The Management of Equipment Aging In the Manufactoring Industry

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Chapter1. Abstract

Mechanical equipment is an indispensable weapon for the survival and development of enterprises. Only first-class machinery and equipment can produce first-class products and create first-class income. Through effective equipment management and maintenance. In order to ensure that the equipment is in good condition,and complete the task with the least investment in equipment.

For the biggest production task, achieving the production requirements, seeking the best economic benefits, and ensuring the realization of the short-term and long-term profit goals of the enterprise. In the fierce market competition, how to scientifically supervise, use, detect, prevent and protect machinery and equipment is not only necessary condition for maintaining simple reproduction, but also extremely important for improving the economic benefits of enterprises.

However, with time, production environment, improper operation, etc., equipment aging is inevitable. The aging of equipment will seriously affect the safety of machinery and factories. I will start from the classification of aging and aging, combined with the case study of China Semiconductor H Company, to explain the strategies and research adopted by mechanical aging at all levels. With the rapid industrial development, how to prolong the aging of machinery and equipment, reduce business losses, and improve workers' safety is a topic that we always need to study.

Chapter 2. About AGING

2.1 What's the aging

From [1] i know: The ageing of mechanical structures can be defined as partial or total loss of their capacity to achieve the purpose for which they were constructed a slow, progressive and irreversible process that occurs over a period of time. Aging can lead to changes in engineering properties and may affect the static and dynamic responses, structural resistance/capacity, failure mode, and location of failure initiation. The ageing effects may impact the ability of mechanical system to withstand various challenges from operation, environment, and natural events.

2.2 Classification of aging

After consulting a lot of literature, I found aging of mechanical equipment can be divided into two forms: physical aging and invisible aging.

Physical aging refers to mechanical equipment and parts in the process of use, storage or idle, due to friction and wear, deformation, impact vibration, fatigue, fracture, corrosion, etc., the physical form of the machine changes, accuracy is reduced, and performance deteriorates.

Physical damage caused by mechanical equipment in operation is the first type of tangible aging. Generally manifested in: 1. The original size and even shape of the parts have changed. 2. The nature of the tolerance fit between the parts has changed and the accuracy is reduced. 3. The parts are damaged.

The first type of physical aging can be divided into normal aging and abnormal aging according to its nature. The former refers to the inevitable aging that occurs under normal conditions of use. The latter refers to a type of aging that can be avoided under normal circumstances. For example, mechanical friction and wear are inevitable aging. Under normal conditions of use, wear is slow, which is normal aging. For normal aging, we should try to slow down the rate of its generation and development process.

On the contrary, if rapid wear or catastrophic wear is caused by other reasons, it is abnormal wear and will cause abnormal aging. For abnormal aging, various measures should be taken to eliminate its root causes and conditions. The first type of physical aging is related to use time and strength.

Due to the action of natural forces, deformation, metal corrosion, material aging and deterioration caused by the process of storage and idle are the second tangible aging. The second type of physical aging is related to idle time and storage status.

Continuous improvement of design, selection of durable materials, improvement of parts processing accuracy, increased structural reliability, correct use, timely maintenance, reasonable storage, and the adoption of advanced repair techniques will slow down the development process of tangible aging. Technological progress is often associated with increasing speed, pressure, load, and temperature, which will aggravate the physical aging of machinery. When the machine ages to a certain degree, its use value decreases and its use cost increases. To eliminate tangible aging, it can be restored by repair, and the repair cost should be less than the value written on the new machine. When the tangible aging reaches the mechanical loss of working ability, and its function cannot be restored through maintenance, it is necessary to replace the original machinery with a new one.

When mechanical equipment is in use or idle, the value of mechanical equipment is lost due to non-natural forces and non-use. The aging phenomenon that is invisible in the physical form is called invisible aging or economic aging. Invisible aging is divided into two forms: 1. Due to scientific and technological progress, the production rate has increased, the labor cost has been reduced, the production process has been improved, and the production scale has been increased. Although the technical structure and economic performance of the mechanical equipment have not changed, the reproduction The phenomenon that the price of this kind of machinery decreases and its value depreciates is called the first invisible aging. 2.Due to the continuous emergence of new mechanical equipment with more reasonable structure, better technical performance, higher efficiency, and better economic benefits, it is the economic aging caused by the original machinery that appears to be outdated in technology and backward in function (the value of the original machinery is relatively reduced). As the second invisible aging. Invisible aging is the result of the development of social productivity. The faster the aging, the faster the technological progress. Therefore, for invisible aging , we cannot prevent it. Instead, we should study its laws to make the machinery put into use as soon as possible after purchase, increase the utilization rate, create more value during the economic life, and achieve higher economic benefits.

Chapter 3 Mechanical aging phenomenon in Industry

3.1 Thermal aging on cables

From the literature [21] and [22] ,i know that there are two main forms of aging of rubber and plastic insulation parts of mechanical equipment, which can be divided into two types: thermal oxidative aging and electrical aging. The thermal oxygen aging of the insulating parts of mechanical equipment means that the oil of the insulating parts of mechanical equipment is exposed to light, heat, electromagnetic fields and various aging that occurs under the action of metal.The principle is to treat oxygen molecules as unsaturated compounds can directly use molecules (hydrocarbon molecules) combined with oxidizing substances to form peroxides without being decomposed into atoms. They are very unstable and have stronger oxidizing energy, which can further oxidize other substances that are difficult to oxidize.

The research on the prediction of insulation aging and life assessment of mechanical equipment keeps the safe operation of mechanical equipment and improve its economic benefits. Therefore, it is necessary to regularly determine the degree of aging of the insulating paper to grasp the service life of the mechanical design equipment, so that it can be replaced at an appropriate time to ensure safe production and achieve the best economic benefits. Currently, insulation degradation diagnosis systems or most mechanical equipment evaluation methods are used to detect insulation caused by medium, thermal or mechanical shock. The degree of aging of the limbic system. As the insulating material of mechanical equipment is in the process of thermal aging, a large amount of mixed gas, oil, furfural, etc. will be produced. Therefore, it is not enough to rely on a single method in insulation aging analysis. Usually, there is only one diagnostic method that cannot detect the defect.

From the literature [23] and [24] i learn that the influence of thermal aging on high voltage DC cables and mechanical properties.

As a clean, efficient and fast-transmitting secondary energy source, electric energy has played a very important role in the development of human society. The production and life of modern society are closely related to electric energy. Electric energy has the characteristic that it cannot be stored in large quantities. The generation and use of the converted electric energy are synchronous, and the goal of power grid operation is to ensure low-loss transmission of electric energy and pursue better power quality.

There are many reasons for the aging of cable insulation materials, which can be specifically divided into: thermal aging, mechanical aging, voltage aging, contaminant aging, water aging, and overload aging. Most of the cable aging mechanism takes the form of temperature increase of the insulating material. The temperature increase accelerates the chemical reaction rate of the insulating medium and also accelerates the insulation degradation process caused by other aging factors.

Thermal single-factor aging method. Thermal aging refers to an aging method that increases the ambient temperature during aging of the aging test sample to accelerate the aging rate. The essence of thermal aging is the slow chemical reaction of the insulating material when it is heated, which will affect the structure and composition of the insulating material, and this chemical change is unidirectional, so thermal aging is irreversible. The structure and composition of the insulating material determine the degree of thermal aging, but generally speaking, as the reaction temperature increases, the speed of the chemical reaction will increase and the degree of thermal aging will deepen.For XLPE insulated cables, thermal aging will have an aging effect on the electrical and mechanical properties of the cable. Specifically, thermal aging will affect the crystalline form of cross-linked polyethylene. At lower temperatures, thermal aging will increase the size of the cross-linked polyethylene and further improve its crystalline form; but at higher temperatures, thermal aging will separate the crystal structure of cross-linked polyethylene, reduce crystallinity, and reduce the crystallinity of the cross-linked polyethylene. The crystal size becomes smaller, destroying its crystal morphology. Thermal aging will affect the molecular structure.

There are many heat aging methods for cross-linked polyethylene. As far as the experimental materials are concerned, it can be divided into the aging of a section of the cable, the aging of the cable slices and the aging of a single cross-linked polyethylene of the cable insulation material; As far as the sample placement method is concerned, it can be divided into overall placement aging, horizontal placement aging of slices, and suspension placement aging of slices; in terms of heat aging temperature, there are aging temperatures and temperature gradients ranging from 80°C to 160°C; in terms of insulating materials The types can be divided into DC cables and AC cables. In terms of voltage levels, there are cables ranging from 1kV to 100kV.

3.2Aging for for turbofan engine components

The effect of component deterioration on engine performance is considerable . This influence can not be easily computed with normal engine steady performance computer program . A new mathematical method and computer program were developed to accurately compute the effect of component deterioration on engine performance .【27】Firstly, the mechanisms of the effect of component deterioration on engine performance were analyzed； then statistical method was used to calculate this influence . Taking a turbofan engine as an example， the effect of component deterioration on engine performance, such as specific fuel consumption and temperature at turbine inlet was computed with this method, and compared with experimental data . The results indicate that the mathematical model in this paper can be used to compute the effect of component deterioration on engine performance .

The performance aging of engine components originates from a variety of reasons, including gas path corrosion, increased seal clearance due to wear, and changes in the appearance and surface finish of moving and stationary blades. Generally, these changes are caused by corrosion, foreign object damage, and repair of certain parts. In order to explain the problem more clearly, the following takes the aging of high-pressure compressor components as an example, from which we can understand the reasons for the aging of engine performance in detail.

The three main reasons for the performance loss of the high-pressure compressor can be summarized as follows: (1) the change of the rotor blade tip clearance; (2) the rough airfoil surface; (3) Airfoil profile corrosion.

From[28]we can know that :

(1) The change of rotor blade tip clearance: the change of tip clearance

Mainly due to: ①The unstable operation of the aircraft/engine causes the formation of channels in the wearable friction zone; ②The corrosion of the friction zone; ③The shortening of the blades. When the engine is used for a short time, there will be no corrosion on the blades and friction belts. However, when the engine is designed, it is allowed to cooperate with a predetermined friction, so that a channel is formed between the blade and the friction belt. In the mid-stage of use, although the effect of friction on the depth of the channel becomes smaller, the relative depth of the channel decreases, but the blade and the walls before and after the tip of the blade begin to corrode, and the gap between the blade and the wall increases. For a longer period of use, blade corrosion and channel corrosion occupy the main position. Further corrosion will shorten the blade, and the wall surface corrosion will also reach the point where the channel disappears, and the total gap will further increase.

(2) Surface roughness: Due to the accumulation of pits and dust, the surface finish of the blade changes. Pratt & Whitney measures new and used parts of an engine. According to the measurement results, the surface roughness change trend cannot be observed after more than 2 000 flight cycles, while the surface roughness increases rapidly within 2000 flight cycles. At the same time, it is also noticed that the effect of surface roughness on airfoil loss is a function of airfoil chord length and Reynolds number. With the increase of roughness/chord length, the influence of

surface roughness on airfoil loss increases. As the Reynolds number increases, the influence of surface roughness on the airfoil loss decreases.

(3) Airfoil corrosion: The corrosion of the airfoil along the chord length of the high-pressure compressor rotor blade mainly occurs on the surface close to 50% of the rim, and the surface close to the hub 50% has very little corrosion. In addition, the corrosion of stator blades and rotor blades are different. When the stator blades of the high-pressure compressor have a small number of flight cycles, the airfoil corrosion will basically not cause the loss of the shape of the blade. This effect is only in the case of a large number of flight cycles. Will appear. From the statistical data of the JT9D engine, it can be seen that corrosion of the stator blades only occurs when the number of flight cycles is greater than 5,400, and the rotor blades always have corrosion, so it can be concluded that within a certain number of flight cycles, The corrosion of stator blades is not the main cause of compressor performance aging, but the external corrosion of rotor blades is the main cause of performance aging.

Chapter 4 Analysis of equipment aging in nuclear power plant

4.1. Research on aging mechanism

From [27],[28],[29] we can know that the aging of structures, systems and components (SSC) refers to the general process in which their physical properties gradually change over time or use. It is a complex process that begins when the parts or structures are formed and transitions through the entire nuclear plant lifespan. The aging of nuclear power plant system equipment will lead to the destruction of defense-in-depth defects, an increase in the probability of component abnormalities, and a series of safety issues such as common cause failures.

The methods and implementation steps of aging management should establish a set of appropriate aging management methods.

All issues related to or interacting with long-term power plant operation strategies should be evaluated for safety to ensure that the safety performance of nuclear power plants is not impaired. In addition, when evaluating the impact of aging mechanisms on equipment or components, the following two aspects should be considered.

One is the factors that may cause failures under normal conditions; the other is the factors that may cause failures under accident conditions.[29]

The process should consist of three steps:

(1) Screen the important safety equipment that needs aging management;

(2) Understand the main aging mechanism of the selected equipment, determine and develop effective and practical methods to monitor and slow down the aging of the equipment, that is, conduct aging management research on the selected equipment;

(3) Adopt appropriate aging management activities, that is, effectively implement monitoring and mitigating equipment aging methods in supervision, maintenance and operation to control the aging degradation of selected equipment.

The aging management of nuclear power plant equipment should first determine the equipment that aging management focuses on.Providing the screening process (see Figure 1), and fully considers nuclear power plant related systems, equipment design requirements, material characteristics, and systems. Or the impact of equipment failure on safety and the status since operation, the screening is divided into three steps: system screening, system-level screening, and equipment-level screening.

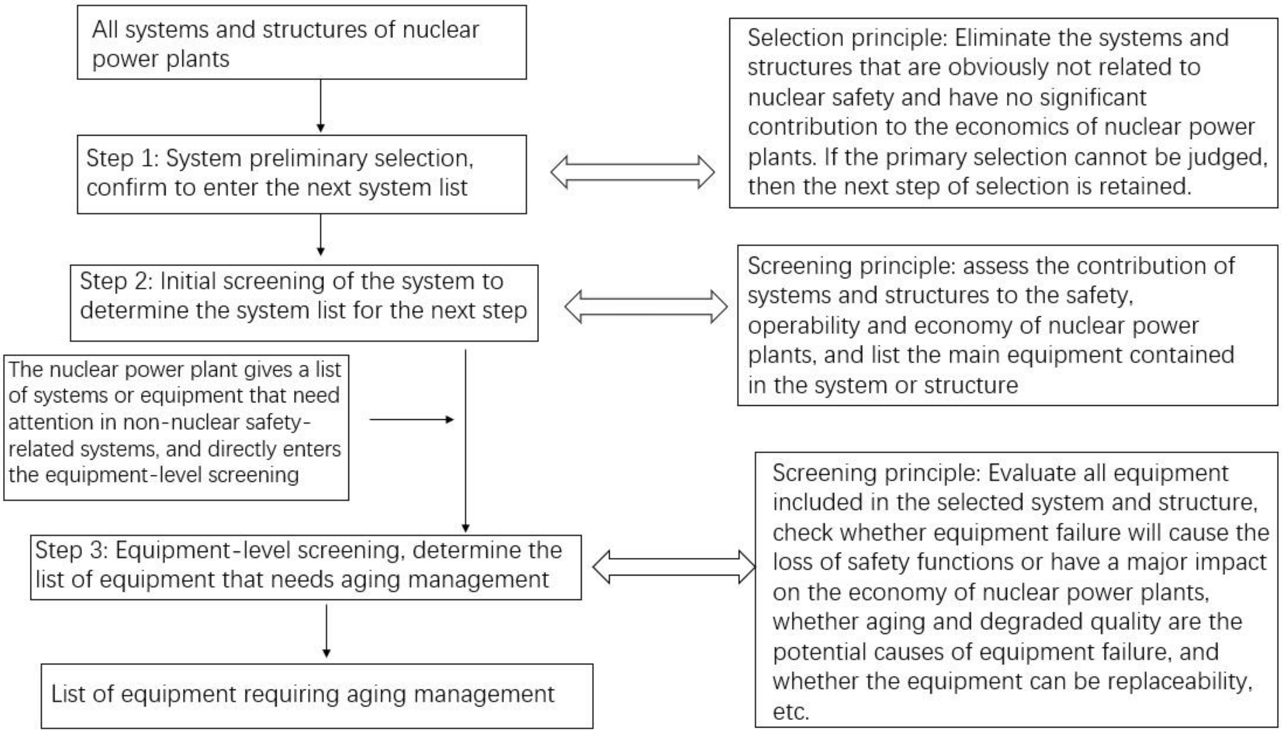


Figure 1

The system-level screening of PWR nuclear power plants involves hundreds of structures and systems of PWR nuclear power plants. Some of these equipment are contained in some structures and systems, such as reactor plant equipment gates, containment penetrations, etc. Some equipment, such as instrument control cables, are difficult to classify as a system during system screening. Therefore, the screening of cables will be carried out during equipment-level screening. The screening of non-safety important equipment will be carried out directly at the equipment-level screening based on the list of equipment requiring attention provided by the relevant departments of the nuclear power plant. After the equipment screening is completed, a list of recommended equipment is formed based on the actual examples and experience feedback of the equipment screening of nuclear power plants at home and abroad. The nuclear power plant then reviews and supplements according to the operating experience and actual conditions, and gives a number of equipment requiring special attention.

