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รายงานนี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรวิศวกรรมศาสตรบัณฑิต

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สถาบันเทคโนโลยีพระจอมเกล้าเจ้าคุณทหารลาดกระบัง

ปีการศึกษา 2561

Cooperative Title: Yield Loss Investigation and Slider Tray Cleanliness Improvement

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ABSTRACT

In June 2018, the contamination yield loss in Seagate Korat plant was increased from 0.5% to 0.9%. It increased overall yield loss and operation cost. The purpose of this project is to identify the causes of the problem to decrease the contamination yield loss in this plant. The defect sample was inspected by an optical microscope and identified a type of material by IR spectroscopy. Liquid particle counter was used to compare cleanliness between a rough and smooth tray and the contamination yield loss of both groups was determined to test a hypothesis that a rough tray is a cause of the contamination problem.

The IR Spectroscopy show the defect on part is the material of slider tray which used in the production line. For smooth tray, it has average particle about 1622 particle/cm^2 and 7.28% for contamination yield loss. The rough tray has average particle about 2708 particle/cm^2 and 12.62% for contamination yield loss. This comparison shows the rough tray is one factor that increases a contamination yield loss, so it was separate out from the production line. After that, the overall contamination was decreased from 0.9% to the baseline of 0.5%.

Keyword: Contamination yield loss, Infrared spectroscopy, Liquid particle counter.

Acknowledgements

I would like to thank Seagate Technology (Thailand) Co., Ltd for this opportunity to learn a lot of precious experience from Co-operative Education Program. Moreover, I would like to thank my mentor, Ms. Araya Saengkanuk (Engineering Manager), and all staff who supporting and instructive for my project

I would like to express my gratitude to my advisor, Assoc. Prof. Dr. Duangkamol Na-Ranong for the continuous support of Co-Operative Education Program, for her motivation and immense knowledge.

Finally, if there are any mistakes in this project, I apologize.

Mr. Patchara Vatcharasin

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CHAPTER I

INTRODUCTION

1.1 Background

Seagate Technology LLC is an American data storage company. Seagate was established in 1979 at Scotts Valley, California. Later, Seagate was expanded to other regions in Europe and Asia. There are 2 factories in Thailand: Korat and Teparak. Korat plant is manufacturing base and assembling hard disk, divided into Drive Operation, Head Gimbal Assembly, Head Stack Assembly, and Slider (The part that has a reader and writer). Teparak plant produces some parts about the reader and recorder, Head Gimbal Assembly, and Head Stack Assembly.

In Korat plant, my organization (Process Development Integration - Cleaning) is responsible for product cleanliness in each process. Because cleanness decreases a reading and writing performance of hard disk. Cleanliness is important for hard disk manufacturing, so each process has a cleaning machine such as Ultrasonic cleaning machine and Brushing cleaning machine.

In June 2018, the contamination yield loss was increased from 0.5% to 0.9%. It increased overall yield loss and operation cost because the contaminated products need to re-clean. Inspection of rejected sliders revealed a new type of contamination defect which has not been detected in this plant. It looks like a black line near the edge of the slider.

The purpose of my Co-operation Education project is to investigate a root cause of this contamination and decrease a contamination yield loss back to the baseline by using chemical engineering knowledge to solve the problem.

1.2 Objectives

1.2.1 To investigate a root cause of contamination yield loss.

1.2.2 To decrease contamination yield loss.

1.3 Scopes of Work

1.3.1 Contamination yield loss investigation.

1.3.2 Ultrasonic Cleaning Machine.

1.3.3 Slider tray cleanliness improvement.

1.4 Expected Outputs

1.4.1 Discovered the root cause of the contamination yield loss problem.

1.4.2 Decrease contamination yield loss to baseline.

1.4.3 Gain experience about problem-solving by chemical engineering knowledge.

CHAPTER II

THEORY AND LITERATURE REVIEW

This chapter will provide background information that necessary for Yield loss investigation and slider tray cleanliness improvement project including hard disk drive component, hard disk drive working principle, overall hard disk drive production process, the importance of cleanliness, the principle of infrared radiation spectroscopy, and the principle of the liquid particle counter.

2.1 Hard disk drive component [1]

The hard disk drive has only a few parts, according to the information below.

1. An actuator that moves the read-write arm.
2. Read-write arm swings a slider back and forth across media disc.
3. Spindle motor allows media disc to rotate at high speed.
4. Media disc stores data in binary digits.
5. Plug connections link hard disk drive to a motherboard in the computer.
6. The Slider is a small part that writes and read data on a media disc.
7. Circuit board on underside controls the flow of data to and from the media disc.
8. Flexible connector carries information from circuit board to slider and media disc.
9. Small spindle motor that allows the read-write arm to swing across media disc.

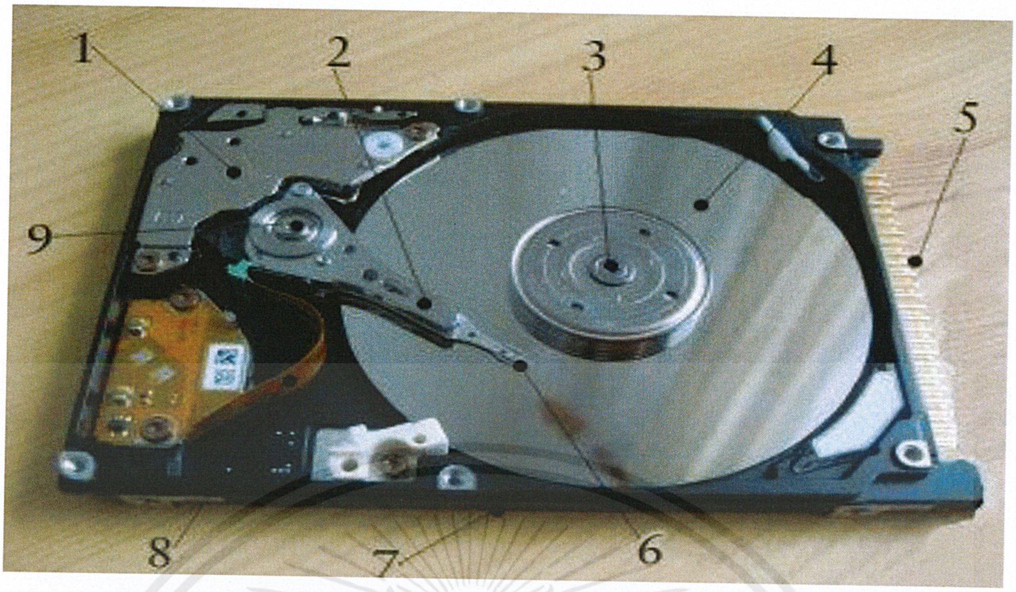


Figure 2.1 Details of hard disk drive. [1]

2.2 Hard disk drive working principle [2]

In hard disk drive has a media disc coated with magnetic material, divided into billions of tiny area. Each of these areas can be independently magnetized to store a one or demagnetized to store a zero (Binary digits). Magnetism is used in hard disk drive storage because it still stores a data even when the power off until demagnetize it. The hard disk drive used perpendicular recording technology to write and read data. The writing head inputs the current for the coil at the tip of the reading head, causing temporarily electro magnetized and induction on the recording layer to arrange the direction according to the format of the data that need to record. The reading head is in a state of no electricity, resulting in induction by electromagnetic causing a weak electrical current at the coil, which is the value of the current that is the data read from the hard disk.

