

Research Article

Design and Implementation of Swastika Forms in Tenon and Tenon Structure Furniture

Lijuan Liang ¹ and Yafei Fan²

¹Zhongyuan Institute of Science and Technology, Zhengzhou, Henan 450000, China

²Zhengzhou Vocational College of Finance and Taxation, Zhengzhou, Henan 450048, China

Correspondence should be addressed to Lijuan Liang; llj202204@126.com

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With mortise and tenon structure furniture as the design carrier, the cultural connotation of traditional symbols is absorbed and new ideas for the inheritance and development of traditional culture in modern life are explored. Starting from the analysis of the modeling characteristics, decorative characteristics, and allegorical connotations of the swastika, its feature elements is summarized, the keywords of the design elements are screened, applications and extensions on this basis are designed, the basic model of furniture products is established, then the tenon and tenon forms that meet the strength requirements and material requirements according to the model are screened, the overall construction of tenon and tenon structure furniture products is completed, and the physical production of the products is guided. Combining the swastika form with the tenon structure bookcase design, the traditional symbolic feature elements are effectively integrated into the design of the tenon structure furniture, which verifies the feasibility and effectiveness of the method and provides a reference for the design research of related tenon and tenon products.

1. Introduction

Tenon and tenon is the main structural mode of traditional Chinese architecture, furniture, and other instruments. It is a connection mode of combining concave and convex parts on the two components. Tenon and tenon is the essence of traditional furniture design in China, with a variety of types and diverse shapes. In the new market development situation, it is necessary to be able to do a good job in the redesign of tenon structure furniture and better meet the market demand in the case of further improving the design level [1].

With the introduction of the concept of cultural self-confidence, the research and innovative application of traditional cultural connotations have received more and more attention. The tenon and tenon structure is a model of traditional Chinese creation structure and is the most researched way to connect [2]. This paper takes the tenon structure furniture as the design carrier, uses reasonable design analysis methods, and combines the traditional

swastika form in three-dimensional, functional, and other forms, which can not only effectively reflect the unique artistic charm of traditional symbols but also enhance the cultural added value of furniture, while meeting consumers' demand for product function, so that consumers have a deeper understanding of traditional symbol forms and tenon structure culture.

With mortise and tenon structure furniture as the design carrier, the cultural connotation of traditional symbols is absorbed and new ideas for the inheritance and development of traditional culture in modern life are explored. Starting from the analysis of the modeling characteristics, decorative characteristics, and allegorical connotations of the swastika, its characteristic elements are summarized, the keywords of the design elements are screened, application and extension on this basis are designed [3], the basic model of furniture products is established, and then the mortise and tenon shape that meets the strength requirements and material requirements according to the model is screened, and the

overall construction of the tenon and tenon structure furniture products is completed, and, to guide the physical production of products, the production process of customized swastika traditional furniture is shown in Figure 1. All characters form and mortise and tenon structure bookcase design, effectively integrate the traditional symbol characteristic elements into the mortise and tenon structure furniture design, verify the feasibility and effectiveness of the method, provide reference for the related of mortise and tenon product design research, also to promote Chinese traditional culture has important practical significance, make the mortise and tenon structure furniture design more diversity.

2. State of the Art

2.1. Signifier of Traditional Chinese Swastika. Swastika can refer to the “swastika” glyph ornament, and its harmonic pronunciation is “wan,” which means ten thousand blessings, longevity, good luck, and auspiciousness, carrying people’s expectations for a better life. The signifier shape of China’s traditional swastika is relatively simple, but the combination method is flexible and changeable, and, from the composition of its pattern alone, it is mainly divided into the following types: The first is independent individual pattern [4]. It is a monolithic pattern, mostly appearing on porcelain, fabric, and jade, and is presented by drawing, weaving, carving, and so forth and can also be combined with other patterns. The second is opposing individual pattern. It is composed of two or more monomer patterns to form a symmetrical relationship. The third is back-standing individual pattern. It is composed of “swastika” and “swastika” opposites. The fourth is vertical two-sided continuous pattern. Its line is vertical, extending horizontally or vertically, while the length of the line is distinguished from each other, and the “swastika and swastika” are used in combination. The fifth is continuous quadripartite continuous pattern. Using rectangular or square concatenations, the “swastika” or “swastika” extends in all directions [5] as shown in Table 1.

