Innovative design of storage cabinet for Miao embroidery pieces based on QFD and TRIZ

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Abstract: Due to the rapid development of modern technology and the e-commerce industry that threatens the Miao embroidery industry and Miao embroidery skills, there is a requirement to design a Miao embroidery piece storage cabinet that integrates scientific management and protection of Miao embroidery works and pieces, which can guarantee the inheritance of Miao embroidery skills, effectively provide services to enterprises that correspond to social requirements and national policies. The existing storage cabinets on the market only meet the problem of storing objects. However, storage alone is not enough for Miao embroidery pieces. This paper uses QFD and TRIZ theories to solve the design problem of a storage cabinet for Miao embroidery pieces. In addition, the paper combines the essential formulas to calculate the importance of the enterprise's requirements, uses a decision algorithm to calculate the decision attributes of the requirements, and further transforms the design requirements into the technical characteristics of the storage cabinet for Miao embroidery pieces. Furthermore, the TRIZ theory problem-solving tool was later used to analyze the design conflict and propose design points. Finally, the TRIZ theory summarized the innovative design direction and designed a multifunctional Miao embroidery piece storage cabinet with a single color, elegant shape, and floating body that combines embroidery piece storage, scientific management, fire, theft, and rat prevention to meet the requirements of the enterprise. Therefore, combining QFD and TRIZ theory in product design was feasible and provided a new reference for product design procedures.

1. Introduction

Miao embroidery is mainly found in the remote mountainous regions of Guizhou, Hunan, and Guangxi in China. As Miao embroidery has a long history, every stitch records the evolution of the Miao people. Many Miao people mainly rely on Miao embroidery as an economical source for their daily life. Since the launch of China's rural revitalization and poverty alleviation programs, many Miao embroidery collectors, inheritors, and enterprises have collected a large number of Miao embroidery pieces and have joined forces with embroiderers to create new Miao embroidery pieces in order to respond to the government's call and to pass on their skills forever. Thus contributes to employment alleviation in the countryside and sustaining Miao embroidery skills.

The chemical bonds of the fibers in Miao embroidery works can break in an environment with high temperature and humidity fluctuations. As a result, the fibers lose their proper elasticity and toughness, causing the cotton to shrink unevenly, resulting in overall deformation and fading [1]. In addition, due to the limitations of the storage area and conditions, the existing Miao embroideries are mainly stored in stacks and hanging. When a box is used for storing Miao embroidery, multiple pieces of embroidery are stacked on each other, creating creases [2]. The large, long, flat fabrics that have been used for many years are not strong enough to withstand any external forces, so stacking and hanging can cause secondary damage to the embroidery, and it is better to choose a flat storage method that also meets the requirements of handling, exhibition, and research [3]. Therefore, the design of a storage cabinet for Miao embroidery pieces is the most urgent requirement for companies today. In this paper, we have designed a storage cabinet for Miao embroidery companies to address the main problems and requirements of Miao embroidery companies.

2. Related theory

QFD is a method of identifying design problems driven by customer needs and using HOQ as a technical analysis tool, while TRIZ is a method of solving design problems using tools such as conflict matrices and invention principles. QFD aims to explore the requirements acquisition problems in the design process, while TRIZ is dedicated to exploring how these problems can be realised.

Li [4] established the design of a medicine bottle for the visually impaired based on the integration of QFD and TRIZ theory. Caligiana [5] integrated QDF and TRIZ for innovative design to validate the direct molding design method and AHP for innovative design and product development of related parts on automobiles. In China, Wang [6] proposed a method based on integrating QFD theory and TRIZ theory to address the problem of lack of capability in mass production in enterprises. By combining QFD and TRIZ theory, Zhang [7] designed four integrated environmental cooker design solutions. In summary, scholars at home and abroad have a greater tendency towards integrating QFD with TRIZ. Although many researchers have used these theories, they do not meet all product design requirements, and there is still much room for improvement. Each theory has its strengths and weaknesses, which are extremely important in all stages of product design [8]. In the innovation design phase of product development, QFD and TRIZ theories are commonly used to guide design [9-12]. An in-depth analysis of the current development of Miao embroidery and the current situation of Miao embroidery enterprises was carried out to address the urgent requirements of Miao embroidery enterprises. Moreover, An innovative design was developed to meet the requirements of the enterprises for effective storage of Miao embroidery pieces. The innovative design requirements to be guided by a theory that can effectively reduce the design time and cost and thus improve the product's quality.