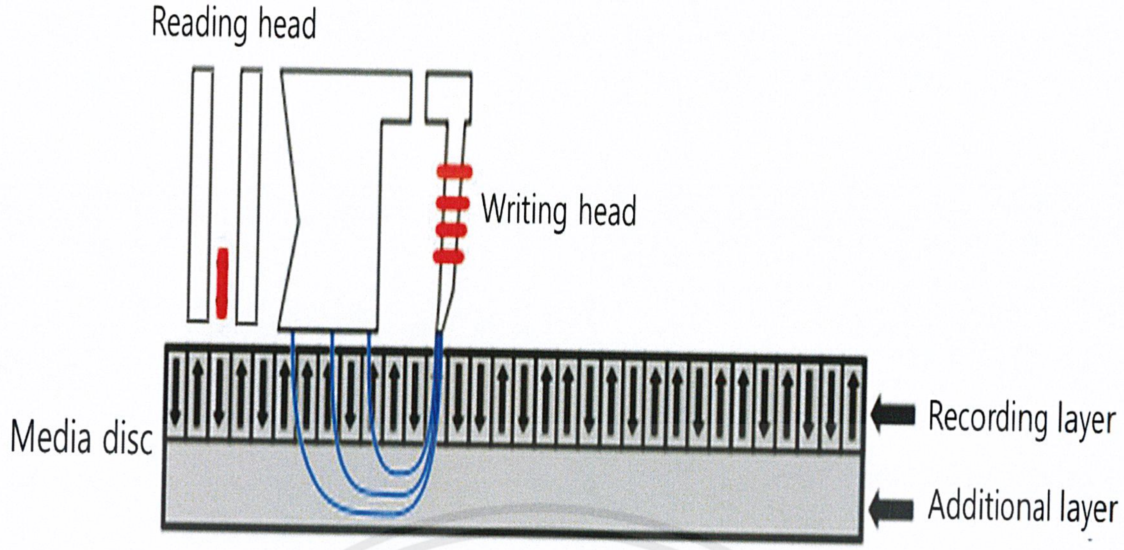


Figure 2.2 Perpendicular recording. [2]

2.3 Overall hard disk drive production process [3]

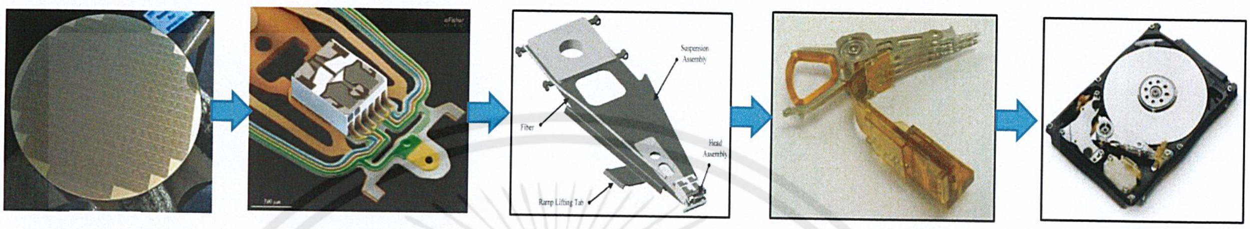
Hard disk drive production process takes place in a clean room, where the amount of particle is very low. This process is strictly controlled and monitored. Employees are dressed in special suits that completely cover the body, to avoid the contamination.

The overall hard disk drive production process consists of Wafer Fabrication, Fabrication, Head Gimbal Assembly, Head Stack Assembly, and Drive Assembly. In most cases, the wafer is made in one plant. The slider has produced someplace else, while the drive product is assembled in another factory. This way production cost is kept low.

The wafer is a common word of raw material for electronic manufacturing. Usually thin, and round. Most wafers are made from silicon extracted from sand because being the most a bountiful element in nature. Moreover, it has an environmentally friendly property.

The slider is one individual head which consists of reader and writer transducers. It is a small part but very important. The wafer was slice to a bar form that has many sliders in a low. After that, a bar was lapped to meet the specification. Then, a bar was diced to a slider form. The Slider fabrication has many cleaning processes to prevent contamination.

Head assembly consists of head gimbal assembly and head stack assembly. Head gimbal assembly is connected to the actuator arm front end. The slider was soldered on a tip of the actuator arm. It is the most important part of entire this assembly. Head stack assembly is a stacking an actuator arm after head gimbal assembly process to increase storage capacity in a drive. Finally, every part is assembled together and test the performance of a hard disk drive in drive assembly process.



(a) (b) (c) (d) (e)

Figure 2.3 Overall hard disk drive production process (a) Wafer Fabrication, (b) Slider fabrication, (c) Head Gimbal Assembly, (d) Head Stack Assembly, and (e) Drive Assembly. [3]

2.4 The important of cleanliness in hard disk drive production

The hard disk drive production has many cleaning processes such as brush cleaning, ultrasonic cleaning, and ultrasonic cleaning with a solvent. Because a distant of reading and writing on a media disc about 1 micrometer, any material that remains on the surface of slider and media disc such as a particle, smoke, red blood cell, and fingerprint will cause problems at the part or higher level assembly such as scratching in media disc and slider surface during operation, and corrosion of slider and media disc. It is typically call contaminant.

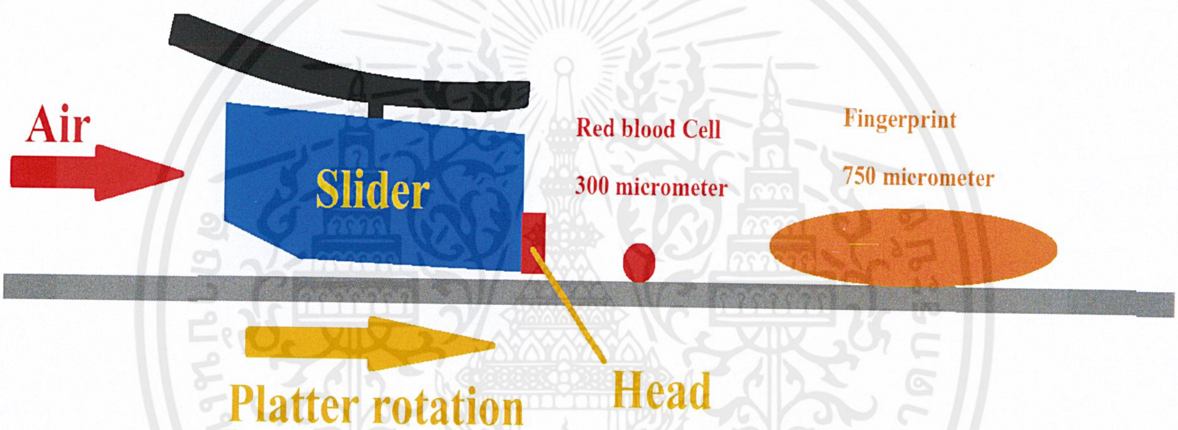


Figure 2.4 Comparison of contaminant sizes and flying height. [4]

2.5 Principle of infrared spectroscopy [5]

Infrared spectroscopy is a popular method that analyzes about molecular of material. It is the spectroscopic technique that uses infrared light and studies molecular interaction. It can give the functional groups with a sample. The bonds between the atoms vibrate and have two types of vibrational motions including Stretching and Bending. For stretching, the bond length would change. Stretching vibration has two types including Asymmetric and Symmetric vibration. Bending vibration is the vibration that leads to change a bond angle concerning the normal bond axis. For this vibration, one bond may rock back and forth within the plane it shares with another bond or bends back and forth outside that plane. Bending vibration have four types including Twisting, Rocking, Scissoring, and Wagging. In each of these vibrations would absorb different frequencies of the infrared. A photon of light which has a frequency in an infrared range will be absorbed if the bonds between atoms in the target sample allow these atoms to vibrate in this frequency.