The organizational structure of China’s traditional swastika has the following types: single body molding, mainly relying on the swastika monomer molding, and combination structure, of which the single structure is the main structure; on this basis, there are five subtypes: single thick line, double hook line, double hook center vertical line, epitaxial expansion, and epitaxial expansion. In the later period, the combined structure was mostly adopted; that is, a swastika was used as the basic shape, and it was combined with one or more other patterns, and the subject matter of other patterns included animals, texts, and geometric shapes.

2.2. Tenon and Tenon Structure Furniture Design. In the process of continuous development of society, the tenon and tenon structure is gradually faded out of the market because it cannot be adapted to the modern production mode; in this case, how to redesign the tenon and tenon structure to meet the development needs of the modern market has become a

very important content [6]. Tenon and tenon structure is the main structural method in traditional architecture and furniture, and its structural strength and high precision are considered to be the most stable way of combining wood. However, the production process of mortise and tenon structure is cumbersome and difficult to adapt to modern mass production methods, so it is mostly replaced by hardware connection components [7]. However, the national wisdom and traditional cultural connotation contained in the tenon structure cannot be replaced by modern technology, so many researchers have tried to improve the tenon structure production process from mechanical processing and tool improvement and have achieved more results [8]. Tang Lin et al. developed an efficient tenon intelligent processing code generation system, to achieve the tenon processing CNC program design and code intelligent compilation, for the digital improvement of tenon and tenon to provide a theoretical basis. Liu Zhifeng et al. proposed an improvement scheme for the fixture system of tenon and tenon machining centers to improve the machining accuracy of tenon and tenon machining centers. The simplified process reduces the cost of tenon furniture, allowing it to enter thousands of households. However, at present, the relevant research is more focused on the innovation of tenon and tenon structure processing and production mode, and insufficient attention is paid to the expansion and development of the cultural connotation of tenon and tenon structure, resulting in the homogenization of the tenon and tenon furniture market, affecting the development and dissemination of tenon and tenon culture [9]. Therefore, more design form innovation is needed to enrich the expression of tenon and tenon structure furniture and expand its cultural connotation. In this paper, the tenon and tenon structure is studied and analyzed, and the function and composition form of the tenon and tenon process structure are explored by comparative study of the traditional tenon and tenon structure, and the typical element characteristics of the swastika form are used to design the tenon structure furniture with national cultural characteristics.

2.3. Tenon and Tenon Structure Furniture Redesign. In the long-term development of our country, the mortise and tenon structure has played an important role in furniture design. In the new market environment, in order to be able to better adapt to modern lifestyles and technology types, it is necessary to actively improve the tenon structure and further reduce the difficulty of processing. In modern furniture design, under the influence of materials, processes, and techniques, the specific application needs to be able to do a good job in the assessment of factors such as equipment, materials, and processes and apply them in a scientific redesign way to ensure that they have scientific and reasonable characteristics, better to play a role in the modern market [10].

In the process of traditional furniture production in China, manual production is usually the main production method, because the existence of this situation also restricts the development of traditional industries to a certain extent

