A Study on the Mode of Introducing Independent Maintenance into Traditional Industries That Rely on Manual Work

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Abstract

The vast majority of Taiwan's enterprises are small and medium-sized enterprises, which account for 98% and mostly are built up by the traditional industry. But along with the technical progress and development of production technology, the traditional industry is faced with survival bottleneck because of high cost and various competitors. Therefore this research aims to explore the mode of introducing independent maintenance to traditional industries, and to develop a suitable one for today's traditional industries. Research results will be provided to the domestic traditional industries for reference in order to reduce the cost and difficulty they may have in importing independent maintenances.

Keywords: Traditional industry, independent maintenance, competitive power

1. Introduction

The economic construction of Taiwan is led by the development of industry, which mainly relies on manufacturing sector. In terms of the production specifications, manufacturing sector can be divided into traditional industries, basic industries, science and technology-intensive industries. The vast majority of Taiwan's enterprises are small and medium-sized enterprises, which account for 98% and mostly are built up by the traditional industry. Nowadays with the rapid development of society, technology and information communication, in order to protect the traditional industry from being impacted, and remain its role in the economic development, we must firstly understand the characteristics of the traditional industries and then take proper measures accordingly. In order to enable them fully play their roles, a joint cooperation between the industry, the official sector and academic institutions is required, so that the traditional industry can be led into a higher level of development. The whole staff's awareness of and support for independent maintenance and their dedication is also important for the continuous development of enterprises' operating structure. Only with these efforts can the traditional industries of Taiwan can be transformed and the competitiveness of enterprises enhanced. The first systematic concepts and methods of maintenance were developed in the late 1960s when airlines grew interested in equipment maintenance because of the issue of improving the work efficiency of jetliner maintenance. And then the method of Reliability Centered Maintenance (RCM) was developed, which became widely used among the aviation community. In the early 1970s, the military also used this method in military aircraft and warships. RCM method is designed mainly for diverse and complex equipment maintenance. It makes reliability as the core consideration and prioritizes the maintenance work coordinated with failure mode and effect analysis (Failure Mode and Effect Analysis FMEA) so as to make the reliability of the equipment system achieve the best state.

There are six stages in the evolution of the TPM: 1. The Era of Break-down Maintenance. (Break-down Maintenance; before the BM-1950) [Gera1d J. Hahn, and Samual S. Shapiro]; the maintenance work begins after the equipment fails to work or the performance deteriorates. The maintenance features the ex-post rush repair of the repair personnel, who usually have no awareness of equipment management. 2. The Era of Preventive Maintenance (Preventive the Maintenance; PM-1951's) [Edward A, Si1ver and Claude-Nico1as Fiechter]; Periodic inspections and scheduled checks for a variety of devices are carried out so that the poor operating condition of equipments, if any, can be discovered as soon as possible and so the failure can be prevented. (Routine maintenance, roving maintenance, periodic maintenance, preventive maintenance, and repair) therefore preventive maintenance is the inspection and check work conducted mainly by the maintenance personnel. 3. The Era of Productive Maintenance (Productive the Maintenance; PM-1954): it is advocated by the U.S. General Electric Company, which means that in consideration of the economic value of the equipments, the factory carries out scheduled checks, lubrication and minor repairs in order to reduce the cost caused by downtime and substantial maintenance work. It is the integration of ex-post maintenance and preventive maintenance and aims to achieve the purpose of economic production. 4. The Era of Corrective Maintenance (Corrective Maintenance; CM-1957~) [Von Alven, WH: It means upgrading the quality of equipments and relevant parts in order to improve their reliability and durability. 5. The Era of Maintenance Prevention (the Maintenance Prevention; MP-1960~) the [Samue1 S Shapiro, and A1an J. Gross]: improve the project plan so that the devices do not need maintenance or only requires minimal and simple maintenance. 6. The Era of Total Productive Maintenance (Total Productive Maintenance; the TPM-1970~) [Seiichi NakaJima]: a comprehensive and universal system which focuses on integrating inter-departmental and within-departmental communication and cooperation. That is, let all departments of a company from the management to operators; let all the staff take an active part in the plan and maintenance of equipment so as to establish a comprehensive production and maintenance system.