3. Research Framework

3.1 Design Process

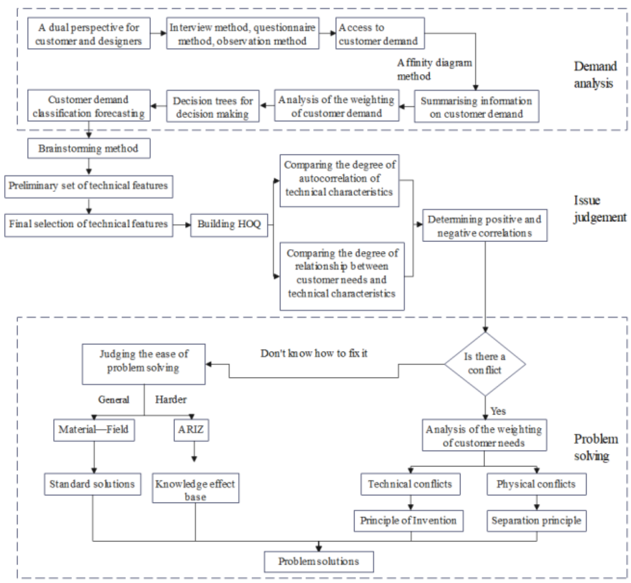


Fig.1. Design flow of the embroidery piece storage cabinet for Miao embroidery

According to the process of realization of user requirements, the QFD model, decision tree, and TRIZ theory were combined to construct an innovative storage cabinet design system. The different requirements of users were obtained through direct observation, questionnaires, and interviews, and the obtained requirements were classified based on the HOQ model: performance, functional, and appearance requirements. Subsequently, questionnaires were issued to determine the relative importance of customer requirements. The scores were then used to determine the relative importance of the customer requirements and summarized to calculate the importance of those requirements. The results were then ranked by comparing the information gain of the conditional attributes: the maximum value of the information gain of the identity was used as the decision point to build a decision tree of the customer requirements of the product. Finally, the TRIZ principle of conflict analysis and invention was applied to explore the storage cabinet's product design points. A design solution was proposed for the innovative Miao embroidery storage cabinet design by combining the specific practical background and design theory. As shown in Fig.1.

3.2 Demand analysis

This study takes designers and customers as the starting point, and through naturalistic observation, user interviews, and questionnaires, the most urgent requirements of the moment are investigated, analyzed, and summarized.

Posting questionnaires on the questionnaire star platform through the network to obtain the relevant demand can quickly and effectively obtain the relevant survey results. After the survey, it was found that: 50 people, 12 at the management level and 38 at the grassroots level, filled in more than 90% of the current problems. For example, 64% spent 3-4 hours because they were looking for embroidery pieces, 94% thought about sorting and storing embroidery pieces scientifically, more than 92% filled in the performance, 80% filled in the function, and 88% filled in the appearance that they expected to meet. Use affinity diagram: The method will summarize the information obtained from the research and organize the information with similar meanings in these requirements together, forming a variety of expressions with different meanings, which can effectively and quickly obtain the main requirements of the storage cabinets. For example, after simplifying and summarizing these requirements to obtain the requirements as shown in Table 1.

Table 1. Structure of information on customer requirements for storage cabinets

Level 1 requirements	Secondary requirements	Tertiary requirements
Performance	Practicality	Long-lasting
	Security	Keeping objects safe
	Diversity	Variety of storage items
	Applicability	Multiple occasions
Function	Spatial division	Save space
	Storage	Storage of objects
	Anti-bacteria, temperature, and humidity control	Providing a sterile environment
	Auxiliary	Built-in sensors
Appearance	Styling	Elegant temperament
	Material	Protecting the environment
	Body Type	Lightweight
	Color	Elegant and dignified

3.2.1 Analysis of the importance of the demand

Based on the information of secondary and tertiary customers' demand summarized by the affinity diagram method, the relative importance of the storage cabinet customers' requirements was scored through the process of filling in the questionnaires by the customers (using a scale of 1 to 9 odd points, the more important options the respondents felt were rated higher). 50 valid questionnaires were collected and statistically analyzed using the formula (1):

$$\overline{R_i} = \frac{\sum_{n=1}^{m} R_i K_{n_1}}{m} \tag{1}$$

($\overline{R_i}$ is the average importance of the demand; m is the number of respondents; K is the user demand rating; n is the user demand number; R_i is the importance of the demand). The importance of the customer requirements for storage cabinets is calculated and ranked in order of importance, as shown in Table 2.

Table 2. Importance and ranking of customer demand for storage cabinets

Secondary requirements	Tertiary requirements	Customer demand scoring headcount					Importance	Sort by
		1 mark	3 points	5 points	7 points	9 points		
Practicality	Long-lasting	0	4	8	18	20	7.16	2
Security	Keeping objects safe	0	2	3	20	25	7.72	1
Diversity	Variety of storage items	1	9	4	21	15	6.60	5
Applicability	Multiple occasions	3	4	16	13	14	5.14	12
Spatial division	Save space	1	2	13	19	15	6.80	4
Storage	Storage of objects	1	0	12	21	16	7.04	3
Anti-bacteria, temperature, and humidity control	Providing a sterile environment	1	6	16	13	14	6.32	7
Auxiliary	Built-in sensors	3	4	11	20	12	6.36	6
Styling	Elegant temperament	3	9	15	18	5	5.52	10
Material	Protecting the environment	4	3	17	16	10	6.00	9
Body Type	Lightweight	0	10	14	16	10	6.04	8
Color	Elegant and dignified	0	15	15	9	11	5.28	11

3.2.2 Requirements decision tree analysis

The ID3 algorithm is a classical decision tree algorithm [13], which is based on information theory, using information entropy and information gain as the measure to achieve the inductive classification of data. Entropy E refers to the degree of information confusion; the higher the value, the greater the uncertainty of the variable, and information gain G refers to the change in entropy before and after the division. Dividing the data into conditional attributes S and decision attributes A, A = f(S), S = {secondary customer demand 1, secondary customer demand 2, secondary customer demand 3..., secondary customer demand n}, A = {satisfaction level}.