Taking Qinshan Nuclear Power Plant as an example, Qinshan Nuclear Power Plant conducted a preliminary screening of 384 systems and found 68 systems that require further system-level screening. After equipment-level screening, 16 devices that require aging management were finally obtained, including reactor pressure vessels, Steam generators, regulator wave tubes, reactor internals, regulators, main pumps, main pipes, cables, containment and concrete structures near the reactor cavity, control rod drive mechanisms, and reactor coolant systems cannot isolate stagnant branches Management topic, steam turbine, main transformer system, 20KV closed separated phase bus, spent fuel storage pool.

The description of the aging mechanism of the equipment that needs aging management should be based on the full analysis of the equipment structure, main design parameters, specifications and standards followed by the design, structural materials, equipment manufacturing, installation, commissioning, operation, maintenance records, etc. On the basis of the screening, we should focus on studying it.

Through visual inspection, field test, laboratory test, inspection and supervision data and other methods, the safety status of structural components is evaluated to obtain the results of aging mechanism analysis, so as to determine whether to take remedial measures and whether to continue service.

Establishing a complete data collection and record keeping system is one of the important contents of nuclear power plant aging management activities, which provides a guarantee for the effective development of systematic aging management. The aging management of nuclear power plants depends to a large extent on whether the data collection and record management system is perfect, and the data management is good.

The damage directly affects the effectiveness of aging management.

The database should include at least the following three types of information:

(1) Original data: Reflect the conditions in the design, manufacturing, installation, and commissioning stages;

(2) Operating data: Reflected in operating conditions, usability tests and actual results;

(3) Maintenance data: Reflected in monitoring and maintenance status.

The aging mechanism analysis is based on the collection of equipment design, manufacturing, installation, commissioning, operation, in-service inspection and maintenance and other data information, combined with existing theoretical knowledge and operating experience, and determined from the basic components such as equipment components and parts The root cause of equipment aging.

The aging mechanism of mechanical equipment mainly includes corrosion, fatigue, embrittlement, abrasion, and concrete degradation. Specific aging mechanisms include radiation embrittlement, radiation swelling, thermal aging, stress corrosion cracking, and intergranular stress corrosion cracking.

Drawing lessons from domestic and foreign experience, summarizing the degradation mechanism related to the aging of reactor pressure vessel components, the main points are:

(1)Irradiation embrittlement; (2) Thermal aging; (3) Tempering ; (4) Fatigue; (5) Corrosion; (6) Abrasion. The most important aging degradation mechanism for the core area of the reactor pressure vessel barrel is irradiation embrittlement.

To slow down equipment aging, fatigue aging can be relieved by reducing transient events during operation, water chemical conditions can be controlled to alleviate corrosion, and stress corrosion cracking can be relieved by surface treatment.

Take the method of reducing the embrittlement of the reactor pressure vessel as an example. The main method is to reduce the neutron fluence from the beginning of operation. This will extend the time for the critical neutron fluence of the reactor pressure vessel to reach, thereby prolonging the reactor pressure vessel's capacity. life. The use of fake fuel elements and low neutron leakage loading mode can reduce the neutron fluence, but at the same time it will also reduce the power generation.

If the embrittlement of the reactor pressure vessel has reached the limit allowed by the design, reducing the neutron fluence will not contribute to the operation or prolonging the life of the nuclear power plant. The only way is to perform thermal annealing to restore the mechanical properties of the reactor pressure vessel.

4.2 Aging management organization and division of labor

Nuclear power plants shall establish an aging management program, which shall ensure timely detection and mitigation of significant aging of systems, structures and components important to the safe and reliable operation of nuclear power plants, so as to maintain their structural integrity and functionality, so as to ensure the continued safety and reliability of nuclear power plants.

The nuclear power plant shall set up a special department for centralized management, and full-time personnel shall be engaged in this work. As the aging management work continues to deepen, the form, scale, authorization, and work methods of the aging management organization need to be adjusted and improved according to the situation.

The IAEA [29]proposed an organizational model for aging management:

(1) Nuclear power plant managers: responsible for promoting the implementation of the aging management program in nuclear power plants;

(2) The aging management program group: coordinate the relevant programs and procedures, evaluate and optimize the effectiveness of the aging management program;

(3) Aging management project team: Carry out aging assessment for specific issues;

(4) External collaboration unit: Provide aging management and evaluation related services and establish corresponding standards;

(5) Nuclear power plant implementing department: implement aging management measures.

IAEA has promoted a set of systematic aging management methods, the core of which is to strengthen and improve various management program procedures for nuclear power plants, and use a general aging management program that covers the main aspects of nuclear power plants to regulate daily operations Various activities, such as inspection, maintenance, etc., make these activities reflect the requirements of aging management, emphasizing the division and coordination of various organizations related to aging management, that is, the PDCA (Plan-Do-CheckAct) cycle.

Developed during the full review, the functions provided by SGAMDB

Mainly include the following aspects:

(1) Daily management and maintenance of data;

(2) Diversified data query and display methods;

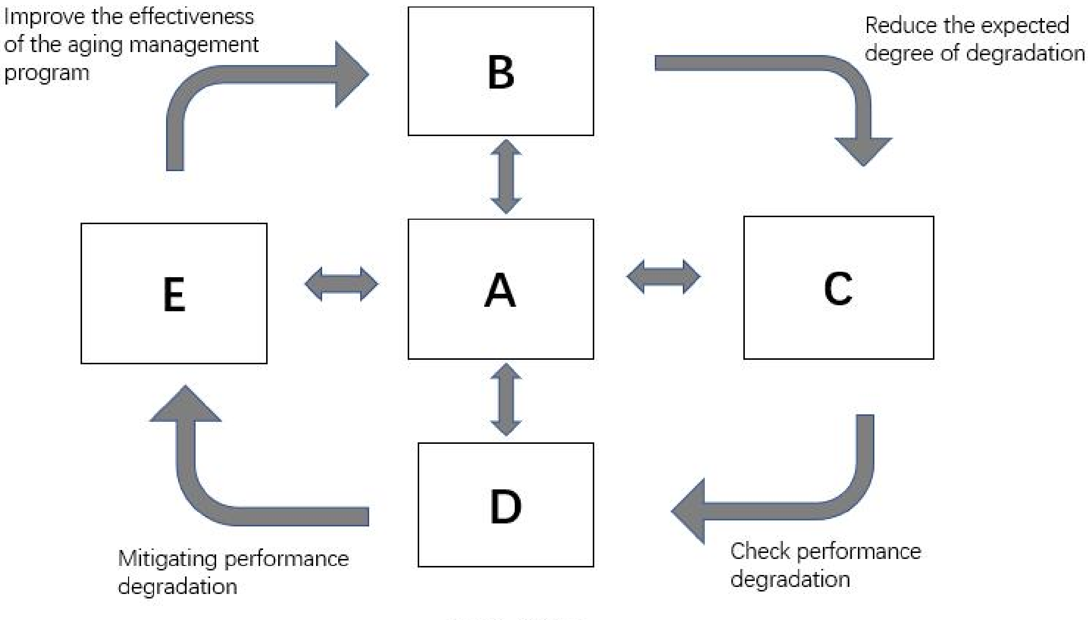
(3) Preliminary sorting of data, providing simple trends

Analysis and basic calculations;

(4) Provide aging analysis and evaluation interface;

5) The management function of the database.

SGAMDB serves SG aging management. The scope of its data collection is based on the needs of SG aging management, and strives to achieve completeness and accuracy.



PDGA CYCLE

Including part A:

For the understanding of the aging of structures/components, the key to effective aging management lies in:

1.Material and material properties, manufacturing method

2.Sources of stress and operating conditions

3.Aging mechanism

4.Deterioration of the foundation

5.Consequences of aging deterioration and failure

6.research report

7.Operating experience

8.Inspection/monitoring/maintenance records

9.Ways to eliminate harmful consequences

10.Current state

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Chapter 5 Strategies of the management of aging

5.1 Management technology case of chemical machinery and equipment

From [30] ,we can know that in the chemical production process, mechanical facilities will wear out during long-term operation. The phenomenon will affect the operating efficiency of the machine. Therefore, the lubrication management of mechanical facilities is important. Need to start lubrication management from the following aspects:

(1) Pay attention to the reasonable choice of lubricants. In the selection process, the technicians should make the selection based on the working characteristics of the mechanical facilities.

(2) Pay attention to the management of lubricants. When managing lubricants, it is necessary to establish corresponding responsible departments and improve corresponding management systems. The lubrication composition system includes the following departments, such as the supply department, the inspection department, etc., which have certain responsibility for the management of lubricants. The supply department is responsible for fulfilling its responsibilities in the procurement process, such as ensuring that the quality of the lubricating oil purchased by itself is qualified; the testing department is responsible for checking the oil information. In addition, it is necessary to do a good job in technical management of information resources. It is also necessary to

conduct regular inspections on the lubrication of mechanical facilities, and solve the problems in the lubrication system in a timely manner.

Chemical machinery may be corroded during long-term use, which requires technicians to pay attention to the anti-corrosion management of machinery. Specifically, we can start from the following aspects:

(1) Design stage. Generally speaking, if there is a problem in the design, it will inevitably have an adverse effect on the corrosion of the machine. Therefore, in order to prevent problems in the production process, it is necessary to pay attention to the analysis of various influencing factors in the design process. First, it is necessary to clarify the material of the facility based on the environment of the medium. In the selection of the material, it is necessary to analyze the heat preservation and compositeness of the material. Second, we must comprehensively analyze the partial corrosion situation and pay attention to the structural design of the facility. In the design process, the appearance of gaps is inevitable. However, in order to avoid the phenomenon of solution penetration, the gaps must be welded.

(2) Production stage. When designing mechanical equipment, designers need to carry out work according to corresponding regulations. In the process of feeding materials, designers need to conduct a comprehensive monitoring of all information, and then do a good job of recording and managing the materials, and regularly review the materials. In the

production process, the welding technology is more critical, and fast welding must be done. After the welding is completed, it must be cooled in time.

(3) Application stage. In the application of mechanical facilities, it is bound to come into contact with some corrosive media. In addition, in high temperature, high pressure and other environments, mechanical facilities are more susceptible to corrosion, which requires the management of mechanical facilities to pay attention to the inspection of the performance of the equipment and facilities, and to regularly inspect the mechanical equipment. In this way, Fang can have an understanding of the corrosion status of the facility

In the management process of chemical machinery and equipment, the routine maintenance of equipment is an important part of it. It contains the following aspects: (1) Routine inspection before class. (2) During the shift, the maintenance staff need to work according to the corresponding maintenance regulations, monitor the operating status of the equipment, and inspect the installation of the equipment to see if it meets the requirements. (3) After shifts or before holidays, maintenance workers need to clean the machinery and equipment comprehensively, and do a good job handover .During the work process, if a problem is found, the staff needs to eliminate it in time. If the problem is more serious, it must be reported immediately to ensure the cleanliness and safety of the mechanical equipment. Its specific work content includes the following points: (1) Testing the safety of the equipment, such as testing the stopper of the equipment, testing the protection device of the equipment, and checking whether it meets the requirements. (2) Check the lubrication condition of the facility.(3) Detect the looseness or fall-off of the equipment.

5.2 Maintenance of machinery and equipment

From [31],[32] i learn that The primary maintenance of the equipment is also called monthly maintenance, that is, the maintenance work is carried out on a monthly or quarterly basis. This maintenance refers to the need for comprehensive maintenance of the equipment if a certain period of time is reached during the operation of the mechanical equipment. After the first-level maintenance is carried out, it is necessary to carry out acceptance and evaluation according to the working conditions of the technicians, and the relevant staff shall make the equipment maintenance records. The main contents are:

(1) According to the application situation of the equipment, monitor and clean the disassembly of the equipment.

(2) Not only need to carry out routine maintenance, but also adjust the fit gap between the equipment, such as fixing the loose part of the

screw in the equipment.

(3) Clean the filter or other dust-proof facilities in the equipment, and use this measure to ensure that the pipeline is unobstructed.

(4) Check some important electrical control units in the equipment. If the components in the equipment are defective, they need to be replaced in time. This maintenance measure can effectively reduce the loss of mechanical equipment, thereby increasing the service life of the equipment. The first-level maintenance has a long time interval, usually a two-shift system, which is once a quarter. Of course, the maintenance time can be carried out according to the actual situation.

This maintenance is also called annual maintenance, which mainly includes the following aspects of work: (1) Complete all the contents of the first-level maintenance. Then, according to the use of mechanical equipment, the equipment is decomposed and inspected. (2) Make corrections to the parts with large losses in the equipment, and provide information for the next maintenance work. (3) Maintenance workers need to clean the oil tank, water tank, etc., and replace the oil and water in them. (4) Perform a comprehensive test on all electrodes in the equipment to ensure that the electrical circuits in the equipment are effective. (5) Detect the precision items in the equipment.

Chapter 6 OEE Theory

The overall equipment efficiency (OEE) theory is a brand-new measurement method of advanced equipment effectiveness. This theory was originally produced in the context of the Japanese industry's promotion of Total Productive Maintenance (TPM).From [2] i know that TPM's concerns mainly include how to eliminate 16 major losses that affect production efficiency, including 6 major losses that affect equipment effectiveness: shutdown losses (unplanned Maintenance shutdown), mold change loss or engineering debugging loss, minor shutdown loss (temporary shutdown, production is not smooth or equipment jam), speed loss, start-up loss, defective product loss (rework or scrap). The overall equipment efficiency (OEE) was originally used to determine how much of the loss in a manufacturing company was due to equipment-related issues.And where did these losses occur. The overall equipment efficiency (OEE) theory can relatively accurately determine the 6 major losses of equipment and divide the 6 major losses into 4 categories, so that manufacturing companies can use OEE theory to analyze their own problems and propose effective solutions. Programs, these 4 categories include: Availability Efficiency, Operational Efficiency, Rate Efficiency and Quality Efficiency, where the product of the product of the operational utilization rate and the production rate is the equipment performance efficiency. Therefore, in the overall equipment theory, from [3] i know that there are three key performance indicators (1) equipment availability (2) equipment performance efficiency (3) product qualification rate

Now,OEE is defined as a true and effective test measurement method for all aspects of equipment efficiency.

From [8].After various semiconductor manufacturers have successfully promoted the OEE theory, more and more international companies have gradually come into contact and introduced the OEE theory into various industries such as beverages, medical treatment, and steel.

