Innovative Design of Multi-functional Sanitation Vehicle Based on TRIZ Theory

Li Sheng[1*], Wang Puyi [1*], Ning Ju[2], Chong Wen Tong[1], Cui Xiaohui[3]
*Corresponding Author

Author e-mail: lisheng_lx@outlook.com, wangpuyi2021@163.com, ningju0805@163.com, chong_wentong@um.edu.my, 1971228968@qq.com

[1]Faculty of Engineering, Universiti Malaya, Kuala Lumpur 50603, Malaysia

[2]Art College, Changchun University, Changchun 130022, China

[3]School of Economics and Management, Heilongjiang Bayi Agricultural University, Daqing 476000, China

Abstract—In order to bring convenience to sanitation workers and residents and help build smart cities. The innovative method of TRIZ concept is introduced into the design of sanitation vehicle, the method of System & Component Analysis and STC Operator are used to analyze this problem, and then the Technical Contradiction Analysis, and other methods are used to solve this problem. This paper scientifically analyzes various problems existing in sanitation vehicle that need to be improved, obtains a variety of technical schemes, and finally comprehensively analyzes and designs a modular design sanitation vehicle that can be used in a variety of occasions and has a variety of functions. The innovative method of TRIZ theory is used for design, and it also provides method application cases for other products with this demand.

Keywords-innovation method; TRIZ theory; sanitation vehicle design; modular design; wisdom city

1 INTRODUCTION

With the development of science and technology, the national investment in smart city construction has increased, the requirements for road cleaning have also increased, and the demand for new sanitation tools is also increasing. In particular, sanitation vehicle plays an indispensable role in cleaning roads and other functions, but their shape design has been unified and lack of functional research below [1]. The complexity of road environment and people's high demand for road cleaning efficiency. People have more and more diverse functional requirements for sanitation vehicle, which makes multi-functional sanitation vehicle functional design research have good prospects. Among them, modeling design will also be an indispensable help to its functional expression. TRIZ theory and method are constantly developed and improved at any time, which can solve many production and invention problems in life and the design problems of sanitation vehicle. Deng and others used TRIZ theory to creatively design the road sweeper, overcoming the contradiction between good working environment, small dust and strong sweeping ability [2].

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2 PROBLEMS OF EXISTING SANITATION VEHICLES

Most of the countries with special road cleaning and sanitation vehicles are developed countries. In non-developed countries, there are few special sanitation vehicles working on the streets, or even no special cleaners. Therefore, the demand for the environment varies from country to country. Most developed countries have small territory and lack of materials, so they also have high requirements for environmental protection. With the continuous development, developed countries have more and more advanced and higher requirements for the intelligent design technology of sanitation vehicles [3]. The most representative is DULEVO road sweeper, whose company is one of the most professional manufacturers of road sweepers abroad. It has the advantages of simple structure, less wear parts, convenient maintenance, simple operation and low operation and maintenance cost. However, there are also the following problems. The driver's operation is more complex, some narrow areas cannot be cleaned, and the function is relatively single, which can only meet the road cleaning work. In the face of complex roads, such as ice and snow roads, it is impossible to clean and deal with them reasonably.

3 INNOVATIVE DESIGN BASED ON TRIZ THEORY

3.1 Overview of TRIZ Theory

TRIZ is a knowledge-based and human oriented systematic method for solving invention problems. With the improvement of national economy and the rapid development of manufacturing industry, TRIZ innovation method occupies a unique position in the field of global innovation and creativity research because of its good operability, systematisms and practicability. The Causal-Analysis method, Function Analysis and other methods of TRIZ innovative method can analyze the advantages and disadvantages of various functions and components of the design. The environmental sanitation vehicle now plays a very important role in our daily life. It is required that the environmental sanitation vehicle not only has a good shape, but also has various functions. Using the excellent characteristics of TRIZ theory, the design of multi-functional environmental sanitation vehicle will meet various design requirements.

3.2 Problem Description and Analysis

Sanitation cleaning vehicle has become the main operation tool of sanitation workers. Therefore, the appearance, functionality, convenience, practicability, safety and other factors affected by the design of sanitation cleaning vehicle affect the orderly, efficient and safe development of sanitation work. Use the TRIZ innovation method theory to find the innovative application of innovative methods, combine the modern multi-functional sanitation vehicle with modern industrial technology, and make it adapt to the new functions, new materials and new technologies of modern society, so as to make the sanitation vehicle derive new products through TRIZ theory [4].

3.2.1 System and Compinent Funcition Analysis

The product exists because of the function, and the product is also the carrier of the function. The function analysis method of TRIZ theory is used to decompose the existing sanitation

vehicle system, clarify the useful functions, performance levels and harmful functions of each component, and analyze the research object sanitation vehicle as a complete functional component according to the method of system function analysis.

