranteed for enterprise. It is available for an effective managing to process control through reducing errors. So, to reduce errors on processing of product, it needs to gather and analyze the process data in real time and to predict and prevent an error on that. Therefore, this paper described the necessity of gathering data in real time in automated process, the data gathering system that gathered the process data and the methods to gather and analyze that data for simulation. Especially this paper presented that system is active on APC in automated process of semi-conductor industry or FPD industries and brought to reduce errors in micro process control. The gathered data in real process are classified according to crucial factors are influence on the productivity, overall equipment efficiency, yield and quality of products and gathered based on parameters are selected by engineers. In future work, it need to study of analyzing that data of itself, predicting errors in occurred on processing and preventing an error based on the prediction.

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