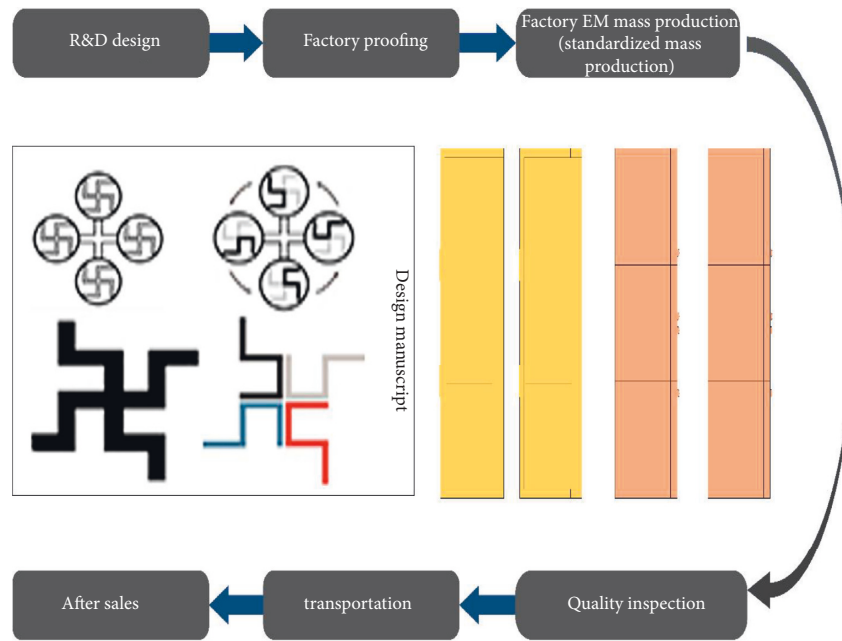


FIGURE 1: Production flow chart of custom furniture.

TABLE 1: Traditional swastika pattern types.

Pattern type	Features
Stand-alone individual pattern	A monomeric pattern that appears on porcelain, fabric, and jade and is presented by drawing, weaving, and carving
Opposing individual patterns	It is composed of two or more monomer patterns to form a symmetrical relationship
Stand-up individual pattern	It is composed of “swastika” and “swastika” opposites
Vertical two-sided continuous pattern	The line is vertical, extending horizontally or vertically, while the length of the lines are distinguished from each other, and the “swastika and swastika” are used in combination
Continuous quadripartite continuous pattern	Using rectangular or square concatenations, the “swastika” or “swastika” extends in all directions

[11]. In modern furniture design, the rapid development of manufacturing technology has made it possible for the modern application of mortise structures [12]. In furniture production, the choice of processing equipment and method selection is very critical, and it is also the key guarantee of the technical level. In the case of applying advanced technology, it can effectively improve production efficiency and transform design concepts into practical results. In the furniture design, we are also exploring the possibility of further improvement to better meet the diverse needs of consumers. For example, in today’s wood processing, curved surfaces and bending molding methods are used a lot, and, in the case of long curved timber, the installer is effectively simplified; and, in the case of the application of CNC technology, it can also effectively improve the production efficiency of the tenon structure, and the equipment is processed into complex shapes by CNC machine tools, and then, by mortise, the application meets the design goals [13] as shown in Table 2.

2.4. Application of 24,000 Character Forms in Modern Design. The swastika usually refers to the “swastika” glyph ornament, and its harmonic pronunciation is “wan,” which means ten

thousand blessings, longevity, good luck, and auspiciousness, carrying people’s expectations for a better life. In modern design, designers use swastika shapes as a carrier to design different forms of swastika graphic languages. In design practice, swastikas usually appear in the form of two-sided continuous or four-sided continuous pattern; for example, at the 2014 Beijing APEC conference, the costumes of national leaders were based on the song jin improved middle suit with swastika as the fabric shading, and the swastika is often carved on the product as an auxiliary pattern, such as the sour branch swastika that symbolizes auspiciousness. The use of swastika characters enhances the cultural added value of the product and at the same time extends its graphic form and spiritual connotation, so that consumers have a deeper understanding of traditional symbol forms [14].

The special expressiveness of the swastika form itself is the charm of traditional decorative arts, and the swastika also has broad application prospects in modern design. With the help of design principles, this paper applies the swastika form to the field of tenon structure furniture design and enriches the expression form of the tenon structure and its cultural connotation with the help of swastika as shown in Figure 2.

TABLE 2: Tenon structure furniture redesign.

Method	Method	Content
Innovative design approach	The combination form is simplified	When designing furniture, you can actively explore the characteristics of tenons as an exploration of material application and reduce the use of components and form a unique design style through the application of this method.
	Combined with exposed design	In today's design, it is possible to combine aesthetics and use features, and the tenon structure can be designed in an exposed way, which is also an aesthetic way to reflect visual value.
New material use	Application diversification	In the case of the change of the traditional material use mode, different materials for reasonable collocation are fully used, in the case of giving full play to the performance of different materials, for the furniture in the function, shape, and other aspects of the good design effect.
	Modernization of manufacturing processes	In the case of applying advanced technology, it can effectively improve production efficiency and transform the design concept into practical results; in furniture design, it can also explore the possibility of further improvement, better meeting the diverse needs of consumers.

