UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

TRANSFORMATION OF CONVENTIONAL WAFER DEFECT DISPOSITION SYSTEM INTO WEB BASED APPLICATION TO IMPROVE MANUFACTURING PERFORMANCE

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TRANSFORMATION OF CONVENTIONAL WAFER DEFECT DISPOSITION SYSTEM INTO WEB BASE APPLICATION TO IMPROVE MANUFACTURING PERFORMANCE

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in fulfillment of the requirements for the degree of Master of Science
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DECLARATION

I declare that this thesis entitle "Transformation of the Conventional Wafer Defect Disposition System into Web Based Application to improve Manufacturing Performance" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : NARISHAH MOHAMED SALLEH

Date : 25TH JULY 2013

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Master of Manufacturing (Manufacturing System Engineering). The member of supervisory committee is as follow:

Supervisor

DEDICATION

I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving husband, Ahmad Khalid for the support and encouragement, love and cares. Not to forget to my sisters: Nurul Salini and Nor Asikin for the support and assistance with all the household chores in the entire years and assisting my kids at every angle.

I also dedicate this dissertation to my many friends and my colleagues who have supported me throughout the process. I will always appreciate for what have they done, especially my study partner, Puan Zainila for being the motivator to continue with the thesis.

I dedicate this work and give special thanks to my best friend and also my husband Ahmad Khalid,
my wonderful and adorable kids Syafiq and Shasha for being such understanding persons throughout the
entire master program. Both of you have been my best cheerleaders and supporters.

ABSTRACT

Material flow in complex manufacturing environment which consist of few hundred steps is highly dependent on effective information flow. Information flow interruption may impact business operations efficiency that caused higher product lead time and poor product quality performance. High dependence of human intervention to process and transfer the data will lead to late detections of the issues and high product lead time due to inefficient of response process. The objective of the study is to develop an interactive and systematic web based applications which transformed from complex and tedious desktop application system. Web base Information System through integrating data mining with knowledgebase approach is proposed for the automation purpose. The research will be carried out at CDSEM OFF-LINE Station at Penang Seagate Slider Factory. The system will be developed using online Penang Seagate Factory Information System facilities (FIS) with the ORACLE Data Mining and Knowledgebase principles. Experimental approach is developed based on Pre-Test and Post-Test principle to investigate its relative gain to the organization. The result had shown a significant impact with 50% reduction in disposition cycle time, real-time data update and 60% improvement in resources efficiency. Further improvement should be focused to improve the web based features to make the system more efficient in terms of data analysis user friendly functions by expanding the query functions. Integration of the system with the Quality Containment Web system should further evaluated to eliminate human intervention to ensure early containment.

ABSTRAK

Aliran bahan dalam persekitaran pembuatan kompleks yang terdiri daripada beberapa ratus langkah-langkah yang sangat bergantung kepada aliran maklumat yang berkesan. Gangguan aliran maklumat boleh memberi kesan kepada kecekapan operasi perniagaan yang menyebabkan higher product lead time dan kualiti produk yang semakin menurun. Pergantungan yang tinggi kepada campur tangan manusia untuk memproses dan memindahkan data akan membawa kepada pengesanan lewat bagi setiap isu-isu dan meninggikan masa penghantaran kepada pembeli kerana ketidakcekapan dalam memberikan tindak balas. Objektif kajian ini adalah untuk membangunkan aplikasi berasaskan web, yang interaktif dan sistematik yang mengubah sistem aplikasi komputer yang kompleks dan membosankan. Sistem maklumat berasaskan web, melalui pengintegrasian perlombongan data dengan pendekatan pengetahuan adalah dicadangkan untuk tujuan automasi. Kajian ini akan dijalankan di CDSEM OFF-LINE proses di Seagate, Pulau Pinang. Sistem ini akan dibangunkan dengan menggunakan kemudahan system maklumat Seagate (Penang Seagate Factory Information System facilities - FIS) dengan ORACLE Data Mining dan prinsip Pengetahuan (Knowledgebase Rules). Pendekatan eksperimen, iaitu prinsip Ujian Pra dan Pasca digunakan untuk mengkaji keuntungan relatif kepada organisasi. Hasil kajian menunjukkan peningkatan ketara dengan pengurangan 50% dalam masa kitaran pelupusan, kemaskini data dalam masa sebenar dan peningkatan 60% dalam kecekapan sumber. Penambahbaikan perlu diberi tumpuan untuk meningkatkan ciri-ciri berasaskan web untuk menjadikan sistem lebih cekap dari segi analisis data yang mesra pengguna dengan mengembangkan fungsi mengakses informasi secara lebih holistik. Integrasi sistem ini dengan system Quality Containment Web harus dinilai untuk menghapuskan campur tangan manusia untuk memastikan kawalan awal.