The entropy of the decision is calculated using the following formula (2):

$$I(a_1, a_2, ...a_n) = \sum_{i=1}^{n_2} I(a_i) = \sum_{i=1}^{n_2} p(a_i)\log_2 \frac{1}{p(a_i)} \tag{2}$$

(I represent the desired information; n is the number of outcomes in the decision attribute; a_i is the information element).

The sample probability is calculated by Formula (4):

$$P(S_i) = |S_i|/|S| \tag{3}$$

(S is the set of training samples; $|S_i|$ is the number of training samples, and the samples are divided into n different classes, denoted as $|C_1|$, $|C_2|$... $|C_n|$; P (S_i) is the probability that any sample S belongs to class C_i) [14].

Formula (4) for calculating the average information expectation is:

$$E(S, A) = \sum P(S)I(A) \tag{4}$$

(E(S, A) is the average information expectation; S is the conditional attribute; and A is the decision attribute).

The information gain is calculated by Formula (5):

$$G(S,A) = I - E(S,A) \tag{5}$$

(G(S, A) is the information gain of attribute A on the set S; I is the "satisfaction level" value of attribute A in the decision) [14].

Taking performance, appearance and functionality as examples, 50 management and grassroots employees in a seedling embroidery company were taken as the targets of a survey on storage cabinet customer requirements. By collating the results of the current research on the performance, appearance, functionality, and satisfaction levels of storage cabinets, the survey was tabulated as shown in Table 3.

Table 3. Satisfaction survey for storage cabinet customer demand

Number of people	Identity	Function	Appearance	Performance	Satisfaction
20	Grassroots	Good	Excellent	Excellent	Unsatisfactory
20	Grassroots	Excellent	Excellent	Excellent	Unsatisfactory
45	Grassroots	Good	Excellent	Excellent	Satisfaction
19	Grassroots	Good	Good	difference	Satisfaction
20	Management	Good	difference	difference	Satisfaction
20	Management	Excellent	difference	difference	Unsatisfactory
20	Management	Excellent	difference	Good	Satisfaction
45	Grassroots	Good	Good	Excellent	Unsatisfactory
20	Management	Good	difference	Excellent	Satisfaction
46	Management	Good	Good	difference	Satisfaction
20	Management	Excellent	Good	Excellent	Satisfaction
10	Grassroots	Good	Excellent	Good	Satisfaction
10	Management	Excellent	Good	Excellent	Satisfaction
20	Grassroots	Excellent	Good	Excellent	Unsatisfactory

As can be seen from Table 4: satisfaction is divided into satisfactory (S_1) and unsatisfactory (S_2).Using information gain as the selection criterion for the attributes, by comparing the ranking results of the conditional attribute information gain, the conclusion was drawn as shown in Table 4: $G_{Identity} > G_{Performance} > G_{Function} > G_{Appearance}$. The decision tree of storage cabinet customer requirements was constructed using the information gained from the maximum identity as the decision point of the decision tree, as shown in Fig.2. The figure shows that the management and the grassroots are more concerned with the performance of the storage cabinets, followed by the functionality and appearance.

Table 4. Ranking of conditional attribute information gain

Conditional Properties	Identity	Performance	Function	Appearance
Information gain	0.174	0.138	0.044	0.023