Design mainly has three stages: symbolic element analysis, design element extraction, and design application. Firstly, the basic characteristics and connotations of the “swastika” symbol are investigated through relevant literature and data, and its characteristic elements are analyzed and refined. Secondly, the key words of design elements are screened out, and the design application and extension are carried out, so as to build a basic model of furniture products. On this basis, the useable mortise and tenon types are screened, and the structural strength analysis and material selection are carried out to complete the overall construction of the tenon and tenon structure furniture products. Finally, the rationality of the design is tested through the production of the product.

In the process of applying the “swastika” pattern, the three structural characteristics of continuity, central symmetry, and regularity are the main entry points. For continuity, the “swastika” pattern adopts a square structure, shaped like a “tian” character with half the length cut off on all four sides, and the combination of long and short lines reflects a sense of continuity. For central symmetry, the “swastika” pattern is a central symmetrical figure formed by rotating a simple element by rotating 90° and 180°, and this form of rotational symmetry gives the “swastika” more design representation. For regularity, “swastika” is an interlaced symmetrical symbol formed by the rotation or flipping of two “Z” symbols, which has regularity, but rotates like a windmill, and the static symbol shape has dynamic expression. According to the above analysis, the final design elements keywords are continuity, symmetry, rules, and dynamics, and researchers can also use this as a reference for corresponding product design innovation [15].

3. Methodology

3.1. Basic Model Construction. Based on the analysis and research of the swastika modeling characteristics, decorative characteristics, and allegorical connotations, the characteristic elements of the swastika form are summarized, and it was used as the design carrier; the design team adopted the brainstorming method to obtain part of the sketch scheme;

according to the characteristics of mortise and tenon structure and the effect of combining mortise and tenon structure, the corresponding feasibility analysis is made, selected the tenon structure rotating bookcase design scheme. The bookcase makes full use of the structural characteristics of continuity, central symmetry, and rules of swastikas and displays the flat symbol shape in a three-dimensional form, so that the original swastika form has a new way of expression. The bookcase is mainly connected by a mortise and mortise structure, and each layer can be rotated independently, adding dynamic expression to the static symbol shape. After the corresponding sketching and computer 3D modeling software for the basic model construction, the basic model of the product formed is shown in Figure 3.

In Buddhism, the ten thousand characters are surrounded by open spaces, and this feature is used to divide the overall space of the bookcase into four parts, and the user can sort the books according to their personal preferences [16]. At the same time, each module can be rotated freely by 360°, which not only improves the use function of the product but also meets the dynamic feature expression needs of the symbol itself.

The typical swastika structure is shown in Figure 3, which can be represented by a matrix:

$$R = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & & \\ 1 & 1 & 1 & 1 \\ & 1 & 1 & \\ 1 & 1 & 1 & 1 \end{bmatrix}. \quad (1)$$

The transformation of swastikas can be achieved using the transformation of the matrix, using the following methods.

Tensile transformation is as follows:

$$\text{scale}(s_x, s_y) = \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix}. \quad (2)$$

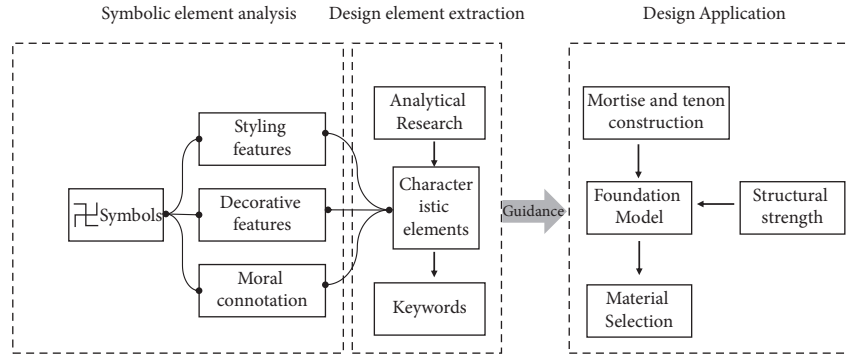


FIGURE 2: Design application flow.

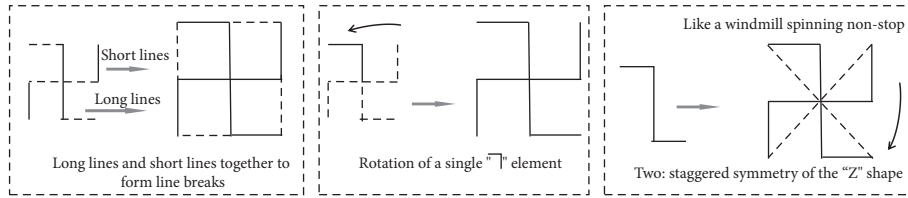


FIGURE 3: 10,000-character analysis diagram.

