Analysis of Stirling Engine Structure and Assembly Technology by Virtual Reality Technology

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Abstract. Virtual reality technology is a simulation technology that makes the display world more realistic with the help of computer technology. It is one of the hotspots of research and application in recent years, and its application field is very wide. Under this background, this paper introduces the concept and characteristics of virtual reality technology, and analyzes the structure and assembly process of Stirling engine by using three-dimensional parametric modeling software Unigraphics and virtual reality editor software VRP Builder.

1. Overview of Virtual Reality Technology
Virtual reality is to construct a vivid model in the computer. People can interact with this model and generate the same feedback information as in the real world, so that people can get the same feelings as in the real world.

Virtual reality technology is a comprehensive technology, focusing on computer technology, which comprehensively utilizes computer three-dimensional graphics technology, simulation technology, sensing technology, man-machine interface technology, display technology, servo technology, etc., to generate a realistic three-dimensional perception world such as vision, touch and smell. Therefore, users can browse and interact with the generated virtual world objective body from their own perspective, using their own functions and the assistance of some devices. Using computer-aided technology to construct the nonexistent environment, developing products rapidly in virtual environment, and applying to various research fields for system simulation. Virtual reality technology, together with theoretical analysis and scientific experiments, has become one of the important means for human beings to explore the laws of the objective world.

Here, by using virtual reality technology to analyze the principle, structure and function of Stirling engine, the part structure and assembly process function of Stirling engine in the actual production application environment can be simulated by means of virtual reality, which is convenient for the dynamic system simulation of the working process of Stirling engine under different conditions, at the same time, it can shorten the cycle and save the cost.

2. Overall architecture design of Stirling engine virtual reality simulation system
Stirling engine is a closed cycle reciprocating heat engine with external combustion, which was invented by R Stirling of Scotland in 1816. Compared with internal combustion engines, this engine has the advantages of high efficiency, low pollution and low noise, and can be used as a clean and efficient power machine in many fields, which is of great significance to energy conservation and emission
reduction and environmental protection. However, there is no way to understand the internal structure and assembly process of Stirling engine directly. Therefore, the virtual reality simulation system of Stirling engine can be used by developers in the field of application for the research and development of renewable new energy and energy conversion technology.

The virtual reality simulation system of Stirling engine is designed by using three-dimensional parametric modeling software Unigraphics and virtual reality editor software VRP Bulider.

Unigraphics software is the software developed by UGS Company in the United States, which is called UG software for short. It is a 3D parametric software integrating CAD/CAE/CAM, a high-end software for manufacturing industry, and one of the most popular industrial design software nowadays. It integrates the functions of conceptual design, engineering design, analysis and manufacturing, and realizes the combination of optimized design and product production process.

VRP Bulider software is a virtual reality software directly facing 3D artists. The internal parts structure and assembly process of Stirling engine can be analyzed by importing the model of 3D scene, post-editing, interactive production, special effects production, interface design, packaging and publishing. The virtual reality simulation system can be widely used in all kinds of hardware platforms. It can switch many browsing modes by controlling hotkeys, including walking, flying, still life observation, camera animation.

The overall design architecture of Stirling engine virtual reality simulation system firstly uses UG software to design and model each part structure of Stirling engine and create assembly relationship. Then, with the help of 3Ds Max, the parts model of Stirling engine is imported into VRP Bulider to design the scene, including two-dimensional index interface, adding panel and "Run" button, introducing Stirling engine and its parts, setting hot spots and actions, compiling and running programs. In the three-dimensional scene, the imported model is mapped with VRP Bulider's own material library, and the virtual scene is designed to add surrounding maps and vivid elements. Then the parts are dissected, and the animation process demonstration system is made according to the assembly process sequence. Create the process flow of disassembly and assembly of each part of Stirling engine, compile the running program, and generate EXE executable file.

3. Construction of Stirling engine mechanism model by UG

According to the dimension parameters and motion parameters of Stirling engine parts, UG 3D parametric design modeling software was used to create the parts model and construct a 3D three-dimensional model. After all the parts are created, assemble them and use the simulation function to achieve the effect.