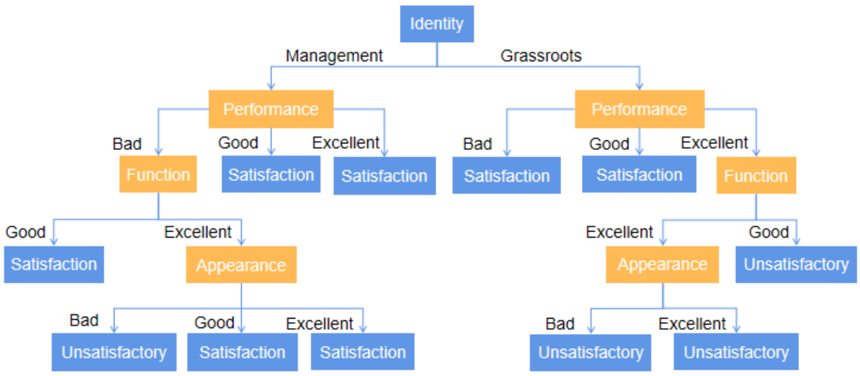


Fig. 2. Decision tree for Miao embroidery piece storage requirements

3.3 Problem determination

Based on the user requirements analysis, the company's performance requirements for the Miao embroidery piece storage cabinet are durability, protection of objects, and storage of various objects and occasions. Functional requirements are space-saving large or small storage, sterilization, temperature, and humidity control. Appearance requirements are elegant and graceful shape and color, lightweight, green and pollution-free materials, etc. Moreover, through the information gained from the decision tree, it is calculated that the enterprises value the performance of the embroidery piece, then the function and appearance. By transforming the technical characteristics into the company's requirements and analyzing them, the main requirements are transformed into technical characteristics that the researcher can better understand, thus realizing the construction of HOQ and the analysis of the autocorrelation between technical characteristics, which can be used to guide the subsequent design.

3.3.1 Acquisition of technical characteristics

A brainstorming group was formed with the management and grassroots staff of the Miao embroidery company as customer representatives, teachers and students of the school's industrial design program, and other relevant personnel. Based on the process model of technical feature acquisition, and taking into account the human element, the economic element, and the physical nature element, the group members actively envisaged the conversion of the technical language of the storage cabinet to form a preliminary set of technical features, comparing their feasibility. The final selection of technical characteristics is shown in Table 5.

Table 5. Summary of analysis of technical characteristics

Customer demand			Technical characteristics	
Level 1 requirements	Secondary requirements	Tertiary requirements	Primary Selection	Final Selection
Performance	Practicality	Long-lasting	Stainless steel metal	Working life
	Security	Keeping objects safe	Fire, moisture, and rodent proofing	Defensive properties
	Diversity	Variety of storage items	Various types of objects can be stored	Storage range
	Applicability	Multiple occasions	Available for a variety of applications	Scope of application
Function	Spatial division	Save space	Interior space varies in size	Layered structure
	Storage	Storage of objects	Can be stored in large or small	On-demand storage
	Anti-bacteria, temperature, and humidity control	Providing a sterile environment	Objects are less prone to deterioration and spoilage	Storage time
	Auxiliary	Built-in sensors	Sterilization, temperature control, humidity control	Intelligent monitoring
Appearance	Styling	Elegant temperament	Smooth line profile	Beautiful styling
	Material	Protecting the environment	Environmental Philosophy	Green
	Body Type	Lightweight	Small size and lightweight	Floating posture
	Color	Elegant and dignified	Simple and single	Single color

3.3.2 Calculate the weights of the final selection set

The formulas are:

$$T_j = \sum_{i=1}^{n} K_j R_{ij} \tag{6}$$

$$W_j = \frac{T_j}{\sum T_j} \tag{7}$$

T_j is the relationship matrix score for this technical characteristic; K_i is the i-th customer demand importance; R_{ij} is the value obtained by scoring judgement. In the matrix, blank indicates no relationship and is scored 0; △ indicates a low relationship and is scored 1; ○ indicates a low relationship and is scored 2; ⊙ indicates some relationship and is scored 3; ⭘ indicates a high relationship and is scored 4; ● 5 marks for the highest stated relationship.

Brainstorming and innovative thinking by the team members obtained the final set of technical characteristics for the storage cabinets. After the brainstorming team had identified the technical characteristics, the technical characteristics, and the secondary requirements were scored separately, As shown in Table 6. Finally, the evaluated data was calculated and analyzed using the weighting formula, resulting in the analysis table shown in Table 7.

Table 6. Relationship between technical characteristics and demand

Secondary requirements Technical characteristics	Working life	Defensive properties	Storage range	Scope of application	Layered structure	On-demand storage	Storage time	Intelligent monitoring	Beautiful styling	Green	Floating posture	Single color	Importance
Practicality	●	●	⊙	⊙	△	○	⊙	●	⭘	⭘	●		7.16
Security	⭘	●	⊙	○	○	○	○	△	△	△	○		7.72
Diversity	⊙		●	△	○	○					△		6.60
Applicability	○	○	⊙	●	○	△		○			△	△	5.14
Spatial division	○	○	○	△	●	○		△			⊙		6.80
Storage		⊙	○		⭘	●	●	△					7.04
Anti-bacteria, temperature, and humidity control		△	△			△	⭘	●					6.32
Auxiliary	△	△					⊙	●		△			6.36
Styling				△				△	●	⭘	●	⊙	5.52
Material				○					●	●	○	⊙	6.00
Body Type				○					●	⭘	●	●	6.04
Color		△							⭘	●	○	△	5.28
Technical characteristics score	116.72	137.36	127.06	105.62	94.16	103.22	116.48	136.56	130.96	107.92	163.74	75.18	1414.98