As we all know, this is very expensive for strategic capital equipment and corresponding TIU in the semiconductor assembly and test (ATM) industry. The most important thing is that with the upgrading of semiconductor products more and more, due to market demand, the corresponding TIU upgrades are also very fast. Therefore, how to improve the efficiency and capacity of ATM equipment has become one of the most important research fields. Therefore, how to effectively measure, control and improve the capabilities of equipment is one of the focuses of all semiconductor manufacturers. In order to measure, control and measure the efficiency of semiconductor company equipment, SEMI (Semiconductor

Equipment and Materials International) has developed a specification, namely SEMI E79. In this specification, OEE (Overall Equipment Effectiveness) is introduced to measure equipment efficiency. This efficiency can meet the current requirements of the semiconductor industry and make up for the shortcomings of traditional measurement methods. This is why specifications can become very important in the semiconductor industry. popular. This is the actual situation of the aging module in the production of H company.

In the mid-1990s, the United States gradually introduced OEE theory into the semiconductor industry, and thus created the SEIM-E79 specification. In this specification, OEE is defined as a true and effective test measurement method for all aspects of equipment efficiency.The full name of SEMI is Semiconductor Equipment and Materials International.From [4]i know that the SEMI is a global industry association whose purpose is to promote integrated circuits and displays.And the overall development of the industrial chain such as solar photovoltaic. The SEMI standard is an international standard specification independently formulated by the association. The specification assists semiconductor companies worldwide to reduce the cost of semiconductor manufacturing, packaging and testing, while also helping to protect the freedom of the global market. SEMI specifications apply to chips in the semiconductor industry.In the process of manufacturing, packaging and testing equipment, the SEMI Association and SEMI specifications play a very important role in the promotion of integrated circuit solutions and the realization of electronics.From [5] Among all SEMI specifications, there are two specifications that are closely related to this paper, one is SEMI-E10, and the other is SEMI-E79. SEMI-E10 is a set of definitions and measurement standards for the integration of reliability, availability, and maintainability of semiconductor equipment, which is known as RAM. It also provides a common language for semiconductor equipment manufacturers to anticipate semiconductor equipment users to track the performance of semiconductor equipment and establish Industry benchmark. In SEMI-E10, semiconductor equipment is used as a research target. For example, the time (generally scheduled schedule week, 168 hours is a week) is divided into three categories: (1) Equipment Up Time (Equipment Up Time, the total time that the equipment is performing well and theoretically available) (2) The equipment is down Time (Equipment Down Time, equipment active maintenance time and equipment failure down time) and (3) equipment auxiliary down time (such as holidays, etc.). The difference between the equipment downtime and the equipment auxiliary downtime is that the former is the active maintenance downtime of the semiconductor equipment users or the equipment. For the time that the failure cannot be used for production, this time shows the performance of the equipment itself. The shorter the equipment's qia time, the better the maintenance of the equipment and the smaller the probability of failure. The latter is due to equipment downtime caused by holidays or non-equipment problems such as water and electricity.

The performance of the semiconductor device has nothing to do with it. No matter whether the time is long or short, it cannot explain whether the performance of the semiconductor device itself is good or bad.From[6]i search these information and get the following summaries. These three types of time make up 168 hours of the entire calendar week, and these three types of time can be subdivided as follows:The theoretical available time of equipment is divided into effective production time (Productive Time, this time is the time that semiconductor equipment is actually used for production), idle waiting time (Standby Time, this time is due to insufficient personnel, insufficient spare parts or insufficient production raw materials, resulting in equipment idle Waiting time), Engineering Time, the equipment performance is good, but due to engineers doing experiments on the equipment, the equipment can not run production time. Equipment downtime can be divided into scheduled equipment downtime (Schedule Down Time, proactive preventive maintenance or die change time) and equipment unscheduled down time (Unscheduled Down Time, the time the equipment cannot be used for production due to equipment failure)).

Equipment auxiliary downtime. This time has nothing to do with the performance of the equipment itself. It is mainly due to holidays or water and electricity issues that cause the equipment to fail to produce normally. In general, the Model of the Industrial Engineering Department (IE) does not specifically indicate the auxiliary downtime of the equipment, because this situation is relatively small, so 168 hours in a calendar week can simply be equal to the equipment The sum of theoretical available time and device down time. That is, 168 hours in a calendar week = theoretical equipment availability (Availability) + down time (Down Time), and equipment theoretical availability (Availability) = production availability target time (Goal Utilization + Gap, and Gap = Idle Time or Standby Time + Engineering Time)

In a certain company's packaging and testing aging test equipment, according to the IE model, the company's aging test equipment theoretically can be used for 96% of the time (96% of the time in a week is theoretically available for production). The downtime was 4%, including 1.9% of planned downtime and 2.1% of downtime. In 96% of the theoretically available time, the actual production available target time is 93%. The other 3% difference is mainly 1% engineering time and 2% idle waiting time, as shown in the table:

	MOR
AVAILABILITY TIME	96.00%
DOWNTIME	4.00%
SDT TIME	1.90%
USDT TIME	2.10%
MTBF	7
MTTR	0.38
IDLING TIME %	2%
EE TIME%	1%
GU%	93%

In OEE theory, there are mainly three percentage systems multiplied to obtain, The three percentages are: (1) Availability Efficiency,

(2) Equipment performance efficiency

(3) Product qualification efficience, and the second parameter

equipment performance = Operational efficiency x Productivity Efficiency

From [7] i know that for the three key performance indicators defined by E79 (1)equipment availability, (2) equipment performance efficiency (Performance Efficiency), (3) qualified product rate), the corresponding indicators can be found in E10. The equipment availability efficiency loss defined by E79 is the non-Scheduled Time defined by E10, scheduled downtime, and unscheduled downtime. sum.

The equipment performance loss (Performance Efficiency Loss) defined in E79 is the product of the engineering time and equipment idle waiting time defined in E10. Among them, the sum of engineering time and equipment idle time is equal to the loss of operating efficiency, because when the equipment is available, manufacturing enterprises have problems such as insufficient personnel and insufficient raw materials due to operation and management reasons, which causes the equipment to be unable to be used for production.

The starting point of SEMI's release of this set of specifications is to propose a complete system and calculation method, so that semiconductor equipment suppliers and customers can use a common language to measure the true effective utilization of semiconductor equipment, or to measure the effective output of semiconductor equipment per unit time. Because the fact that semiconductor equipment is expensive determines the semiconductor. Manufacturers must think about a problem, how to maximize the effective utilization of existing equipment, only semiconductor manufacturers can maximize the effective utilization of the development of equipment, in order to enable enterprises to reduce costs and increase revenue.

From [9] i know that OEE can make a comprehensive measurement of the operating efficiency of a piece of equipment, an assembly line or the entire manufacturing plant. That is to say, OEE can reflect the impact of production equipment management on the efficiency of equipment for different research objects, and it has become various The industry's internationally accepted standards and norms, and the most important thing is that through the theoretical analysis of OEE, you can get how much loss you have in the manufacturing process, and where each loss occurs, so that manufacturers can continuously improve labor productivity and labor. Productivity provides a guide to increase productivity and productivity, optimize productivity, and reduce costs.

From [10] In the SEMI-E79 specification, OEE is defined in detail as a set of independent measurement tools used to measure the ratio of the actual production capacity of the manufacturing company to the theoretical production capacity. The manufacturing company can also use OEE analysis to find out where in the production link There are losses, how many losses, and from this, you can formulate corresponding solutions to further improve the effective utilization of equipment. To deeply understand the concepts and calculation formulas of OEE theory, it is necessary to understand the three key performance indicators in OEE theory: 1) Availability Efficiency, 2) Performance Efficiency, and 3) Quality Efficiency.

Availability Efficiency: The part of the time (or ratio) that the equipment can be used to run production. During this time, the equipment is normal and trouble-free, so it is also called Up Time.

Equipment Availability Efficiency = Equipment Uptime)/ Total Time

Performance Efficiency, when the equipment is UP (available for production) Inside, the actual output produced by the equipment under theoretical efficiency. Performance Efficiency = Operational Efficiency x Rate Efficiency. Among them, Operational Efficiency refers to the time that the equipment is actually used for production during the time that the equipment is available. During the time the equipment is up, part of the time is that the equipment cannot be used for production due to lack of personnel and materials. Time is the loss of operational efficiency. Operational Efficiency) = Production Time / Equipment Uptime.

And Rate Efficiency refers to the actual output of the equipment in a specified time, that is, how many units are actually produced. For semiconductor manufacturers, it is how many units are actually produced within the specified time. Rate Efficiency=Theoretical Production Time for Actual Units/Production Time. Quality Efficiency refers to the effective output in the specified output, and the effective output refers to the output that fully meets the normal process requirements and quality requirements. The invalid output is also the output of the equipment, but the products of the invalid output are either scrap products or products that need to be reprocessed. This invalid output takes up the time of the equipment but does not bring any benefits to the enterprise.
The calculation formula of Efficiency is Quality Efficiency = Theoretical Production Time for Effective Units/ Theoretical Production time for Actual Units

The OEE is equal to the product of the above three key performance indicators (percentages), namely: Overall Equipment Efficiency (OEE) = Theoretical Production Time for Effective Units /

Total Time = Availability Efficiency x Performance Efficiency x Quality Efficiency = Availability Efficiency x Operational Efficiency x Rate Efficiency x Quality Efficiency.

From [11] i know that OEE defines six types of losses, which correspond to the three key performance indicators of OEE loss of equipment availability corresponding to equipment availability, including equipment auxiliary downtime, failure downtime and planned downtime (planned overhaul or mold change); performance efficiency loss corresponding to performance efficiency, including equipment idle Waiting time (equipment idling due to lack of personnel or materials), equipment minor failure time (generally less than 6 minutes crash minor failure, Assistant); and the qualified product rate loss corresponding to the qualified product rate, including production of scrap products Scape) time and the time to produce products that need to be reworked (Rework).

From [12] among them:

Availability Efficiency= T1 / T

Performance Efficiency = T2 / T1

Quality Efficiency= T3 / T1

therefore:

Overall Equipment Efficiency (OEE) = Availability Efficiency x Performance Efficiency x Quality Efficiency) = (T1 / T) x (T2 / T1) x (T3 / T2) = T3 / T

Therefore, from the above formula, it can be seen that the overall equipment efficiency is not only determined by the available time of the equipment, or the operating time of the equipment, but also by the actual available time, performance efficiency and qualified product rate of the equipment. Three key performance parameters ultimately determine the overall equipment efficiency.

7.CASE STUDY :Overall Equipment Aging Chinese SEMI Company

7.1 what is H company

Packaging and Testing H company is a factory mainly engaged in computer management and chip set packaging and testing. The main products of H company are the packaging and testing of the microprocessor (CPU) and the Chipset and part of the wafer pre-processing. In the process of introducing new products, burn-in equipment encountered a big bottleneck problem-that is, there is a big gap between the actual production capacity of burn-in equipment and the expected production capacity, and the company is in the process of introducing new products According to the forecasted production capacity, it will purchase corresponding equipment, test interface modules and other valuables. In addition, the supply period of these equipment and test interface modules is generally more than one quarter, even if the company is willing to invest heavily in the purchase. Corresponding equipment and test interface modules are not too late in time. In this case, Company H is likely to extend the delivery period of new products to customers due to insufficient capacity of existing burn-in test equipment. In the early stage of trial production, the project team predicted a huge gap between actual effective production capacity and theoretically predicted production capacity through small batch trial production. First, let me summarize and introduce the microprocessor packaging and testing process of the company :

Hierarchical testing is due to the expensive test equipment, test interface module (TIU) and the longest test time, leading to the largest unit product test cost. Therefore, the hierarchical test is defined as the bottleneck (Constraint Module) of the whole line during the factory design. In the process of new production of microprocessors, it was discovered that the hierarchical test module was not the real bottleneck module in the introduction of new products. The real bottleneck module was burn-in equipment (Burn-In Equipment). There is a huge gap in the capacity of the IE budget. Therefore, Company H is very likely to extend the delivery period of new products due to the problem of the capacity of the aging test equipment, and the greater impact is that the main customer of the new product is Company P. Company P is also the main source of company H's profits. For its own reasons, it is necessary to extend the originally promised delivery period, which will not only have a huge impact on the cooperation between Company H and Company P, but will also cause huge losses to the profits of Company H this year.

The aging test equipment of H company adopts the self-heating aging test equipment of W company, as shown in the figure1-1 below. The aging test equipment can be divided into a robot (Handler) part and a test module (Chamber) part. The test module (Chamber) part can be divided into 32 independent slots, each of which corresponds to a burn-in test board (Burn-In-Board, in the burn-in test module, the test interface module TIU is also called the burn-in test board).), each aging test board generally has several test sockets (Socket). For the old products, each burn-in board (Burn-In-Board) has 18 test sockets (Socket), which means that each burn-in test device can theoretically test 580 chips at the same time, but due to the complexity of the new product The degree of increase, resulting in each burn-in test board (Burn-In-Board) needs to contain more components, so that each burn-in test board (Burn-In-Board) can accommodate sockets (Socket) from 18 At 14, the number of chips that can theoretically be tested at the same time for each burn-in test equipment has been reduced from 580 to 450. This is a great loss to the utilization rate of the equipment, which is equivalent to the reduction in the number of test sockets (Socket), which makes the theoretical Design capacity has been reduced by 22%.

Figure 1-1 the self-heating aging test equipment

During the trial production of new microprocessor products by Company H, the actual effective output was calculated by the Industrial Engineering Department (IE) (only the effective output per unit time was measured, and the output of waste and defective products was not included). There is a 42% gap between the effective output and the theoretical design effective output. It should be noted that the actual OEE is not simply equal to 1 – 42% = 58%. This is because the industrial engineering model (IE Model) has already dealt with the difference The parameter estimates a certain theoretical target loss value. Therefore, the actual OEE will be smaller than 58%, that is, the effective run rate loss (Effective Run Rate) will be greater than the 42% loss. The working group responded to the problems of the aging test module in the process of introducing new microprocessor products in a timely manner. It united the representatives of the testing department, industrial engineering department, manufacturing department, product department and other departments to collect a large amount of data, and used OEE theory to analyze In terms of the three losses of the new microprocessor products in the aging test module, corresponding strategies can be formulated to reduce or even eliminate these three losses, and finally supply customers on time and in quantity, and avoid investing more capital allocation.

7.2 Aging Problems about H Company

The loss of qualified product rate in the aging test equipment is the first key performance indicator that needs to be discussed, because the rework rate of the new product is as high as 30% within 2 weeks of trial production of the new product. Among the sites in the entire test area, only the burn-in test site has the highest chip temperature (up to 135 degrees Celsius) and the longest test time (up to 168 hours) due to the need to burn-in the product.), which leads to an important task at the burn-in test site, how to control the test temperature of the chip within a specified range. Moreover, there are more sensitive factors for new products. This product has the largest bare chip area and relatively high heat generation. Therefore, in the early stage of new product development, the company's expected goal is the total rework rate (Rework Rate or Klot).) Within 7%, but the actual situation is that the average rework rate of the actual product is as high as 30% during the two weeks of trial production of the new product, as shown in Figure 1-2 below. Due to the high rework rate of the product, it means that about 30% of the chips after the burn-in test need to go back to the burn-in test site for a burn-in test, and the chips that fail the second burn-in test will be directly scrapped. , It also leads to a huge waste of the capacity of the burn-in test site, and the scrapped chips themselves also have production costs.

