BACK END PROCESS YIELD IMPROVEMENT BY VERIFICATION OF SEEDER BULK ERASE QUALITY FOR 3.5" REWORK HARD DISK DRIVE

MOHAMAD FADLI BIN SAIDIN

A thesis submitted in fulfilment of the requirement for the degree of Master in Manufacturing Engineering (Manufacturing System Engineering)

Faculty of Manufacturing Engineering

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Supervisor Name : MD. NIZAM BIN ABD. RAHMAN
Pensyarah Kanan
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ABSTRACT

Hard disk drives (HDD) are key components of typical computers. One of the important processes in hard disk drive manufacturing is the servo track writing. Servo sectors are typically created and are not subsequently overwritten or erased. The process of writing servo sector patterns is known as Servo Track Writing (STW). During the STW process, interaction between the software command and hardware performance normally will cause several errors and imperfection in the process. Thus, this kind of failures required the media of the HDD to be erased to ensure no overlapping tracks or any signal/noise residue after it tested again as rework HDD. This research studies the process of erasing the servo signal in the rework hard disk drive using the bulk erase technology in Western Digital Malaysia. This project observed the current practice on how the defected servo signal written drives analysed and reworked using bulk erase method in the factory and also the status of current production yield, particularly in Tressels program. The focus of this project is to improve the yield of filler back end process by implementation of TAA profiling gating algorithm in the HDS seeder software at STW stations. Result of experiments tested and discussed with several statistical analysis tools such as ANOVA and T-Test to verify the yield improvement. With failed drives filtered from going to filler station using the enhanced algorithm in the HDS production software, yield improvement at back end process achieved around two percent.

ABSTRAK

Pemacu cakera keras (HDD) adalah komponen utama komputer semasa. Salah satu proses penting dalam pembuatan pemacu cakera keras adalah penulisan trek servo. Sektor servo biasanya dicipta dan tidak kemudiannya ditulis ganti atau dipadamkan. Proses menulis corak sektor servo ini dikenali sebagai 'servo track writing'. Semasa proses STW, interaksi antara arahan perisian dan prestasi perkakasan biasanya akan menyebabkan beberapa kesilapan dan ketidaksempurnaan dalam proses. Oleh itu, kegagalan jenis ini memerlukan media HDD dipadamkan untuk memastikan tiada trek yang bertindih atau mana-mana sisa isyarat atau gangguan isyarat, selepas ia diuji sekali lagi sebagai HDD kerja semula. Kajian ini akan mengkaji proses terkini di mana isyarat servo pemacu cakera keras yg terjejas dianalisa dan diulang buat menggunakan pemadam jisim besar. Ia juga menganalisa nisbah pembuatan produksi khasnya kepada program Tressels. Kerugian nisbah pembuatan dikenalpasti dan cara memperbaikinya akan dilakukan di dalam kajian ini menggunakan kaedah pelarasan algorithma pengasingan di dalam perisian proses HDS. Instrumen analisis statistic seperti ANOVA dan Ujian-T digunakan untuk mengesahkan pembaikan dilaksanakan. Dengan mengenepikan HDD yang bermasalah dari memasuki proses seterusnya, ia dapat mengembalikan prestasi dan peratusan keberjayaan pembuatan di proses seterusnya pada kadar lebih kurang dua peratus.

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LIST OF ABBREVIATIONS

ABS	Air Bearing Surface
AC	Alternating Current
ANOVA	Analysis of Variance
DC	Direct Current
DOE	Design of Experiment
HDD	Hard Disk Drive
HDF	High Density Fill
HDS	High Density Servo-write
ID	Inner Disk
IDCS	Inner Disk Crash Stop
OD	Outer Disk
PES	Position Error Signal
PMR	Perpendicular Magnetic Recording
RM	Ringgit Malaysia
RPM	Revolution per Minute
RRO	Repeatable Run-out
S4W	Self-write Spiral Servo Write
STW	Servo Track Write

