

Improvements of Fast Disinfection Gateway Design by TRIZ Method-Taking A Company as an Example

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Abstract

The outbreak of COVID-19 in Wuhan, China in December 2019, began spreading around the worldwide and became a global concern. This has changed people's consumption habits and lifestyle. More importantly, people pay more attention to the environment and personal hygiene habits. Enterprises have purchased many disinfecting equipment attempting to minimize the spread of the pandemic and reduce getting harmed.

This research uses the TRIZ method analysis of disinfection gateway. The water and disinfectant in the original gateway were done manually by the operators and the imprecise proportions was causing ineffective sterilization. The acidity in the disinfectant will slowly corrode the equipment due to long-term use, shortens service life of the equipment. Firstly, analyze problems by using Mind Map. Secondly, the problem of equipment is solved by the contradiction matrix of TRIZ, problem hierarchy analysis (PHA), 40 inventive principles, substance-fields analysis and 76 standard solutions. An automated system eliminates unstable disinfection dispensing. To fulfill the responsibility of the manufacturer to achieve the concept of circular economy, automatic cleaning system for prolonged the products' life expectancy of equipment was added. In trial results, the initial estimate of automatic water and disinfection system was stabilized, which not only improved the convenience of operation but also prolonged the products. The trials effectively achieved the effect of epidemic prevention, reducing the loss of shutdown.

Keywords: TRIZ, Covid-19, disinfection gateway

1. Introduction

Research background and motivation

At the end of 2019, a sudden outbreak of the Covid-19 virus spread to more than 200 countries in just a few months, and the cumulative death toll exceeded 5.99 million in March, 2022, and the number of infected people reached 445 million (WHO Dashboard, 2022). The severity of the epidemic has caused all countries in the world to spare no effort in various epidemic prevention work and vaccine research and development, and the epidemic prevention, sterilization and disinfection channels have also emerged as a result. The increase in the number of deaths has resulted in insufficient medical care and a lack of social resources. However, the required epidemic prevention resources are also focused on masks and disinfection products. As a result, various anti-epidemic disinfection systems have emerged in the market, and a variety of disinfection equipment has also appeared in enterprises, schools, government agencies, shops and medical institutions...etc.

This study focuses on the two major problems faced by small and medium-sized enterprises in setting up epidemic prevention and disinfection channels: 1. The original equipment is manually replenished with water and drugs by personnel, resulting in uneven portion and unstable disinfection effect; 2. The equipment is accelerated corrosion and oxidation and shorten the service life due to long-term use of disinfection solvents.

Through the application of TRIZ theory to improve the design of personnel disinfection, and establish a disinfection and sterilization system that can better meet the needs of enterprises. It is improved to the existing disinfection channel design, making the disinfection channel safer, easier to operate and better in disinfection effect. Improve the manual replenishment of water and dosing by personnel, so that the system can automatically adjust the ratio to eliminate the instability of the disinfection effect and ratio caused by the operation of personnel. If the equipment is used for a long time, it is easy to cause equipment erosion due to the pH value in the disinfection solvent, which shortens the service life of the equipment. The automatic cleaning function is added to

prolong the service life of the product and save labor hours for maintenance.

2. Literature Review

2.1 Introduction of Disinfection Gateway

The disinfection gateway originated from the outbreak of African swine fever in Asia in 2018. As of June 30, 2019, there were 143 African swine fever outbreaks in mainland China. Due to this reason, the epidemic prevention and sterilization channel is widely used in animal husbandry. The so-called disinfection is to kill pathogenic microorganisms. Disinfection can prevent the occurrence of infectious diseases in animal husbandry and is one of the ways to cut off diseases. Strict disinfection can effectively reduce the incidence of disease in farms by 80%. For good economic benefits, disinfection work must be carried out reliably. Make good use of the animal husbandry disinfection system and introduce this concept into COVID-19 epidemic prevention and sterilization, so as to effectively reduce the risk of virus spread and achieve the effect of epidemic prevention (NICOLER, 2019).