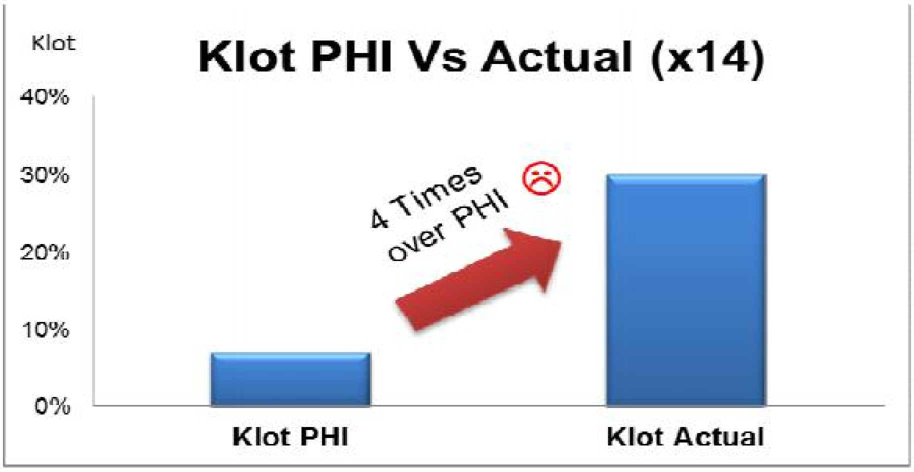


Figure 1-2 Loss and target of new product pass rate before improvement

The expected rework rate lost time is:

121.8 X 2 X 7% = 17.1 hours

And the actual rework rate lost time is

T2 – T3 = 121.8 X 2 X 30% = 73.1 hours,

Where T2 = 121.8 hours, which is the actual utilization time of the equipment (that is, the Actual

Utilization)

Therefore, the effective use time of the equipment and the time of OEE are only T3 = 243.6 – 73.1 = 170.5 hours

7.3 Analysis and strategies on aging problems of H company

I think that Company H adopts a fully automatic data acquisition system, which can automatically collect the time of the equipment in different states, thereby obtaining various indicators of the equipment. From collection data and search extensive literature. [13][14][15]We get the automatic data collection completely refers to the various states defined by SEMI-E10 to record the operation of the equipment. Among them, the 1000 series represents the system is in normal production, the 2000 series represents the equipment in idle waiting state due to various reasons, the 3000 series is the time for engineering debugging (the equipment is normal but due to the engineer's debugging and occupied, so it cannot be used for production), and the 4000 series is the planned The 5000 series is the failure and shutdown series, and the 6000 is the system auxiliary shutdown series.

Industrial Engineering Department (IE) engineers collected data on various statuses of designated equipment for a specific two weeks (14 shifts). The following data uses equipment

The percentages of various states in these two weeks.

Productive-1000 series

Idle Waiting Time (Standby)-2000 Series

Engineering debugging time (Engineering)-3000 series

Scheduled Down Time-4000 Series

Unscheduled Down Time-5000 Series

System Auxiliary Down Time (Non-Scheduled Down Time)-6000 Series

There is also an unknown time (Unknown Time). This time should be zero in principle. The starting point for defining this time is that if a system communication problem may cause the data acquisition system to fail to receive the status of the device, this time is Return to Unknown Time, as i sort data and shown in following Figure： it introduces that before the improvement, the aging test equipment and the state indicators before the improvement

FACTORY	MODULE TYPE	TOOL ENTITY	E10 STATE	WW13.1D	WW13.1N	WW13.2D	WW13.2N	WW13.3D	WW13.3N
CD	BURN-IN	DBI001	ENGINEERING	1.3%	3.1%	4.6%	1.0%	4.0%	0.6%
			NON-SCHEDULED TIME	19.7%	0.0%	0.0%	0.0%	0.0%	0.0%
			PRODUCTIVE	46.8%	56.4%	56.8%	68.5%	70.6%	76.2%
			SCGEDULED DOWNTIME	3.3%	3.5%	1.3%	1.0%	2.0%	1.5%
			STANDBY	19.7%	29.0%	25.7%	19.7%	12.9%	10.5%
			UNKNOWN	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
			UNSCHEDULED DOWNTIME	9.1%	8.0%	11.6%	9.8%	10.4%	11.1%
FACTORY	MODULE TYPE	TOOL ENTITY	E10 STATE	WW13.1D	WW13.1N	WW13.2D	WW13.2N	WW13.3D	WW13.3N
CD	BURN-IN	DBI001	ENGINEERING	0.0%	0.0%	1.7%	1.4%	0.3%	0.0%
			NON-SCHEDULED TIME	2.4%	0.0%	0.0%	1.2%	0.5%	0.0%
			PRODUCTIVE	79.0%	67.7%	68.2%	74.5%	81.0%	82.0%
			SCGEDULED DOWNTIME	0.8%%	1.9%	1.1%	0.7%	1.1%	2.1%

			STANDBY	8.4%	22.2%	21.2%	14.2%	8.9%	7.4%
			UNKNOWN	0.0&	0.0%	0.0%	0.0%	0.0%	0.0%
			UNSCHEDULED DOWNTIME	9.4%	8.2%	7.7%	8.0%	8.1%	8.4%
FACTORY	MODULE TYPE	TOOL ENTITY	E10 STATE	WW13.1D	WW13.1N	WW13.2D	WW13.2N	WW13.3D	WW13.3N
CD	BURN-IN	DBI001	ENGINEERING	1.9%	0.1%	0.0%	1.4%	0.0%	0.0%
			NON-SCHEDULED TIME	0.2%	0.0%	0.0%	0.0%	12.7%	0.7%
			PRODUCTIVE	75.2%	84.0%	95.3%	89.6%	53.1%	67.9%
			SCGEDULED DOWNTIME	1.6%	2.1%	1.0%	0.3%	1.4%	0.6%
			STANDBY	13.4%	5.8%	-3.8%	1.0%	23.3%	21.9%
			UNKNOWN	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			UNSCHEDULED DOWNTIME	7.8%	8.7%	7.4%	7.7%	9.4%	9.0%
FACTORY	MODULE TYPE	TOOL ENTITY	E10 STATE	WW13.1D	WW13.1N	WW13.2D	WW13.2N	WW13.3D	WW13.3N
CD	BURN-IN	DBI001	ENGINEERING	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			NON-SCHEDULED TIME	0.1%	0.8%	6.0%	0.0%	0.0%	0.0%
			PRODUCTIVE	68.0%	72.9%	67.0%	74.7%	68.7%	72.7%
			SCGEDULED DOWNTIME	1.2%	1.0%	1.7%	1.2%	0.9%	1.5%
			STANDBY	22.9%	16.6%	17.2%	15.4%	22.0%	17.5%
			UNKNOWN	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			UNSCHEDULED DOWNTIME	7.9%	8.7%	8.1%	8.7%	8.3%	8.3%

A summary analysis of the above raw data shows that the equipment availability during the two weeks of trial production of the new product is about 88%, that is, Figure 1-4 MA (Machine Availability) in the figure below, which has 88% of the time equipment It can be used to run production, and the other 12% can be regarded as a loss of equipment availability.

The total time of two weeks is

T = 168 x 2 = 336 hours

The available time of the equipment in these two weeks is:

T1 = 336 x 88% = 295.7 hours

That is, the lost time of equipment availability is:

T – T1 = 336 – 295.7 = 40.3 hours

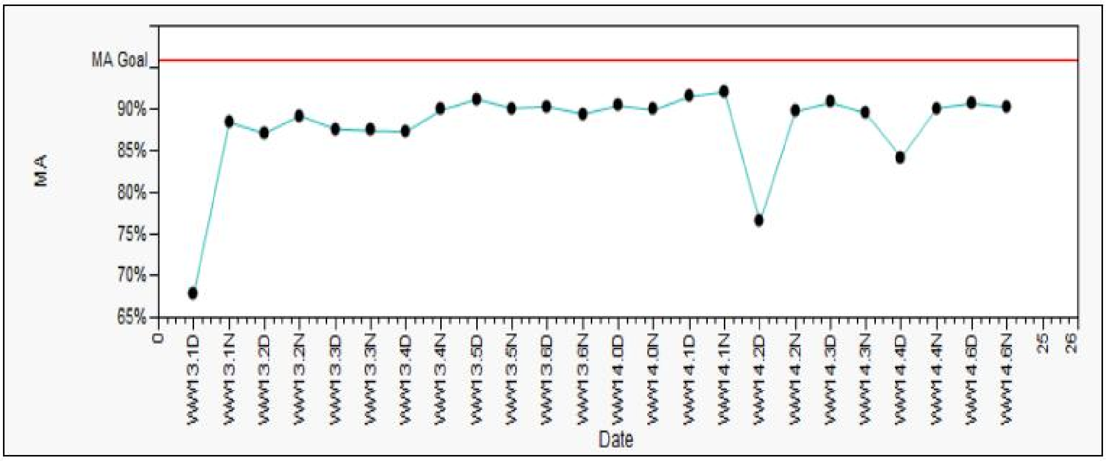


Figure1-4 Trend chart of availability of aging test equipment before improvement

Let me analyze the main source of the 12% equipment availability, that is, the loss of 40.3 hours.

First, from Figure 1-5 below, it can be seen that the average value of equipment failures and downtime in the two weeks is 8.7% (29.2 hours), that is, in terms of the loss of equipment availability, due to the process of equipment operation The crashes caused by various failures in the IE model accounted for 8.7% of the rate. This ratio is still 6.6% away from the 2.1% target value in the industrial engineering model (IE Model). Deal with the solved problem. This involves not only the technology, ability and attitude of the equipment maintenance personnel, but also the coordination and teamwork capabilities of the four shift technicians and the engineering department. After that, I will deal with the failure analysis and solutions to crash problems.

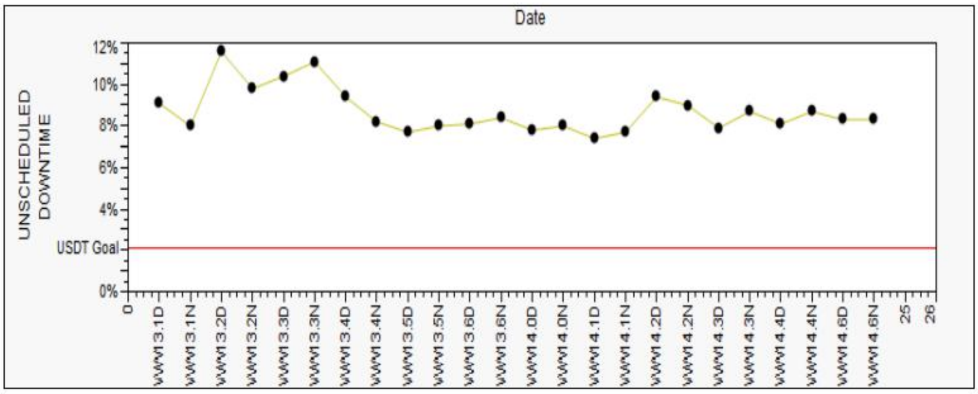


Figure 1-5 Trend chart of failure and downtime of aging test equipment before improvement

Second, in addition to the above two points that will cause the loss of equipment availability, there is also a planned downtime (the time taken for preventive equipment maintenance and mold change, as shown in Figure1-6 Scheduled Time in the figure below) The average value in these two weeks is 1.5%, that is, the planned crash loss is 1.5% (about 5 hours). This value is basically within the target predicted by IE (the target set by IE for this state is 1.9%). The loss of equipment availability caused by planned downtime can be considered to be within the controllable range.

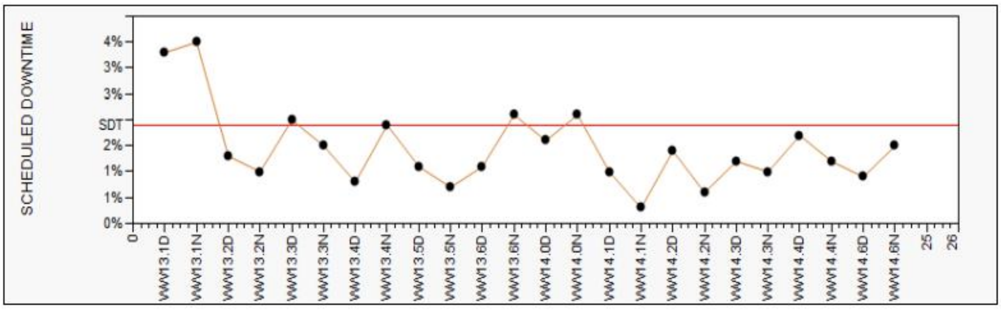


Figure 1-6 The planned warranty shutdown trend chart of the aging test equipment before the improvement

Thirdly, the auxiliary system downtime is the Non-Scheduled Down Time shown in Figure 1-7 below. The real two-week average value accounts for 1.8% (about 6 hours). In the IE prediction model, this part is not It will be put directly in. If it is necessary to stop work during holidays, it will usually be reflected in the capacity model, that is, the capacity of certain shifts is directly deducted from the capacity budget model, which can simplify the IE model.

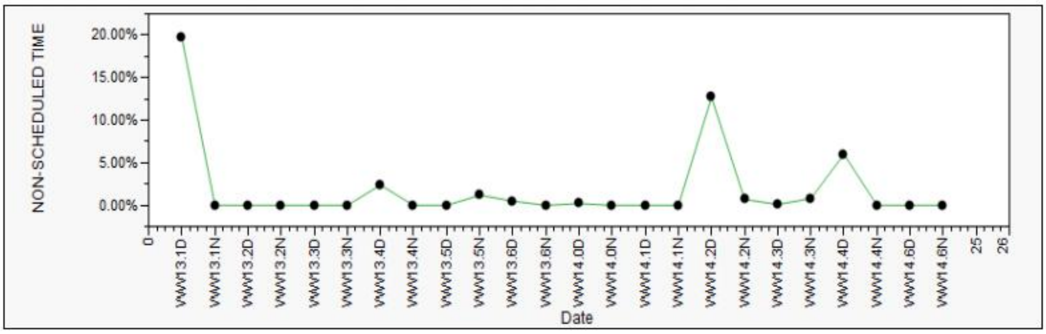


Figure 1-7 Auxiliary shutdown of aging test equipment system before improvement

The above analysis is an overall analysis of equipment availability. An important conclusion can be drawn from the overall analysis: the equipment availability loss is about 12%, most of which are due to equipment failures and crashes. It is that the equipment cannot operate normally due to various reasons of the equipment itself during the normal production process, and equipment technicians or engineers are required to repair it. Therefore, the solution to the problem of low equipment availability lies in how to reduce the impact of equipment crashes due to malfunctions.

From the above analysis, it can be known that the equipment availability during the two weeks of trial production of the new product is 88%, but what is the actual utilization rate of the equipment (the actual utilization rate of the equipment is the time the equipment is actually in production) The parameter in the automation system of company A is the actual utilization of the equipment, that is, AU (Actual Utilization), that is, the Productive time in the figure below is only 72.5% (that is, the equipment in the two weeks of trial production of the new product can be learned from the above analysis During the two weeks of trial production of the new product, the equipment utilization rate was 88%, but what is the actual utilization rate of the equipment (the actual utilization rate of the equipment is the time when the equipment is actually in production). The following parameters are in the automation system of company A The middle is the actual utilization of the equipment, that is, AU (Actual Utilization), that is, the Productive time in the figure below is only 72.5% (that is, the actual utilization time of the equipment in the two weeks of trial production of the new product is 243.6 hours, T2 = 243.6 hours)

then The performance efficiency loss of the equipment is also

T1 – T2 = 295.7 hours – 243.6 hours = 52.1 hours

The equipment performance efficiency loss ratio is:

52.1 / 295.7 = 17.6%

So we need to analyze where the 17.6% performance loss comes from.

First, from Figure 1-9 below, it can be seen that the average time of equipment idle waiting (ie Standby in the figure) in these two weeks is about 15.5% (52 hours), which accounts for the largest proportion of equipment availability loss However, this part of the time is not entirely caused by lack of personnel or spare parts, and the specific reasons need to be analyzed in detail.

