Restoration and Reuse Design of Industrial Heritage based on Virtual Reality Technology

Chen Jue1 and Wang Chen2,*

1School of Arts and Design, Guangdong University of Finance & Economics, No. 21, Luntou Road, Haizhu District, Guangzhou, Guangdong Province, China
2School of Design, South China University of Technology, University Town, Panyu District, Guangzhou, Guangdong Province, China

*E-mail: 20181032@gdufe.edu.cn

Abstract. Based on the practical work of revitalizing the old industrial heritage of Zhengzhou No.2 Abrasive Wheel Factory, the method and technical feasibility of the restoration and reuse design of industrial heritage based on virtual reality technology are discussed in the paper. The research is based on MARS virtual reality technology platform, which is compatible with traditional modeling software, such as SKETCHUP and 3D MAX, and can directly use related software for modeling and import, reduce repetitive work and greatly shorten working time. In addition, the platform has good post-scene simulation function and is suitable for restoration and creative conceptual design in complex environment. The paper is divided into three parts. The first part is a brief introduction of the project background and task. The second part discusses the virtual reality technology solution proposed according to the project needs, and further analyzes the implementation process and technical characteristics of the solution. The final part evaluates the role of virtual reality technology in the restoration and reuse design of industrial heritage, so as to provide some inspiration for relevant designs.

1. Introduction
The project base of Zhengzhou No.2 Abrasive Wheel Factory is located in the former No.2 Abrasive Wheel Factory in the west of Huashan Road and South of Zhongyuan Road, Zhongyuan District, Zhengzhou City, with a total area of about 0.56km2. Built in 1953 with the aid of the Democratic Republic of Germany, it was the largest Abrasive Wheel Factory in China. The project is close to Zhongyuan Road, the main axis of the east-west development of Zhengzhou, and close to the west third ring road, enjoying good surrounding business atmosphere, perfect supporting facilities, and good accessibility, key development location toward west, as well as good development potential. The base is rich in industrial heritage and historical resources, and has a high degree of scarcity and historical and cultural significance. There are seven cultural relics buildings in the factory, which are listed as city level, namely, Ceramic Abrasive Wheel Manufacturing Workshop, Emery Sand Warehouse and Binder Treatment Workshop, Refractory Materials and Binder Processing Workshop, Spare Parts Tools and Lubricating Oil Warehouse, Abrasive Wheel Finished Products Warehouse and Delivery Room, Rubber Abrasive Wheel Manufacturing Workshop and Factory Office Building. Among them, the Rubber Abrasive Wheel Manufacturing Workshop is a single-storey workshop with a construction area of about 3,000m2 (100m long and 30m wide) (Figure 1). It is made of reinforced concrete roof frame, and has
large clearance at the bottom, high artistic value, reuse value, and excellent potential to transform and reuse industrial heritage buildings.

2. Project analysis

2.1. Tasks
The project aims to restore the original appearance of the former industrial heritage buildings, focus on the city and industry of Zhengzhou, find the core driving force of the project development, create a multi-functional compound place with diverse needs of people, and form a cultural and creative industrial base with the continuous vitality of the whole life cycle combining functions and prominent driving force.

2.2. Design Scope and Technical Indicators
The design scope of this case is the remains of original equipment in and around the Rubber Abrasive Wheel Manufacturing Workshop. The building structure is well preserved. As the second largest building in the construction park, it is 9.5m in height, 35.4m in length from north to south, and 105m in length from east to west. Due to its huge volume, we hope to take this case as an experimental project and copy its experience after its success, so as to prepare for the overall design.

2.3. Guiding Thought and Design Principles
The case aims to retain the primitive historical sense of the original factory building, restore the original appearance of its cultural relics building, integrate the internal and external resources of the project, and make full use of the transportation convenience, make good use of the external environment, and improve the cultural quality. The design style is inclined to modern fashion, but peculiar exaggerated shape is not advocated so as to moderately control cost.
2.4. Difficulties in the Design
The main problems encountered in the design mainly include the technical restrictions on the restoration of the original building appearance and the protection of industrial heritage buildings and cultural relics, as well as the feasibility study on the implantation of new space functions.