Product bracket, channel cover, nozzle and control box

Economical (detachable) disinfection gateway brackets are available in the market with various materials: SUS304 stainless steel pipe, galvanized iron pipe, aluminum alloy, PVC plastic pipe and other materials. Each material type has its own advantages and disadvantages.

The simple disinfection channels available in the market are with and without covers. The water molecules in the anti-epidemic channels without covers are easily blown away by the wind and affect the disinfection effect. The better the sealing, the better the disinfection effect will be. The gateway cover materials on the market include: PVC, high-strength aluminum extruded materials, cold-rolled steel plates, stainless steel (white iron) and other materials. The low-cost nylon cloth cover can also achieve the same effect as the high-cost and expensive disinfection cover, and it is easy to remove and store.

This research system uses logic control circuits to replace more sophisticated and complex single-chip and programmable logic controller PLC (Programmable logic controller) and other control equipment, although single-chip and programmable logic controllers are widely used in industrial production and can be. It is more complex and multi-function control, but its price is high, maintenance is not easy (professional maintenance personnel are required), and it is not resistant to the harsh en-

vironment of agricultural production. The traditional wiring control circuit has the advantages of low price and easy maintenance. A hydroelectric maintenance worker or farmer with a little knowledge of circuit control can perform maintenance and replace parts (Wu, 2004).

2.2 TRIZ Principle of Innovation and Invention

TRIZ was founded by Russian inventor Genrich Alshuller in 1946; Alshuller and his team conducted in-depth research to obtain the results of the laws of invention, and sorted out a systematic approach for innovative ways to solve. The theory sorts out 39 engineering parameters, and uses the conflict matrix to lead the designer towards the direction of the invention principle to solve the conflict and then find the solution in the field.

TRIZ provides a comprehensive analysis toolkit, which covers problem hierarchy analysis, 39X39 contradiction matrix, 40 invention principles, matter-field analysis and 76 standard solutions, etc. Solve problems from different perspectives, based on a wide range of inventor knowledge and experience. In recent years, the TRIZ method has been widely used in relevant literature research in various industries.

Applying curriculum and practical solutions in EFL in education demonstrates valuable contributions (Chang, 2012). Industrial manufacturing is used to improve design and entrust OEMs to eliminate the deadline to complete the delivery in the case of shortened product life cycle, and use the smartphone development project to summarize the most common problems in the development process (Lin et al., 2020). The service industry can be applied to medical services such as technology, nursing, rehabilitation and other professional fields to improve the quality of overall medical care management (Chen et al., 2011). In the application of green economy, the product improvement through TRIZ is to replace the old core type with the new core type, so that the energy conversion rate of the product can reach 5% and it is more in line with environmental protection demands (Trappey, et al, 2011). The TRIZ method is not only about adding and subtracting methods to solve the problems faced by existing engineers, but also can be widely used in various fields. Therefore, this research uses the TRIZ method for product improvement and innovation.

2.3 Related Application Research of Disinfection Device

Gao et al. solved the current manual operation problem of public handrail disinfection, and analyzed the deficiencies in the current

system by using the functions of TRIZ, which is the most effective solution in this study. After analysis by the ARIZ algorithm, the final plan adopts a three-stage design to solve the problems faced, so that the disinfection ring can pass through the bend of the public handrail autonomously. The original O-shaped shell is improved into a U-shaped shell, and the opening is connected with a stopper rod. The connecting part is moved to prevent the disinfection ring from being blocked by the joint of the public handrail, and the motor device is used to drive the rubber wheel to provide power. Use ultraviolet irradiation instead of spray disinfection, saving time for personnel to replenish disinfectant. The front and rear ends of the disinfection ring provide horizontal power, and the middle part rotates upward to carry out enveloping disinfection on the disinfection ring. This paper uses TRIZ tools to improve its original products. The notable features are: non-contact automatic cleaning design, automatic disinfection of public handrails, eliminating the need for manual operations, ultraviolet radiation disinfection instead of disinfectants, eliminating the need for personnel to replenish operations, and the final improvement plan as shown in Figure 1. The essence of the design is to meet the maximum needs of users. Through the improvement of public handrail disinfection devices through TRIZ, it can meet people's urgent needs for public health safety under the threat of the epidemic (Gao et al., 2021).