Table 7. Weighting analysis of technical characteristics of storage cabinets

Serial number	Secondary requirements	Technical characteristics	Weighting
1	Practicality	Working life	0.08
2	Security	Defensive properties	0.10
3	Diversity	Application areas	0.09
4	Applicability	Scope of application	0.07
5	Spatial division	Layered structure	0.07
6	Storage	On-demand storage	0.07
7	Anti-bacteria, temperature and humidity control	Storage time	0.08
8	Auxiliary	Intelligent monitoring	0.10
9	Styling	Beautiful styling	0.09
10	Material	Green	0.08
11	Body Type	Floating posture	0.12
12	Color	Single color	0.05

3.3.3 Construction and analysis of HOQ

The HOQ model is constructed with the "left wall" being the customer's requirements. The "ceiling" is the technical characteristics of the product, the "room" is the correlation between customer requirements and technical characteristics, the "right wall" is the importance of customer requirements, and the "basement" is the weight of technical characteristics. "Basement" is the weight of technical characteristics; by analyzing the relationship of "roof,": "+" indicates a positive correlation, and "-" indicates a negative correlation. The results are then summarized to draw organizational conclusions that can be used in subsequent designs to create a product that better meets the user's requirements.

The previously obtained requirements and the calculated importance results, the converted technical characteristics, and the calculated weight results were used to construct the quality house model, which resulted in the quality house model for the storage cabinet shown in Fig. 3. The quality house model makes it possible to identify the problematic areas of the storage cabinet relatively straightforwardly.

As depicted in Figure 3, the practicality, safety, versatility, and applicability of the storage cabinets are related to the technical characteristics such as working life, defensive performance, and storage range. The space division, storage, and sterilization are related to technical characteristics such as layered structure, storage on demand, storage time, and intelligent monitoring. The customer's requirements in terms of shape, material, size, and color are related to technical characteristics such as aesthetics, greenness, environmental friendliness, ease of movement, and single color.

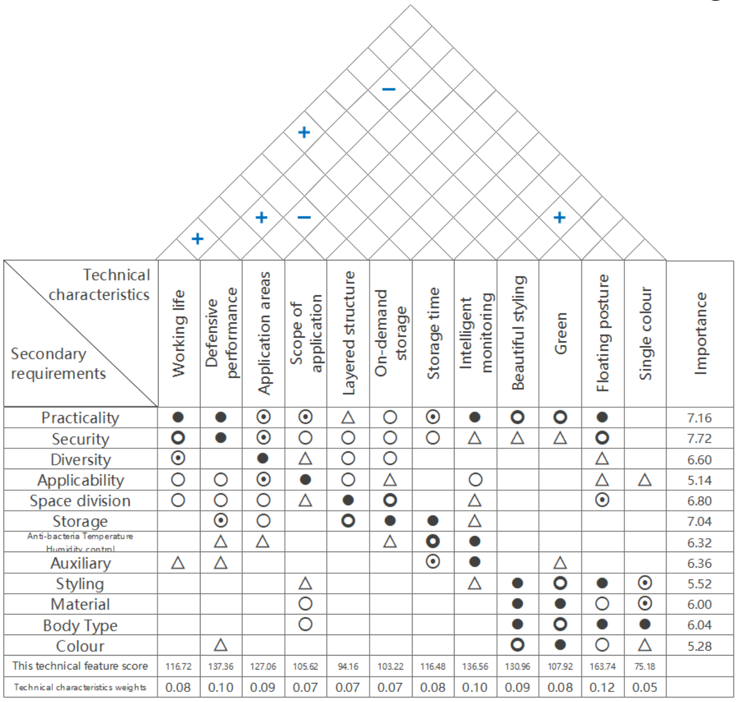


Fig. 3. Storage cabinet HOQ

3.4 Problem-solving

3.4.1 Determination of conflicting properties of storage cabinets

Table 8. Conflict determination of Miao embroidery piece storage

Negative correlation	Type of Conflict	Reasons for conflict
Storage range	Technical conflicts	When the technical characteristic of the storage range of the cabinets was introduced, it made the structural characteristics of the storage cabinets in terms of layering more difficult. As the layering of the cabinets increased, this led to a deterioration in the storage range characteristics of the cabinets.
Layered structure		
Defensive properties	Technical conflicts	When the defensive properties of the storage cabinets are introduced, the material requirements of the cabinets are increased, and the material has an absolute impact on the environment, so the increased defensive properties lead to a deterioration of the green properties
Green		

When analyzing the autocorrelation in the HOQ model of the Miao embroidery piece storage cabinet, it was found that the Miao embroidery piece storage cabinet has a negatively correlated characteristic. Table 8 shows that the storage range of the Miao embroidery piece storage cabinet and the layered structure is technically conflicting, as the company wants the cabinet to meet both the wide storage range and the layered structure of the embroidery piece storage. Therefore, it can store other objects and Miao embroidery pieces, which are adaptable, versatile, and complex. It is a technical conflict between defense performance and environmental friendliness, meaning to meet the performance of defense and at the same time to meet the environmental friendliness of the material, as well as to have reliability and not pollute the environment.