TAA	Track Amplitude Average
TPI	Tracks per Inch
VCM	Voice Coil Motor
VMI	Visually Manual Inspection
WDC	Western Digital Corporation

CHAPTER 1

INTRODUCTION

1.0 Introduction of the Research

Western Digital Corporation (WDC) is a well-established hard disk drive (HDD) manufacturer in the world. In decades, as a pioneer of the storage industry, WDC contributed the largest market share holder and emerge as a major HDD supplier to the world. Based in Irvine, California, the headquarter leads the key manufacturing sites of its product located in Thailand and Malaysia. Western Digital Malaysia (WDM), one of the factories, mainly produced the HDD as their business core which is commonly used as the storage solution for servers, personal computers, notebook and others. HDD basically produced in form of 3.5 inches HDD, mainly used in maximum performance and higher end peripheral requirements like desktop and enterprise. In the other hand, 2.5 inches drives mostly used in average processing power computers used in notebooks, tablets as it categorized as mobile type.

In WDM, the complete process of making the HDD is done in every floor of it factories. From the assembling the parts and components, servo systems, back-end testing and qualification, to the staging, storage and shipping, all the process done in the plant building all over the WDM free industrial zone complex. In manufacturing the HDD, one of the critical processes required after the assembly line is called servo track writing (STW) or basically dubbed as seed process. STW is important to the HDD as the medium to allocate and prepare the best passageway for the servo systems to be stored in the HDD. The servo system is critical to the HDD, in term of the HDD control coordination as well as the interface for the

drives and the head read/write operations. Servo systems in applied to the HDD at the back end processes consist of filler process, servo, reliability test, FIT and others. Figure 1.1 shows the generic HDD assembly process and its process flow.