Cut operation is as follows:

$$\text{shear} - x(s) = \begin{bmatrix} 1 & s \\ 0 & 1 \end{bmatrix}, \quad \text{shear} - y(s) = \begin{bmatrix} 1 & 0 \\ s & 1 \end{bmatrix}. \quad (3)$$

Rotation operation is as follows:

$$R_\theta = \begin{bmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{bmatrix}. \quad (4)$$

Horizontal flip operation is as follows:

$$x' = -x, \quad y' = y, \quad \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}. \quad (5)$$

Translation transformation is as follows:

$$x' = x + t_x, \quad y' = y + t_y. \quad (6)$$

3.2. Tenon Structure Analysis. After establishing the basic model, starting from the structure and function of the product, according to the overall morphological characteristics of the bookcase and the combination between the shapes, the appropriate mortise and tenon parts are selected to enhance the stability and overall strength of the furniture [17]. At present, the bookcase is mainly the joint between the surfaces, the two sides are perpendicular to each other, and the cross-sectional area of the intersection is large, screening the current commonly used tenon structure, listing several types of tenons that meet the structural conditions of the target product, and summarizing its structure and corresponding characteristics, as shown in Figure 4.

The single model unit of the bookcase is mainly composed of three planes of different dimensions, and the force direction forms a three-dimensional direction, which requires high stability performance of the mortise and mortise structure. At the same time, taking into account the demand for mass mechanized production, the use and advantages of the common mortise and mortise structure in the current mortise and tenon furniture are compared and analyzed, and the thin plate groove mortise, the tenon, the cross tenon, the square material T-shaped mortise, the six kinds of tenons, and the tenon and the straight mortise serve as the connecting components of the target bookcase structure. Among them, there are 5 types of tenons: thin plate groove mortise, tilde, cross mortise, square material T-shaped mortise, and straight mortise [18]. The structure is relatively simple, the machine cutting process is more convenient, and the structural adjustment is small.

The rice dumpling corner tenon used at the right corner of the bookcase is named after the shape of the rice dumpling corner, which is formed by the interspersed corners of each grid of three square materials to form 6 45° angles' tenon and tenon structure. The tenon head is in the middle, and there are mortise shoulders on both sides, and the mortise and mortise shoulders rely on each other to share the pressure, which enhances the stability and support of the structure, thereby improving the safety and stability of furniture products.

In many tenon and tenon structures, the dovetail mortise is known as the “mother of ten thousand mortise,” whether it is the open buckle and hidden buckle of the drawer frame, or the collus pin in the small wood furniture, all of which use the mechanical principle of the dovetail mortise. In the parametric design of swallowtail mortise, the ratio of tail mortise to head mortise, the taper of the tenon cone angle, and the numbers of dovetail heads and plug joints all determine the firmness of the

splicing, while the length, width, and height of the wood determine the size of the overall part of the dovetail mortise. Its structure can be represented by a parametric model:

$$a = \frac{(L/n - 2H/m)}{(k + 1)}, \quad (7)$$

$$b = \frac{2H}{m + a}, \quad (8)$$

$$c = ka. \quad (9)$$

Swallowtail mortise is usually subject to tensile force, and good tensile performance is required in practical application. Therefore, this section takes the maximum equivalent force of the dovetail tenon under the action of the tensile force as the objective function, as well as the ratio of the tenon head and the ratio of the head and tail tenon as the design variables, and, at the same time, in order to ensure the symmetry of the overall structure and the generation of the dovetail mortise, the large head of the head mortise should be greater than the small head of the head mortise, and the width of the mortise on both sides should be greater than zero. In summary, it is possible to establish a dovetail tenon tensile optimization model:

$$\begin{cases} \min F_{\max} = F(m, k), \\ s.t. 1 \leq k \leq 10, \\ 4 \leq m \leq 12, \\ \frac{k(l/4 - 2h/m)}{(k + 1) - 2h/m} \geq 0, \\ \frac{(l - 4(l/4 - 2h/m)/(k + 1) - 3k(l/4 - 2h/m)/(k + 1))}{2} \geq 0 \end{cases} \quad (10)$$

Here, F is objective function, F_{\max} is maximum equivalent force, MPa, k is the ratio of the width of the head and tenon to the tail, m is mortise taper, l is plank width, mm, and h is mortise height, mm.