3.4.2 Conflict resolution in storage cabinets

3.4.2.1 Analysis of the principle of the invention

By describing the conflict, the standard engineering parameters to be improved are 35 adaptabilities and versatility. The generic engineering parameters to be worsened are 36 complexity, corresponding to the inventive principles 1, 13, and 31. The standard engineering parameters to be improved are 27 reliability, and the generic engineering parameters to be worsened are 31 harmful factors generated by the object, corresponding to the inventive principles 35, 2, 40, and 26.

3.4.2.2 Design point elaboration

By summarizing and analyzing the inventive principles of the Miao embroidery piece storage cabinet in Tables 9. After an in-depth reading of all the corresponding principles, the 1st, 26th, and 40th inventive principles were finally selected as the principles for the innovative design of the Miao embroidery piece storage cabinet, with the detailed design points elaborated as shown in Table 9 below:

Table 9. Description of the design points for the Miao embroidery piece storage cabinet

Principle of Invention	Design elaboration
1 Principle of segmentation	The modular design of the storage cabinet is based on the classification of Miao embroidery pieces. Each classification is independent but has a certain connection, making it easy to store Miao embroidery pieces.
26 Substitutes	Replacing unmanageable, expensive, and fragile objects with simple, inexpensive replicas reduces the cost of materials and the storage cabinet's weight, making it lighter.
40 composite materials	Using composite materials instead of mono-materials effectively protects the embroidery piece, reduces environmental pollution, and increases the product's working life and service life.

3.4.2.3 Determine the innovative design direction of the Miao embroidery piece storage cabinet

Based on the above analysis, the design of the storage cabinet for Miao embroidery pieces was determined, as shown in Table 10.

Table 10. Innovative design directions for Miao embroidery piece storage cabinets

Design Scope	Design Direction
Performance	Use of composite materials to increase the service life and defensive properties of storage cabinets
	Increase the range and applicability of the storage cabinets by zoning
Functionality	Adding intelligent control technology to control temperature, humidity, and sterilization
	Multi-category storage for objects and embroidery pieces
	Composite materials are effective in preventing external factors such as rodents and mosquitoes
Appearance	Designing storage cabinet details to achieve an aesthetically pleasing look
	Composites for a non-polluting environment
	A smaller mass of composite material reduces the weight of the storage cabinet
	The single color looks more modest and elegant

4. Design Practice

The design of the Miao embroidery storage cabinet is based on the above-mentioned innovative design directions. In addition, it is based on a comprehensive analysis of performance, functional, and appearance aspects, respectively. As a result, the study will design a multifunctional embroidery storage cabinet with a single color, elegant shape, and a flowing body, combining embroidery piece storage, scientific management, fire and theft prevention, and rat prevention. After analysis, two design options have been summarized that are more in line with the design of the Miao embroidery piece storage cabinet. Option 1, to maximize the storage of embroidery pieces, the cabinet is divided into six areas, which are stored separately according to the size range of the Miao embroidery pieces and the classification of the embroidery pieces, with a square shape and with functions such as intelligent monitoring and anti-theft as shown in Fig.4. Option 2, square-liked elegantly shaped, with six sorted storage areas, intelligent monitoring and fire and rat prevention, and four corners for storing small items, as shown in Fig.5.

Fig. 4. Sketch of Option 1

Fig. 5. Sketch of Option 2

The advantages and disadvantages of the two options were analyzed, and Option 2 was finally chosen as the final option for the refinement of the scheme. The final design of a new Miao embroidery piece storage cabinet for the requirements of Miao embroidery companies is shown in Fig.6.

In terms of performance, the strength and modulus of epoxy resin and carbon fiber composite materials are greater than aluminum and steel alloys and have excellent and stable chemical properties, wear resistance, heat resistance, fatigue resistance, electrical insulation properties, etc. Therefore, using epoxy resin and carbon fiber composite materials as the primary material guarantees the working life of the storage cabinet and strengthens its defensive properties of the storage cabinet.

In terms of functionality, the system is monitored by an intelligent monitoring system that incorporates temperature and humidity sensors, sterilization, and other tools, effectively controls the temperature and humidity inside the storage cabinet, sterilization, and reduces the size of the components so that they do not occupy the internal space of the storage cabinet. The system is also a control center for controlling the access to the embroidery piece clips and a statistical center for recording the access to the embroidery pieces. Moreover, the system combines sterilization, humidity control, and storage, meeting the company's requirements. Imagine that when a company requirements to take out embroidery pieces, they can search for the keywords describing the pieces as were previously stored on the computer, find the relevant content, open the embroidery piece cabinet with one click, and take out the required embroidery pieces directly. The functional partitioning of the storage cabinet divides the storage cabinet into different classification areas to effectively manage the stored embroidery pieces.

In terms of appearance, the appearance is elegant and temperamental; the smooth lines give a sense of extreme stability and security. In addition, the silver and grey color scheme gives a sense of modern design, the chamfered details add to the aesthetics of the storage cabinet, and the use of epoxy resin and carbon fiber composite materials reduces the overall weight of the storage cabinet and reduces environmental pollution.

