

CASE STUDY OF THE ESTABLISHMENT OF MAINTENANCE MECHANISM OF INJECTION MACHINE

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ABSTRACT

Maintaining the normal operation of machinery and equipment in order to reduce the failure rate and increase the utilization rate is one of the most important tasks of on-site management. This research is mainly based on the establishment of relevant equipment inspection and maintenance specifications, the establishment of tables, and the promotion to on-site practical explanation, operation drills, and introduction and implementation. And use the DMAIC process of Six-Sigma to verify the improvement process. Before the equipment maintenance mechanism is introduced, the utilization rate, downtime, and number of failures were about 64.9%, 1603 min/month, and 16.7 times/month, respectively. After about half year implementation of the maintenance mechanism, its utilization rate, downtime, and number of failures were 76.13%, 250 min/month, and 3.5 times/month, respectively. Which has a significant improvement. Furthermore, in terms of tangible aspects, there are obvious improvements in increasing the utilization rate, reducing the number of failures, shortening the downtime, reduce manpower need, and raw material consumption. In the intangible aspect, the operator thus feels the cleanliness of the equipment is improved, the normal operation to reduce workload, and the work in a happy mood.

Keywords: *equipment maintenance, inspection and maintenance, utilization rate, value stream mapping.*

1. INTRODUCTION

In 2019, the total number of all enterprises in Taiwan was 1,527,272, of which 1,491,420 were small and medium enterprises, about 97.65% of the total number of entrepreneurs. In recent years, the enterprises have been continuously introducing various business management models, with the aim of improving and optimizing the management physique, hoping to adapt to the ever-changing business environment and timely adjust the business strategy in this fiercely competitive environment.

Case company is a small traditional manufacturing factory. The machinery and equipment in the factory are often shut down due to failures, resulting in low utilization rate, which affects production efficiency and employee morale. There are no internal management regulations and benchmarks related to the maintenance of machinery and equipment for on-site operators to conduct daily inspections and regular maintenance operation guidelines. Only rely on traditional experience to solve failure problems, resulting in a high failure rate of injection machines. And the downtime is long and affects the operation of the company.

Therefore, if there is a set of effective relevant management regulations and inspection benchmarks can be formulated and provide on-site operators with the basis for daily inspection and regular maintenance, thereby reducing the number of failures and downtime and improving the utilization rate. The on-time of delivery rate and the completeness of all aspects of the machinery and equipment can produce stable quality products.

The objectives can be achieved after this research period:

- (1) Summarize the basic knowledge of injection machine and the key points and benchmarks of inspection and maintenance required.
- (2) Reduce the times of equipment failures and downtime, improve the utilization rate and the on-time delivery rate.
- (3) As the future activities of case company in promoting TPM (Total Productive Maintenance).
- (4) The established mechanical and equipment management regulations and related Tables can be used for the future application of ISO 9001 certification.

2. LITERATURE REVIEW

The Relationship between Equipment Maintenance and TPM

TPM is mainly a method to reduce the loss of equipment failure downtime, short-term downtime, equipment running speed, and defects.

TPM is based on maintenance, and seeks to maximize efficiency and minimize costs in terms of production efficiency.

Chen [1] mentioned that its spirit is to ensure that materials and goods can be delivered to the workstation on time through a repetitive production system, and to aim at the lowest cost, the largest profit and the least waste.

The purpose of the implement of equipment maintenance management is not only to cultivate basic operators to carry out maintenance actions and related knowledge, but also to reduce part of the management cost and lay the foundation for future TPM implementation.

Whether it is the introduction of TPM, TPS and other management modes, equipment management is the basis of on-site management.

One of the main essences of TPS, the JIT (Just in Time) system, was created by Taiichi [2] the former vice president of Toyota Motor in Japan. The lowest cost and the highest profit and the least waste are the goals.

The purpose of equipment management is not only to cultivate basic operators to implement the actions and related knowledge of spot inspection and maintenance; more importantly, it can reduce part of the management cost, but also lay the foundation for the implementation of TPM in the future.