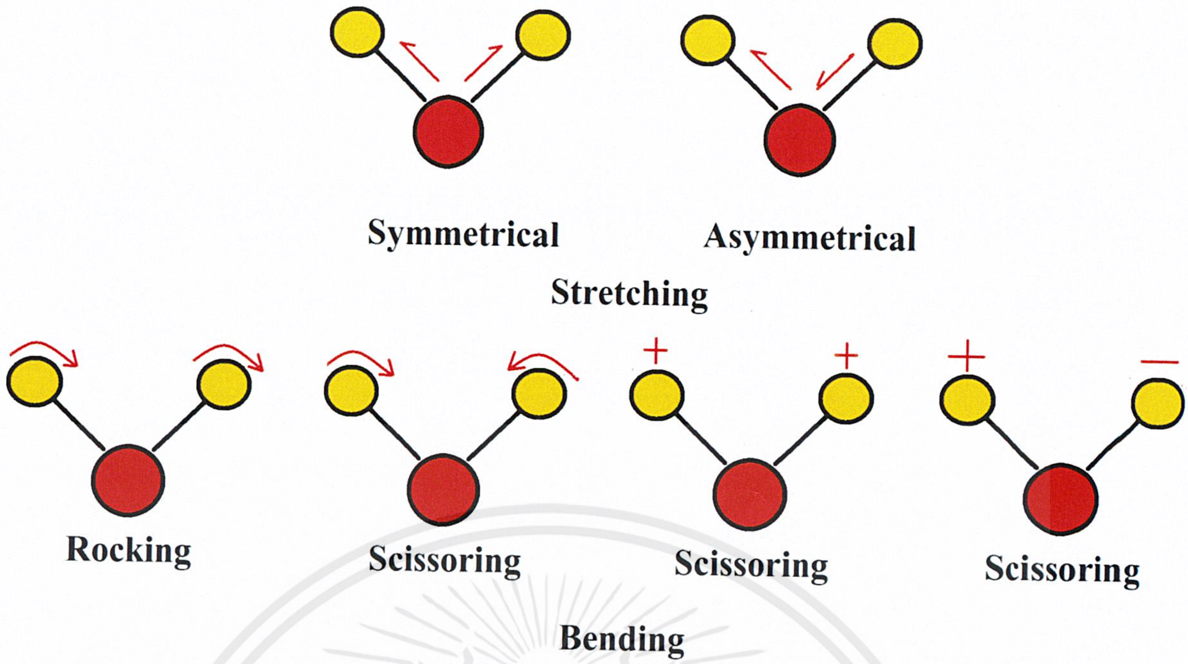


Figure 2.5 Examples of Molecule Vibration and Rotation Models. [6]

The infrared instrument has a metal that heated to a high temperature at about 1500-3000K. The metal will emit the infrared radiation. Infrared radiation is allowed to separate from gratings. A chopper is located inside the instrument that chops the infrared radiation at regular intervals and separates them in two directions together. There two cells placed. First is a reference, and another is a sample. Therefore, chopper makes sure which the infrared radiation from the same source and same wavelength pass through both sample cells together. The chopper rotates about 10 rotation per second. Every molecule has a unique infrared radiation spectra, then infrared radiation spectra of any two molecules cannot be the same. For infrared radiation spectroscopy, the transmittance of the infrared radiation was checked. If there is any bond vibrating at the frequency that same as the infrared radiation, then the infrared radiation would be absorbed. Therefore, the transmittance would significantly decrease for that particular frequency. The result is shown the absorbance in the vertical axis and wave number of radiation in the horizontal axis.

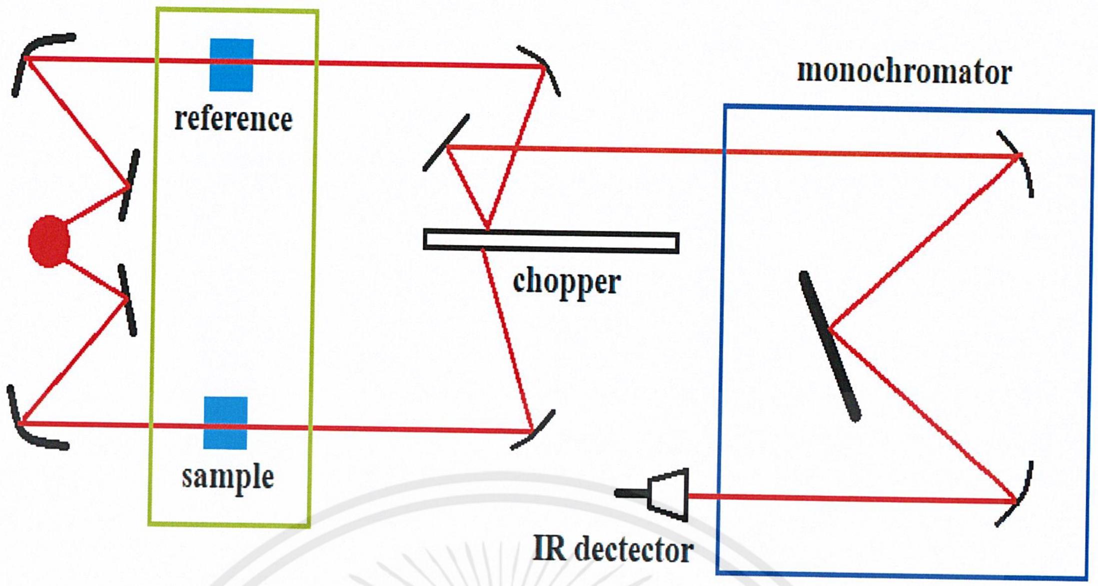


Figure 2.6 Infrared radiation spectroscopy instrumentation. [5]

2.6 Principle of liquid particle counter [7]

In this project, the liquid particle counter is a method which used to test the cleanliness of a sample. It can measure the distribution and size of particles in a liquid or solid sample. The particle size and distribution are determined by irradiating a sample with a laser diode and detecting an extinction light for a particle that more than 1 micrometer, and detecting a scattered light for a particle that less than 1 micrometer. This project has a specification of a particle that more than 0.3 micrometers, so detecting an extinction light method was used for this project.

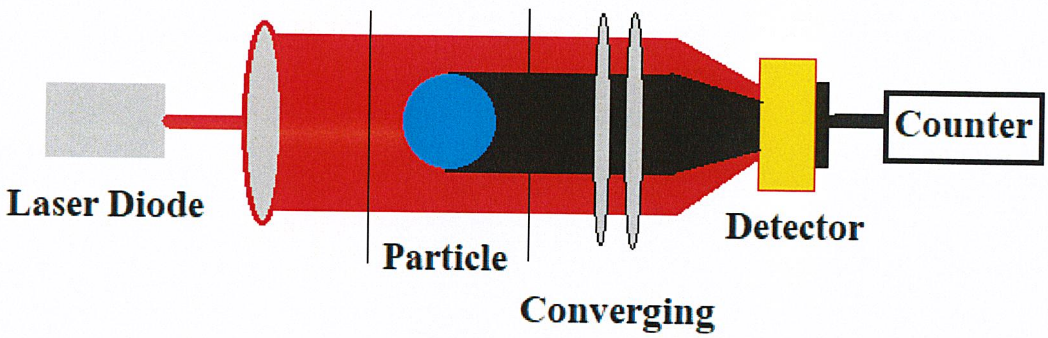


Figure 2.7 Liquid particle counter instrumentation (Extinction Mode). [7]

From Figure 2.7, the detector detects an irradiating that pass a flow cell and calculate a light extinction because almost of the irradiating was blocked by a large size particle. Therefore, this mode was used for a large size particle to increase accuracy and precision of measurement.

CHAPTER III

EXPERIMENTAL

From objectives of this Co-Operation Education Project, first is to investigate a root cause of contamination yield loss in Seagate Korat plant. Next step is to decrease contamination yield loss for saving operation cost due to re-clean operation. Experimental flow diagram for yield loss investigation is shown in Figure 3.1. The first step is defect sample collection, follow by inspection, laboratory analysis, identification of a problematic unit, identification of problematic operating parameter, evaluation and implementation.