Fig.6. Effect of storage cabinet for Miao embroidery pieces

The parts of the storage cabinet are shown in Fig.7: 1 is the storage cabinet of animal patterns, 2 is the large-size embroidery pieces storage cabinet , 3 is the storage cabinet of the character pattern, 4 is the storage cabinet for other patterns, 5 is the storage cabinet for other objects, 6 is the storage cabinet of plant patterns.

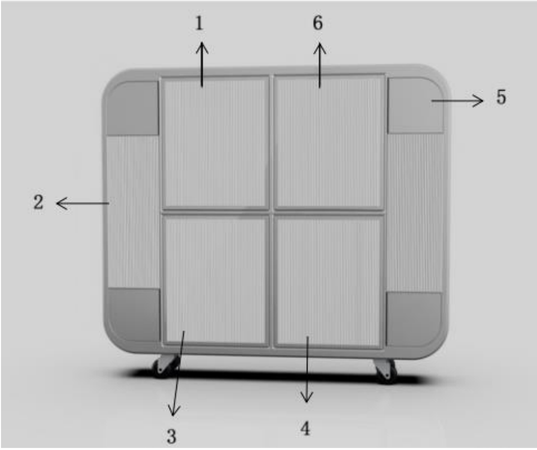


Fig.7. Diagram of the constituent parts of the Miao embroidery piece storage

The intelligent control device is shown in Fig.8: 1 is an integrated controller, 2 is an ultraviolet sterilization device, 3 is a temperature and humidity sensor, 4 is a bacteria sensor, 5 is a control device.The exploded view of the Miao embroidery piece storage cabinet is shown in Fig.9. The workflow is shown in Fig.10.

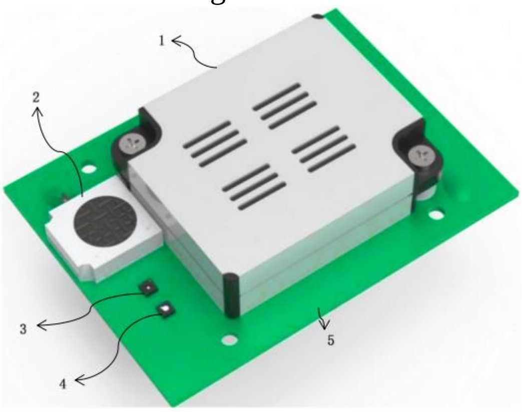


Fig.8. Internal diagram of the intelligent control unit

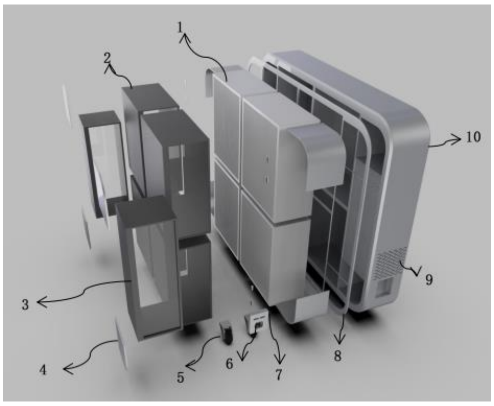


Fig.9. Exploded view of the storage cabinet

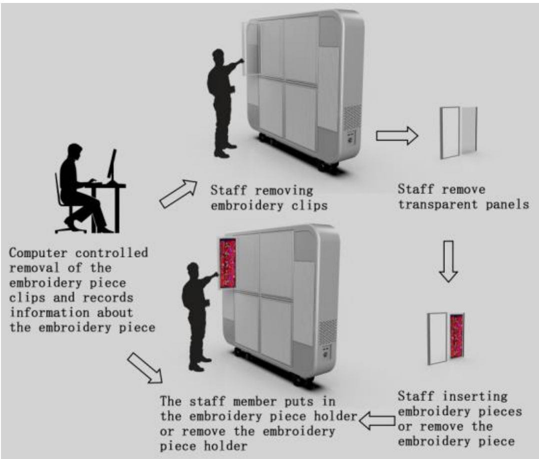


Fig.10. Workflow diagram

The structure of the Miao embroidery piece storage cabinet is shown in Fig.11: 1 is the detailed display of the Miao embroidery piece, 2 represents the clamping device for the embroidery piece, 3 is the storage box for other objects, 4 is the power socket of the storage cabinet, 5 is the cooling holes on both sides of the Miao embroidery piece storage cabinet.

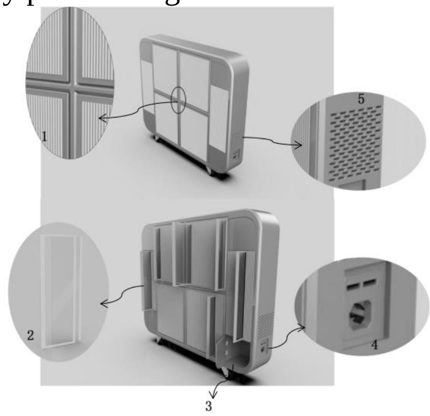


Fig.11. Structure of the embroidery piece storage cabinet for Miao embroidery

The three views of the Miao embroidery piece storage cabinet are shown in Fig.12.Three views of the large clip are shown in Fig.13, and three views of the small clip are shown in Fig.14.