Figure 1: Schematic Diagram of the Final Plan for Disinfection of Public Handrails

Dai et al. used TRIZ invention theory to improve the problem of imperfect disinfection and delayed disinfection operations, resulting in a wide range of virus infection problems, and proposed a structural scheme for automatic disinfection robots. The research is based on the fact that manual disinfection is easy to increase cross-infection between people, poor disinfection effect, unstable quality and harm to the human body of disinfectant, and the disinfection robot shaves the above shortcomings. Eliminate harmful effects through substance and field analysis, and analyze obstacles encountered in the final ideal product. Then solve complex problems through technical contradic-

tions and invention principles, and find out the relevant corresponding matrix tables. Obtaining the principle of the invention of composite materials will allow the robot to replace the steel structure with engineering plastics, which can effectively reduce the overall weight and improve the flexibility of the robot. Finally, by changing the color of the invention, the original ultraviolet lampshade was changed to a high-permeability acrylic plate to increase the light-transmitting area and improve the disinfection efficiency and effect. Sterilization is the highest priority goal, so the number of ultraviolet disinfection lamps is increased, and the original single disinfection lamp device is increased to two. The total number of disinfection lamps on the base is three disinfection lamps arranged at an angle of 120° to each other, and the ball screw is used to drive the expansion and contraction. The structure diagram of the disinfection module is shown in Figure 2. A servo is installed on the top of the module to drive the middle ball to rotate, and the connecting rod is pushed to drive the disinfection lamp out. The three disinfection lamps are arranged at an angle of 120° to each other to ensure that the disinfection robot has no dead angle for 360° disinfection. The structure of the mobile module is shown in Figure 2-20. It is an automatic guided vehicle. It collects information through transmission and induction, calculates its own position and attitude based on the SLAM algorithm, performs autonomous positioning and navigation, and autonomously returns to the charging station for charging to realize automatic disinfection. The demand (Dai et al., 2021).

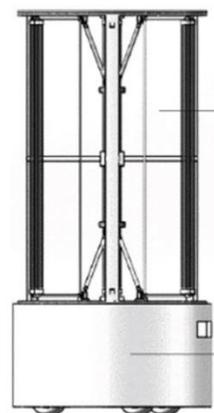


Figure 2: Schematic Diagram of the Structure of the Disinfection Module

The outbreak of COVID-19 caused large-scale infections, among which the contact between people is the fastest transmission route, reducing the contact between people and things is the primary focus of epidemic

prevention, and the contact interaction method in the elevator with poor air flow has become an epidemic. There is a big worry. In order to prevent users from directly touching the elevator buttons, Zhang et al. first used AD to analyze the functional requirements of the product to find out that the operation and control functions and the operation and control devices without public contact are mutually contradictory factors; then TRIZ obtained the final design plan and to verify its feasibility, use the extraction principle to adopt a non-public contact interactive operation mode, and conditionally separate to provide different disinfection systems for disinfection under manned and unmanned conditions. In the exclusive areas of commercial buildings and residential buildings, it can also be combined with the face recognition system to grant access rights, eliminating the need for contact elevator buttons. The practical application of this research verifies the AD and TRIZ methods, which not only improves the efficiency of product design and development, but also meets the needs of customers

more accurately. The scheme design of the interaction mode between the two can provide an effective theoretical support for new products (Zhang et al., 2021).