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CHAPTER 1

INTRODUCTION

Most of the industries automation today is shifting towards information system integration. This is due to large amount of information that rapidly growing over the time and most processes is highly dependent on the information obtained to proceed to next actions. It becomes a big challenge when analysis of data is highly depending on human resources to perform data mining and to transfer the information from one system to other system to ensure no interruptions in material flow.

Valuable man hours are also lost between analyzing and transferring the required data. Not to mention about the errors generated from the report and the longer hours to had to spend to convert data from one format to other format before it became valuable information. Many industries are moving towards data automation through information integration due to constraints of skilled workers. This is to avoid mistakes done by human which cause poor quality of data, improve information flow by reducing the processing time of data analysis, reduction of product lead time and improve quality performance that caused by late detection.

Information integration is a collection of technologies that combines database management systems, web services, replication, federated systems, and warehousing functions into a common platform. It also includes a variety of programming interfaces and data models. Using information integration technology, diverse types of data either structured, unstructured or semi-structured can be transformed into different type of format

that provides easy access to information across the business functions through information integration with the following functions:

a. Provides real-time read and write access
b. Transforms data for business analysis and data interchange
c. Manages data placement for performance, currency, and availability

There are many ways how to automate data integration to ease information flow in manufacturing system. This has intensified with the development of information and communication technologies (ICT), the Internet and World Wide Web (WWW) to overcome the ever-increasing complexity of the systems between supplier and assembly relationship (Gunasekarana and Ngai, 2004).

The aim of this research is to develop a Web Information System to facilitate information sharing between various parties that are dispersed at different geographical locations and to achieve simultaneous data accessing and processing. CDSEM-WIS system can be defined as an application that not only disseminates information, but also proactively interacts with the user to aid to complete the tasks.

Since we are operating in information and automation intensive world, there is a need for knowledge workers to contribute to the value-adding activities in advanced organization. Kusiak (2000) described that knowledgebase system approach begins with knowledge and capabilities of the experts which able to solve the problems by using subjective and heuristic method. Knowledgebase is the representation of knowledge from the experts by means of different technics. This research will focus more on the production rules as one of the key for knowledgebase representation approach.

The Production rules consists of computational model implements the notion of a set of rules, where each rule has a condition and a consequential action. The system runs the rules on the data through a series of cycles where each cycle identifying the rules

whose conditions match, then executes the rules' actions. Development of production rules like **IF-Then** rules is to coordinate actions for integrations purpose from input and output of one system to another system which will improve information flow in the entire system architecture.

1.1 Motivation

The problem started in June 2012 where customer in Thailand reported high functional failures due to wafer defects which demanded corrective actions from Seagate Penang team. The customer weekly data also observed increasing trend in escapee rate. This leads to poor quality costs as the parts need to be scrapped or shipped back from customer site to perform screening. Not only that, an increasing trend of parts waiting time at store room had delayed shipment delivery and causing upside in the production schedules.

Next section will provide in detail what are the main factors contributed to the issues. Firstly, to briefly describe the procedures of the affected process such as what is the process objective, what are the key metrics in the process itself. Secondly, is to analyze problem identification by understanding and defining gaps within the process through a process mapping.

1.2 What is CDSEM Off-line Disposition System?

CDSEM is an equipment to capture high magnification images of slider writer pole area. This system is storing all high magnification images which already screened by the operators from earlier process. It contained both good and bad images of transducers. Bad images are known as wafer defects. Wafer defects are the abnormalities observed at the slider transducer pole region such as void, corrosion, layer separations and exposed carbon

materials. Type of wafer defects are referring to Material Disposition Agreement Guideline Rev 10 (MDA) which categorized into High Risk, Medium Risk and Low Risk defective mode categories depending on the severity towards drive functional failures. Each failed wafers need to be contained and hold for experts to do failure analysis and finalize the disposition through a lengthy discussion. Figure 1.1 shows an example of wafer defects which captured at different magnification.