But in general, in the process of introducing new products into trial production, a big problem will be encountered because the output itself is not high, which will cause the problem of equipment waiting for the front-end material, and this problem itself is determined by the level of output. In the actual production process, we still need to spend energy to track this parameter. If the expected effect is still not achieved, we need to do a detailed analysis of each different case to find out the main problem and grasp the main problem. Summarize the solution on the basis of the.

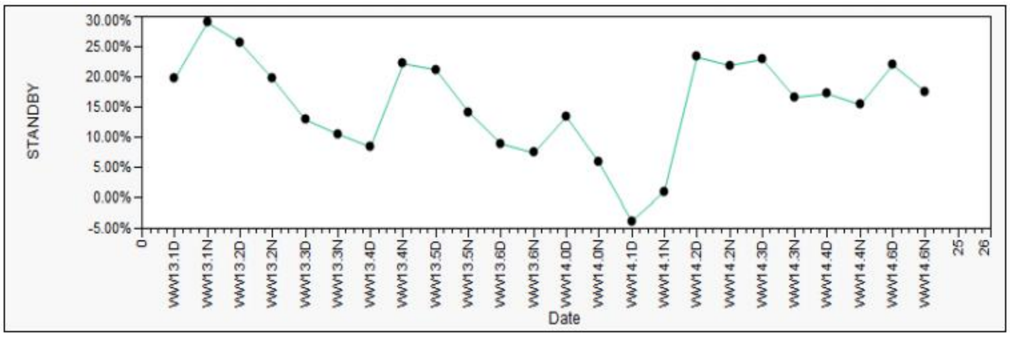


Figure 1-9 Idle waiting trend chart of aging test equipment before improvement

Second, in addition, it can be seen that there is less than 1% of the engineering debugging time, as shown in Figure 1-10 below. This is basically within the target value of the IE model, and considering the process of introducing new products In, the product department and the testing department need to verify the quality and reliability of equipment and new products through a large number of experiments. As the product matures, the actual engineering debugging time required after mass production will be greatly reduced. Therefore, this state is not within the scope of attention.

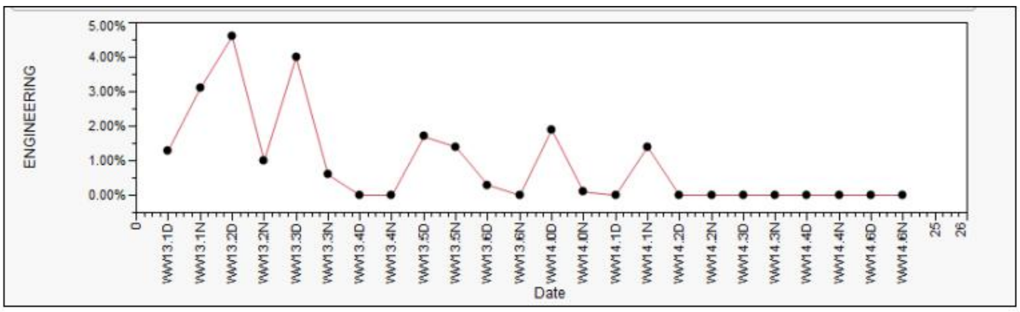


Figure 1-10 Debugging time trend chart of aging test equipment before improvement

From the results of the final analysis, it can be known that the actual utilization rate of the aging test equipment was only an average of 71.5%

since the new product was put into production for two weeks, as shown in Figure 1-11.

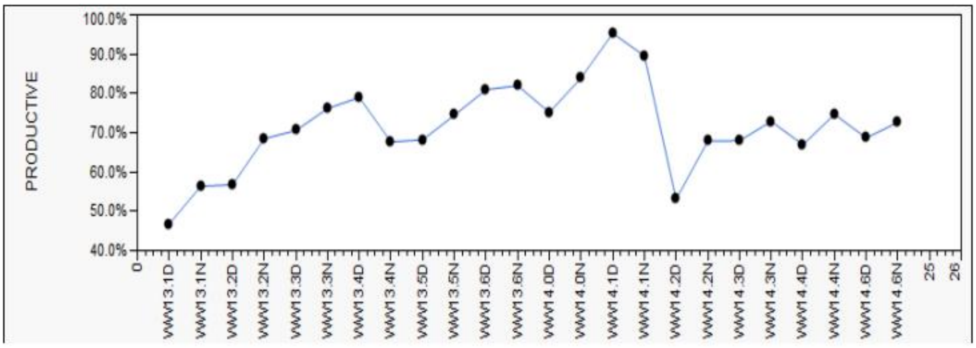


Figure 1-11 Trend chart of actual utilization rate of aging test equipment before improvement

Therefore, in the two weeks of trial production of the new product, the effective production time T3 is only 170.5 hours, that is, the overall equipment efficiency OEE ratio is:

OEE = T3 / T = 170.5 / 336 = 50.8%

Therefore, the overall equipment efficiency is only 50.8% and the overall equipment loss is as high as 49.2%.

In the three key performance indicators of OEE:

(1) Equipment availability (Availability Efficiency)

(2) Equipment performance efficiency (Performance Efficiency)

(3) The analysis of Quality Efficiency and the loss of these three key performance indicators shows that we need to focus on the following three aspects:

First, the problem caused by the high rework rate of the product. The problem of product rework is placed first in the priority position, because the loss of product rework is as high as 30%. This means that up to 30% of the products after the first aging test need to be replaced with the aging test equipment for another aging test. In the second aging test, up to 30% of the products will fail the test, and the products that fail the second aging test will be directly scrapped. Therefore, the high rework rate of the product is not only the burn-in test equipment itself, but also the man-hours of the front-end equipment and the loss of raw materials in the chip manufacturing process.

Second, the failure and crash loss in the loss of equipment availability. In the semiconductor production process, the impact caused by the failure of the machine not only affects the test site, but also has a great impact on the production of the entire line. This is because when the equipment fails and crashes, the most obvious impact is that the production capacity of the equipment itself is greatly affected, and a large amount of manpower and material resources are required to ensure that the equipment can resume production as soon as possible in the process of repairing the equipment. Moreover, in the semiconductor packaging and testing production line, because the process flow involved is more complicated, there are more packaging and testing modules involved, so in the process of packaging and testing production line design, the whole line will be calculated based on the cost-effective production capacity, that is, the cost of producing each chip. Bottleneck module, and then ensure the maximum operating rate of the bottleneck module. If the equipment fails on the production line, it will cause the bottleneck of the production line to be dynamic at different times. In order to ensure a high operating rate of the bottleneck site, more materials (WIP) have to be accumulated at the bottleneck site, which will also cause the actual production cycle of the production line to be higher than the set theoretical production cycle, and also cause the accumulation of raw materials.

Thirdly, the loss caused by equipment idle waiting. This loss is obvious when the output is high enough. The factory invests a lot of money to purchase expensive equipment, but the equipment is idle due to reasons other than the equipment itself, and the idle equipment of this site may cause subsequent visits to other sites. The instability of materials, such as the idleness of the bottleneck site (this will be the biggest loss for the manufacturing factory), the reduction of the production efficiency of the whole line, and the long production cycle of the production line.

Due to the high rework rate of new products, the qualified product rate is one of the key points. In the case of the limited technical capabilities of the packaging and testing factory, H Company promptly sought help from the packaging and testing R&D headquarters to solve the high rework rate in the product trial production process. problem.

The resistance encountered in the process of heat transfer becomes thermal resistance, which reflects the size of the medium or the ability to transfer heat between media, indicating the size of the temperature rise caused by 1 watt of heat, and the unit is °C/W.

There are three ways of heat conduction. The first way is heat conduction. Heat conduction is the transfer of heat from the end of the object with high temperature to the end of the object with low temperature. This method mainly exists between solids and solids; The second method is thermal convection, which only exists between liquids. It is the process of heat transfer caused by the relative displacement of fluids of different temperatures due to the macroscopic motion of the fluid; the third method is thermal radiation, which refers to An object is stimulated by a certain factor. The way in which the object transfers heat outward along a straight line. Among the three temperature transfer processes, the heat conduction method is the most effective for chip control. How to control the temperature in time and effectively is an important topic in the aging test equipment. The aging test mechanism of H company lies in: passing a higher voltage, the chip heats itself during the load process, and then The temperature control module transfers and emits excess heat from the chip itself. However, because the surface of the chip and the surface of the temperature control module seem to be in good contact with the smooth surface, it can be seen under the microscope that there are gaps of different sizes on the surface of the chip and the surface of the temperature control module, which leads to In the process of dissipating and transmitting the excess temperature of the chip, it is not entirely dependent on the most efficient heat conduction method, but between the two contact surfaces is dependent on the gas heat convection and heat radiation in the gap, and these two The ability of the heat transfer method is far less than the heat conduction through the existence of solids. This is the problems of the semiconductor to be avoided during the test.

During the two weeks of trial production of the new product, the aging test equipment had a rework rate of up to 30%, and the bar chart below shows that the biggest influence factor or failure cause is the temperature control problem during the aging test.

The bar chart below (Figure 1-12) shows all the classification information of the new product since it was put into trial production for two weeks.

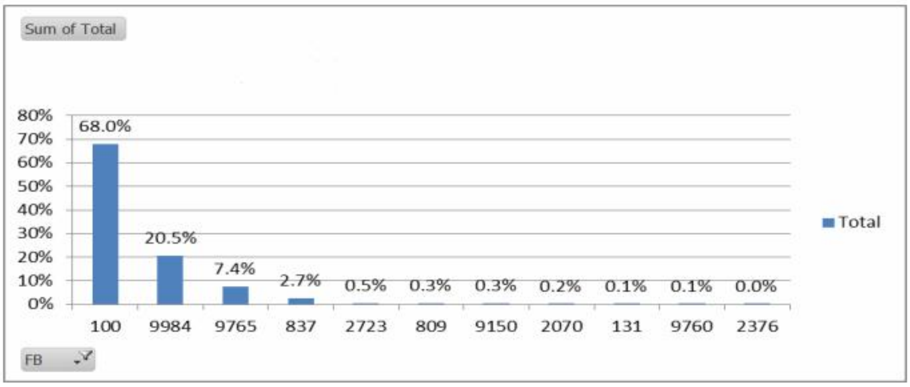


Figure 1-12

Through two sets of different sampling experiment hypothesis tests, it can be known that increasing the pressure and replacing the silicone grease material with better thermal conductivity, CTIM, has greatly improved the quality of the aging test, and after the subsequent mass production results, after the improvement The rate of qualified products in the aging test has increased from 70% to nearly 97%. The comparison effect is very obvious, as shown in Figure 1-13.

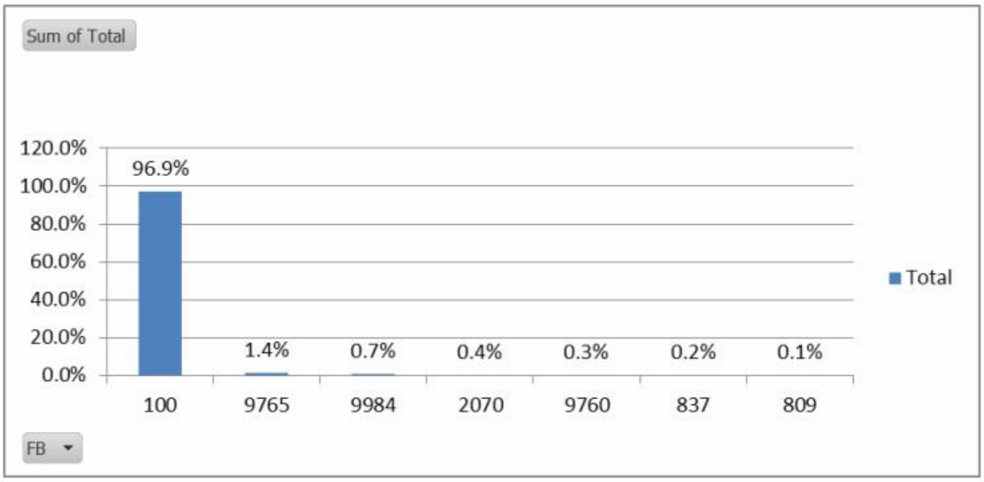


Figure 1-13 Improved histogram of Failure-Bin

Although the problems of qualified products have a great impact, from the perspective of the solutions to the problems, the problems and solutions are relatively simple, because the material of the heat sink is changed from graphite to silicone grease, which increases the pressure of the chip from 15 pounds to After 20 pounds, these two new changes can continue to work, so the yield rate of the product test will not fluctuate too much. So there is no one-time solution for the loss of equipment availability. As the working life of the equipment increases, the components on the equipment also have the problem of aging and failure. Therefore, for the equipment itself, there is also an aging curve. The early stage of the curve is the running-in period of the equipment. Failure; and then to the middle part of the curve, which is the stable period of the equipment. During this period, the probability of equipment failure is greatly reduced; at the back end of the curve, the equipment enters the aging period. During this time, the Many parts and components are gradually aging. Both mechanical parts and electrical parts will encounter the same problems, so the equipment is prone to frequent failures again. This is why there is no permanent loss of equipment availability. The solution, but for how to improve the availability of equipment, it can be continuously updated and improved.

First of all, I think it is necessary to conduct a detailed analysis of the types and causes of equipment failures in order to find the best solution. Firstly, the equipment failures are summarized, simple classification is carried out, detailed analysis is carried out in combination with FMEA and corresponding solutions are developed. After categorizing through FMEA tools, we can use Failure Mode and Effects Analysis (FMEA) to find out which problems need to be solved first and which can be temporarily solved.

The question was shelved. [16]FMEA is a popular analysis tool in the industry. It is actually a combination of failure mode analysis and failure impact analysis. FMEA needs to evaluate and analyze various possible risks and failures, so as to facilitate the use of existing technologies. Based on this, find a solution how to minimize the risk and minimize the frequency of failures. In the analysis of the cause of equipment failure and crash, we transplanted the analysis method of FMEA to equipment failure analysis. The analysis methods and analysis modes adopted are similar to FMEA. Therefore, in the equipment FMEA, through the analysis or prediction of the existing fault data, the corresponding process (RFC) is specified to deal with failures or prevent possible failures. FMEA needs to analyze and predict every possible failure mode, and it needs to analyze the various causes of each failure, and the possible impact if such a failure occurs, the frequency of the failure (empirical data or prediction), if Measures or solutions to be taken when a fault occurs, the difficulty and effectiveness of fault detection, the priority level of the fault, and the final risk level that needs to be calculated through different parameters.

Compared with other analysis models, the biggest advantage of FMEA is that it can not only list all the causes of failure models, but also quantify them according to standard quantitative methods. This quantitative response is the cause of each failure mode. Risk factor, when you encounter problems at work, you can quickly grasp the direction and focus of the work through the quantifiable risk factor, avoiding the contradiction of priority and priority in work.

After roughly locating all the potential causes of the failure and crashing, create a small report through FMEA.The group uses FMEA to quantify all potential causes, that is, the failure mode of the failure, so as to obtain the risk coefficients of all the potential failure modes that caused the failure, and then through the classification of the potential failure mode sub-factors, We can know where the focus of work is to reduce downtime and improve equipment availability. The following is a partial display of the FMEA analysis results and corresponding improvement measures, as shown in Figure 1-15.