Developed by Bin and others, the dynamic preventive maintenance system (Failure and Scheduled Maintenance Analysis--FASMA), which is human-centered, is designed for a manufacturing environment that is cellular based, system-oriented, and that emphasizes comprehensive qual

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ity management. This system adopts a deductive database with dynamic interface, and use foregoing RCM method to continuously improve preventive maintenance plan so as to minimize downtime. This system infers the category of fault and the time to maintain only from the historical data and fault knowledge, not including experiential maintenance knowledge and real-time status information of equipments. Okogbaa and others [OKogbaa, G., Hliarlg, J. and She11 R L.] came up with a preventive maintenance system (PPMS) for the automated manufacturing systems, stressing the concept of opportunistic maintenance. When implementing preventive maintenance, this system tells the distribution of the failure based on statistical analysis of historical data collected by equipments and uses simulation analysis to predict failure and derives the best timing to maintain, which is very helpful for the reduction of production costs. McFadden [McFadder1, RH] explored the process of establishing a database system with reliability, operability, and maintainability. He also analyzed in detail the data types, as well as the design of the database. The Pintelonm and Wassenhove [Pintelonm, L. and Wassenhove, LV] put forward a control panel that includes various performance indicators and detailed reports. The performance indicators include a comprehensive indicator for maintenance management. The range of measurement covers fields like cost, equipment, manpower, materials, and work. These performance indicators help managers to evaluate maintenance effectiveness; while early warning information provided by CB and detailed information by DR is useful for decision-making. The above literature is the overview of precedented research on equipment maintenance. Because in the past years the maintenance management of equipment didn't draw sufficient attention, there are few researches on equipment maintenance or TPM in Taiwan. .[Shen Ji Zhi, Ling Ben Taro, Qiu Yuanxi, etc.]. In foreign countries, excepts Japan(Sasaki, Terumi, Ling Ben Taro, Marcelo Rodrigues, Kazuo Hatakeyama, Amir.Khanlari, Kaveh Mohammadi), researches in this field has also been valued in recent years.(the Bin Wu and Jonathan J M. Seddon, Edward A, Si1ver and Claude-Nico1as Fiechter, OKogbaa, G., Hliarlg, J ., and She11, R. L., Pintelonm, L. and Wassenhove, LV, Kristy O.Cua, Kathleen E.Mclone, Roger G.Schroeder, G. .. Chand, B. Shirvani)

2. Method

2.1. The Basic Concept of Independent Maintenance and Its Implementation Steps

The so-called independent maintenance means that with the purpose of taking care of one's own equipment, each staff member carries out routine point inspections on their own equipment, lubricate, replace parts, and detect abnormalities early and correct precision so as to prevent a serious fault from happening. In order to implement the independent maintenance, workers must be trained into masters in equipment. Equipped with operating skills, workers also must have the ability of detecting abnormalities, of improving them and then the ability of understanding the relationship between equipment with quality of products. It often thought that the failure or the deterioration of equipment function is due to human misconducts. So if this kind of ideas can be changed and people can have the concept of "zero defect" and "zero failure", gradually they will change the equipment and on-site. The systematic stimulation of the company will help ensure the full participation of the whole staff in the staged implementation of independent maintenance.

The steps of implementing independent maintenance are as follows: 1.the initial cleaning: cleaning equipment is helpful for understanding the equipment and finding whether the device is normal or not. In other word, cleaning is point inspection. 2. the solution for the source of failure and difficult parts: find the source of pollutants in equipments and working environment in order to prevent pollution. As for those parts on which the daily maintenance work like cleaning, point inspection and lubrication is hard to carry out, measures also should be taken to improve them so that the maintenance work can be done easily.3. develop interim benchmarks for independent maintenance: base on experience gained from the first two steps, suggestions should be made on issues like which parts needs point inspection, lubrication and cleaning, the corresponding methods and also the period.4. the overall inspection: In order to seek the highest efficiency of the device, workers must understand the structure, function, principles of equipments and should know the status of the equipment, so a comprehensive inspection is a must in order to find out the potential defects and restore the original status which the equipment is supposed to maintain.5. independent Inspection: the purposes of the first four steps are to maintain the device and improve its degradation. If the reliability, maintenance and quality of the equipment is about to be further improved, then the benchmark made previously for cleaning, lubrication and overall inspection must be re-examined so as to improve the efficiency of point inspection, making no inspection mistakes. A summary of the benchmarks of independent maintenance will then be achieved as a result. 6. Standardization: Step one to five center on devices, but a standardized set of practice is needed in order to administer and implement such activities like the preparedness of the basic conditions and daily point inspection. The standardized practice will enable a person to do the job well alone no matter who the person is and where he is, achieving self-management. 7. the thorough implementation of self-management : this step is to summarize the activities promoted in the foregoing six steps, and show improved results by changing the equipment, personnel, and on-site, which brings more self-confidence and courage to challenge more ideal targets like zero defect, zero breakdown, zero disasters and zero short-term downtime.