3. Research Methods

Research Process

This study will take the case company-A company as an example of the practical theory of the case study method, and analyze the problems of the epidemic prevention and disinfection channels. The original equipment is manually replenished with water and drugs, resulting in uneven distribution of the ratio, resulting in unstable disinfection effects, and the long-term use of disinfection solvents to accelerate the nozzles and water spray pipes of the equipment has shortened the service life due to corrosion and oxidation of the pipelines due to long-term storage of liquid medicine. The research processes of this study (Figure 3) are shown as follows:

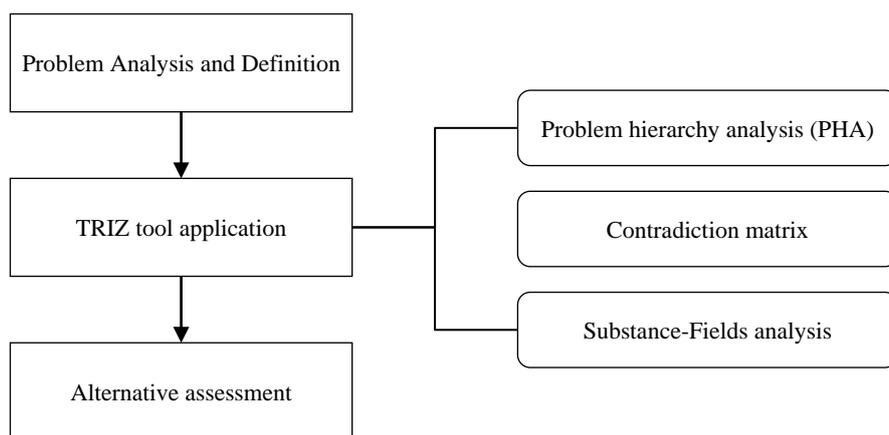


Figure 3: Research Process

Existing epidemic prevention disinfection gateway system of the case company

Due to the rapid and rapid outbreak of the epidemic, through communication with the manufacturer to purchase the epidemic prevention disinfection and sterilization gateway in a customized way, so that it can be quickly provided to the company's employees before entering the factory, so as to prevent the spread of the epidemic in the enterprise and cause shutdowns loss. The original design must use manual water replenishment and dosing actions, and it is necessary to ask personnel from time to time to confirm whether the volume of disinfection solvent in its volume is sufficient.

Problem hierarchy analysis (PHA)

Analyze the existing problems in the disinfection channel. Because the existing system must manually replenish water and add medicine, it not only consumes manpower, but also easily increases the probability of unstable proportion of disinfection solvent due to personnel operation, resulting in reduced sterilization effect and long-term use of disinfection solvent. Shortened lifespan. Therefore, two questions are raised as follows:

1. Improper operation of personnel causes uneven distribution of disinfection solvents and reduces the sterilization effect.
2. The acid in the solvent slowly corrodes the equipment and shortens the life of the product.

Contradiction matrix and 40 inventive principles

Find out the pain points of the research equipment system through the mind map and problem level analysis, and then use the contradiction matrix to describe the product problem, and seek the corresponding solution of the engineering parameters from the contradiction matrix to the corresponding 40 invention principles.

Facing problems:

1. The disinfection and epidemic prevention channel is easy to be operated by different personnel due to manual water replenishment and dosing by personnel, resulting in an unstable ratio of disinfection solvents. .
2. Due to the long-term use of the equipment, the acid in the disinfection solvent is easy to corrode the equipment slowly, shortening the product life.

Substance-Fields analysis and 76 standard solutions.

The process of using matter-field analysis to obtain answers must first find out the problem, define the problem it is currently facing, and list the matter-fields interacting with all the related elements from the interacting elements. Through these interactive components, the matter-field structure is modeled, and a new matter-field model is constructed according to the feasible solutions listed therein.

4. Case Study

Applying Problem hierarchy analysis

Through the Problem hierarchy analysis method, conduct problem research and extension for the design of epidemic prevention and sterilization channels, and find out the parts that can be improved and product optimized. Figure 4 is a PHA diagram after analysis.