3.3. Tenon and Tenon Structure Improvement. The internal structure of traditional rice dumpling tenon is complex, the requirements for processing accuracy are extremely high, the mechanical processing process is difficult, and it is difficult to carry out mass production. To this end, the internal structure of the rice dumpling angle tenon is improved and optimized, and the improved tenon structure of the rice dumpling angle tenon is adapted to the process requirements of modern mechanized production under the condition of maintaining its neat appearance and rigorous structure, ensuring the strength of the internal structure and the overall stability [19]. The transparent mortise part in the traditional rice dumpling tenon is simplified, the slanted shoulder part is optimized, and the scribe tenon structure is added to strengthen the overall structure, while the rubber groove is reserved for later installation and reinforcement.

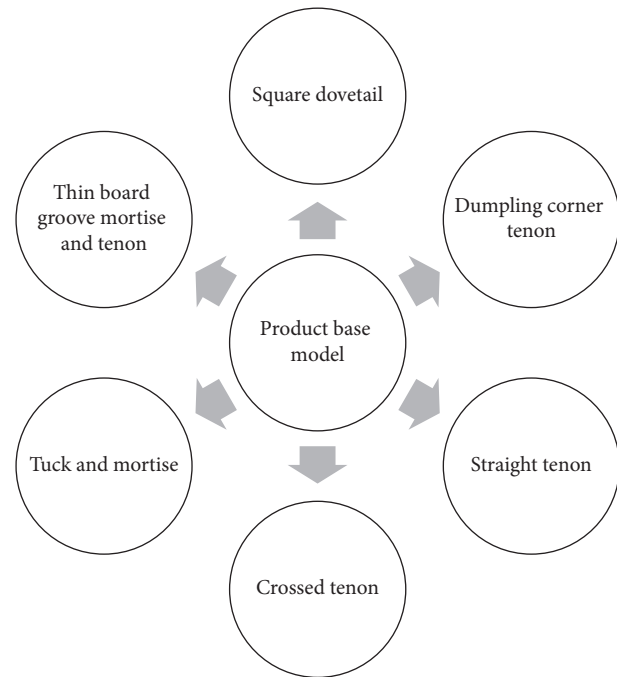


FIGURE 4: Tenon structure analysis.

3.4. Material Analysis. The material has its own unique modeling language, and its inherent characteristics determine the structural characteristics of the furniture, so the selection of furniture materials is very important. The tenon structure of traditional furniture is generally based on mahogany with dense texture as the main material, but, for modern furniture, expensive mahogany is easy to lead to a narrow audience of products, so it is necessary to choose suitable alternative materials. In this design, researchers should choose materials with strong physical properties, rich color textures, and moderate processing difficulties, so as to control the production costs of products while ensuring the stability of the tenon structure and the aesthetics of furniture products.

After clarifying the product positioning, the researchers investigated several kinds of wood commonly used in the design of solid wood furniture on the market, such as beech, rubber wood, ash wood, teak, pine, and black walnut, and selected the most suitable wood for the design of this bookcase by comparing its mechanical properties, unit price, color texture, processing difficulty, and so forth [20]. Different material parameters are shown in Table 3, in terms of physical properties, beech, white wax, teak, and black walnut which meet the basic needs of the product; the damage load of beech is 2.86 MPa, which is the highest of these materials, indicating that the material is strong; teak has the highest bending strength, 116.47 MPa, but the most expensive, white wood, monotonous texture; the price of teak is difficult to control the cost. In order to ensure the structural stability of the bookcase and the aesthetics of the product, while reducing the production cost, the beech wood with high cost performance and the black walnut that is closest to the performance of the mahogany are finally selected as the main materials.

TABLE 3: Comparison of mechanical properties, texture, and color of several commonly used woods.

