

## Research on the Production Process Optimization of Special Shaped Parts of Wood Furniture and Automatic Milling Technology

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**Abstract.** This paper makes an investigation and analysis on the status of special shaped parts processing of wooden furniture. On this basis, according to the shape and structure characteristics, the special shaped parts are classified. In addition, the processing procedure of solid wood special shaped parts is further optimized, and a novel processing scheme is proposed for different types of parts. The novel scheme provides reference for the equipment arrangement of enterprises, to improve production efficiency and machining accuracy, and reduce labor costs.

### Introduction

With the development of society, people's demand for life and production has been gradually improved. At present, advanced processing equipment, such as automated machining centers and computer numerical control (CNC) machine tools, has been imported by some enterprises, but because of the high cost, enterprises are more willing to use cheap labor to manual processing, affecting the plant's economic benefits.

The main contributions of this paper can be summarized as follows. The utilization of special shaped parts, processing machinery, processing and existing problems in the process, investigating are investigated. Moreover, special shaped parts are classified according to their types and structural features. Additionally, the optimization scheme of process flow for different types of special shaped parts is proposed.

### Concept and Processing technology status of wood furniture special shaped parts

#### Concept of special shaped parts

During production process in wood furniture enterprises, to meet the functional and modeling requirements, furniture parts required to be made into various shaped or curved surfaces are called special shaped parts [1]. Figure. 1 shows some special shaped parts.



**Figure 1.** Special shaped parts.



**Figure 2.** Milling of special shaped parts.



**Figure 3.** Special shaped parts processing molds

During practical application, special shaped parts exist in all aspects of furniture products, such as legs of desks or chairs, back rail of chairs, head board of beds, chair arms, table top of end tables and top panel, end panel and door panel of cabinets.

#### Processing technology status of special shaped parts

This subsection demonstrates the present status of special shaped part processing technology.

(1) Traditional machining is the mainstream of special shaped parts processing methods. It is very rare in China that the whole special-shaped parts are processed with advanced equipment. Milling

machine, planer, thicknesser, lathe and other traditional mechanical equipment are still the main types of equipment for milling processing of wood furniture special shaped parts.

(2) The special shaped parts cannot be formed in one milling process. Unlike the one milling process of numerical control (NC) equipment, because of the use of traditional mechanical equipment, special shaped parts often need two or more processing to form.

(3) Imperfection of NC machining technology for special shaped parts. Advanced equipment can improve quality and quantity of special shaped parts processing in a short period of time, but comparing the high cost of equipment with low labor costs in China, enterprises are more willing to choose cheap labor for "hand feed + milling" production mode. Therefore, the numerical control technology has little things to do with the promotion of special shaped part processing.

(4) The structure of special shaped part is complex and changeable, and the standard classification is not complete. In addition to the problems caused by processing equipment, the difficult processing of special-shaped parts is mainly because of its complex shape. Because of the complex shapes and structures, the structure of the special shaped parts should be standardized before processing. However, the reality is that there are almost no classifications and standards for the existing special shaped parts in enterprises.

### **Issues in the processing of special shaped parts**

(1) Poor safety. The most important safety problem in the process of wood furniture processing is the damage of machinery and equipment [2]. In the process of machining special shaped parts, we must rely on high-speed cutting motion of machine tools to get ideal shape and better surface quality, as shown in Figure. 2. Therefore, the use of traditional machine tools and process on the special parts processing extremely easy to cause high-speed mechanical damage.

(2) Low efficiency and quality. During traditional special shaped parts processing, workers tend to first draw on the timber some approximate line drawings, and then milling according to the line drawings. As the process is in proportion to manual lofting, there will be some errors during scribing, milling, sanding and other processes, resulting in the differences between different individuals of same parts, which will cause low quality and accuracy. In particular, new special shaped parts needs new mold design. Therefore, workers need a process from adaptation to familiarization during milling.

(3) Serious environmental pollution. In the processing of shaped furniture parts, environmental pollution is the most serious problem in all machining processes [3]. Due to the continuous production of wood waste and dust of different sizes such as shavings and sawdust in the process of processing, it is extremely likely to cause fire and environmental hazards and affect workers' respiratory system.

(4) Difficult to manage. As a result of ordinary woodworking machinery and equipment for processing of shaped parts, mold is an essential auxiliary processing equipment. When the number of molds and sample molds reaches a certain level, it will bring difficulties to management, use and maintenance. The more molds, the harder it is to manage the molds, as shown in Figure. 3.

### **Structural optimization of special shaped parts**

#### **Purposes and principles of special shaped parts structural optimization**

The purpose of structural optimization of special shaped parts is to simplify and sort out complex structures as much as possible to the standardized shapes during the design of special shaped parts for wooden furniture enterprises so as to reduce various kinds of problems easily appearing in the processing of special shaped parts.

The principle of structural optimization of irregular parts is that it is convenient for processing equipment selection and maximally increasing production efficiency and processing safety under the premise of meeting user's requirements and functions.