The Relationship between Equipment Maintenance and Autonomous Maintenance

The focus of autonomous maintenance should be to carry out daily and regular maintenance operations through standardized inspection and maintenance to prevent the occurrence of deterioration and failure of machinery and equipment.

Thus, to ensure that the operation of machinery and equipment can maintain a certain level, for example; the correct operation of equipment methods, conditions during normal operation of equipment, confirmation of basic setting conditions, appropriate adjustments during mold change and line change, and response and recording when abnormal conditions occur.

The Relationship between Equipment Maintenance and 5S

5S is sorting (seiri), rectifying (seiton), cleaning (seiso), cleaning (seiketsu) and habit (shitsuke). When these work concepts are instilled into the consciousness of the equipment operators, the equipment operators can focus on the maintenance of the equipment and implement active inspection and maintenance.

The focus is not on neatness and cleanliness, but from the process of implementing 5S activities, to gradually understand the basic structure, function and location of related problems of the equipment, and then develop the ability to think about problem analysis and countermeasures.

The Relationship between Equipment Maintenance and Equipment Total Efficiency

Qiu [3] reported on promoting of TPM and related performance, 75% of the motivations for implementing equipment maintenance in Taiwan are due to the high failure rate of mechanical equipment, and 67% due to poor performance of equipment maintenance.

The overall equipment effectiveness (OEE) calculation formula is as follows:

Total equipment efficiency = time utilization rate × equipment utilization rate × yield rate.

Time utilization rate = (load time - downtime) / load time

Equipment utilization rate = (standard working hours × output quantity) / working time

Yield rate = (output quantity - defective product quantity) / output quantity

Time utilization rate is one of the benchmarks for the results of this study. It represents the rate at which equipment can operate normally. That is, the load time of equipment (design and production time), the ratio of the actual production time (actual production time = load time - downtime) simply represents the production time of mechanical equipment production, regardless of its product quality status.

Tsai [4] and Lin [5] repeatedly mentioned the impact of losses in their papers. There are various losses in the company's business activities, that is, the so-called waste. The material loss, energy loss, quality loss, logistics loss, and management loss.

In conclusion, it is an imperative policy for enterprises to promote the equipment management mechanism, so as to stabilize the production efficiency and equipment utilization rate of the manufacturing site and improve the product yield.

3. CASE COMPANY PROFILE

The case company has a history of about 12 years since its establishment in 2009, and the current number of workers is about 20. There are 5 injection machines. At present, more than 60% of the main order sources are orders placed by customers in Taiwan, and less than 40% of the orders are for export.

The production process of case company is for customers to place orders, and then the production management unit executes orders for raw materials to relevant suppliers and schedules on-site production plans.

Due to the excessive downtime of the machine failure, the on-site process cannot be effectively connected, resulting in the phenomenon of insufficient delivery. In addition, the defective products derived from the machine failure are too high.

Under the causal relationship of this vicious circle, the high internal personnel costs, raw material costs, and management costs. Personnel performance is poor and performance cannot grow, which is one of the main factors that make the company unable to make profits.

The case company hope to take this equipment maintenance and improvement activities to achieve the goal of reducing equipment failure rate, increasing utilization rate, and improving excellent quality of enterprise management and management.

4. RESEARCH STEPS

The main method of this study is to use and refer to the five-stage improvement model (also known as DMAIC), which is increasingly used in the Six-Sigma method, which is a process improvement management system, that is: Define → Measure → Analyse → Improve → Control. The research steps are described as follows:

Define

Preliminary definition the daily inspection and regular maintenance items, including machine safety protection mechanism, lubrication system function and oil level confirmation of each department, heating system function and stability, cooling system function, actuating oil level confirmation, electronically controlled cooling system and other items.

Measure

Company currently does not have relevant management regulations and implementation procedures, inspection and maintenance project benchmarks for its daily inspection and regular maintenance procedures. Resulting in the inability to carry out effective spot inspection and maintenance activities for injection machines on a daily basis, resulting in a high number of equipment failures and a risk of long downtime.

Therefore, in order to obtain more accurate data on the number of downtimes, maintenance man-hours and utilization rates for the next step analysis. The authors started to collect and record relevant fault maintenance data from March to September 2021 to obtain basic research information. And from October to December 2021, the information collected will be used to formulate a flow chart of injection machine equipment maintenance management, and then establish its related equipment management methods according to the machine equipment maintenance management flow chart.

