SUSTAINABILITY OF ZERO CONTAMINATION DEFECTS INCOMING QUALITY INSPECTION: A CASE STUDY OF AUTOMATED OPTICAL VISUAL INSPECTION

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A thesis submitted
in fulfillment of the requirements for the degree of Master Manufacturing System Engineering

Faculty of Manufacturing Engineering

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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:

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DEDICATION

For my beloved father, mother & siblings, thank you for all the support and patience.

ABSTRACT

Company-X launched the 'Non Incoming Inspection' in the year 2000 and has been practising it ever since. However, this practice has led to the quality issues that revolve around PART-A components. Data show that nearly 20,000 defective parts were recorded. In view of this fact, this study aims to achieve the following two objectives; i) to identify which product has the highest DPPM, ii) to verify the effectiveness of the automated visual inspection system that was implemented at the component supplier's factory. One of the best approaches to address this situation is by using the automatic visual inspection machine. Images are segregated by the supplier to identify defective parts. Data collected such as the 'automated vision inspection yield', 'outgoing inspection (OGI)– DPPM', 'lot acceptance rate (LAR) and 'Company-XY incoming quality assurance (IQA)–DPPM' determine the outcome of this study. The system's effectiveness is evaluated by testing 200 units at the first lot and 2,000 units at the second lot. The first step is to analyse available data. The results show that the supplier for F component, a 2.5" product and Model B, show the highest value of DPPM; hence, they were chosen for further analysis in this study. The following results reveal a large number of defects, with a record of 6,075 DPPM in the 4^{th} quarter, 10,000 DPPM for the first lot and 8,000 DPPM for the second lot. This is due to foreign objects in the product, such as polyethylene terephthalate (PET), pieces of aluminium and pieces of polyether kethone (PEEK). Results show materials received at Company-XY is still at an unsatisfactory level and the automated vision inspection system is less effective. This is due to certain factors, especially in the packaging process area. Studies have shown that the automatic visual inspection machine does not guarantee 'zero defect'. Some limitation and suggestions are presented towards the end of the last chapter to mitigate this issue. Further research needs to be done on the ways to use PET and proper steps to clean 'trays' to remove foreign materials such as aluminium and PEEK.

ABSTRAK

Company-X telah melaksanakan 'Non Incoming Inspection' semenjak tahun 2000 lagi. Kini, dengan menpraktikan 'Non Incoming Inspection' terdapat masalah kualiti yang melibatkan pencemaran kepada komponen PART A. Data analsis menunjukkan bahawa 20,000 nilai Defect Part Per Million (DPPM) telah direkodkan. Selaras terhadap permasalah ini, dua objektif telah ditetapkan di dalam kajian iaitu: i) mengenalpasti produk yang mempunyai nilai DPPM yang tertinggi ii) penilaian keberkesanan 'Automated Vision Inspection' sistem yang di implementasikan di kilang pembekal komponen. Tujuan utama projek ini dijalankan adalah untuk mengurangkan nilai DPPM kecacatan produk di bahagian kemasukan komponen di Company-X (M) Sdn Bhd. Di antara pendekatan popular yang di gunakan bagi menyelesaikan permasalahan sebegini adalah dengan penggunaan mesin pemerhatian visual secara automatik. Kaedah pembahagian imej secara segmentasi telah dipilih oleh pembekal untuk mengenalpasti bentuk-bentuk pencemaran dan kecacatan. Data-data yang diperolehi daripada kajian ini seperti 'automated vision inspection yield', 'Out Going Inspection (OGI) - DPPM', 'Lot Acceptance Rate (LAR)' dan juga 'Company-XY incoming Quality Assurance (IQA) - DPPM' yang menjadi penilaian untuk kajian ini. Kajian keberkesanan system ini dinilai melalui dua lot awalan yang telah diatur iaitu 200 unit untuk lot pertama dan 2000 unit untuk lot yang ke dua. Langkah pertama adalah menganalisa data yang sedia ada. Keputusan daripada data analysis menunjukkan bahawa pembekal komponen F, Produk 2.5" dan juga Model B merekodkan nilai DPPM yang tertinggi dan telah dipilih untuk terlibat di dalam kajian ini. Seterusnya hasil keputusan daripada langkah yang kedua mendapati nilai kecacatan yang direkodkan adalah sebanyak 6,075 DPPM untuk suku ke-4, 10,000 DPPM untuk lot pertama dan 8,000 DPPM untuk lot yang ke dua. Antara jenis pencemaran yang telah dijumpai berpunca dari bahan seperti Polyethylene Terephthalate (PET), serpihan aluminium dan serpihan Polyether Ketone (PEEK). Penilaian keputusan terhadap keberkesanan system tersebut di bahagian penerimaan bahan Company-XY adalah berada di tahap yang tidak efektif kerana kedua-dua lot awalan mencatatkan nilai tahap keberkesanan yang rendah. Ini adalah di sebabkan oleh beberapa faktor yang melibatkan proses akhir terutama sekali di bahagian pembungkusan pembekal. Kesimpulan kajian ini mendapati, pengunaan mesin pemerhatian visual secara automatik tidak dapat memberikan jaminan 'zero defect' untuk pemeriksaan kemasukan komponen. Beberapa cadangan telah disyorkan di akhir bab bagi lanjutan penambahbaikan terhadap permasalah pencemaran ini. Cadangan kajian lanjutan lain adalah kepada bahan plastik PET yang digunakan, tatacara pengendalian serta prosedur pembersihan 'tray', serpihan daripada bahan alumunium dan PEEK.