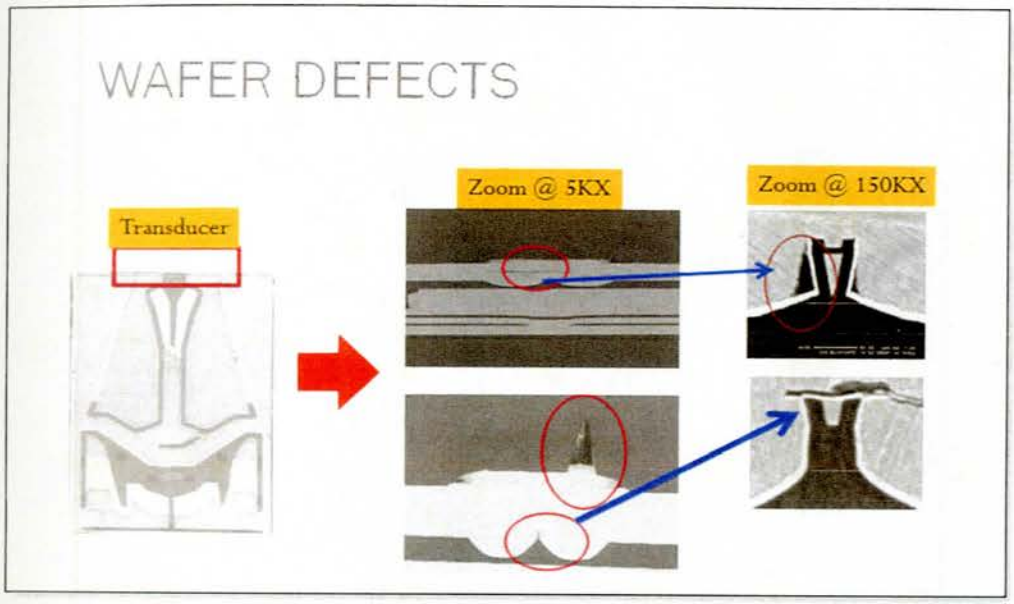

Figure 1.1 Transducers with different mode of wafer defects
(Source: Seagate Wafer MDA Guideline Rev 10, 2011)

Wafer defects are originated from wafer supplier and current Final gate wafer processes are not capable to screen the wafer defects due to its design complexity and high cost. Thus, it leverages from slider equipment in Seagate Penang to do screening and disposition.

Lab analysts have to perform wafer defects analysis procedures to convert raw data into descriptive statistical summary, such as overall quantity inspected and failure rates. Lab personals have to perform data conversion using converter software to convert images

format into valuable text file data. These data will be copied into Wafer Mapping software to perform wafer mapping analysis. This is to view the distribution of defective heads located on each wafer as displays in Figure 1.2. Green colors mean good heads and other colors are failed heads which categorized by defect mode risk. This is important for wafer process engineering team to identify which possible wafer process contributed to the mode of failures.

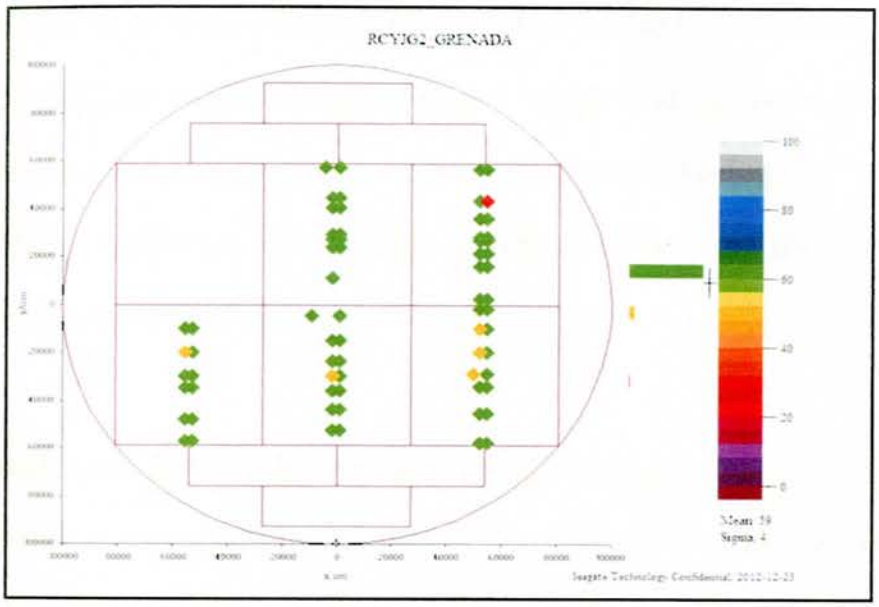

Figure 1.2 Wafer Mapping Analysis Chart
(Source: Penang Seagate Wafer Mapping manual, 2011)