2.4.1 Technical Requirements for the Restoration of Industrial Heritage. Since the project has been updated and changed in the course of its use, it is now necessary to restore its original shape and structure based on the information. The comparison of surface shape and original shape of each part is shown in the following table 1:

| Part       | The Status Quo                                      | The Original Shape and Structure                      |
|------------|-----------------------------------------------------|------------------------------------------------------|
| Skylight   | Upper skylight is loose, ventilated, polluted and broken | The same to the status quo                           |
| Facade     | Rot, deformation and broken glass is common         | Wooden western-style window, and glass is installed inside the window |
| Roof       | Aging, leakage and other phenomena                  | The same to the status quo                           |
| Doorway    | North facade: specification of 1#, 2#, 3# and 4# is 1500x2000; specification of 5# is 2500x3200; South facade: specification of 6# is 1000x2200; specification of 7# and 8# is 2500x3000; West facade: specification of 9# is 2000x2600. The current situation is all iron doors; | North facade: specification of 1#, 2#, 3# 4#, and 5# is 1500x2000; South facade: no doorway for 6#; specification of 7# and 8# is 2500x3000; West facade: specification of 9# is 1000x2000. The reasons for the discrepancy between the present situation and the original shape and system are all transformation by later generations. The original doorway is made of iron. |

2.4.2 Implantation of New Space Functions. According to the general design policy of the creative base, it is necessary to put the show function (show, assembly, exhibition and other functions of large flow of people) into the building. The following problems should be considered: a. The number and width of door openings in the original shape system do not meet the evacuation requirements of large flow of people, and the demand for access channels of large equipment. b. Therefore, according to the evacuation needs of the crowd and the actual use needs, combined with the existing outer eaves door
size, it is advisable to completely retain the size of the door and combine with the overall effect, try to make use of the current situation of the door, and appropriately add door holes. c. Before meeting the premise of safety and use, it is necessary to respect history as much as possible, refer to the facade style of original door leaf, and make and install according to the size of hole, but ensure that the facade effect of door leaf is in harmony with the original shape. d. The added equipment and pipes shall not be destructive to the original building structure and shall meet the recoverable principle, ensuing future demolition shall not affect the structure.

3. Virtual Reality Technology Solutions
One goal of virtual reality prototyping is the substitution of physical prototypes by using virtual models [1]. Two aspects need to be addressed:

• augmentation of physical prototypes with (interactive) virtual content
• virtual simulations of physical prototypes [2]

To solve the technical problems that restoration of industrial heritage complex construction environment and building reuse may involve, evaluation and validation are conducted. The virtual reality technology is introduced into the design. It is designed based on the MARS virtual reality researched and developed by “shining city”. The recovery and reuse design platform of industrial heritage based on virtual reality technology is compatible with commonly-used architectural design software such as SKETCHUP and 3Dmax, and can directly use the related software for modeling, reduce duplication of effort and shorten working hours. The design process is divided into three stages: (Table2)

• The first stage is to generate a 3D model by measuring the existing environment.
• The second stage is to restore the shape and structure of the original buildings and restore the original appearance of the heritage buildings based on the current 3D model.
• The third stage is to bring the status model into the scene design, and verify the possibility of reuse of the building by inserting roles and formulating functional ways. In the stage, the virtual reality technology plays an important role, which enables people not only to experience industrial heritage buildings after reduction through the roaming space, but also more vividly feel environment after transformation and utilization in the existing cultural relics under the premise of building construction and not influence. Besides, it can provide explanatory design scheme for decision makers to develop project development plans.

| Table 2. Three stages and different work contents |
| Stages | Contents |
|--------|---------|
| I      | Generate a 3D model by measuring the existing environment |
| II     | Restore the original appearance of the heritage buildings |
4. Technical Evaluation

VR also defined as three Dimensional (3D) graphical simulation models, where a user can control the viewpoints, motion and interact intuitively in real time.[3] Compared with 3Dmax, SketchUp and other commonly-used 3D simulation software, the most prominent feature of MARS virtual reality technology is the addition of 3D glasses and digital handlebars to realize 3D real-time graphics display and other functions. It has a good performance in immersion. Users can feel the space distance, speed, including sound distance and field characteristics in the 3D virtual environment created by computer.[4] In terms of interaction, MARS can real-time control and grasp objects through functional handles. However, due to constraints of hardware and network, it has weak interactive experience, cannot simulate the free grasping experience of virtual objects by human hands, nor accurately perceive the weight of objects. MARS provides certain possibilities on imagination. In the multi-dimensional information space of the virtual world, users can obtain more knowledge and feelings than traditional design methods by relying on their own perception ability, which plays a positive role in solving problems (Figure 2, Figure 3).

5. Conclusion

By adopting MARS virtual reality design system, the technical problems of old building restoration and new space function implantation and research are solved in the design of industrial heritage restoration and reuse of Zhengzhou No. 2 Abrasive Wheel Factory. VR technologies are a promising tool,[5] compared with the traditional 3D design software, MARS virtual reality technology has higher work efficiency, provides users with better immersion and imagination experience in the environmental rehabilitation experience. However, in terms of interaction, it is not essentially superior to the traditional design methods. Therefore, there is still a great space for technological breakthroughs and development.

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