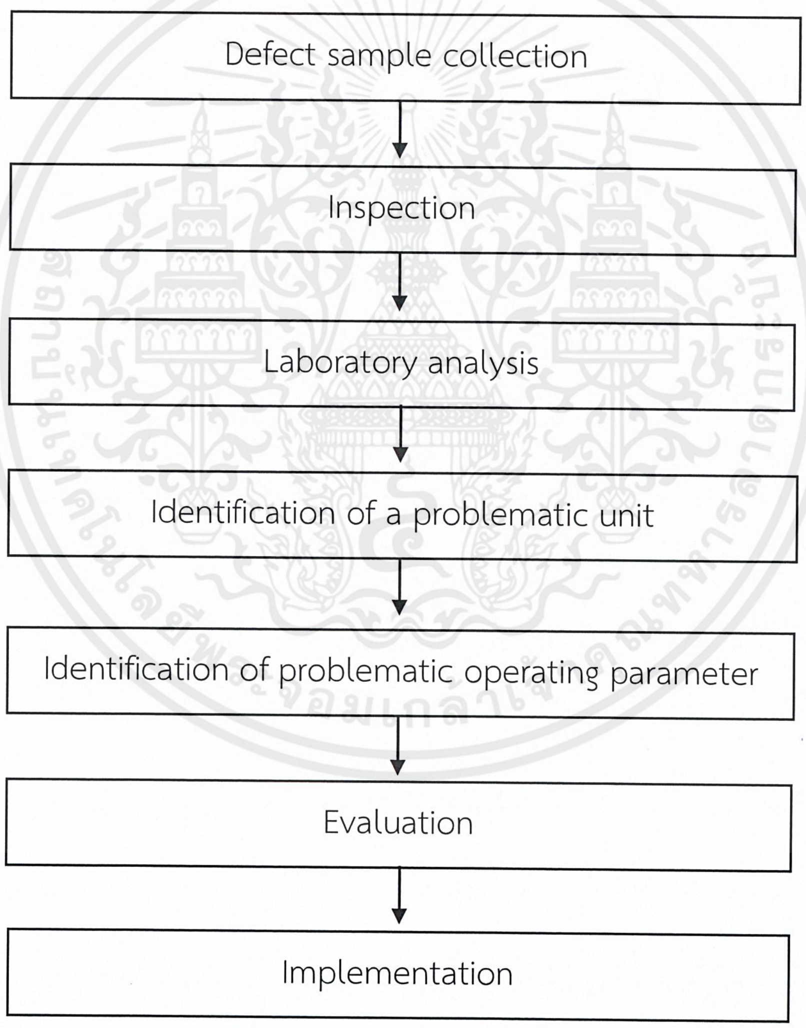


Figure.3.1 Experimental procedure

3.1 Defect sample collection

Defect sample collection is the process of gathering finished goods defect sample from the production line. Because of the contamination problem was occurred in this plant, my organization is responsible for finding the cause of this problem. Because unknowing for the type of contamination, so defect sample collection is the first step for troubleshooting. The sample size for inspection is about 500 sliders.

3.2 Defect sample inspection

Defect sample from the previous step is inspected by a 100x magnification optical microscope for classifying a type of contamination (physical characteristics). If the major contamination mode is a common type that always found, will know about the cause of the problem. But for this case, the major contamination mode from inspection is never found before for this plant. This case cannot identify anything about this contamination problem. Then, contamination defect has identified the type of material in the next step.

3.3 Laboratory analysis

In this step, the defect contamination has identified the type of material (chemical characteristics). Because the slider production process has a lot of steps that can be a contamination problem. If knowing the type of material of defect contamination, the scope of this contamination problem can be defined by the type of material. The analysis instrument that used to analyze the defect sample is infrared spectroscopy. It can identify a type of material of the defect sample by comparing a defect sample infrared spectral with the infrared database.

3.4 Identification of a problematic unit

The slider process was separated into three sections including wafer, bar, and slider that show in Figure.3.2. Wafer section is a slicing process that slices a wafer to bar. Bar section has a lapping and milling process to make a slider surface shape. Slider section has a cleaning process, inspection, quality control, quality assurance, and packing. In each section have specific equipment that only used in each section. When got the infrared spectroscopy result as the type of material of a contamination defect sample, the section of the contamination problem can be defined. After that, the problem section is investigated to identify a problematic unit by comparing contamination yield loss between each unit in the problem section.

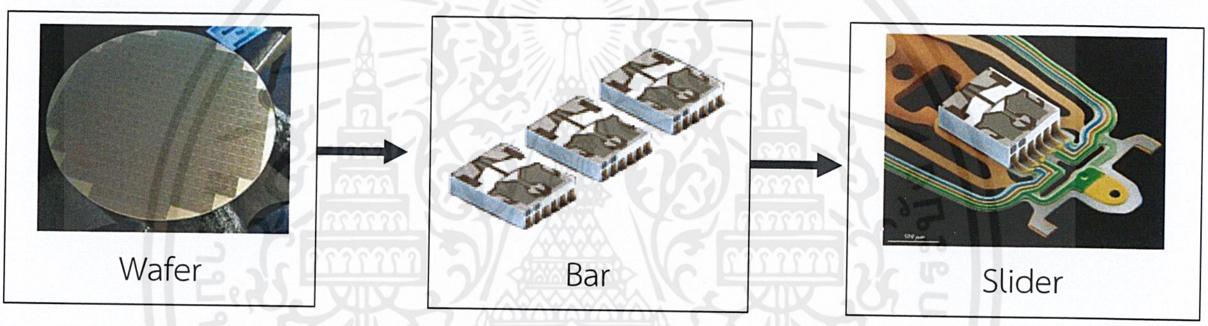


Figure.3.2 Slider process

3.5 Identification of problematic operating parameters

The problematic unit was identified in the previous step. This step is operating parameter investigation in problematic unit. My team has discussed the hypothesis of this problematic unit. It is investigated and checked a recipe to find a parameter that is likely a root cause of this contamination problem. The appropriate analysis instrument is used to identify a problem parameter such as liquid particle counter that can measure a particle in any liquid or solid sample to test the cleanliness of the sample.

3.6 Evaluation

After knowing the problem parameter, this step is an evaluation of this parameter to compare contamination yield loss with a control group. The results of the evaluation will ensure that this problem parameter is a root cause of the contamination problem. If this parameter ,not a root cause, then the new hypothesis will set, other parameters that are likely a root cause will be investigated and evaluated again until found a root cause of this contamination problem.

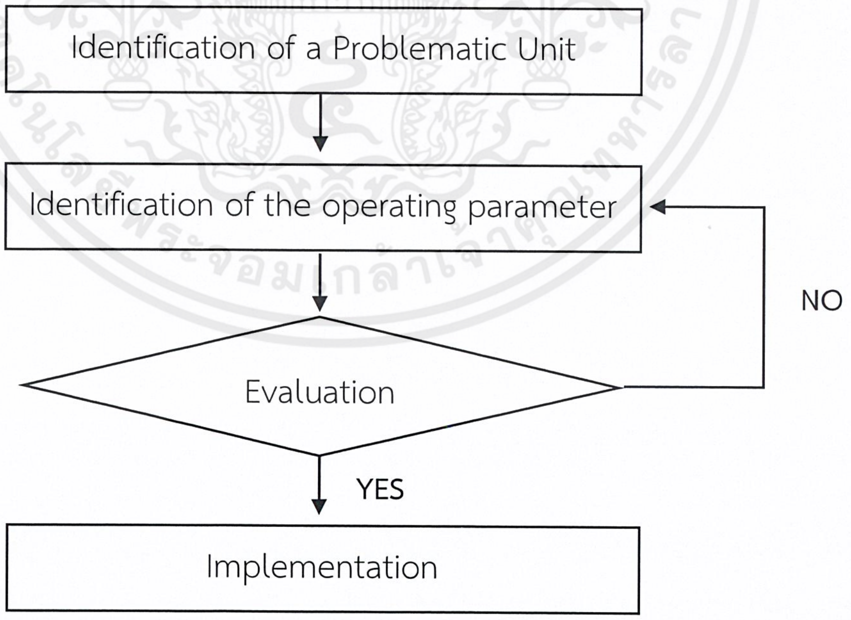


Figure.3.3 Re-evaluation step

3.7 Implementation

Finally, when knowing the root cause of the contamination problem, this step is finding a solution to the problem and implementation. The objective of this project is to decrease the contamination yield loss, so our implementation must be resolved and must not affect other section of the hard disk drive process.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter describes the contamination defect analysis results, infrared spectroscopy results, identification of a problem unit and operating parameter results, evaluation results, and implementation results of the contamination problem in slider product.

