Design of Subway Station Rest Facilities Based on TRIZ Theory

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Abstract: With the continuous construction of urban subways, the basic service facilities in subway stations are also constantly improving. Rest facilities are also essential as one of the basic service facilities in subway stations. At present, it is not uncommon for rest facilities in subway stations in China not to meet the needs of users due to large passenger flow and insufficient space. This paper identifies and utilizes the TRIZ invention principle required for the design of rest facilities in subway station, guides the design of rest facilities that meet the needs of users without affecting the flow of people, and provide new ideas, new guidelines and new horizons for the design of subway station space rest facilities.

Keywords: TRIZ theory, Rest facilities, Metro station space

1 INTRODUCTION

In China, the subway, as a safe, punctual and fast means of transportation, is the choice of most users. The subway station is a transit space for users to ride and wait for the subway, where rest facilities compose a very important part of the composition of the station space. Currently, there are too few seats in the rest facilities of subway stations in China to meet the rest needs of users, and too much increase in the number of rest facilities will also hinder the steam of users in the space. Therefore, how to design a rest facility that can meet the needs of users without affecting the steam of people in the space is a problem worth thinking about.

In recent years, TRIZ theory has developed rapidly and has become a powerful auxiliary tool to help solve product invention problems. This paper uses TRIZ theory to design subway station rest facilities, analyzes their problems, uses TRIZ tools to solve them, and gives a final design plan.

2 AN OVERVIEW OF THE INVENTION PRINCIPLES OF THE TRIZ THEORY

TRIZ theory was founded by Gen Rich Genrikh Altshuller in 1946 who also brought it into the public eye. The Triz Theory was founded on the idea of giving people scientific rules and methods to follow when solving technical problems or inventing and creating, so as to quickly solve problems and invent innovations. Altshuller led the team to analyze nearly 2.5 million of the world's high-level invention patents and their invention processes, and summarized,

ICICA 2022, December 02-04, Chongqing, People's Republic of China

DOI 10.4108/eai.2-12-2022.2327944

concludeded and refined them to form a methodology for solving invention problems, namely TRIZ theory. After nearly 70 years of development and practical verification, TRIZ theory is known as one of the highest scientific thinking methods in the world today, and is a tool for technological innovation and modernization. Especially in the field of product technology innovation, it can play a more effective role with half the effort.

TRIZ theory holds that the innovation and development of any product, whether simple or complex, is an activity that follows certain innovative principles and methods. The content is divided into nine items, namely: 40 innovative principles, 39 general parameters and Altshuller contradiction matrix, scientific effects and phenomena knowledge base, Algorithm for Inventive-Problem Solving (ARIZ), 76 standard solutions to invention problems, matter-Field model analysis, physical contradictions and the four principles of separation, ideal final resolution (IFR), 8 evolutionary laws of the TRIZ technology system. Among them, 40 innovation principles are the core of innovation and creativity, which can promote the production of innovation concepts and break through inherent ideas. It can also be combined with 39 general parameters and the Altshuller contradiction matrix to better obtain a general solution to the problem. In the process of solving, we must first clarify the specific problem, then convert the problem into a TRIZ general problem, use different TRIZ tools to get a general solution according to the problem and finally convert it into a specific solution according to the general solution (Figure 1). Different from traditional methods such as "trial and error" whose results are random and uncertain [1] (Figure 2), TRIZ is well-organized and directed. It is possible to avoid consuming a lot of manpower and time as the traditional method tries their luck.