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ADMS	-	Automated Data Monitoring System
ANN	-	Artificial Neural Network
AVI	-	Automated Vision Inspection
CPK	-	Process Capability
CTF	-	Critical Tool Functioning
DPPM	-	Defect Part Per Million
FIPG	-	Form in Place Gasket
IQA	-	Incoming Quality Assurance
LAR	-	Lot Acceptance Rate.
MIL-STD	-	Military Standard
OQA	-	Outgoing Quality Assurance
POU	-	Point of Use
PQE	-	Product Quality Engineering
QC	-	Quality Control
SQE	-	Supplier Quality Engineering
SVM	-	Support Vector Machine
TCTF	-	Tooling Critical Tool Functioning
TP	-	Through Positioning
VMI	-	Visual Measurement Inspection

CHAPTER 1

INTRODUCTION

This chapter covers project background, problem statement, objective, scope and the thesis outline. The project background will be described in Company-XY nature of business and in the project's overview. Problem statement has been clarified to define the objective and scope of this project.

1.1 Background

Company-XY is a leader of the Hard Disk manufacturing industry in the world. Customer satisfaction is the main focus for 's management. Company-XY needs to ensure suppliers continuously deliver the goods and quality products all the times. Due to competitive wages charges in Malaysia, under steps to ensure quality delivered, Company-XY made a deliberate effort to emphasize the quality inspection responsibility of the suppliers. This also improved reaction time. The cleanliness sustainability of the incoming material became one of the parameter to improve and thus the target of zero incoming defect was introduced.

Failure to comply with the cleanliness procedure causes quality issues on the drive. Contamination continues to be a main consideration for the hard disk industry and it has become more challenging. Contaminants effects the hard disk product quality in several ways such as the read and write of the heads and space separated between the layers of the media which is only at five micro inches or can be lesser. The idea to use auto vision inspection machine at supplier stage is to help by eliminating or to reduce the number of

overlooking issues by manual inspection activities (Vision Manual Inspection or VMI). There are several studies on how the effectiveness of the auto vision machine has been implemented by various types of industries, in the hopes towards reducing the number of contamination rejection in Company-XY.

1.1.1 Material Defects

For years, the issue on material defects found in production assembly lines had caused major line interruptions, time loss and setback on total output. A study on ways to improve defects and deliver to customers has been studied by Company-XY to their 1st tier customers. During the initial start-up process, Company-XY has worked with one of the PART-A supplier to verify the effectiveness of Automated Optical Inspection. Supplier Defect Part Per Million (DPPM) was one of the parameter that synchronized with Company-XY's '*incoming workstation yield and fallout pareto*', '*supplier outgoing inspection data'* and '*Company-XY incoming inspection data*'. Other parameters were '*supplier inspection data*' and '*Company-XY production line fallout data*'.

1.1.2 Monitoring System

Company-XY had developed a system to monitor the incoming material since the beginning of their business. Since there was no incoming inspection enforced in the year 2000, all logistic activities were controlled by the suppliers. Since then, a Supplier Quality Engineering (SQE) department had been formed and a system was created to monitor supplier mechanical performance which was known as Automated Data Monitoring System (ADMS). ADMS was solely created for the purpose to monitor critical parameters such as Process Capability value (CPK), Critical to Function (CTF), Tooling Critical to Function (TCTF) & Through Positioning (TP) and also to monitor the cleanliness in each

component. This was also used as a medium to continuously monitor supplier's data. The compilation and proper analysis from these data has helped to monitor the performance and effectiveness of the automated vision inspection.