4.1 Contamination defect analysis results

From the introduction, Seagate Korat has a contamination problem in June 2018. A lot of contaminants was detected on a surface of the slider product, resulting in a need for rejection and re-cleaning a slider product. It increased overall contamination yield loss and operation cost. The objectives of this project are investigation a cause of contamination problem and decreasing a contamination yield loss in a slider product. The first step of this project is the sampling and inspection of 500 contamination defect sliders to identify physical characteristics of a slider defect and classify a type of contamination following a database. From inspection, found an old type contamination that always found in the production line such as type A and B contamination that is shown in Figure 4.1 and Figure 4.2. Both of contamination defect can troubleshoot because knowing the root cause of both defects. Type A contamination can be considered any solid material that is on the slider surface as dust, metallic fragment, and fibers. This defect occurs from grinding and dicing operations, machining process, packaging, and environmental storage. Type B contamination can be considered a cleaning chemical residue on the surface of the slider due to a problem of rinsing and drying. But the majority contamination defect that found from inspection is a new type defect that never discovers before. This defect looks like a line at the edge of the slider product, then the contamination defect as shown in Figure 4.3 was being called new type contamination

Figure 4.1 Type A contamination.

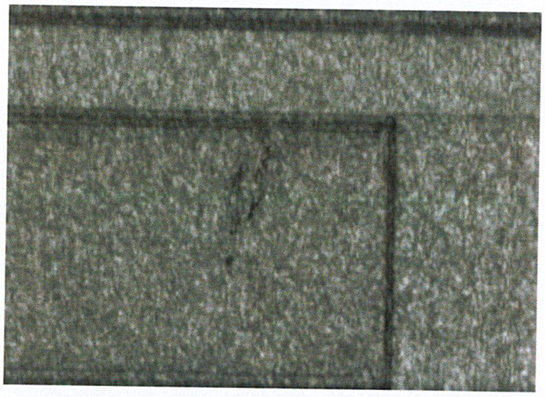


Figure 4.2 Type B contamination.

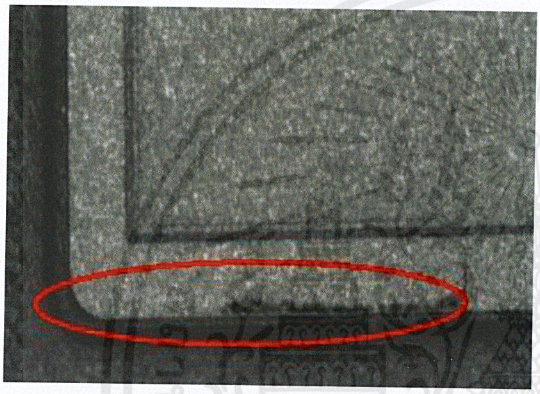


Figure 4.3 New type contamination.

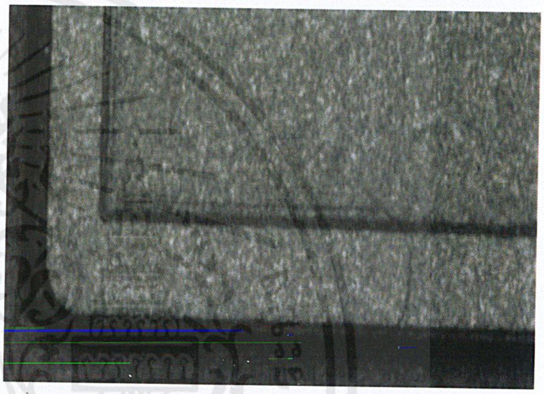


Figure 4.4 QC passed product.

In the quality control process, contamination defect was detected by the difference of reflecting light. For new type contamination, it was difficulty detected because it occurs nearly edge of slider product with the similar reflecting light. Therefore, there will be a number of this contaminant that cannot be detected which will cause the slider product to be a problem when customers use it. So, the new type contamination is a critical problem because of the loss of re-cleaning operation cost. Moreover, it may reduce the reliability of the slider product also. Consequently, the new type contamination problem must be solved as soon as possible.

Next step is a laboratory analysis because of the need to know the chemical characteristic of this contamination defect. In this step, new type contamination sample that is shown in Figure 4.5 was sampled to identify a type of material by infrared spectroscopy. The infrared spectroscopy results were shown in Figure 4.6.

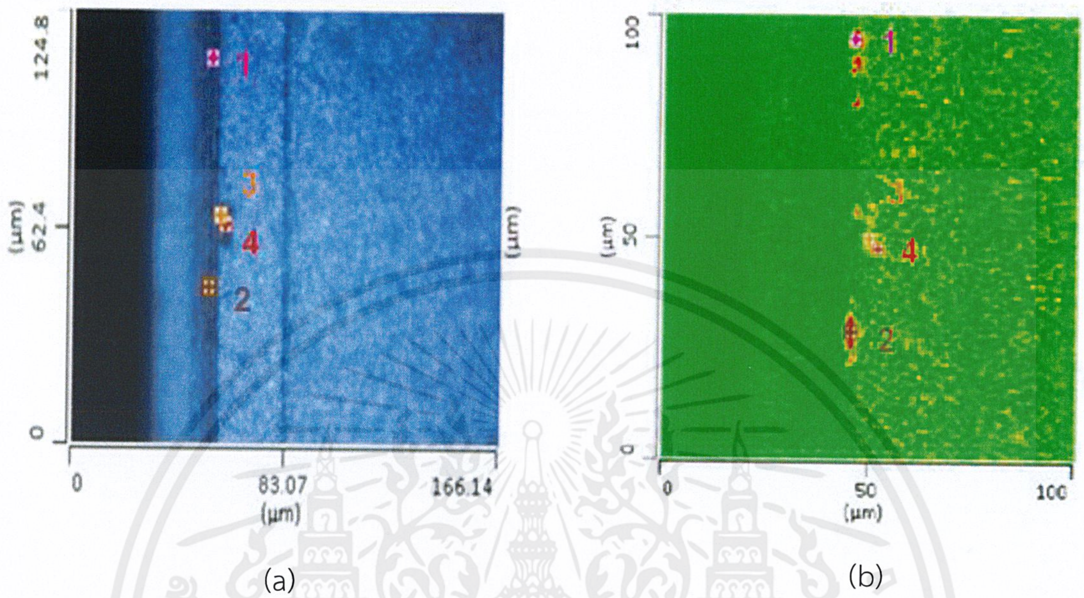


Figure 4.5 New type contamination defect sample image (a) the optical image (b) the optical photothermal infrared at 1492 cm^{-1}.

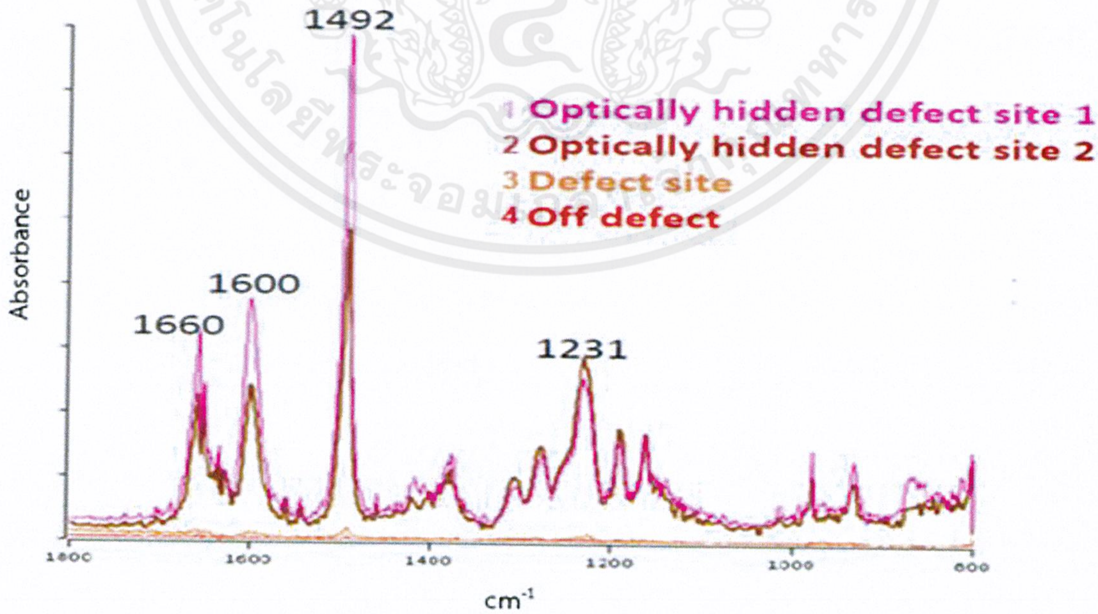


Figure 4.6 Infrared spectral of new type contamination.

