Packing Design and Application Based on VR Technology

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Abstract: Improving the adaptability of packing box and packing materials is the main target of packaging. Introduction of VR technology to packaging design could reach the virtual reality modeling language, so it is convenient for the calculation of inner space of packaging to enhance the comfort of packaging. Or the outer size of packaging could be calculated according to the interaction of inner space and outer space for the convenience of appearance design to enhance artistry. The main method is as follow. Firstly, build up model with 3Dax software; secondly, the structure, node and outer packaging size of virtual space through VRML; thirdly, a link is generated through system to have a 3D printing of the filling modeling of inner space. The picture of outer packaging and commodity information are set with the combination of inner data of the packaging; and then the virtual appearance of packaging would be generated through VR technology light and rendering, so as to gain the final result of the packaging design. It could be confirmed according to the experimental analysis data, the packaging compactness would be 37% increased and the compression resistance ratio is also 29% increased through the 3D VR packaging design. It is proved that the packaging effectively improve the seismic performance of products. The application of the virtual outer packaging design of product also sufficiently proves the important use value of the method.

1. INTRODUCTION
Packaging design is one of common designs in the modern society. Excellent packaging has direct relationship with the acceleration of social development and the improvement of commercial activity. Meanwhile, packaging is also an art. Along with the market refining, packaging design also needs correspondent design positioning to improve the product competitiveness. Along with the development of society, the saying that technology means productivity has been proved and recognized by all industries, and the entry of digitalized information to packaging design is a huge trend. The VR virtual technology has been a highlight of packaging design.

VR is a computer graphics, models and visual, auditory, tactile and other perceptual integration of immersion information experience. Especially, there is authenticity and artistry in texture design technology, texture mapping and material processing technology. The application to packaging design of product could improve the adaptability, compactness and compression resistance of packaging from the inner and it would be good for the transport and storage of products. For the outer, the packaging design scheme could be quickly determined through graphics and packaging structure.
settings, 3D rendering, visual contrast. A structure picture could be generated in virtual space, and it could be applied to the packaging structure of real products, so it could be so convenient for saving vast of work of packaging design. It is suggested with packaging engineering design method of virtual reality modeling language of packaging based on VR technology; besides, the operability of the method would be achieved through the application study.

2. DESIGN METHOD of VRML

Process of Product Packaging

The design method of virtual reality modeling language is introduced to packaging design, and there would be understanding on the main process of packaging design. All works and missions in all stages of packaging design could be seen from the figure 1, packaging design workflow. The first stage is to mobilize design mission, including defining packaging size, material and making packaging engineering picture. Stage two is to make the sample of packaging. Stage three is the packaging test. Stage four is the final scheme of packaging and release of engineering diagram. The presentation of the four stages shows a starting point for the beginning of packaging design method of virtual exchange space.

![Figure 1. Packaging Design Workflow](image)

2.1 Algorithm of Products’ Internal Spatial Data

It is divided into the inner packaging and outer packaging. Outer packaging puts emphasis on the visual effect and product performance presentation; while inner packaging focuses on the internal adaptability, stable and strong packaging, and it should be considered from compactness and compression resistance. Inner packaging is the crux and the spatial structure of inner space structure should be calculated with core technology to provide correct data for the outer packaging. The extraction of the adaptability data of the inner space material of packaging is in need of vast of detection and some of them are difficulty, such as thermal data, flow data, temperature difference and specific heat capacity data, etc. The inadaptability of packaging structure is formed by the accumulative deviation caused by the complexity of these data. The computer application VR technology could generate a space turbulence module in virtual space. Gaining the correspondent inner packaging structure data of the current industrial products with the module could reduce measurement cost and improve the data accuracy at the same time.