1.3 **Root cause of the problems**

Root causes of the problems are identified through the application of USA principle developed by Mikell (2001). USA principle stands for Understand, Simplify and Automate the process and procedure. He suggested that understanding the process workflow is vital to identify weaknesses of the entire system. Kuang (2006) used process flow diagram to identify discontinuity in the information integration between data transformation and

storage database system. The scenario agreed by John (2009) where he constructed process workflow to visualize the implicit knowledge of the entire system situation.

Thus, constructing a flow diagram of current situation helped to evaluate the significant factors contributes in the information interruptions. Appendix A displays the process flow diagram. Analyzing the process flow had come to conclusion that there were three main factors contributed to high escapee rate and longer disposition cycle time which summarized below:

a. Complex and tedious processing steps which lead to late detection capability
b. Non-effective communication system which lead to longer response time between wafer supplier team and fabrication team in Penang.
c. Highly dependence on human to perform every steps of the process lead to resources inefficiency.

1.3.1 Complex and Tedious Processing Steps

Appendix A displays the overall flow of the entire system. The process starts from the input data which need to be retrieved from CDSEM Offline Software. These raw data has to be processed to filter defective images and uploaded into local server. The operators then notified lab personnel through email or personal paper notes. The challenge of today situation is the large amount of data that need to be processed by the team which long hours has to spend at each step in order to complete a cycle of task. Since the analysis is highly dependent on human intervention, high probability of late detection occurred which lead to defect escapees. The process continues with human interactions to upload relevant images into information database storage. Later, individual emails will be sent to respective product engineer and wafer quality engineer to communicate the information and requesting for feedback. Then, the analysts have to log into Local Quality Containment

system to block the wafers from shipping to customers. At the same time, the analyst also has to log into failure analysis database to perform FESEM test for the affected failed material. All above process is highly dependent of human interactions to process, to inform and to transfer from one system to other system.

1.3.2 Non-effective Communication System

Current communication system is considered not effective because of the limited capability of conventional database system to store all the information. Images are downloaded into database manually and also with limited space. Users have to download all the images into other type software applications which definitely take longer time in processing and analyzing the failure trend. The navigation features in conventional database which based on Lotus Notes applications were not user friendly which each type of images needs to be downloaded to local drives to perform diagnostic analysis.

The information of the response between the parties was done through email only where distributions are limited. Sometimes, the chain of the entire email was broken up where the information is missing along the communication line. This leads to longer response time between wafer supplier and Slider manufacturing team that impact the production schedules. The information is transferred back and forth between the team to drill down to detail information.

The other significant issue with the conventional database is, the chain of information is not traceable and not visible to the ground floor team too. The production floor team do not know the status of each material, thus blindly sampled the parts for other testing which lead to over rejection or under rejection of the materials. .

1.3.3 Resources Inefficiency

Tedious and complex process flow couples with conventional database system had led to resources constraint. Resources constraint is divided into equipment and operators. Analysis revealed that FESEM machine was overloaded with so many parts of wafer defects for failure analysis confirmation. Due to process complexity, operators' utilization are poor and inefficient. This is because every process steps are highly dependence on human to process, to retrieve the information and to enable communication between different parties. Each wafer failures will be retrieved manually and analyzed by operators to populate the failure rate.

Thus human interactions to process the large amount of data and to transfer information from one system to another system are no longer reasonable which not only cause delay in the entire system but also impact the quality of data. This is because human are pruned to errors and mistakes that may cause redundant in generating the report. Automating the procedure using computational intelligence is highly recommended to maximize the utilization of resources and to avoid waste of non- valued added activities.

1.4 Research Questions

In this dissertation, three specific research questions are raised related to the methodological approach and its approach of meeting the objective of the research in solving the issues. Those research questions are:

i. Will development of an online ORACLE data mining improve detection capability?
ii. Will production schedules improve through development of web base information system?
iii. Will implementation of web based application system maximize resources utilization?