This laboratory analysis determined four locations such as optically hidden defect site 1&2, defect site, and off defect. The spectra results show the both of optically hidden defect sites are the same trend chart but defect site and the off defect cannot detect spectra. Because of a defect site and off defect are too thin to detect spectra as shown in the optical photothermal infrared at 1492 cm^{-1} in Figure 4.5b.

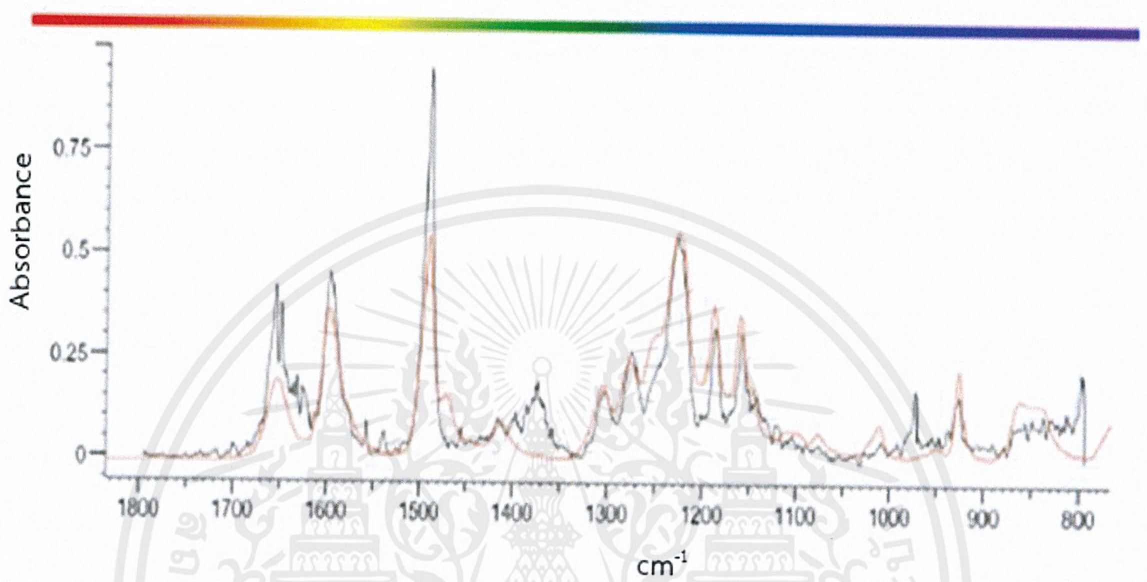


Figure 4.7 Infrared spectral of new type contamination matching with database.

Figure 4.7 shows good spectral matching of infrared spectral of new type contamination with the slider tray. The slider tray is specific equipment that used to pack up sliders in the cleaning process at slider section. Therefore, the section area of new type contamination problem was identified by this results.

The cleaning process has many cleaning units that clean difference contamination by difference method. The next step will show Identification of a problem unit for new type contamination.

4.2 Identification of a problem unit results.

The cleaning process has three cleaning machine units including brushing cleaning machine, ultrasonic cleaning machine, and ultrasonic cleaning machine with solvent. Moreover, this section area has inspection units to check the cleanliness of slider product and reject a contaminated product. The cleaning process of the slider section was shown in Figure 4.8.

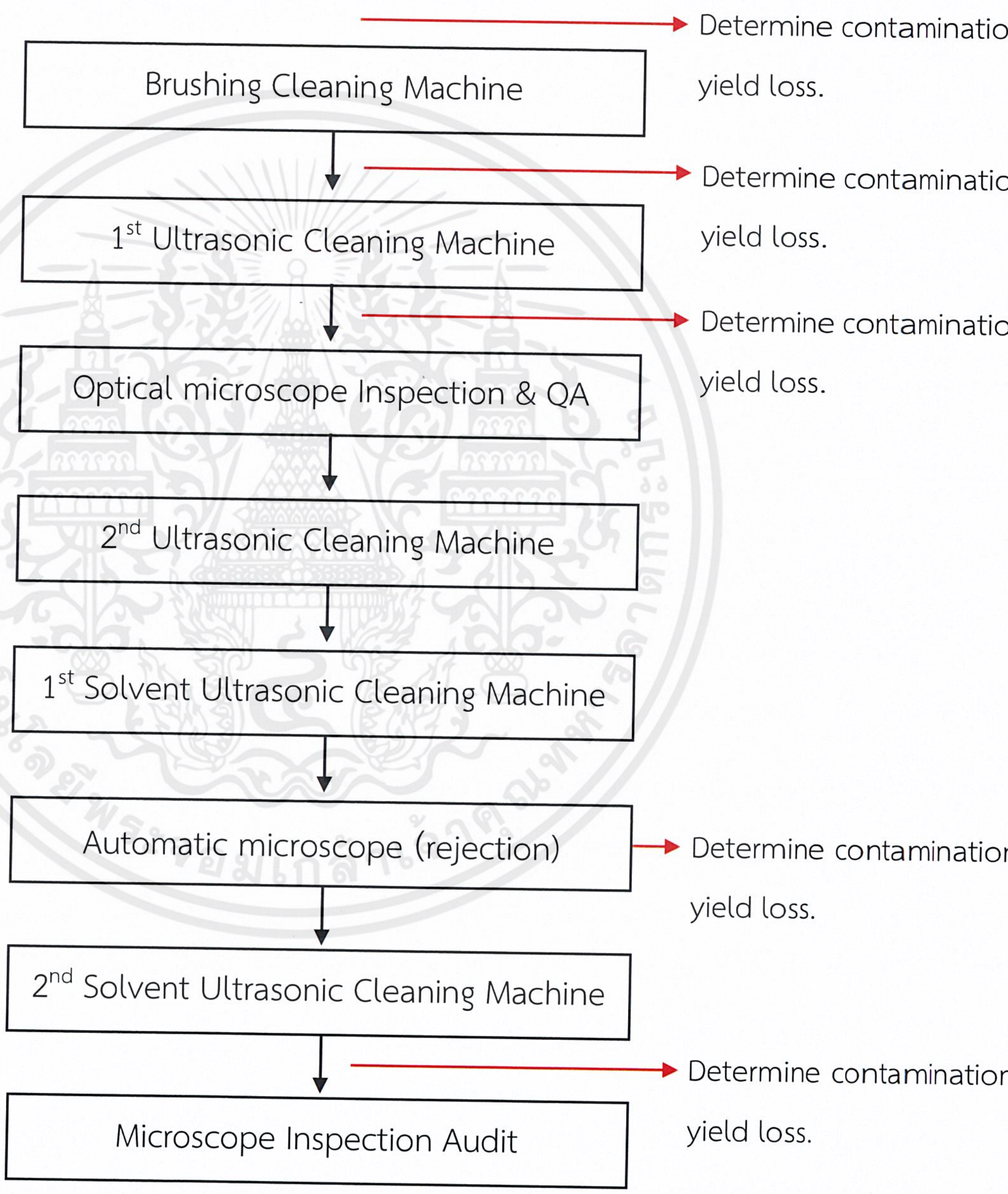


Figure 4.8 Cleaning process of slider section.

To identify a problem unit, the contamination yield loss before and after each units was determined by using optical microscope to inspect a slider sample. The sample size of this experiment is about 5,000 sliders. The Identification of a problem unit results were shown in Figure 4.9.