Its components include body, fuel tank, fog gun, water tank, cleaning equipment, engine, gearbox, brake, wheel, window, etc; Super system components include people, roads, air, bacteria and viruses, dust, fire and snow. Establish the component interaction analysis diagram to clearly express the interaction analysis of each component. The relationship between components is shown in Tab 1. The "+" in the table indicates that there is a function between components. The specific function of each component needs to be analyzed later. The "-" in the table indicates that there is no function between components. The function of this part will not be considered in subsequent analysis [5].

Tab 1. Interaction between components

Component	Body	Fuel Tank	Fog Gun	Water Tank	Cleaning Equipment	Sprinkler Pump	Engine	Human	Road	Air	Dust or Snow
Body											
Fuel Tank	+										
Fog Gun	+	-									
Water Tank	+	-	+								
Cleaning Equipment	-	-	-	-							
Sprinkler Pump	-	-	-	+	-						
Engine	-	+	-	-	-	-					
Human	-	-	-	-	-	+	-				
Road	-	-	+	-	+	-	-	+			
Air	-	-	+	-	-	-	-	-	-		
Dust or Snow	-	-	-	-	+	-	-	-	+	-	

The purpose of function analysis is to analyze the system, subsystem and super system from the perspective of completing various functions of the sanitation vehicle, rather than from the perspective of manufacturing sanitation vehicle technology. It is necessary to study whether each function of the sanitation vehicle is necessary and, if necessary, whether other components in the system can replace it to complete the corresponding functions.

Simply analyse the component relationship table, put forward the design concept, and put forward the following technical scheme.

Technical scheme 1: consider using new energy or hybrid oil and electricity to drive, so as to reduce pollution.

Technical scheme 2: through the concept of modular design, some parts of the sanitation vehicle can be replaced at will, making the operation function more extensive. For example, the cleaning tool in front of the sanitation vehicle body can be replaced as needed.

Technical scheme 3: integrate the functions of existing road sweepers, snow removers, high-pressure cleaning vehicles and other sanitation vehicles.

3.2.2 STC Operator Method

STC is the acronym of three English words: size, time and cost. As shown in Tab 2, this method is used to analyze these three aspects of sanitation vehicles [6].

At the same time, use the limit solution of other parameters to think: for example, imagine the infinite and infinitesimal energy expenditure, and put forward the following technical scheme.

Technical scheme 4: the design is moderate in size and can be used in multiple occasions and seasons.

Tab 2. STC Operator Method

Solution ideas	Methods of resolution
Imagine the solution of infinite size ($s > \infty$) of the research object;	A cleaning system that occupies the entire road.
Imagine the solution of the infinitesimal size of the research object ($s > 0$);	A portable cleaning tool that can be picked up with one hand.
Imagine the solution of infinity ($T > 0$) in the time of working process or the speed of object movement;	Be able to find places to clean at any time.

Continued TAB 2

Solution ideas	Methods of resolution
Imagine the solution of infinitesimal ($T > \infty$) in the time of working process or the speed of object movement;	It can clean the road safely and slowly.
The solution of imagining that the cost of expenditure (allowable expenditure) is infinite ($c > \infty$);	It can provide various intelligent cleaning equipment for sanitation personnel and increase intelligent functions.
Imagine the solution that the cost of expenditure (allowable expenditure) is infinitesimal ($c > 0$).	Each sanitation worker is equipped with a different cleaning equipment, which needs to be exchanged when using different functions.

3.3 Solutions to Problems

3.3.1 Technical Contradiction and Problem Solving

The expression of the technical contradiction of the original problem is shown in Fig 1.

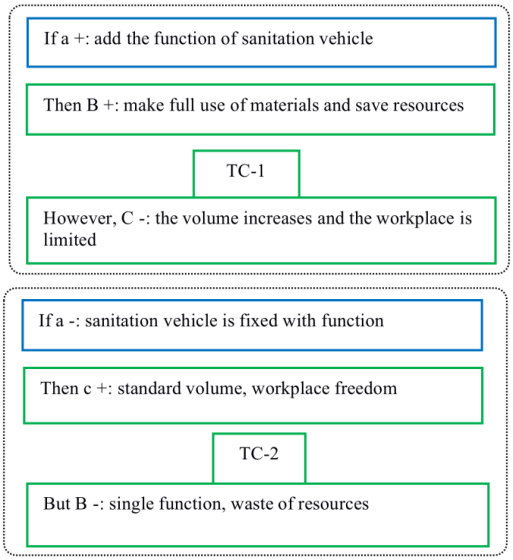

Figure 1. Analysis of Technical Contradiction.

It is determined that the technical contradiction to be solved is TC-1, which occurs between (making full use of materials and saving resources) and (increasing volume and limited workplace), and when (increasing the use function of sanitation vehicle).

3.3.2 Problem Model

Corresponding 39 general engineering parameters.

Improved parameters: 23 material loss 26 quantity of material or things.

Deteriorating parameters: 7 volume of moving object 22 energy loss.

3.3.3 Solution Model

According to the Archie Schuler contradiction matrix, the reference innovation principle is: 1 segmentation method 2 local quality 5 combination 6 versatility 15 dynamic [7].