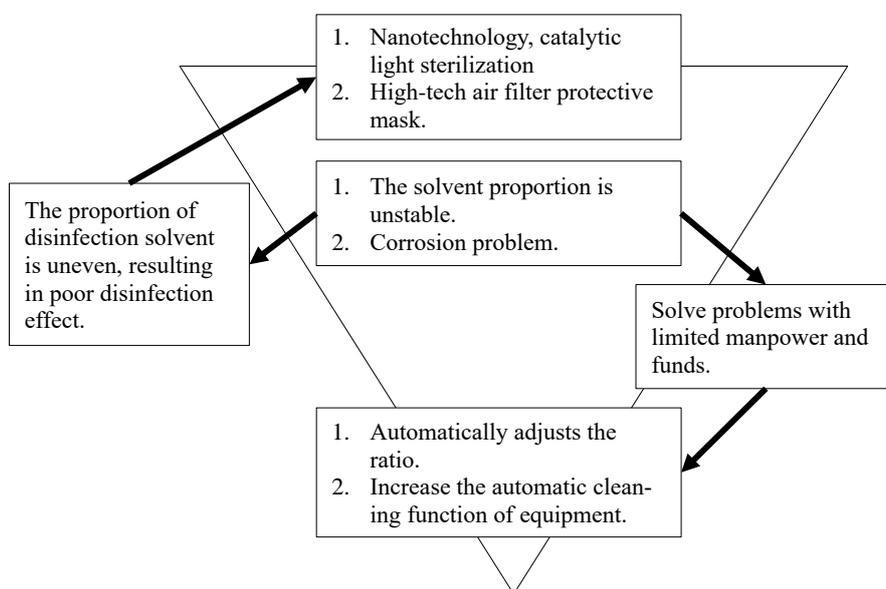


Figure 4: PHA Diagram

The PHA plan for the design of epidemic prevention, sterilization and disinfection channels is shown in Table 1. In this study, the most suitable improvement plan for this study is the

automatic allocation ratio of the machine and the addition of the automatic cleaning function of the equipment.

Table 1: Alternatives by PHA

Item	Project name	Key words	Key attribute	Remark
1	Nanotechnology, catalytic light sterilization	Nano, light sterilization	Equipment has no corrosion problems	High cost and technical level
2	High-tech air filter protective mask.	Air filter	No equipment required	High cost
3	1 .Automatically adjusts the ratio. 2. Automatic cleaning	Automatically adjust Automatic cleaning	Personnel do not need to operate frequently	Cost-effective

Applying contradiction matrix and 40 inventive principles

In order to improve the problem of unstable sterilization effect caused by human factors, this study uses the parameters corresponding to the contradiction matrix to obtain the system characteristics expected to be improved on the

left, and the up side of the matrix table is the corresponding parameters to improve the contradictory characteristics that cause deterioration, through the correspondence table of the contradiction matrix in Table 2, find out the direction and target that can potentially be improved.

Table 2: Contradiction Matrix Correspondence Table

Improve	Worsen	35. Adaptability	34. Convenience of repair
28. Accuracy of measurement		13、35、2	1、32、13、11
33. Convenience of use		15、34、1、16	12、26、1、32

From Table 2, the characteristics to be improved and the results to avoid deterioration obtained, the "measurement accuracy" in the 28th column and the "ease of use" in the 33rd column correspond to the "adaptability" in the row 35th and the "adaptability" in the 33rd column. The "maintenance" in the row 34th is obtained through the grids where the rows and

columns meet to solve the contradictions faced: 1. Segmentation, 2. Separation, 11. Cushion in Advance, 12. Equipotentiality, 13. Reversal, 15. Dynamics, 16. Insufficient or excessive effect, 26. Duplication, 32. Color change, 34. Discard and restore, 35. Parameter change. This study will repeat the two principles for research, as shown in Table 3.

Table 3: Alternatives by 40 Inventive Principles Solutions

Invention principle	Improved design
1. division	Divide water and liquid medicine into two independent parts, and set the proportions separately. By adding medicine and replenishing water system, automatic deployment can reduce personnel errors and stabilize the proportion of disinfectants. The principle of easy disassembly and assembly of each assembly part is conducive to the flexible use of equipment.
13. reversals	The reverse operation of the original manual deployment ratio of personnel is changed to automatic deployment, so that personnel only need to be replaced after the potion is used up.

This study will use the principle # 1 "division" and # 13 "reversals" as the basis for improvement. First of all, the use of divided objects into several independent parts makes the use of the product more flexible, and then the opposite effect is used to replace the principle of the original action, and the original manual proportional allocation of personnel is changed to automatic allocation of the system. Finally, an automatic cleaning system is added to extend the service life of the equipment.