Function/Process Step	Potential Failure Mode	Potential Effect(s) of Failure	SEV	Cause(s) of Failure	OCC	Current Controls	DET 1	Current Containment	DET 2	RPN 1	RPN 2
TLU Transfers Singulated Tray to TPU	DUTs no longer seated properly	Minor yield loss, High TPT	4	Calibration error	4	Validation run	3				48
TPU Precises Tray	Tray presence error	Equipment damage, minor yield loss	5	Bad sensor	2	Reliability testing	2				20
	Tray positioning error	Equipment damage, minor yield loss	5	Bad sensor	2	Reliability testing	2				20
BLU Transfers DUT from Tray to BIB	DUT pick up error	Minor yield loss (DUT may be damaged by double stack)	3	Suction cup problem, air leak	3	Offline PCS, hard stop immediately	3				27
	DUT pick up error	Minor yield loss (DUT may be damaged by double stack)	3	FM on DUT	3	Offline PCS, hard stop immediately	3				27
	DUT pick up error	Equipment damage, minor yield loss (DUT may be damaged by double stack)	3	Calibration error	3	Validation run	3				27
	Handler position time out error	High TPT	3	Loss of communication	3	Stops processing	3				27
	Handler motion failure	Minor yield loss, equipment damage	3	Mechanical failure	3	Reliability testing	3				27
	DUT loading floating sensor not tripped	Minor yield loss, equipment damage	3	Bad sensor	2	Reliability testing	3				18
	DUT not released	Minor yield loss (DUT damaged during next pick - double stack), equipment downtime to repair	3	Vacuum problem	3	Reliability testing	3				27
	DUT dropped	Minor yield loss, equipment downtime to repair	5	Vacuum problem	3	Reliability testing	3				45
	MS/MTE incorrectly replaces unit	Lot mixing	9	MS/MTE tries to replace a unit after a vacuum failure or part drop, other handler stop	1	Business process training, lot count, unit marking	5				45
	DUT Placing error	Minor yield loss, equipment downtime to repair	5	Socket heatslug not fully open obstructing BLU to load DUT and trigger an error, detached heatslug	3	Bib PM. Handler Error	3	Handler error			45
	Lid marked, stained, substrate damaged or marked	FVI Yield losses	7	FM or oil on vacuum cups, wrong machine settings	3	PM and cleaning, handler error clearing, recipe verification	5	Post BI count may or may detect - operator dependant			105
	Die Damage, die marked, die chipped or cracked	Yield loss	7	During socket actuation heatslug making contact with the die	3	Control the speed of the Slug to 1 in / sec. Verified in SFF solution to work.	5	Class test Open-Shorts test and EOL FVI			105
	Bent Pins/Ball Damage	Yield Loss	7	Tooling interactions, alignment poor	2	Monitor MIYL, register any handler errors	5	Post BI count may or may detect - operator dependant			70
	FM on pin or lands/balls	Yield Loss	3	FM in socket, transfers to pin	2	Electrical fail	7	Electrical fail, PCS for multiple fails			42
	DUT pin 1 misorientation	Major yield loss	4	Incorrect handler parameter setting	1	Validation run	3				12

Figure 1-15

In response to failures and crashes, quantified key improvement points were obtained through the FMEA analysis method. The working group formulated corresponding measures for the key areas that need to be improved. From the results of the current FMEA analysis, the areas with relatively high risk coefficients are concentrated in:

(1) The manipulator cannot accurately grasp the chip from the tray to the burn-in test board. The main reason is that the manipulator is not positioned correctly or the pins of the incoming material are tilted, which makes the chip not correctly inserted into the burn-in test board.

(2) The aging test board cannot be positioned correctly during the test.

The main reason is that the air pressure is unstable due to the design defects of the cylinder control valve. Therefore, the effective solution is to use a cylinder with higher precision.

(3) The manipulator cannot accurately grasp the tested chip from the burn-in test board to the tray. The main reason is that the manipulator is inaccurately positioned and the vacuum fails for some reasons (inaccurate positioning, vacuum nozzle leakage, etc.). Because through the analysis of FMEA, the special working group can accurately locate the key problems, so it is helpful for the working group to formulate effective solutions to the key problems.

Through various methods of analyzing equipment failures, we can focus on finding the main reason to solve the problem, but the cause of equipment failure must change from week to week, so how to provide an effective feedback mechanism for this change, here we use the [17]PDCA method.

The meaning is as follows: P (Plan)-plan; D (DO)-implementation; C (Check)-inspection; A (Act)-action, summarize the results of the inspection for processing, and affirm the successful experience and promote it appropriately. Standardization; the lessons of failure are summarized, and the unresolved problems are placed in the next PDCA cycle, as shown in Figure 1-16.

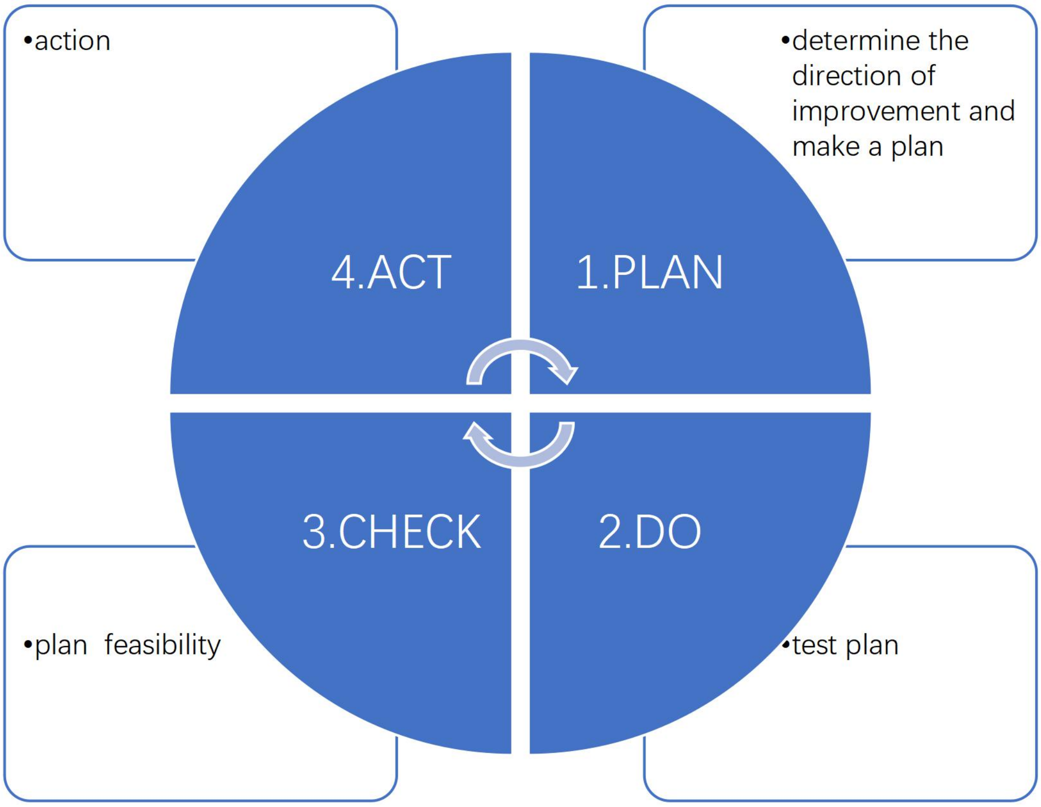


Figure 1-16

Every week, the FEMA working group will make a simple update of the FMEA based on the historical data of the previous week, and then find the focus of the next week, and find the focus and direction of the work for the online staff.

Therefore, I found that the following content should usually be included in the process control system:

(1) Real-time monitoring of key parameters

(2) The target value and upper and lower limits of key parameters, some key parameters may only have unilateral values, such as only upper or lower limits

(3) Early warning mechanism or algorithm, what standard will the SPC

system trigger an alarm

(4) The response process after triggering. With these contents, it can be ensured that any expected deviation in the manufacturing process will trigger the alarm in time, and then the relevant personnel can refer to the response process of each triggering alarm to adjust the production process flow, thereby changing these key parameters from relatively large deviation Adjust the range to within the expected deviation range to ensure the quality of the product. To realize automatic collection, summary, and analysis of alarm information based on existing equipment and systems, a detailed analysis of the current system is required.

Let me first accept how the existing aging test systems communicate with each aging test device itself. In addition to the mechanical and electrical hardware, each aging test device has four important components:

(1) The main test PC, also called IC (Integrated Controller), is the brain of each aging test equipment. The aging test program runs on this computer and controls each aging test through the internal LAN or external Ethernet. All the behaviors of the device, and collect all the test information of the storage chip. And only this computer is directly connected to the main router of the production line through Ethernet, and uploads the performance parameters of the equipment (such as SEMI status, MA, SDT, USDT, etc.) to the database that supports the production line. These production-supported databases are Alarm Another important source of

data for PCS).

(2) Manipulator control server (Handler PC). This server can be regarded as the brain of the manipulator. The main test PC only tells the aging test equipment that it needs to feed, test or discharge materials. The manipulator control server will tell all the mechanical and electrical components what to do (for example, which manipulator needs to move which chip from where to where), and the database on this server can record all the actions of the manipulator in detail And alarm information (this is also an important data source for Alarm PCS).

(3) The main PLC, which is connected to the manipulator control server through the internal virtual local area network, controls the specific actions or positions of each component.

(4) Station Controller, this is a production activity client directly connected to the main router of the production domain name, and terminal customers directly operate this client for production activities.

FMEA is an effective tool used to analyze the failure mode of failures. This helps the work team to find corresponding effective measures in terms of design, control and detection methods. This is to reduce failures and improve equipment effectiveness. A critical step for utilization. However, in the daily follow-up work, how to ensure that all employees can work together to solve the failure and crash, and whether all employees can know the performance of each device or the trend of the performance of the equipment at a certain stage in real time. I think this is Another very important aspect. In order to solve this problem, the working group introduced the concept of Statistical Process Control (SPC) when dealing with failures and crashes, that is, while recording alarms, it also records alarm trends and defines alarms for each time period. The upper limit of the number of times determines that the entire process is within the controllable range. Statistical process control is mainly a quality control system from the first set of procedures to the end of the last set of procedures in the production process. It is a very important quality control link in the production process of production enterprises. Statistical process control The main purpose of the system is to alarm the parameters with large changes through real-time monitoring of some key parameters, and then the relevant personnel can deal with this abnormality according to the corresponding response process (RFC), thereby reducing the variables in the production process .

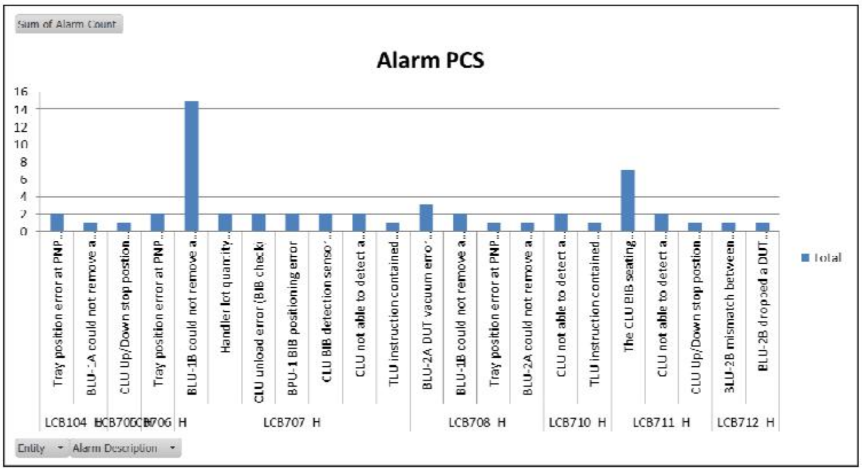
The following is the PSC table diagram of the aging test alarm I made based on relevant data.

LCBI TOTAL ALARM BY TOOL	
ENTITY	ALARM COUNT
LCB104_H	3
LCB705_H	1
LCB706_H	2
LCB707_H	26
LCB708_H	7

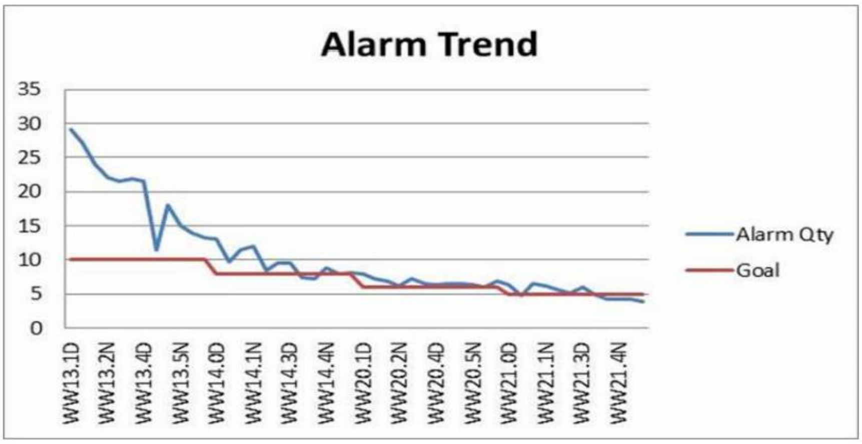
LCB710_H	3
LCB711_H	10
LCB712_H	2

ENTITY	ALARM DESCRIPTION	ALARM COUNT
LCB104_H	BLU-1A COULD NOT REMOVE A DUT FROM THE JEDEC TRAY.MAY BE REMOTELY RETRIED/SKI	1
LCB104_H	TRAY POSITION ERROR AT PNP POSITION FOR LOAD PORT 4	2
LCB705_H	CLU UP/DOWN STOP POSITION IS SHIFTED (OUT OF POSITION)	1
LCB706_H	TRAY POSITION ERROR AT PNP POSITION FOR LOAD PORT 6	2
LCB707_H	BLU-1B COULD NOT REMOVE A DUT FROM THE JEDEC TRAY.MAY BE REMOTELY RETRIED/SKI	15
LCB707_H	BPU-1 BIB POSITION ERROR	2
LCB707_H	CLU BIB DETECTION SENSOR FAILURE	2
LCB707_H	CLU NOT ABLE TO DETECT A BIB ON THE FORK	2
LCB707_H	CLU UNLOAD ERROR (BIB CHECK)	2

The following is the histogram of the Alarm PCS[18]of the burn-in test equipment:



After adopting the method mentioned before and after PDCA Cycle improvement, the number of alarms for each shift of the equipment has a downward trend, and in order to give full play to everyone's enthusiasm and create a sense of oppression, the management monitors the number of alarms for each shift. The goal is to gradually decrease every week, so as to fully encourage employees to actively display their subjective initiative and actively participate in the effective maintenance of equipment, as shown in Figure 1-17(SPC CONTROL FIGURE).



In the two weeks since the new product was put into production, only 1.5% of the scheduled maintenance downtime of the aging test equipment has been within the expected target of IE. But this is because the aging test maintenance can be divided into monthly maintenance, quarterly maintenance, half-year maintenance and annual maintenance. The planned times are as follows: monthly maintenance within 8 hours, quarterly maintenance within 12 hours, semi-annual maintenance within 16 hours, and annual maintenance within 24 hours. In other words, an aging test equipment needs to undergo 6 monthly maintenance (total time 48 hours), 4 quarterly maintenance (total time 48 hours), one half-year maintenance (16 hours) and one annual maintenance (24 hours), the total time spent on maintenance throughout the year is 136 hours, accounting for 1.6% of the entire year. On average, the proportion of maintenance time throughout the year is very low, but it does not mean that this very low maintenance time will not have a big impact on production. As the product cycle becomes shorter and shorter, if a piece of equipment needs maintenance, especially annual maintenance, there will be no output compared to 3 shifts. In order to ensure that the subsequent processes are not short of materials, it needs to be produced before maintenance. More semi-finished products come out, and these semi-finished products are piled up in the back, but this will not only have a huge impact on the product cycle, but also greatly increase the cost of products in the production line, not to mention when the bottleneck of the production line is dynamically changing. Long-term maintenance will undoubtedly bring high management costs and raw material costs to the enterprise.