Analysis

The production process of case company is for the customer to place an order for the business, and then the production management unit executes the raw material order and on-site production scheduling production plan.

From the production flow of the daily injection process, it is found that the time spent waiting for the machine to heat up and adjust the production conditions before starting production is about 30 minutes.

The average number of failures in the month before the improvement was 16.7, the average monthly failure time: 1603 minutes, and the monthly average equipment utilization rate: 64.9%.

The types of failures analysed from the equipment maintenance record are concentrated in the lubrication system (30 times, 26%), material pipe heating system (31 times, 27%), and electronically controlled cooling system (16 times, 14%), cooling water system (8 times, 7%), safety protection system (6 times, 5%), and others (25 times, 21%), etc.

The value stream mapping before improvement was shows as Figure 1.

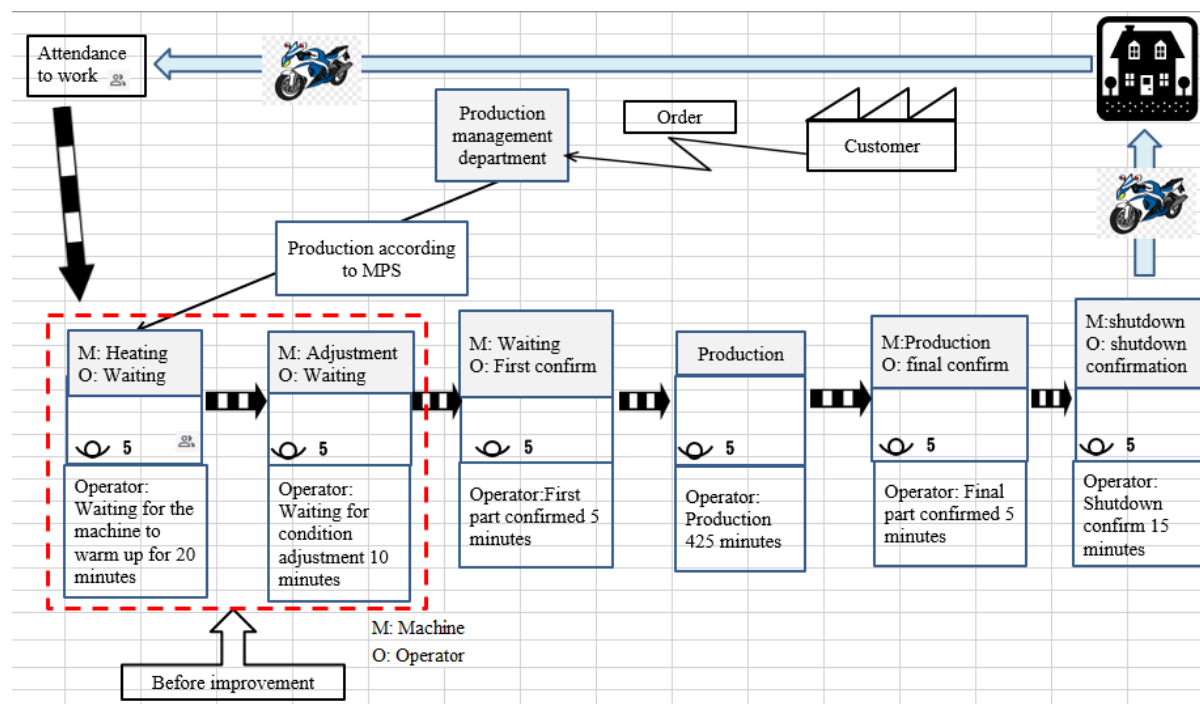


Figure 1 The Value Stream Mapping Before Improvement

Improve

The activities of this stage are for the field operators to carry out the level of maintenance and inspection of injection machines. In addition to establishing relevant inspection and maintenance standards and regulations, they also establish with the field operators the important concept of "self-maintenance of their own equipment". The improvement, the sense of achievement obtained from the change, and the emphasis on the establishment, inheritance and management of data.