Applying substance-fields analysis and 76 standard solutions.

The pain points that need to be improved in the analysis of the case channel design are 1. Manual potion dispensing and 2. The acidity in the disinfection solvent causes equipment corrosion. A new material-field analysis is carried out for these two points, and the proposed solution is found through the 76 standard solution Improve direction.

According to the standard solution, to improve the proportion of manual disinfectant, by adding an information field, from the 3-1 item "transformation to dual-multi-system" model in the third category "transition from su-

per-system or micro-system", Propose solutions for improvement. The project "System Evolution 3-1-1 Creation of Dual and Multi-systems" is strengthened through the combination of systems to build a more complex dual and multi-system, as shown in Figure 6. Disinfection channel automatically proportioned material-field Model, the ratio of clear water and liquid medicine is set by the automatic control element. The automatic dosing system uses the concept of a floating ball to add a micro-switch of the floating ball to control the upper and lower water levels of water replenishment through micro-signals. When the water level is at the lower water level, the no-water stop light will activate to notify the system to replenish water and dosing; at this time, when the dosing light is on. At this time, the water supply system will automatically start the water supply device to the full water level to complete the automatic dosing and mixing ratio, so as to save the time of manual dosing, the wrong dosing ratio, and the volatilization of the medicine due to manual supplementation, which will cause the medicine to be in an invalid state.

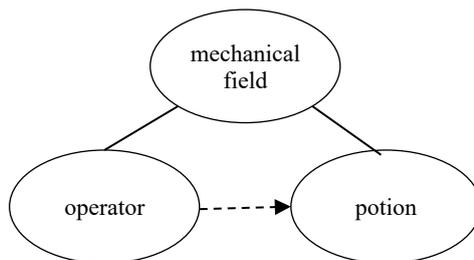


Figure 5: Manual Deployment of Scaled by S-F Model Analysis

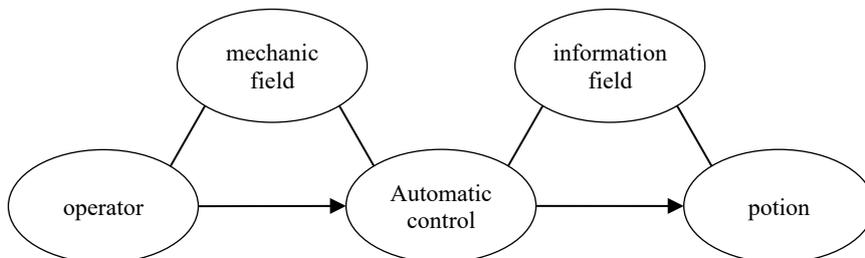


Figure 6: Disinfection Gateway Automatically Proportioned by S-F Model Analysis

In response to environmental protection, companies hope to extend product life and reduce unnecessary waste. After a long period of use, the equipment will be corroded due to the acidity and alkalinity in the solvent. Through the 1-2 items in the first category of "13 standard solutions for establishment and destruction" in the 76 standard solutions, the model of "destroying, eliminating or counteracting harmful effects in the system" is improved. Item 1-2-2 "Eliminate the harmful relationship by changing the existing substance" eliminates the harmful effect by changing the substrate.

According to the standard solution, to improve the problem of equipment erosion, the original harmful substances can be extracted

from the system, as shown in Figure 5. The disinfection channel automatically cleans the substance-field model. Remove the original potion and clean the equipment with clean water. By setting the status of activated cleaning and deactivated cleaning. If you choose to start cleaning, when the system is shut down, the liquid medicine pipeline will be set not to start, and only the clean water pipeline will be started; the equipment will automatically clean the water spray pipeline to prevent corrosion and oxidation of the water spray pipe due to long-term storage of liquid medicine. This action can extend the service life of the equipment, it is not necessary to frequently replace the water spray pipeline and the channel body.