According to previous data observations, it is found that the maintenance time often exceeds the expected time of IE. The actual monthly maintenance average time is 12 hours, and only a few weeks of monthly maintenance can meet the time requirement of no more than 8 hours. However, after analyzing with technicians, I found that this situation is not only happening in H company, but also in other factories. The length of maintenance time is not only related to the number of personnel, but also whether the maintenance personnel will be strict. Operate every maintenance requirement in accordance with the specification. Obviously, since there is such a big difference in the average monthly maintenance time in different weeks, there must be some maintenance items that should not be done. Therefore, what maintenance should be done in total, and should every maintenance item be done? Do different maintenance personnel have uniform standards when doing maintenance? These maintenance-related issues are very important aspects related to mechanical aging.

From the company's data statistician, I learned that the factory has arranged a week to gather maintenance-related technicians and engineers together. The focus of everyone's discussion is:

(1) How to optimize maintenance steps

(2) How to standardize maintenance items

(3) How to make maintenance items truly valuable. Therefore, the following programs were adopted in the maintenance training camp.

First, the participants read the equipment maintenance guide in detail, thoroughly understand each item in the maintenance and know why this maintenance is needed. If the maintenance of low value is considered to be cancelled or postponed from the monthly maintenance to the quarterly maintenance or even Semi-annual and annual maintenance is in progress, thereby reducing the frequency of maintenance. I learned from the relevant technicians which parts need to be maintained in a monthly maintenance. There are 24 maintenance items in the load port. However, after the analysis of the team, there are only 13 maintenance items that are really meaningful. Items, that is to say, nearly half of the maintenance items are of no value or very low value.

Secondly, after the maintenance items have been optimized, organize personnel to conduct field exercises on the maintenance items, and arrange for a dedicated person to do direct observation (DO, Direct Observation) and record all the routes of the maintenance personnel in detail, so as to find the maintenance from the road map The sequence of items and the placement of maintenance tools reduce the unnecessary time lost by maintenance personnel on the road. Because two technicians are required to participate in the maintenance of the aging test equipment, two DO observers are arranged to follow the two maintenance personnel separately. Some routes are repeated a lot. When the route is repeated a lot, this place is indicated. Can be changed into the space. There were many routes before the process optimization, but after the improvement, the road map became very simple.

The following measures are mainly taken through direct observation:

(1) Optimize the route of maintenance items, put the maintenance of the same part of the equipment in the same step as much as possible,

(2) From the road map before the improvement, it can be seen that the maintenance personnel have an obvious concentration point. This concentration point is the point where the maintenance tools are placed. After the route is optimized, it can be seen that the tools needed are divided into categories when preparing for maintenance. Placed in a different place, so as to reduce the loss caused by the maintenance staff changing and taking tools.

Third, add the inspection of certain parts that are prone to aging to the key maintenance steps. Prevent failures and crashes caused by aging parts, and standardize the range of inspection values.

This seems to increase the downtime of planned maintenance a little bit, but it will greatly reduce the time and frequency of downtime.

Fourth, refine the maintenance steps, let the maintenance experts issue detailed Standard Working Instruction (SWI, Standard Working Instruction) based on the optimized maintenance steps and maintenance items, because the maintenance specifications only explain what needs to be done, and it is not very clear Explain what should be done, and standard work instructions can standardize each maintenance step to reduce the different understanding of the steps among different personnel, thereby improving the efficiency of support.As the following figure SWI:

*Local Spec Owner LI,Martin / 11254126	*Spec# (Rev##) 75-4114 (Rev 23)	SWI Release Date 5/9/13	*SWI # (Rev ##) 75-4114-06(04)
PM SWI Owner Yu, Tian / 11414208		SWI Expiry Date 5/9/14	*Checklist Section in the Spec: 6.1
Stamp Goes Here No Valid Without STAMP		*Change Description (fr. previous rev)	Tool Shop Bar Code LC001,LCB101,LCB102,LCB103,LCB104,LCB705 LCB706,LCB707,LCB708,LCB710,LCB711,LCB712,LCB713 LCB714,LCB715

LCBI monthly PM SWI

LINE ITEM	Check Box	PM PREPARATION ACTIVITIES	Considerations	Duration
1.01		1.01.1 Perform this preventive maintenance activity ONLY by L2 or L3 certified personnel (Technician or Engineer). 1.01.2 It is require at least 2 people for any LCBI PM.		
1.02		Verify the PM type in workstream using Function VSEN. Steps: Login SC> Open WS>Login WS>Function: VSEN> Entity		1 minute
1.03		Use the required PPE	Gloves Safety gloves Safety shoes Hard Hat	1 minute
1.04		1.04.1 Change the AEPT status to "Scheduled Downtime" 1.04.2 Select the PM type 1.04.3 Ensure the change is reflected in VEGA (optional 5 minutes)		1 minute
1.05		1.05.1 Ensure that the tool has no production units inside the handler and/or chamber. 1.05.2 Purge any remaining lot before starting the PM.		5 minutes
1.06		Place the barricades around the tool and working area. NOTE The quantity of barricades may vary depending on the tool location. (Quantity=2 baricades)		10 minutes
1.07		1.08.1 Bring the PM Cart to the area 1.08.2 Check the PM Cart has the tools and consumables required for this PM. NOTE Consumables are listed in this PM SWI, section "Spares Required"		5 minutes
1.08		1.09.1 Open the PM checklist from Workstream using the funcion 1PCE 1.09.2 Specify the module under PM 1.09.3 Select the first task in PM checklist and start the PM activity		2 minutes

Figure 1-18 Standard work instruction for maintenance of aging equipment (SWI)

From the previous two weeks of trial production of the new product's equipment availability, the actual utilization analysis results show that the equipment availability is about 88%, but the actual utilization (AU, Actual Utilization) is only 71.5%, that is, The performance loss of the equipment is as high as 18.8%.

T1 – T2 = 295.7 hours – 240 hours = 55.7 hours

The equipment performance efficiency loss ratio is:

55.7 / 295.7 = 18.8%

However, during the two weeks of trial production of the new product, because the output of the trial production was not very high, the aging test equipment of the new product CW was in idle waiting state for some time. Therefore, just look at the data of these two weeks. Can not fully explain the problem, so how should we deal with the performance efficiency of the aging test equipment? The following table 1-19 is the approximate time distribution ratio of all states of SEMI in the capacity model of the Industrial Engineering Department. The idle time target of equipment should be less than 2%.

Resource	GU%	MA%	DT%					GAP%		
			SDT&-PM	SDT%-CONV	SDT%-OTHER	USDT%	DT TOTAL	EE%	IDLE%	GAP TOTAL
LCBI	93.0%	96.0%	1.3%	0.60%	0.00%	2.10%	4.00%	1.0%	2.0%	3.0%

So when the actual output is relatively high, how does the production line control the production capacity of the entire line?

First of all, it is necessary to determine the scope of the operator's work, and to regulate the time required for each operation of the operator through direct observation (D.O: Direction Observation) and time study (Time Study). The average shift time is 12 hours, of which the non-productive time is 3 hours, including the time spent on eating, meeting, resting, and workshop exercises. The time actually planned for productive use is 9 hours. In other words, the productive time is mainly loading and unloading, counting, simple visual inspection, etc. It also includes daily cleaning work.

7.4 The general mechanisms of aging

The resistance encountered in the process of heat transfer becomes thermal resistance, which reflects the size of the medium or the ability to transfer heat between media, indicating the size of the temperature rise caused by 1 watt of heat, and the unit is °C/W. There are three ways of heat conduction. The first way is heat conduction. Heat conduction is the transfer of heat from the end of the object with high temperature to the end of the object with low temperature. This method mainly exists between solids and solids; The second method is thermal convection, which only exists between liquids. It is the process of heat transfer caused by the relative displacement of fluids of different temperatures due to the macroscopic motion of the fluid; the third method is thermal radiation, which refers to An object is stimulated by a certain factor, and it is a way in which heat is transferred from the object along a straight line. Among the three temperature transfer processes, the heat conduction method is the most effective for chip control.

How to control the temperature in a timely and effective manner is very important in the aging test equipment. After understanding, the aging test mechanism of H company is: through a higher voltage, the chip heats itself during the load process, and then the excess temperature is removed through the temperature control module. The heat from the chip itself is transferred and dissipated. However, since the surface of the chip and the surface of the temperature control module seem to be in good contact with the smooth surface, it can be seen under the microscope that there are gaps of different sizes on the surface of the chip and the surface of the temperature control module, which leads to In the process of dissipating and transmitting the excess temperature of the chip, it is not entirely dependent on the most efficient heat conduction method, but between the two contact surfaces is dependent on the gas heat convection and heat radiation in the gap, and these two The ability of the heat transfer method is far inferior to the heat conduction through solids, which is a problem that needs to be avoided during semiconductor testing.

In the process of engineering sample testing, we initially determined that the pressure loaded on the chip was 15 lbs. At that time, a large number of sample experiments proved that the pressure of 15 lbs is a relatively effective pressure, one of which can meet the requirements of chip heat dissipation; The second is that it will not cause any mechanical damage to the inside or outside of the chip. But obviously in the test of new products, because the surface area of the chip is too large, and the design power consumption exceeds 35 watts, we began to consider whether we can increase the pressure on the chip to increase the heat transfer capacity, and at the same time, it will not Will cause mechanical damage to the inside and outside of the chip. Based on a large number of historical experimental data,as well as the design rules, we decided to try a pressure of 20lbs. Then it is necessary to prove that all the key parameters under the pressure of 20lbs can achieve our expected results through sampling experiments of enough samples. The key parameters are divided into total yield loss (Total Klot), thermal yield (Thermal Klot), average test temperature and mechanical yield loss .

Prove the results of the following different experiments through sample experiments:

Firstly: The total yield loss under the experimental conditions of 20lbs is statistically better than the results under the experimental conditions of 15lbs.

Secondly: The average test temperature under the condition of 20lbs is statistically equivalent to the result under the condition of 15lbs.

Thirdly: The mechanical yield loss under the condition of 20lbs is statistically equal to or better than that under the condition of 15lbs .

Therefore, it is defined that the sample size of experiment 1 and experiment 2 are both 2500 pieces, and the test is carried out under two different conditions. Except for the pressure, the conditions of the two experiments are the same. Other conditions are the same, including the same equipment, test board, test program, etc.

The experimental results show that there are a total of 2500 chips in the experiment, the test result is that the number of thermomal klots is 701, and the result of experiment two is that the number of thermomal klots is only 376. The calculation and JMP analysis output is: Reject the Null Photheis: p of NEW is SB than POR, that is, the result of Experiment 2 in Thermal klot is better than Experiment 1, that is, when the key parameter heat pressure klot increases from 15lbs to 20lbs , There is a significant improvement. The same result is also displayed in the total klot. In the first experiment, the total number of failed chips was 876, and the total number of failed chips in the second experiment was 451. The result input of JMP shows that the key parameter total klot in the hypothesis test, the experimental condition of 20lbs is better than the experimental condition of 15lbs. Similarly, the test temperature and the average value of mechanical property loss are tested. Finally, it can be seen from the results that the test pressure was adjusted from 15 lbs to 20 lbs. The experimental results are completely consistent with our expected results. The specific comparison parameters are shown in Figure 2-1.

8. Summary of Results:

Quality Characteristic	Ideal Target (Target Spec)	POR Mean	POR Std Dev	δ (from PWP)	Accept Criteria (from PWP)	New Mean	New Std Dev	Mean Result	Std Dev Result
Thermal Klots - 9984, 9765, 8x	0%	28% (701/62500)	NA	4%	SB to POR	15% (376/2500)	NA	SB to POR	NA
Total Klot	0%	35% (876/2500)	NA	4%	SB to POR	18% (451/2500)	NA	SB to POR	NA
TjcAvg (Burn-In control tempe	85 ± 1°C	85.056 C	0.19°C	1°C	SE to POR	85.00°C	0.20°C	SE to POR	SE to POR
MIYL	0% (<0.09%)	0% (0/66601)	NA	0.01%	SEB to Target	0% (0/12500)	NA	SB to 0.1%	NA

Figure 2-1 Summary of comparison results of key parameters of pressure experiments

From the above experimental production results, it can be seen that the main reason for the high rework rate is that the equipment does not control the temperature according to the expected curve during the aging test. Therefore, first of all, we need to measure the maximum temperature or maximum that can be controlled in the current heat dissipation scheme. What is the power of the heat sink, and from the following formula, it can be concluded that the greater the temperature that the heat dissipation solution can control, the minimum thermal resistance of the heat sink.

Thermal Resistance (Θ) = (Δ T / Power)

Among them, thermal resistance is the thermal resistance, ΔT is the temperature difference from the high temperature end to the low temperature section, and Power is the power of the chip when it heats up. The following figure shows the algorithm (Figure 2-2) and schematic diagram (Figure 2-3) that collect the maximum temperature (power) control of the temperature control module. From the following algorithm, we can know that we need to collect the temperature control module can control For maximum power (Pmax), three main parameters need to be collected: Vcc, Tj and Icc, so in the experiment we mainly collect these three parameters in order to derive the value of Pmax.

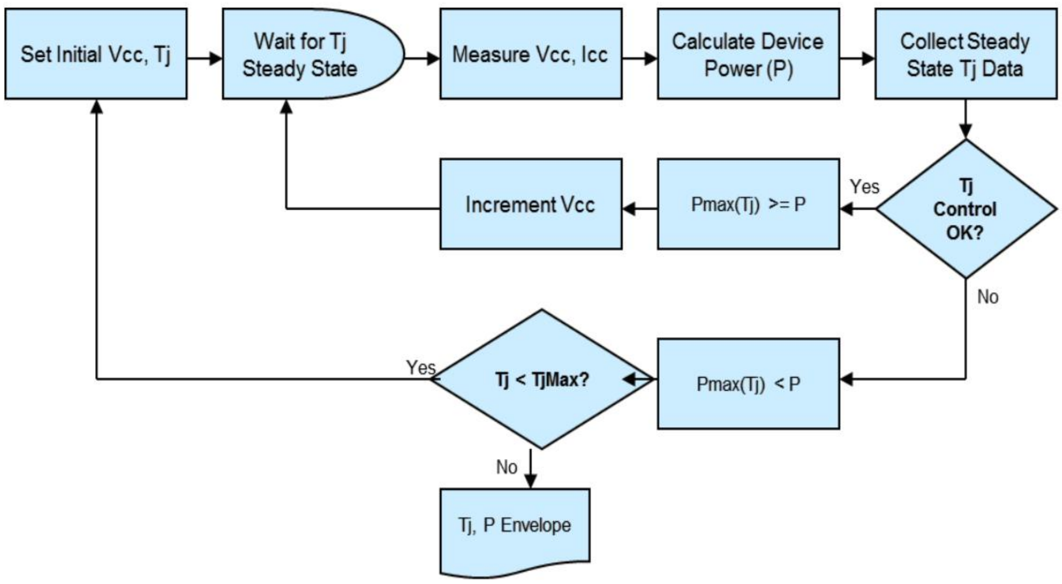


Figure2-2 Burn-in test equipment Pmax algorithm

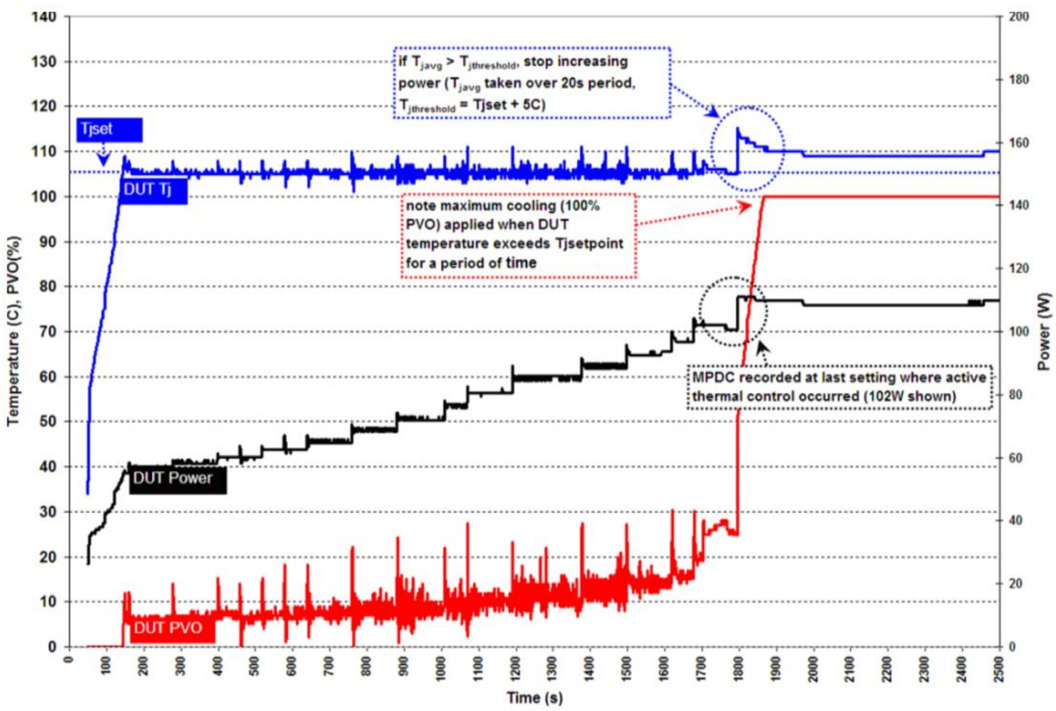


Figure 2-3 Pmax curve of aging test equipment

According to the formula between thermal resistance, temperature difference and power, it can be calculated that there are big differences in the thermal resistance of heat sinks in different materials: graphite and silica gel. Through the above thermal resistance and Pmax (highest power) experiments, the personnel in the experimental team learned that the H company work team changed the heat sink material for the new product from graphite to silicone grease. Because on the packaging and testing production line, the burn-in test site is the site with the longest test time, the highest test temperature, and the largest test voltage, and the temperature control accuracy requirements at the burn-in test site are also the highest. If the temperature control is not good, for example, the temperature error range is too large, it may cause excessive aging of the tested chip, not only allowing the chip to reach the early failure period earlier, but also reducing the normal life of the chip.