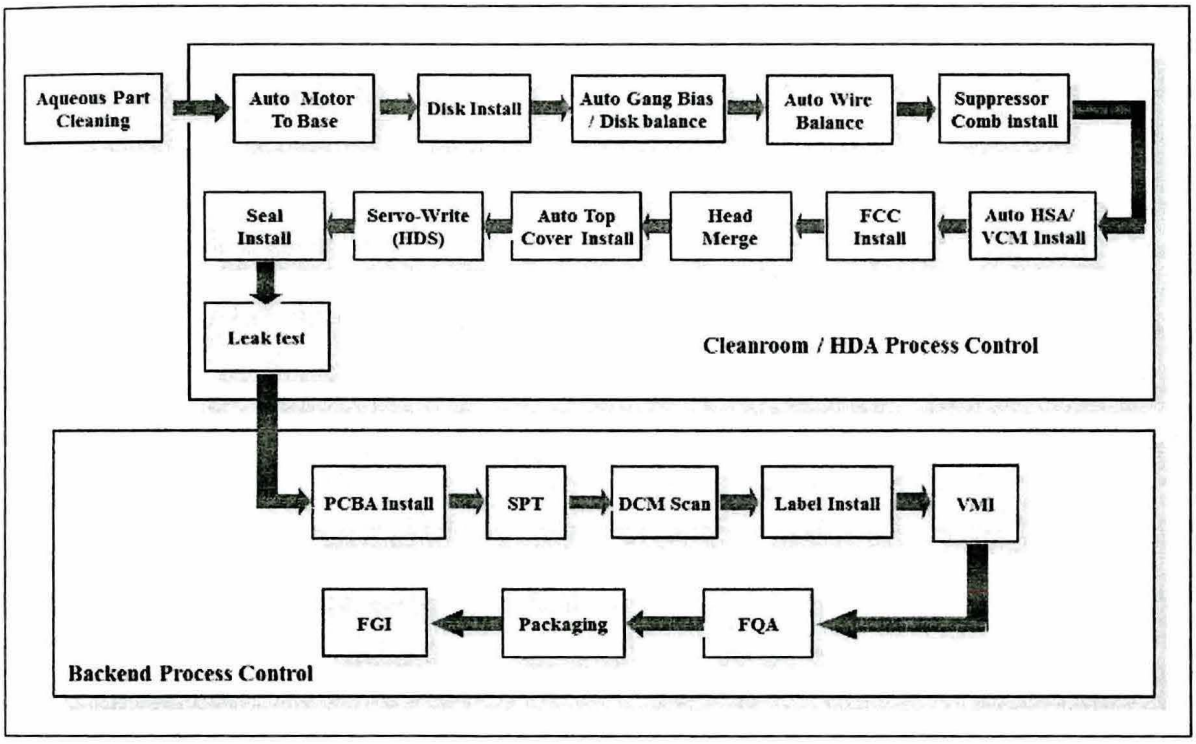

Figure 1.1 Generic 3.5" HDD Assembly and Production Process.

During the seed process, interaction between the software command and hardware performance normally will cause several errors and imperfection in the process. Thus, this kind of failures required the media of the HDD to be erased to ensure no overlapping tracks or any signal/noise residue after it tested again as rework HDD. In the previous technology used, rework drives was processed with the conventional read/write erase which normally took longer to perform because the basic steps of erasing commands was done internally in the

HDD using the heads. Later on, this erasing tracks process is simplified and shortened by the implementation perpendicular magnetic recording (PMR), a direct magnetic erase concept, generally known as bulk erase. After erasing process, these drives are reseeded and will go through the seed test and proceed to next process which is back end processes.

1.1 Research Problem Statement

As this research covers on the area of observing the erase quality on the rework drives using the bulk erase machine, several weaknesses and problem raised and become the subject of the research. After erase process, the rework drive that pass the reseed test will be sent to back end processes without any verification step for spiral signal overlapping the previous residue of spiral signal, due to deficient bulk erase quality.

The back end processes yield can be compromised by failures consists of the material quality issues, back end processes qualification test failures and also the above mentioned seed-servo related failures. For this research, the focus is on the seed servo related failure only. Significant low production yield at the back end process, particularly caused by the bad quality of spiral signal on the reseeded rework drives is the focus of this research.

In this research, data from the production yield lost were collected and correlation of it with the failures was studied. The failures were segregated accordingly and the root causes were identified. The brief explanation of the specified process area is described in Figure 1.2.