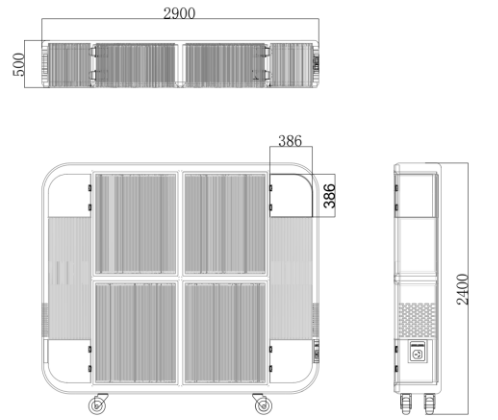
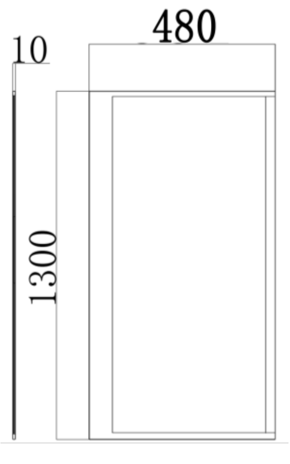


Fig.12 Three views of the Miao embroidery piece storage cabinet



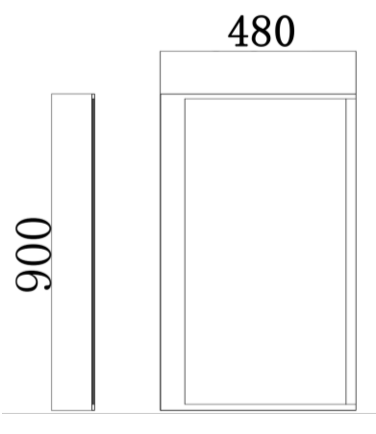


Fig.13. Three views of the large clamping device Fig.14. Three views of the small clamping device

5. Conclusion

Using various research methods to obtain enterprise requirements on a one-to-one basis and the affinity diagram method to summarize and organize them, the importance of the requirements is calculated using the importance formula. Next, the decision attributes of the requirements are calculated, the HOQ tool in QFD is combined to convert the enterprise requirements into technical characteristics, and the correlation of the technical characteristics is analyzed to obtain negative correlations. Then the problems arising from the negative correlations are determined and analyzed through the TRIZ correlation theory tools, and the conflicts are resolved. Finally, a storage cabinet for Miao embroidery pieces was designed. The cabinet's design is an innovative solution for storing embroidery pieces, scientific management, fire and mouse prevention, and a multifunctional cabinet with a single color, and elegant shape. The combination of QFD and TRIZ theory in product design is feasible and provides a new reference for the product design process.

Contribution to this article:

(1) To obtain more accurate and realistic enterprise requirements, this paper combines multiple research methods with decision tree algorithms and QFD theory, which can further improve the objectivity and completeness of requirements decisions, thus improving the accuracy and objectivity of HOQ decisions.

(2) The requirements of companies obtained on a one-to-one basis are summarized and collated using the affinity diagram method, which ensures consistency and authenticity in the technical characteristics of the conversion.

(3) The innovative design of the Miao embroidery piece storage cabinets set the characteristics of embroidery piece storage, scientific management, fire, and burglary prevention, and rat-proof in a single color, elegant shape, and floating body based on meeting the basic functions.

Research significance:

(1) This research theory can effectively identify problems and accurately solve problems in designing Miao embroidery piece storage cabinets. It also provides theoretical references and innovative ideas for new product innovation designs.

(2) The innovative design of the Miao embroidery piece storage cabinet can better preserve and manage the collection of Miao embroidery pieces, allowing the company to efficiently and quickly produce Miao embroidery products to the satisfaction of consumers. In return, it will gain a greater advantage in the fierce competition in the Miao embroidery industry, thus making significant profits and earning obvious economic benefits for the Miao embroidery company.

(3) A storage cabinet for Miao embroidery pieces with the company's requirements in mind will better enable the company to efficiently and quickly produce Miao embroidery products to the satisfaction of consumers in conjunction with the Miao embroidery platform. Furthermore, the preservation of Miao embroidery pieces is also of great importance to the heritage of Miao embroidery culture, the research and study of Miao embroidery techniques, and the sustainability of Miao embroidery techniques and culture.

However, the storage cabinet designed for this study did not have a dynamic analysis due to the limited conditions. Therefore, there is no way to determine the structural stability and safety of the product in use. Further analysis of the storage cabinet should be carried out in future studies to ensure that the cabinet is designed better to serve the company's future and Miao embroidery.

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