2.2. The basic concept of individual improvement

The so-called individual improvement is the activity of excluding the loss caused by personnel, materials and equipment (such as the loss brought about by the operating mistakes of workers, by the equipment failure or short downtime and by lost work time due to unbalanced production line). That is, to maximize productivity and aim at real effect. Before the improvement activities begin, personnel, materials, equipment, and other various types of loss projects should be mastered along with corresponding data, so that benchmark values for each loss projects can be set to server as the comparison with the improved situation in the future. Following are the ten steps to carry out individual maintenance: 1. select the equipment, production line and project for demonstration:(1) Those defective production lines and projects and equipments that wear a lot in the

individual improvement plans, (2) Horizontally lay out those ones with great importance. (3) The equipment, projects and equipments that are the same with those in independent maintenance activities. 2. form an ad hoc group: members of the ad hoc group, in addition to the project they are in charge of, should also offer technical analysis and support for others' loss projects, bringing into full play the role of interpersonal relationship. (1) The managers of departments become leaders (leaders of demonstrative departments become managers and leaders of demonstrative section become section supervisor). (2) Invite the assistant units of technology, design and production to join in. Whenever loss occurs, it should be borne by the unit which is in charge for the corresponding loss unit and which causes the loss. (3) The promoting units designate members of the group and directs. 3. grasp information about the current loss: (1) Check and know about the loss. (2) When there is not enough information about loss, collect them. 4. set the theme and the goal of improvement:(1) Set the theme of improvement according to the findings of research on the current situation.(2) Set the goal and period of improvement based on the concept of zero-loss.(3) Determine the person in charge of the countermeasures for loss. 5. work out plans for improvement:(1) Complete a plan including analysis, countermeasures and procedures of improvement. Make a schedule to promote implementation of the plan.(2) Carry out high-end diagnosis. 6. analyze and develop strategies and assessment:(1) utilize all the skills and methods like analysis, investigation and experiments. Establish the improvement case and develop the assessment method.(2) Make efforts continuously until the goal is achieved.(3) Carry out high-end diagnosis (looking for better ways in the form of announcement campaign) for the purpose of enrichment. 7. put into to effect measures for improvement t: implement necessary budget management, and make improvements. 8. confirm the effect: to confirm the effect of improving various loss projects. 9. standardization:(1)Standardize the standards for the manufacturing, operating, material-choosing and maintenance and make countermeasures for the prevention of the recurrence of loss.(2) Make the manual for horizontal implementation..(3) Make high-end diagnosis.10.horizontal lay-out: lay out the same production lines, projects, equipment horizontally.

3. The process of introducing independent maintenance into traditional industries

3.1. The Plan of Importing Independent Maintenance Pillar

The master plan is a rough plan, so when the industry is about to promote the independent maintenance comprehensively, it should develop a more detailed overall plan of importing the pillar based on the benchmark of master plan, and then import the overall plan to make a three-year schedule and a promotion plan for the current year. The promotion plan should be more detailed than the three-year plan. Although there are many plans during the promotion process, a complete plan is needed in order to carry out all works smoothly. The following is about how make the plan of importing the pillar of independent maintenance: this study divides the independent maintenance plan into two parts for illustration. The first part is the overall plan of importing the pillar of independent maintenance, whose content is as shown in Table 1. The second part is the plan of importing the four steps of independent maintenance, whose main work item and order are as shown in Table 2. A Gantt chart, namely the plan for the importation of each steps, can be made according to the items and order listed in Table 2.