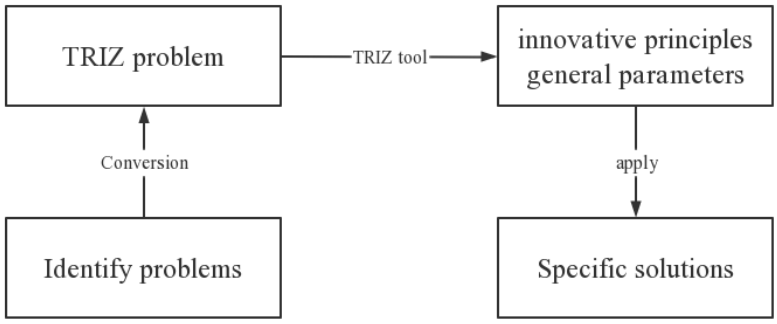

Figure 1. TRIZ problem-solving flow

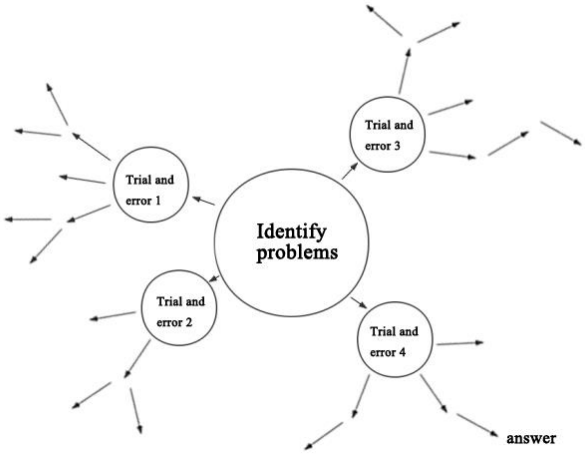

Figure 2. Trial-and-error problem-solving process

In this paper, the author uses the TRIZ theory to innovate the design of the rest facilities in the subway station space, and uses analysis tools to quickly and effectively address the contradiction of how the rest facilities in the subway station meet the needs of users without affecting the flow of personnel, and thus proposes a Design of subway station rest facilities based on TRIZ theory. It can also verify the feasibility guidance effect of TRIZ theory on innovative design activities.

3 INVESTIGATION AND ANALYSIS OF USER NEEDS AND DESIGN REQUIREMENTS OF LEISURE FACILITIES IN SUBWAY STATIONS

At present, the subway has become the main means of transportation for people to travel. The subway station as the hub for people to take the subway, its supporting facilities are also constantly improving, of which the most common demand for people is the rest facilities. Such facilities are mainly set up in the platform of the subway station, which has certain enclosed characteristics, and the space is tight and limited [2]. This area is precisely the largest circulation of personnel, and the space where people are most likely to stay. Therefore, the design of rest facilities in this area should meet the characteristics of unobstructed and small floor space.

The design of subway station rest facilities should take the needs of users as the starting point, and comprehensively consider the behavior and needs of passengers of all ages in the design. This in turn involves all-age adaptability to the user. Through on-site interviews and questionnaire surveys, the subway personnel and workers at multiple subway interchange stations in Harbin were investigated and analyzed on the demand for the use of rest facilities in the subway station space. According to the survey, young people and the middle-aged are the main people who take the subway, accounting for 92.3% of the people investigated. The rest are children and the elderly, accounting for 7.7% (Figure 3). And 100% of passengers

think that rest facilities are necessary. Therefore, the design of subway space rest facilities should be mainly based on young people and the middle-aged, supplemented by children and the elderly.

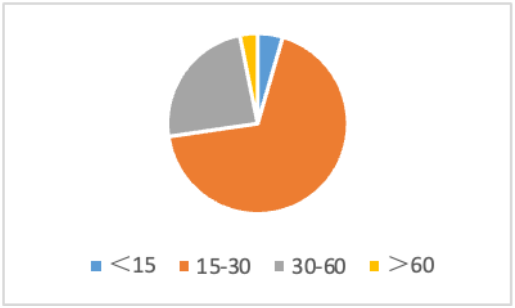

Figure 3. Age survey of geomorphic users

In terms of the function of the rest facility, 100% of users expect the rest facility to meet the needs of small break. In terms of the function of the rest facility, the vast majority of users hope that the rest facility is in the seat shape, the seat surface is wide, and the seat edge is rounded to prevent safety hazards. Most users prefer leather or composite materials for the rest facilities. However, because the materials of rest facilities should have fire protection characteristics [3] and the leather is flammable, instead of leather materials, composite material is considered to be designed with in this article.

In addition, rest facilities are public facilities in the subway station, so it is the subway station staff that are responsible for its installation and maintenance, which makes their idea and feedback also very important. According to the feedback of the subway staff, due to the large flow of people in the subway station, the use of rest facilities is frequent, so it will often cause damage or destruction in the process of use and short service life [4]. Therefore, in the design, we should try to consider the durability and strong structure to reduce the difficulty of later maintenance.

4 DESIGN OF SUBWAY STATION REST FACILITIES BASED ON TRIZ THEORY

The main behavioral activities of users in subway stations are two types of activities: traffic and rest, and corresponding public facilities are often required at this time. The main population of subway users is 15-60 years old, which indicates that most of them travel for the purpose of going to school, going to work. The frequency of use of rest facilities is very high due to high intensity and pressure of work and study, which is easy to produce fatigue. After investigation, it was found that at present, due to the limited space and large flow of people in subway stations, there are problems such as large occupied area and few seats in China's subway stations (Figure 4).

Figure 4. Contradictions arising from the design of the ground station space and the leisure facilities

Based on the needs of subway station users, this chapter innovatively designs the rest facilities in subway stations and systematically analyzes the problems and derives solutions using TRIZ tools. It proposes a set of TRIZ processes for the innovative design of rest facilities suitable for large traffic spaces and eventually demonstrate the possibility of applying the TRIZ theory to rest facilities.