1.2 Problem Statements

Company-XY has been practicing a non-incoming material inspection since the year 2000. The core of the drive manufacturing is the 'base' which consists of 60% of the assembly material. The wider surface of the material exposes the material's defective part especially due to material handling. There are two major problems resulted from the current method of non-incoming inspection:

a. **Higher DPPM for PART-A at incoming inspection.**

   Weekly QC incoming inspection data sampling showed inconsistency of DPPM performance due to contamination. The reported DPPM has reached above 20,000.

b. **Foreign Material and Contamination Issue**

   The top pareto is mainly due to contamination foreign material issue. Different types of contamination defects cause by fibres, foreign materials, human skin, hair, plastic materials and etc. Contaminated materials that failed in the Backend Tester were send for failure analysis and supplier countermeasure.

The PART-A component is among the highest fallout pareto due to contamination. Figure 1.1 shows the Company-XY incoming material DPPM in a percentage value. 41% comes from PART-A which is the biggest portion of the pie chart. Figure 1.2 shows a pie

chart of the PART-A's top supplier which has the highest quality issues in the Company-XY incoming inspection.

As can be seen in Figure 1.3, the highest DPPM report due to contamination on PART-A has reached above 20,000 DPPM. This sudden spike trend shows that improvement and investigation need to be done from supplier process until at the incoming material inspection area in Company-XY.