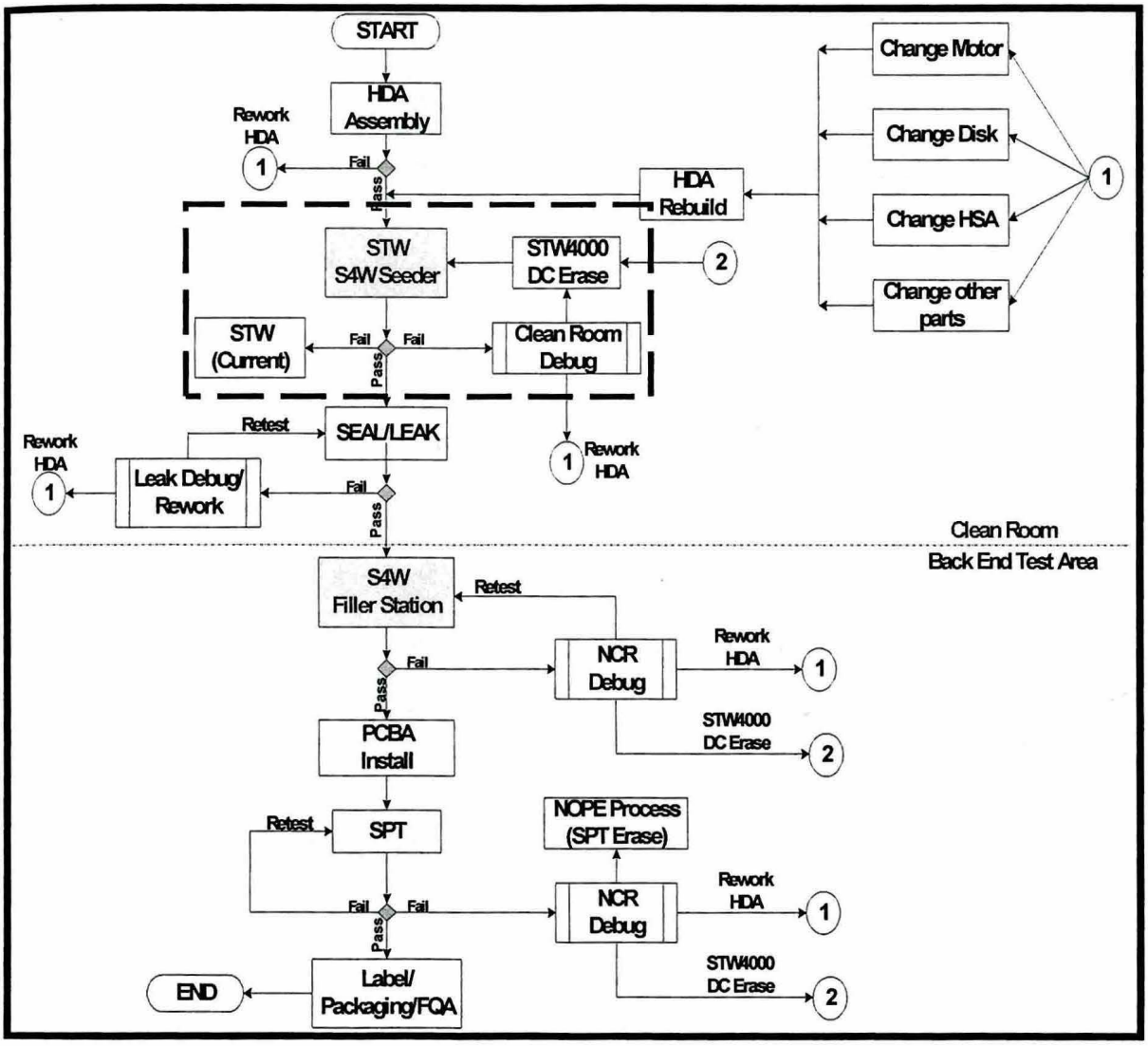

Figure 1.2 Area Focus on the Work Flow of the Seeder STW Prime and Rework Process in Clean Room Production.

The low yield at back end due to bad quality of spiral signal on the reseeded rework drives caused a lot of rework activities. This causes bottle neck situation at seeder tester operation. This resulted in operational inefficiencies due to defect failures analysis, rework and high failure rate.

Subsequently, the lack of supporting process to verify and filter the deficient erase quality from the bulk erase process can be look as the chance to improve this problem. The element of statistically approach and data analysis can be used on addressing the current problem, meanwhile, implementing a mechanism such as an internal intelligence or real-time data verification to detect independently any bad erase quality faster and in an efficient way. This can avoid a burden and heavy load on the bulk erase stations due to the queue of the rework return as the result of the poor erase quality from the back end failure.

1.2 Objective of the Research

Two objectives of the research can be identified regarding to the problem statements and the observations on the current production practice. The objectives of this research are:

1) to identify the current yield loss at the back end process caused by the bad quality of erasing at the seed process.
2) to minimize loss due to bad quality erasing by implementing new software TJ.DF.07.RKK.
3) to verify the yield improvement due to implementation of new software, TJ.DF.07.RKK, through statistical analysis.

1.3 Scope of Research

1.3.1 Target User and Location

The current area of business for this research is within the Servo Track Writer (STW) group in WDM. Seeder failure analysis team and floor online team should be the target user for this and can be the major contributor on the inputs and data required during the research.