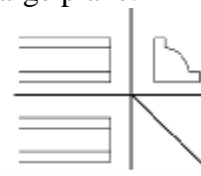
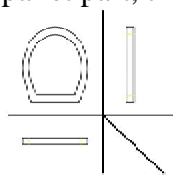
#### **Classification and optimization results of solid wood special shaped parts**

According to the appearance and structure characteristics of the parts, the structure of the special-shaped parts is optimized to the following three categories

(1) One view containing non-circular curvilinear form. According to the different structure, one view contains non-circular curvilinear form can be divided into the following types:

1) planar special shaped parts

The planar special-shaped part is that there is only one view containing non-circular curvilinear, and the area with a non-circular curve is larger or the largest. Its outer contour is approximately rectangular or circular, while the other two views are basically rectangular [4], as shown in Figure. 4. Figure. 4 shows the surface of a pallet part, that is, the outer contour of the large plane.

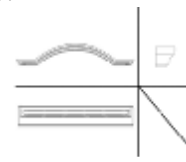


**Figure 4.** Planar special shaped parts.

**Figure 5.** Line shaped parts.

2) Line shaped parts: Line shaped parts refers to the parts with only one basic view, which contains non-circular curvilinear, and the area of the view is the smallest. The other two views are rectangular, which is straight in the vertical direction, as shown in Figure. 5.

3) Planar curve shaped parts: Planar curve shaped parts refer to parts, which are curved in the longitudinal direction, and cross section is a regular pattern, such as a rectangle or a circle [3], as shown in Figure. 6. The parts are more complex in the processing technology. The maximum utilization of wood can be achieved by using a piece of wood at the same time.



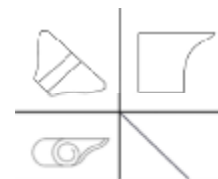
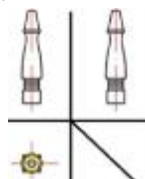
**Figure 6.** Planar curve shaped parts.

**Figure 7.** Bending shaped parts.

(2) Two views containing non-circular curvilinear form. According to the different structure, two views contain non-circular curvilinear form can be divided into the following types:

1) Bending shaped parts: Bending shaped parts refers to parts which present different curved lines in two directions. The frame and moldings of beds and cabinets are the typical curved special-shaped parts, which is shown in Fig 7.

2) Axisymmetric special shaped parts: Axisymmetric special shaped parts refer to parts with two views containing non-circular curvilinear, and two adjacent views are axisymmetric. It is worth noting that each section of a rotary part is round, which is a special axisymmetric special shaped part as shown in Figure. 8.



**Figure 8.** Rotary parts.

**Figure 9.** Space shaped parts.

(3) Three views containing non-circular curvilinear form. According to the different structure, two views contain non-circular curvilinear form can be divided into the following types: In general, the parts of this type are complex shapes made up of flat and curved surfaces or only curved surfaces [4]. The parts are also called space shaped parts, including engraving pattern, as shown in Figure. 9. They are often used as the foot of furniture, such as cabriole legs and S-shaped legs.

## Production process optimization of solid wood furniture special shaped parts

### Solid wood furniture manufacturing process

Solid wood furniture is made of solid wood as the main raw material. Its furniture is loved by consumers because of its warm texture, strong quality and natural color [5, 6]. Because of the emergence of numerical control technology and automatic milling technology, the machining of

complex parts is mostly processed by numerical control equipment [7]. The tool path is automatically generated and all parameters are adjusted. The process is shown as process 4 in Table 1.

**Table 1.** Specific process flow of different types of special shaped parts.

[Name]	[Type of parts]	[Technological process]
[Process 1]	[Planar curve shaped parts]	[Material customization -> Ripping -> Transverse -> Surface polishing -> Panel Solidification -> Line drawing based on mold -> Curve sawing with band-sawing machine -> Copying milling with vertical wood milling machine]
[Process 2]	[Rotary parts]	[Material customization -> Ripping -> Transverse -> Surface polishing -> 1st time board splicing (width determination) -> Thicknessing -> 2nd time board splicing (thickness determination) -> Four side planning -> Precision cutting -> Draw line to fix point -> NC woodworking machine tool turning]
[Process 3]	[Space shaped parts (Manual)]	[Material customization -> Ripping -> Transverse -> Surface polishing -> Panel Solidification -> Line drawing based on mold -> Curve sawing with band-sawing machine -> Copying milling with vertical wood milling machine -> Model drawing -> Sawing the outline with jig saw -> Hand engraving]
[Process 4]	[Space shaped parts (NC)]	[Hand engraving -> Sample scanning -> Modeling graphics generation -> Turning into cutter path -> rough carving, -> delicate carving]

## Conclusions

Our research results can provide reference for modular design, production and equipment selection of irregular parts, forming standardized processing technology, reducing waste time due to process chaos, and improving production efficiency under the condition of guaranteeing the lowest processing cost.

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