During this improvement stage, the four major types of failures of injection machines are mainly used to formulate machine and equipment maintenance and inspection benchmarks, daily inspection forms of machinery and equipment, regular maintenance forms, education and

training to educate operators about basic knowledge of equipment inspection and maintenance, and practical ability development. After passing the written test of the subject and the test of the technical subject, it is logged on the technician education and training score sheet and log-in sheet, so that the operators can understand the purpose and relevant benchmarks behind the inspection and maintenance, so as to shorten the maintenance time, the number of failures and the downtime.

In order to effectively reduce the waste of waiting for workers when starting production operations and to actually perform basic inspections of equipment, inspections before daily operations of machinery and equipment are carried out while waiting for the temperature of the material pipe, adjustment of conditions, and confirmation of the first item. , in order to reduce the waste of working hours.

Furthermore, workers use the 15 minutes before leaving get off work to clean the work area. The operator can find out the potential problems and defects of the mechanical equipment through the inspection before operation and the cleaning mechanism after the operation, and then arrange the time to shut down and invite external professional maintenance technicians to enter the site to perform maintenance operations to restore the equipment to the best possible condition. In the best condition, the failure rate and downtime of the equipment will be reduced, so as to achieve the goal of improving the utilization rate of the equipment.

The value stream mapping after improvement was shows as Figure 2.

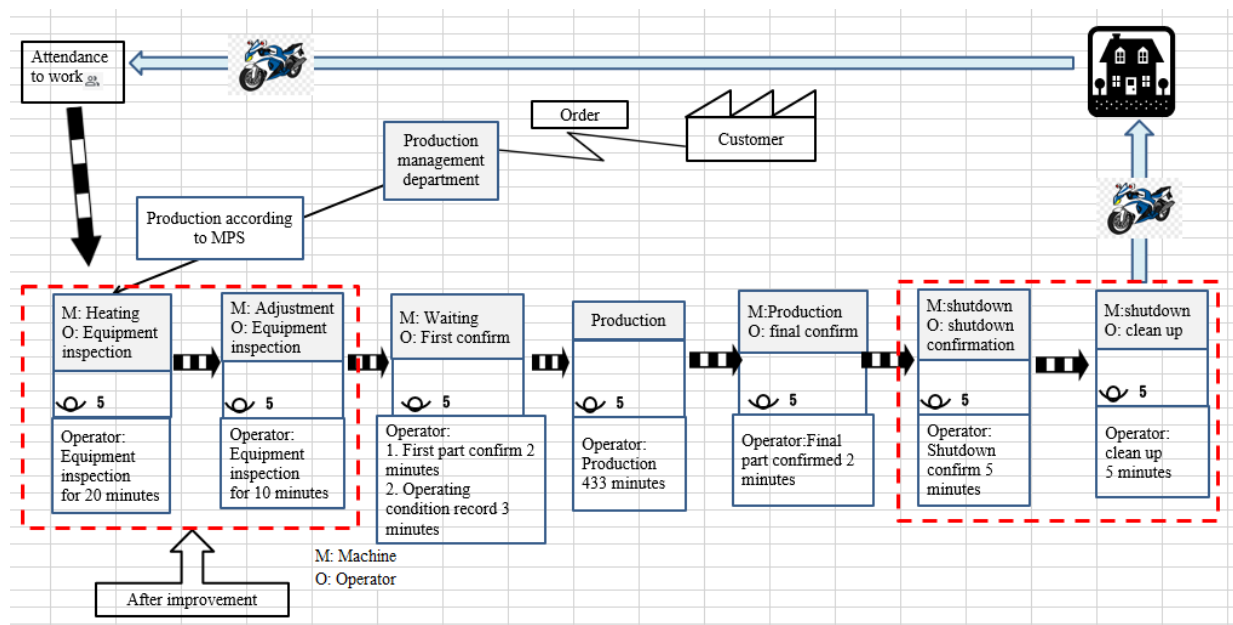


Figure 2 The Value Stream Mapping After Improvement

Control

The purpose of implementing management and continuous improvement activities is still to strengthen the management physique that the enterprise is pursuing, and then achieve the vision of enterprise management. Through the introduction of empirical research results of equipment maintenance management improvement activities, it can be proved that a high-quality production line must be continuously promoted and improved and the cooperation of all on-site operators can improve the level of the production line to a higher level.