1.3.2 Process Related Information Resource

Process related in the research should be around the 3.5" HDD, STW seed process and a process before and after the bulk erasing only. This will not go too deep into the implementation of the servo systems details and back end processes. Resources for this research should be from the WDM production lines, its current technology and its workbench information as far as libraries and external information resources only. The scope specifically will focus on the rework drives processes and only limited to certain failure analysis works. Moreover, the data can be retrieved from the associated industrial research; daily works thus enables us to find out what is already implemented in the field. It can use the statistics, real data collections and collect the information from literature, reports, journal and documentation of the related topics from the same industrial companies.

1.4 Research Significance and Benefit

With the latest technology and methodology, this research should be successfully elaborated and proven helping a lot in the department target. It also supported by the good exposure and focus from the STW team as it huge difference in their job extent, hence relevant for their daily job in improving the performance both in yield and also proactive failures detection. This research categorized the extension of the current technology and treated as a

continuing in previously original piece of work from the major magnetic bulk erase project recently implemented in WDM. It also adding a single original testing technique and enhance the current technique which is the magnetic bulk erasing.

1.5 Plan of Research

For the planning of the research, the preliminary information collection should be held as the initiator of the research and estimated will take around three months. The literature review should take another three months to be completed with all review on the related field from internal and external sources. The methodology, design, and implementation of the project will take at least six months to be finish with the mainframe on implementations of the intended analysis and the data study. At the end, all the review and discussion on the research should be summarized in the last two months duration. Besides, the compilation and the complete report of the research should be documented at the end before finishing the research. The summary of the plan can be described in the Figure 1.3.

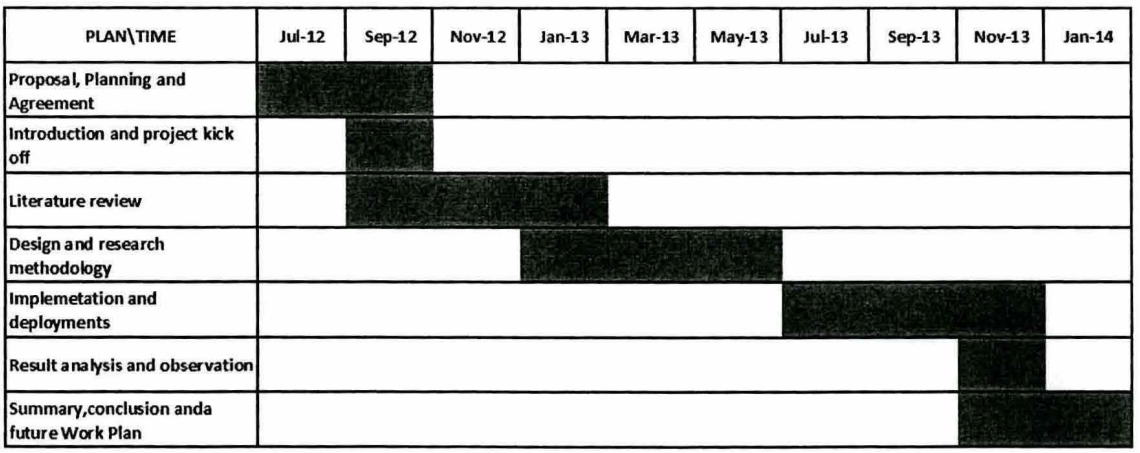

Figure 1.3 Gantt chart of the Research Plan.

1.6 Summary

From the research preliminary information, it can help to minimize the process of rework drives in STW process by avoiding repeatable erase and impact the back end stations. The background of the process, process flow and the related impact of flaw found in the process are explained to illustrate the current practice in the factory's manufacturing process. With the objective and the problem statement defined in the previous pages, a change and additional requirement needed to be added to the current bulk erase process to achieve the targets and aims of the research within the target plans.

The scope and limitations of the research help to determine capability for the research to cover and gain as much as possible research values on its technical and academic context meanwhile, in time, not burden the research with too broad exposure on the unnecessary, complex technical content. The estimation of the research timeline and expectation on the every section of the research identified to ensure the target for every of it followed and shall not delay due to improper task assignment.