4.1 TRIZ Innovation Theory Application Process of the Design in this Case

In terms of product innovation, TRIZ theory provides many tools, such as invention principles, contradiction matrices, matter-field models, etc. How to choose the most effective tool among so many tools is an important task, which determines the degree of innovation optimization of the product.

The author analyzes the needs of users in the subway station space and the subway station space for rest facilities, looks for problems, builds quality houses to analyze the problems, determines technical contradictions, and then analyzes with the contradiction matrix to find the corresponding invention principle to solve the problem and get a solution. If there are still optimization problems in the solution, continue to import the contradiction matrix for analysis and solution until the final solution is obtained (Figure 5)

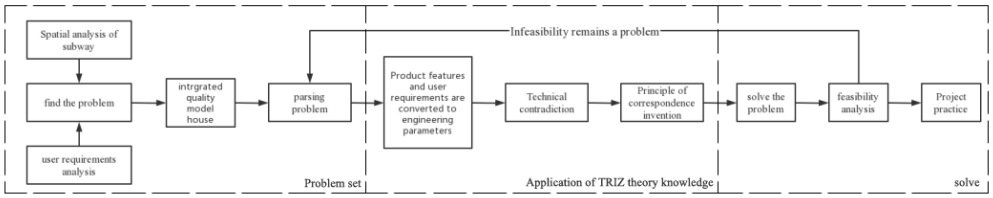

Figure 5. The application process of innovation theory in this case design)

4.2 Build an Integrated Quality House Model

Building a integrated quality house lies in more intuitively analyzing the relationship between user needs and product characteristics. In this paper, the author lists matrices based on survey and query data and uses different symbols in intersecting white space to indicate the strength of the association between the two. The "x" above the House of Quality indicates that there is a negative relationship between the product characteristics and that improving one of them and the other will worsen [5]. It indicates a conflict in the product characteristics of the design (Figure 6).

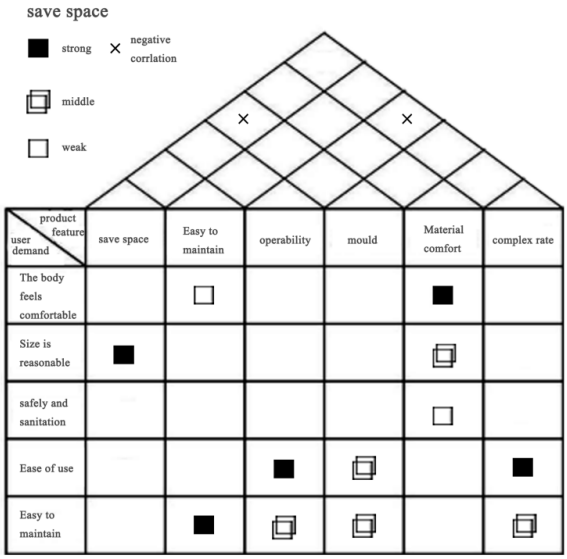

Figure 6. Integrated quality model house

4.3 Product Feature Conflicts and Resolution

It can be seen from the quality house model that there are obvious technical contradictions in the design of rest facilities, which can be understood as the deterioration of the shape of rest facilities while optimizing the space of leisure facilities. We can convert the problem into a TRIZ generic problem and import it into the TRIZ tool for analytical solution. Optimization of product characteristics can convert engineering parameter No. 7: the volume of moving objects. The deterioration of product characteristics can be converted into Project 12 parameter: styling. The invention principles for the solution of this problem by pouring it into the Archischule contradiction matrix are NO.1 segmentation, NO.4 asymmetry, NO.15 dynamic, NO.29 pneumatic and hydraulic structures (Figure 7). For the problem in this paper, the author selects the NO.1 Segmentation Invention Principle and NO.15 Dynamic Invention Principle as the solution to this problem.

Contradiction described	Converting engineering parameters	Solve the invention principle
The optimization of the space of rest facilities will lead to the deterioration of the shape of rest facilities	optimize: No.7 engineering parameters degradation: No.12 engineering parameters	No.7 segmentation No.4 asymmetric NO.15 dynamic No.29 Pneumatic and hydraulic construction

Figure 7. Product conflict description

NO.1 segmentation principle: Divide an overall seat into several seats that can be used as independent rest. The seat maintains the overall state when there are fewer people in the subway station, and the seat needs to be divided to meet the rest needs of more users in the subway station.