Material type	Gas dry density/ ($\text{g}\cdot\text{cm}^{-3}$)	Failure load/MPa	Flexural strength/ MPa	Average market price/($\text{yuan}\cdot\text{m}^{-3}$)	Textured colors	Characteristic analysis
Beech wood	0.70	2.86	90.72	2500	The texture is straight and the color is pale yellow	The material is hard and extremely resistant to stamping
Rubber wood	0.68	1.94	88.41	3650	The texture is oblique and the color is pale yellowish brown	The structure is uniform and the wood is hard
Ash	0.73	2.57	115.82	3700	The texture is uniformly rough, and the color is milky white or slightly pink	Resistant to decay, compressive strength, and tensile strength
Yuzuki	0.69	2.54	116.47	12000	The texture is straight and the color is brownish	Strong and elastic, not warped and not cracked, corrosion-resistant, and wear-resistant
Matsuki	0.50	1.59	78.32	1550	The texture is clear and beautiful, and the color is yellowish	Strong elasticity and permeability
Black walnut	0.78	2.63	89.31	5000	The texture is straight, dark-brown with purple tinges	It has good dimensional stability and strong corrosion resistance

4. Result Analysis and Discussion

4.1. Digging Deep into the Tenon Structure and Traditional Culture. Tenon and tenon structure is a delicate and artistic structure, which makes furniture design more diversified so as to gain more consumer love. Tenon and tenon structure uses the frame combination, the materials and structural forms used determine its strength to a large extent, and the structure is generally connected by the combination points, forming an overall coordination mechanism, carrying the force load brought between various components, and reflecting the traditional structural system of wood. Of course, not only can the excavation of tenon and tenon stay in the structure itself but also it is possible to go deep into the traditional culture of tenon and tenon, and many household products that use tenon and tenon structures on the market at present have few traditional cultural embodiments. The tenon structure implies an interpretation of traditional culture, and traces of traditional culture can be found in many classical works that use tenon and tenon structures. It is of great significance to refine the cultural elements of the tenon structure and reflect them in the design of modern household items. Table 4 lists the legends, names, structural features, and key parameters of common mortise and tenon structures in traditional furniture.

After long-term development and evolution, the tenon and tenon structures have a definite topological shape and appearance characteristics, but, in terms of size determination, most of them rely on the experience of the carpenter master and imitate the relevant legends and albums, there is no unified standard, and the tenon and tenon structure size is more and the uncertainty is larger. Therefore, this paper performs dimensional optimization of four tenon and tenon structures to solve the optimal size combination that satisfies the constraints. The optimization results of the design variables are shown in Table 5, but this result only represents the solution of the program, but it needs to be appropriately corrected according

to the actual processing and production situation, and the corrected results are also listed in the table.

4.2. Externalizing the Tenon Structure. The scientific nature of the tenon and tenon structure is reflected in the fact that the tenon structure can be applied in many different parts, and the joints are very meticulous, and it is difficult to find the flaws without careful inspection. The tenon and mortise structures are connected in a unique way, and each structure can be analyzed as an independent individual. This colorful way of connecting creates a beautiful shape; whether it is a single individual or multiple combinations of each other can reflect the beauty of the tenon structure. This colorful connection method can be fully utilized as part of the product modeling in modern home design, that is, to weaken the unnecessary decorative structure and take the mortise and tenon structure as the part of the modeling, which can not only meet the concept of simple design but also have a certain connection with the tenon and tenon structure.

4.3. Following Modern Design Concepts. Tenon and tenon structures should always follow the concept of modern design in the design of modern household products. The so-called modern design concept is to pay attention to humanized design in modern home design, and the tenon structure should also pay attention to humanized design in modern home design. Modern people pursue a simple and general, high-quality, and green home environment; the previous mortise and tenon structure is generally used in wooden household items which is thick and bulky and does not meet the requirements of modern times. Therefore, in modern times, more concise new materials should be used to replace, and the design in the shape should also be more inclined to simplicity and replace gorgeous decoration, as shown in Figure 5.

TABLE 4: Features and applications of common tenon and tenon structures.