According to the needs of measuring the inner spatial data of packaging products, the inner space of the packaging could be measured with the help of mass conservation, momentum conservation and energy conservation. The specific calculation method is shown as the table 1: Algorithm of Inner Spatial Data.

| Name            | Formula                                    | Meaning                                                                 | Description                                                                 |
|-----------------|--------------------------------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Mass Conservation | \[ \frac{\partial \rho}{\partial t} + \nabla \cdot (\rho u) = S_m \] | In unit time, the actual difference between the fluid quality and the control panel quality in the sealed packaging space. | Sm is the space mass of the primary dispersion and secondary connection of the internal fluid; \( \rho \) is the density of the fluid; \( t \) is the packing fluid control time. |
| Momentum Conservation | \[ \delta F = \delta m \frac{dv}{dt} \] | The change of time and space inside the packaging when it is squeezed outside. | \( \delta F \) is the actual variable of the fluid in the packaging and \( \delta m \) is the guarantee of fluid quality. |
### Energy Conservation

| Energy Conservation | The heat transfer effect of packaging during transportation. | $\alpha$, $x$, $y$, $z$ represent different energy fluctuations, $\lambda$ is the collision source generated by the packaging structure. $pc$ is the viscous dissipation energy |
|---------------------|-------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| $\frac{\partial t}{\partial l} + u \frac{\partial t}{\partial x} + v \frac{\partial t}{\partial y} + w \frac{\partial t}{\partial z} = \frac{\lambda}{pc} \left( \frac{\partial^2 t}{\partial x^2} + \frac{\partial^2 t}{\partial y^2} + \frac{\partial^2 t}{\partial z^2} \right)$ | $\frac{\partial t}{\partial l} + u \frac{\partial t}{\partial x} + v \frac{\partial t}{\partial y} + w \frac{\partial t}{\partial z} = \frac{\lambda}{pc} \left( \frac{\partial^2 t}{\partial x^2} + \frac{\partial^2 t}{\partial y^2} + \frac{\partial^2 t}{\partial z^2} \right)$ | $\frac{\partial t}{\partial l} + u \frac{\partial t}{\partial x} + v \frac{\partial t}{\partial y} + w \frac{\partial t}{\partial z} = \frac{\lambda}{pc} \left( \frac{\partial^2 t}{\partial x^2} + \frac{\partial^2 t}{\partial y^2} + \frac{\partial^2 t}{\partial z^2} \right)$ |

A natural fluid model built by the virtual reality (VR) technology and the three formulas could calculate the data parameter of the packaging structure. In the transportation, there would be mutual impact of the medium between packaging and products, so as to form the exchange and transform among function. These impacts could confirm the transform operation of actual performance according to the current VR picture, such as speed, temperature, pressure, etc. According to the data of performance exchange, the unknowns of structural data of packaging modules for industrial products could be controlled and confirmed with VR space exchange control calculation equation, so as to provide foundation for the following actual packaging.

### 2.2 Virtual Appearance Design

The augmented reality (AR) technology means to add some real data of packaging in a virtual environment to reach the combination of virtuality and reality. Through the building of virtual scenery and VR and the setting of various dynamic shooting, it gains the seamless image linking to achieve the data interaction of three-dimensional data. The working system is shown as figure 2. The virtual effect of AR and VR is achieved by three-dimensional modeling, model optimization, material baking.

![Figure 2. AR/VR Working System Picture](image)

In view of it, the virtual reality modeling language (VRML) of packaging could generate the virtual appearance of packaging with the support of internal turbulence data.

In virtual reality modeling language (VRML), all description of external scene and virtual unit of each structure are called as virtual nodes. The structure of multi-line undertaking relationship could be generated when all virtual nodes are covered and linked to ensure the data density. The sample is shown as the figure 3.

![Figure 3. ARML Holding Sample](image)

According to the description of the structure relationship of ARML in the figure 3, it could be applied to multiple different actual coordinate system node. Multiple models could be generated through various node control, which means to realize the virtual appearance design of three-dimensional space. Hence, the control of structure nodes of ARML is the key of the 3D virtual space design. However, for the spatial structure design of outer packaging, the single use of the nodes...
mentioned above would be far to satisfy the demand of the outer packaging appearance of product and it is necessary to have a setting of complex surface nodes with the principle of VR and AR. According to different intersection of appearance, the different extrusion proportion of corresponding path are set by sections to gain the outer packaging model in the end.