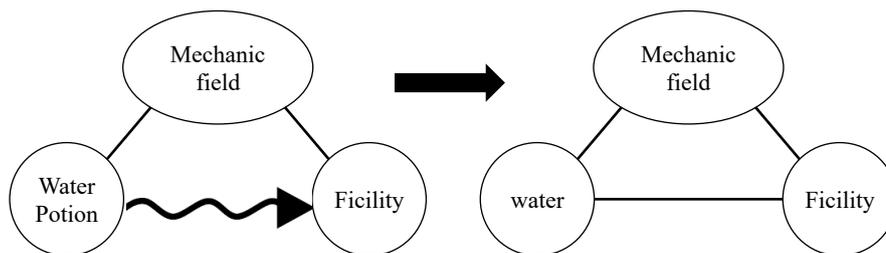


Figure 7: Substance-Field Model for Automatic Cleaning of Disinfection Gateway New System After Improved

This study found that in this system, personnel manually adjust the proportion of disinfectant solution, which will easily make the disinfection effect unstable. Based on the TRIZ Problem hierarchy analysis, it can be concluded that the automatic allocation ratio of the machine and the addition of the automatic cleaning function of the equipment can reduce the cost; the contradiction matrix and the 40 invention principles can be obtained, and the object can be divided into several independent parts to make the product easier to use. In order to be

flexible; the substance-field analysis and 76 standard solutions are obtained to add an information field, and use automatic control components to control the proportion of potion to make up for the deficiencies of the original system.

Automatic water replenishment and drug dosing improvement

In order to stabilize the disinfection effect and reduce the man-hours of personnel, the original manual ratio allocation of personnel

was changed to the improvement of automatic allocation of the system. Substance-field analysis and 76 standard solutions give the addition of an information field, and use automatic control components to control the proportion of

portion to make up for the shortcomings of the original system. The case company actually improved the system and eliminated the manual rationing of portions by personnel.

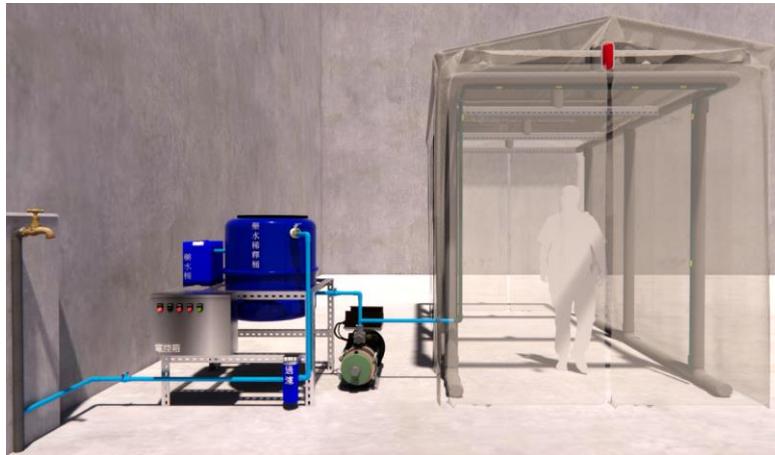


Figure 8: Schematic Diagram of the Improved Disinfection Channel



Figure 9: Improved Finished Product of Disinfection Channel

The acid corrosion of equipment can eliminate the harmful relationship by changing the existing substances, remove the liquid that caused the acid corrosion from the system, and block the activation of the disinfection liquid when the cleaning system is activated, and only

start the action of clean water. The automatic cleaning process is shown in Figure 10. The case company can increase or decrease the number of cleanings according to the degree of use. The improved system is shown in Figure 7.