3.1. Part structure modeling

The main parts structure includes (1) wheel disc (hot), as shown in Figure 1; (2) Connecting rod, as shown in Figure 2; (3) Piston rod, as shown in Figure 3; (4) Hot cylinder (containing heat absorption sheet), as shown in Figure 4; (5) Hot piston, as shown in Figure 5; (6) Combustion chamber, as shown in Figure 6; (7) Wheel disc (cold), as shown in Figure 7; (8) Cold piston, as shown in Figure 8; (10) Cold cylinder, as shown in Figure 9.
Figure 1. Wheel (Hot)

Figure 2. Connecting Rod

Figure 3. Piston Rod

Figure 4. Hot Cylinder

Figure 5. Hot Piston

Figure 6. Combustion Chamber
3.2. System assembly process
Using UG software, every part of Stirling engine is assembled according to requirements through constraints, and a virtual simulation assembly relationship is created. Generate explosion diagram as shown in figure 10 and figure 11:

According to the assembly relationship between various parts of Stirling engine, create a virtual assembly drawing as shown in Figure 12:
4. Analysis of Stirling Engine System by VRP Bulider

The assembly relationship and process of Stirling engine are made by using VRP Bulider virtual editor. The virtual assembly process flow is as follows: (1) Assembling wheel disc, as shown in Figure 13; (2) Assemble the connecting rod, as shown in Figure 14; (3) Assemble the piston rod, as shown in Figure 15; (4) Assemble hot cylinder (including heat absorption sheet), as shown in Figure 16; (5) Assemble the hot piston, as shown in Figure 17; (6) Assemble combustion chamber, as shown in Figure 18; (7) Assemble the cam, as shown in Figure 19; (8) Assemble the cold piston connecting rod, as shown in Figure 20; (9) Assemble the cold piston, as shown in Figure 21; (10) Assemble the cold cylinder, as shown in Figure 22.
5. Application of Stirling Engine System

Stirling engine is suitable for all kinds of energy sources, whether it is liquid, gaseous or solid fuel. When indirect heating is carried out by heat transfer system, almost any high temperature heat source can be used, such as solar radioisotope and nuclear reaction, etc., and the principle and structure of the engine itself need not be changed. Therefore, the analytical Stirling engine system can be used for further system research, so as to promote extensive research and attention in underwater power, solar power, space station power, heat pump air conditioning power, vehicle hybrid propulsion power, etc.
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References
[1] Ren Jie, Sun Surong. Application status and development trend of virtual reality technology in industrial design [C]. Industrial Design Branch of Chinese Mechanical Engineering Society. Proceedings of the 2007 International Conference on Industrial Design (Volume 1/2). China Industrial Design Branch of Mechanical Engineering Society: Chinese Mechanical Engineering Society, 2007: 449 - 453.
[2] Wen Junhui. Interactive Virtual Assembly Design Based on VRP [J]. Shandong Industrial Technology, 2016 (02): 26.
[3] Wang Jianhu, Chen Foliang, Di Xiaoxue. Design and development of desktop-level virtual reality courseware based on VRP-Build [J]. System Simulation Technology, 2017, 13(01): 69 - 73.
[4] Yang Wucheng, Ma Xiangyu, Sun Junru, Tan Chuanzhong. Research and analysis of virtual simulation experiment based on UG software [J]. Journal of Xi’an Aeronautical University, 2018, 36 (03): 45 - 49.
[5] Xia Liwen. Development and Application of Virtual Reality Technology [C]. China Computer Users Association Network Application Branch. China Computer Users Association Network Application Branch 2018 Proceedings of the 22nd Annual Network New Technology and Application Conference. China Computer User Association Network Application Branch: Beijing United University Key Laboratory of Information Service Engineering, 2018: 220 - 222.
[6] Amirhossein Bagheri, William C. Mullins, Phillip R. Foster, Huseyin Bostanci. Experimental characterization of an innovative low-temperature small-scale Rotary Displacer Stirling Engine [J]. Energy Conversion and Management, 2019, 201.
[7] Xiaotian Lai, Minjie Yu, Rui Long, Zhichun Liu, Wei Liu. Dynamic performance analysis and optimization of dish solar Stirling engine based on a modified theoretical model [J]. Energy, 2019, 183.
[8] Wang Weidong. Simulation analysis of virtual assembly based on UG engine [J]. Modern Manufacturing Technology and Equipment, 2019(05):28-29.
[9] Zhang Liang, Jin Yi, Liu Yuanxia, Niu Li. Overview of Virtual Reality (VR) Technology and Development Research [J]. Information and Computer (Theoretical Edition), 2019, 31(17): 126 - 128.
[10] Guo Xiaoyan. Application Research of UG Software in Mechanical Design [J]. Internal Combustion Engine and Accessories, 2020 (03): 219 - 220.
[11] Zhang Guangshu. Virtual reality technology and its application in mechanical design and manufacturing [J]. Science and Technology Innovation and Application, 2020 (18): 151 - 152.