Development of Parametric Drawing System of Corrugated Boxes Based on SolidWorks

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Abstract. Corrugated box is a widely used means of transportation packaging, there are various box types such as slotted type, nested type, folding type, slide type, fixing type, automatic type and other types of boxes, special standards on the type and size of corrugated box is formulated by Chinese national standards. However, when drawing corrugated boxes with various CAD software now, we need to model and edit according to the box shape, specific size of corrugated boxes and the drawing efficiency is low. In this paper, on the basis of the established corrugated box access database, we use the Visual Basic to develop corrugated box parametric drawing system on SolidWorks platform. The users only need to select the desired corrugated box carton and the key parameters, then can get the 2D expansion diagrams and 3D stereoscopic diagrams in accordance with the national standard, which significantly improve the efficiency of the corrugated box drawing.

1. Introduction

With the rapid development of e-commerce in China in recent years, the prosperity of the corrugated box industry has been promoted rapidly. Corrugated cardboard boxes have become one of the most widely used transportation packaging because of their unique advantages in product protection, landscaping, transportation, storage, and environmental protection. However, in the process of corrugated box designing and modeling currently, drafters generally need to query the relevant national standards firstly, and then execute the relevant modeling tools step-by-step, and once a parameter is entered incorrectly, the entire model will be wrong. The author uses the Visual Basic language to develop the national standard corrugated box parametric drawing system on SolidWorks software, which is widely used in 3D solid modeling. Users only need to call the system to select the required corrugated box type and main parameters, then can quickly obtain 2D expansion diagrams and 3D stereoscopic diagrams of the corrugated box generated by the system automatically, which greatly improves the drawing efficiency and accuracy.
2. Corrugated box types and national standards

Special provisions for the box code and structural characteristics of corrugated cardboard boxes has been made by China's national standard GB / T 6543-2008 "Single corrugated cardboard boxes and double corrugated cardboard boxes for transport packaging", as shown in Table 1 [1]. The maximum mass, maximum comprehensive size, and cardboard model of the contents of the corrugated cardboard box is specified by GB / T6544-2008 "Corrugated Cardboard", as shown in Table 2, where the comprehensive size refers to the length, width, and height of the corrugated box in sum, the ratio of length to width of corrugated boxes is generally not greater than 2.5: 1, and the ratio of height to width is generally not greater than 2: 1, not less than 0.15: 1 [2].

Table 1. Carton box type classification numbers and their structural characteristics

| Classification No. | Box No. | Structural features |
|--------------------|---------|---------------------|
| 02                 | 0201    | Slotted box         |
|                    |         | It consists of a piece of cardboard, sealed with glue tape, or bonded with adhesive. |
| 03                 | 0310    | Nested box          |
|                    |         | It is composed of multiple pieces of cardboard and consists of a canopy and a separate bottom. The canopy covers the box. |
| 04                 | 0422    | Folding box         |
|                    |         | Commonly known as a tray, formed from a sheet of cardboard, which does not require nailing or tape bonding, and can be formed as long as it is folded |
| 05                 | 0510    | Slide-type box      |
|                    |         | It consists of several kinds of sliding box covers, which can be put together in different directions. |
| 06                 | 0605    | Fixed box           |
|                    |         | It consists of a main box body and two separated end faces; the sealing method is box nailing or similar sealing. |
| 07                 | 0712    | Automatic box       |
|                    |         | It is composed of a piece of cardboard and can be flattened. It can be used after simple combination. |
| 09                 | 0901    | Linings             |
|                    |         | Lined to improve the reliability and strength of the package. |

Table 2. Corrugated box size specifications

| Kinds              | Maximum mass of contents/kg | Maximum comprehensive size/mm | Class 1 Box code | Cardboard code |
|--------------------|-----------------------------|-------------------------------|------------------|----------------|
| Single corrugated box | 5                           | 700                           | BS-1.1           | S-1.1          | BS-2.1         | S-2.1          |
|                    | 10                          | 1000                          | BS-1.2           | S-1.2          | BS-2.2         | S-2.2          |
|                    | 20                          | 1400                          | BS-1.3           | S-1.3          | BS-2.3         | S-2.3          |
|                    | 30                          | 1750                          | BS-1.4           | S-1.4          | BS-2.4         | S-2.4          |
|                    | 40                          | 2000                          | BS-1.5           | S-1.5          | BS-2.5         | S-2.5          |
| Double corrugated box | 15                          | 1000                          | BD-1.1           | D-1.1          | BD-2.1         | D-2.1          |
|                    | 20                          | 1400                          | BD-1.2           | D-1.2          | BD-2.2         | D-2.2          |
|                    | 30                          | 1750                          | BD-1.3           | D-1.3          | BD-2.3         | D-2.3          |
|                    | 40                          | 2000                          | BD-1.4           | D-1.4          | BD-2.4         | D-2.4          |
|                    | 55                          | 2500                          | BD-1.5           | D-1.5          | BD-2.5         | D-2.5          |

3. Development tools for parametric drawing systems

3.1. SolidWorks software and its secondary development technology

With its powerful 3D design capabilities, SolidWorks has been used more and more widely. In order to improve market competitiveness, companies have developed functions for SolidWorks that meet their special requirements. The parametric modeling function based on feature selection provides a good development environment for developers.