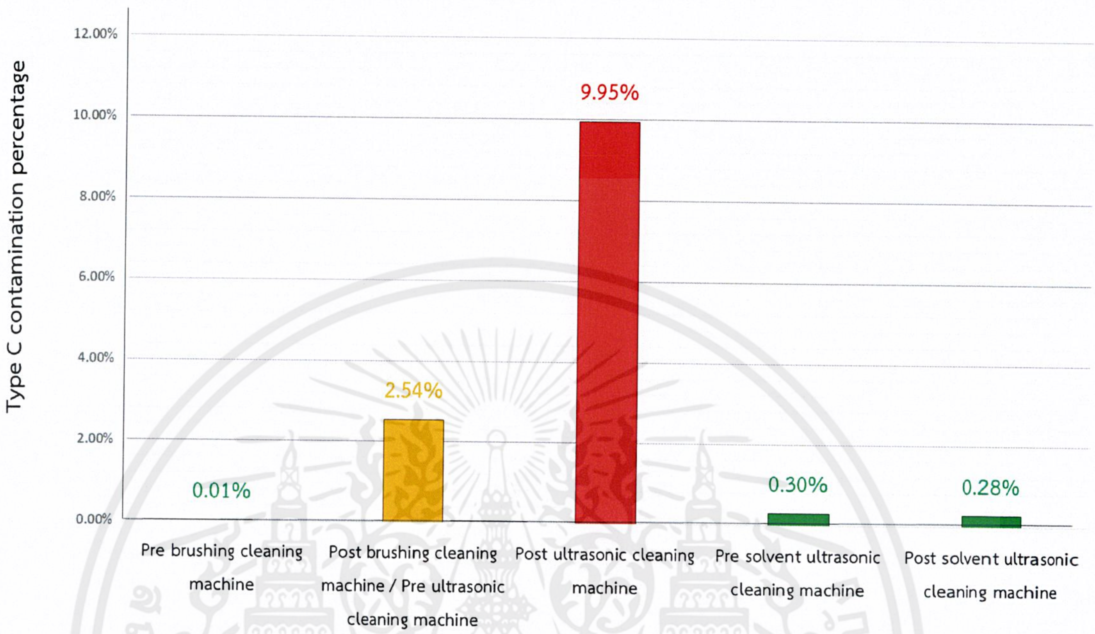


Figure 4.9 Comparison of new type contamination yield loss in cleaning process.

The result show comparison of new type contamination yield loss between each unit in the cleaning process. The new type contamination increase after operates on brushing cleaning machine and greatly increase after operates on ultrasonic cleaning machine about 4 times. After 1st solvent ultrasonic cleaning machine, contamination percentage decreased to 0.30% because this machine uses chemical and sonication to effectively clean. But 0.30% is very high for the specification for only one type of contamination because other old types of contamination still occur. This problem increases an overall contamination yield loss to 0.80-0.90% from 0.5%. This result shows an ultrasonic cleaning machine is a problem unit of this contamination problem, so parameters of this unit machine will be investigated in the next step.

4.3 Identification of problematic operating parameters and evaluation results

This step is to study operating parameters for the ultrasonic cleaning machine to find a root cause of this contamination problem. As the discussion in my team, this problem has two main parameters that affect the increasing of contamination yield loss. The first parameter is the irregularity of the ultrasonic cleaning machine and second is the cleanliness of the slider tray. Both parameters were investigated and evaluated to identify a root cause of the new type contamination problem.

4.3.1 The Irregularity of ultrasonic cleaning machine investigation

After finding the new type contamination, the first parameter that often suspected is Irregularity of problematic machine. Every cleaning machines have a recipe optimization. If some variable in that recipe changed, the performance of the machine will decrease. Key process input variable of this machine including ultrasonic power, ultrasonic time, circulation system, temperature, and concentration of surfactant. Variables were checked back for 1 month, not found any irregularity expect the concentration of surfactant because this machine does not have a concentration measure instrument. Moreover, other variables were controlled by cleaning recipe but the concentration of surfactant was controlled by the employee. They have to control the concentration of surfactant periodically. After a study, the concentration of surfactant can be measured indirectly by measuring solution conductivity and convert back to concentration using the calibration curve. At starting a shift, a surfactant was filled into a wash tank in until reached the controlled conductivity. When the machine is operated continuously, the surfactant concentration will decrease because a part of surfactant has splashed out while moving the product to another wash tank. For our hypothesis, the decreasing of surfactant concentration causes more rubbing between the slider tray and the slider product, thus causing the new type contamination problem.

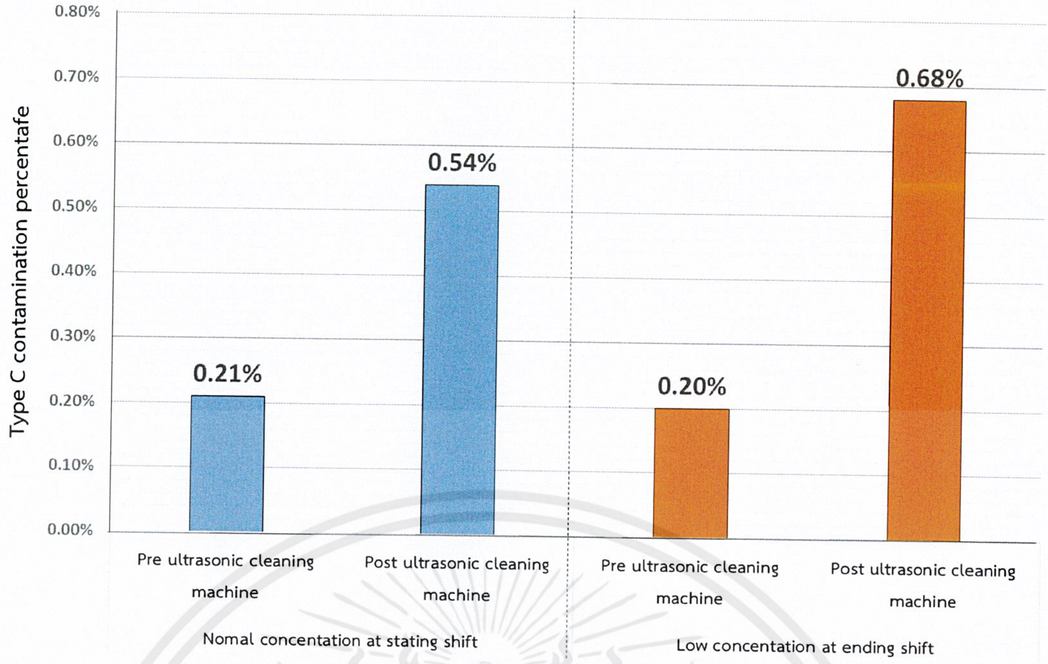


Figure 4.10 The comparison of the new type contamination yield loss between normal and low concentration.

Figure 4.10 shows the comparison of the new type contamination yield loss between normal and low concentration. Moreover, this experiment operates on the ultrasonic cleaning machine at Teparak plant (Bangkok) with the same recipe because of the need to compare the performance of both machines too. From a result, contamination yield loss on the machine at Teparak is lower than Korat because of slider product capacity on Korat was higher than Teparak. The slider product capacity was effected to an amount of contamination on a wash tank that fell out of the slider product, so the cleaning performance was decreased. But both machines have also the same trend for increasing of new type contamination. After operating on ultrasonic cleaning machine, contamination was increased about 0.33% for normal concentration and 0.48% for low concentration. This result shows the effect of decreasing of surfactant concentration is insignificant for this problem because both groups are comparable contamination yield loss after operating in the ultrasonic cleaning machine. From this evaluation, the Irregularity of ultrasonic cleaning machine is not a root cause of the new type contamination problem. Consequently, cleanliness of the slider tray is a next parameter that was investigated.

4.3.2 Slider tray cleanliness investigation

The previous results show the decreasing of surfactant is not the main parameter of this problem, so another factor that is the cleanliness of the slider tray was investigated and evaluated. In May-June 2018, Seagate Korat plant received an old slider tray from Teparak storage that not controlled humidity, temperature, and cleanliness. So, this factor may be a once of a root cause of the new type contamination problem.

The first step of this investigation is the slider tray surface inspection by an optical microscope. Inspection results show that some trays surface are different from the normal tray as shown in Figure 4.11. It looks rough around a pore and likely to be frayed which may be a cause of this problem due to some material of tray be frayed out on slider surface and was heavily rubbed by a cover tray. Moreover, a rough surface increases a rubbing between a slider product and slider tray. It was called rough tray and other trays that do not have this surface problem, called smooth tray.

(a) (b)

Figure 4.11 Surface of tray by optical microscope (a) Smooth tray and (b) Rough tray.