The principles of the invention that can be used are: 1 segmentation method 2 local quality 5 combination 6 versatility 15 dynamic.

Technical scheme 5: in order to optimize the performance of different components in each action stage, so that the object can be adjusted automatically, so that the angle adjustment of snow shovel, disk sweeping machine and fog gun machine can be realized according to the actual situation.

Technical scheme 6: make different parts of the object play different roles to the greatest extent, and each component may have a variety of functions.

4 SCHEME ANALYSIS AND DETERMINATION

4.1 Technical Scheme Arrangement and Feasibility Analysis

Through the proposal of the above 6 technical solutions, the problems faced by the sanitation vehicle need to be solved, including simple and bulky appearance and poor warning; It is not conducive to the cleaning of narrow roads. Accidents are easy to occur when working on urban roads, and the safety is insufficient; Poor integrity and inconvenient operation; The design of sanitation cleaning vehicle should have a complete placement structure between tools and vehicles. Today, most of the tools on the sanitation vehicle are placed at will, without integrity. There is no unified integration in the design of all cleaning tools, resulting in disorder and inconvenient work; The applicability of multi environment, multi occasion and multi season is poor; Facing different environments and climates, sanitation vehicles need different cleaning tools for cleaning. Some narrow roads and snow roads cannot be cleaned in place; Single function and lack of intelligence: road cleaning usually includes cleaning, sprinkling, spray and so on. This requires a multi-functional sanitation vehicle integrating multiple functions and equipment to carry out the above operations at one time. In addition, the intellectualization of the sanitation vehicle is insufficient, resulting in problems such as low work efficiency and long time [8].

Mainly through the subjective consideration of product positioning, use method, manufacturing materials, scope of application, modeling, function and man-machine size; Finally, the final scheme with outstanding performance in product grade, texture, modernity, basic function and rationality is analyzed and designed [9].

4.2 Determination of final product scheme

According to the application and analysis of the above TRIZ methods, the designed multi-functional sanitation vehicle is shown, which can be operated by a single person. There are two fog guns in different working directions at the rear of the sanitation vehicle, which can reduce dust and haze in streets, construction sites and other places, carry out insect disinfection and epidemic prevention in forests, epidemic stricken areas and other places, and the intelligent water tank can prompt the water level and warn the vehicles behind, and the filtering system for water grab, Water can be taken from fire hydrants or lakes and ponds; The predecessor of the vehicle can install tools in winter to achieve the purpose of snow removal with the functions of pushing, sweeping and blowing [10].

4.2.1 Final Renderings

As shown in Fig 2, Rhino modeling is used to deal with the details of the engine and tire of the sanitation vehicle in the modeling process. All parts of the fog gun machine and intelligent water tank of the sanitation vehicle are modeled. Finally, keyshot rendering is used to render the materials of each part.

Figure 2. Final Renderings.

4.2.2 Product Dimension Drawing and Detail Design

As shown in Fig 3, the detailed design of the multi-functional sanitation vehicle, such as the solar panel structure that can be opened and closed automatically, rotates automatically, and can trace the angle of the sun according to the demand; The chassis can be sprayed with water, chemicals and other cleaning materials; If there are two fog gun mechanisms rotating in different directions, such as detailed design.

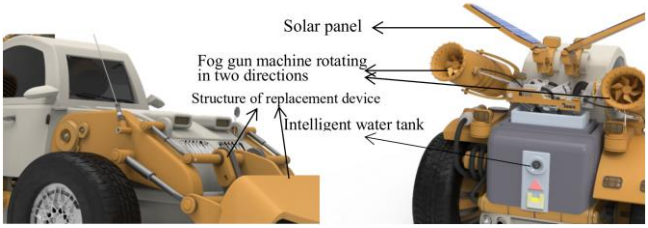

Figure 3. Product Dimension Drawing and Detail Design.

4.2.3 Schematic Diagram of Usage Dituation

The small size of the sanitation vehicle enables it to sweep snow in narrow streets, communities and other places, which is convenient for use in multiple occasions, meets various functions, can be used to the greatest extent in various environments, and provides sweeping for all corners that need to be cleaned. As shown in Fig 4, the schematic diagram of snow sweeping in the community [11].The sanitation vehicles can spray disinfectant in case of epidemic, or spray water with fog gun to remove dust and reduce haze in dry weather.

Figure 4. Usage Scenarios for Various Occasions.

5 CONCLUSION

By combing the functions and aesthetic ideas of multi-functional sanitation vehicles in different countries and regions, this paper summarizes the functional requirements and modeling forms of multi-functional sanitation vehicles. This paper analyzes the relationship between the use environment and function of the sanitation vehicle, and uses the TRIZ innovation method theory to combine the modern multi-functional sanitation vehicle with modern industrial technology to make it adapt to the new conditions, new materials and new technology of modern society, so as to derive a new sanitation vehicle through the TRIZ theory. The innovative method of TRIZ will also be cited in all aspects.

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