Table 1 Overall plan of importing independent maintenance pillar

Item	Abstract	Explanation
1	Members and managers of the organization for plan promotion	• The structure of independent maintenance branches, members doing various jobs and the units they belong to. • The manager of each position
2	Objective	• The overall goal for the coming three years and the goal for the current year should be included.(choose from the projects of efficiency measurement indicators)
3	Projects	• List all the projects to be accomplished in the current year and next three years. Each project should have a manager.
4	schedule	• Every important project should be included in the schedule of promotion in order to facilitate the management. The schedule should specify the beginning date and finishing date of every project through Gantt chart.
5	Plan of promotion for each step	• Express each step in order through Gantt chart, making the plan of promotion.
6	Statistic data of various achievement indicators	• Every clique, group, sections and department should have its own statistic data and collect, analyze and renew them monthly.
7	List of all cliques	• The name of each clique and the units they belong to.

(Concluded by this research)

After the overall plan is done, the goal values should be allocated to all departments. Each department should make its own plan of promoting independent maintenance according to the goal and the activities in the overall plan. The finished plan then will be further implemented in sections and cliques. Every unit should have its own plan for implementation.

Table 2 Plan of each step in importing independent maintenance

Implement ation order	Major work in the first step	Major work in the second step	Major work in the third step	Major work in the fourth step
1	the first step Education training	the second step Education training	the third step Education training	the fourth step Education training
2	the first step Make importation plan	the second step Make importation plan	the third step Make importation plan	the fourth step Make importation plan
3	clean equipments Thoroughly	make temporary benchmarks for cleaning, lubrication and point inspection	make checking form for overall inspection	set benchmarks for reflections on cleaning, lubrication and point inspection
4	marking out defective parts with tags	implement independent diagnosis	Implement overall inspection and mark out defective points	make independent maintenance benchmarks

Table 2 Plan of each step in importing independent maintenance (continued)

5	take off the tags after the first-time improvement is done	implement depart-mental diagnosis or high-end diagnosis	analyze and improve the defective projects	make the schedule for independent maintenance
6	add lubricant to equip-ments and tighten screws		make tem-porary benchmarks for overall inspection	implement independent mainte-nance(cleani ng, lubricat-ing and point inspection)
7	confirm the source of problems and the difficult parts, mark them out and draw coun-termeas-ures(attach tags to the problematic parts)		Implement independent diagnosis	Implement independent diagnosis
8	improve the source of problems and the difficult parts(remove the tags where the improvement job is done)			implement departmental diagnosis or high-end diagnosis
9	confirm and record the parts that have been cleaned, lubricated and point-inspect ed(includes the bench-mark meth-od, dealing method, period, time and the managers)			
10	implement independent diagnosis			
11	implement departmental diagnosis or high-end diagnosis			

(Concluded by this research)

3.2. The Steps of Introducing Pillar of Independent Maintenance into Traditional Industries that Mainly Rely on Manual Work

Because the products and industrial characteristics of each industry are different, they rely on equipment to different degrees. For example, traditional industries that operate artificially have low reliance on equipments. Some industries use simple equipments, which don't break down easily and can restore from failure quickly even if a break down happens. This kind of industries includes assembly industry, electronic plug-in industry, woodwork and bamboo wares manufacturing industry, all of which are based on manual labor. What this kind of industries wants to pursue is how to reduce the loss of manpower and increase work efficiency is. The following is to elaborate the steps of introducing independent maintenance into traditional industries. 1. initial cleaning and improvement of sources of problems: the major activities take place at on-site. All redundant items will be disposed; the original material, semi-finished products, parts and smelting moulds will be cleared up; a thorough and comprehensive cleaning of on-site will be done in order to remove all dust and dirt: strategies will be made to solve problems regarding needless items, source of dust and parts that fail cleaning and point inspections. This belongs to the first stage and the estimated time needed is six months to one year. 2. make the contemporary benchmark for the implementation of 5 S: make action benchmark for effective maintenance and cleaning carried out in short time. The improvement should be easy for the implementation of point inspection and visual management. This belongs to the first stage and the needed time is estimated to be six months to one year. 3. overall inspection and the improvement of the problematic points: understand the structures and functions of products and provisions about quality assurance, find out the loss projects that lower efficiency of the personnel and improve them. (Loss projects include loss caused by operating mistakes of workers, by operation, by logistics, by testing adjustment and so on). Inspect and confirm the condition of moulds, smelting equipments and measuring instruments. Set interim benchmarks for the daily overall inspection. This belongs to the second stage and the needed time is estimated to be six months to one year. 4. independent point inspection and standardized operations: review and revise the contemporary benchmarks for the implementation of 5 S and the interim benchmarks for the daily overall inspection in order to improve efficiency. Train versatile workers and ensure the same quality and output even when there are changes in the operating staff. Set operation standards and let it guide operations. This is to belong to the second stage and estimate import time six months to a year.