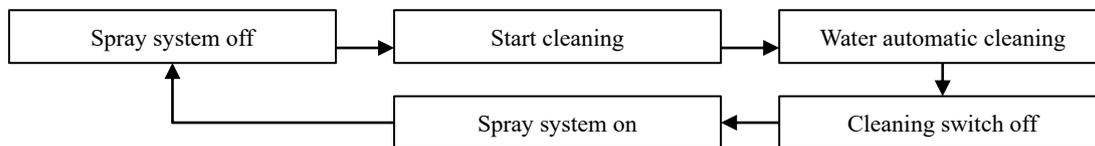


Figure 10: Automatic Cleaning System Process

As shown in Figure 11, the user must first set whether to start automatic cleaning after the spray system is turned off. When the spray system switch on the control box is turned off, it will perform cleaning or not cleaning according to the user's settings. The action is avoid corro-

sion and oxidation of spray pipes. If it is set to turn on automatic cleaning, the water from the faucet will pass through the filter system and then be sent to the disinfection channel pipeline by the red pipeline to clean the pipeline and prolong its service life.

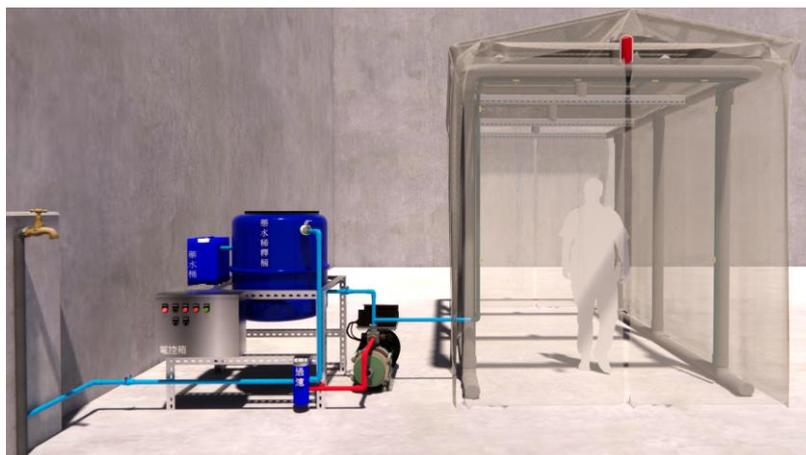


Figure 11: Schematic Diagram of Automatic Cleaning System

5. Conclusion

Improve the disinfection gateway of the case company to make the ratio of liquid medicine stable and save the man-hours of the original operator. The disinfection design of the sterilization channel can be closer to the needs of the enterprise. Therefore, in this study, the action of manually replenishing water and adding medicine by personnel is eliminated. By adding an automatic water replenishing system, when the water level of the float ball is too low, the micro switch of the float ball will be automatically activated. At this time, the water replenishment and water-free lights will light up, the dosing light will also light up as a notification action. Subsequently, the system will automatically start the water replenishment and dosing actions to complete the cycle of the entire automatic system. The introduction of the improved disinfection channel not only saves the time for personnel to replenish water and add medicine, but also effectively stabilizes the ratio of disinfection concentrations and reduces the risk of infection.

Case analysis and improvement through the TRIZ theoretical tool can clearly provide developers with a quick way to find the direction of improvement. This study analyzes the improvement of the disinfection gateway of the case company, and understands that the contribution of TRIZ is as follows:

1. This research uses the contradiction matrix in TRIZ theory and 40 invention principles to solve the problem of manual disinfection solvent deployment in the disinfection gateway and to improve the original equipment to prolong its service life.
2. The improved sterilization and disinfection gateway has been used for more than half a year so far. The results of this study have indeed saved the company from wasting unnecessary staff time. The gateway equipment is easy to install, convenient to

store and store, and has good sterilization effect, which effectively reduces the risk of employee infection. This study verified the benefits and effects brought by the use of TRIZ's improved epidemic prevention and disinfection channels for enterprises.

When the COVID-19 broke out, Taiwan also used its previous experience to take effective preventive measures in the first place to effectively suppress the spread of the epidemic; humans may not have expected that in 2019, after the raging SARS, there would be another large-scale epidemic. This study is based on the SARS and COVID-19 incidents as the research foundation, and it will be deployed in advance for future epidemic prevention. In the face of the epidemic, it can effectively and quickly provide socially useful resources. The final design products can be customized to meet the needs of users in different industries and according to the current usage conditions. With the rapid development of science and technology, the future epidemic prevention equipment will inevitably be more evolved and sophisticated, providing users with more choices.

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