SolidWorks provides rich API functions for secondary development. Any programming language that supports linking and embedding of objects and component object models can be used as a
SolidWorks development tool\cite{3}. Users can not only directly access SolidWorks, but also interact with it by using a high-level programming language, and call events, methods, properties, and related functions in SolidWorks through the SolidWorks API to create personalized SolidWorks functional modules personally. These special modules can either be linked to the SolidWorks menu by generating DLL files as plug-ins, or placed in the user-developed toolbar, or used independently of SolidWorks. So that people can carry out secondary development and design of SolidWorks better \cite{4}.

### 3.2 Visual Basic development language

Visual Basic is one of the most commonly used high-level programming languages. Because the environment for the macro recording function provided by SolidWorks is a VBA environment, which is consistent with Visual Basic syntax rules, Visual Basic is more suitable as a secondary development tool for SolidWorks. In addition, Visual Basic can access various database systems such as Access and FoxPro, as well as various tables such as Excel and Lotus. In SolidWorks, it can also realize the combination of solid modeling and two-dimensional drawing. This kind of data is used to edit the program, so that the programmer can develop the corresponding application software according to the special needs of users.

### 4. Basic process and concrete steps of corrugated box parametric drawing system development

According to the box type and size of the corrugated box in the national standard, use Visual Basic to establish a Microsoft Access database and import the database into the main drawing program, and then develop the corrugated box parametric drawing system based on SolidWorks. The overall development process can be summarized as shown in Figure 1.

![Figure 1. Basic flowchart of the development of a parametric drawing system for corrugated boxes](image-url)
⑴ Firstly analyze the structure, drawing and modeling process of various corrugated cardboard box types and national standards, determine the main parameters for drawing the two-dimensional expanded view and three-dimensional figure of corrugated cardboard boxes. Width, height and corrugated paper thickness.

⑵ Create a sample file of each corrugated box type in SolidWorks, record macro commands for the modeling process of the sample corrugated box so that Visual Basic and SolidWorks can call each other. As shown in Figure 2, select the SolidWorks 2010 Type Library to add to the reference so that Visual Basic calls the API in SolidWorks.

![Figure 2. Object Library that references SolidWorks](image)

⑶ Establish a database based on the box type and size of the corrugated box in the national standard. The secondary development of the corrugated box used Microsoft Access database, which provides a universal database access interface and database access object. In the VB environment, VB applications implement database programming by referencing the ADO type library or by using ADO controls. The schematic diagram of the database programming technology is shown in Figure 3 [5] [6].

![Figure 3. Database programming technology principle block diagram](image)

⑷ Design and establish a human-computer interaction window for the corrugated box drawing system. The author takes three commonly used slotted, boxed, and folded box types as examples. The main interface for human-computer interaction design is shown in Figure 4. Select the interface on this interface. After the box type is required, you can enter the sub-interface of developing each box type according to the selected box type. The author takes folding corrugated boxes as an example. As shown in Figure 5, you can select a box structure on this interface and enter the development interface of the box structure. In the development interface, you can either enter the length, width, height, and
thickness of the corrugated paper to generate a two-dimensional expanded view and a three-dimensional perspective of a specific box structure, or you can select one of the length, width, or height and then find the connected Access The database is used to determine the size of the remaining dimensions, so as to quickly and efficiently draw the unfolded and three-dimensional views of the desired corrugated box. The author takes the second development process of the folding corrugated box 0420 as an example, as shown in Figure 6.

**Figure 4.** The main interface of the corrugated box parametric drawing system

**Figure 5.** Box type structure of folding corrugated box
(5) The editing program defines the values of the variables needed for the secondary development of the corrugated box and links to the database, and assigns the relevant values entered by the user to these variables when drawing.

(6) Run and debug the program. After the debug program is successful, select the required initial interface in the startup object in the project properties, as shown in Figure 7. Finally, the required .exe file is generated to complete the development of the parametric drawing system.

5. Conclusion

In view of the shortcomings of current 3D modeling software in corrugated box modeling and mapping, a corrugated box Access database is established according to national standards and a corrugated box parametric drawing system is developed based on the SolidWorks software platform in this article. Users only need to interact with it by selecting the required box type and key parameters in the interface, they can obtain the two-dimensional expanded view and three-dimensional view of the
corrugated box in accordance with national standards, which significantly improves the efficiency of modeling and drawing of the corrugated box. It is practical and has a good reference for the modeling and custom development of other products on the SolidWorks platform.

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