According to the previous theories, the design method of virtual reality modeling language (VRML) could carry out service in the four stages of packaging design. It could gain the inner spatial data during the drafting stage; or it could help to determine the scheme through VR visualized comparison. It could also reach the comfort by adjusting nodes. Hence, it could pass the collision detection and the release of engineering diagram smoothly.

3. ANALYSIS of EXPERIMENTAL DATA
There are many kinds of activities such as loading and unloading, transportation, storage, carrying and so on during the transportation process of products in various regions, and the products would collide in all activities. Hence, the compactness and compression resistance ratio of the packaging should be the first index of the seismic resistance, and they should be the important consideration of design to think about the way to enhance the compactness and to achieve a good effect of seismic resistance of the packaging. The effect of seismic resistance of packaging transport could be achieved through designing and making diversified simulation experiment. To show the directness of the test effect, a traditional packaging is selected to have comparison.

3.1 Experiment and Analysis of Compactness
The compactness of packaging means the degree of full contact between the substance in the empty part of the packaging and the product itself. The compactness would be better when the contact is closer. Just as people lie in soft mattress and hard board bed, the compactness of soft mattress is higher than that of hard bed, and sleep is more comfortable, shown in the figure 4 sleep compactness.

![Figure 4. Sleep Compactness](image)

Compactness contrast experiment: Five groups of samples with different packaging are randomly selected for compactness evaluation. In the figure 5, the upper side is the compactness of VRML while the down side is the compactness without VRML. It could be easily found in the data comparison in the picture that the compactness of VRML packaging is higher than that of packaging without VRML and it is more than 37% increased. The reason is that VRML is adopted with a virtual model to design the inner structure space of the current packaging with natural fluid parameters, so as to eliminate the “loose” space of the inner part and the packing material and the filling material fit closely to increase the mutual compactness.
3.2 Experiment and Analysis of Compression Resistance Ratio

The shock absorption effect of the packaging is mainly determined by the compression resistance of inner packaging. Compression resistance means the compressive strength of objects, and the compression resistance ratio is a ratio of the compressive strength of the benchmark block to the compressive strength of the test block, which is the core parameter of the compression resistance detection. To improve the correctness of experiment, 10 groups of packaging are extracted in the experiment to take different experiments of compression resistance. The pressure value is random and the extraction result is shown as table 2.

Table 2. Comparison of Compression Resistance Ratio

| Experiment Number | Traditional Packaging | ARML  |
|-------------------|-----------------------|-------|
| 1                 | 0.16                  | 0.232 |
| 2                 | 0.12                  | 0.30  |
| 3                 | 0.20                  | 0.22  |
| 4                 | 0.51                  | 0.75  |
| 5                 | 0.34                  | 0.49  |
| 6                 | 0.31                  | 0.45  |
| 7                 | 0.41                  | 0.56  |
| 8                 | 0.32                  | 0.42  |
| 9                 | 0.12                  | 0.20  |
| 10                | 0.19                  | 0.24  |

The 10 groups of compression resistance ratio in the table 3 means that the application of ARML packaging method could increase the ratio to be 29%, which could prove the higher shock absorption efficiency again.

3.3 Experiment and Analysis of Adaptability

Packaging is divided into the inner packaging and outer packaging. There would be higher adaptability and less collision and damage in carrying, transportation, storage and so on if the compactness between the inner space and packing filler is higher. Hence, it is very necessary to have experiment of adaptability. In the experiment, 5 testing samples are randomly selected to have a test of adaptability from various packaging samples. All of them are put in the packaging with VRML and the packaging with ARML, and then there would be collision with the same force. Then, there would be observation of the damage of the samples to inspect the seismic effect of different packaging for products. The damage of samples is shown in picture 6.
Figure 6. Comparison of Samples Damage

Seen from figure 6, it could be found that there is certain improvement in the compression resistance ratio and compactness of the packaging with VRML compared with traditional packaging method. It could be found from test that the packaging with VRML could minimize the damage degree of samples, which further proves the better seismic performance of the method mentioned in the paper.