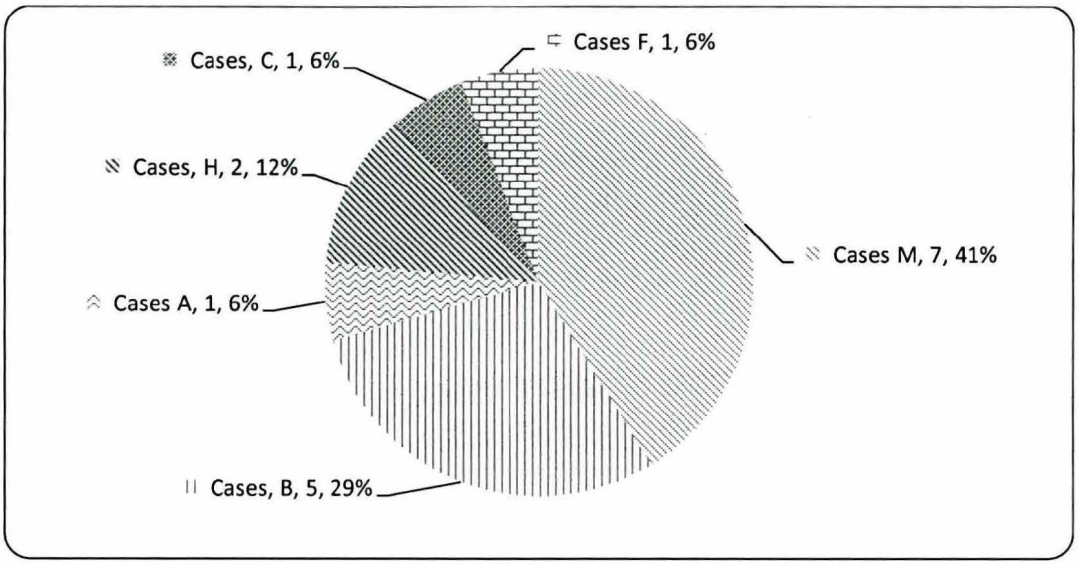

Figure 1.1: Incoming Inspection Material Defects

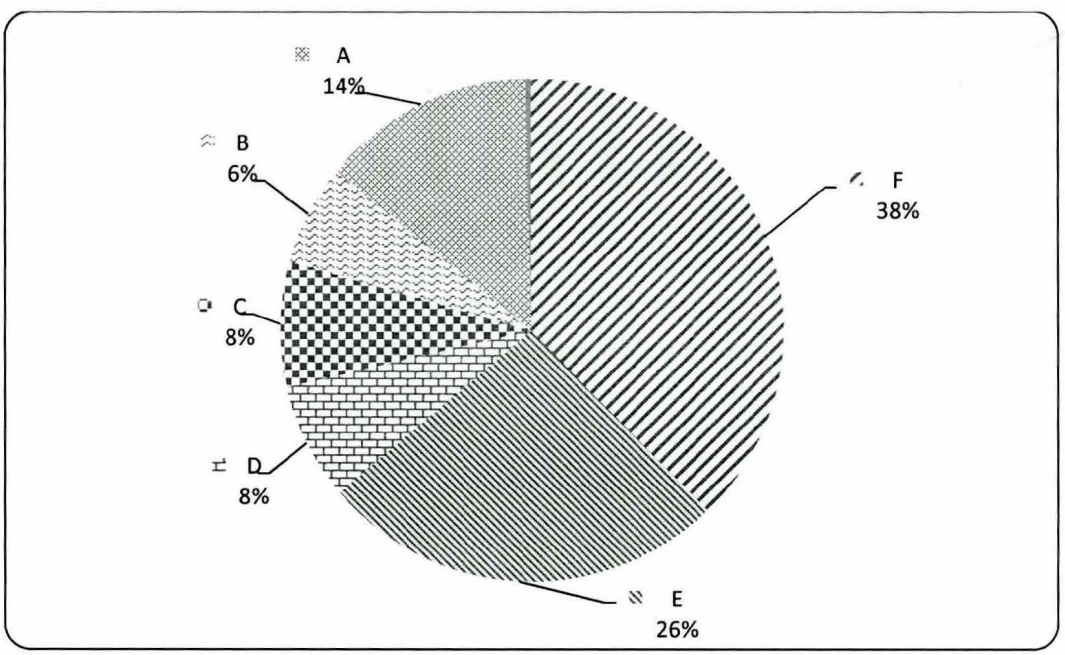

Figure 1.2: Overall PART-A fallout by supplier

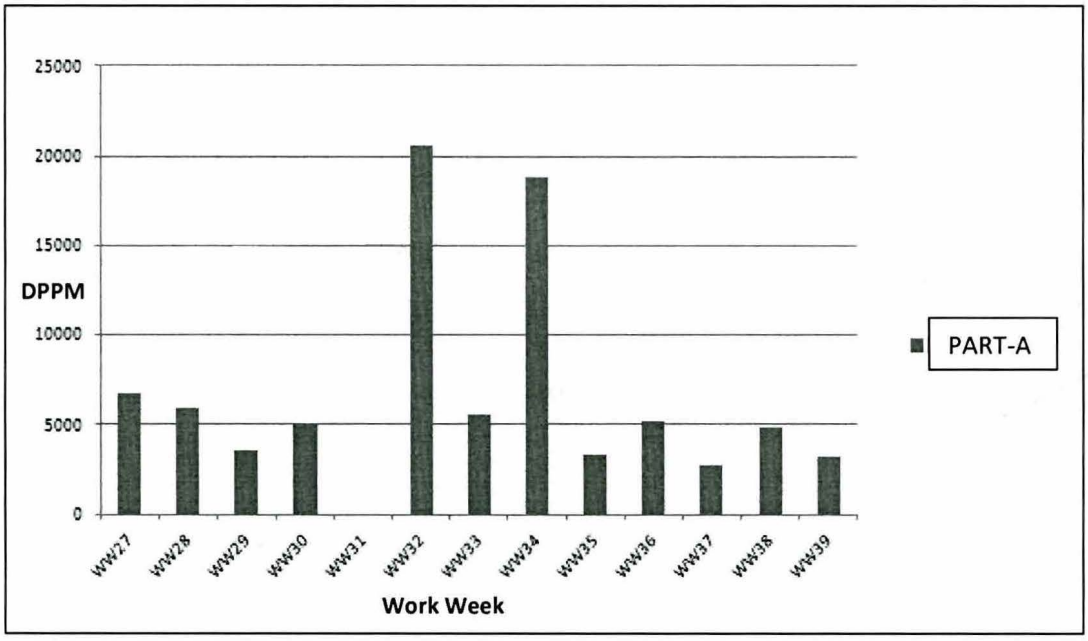

Figure 1.3: Incoming DPPM on contamination for overall PART-A suppliers

1.3 Aim and Objectives

The aim of this project is to reduce incoming material defects of contamination faults found in Company-X. The objectives of this project are:

i. To identify the critical contaminated products.

ii. To verify the effectiveness of the optical vision system that has achieved zero contamination faults for the critical product.

1.4 Scope

This project was done at Company-XY incoming material inspection area in the clean room. PART-A was chosen for validation purpose in this project. This process was divided into 3 phases of sample material submission for a period of 3 to 4 months.

This project was focused at two different locations. The first location was at PART-A supplier and the second location was at Company-XY factory. At PART-A supplier, the collected data were taken at the Automated Vision Inspection station and at Outgoing Quality Assurance (OQA).

1.5 Project Expected Outcomes

The outcome of this study is to improve the DPPM contamination on critical product at the incoming material inspection in Company-XY by applying the application of the automated vision inspection system at supplier factory.