NO.15 dynamic principle: the seat is designed as an axle connection. The pull shaft and the fixture connect the separated seat to each other, so that the seat is convenient to expand or put back to the normal state, to avoid the seat scattered.

In summary, the preliminary plan is to divide the complete seat into several seats that complete the rest function independently, and connect them with the connection shaft. (Figure 8).

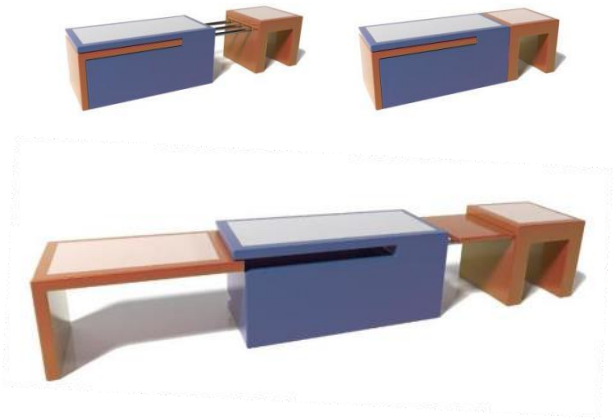

Figure 8. Renderings of the preliminary scheme

5 SCHEME OPTIMIZATION

After the feasibility analysis, it was found that there were still a pair of contradictions and a problem after the initial optimization. The problem is the increased difficulty of maintenance of rest facilities. The contradiction is to optimize the convenience of user operation and the deterioration of the complexity of operating facilities. We can convert the problem to a TRIZ generic problem and import the Altshuller contradiction matrix.

Rest facility maintenance is a simple problem in the TRIZ difficulty problem, it can be addressed by the No. 7 invention principle: nesting principle, all parts integrated design as a separate component, so that when the seat stretching system has problems, there is no need to check the parts one by one and the broken part can be directly replaced. The replacement is convenient and it also greatly reduces the difficulty of maintenance.

In this contradiction, optimization engineering parameter is the No. 33 operation process, namely convenience, and degradation engineering parameter is the No. 36 system, namely complexity. Seat stretching is difficult for some users who are inconvenient to bend over, and it is not very convenient to operate. The invention principle of introducing contradictory parameters into Chischuller's contradiction matrix to solve this problem is NO.12 equivalence, NO.17 equation change, NO.26 copy, NO.32 color change (Figure 9). Advanced analysis using the NO.12 invention principle to solve this problem.

Contradiction described	Converting engineering parameters	Solve the invention principle
Optimize user ease of operation and degradation of operational facility complexity	optimize: No.33 engineering parameters degradation: No.36 engineering parameters	No.12 equipotentiality No.17 variation of longitude NO.26 copy No.32 turn colour

Figure 9. Product conflict description

NO.12 Equipotential principle: The passenger is inconvenient to bend down, which makes the upper body limb can not touch the facility, so we consider the lower body limb to open the stretch seat, of which the use of the foot is the most convenient. The design of recessed foot pedals on the side of the seat is convenient for the passenger to bend over and stretch out the seat to rest (Figure 10).

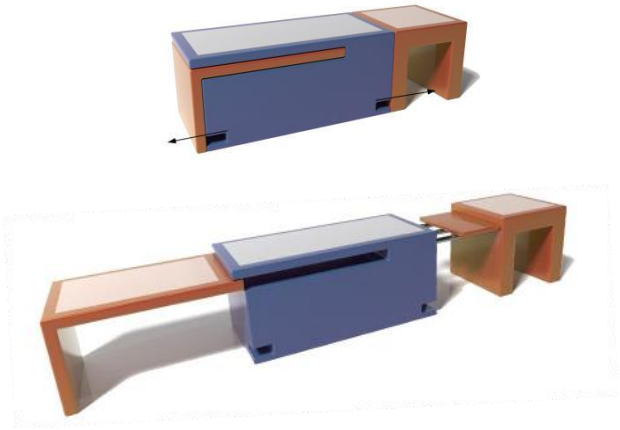

Figure 10. Schematic diagram of scheme optimization

6 CONCLUSION

Based on TRIZ theory, this paper studies the design of rest facilities in subway spaces. First of all, the user's demand for the use of rest facilities in the subway station space is investigated and analyzed, and the appropriate invention principle is screened out for preliminary design using tools such as quality house model and contradiction matrix for demand, and the rest facilities are divided and reorganized and the dynamic principle is used to stretch the facilities. And in the design of the user behavior, equipotential principle is used to optimize the design. Practice has proved that TRIZ theory is effective in practice, which has a strong direction for solving problems, and can quickly find solution ideas when there is a contradiction in design. It greatly shorten the design time, for the design to provide a more efficient mode.

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