4. APPEARANCE APPLICATION of VR PACKAGING BASED on 3DMax

Take the packaging design of honeysuckle tea bag for example. The module is built with 3DMax. The total height of the cylindrical model is 277mm and the diameter is 85mm. The outer packaging picture is processed with PHOTOSP as a mapping material, and then the mapping and material are customized and the VR light is set as dynamic path of 360o soft camera. The details of the packaging could be displayed comprehensively through the VR rendering to reach the virtual and visible effect of digital information.

4.1 Mapping Preparation

The packaging information of product is designed in the same picture with graphic design software PS / AI. The cover of outer packaging should be included with product name, product information, company information, decoration picture and specification. The finished graphic packaging design drawing in the figure 8 is gained from the decorative pattern line draft in figure 7 and the relationship of product.
4.2 Building and Optimization of Packaging Box
Firstly, a 3DMax software is used to carry out the 3D modeling according to the packaging size in the figure 9. The height of the model is 177MM and the diameter is 85MM. The height of lid is 30MM and the diameter is 85MM. Then, the style of the cover lid is adjusted to be the height of 27cm and the diameter of 80cm. The view of the built model is shown in figure10, which is a model without material.

4.2.1 Adjustment of Inner Nodes
The thickness of the packaging corrugated paper is adjusted to enhance the seismic performance; the inner wall diameter of the lid is 80cm to strengthen the compactness. The edge of packaging box is covered with semi-circle to reduce the abrasion and optimize the details.

4.2.2 Mapping and Light Rendering
Put the designed picture 8 into the material implement of 3DMax for edition. The UVW mapping coordinate is set in the map axis, so that it could be realer in the virtual scenery, shown as figure 11 and 12.

4.3 Finalized and Release
The final virtual effect is shown in figure 13. The final drawing and construction diagram would be sent to customer’s company and relevant departments through 3DMax system.

5. CONCLUSION
The seismic performance is one important parameter of the quality of product packaging; meanwhile, the artistic aesthetics of packaging appearance is also one of crucial factors to determine the sales of product. The two parties could be well combined with VR technology, so that the packaging could be more in line with aesthetic feeling and more scientific and technological sense. The VR technology is introduced in the experiment to generate a virtual space, and then there would be a reasonable design of the inner and outer packaging; the data is corrected to complete the packaging design of product. It is stated from experimental data that the design method of the packaging could effectively improve the seismic performance and there is significant strength.

References
[1] Xie Qiong. Research on Innovative Design of Modern Brand Packaging Based on AR Technology [J]. Packaging Engineering, 2017, 38 (2): 60-63.
[2] Shao Fei. Research on Packaging Design Based on VR [J] Automation and Instrumentation, 2018.01:70-72.
[3] Xu Weimin, Wang Shaomei, You Rong. Application of Virtual Reality in Packaging Design [J]. Journal of Wuhan Institute of Technology, 2002 (01): 64-66.
[4] Chen Yao. Design of Qiannan Agricultural Specialty Packaging Design under the Dual View of “Internet+” and “National Culture” [J] Design, 2019 (19): 51-53.
[5] Xu Shiyao. VR Technology in Graphic Design Application Exploration [J] Art Education. 2019 (08): 177-178.
[6] Shangguan Liwan. Teaching Exploration of Product Packaging Design Course Based on Virtual Reality Technology [J] Appreciation. 2018 (27): 271-272.
[7] Li Yaoliang. Research on Industrial Product Packaging Engineering Design Based on VR and AR Technology [J]. Automation and Instrumentation, 2020.02:189-192.