5. CONCLUSION

After synthesizing the above research contents, discussing and actually constructing system management data such as relevant management regulations, benchmarks, and tables, after proper data analysis and actual maintenance, this research has the following improvement results:

- (1) Only through a series of related management systems, benchmarks, specifications and forms can the equipment maintenance be followed.
- (2) The fault maintenance status reported by the original manufacturer's maintenance personnel when they come to the factory for maintenance must be integrated, organized and recorded in the maintenance record data file, so as to facilitate future knowledge inheritance or use when the same problem is encountered again and needs to be solved. By querying the relevant documents or information, and providing reference for solving the problem, it can achieve multiplier effect with half the effort.
- (3) Before the improvement, the average monthly utilization rate was 64.9% before the mechanical equipment maintenance management mechanism was introduced. And, after implement the equipment maintenance mechanism, the monthly average utilization rate is 76.13%, which has indeed improved the utilization rate of the equipment.
- (4) Effects of implement the equipment maintenance is shown in Table 1, Figure 3-5. Before the equipment maintenance mechanism is introduced, the utilization rate, downtime, and number of failures were about 64.9%, 1603 min/month, and 16.7 times/month, respectively. After about half year implementation of the maintenance mechanism, its utilization rate, downtime, and number of failures were reached 76.13%, 250 min/month, and 3.5 times/month, respectively. Which has a significant improvement.

Table 1 Comparison Before and After the Implementation of Equipment Maintenance

Item	Before (A)	After (B)	Improve (C=B-A)	Improve ratio (D= C /A)
Utilization rate	64.9 %	76.13 %	11.23 %	17.3 %
Downtime	1603 min/month	250 min/month	- 1353 min/month	84.4 %
Number of downtimes	16.7 times/month	3.5 times/month	- 13.2 times/month	79.04 %