7.5 Results Application OEE

Based on the company's overall production capacity planning and the actual proportion of products that need to be aging tested, assuming that all required equipment is activated 100% of the time, the human-machine ratio required between different products can be calculated. The product is only 70%. % Of the quantity needs to be aging test, and the remaining 30% do not need to be aging test, if the operator’s labor load is 58.4%, an aging test equipment only needs 0.56 operators, when the operator’s labor load When it reaches 84.9%, three burn-in test equipment require 1.68 operators, which is 0.84 operators for each burn-in test equipment. Other products also require different numbers of operators according to different labor loads. Then according to the weight ratio of output between different products:

(1) Proportion of product 1: 30%

(2) Proportion of product 2: 20%

(3) Proportion of product three: 30%

(4) Proportion of product four: 20%. It is possible to calculate the overall production capacity planning of the current company, the actual product aging test time and the ratio between different products. The weighted average can be used to know that the human-machine ratio at the aging test site is 1:2, that is, one Under the condition of full load, the operator can operate two aging test equipments at the same time according to the production time of 9 hours per shift.

After the improvement measures in the three major areas mentioned above, we can roughly compare the differences between several key performance parameters before and after improvement. The following Figures 1-20 and 1-21 are the overall equipment efficiency, equipment availability and actual equipment utilization before and after the improvement measures are implemented. It can be clearly seen from the following two figures that before and after the improvement measures are implemented. After implementation, the availability of equipment and the actual utilization of equipment have been greatly improved.

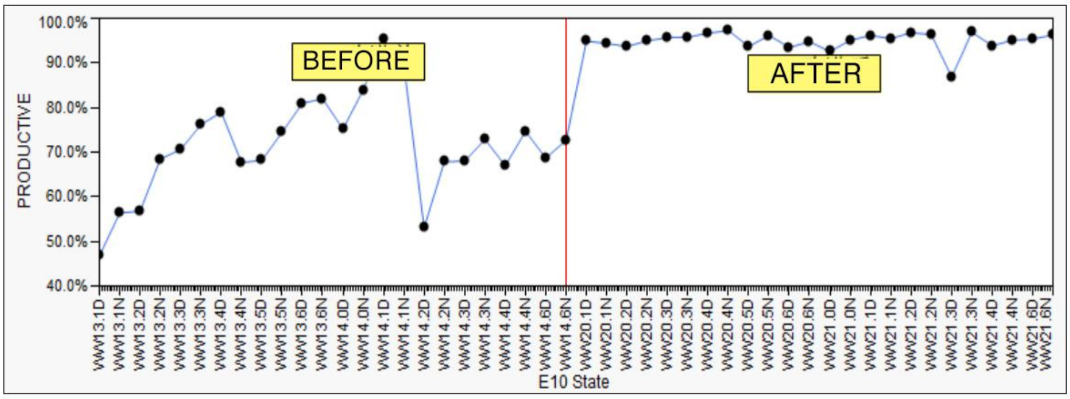


Figure 1-20 Comparison trend chart of aging test equipment availability before and after improvement

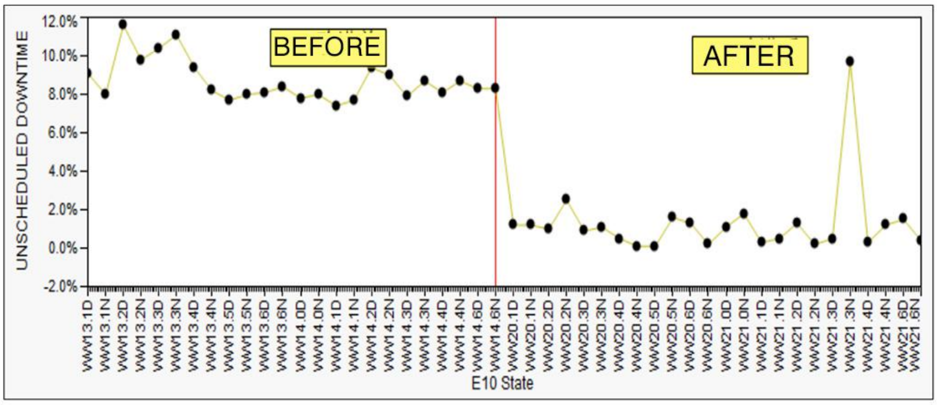


Figure 1-21 Comparison trend chart of actual utilization rate of aging test equipment before and after improvement

The following figure 1-22 is a trend chart of the comparison of equipment failures before and after the implementation of improvement measures, and the breakdown and crash losses account for a large proportion of the overall equipment efficiency loss. Therefore, after the implementation of the OEE improvement measures, you can see The effect is very significant.

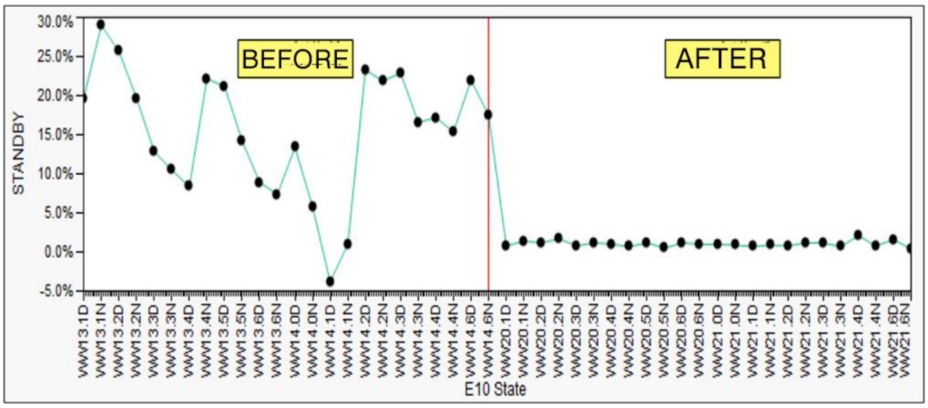


Figure1-22 Comparison trend chart of failure and downtime of aging test equipment before and after improvement

Figure 1-23 below is a trend chart of the comparison of equipment idle waiting losses before and after the implementation of the improvement measures. From the average 15.5% before the improvement, the equipment idle waiting losses due to lack of materials and personnel have increased to about 1%. Figure 1-24 is a trend chart showing the comparison of equipment idle waiting losses before and after the implementation of improvement measures. From the average 15.5% before the improvement, the equipment idle waiting losses due to lack of materials and personnel have increased to about 1%.

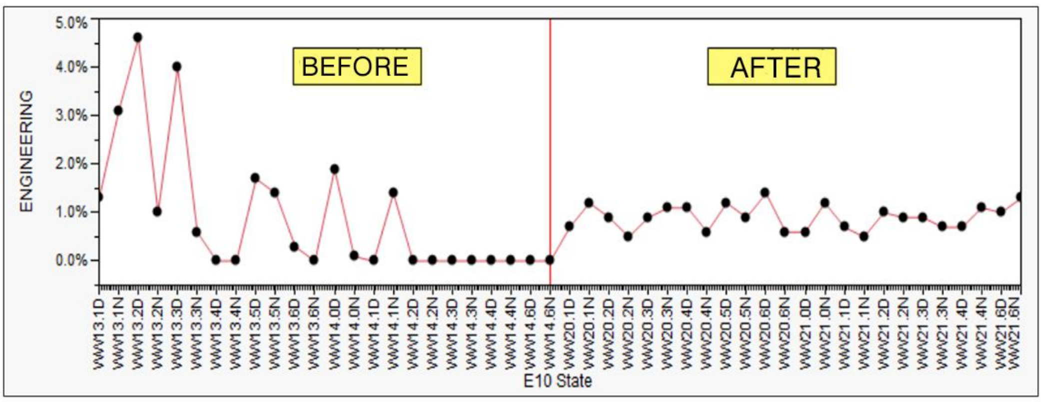


Figure 1-23 Comparison trend chart of aging test equipment before and after improvement in idle waiting

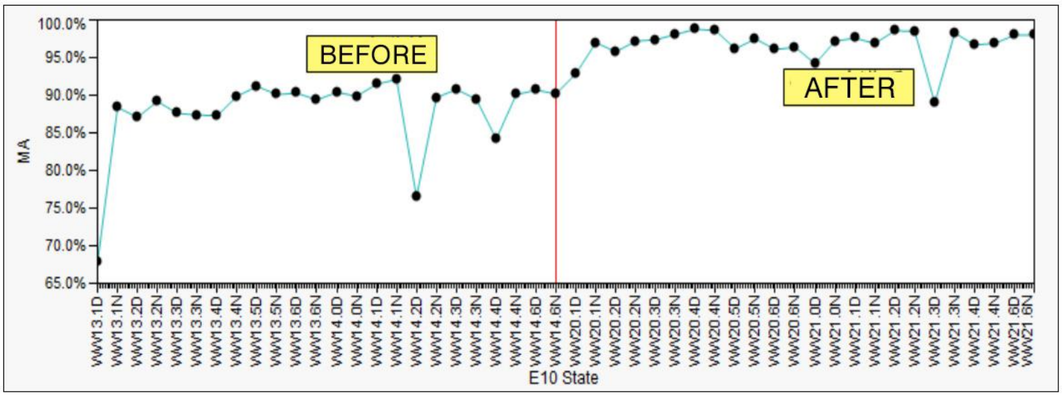


Figure 1-24 Comparison trend of aging test equipment engineering debugging time before and after improvement

Through the analysis of OEE[20] and the improvement measures formulated for different problems, we can see that it is very significant. Looking at the three key performance indicators of OEE, first, the rework rate of new products has been significantly reduced from 30% before improvement to about 3% after improvement, a decrease of up to 27%; secondly, the rate of equipment can be increased to 96.9%; from equipment In terms of performance efficiency, the improved performance efficiency is 82.4%, and the improved performance is increased to 98%. After the improvement measures were implemented, the proportion of OEE increased to 92.2%.

In reality, [19]the improvement of OEE is not only the improvement of the overall equipment efficiency of the aging test equipment, but also the improvement of the performance efficiency of the corresponding test interface module. If Company H cannot effectively solve the bottleneck problem of new product capacity, it must purchase burn-in test equipment and test interface modules (burn-in test boards), or extend the delivery period of new products to customers, which will lead to a decline in H Company's profit. Or damage the cooperative relationship between H company and P company. And because the burn-in test equipment is universal at the burn-in test site, the purchased equipment may be used to produce new products in the future, but because the test interface module is not universal in different products, that is, this time The test interface module purchased again cannot be used for other new products in the future, which is undoubtedly a huge loss for H Company.

While increasing the OEE ratio, the failure and downtime of the burn-in test equipment is reduced, and the mold change time is reduced. Accordingly, the workload of the staff (technicians and operators) on the burn-in test equipment line is reduced. It is possible to increase the human-machine ratio; at the same time, while promoting the increase of OEE ratio, it is also optimizing the work efficiency of the aging test equipment online staff and increasing the enthusiasm of the online staff, which may further improve the aging The human-machine ratio of the staff on the test equipment line, the surplus personnel of the burn-in test site are allocated to other sites or used for other purposes, thereby saving labor costs and reducing total production costs.

8. Conculsion

Combining the above analysis and the application of OEE theory can solve how to improve the effective capacity of company A's aging test equipment, reduce costs, reduce the production cycle of new products, and ultimately meet the customer's supply requirements. On the basis of studying the methods of overall equipment efficiency and learning from the successful experience of other companies, combined with the actual conditions of Company A, it is divided into three modules to analyze and determine the final plan. These three modules correspond to the three of the overall equipment efficiency. Key performance indicators: equipment availability, equipment performance efficiency, product qualification rate.

1. First of all, during the trial production period when H company introduced new products, the aging test equipment encountered a big bottleneck problem of production capacity, which may lead to failure to ship in time or invest more funds to increase production capacity, and there was also company H’s default risks of.

2. The second is to use the three key performance indicators of overall equipment efficiency to refine the capacity bottleneck problem encountered by company A into three parameter calculations, so that the overall equipment efficiency before the improvement is only 50.8%, of which the qualified product rate is only 70%, equipment availability is 88%, and equipment performance efficiency is 82.4%. Then the question of how

to improve the effective production capacity of the equipment becomes how to increase the rate of qualified products, how to improve the availability of equipment and the efficiency of equipment performance.

3. Then, on this basis, develop an improvement strategy for three small problems. Using company A’s existing equipment status, alarm information and other database information, a new solution was formulated to promptly and effectively promote the improvement of equipment availability, including FMEA to analyze the key problems of failures and crashes and innovative methods. The PCS theory is applied to the scheme of how to reduce the fault alarm; in addition, the working methods and working steps of the operators are effectively standardized, and the work efficiency of the workers is improved; finally, the database system of company A is effectively used to provide timely feedback of each shift Performance indicators, thus forming a healthy competition between the four shifts, to achieve the effect of concerted efforts. Judging from the productivity improvement plan of company A's aging test equipment, the effect is very significant. The overall equipment efficiency has increased from 50.8% before the implementation of the improvement measures to 92.2%. The improvement of the overall equipment efficiency is not only an increase in the production capacity of the aging test equipment , On the basis of solving how to supply customers in a timely manner, it also solves the risk of company default and avoids the waste of spending a lot of

money to increase production capacity.

Mechanical aging is an unavoidable phenomenon in various machinery factories and equipment. There are many reasons for mechanical aging. If management is not interfered, it will have a very serious impact on factories and enterprises. Through the previous introduction and summary, we can monitor and calculate the aging time in advance according to the scientific method, track the aging status, and establish related monitoring procedures for more convenient and faster monitoring, feedback the aging phenomenon, and timely manage the mechanical aging .

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