3.2. Individual Improvement of Steps of Importing Pillar Maintenance and the Explanation for Activities

The purpose of individual improvement is to thoroughly eliminate the 16 kinds of loss caused by equipment, personnel and the raw material in order to maximize the productivity, and improve and make use of the technical and analysis ability of relevant personnel through the activity. Eliminate losses. For example, for industries which rely on equipments, to eliminate losses is to bring down to zero the eight kinds of losses that lower the efficiency of equipments; and for those relying on artificial operation, that is to eradicate the loss that reduces workers' efficiency. Table 3 is the illustration for individual improvement of steps of introducing pillar maintenance into traditional industries and the activities.

Table 3 The steps and activities of the individual improvement of the pillar import

Steps	Names	Main activities
1	Select the equipment, and project for demonstration:	• Demonstrative equipment should mainly be chosen from those bottleneck projects in operation, equipment that wear a lot, important equipment and equipment or production lines that have bad horizontal expansion effect.

Table 3 The steps and activities of the individual improvement of the pillar import (continued)

2	Form an ad hoc group	• The manager of the department that this improvement case belongs to become the leader. The larger the case is, the higher the level should be • The group should consist of managers, technicians or designers and indirect personnel. • The special case should get registered and reflect on the job schedule periodically
3	Check and know about the current loss	• Affirm and master the loss projects of the equipment and some relevant information. When there is not enough information, make the best efforts to collect them. (Loss projects includes16 kinds of loss like failure, temporary halt, replacement of mould and lines, amendment of defective products, loss caused by operating mistakes of workers, by operation, and by testing adjustment.
4	Set the theme of improvement and the goal	• Set the theme of improvement according to the findings of analysis (greater loss projects should get improved first). • Set the goal and period of improvement based on the concept of zero-loss
5	work out plans for improvement	• Complete a plan including analysis, countermeasures and procedures of improvement. Designate managers of every operation
6	Analyze problems and draw up countermeasures	• Use every analytical method to find out the real reason that cause various kinds of losses and then draw up feasible resolution.
7	Put into effect improvement plans and check the results	• Carry out indispensable budge management and improve it. • After the improvement, check the results. Keep improving those methods that fail to work out well until the goal is achieved.
8	Standardize the practice of improvement	• Standardize the standards for the manufacturing, operating, material-choosing and maintenance and make countermeasures for the prevention of the recurrence of loss. Make the manual for horizontal implementation.

(Concluded by this research)

4. Conclusions

This study draws up the mode of introducing independent maintenance into the traditional industries, which nowadays mainly rely on manual work. The mode includes contents like importing the pillar of independent maintenance, implementation steps, estimated schedule, indicators for performance measurement, managers of organizations for promoting independent maintenance, training courses needed, the production of import plan for independent maintenance, the way of propaganda, diagnostic procedures of independent maintenance, the form summarizing the collected data and matters that should be noted in the importing process. Research results will be provided to the domestic traditional industries for reference in order to reduce the cost and difficulty they have in importing independent maintenance and help them import TPM smoothly. So that the industrial structure of traditional industries in Taiwan can be upgraded with improved competitiveness and profitability.

With the researching results, this study hopes to achieve the following objectives: Firstly, make the traditional industries understand the definition, philosophy and objectives of independent maintenance. Secondly, make the traditional industries understand the theory and practice of independent maintenance. Thirdly, understand the current situation of the domestic traditional industries, and analyze their bottlenecks and the plight they are facing. Fourthly, analyze the feasibility of introducing independent maintenance into domestic traditional industries and develop the import mode. Fifth, analyze the estimated results of introducing independent maintenance into domestic traditional industries and the bottlenecks that may appear in the process. Finally, it is hoped that the independent maintenance can be successfully imported into traditional industries, improving the struggling situation they have nowadays in the competitive environment.

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