Tenon and tenon name	Structural features and applications	Key parameters
Right-angle tenon	The right-angle tenon has a wide range of uses and a simple structure and is the basic unit of the tenon-egg structure. It is commonly used for simple connections in chair furniture components. According to the tenon type, quantity, and joint method, many right-angle tenon variants can be derived.	Tenon (eye) length, tenon (eye) width, tenon (eye) height (depth), wood length, width, thickness
Dovetail tenon	The dovetail tenon is known as the “tenon of tenon and tenon.” Its root is narrow, the end is wide, and it has a large head shape. It is recognized as the strongest rod joint. It is often used in furniture drawer structure, box structure, table case corner joints of hoardings, etc. According to the shape of the tenon, it can be divided into four types: fully implicit, semi-implicit, fully transparent, and inclined shoulder type.	Board length, width, thickness, number of tenons, tenon taper, ratio of head tenon and tail tenon
Shoulder tenon	The lattice shoulder tenon has a tenon in the middle of the square material, and a triangular sloping shoulder is made on the outside of the tenon. The lattice shoulder can not only help the tenon to bear part of the load but also break the straight and rigid structure of the interface, making the joint more firm and beautiful. It is often used in the connection of various square materials in furniture and is also suitable for the line decoration of the inner corner of the frame structure.	Tenon (eye) length, tenon (eye) width, tenon (eye) height (depth), shoulder height, shoulder thickness
Corner tenon	The mortise and corner tenon is a comprehensive component, which usually consists of four parts: “wiping head,” “big edge,” “wearing belt,” and “face core board,” which can evenly distribute the overall pressure to each component. It is commonly used in frame structures such as chairs, cases, tables, stool surfaces, and cabinet doors.	The length of the whole frame, the width of the whole frame, the thickness of the whole frame, the number of straps.

TABLE 5: Tenon structure size parameters.

Design variable	Initial value/mm	Optimized value/mm	Correction value/mm
<i>Ll</i>	35	43.684	43.7
<i>Dl</i>	9	14.878	14.9
<i>Ls</i>	18	28.175	28.2
<i>Ds</i>	12	12.450	12.5
<i>K</i>	1	1.5439	1.5
<i>M</i>	6	4.5896	4.6
<i>Ll</i>	25	27.844	27.8
<i>Dd</i>	17	29.878	29.9
<i>Hh</i>	8	16.024	16.0
<i>La</i>	400	385.57	385.6
<i>Lb</i>	362	331.93	331.9
<i>Lc</i>	145	197.48	197.5
<i>D</i>	56	57.852	57.9

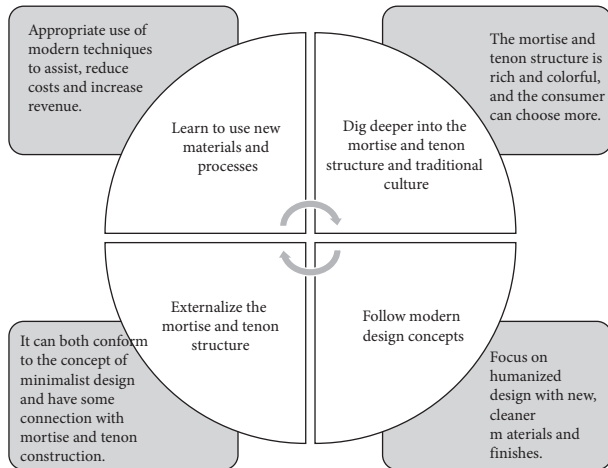


FIGURE 5: Tenon and tenon structure is used in the method of modern home design.

5. Conclusion

The tenon structure is an important part of China's traditional furniture and an important carrier of China's traditional culture. The traditional tenon and tenon structure furniture has great cultural value, integrating the tenon structure with modern popular design methods and giving it a new design connotation. In this article, the swastika form is refined and simplified and applied to the product design of modern tenon and tenon structure furniture, which not only strengthens the embodiment of symbol culture in the tenon structure but also provides a new direction for the design innovation of modern tenon and tenon structure furniture. The combination of traditional symbol culture and tenon structure furniture design is conducive to promoting the innovation and inheritance of traditional culture in China and provides theoretical support for the design of the same type of tenon and tenon product design. We have conducted some research on the redesign of traditional tenon and tenon structure furniture. The combination of traditional craftsmanship and modern trends enriches the furniture production methods, broadens the ideas of product design, and also satisfies the inheritance and development of ancient traditional culture. In the future work, it is necessary to be able to optimize from the perspective of process, material, and design concept and better inherit the tenon and tenon structure design concept through the use of tenon and tenon structure in furniture design and obtain better development in the market.

Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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