From inspection, rough trays that tend to affect the cleanliness of the slider product. Then, a slider tray that used in the production line was sampled and separated to two groups including rough tray and smooth tray for liquid particle counting analysis. This analysis is used to measure the distribution and size of particles in a liquid or on a solid sample. The particle size is measured and the amount of particles present in each size range is determined. This evaluation is a comparison of the cleanliness of a tray between a rough and smooth tray by a liquid particle counter that was shown in Table 4.1.

Table 4.1 Comparison of a number of particles between the rough tray and smooth tray.

Condition of tray	Number of tray	Particle/cm² (>0.3μm)	Average particle /cm²
Rough tray	1	2575	2708
	2	3293	
	3	2967	
	4	2485	
	5	2219	
Smooth tray	1	1613	1622
	2	1648	
	3	1486	
	4	1472	
	5	1899	

The results show the average particle of rough tray group was higher than smooth tray about 1.67 times according to our hypothesis. Therefore, the rough tray decreases the performance of ultrasonic cleaning machine because of a rough surface around a pore of slider tray causing a rubbing between a slider tray and slider product, and a part of tray material was frayed out on a slider surface. Next step is an evaluation to confirm that the rough tray affects to increase of contamination yield loss.

Next evaluation is the comparison of contamination yield loss between rough and smooth tray in each contamination mode including the old type, and new type. For this evaluation, a slider product sample was inspected by researcher, not an automatic microscope causing contamination percentage was higher due to the human sight can detect a new type contamination that near edge of a slider better than an automatic microscope machine.

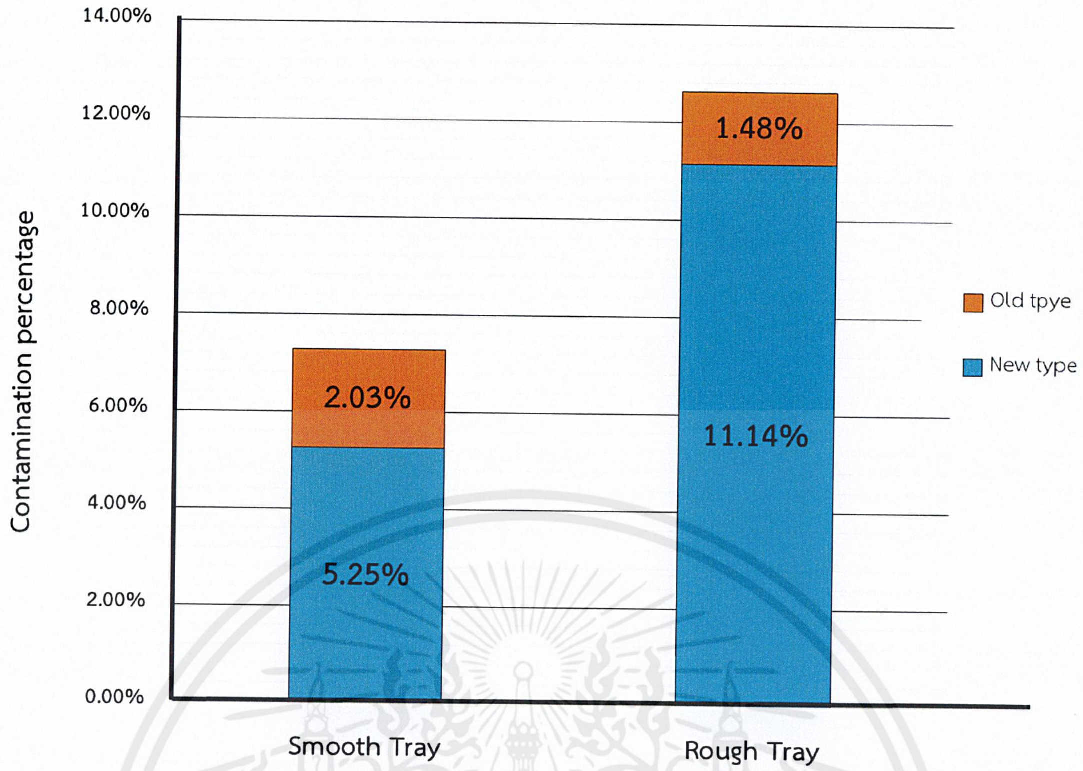


Figure 4.12 The comparison of contamination yield loss between rough and smooth tray.

From Figure 4.12, the new type contamination is a majority contamination mode of both groups. For rough tray group, there is more new type contamination percentage than smooth tray group 2 times. If ignored a new type contamination, both groups are comparable. Therefore, the rough tray effected to increase contamination yield loss by increasing a new type contamination yield loss. Then, it is the reason that rough tray group has more overall contamination yield loss than smooth tray group about 5.34%.

According to the results, the cleanliness of slider tray is one variable that effect to increase a new type contamination yield loss. But not at all, it has other variables that increase new type contamination also because the smooth tray group that not has a rough surface also has the new type contamination too. Therefore, our team has to investigate other parameters that affect an increase of a contamination yield loss continuously in order to solve this problem permanently, but it out of the scope of work for this project.

4.4 Implementation results

All of the results show that the tray cleanliness is one important variable that effects to increasing of contamination yield loss, so the tray cleanliness problem was solved first. The rough tray was separated from production line by year of production. From the investigation, almost all rough tray was produced in 2010, thus it can scan a tray barcode to be able to know a year of production and separate a rough tray from the production line. Seagate has ordered the new tray to replace the old tray that had a problem to prevent the shortage of slider trays. Moreover, every tray in production line was inspected by an optical microscope for making sure that a tray has no a surface or other problems before used. After these actions, the overall contamination yield loss was decreased from 0.9% to baseline that about 0.5%. But not only this action that decreased this contamination yield loss problem, there are other actions from other projects such as cleaning machine recipe improvement, and alternative flow improvement also.

CHAPTER V

CONCLUSION

5.1 Conclusion

In June 2018, contamination yield loss of slider product was increased from 0.5% to 0.9%, causing the additional cost of re-cleaning a slider product. The objectives of this project are to investigate a root cause and decrease a contamination yield loss problem in Seagate Korat plant to saving operation cost by using a chemical engineering knowledge.

First, the contaminated slider was randomly inspected by an optical microscope. The majority contamination mode is a new type that never seen before, called new type contamination. Next step, defect sample was analyzed by infrared spectroscopy and the result shows a good spectral matching infrared database for the slider tray that used in the cleaning process at the slider section. Then, every cleaning machines were investigated by comparison a contamination yield loss before and after operating in each machine to identify a problem unit. The results show an ultrasonic cleaning machine is a problem unit of new type contamination because after operating a contamination yield loss greatly increases from 2.54% to 9.95%. The key process input variable of this machine was investigated, and the result shows no problem of cleaning recipe for this machine, then a slider tray cleanliness was focused and investigated in the next step. After that, a slider tray was randomly inspected for check a surface of the tray and found a rough surface around a pole for the tray that produced on 2010. Rough tray and smooth tray were analyzed by liquid particle counter in order to compare cleanliness of both trays. The result shows a rough tray has an average particle of 2708 particles per square centimeter more than a smooth tray with only 1622 particles per square centimeter. Therefore, the contamination yield loss of both group was compared to make sure that the rough tray increases a contamination yield loss. The result shows rough tray group has overall contamination yield loss of 12.62% including 11.14% of new type and 1.48% of old type and the contamination yield loss of smooth tray is 7.28% including 5.25% of new type and 2.03% of old type. This result shows a rough tray is one variable that increases a new type contamination yield loss causing contamination problem.

Finally, the rough tray was separated out from the production line by scanning a tray barcode to screen a rough tray that almost all produced on 2010. Moreover, every tray in production line was inspected by an optical microscope for making sure that a tray has no a surface or other problems before used. After these actions, the contamination yield loss decreased from 0.9% to baseline of 0.5%.

5.2 Recommendation

The cleanliness of slider tray is one variable that affected to increase of contamination yield loss. But it not only one variable because of the contamination yield loss comparison between the rough tray and smooth tray in Figure 4.12 shows the new type contamination can occur in both groups. Then, this problem has other variables which affect the increasing of the new type contamination that needs to be searched continuously to prevent this problem from occurring again.

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