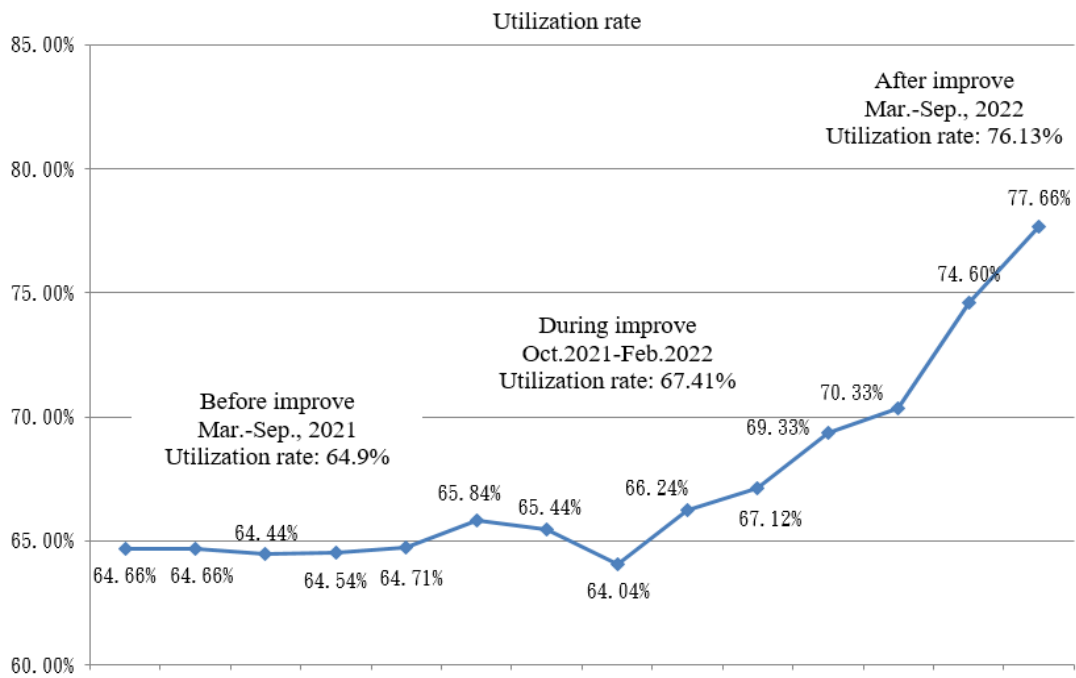


Figure 3 The Utilization-Rate Curve Before, During, and After Improvement

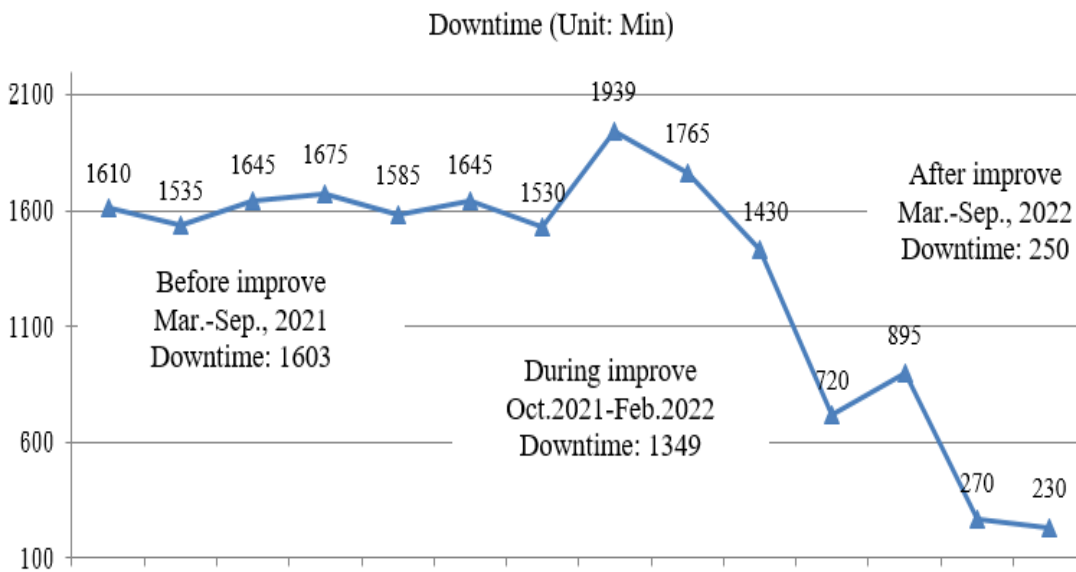


Figure 4 The Downtime Before, During, and After Improvement

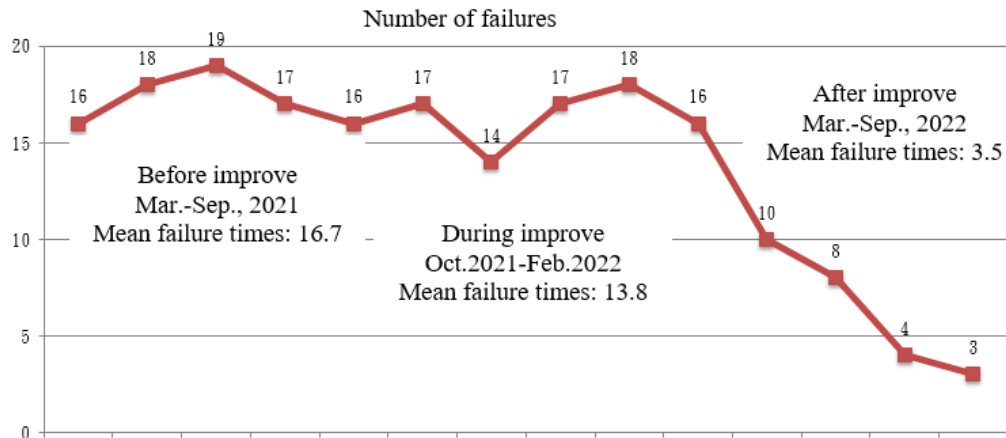


Figure 5 The Number of Failures Before, During, and After Improvement

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