Utilization of 3D VR (Virtual Reality) Technology for Product Development to Improve User Experience

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In the Mitsubishi Heavy Industries, Ltd. (MHI) Group, 3D VR technology has been applied to the entire value chain. As a result of the price reduction of VR devices and the improvement of the environment for the use and production of contents, the scope of application of VR technology has become wider and VR technology has been positioned as "a tool whose existence is taken for granted" in the same way as PCs and smartphones. In such an environment, the MHI Group has promoted efforts to increase the user experience value beyond the framework of the value chain, and 3D VR technology was applied to the factory tour at the Takasago Works of MHPS (Mitsubishi Hitachi Power Systems, Ltd.), resulting in an increase in customer satisfaction.

1. Introduction

In the MHI Group, VR technology has been applied to the entire value chain for "Value Chain Innovation by Using 3D VR Technology" since 2012. Specifically, with the IPT (Immersive Projection Technology) system that was introduced in 2012 and the MR (Mixed Reality) system "Canon MREAL" that was introduced in 2013, the characteristics of "full scale" and "stereoscopic view" were made use of in design, analysis, manufacture, sales and after-sales service of various products, and increased sophistication of reviews, a substantial increase in efficiency and the implementation promotions that provide new experiences were realized.

Since sometime around 2016, which is called "the first year of VR," the 3D VR system has undergone significant changes and the prices of Head Mount Display-type (HMD) products have been rapidly lowered. This has been driven not only by mass production and the effects of business models for the sale of contents, etc., but also technological innovations such as FOV2Go and Lighthouse. In addition, VR software is fulfilling and is broadly divided into three types: (1) GLR (GL-DLL Replacement) that does not require data conversion, (2) data conversion-based software for VR, and (3) game engine-based development environments. This facilitates the development of contents corresponding to various uses.

The scope of application of VR technology has become wider and VR technology has been positioned as "a tool whose existence is taken for granted" in the same way as PCs and smartphones. In such an environment, the MHI Group has promoted efforts to increase the user experience value beyond the framework of the value chain. Recent examples of the application of VR technology are described in Section 2 and efforts to increase the user experience value are described in Sections 3 and 4.

2. VR technology application examples

Three recent examples of the application of VR technology in the MHI Group are described below.

(1) Product review (Chemical/fertilizer/thermal power/nuclear power plants, passenger boat, naval vessel, etc.) (**Figure 1**)

For large amounts of data for plants or ships (**Figure 2**), VR software products using the

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GLR method (Techviz TechvizXL, Fiatlux EasyVR, Cybernet VDR) are used. In the GLR method, only geometry is processed, and a high level of performance can be secured, and in theory, no inconsistencies occur between the original CAD data and the VR representation. Therefore, it is highly applicable to design reviews. The state of completion can be shared with the customer and therefore, discrepancies or returns in downstream operations can be prevented. In addition, it contributes to the improvement of design quality as a review tool for designers.

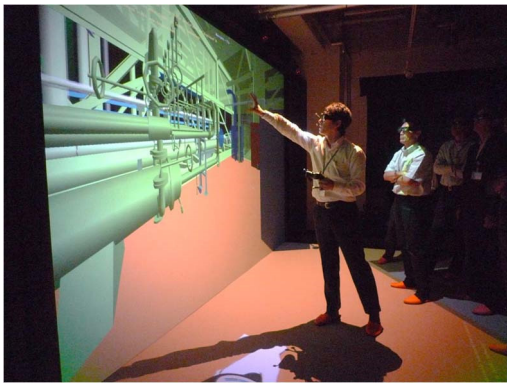

Figure 1 VR review for plant product

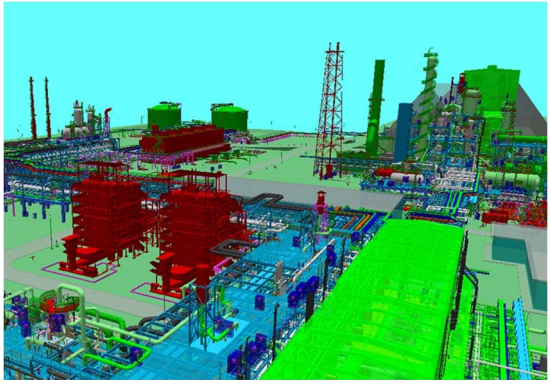

Figure 2 Large amounts of data for plant product

(2) Study of workability (gas turbine for power generation, commercial aircraft, nuclear power equipment, rocket, flying body, etc.) (**Figure 3**)

In the study of manufacturability and maintainability in the product design stage and the workability of a new manufacturing line, VR software products (Redstack Fuzor, Asahi Electronics VirDSE, ESI IC.IDO, COMOS Walkinside, etc.) are used. The advantages of VR software is that it is equipped with several standard functions, allowing the creation of contents without development. Figure 3 presents an example of application to manufacturing workability verification leveraging the ease of simulation of welding operations and representation through animation of the assembly procedure.

(3) Marketing promotion (various exhibitions, exhibition facilities, etc.) (**Figure 4**)

The development environment based on game engines such as Unity and Unreal Engine has been widely adopted, which facilitates the development of elaborate VR contents. Conventionally, exhibitions were conducted mainly for VR software, but now, interactive contents have been produced and used for even greater appeal. Figure 4 illustrates the VR exhibition “MHI VR Mirai Gacha” at Gastech 2017. The contents incorporate game-like elements in which the MHI Group’s products are assembled as if a puzzle was being constructed, and when the assembly is completed within a certain time, a full-scale product experience is unlocked. Many customers enjoyed the contents as a light touch point to the product.

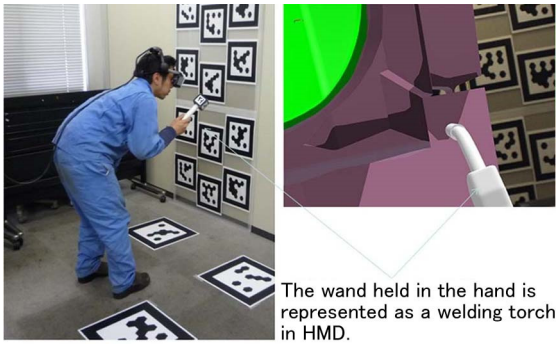

Figure 3 Welding workability verification by VR

Figure 4 MHI VR Mirai Gacha at Gastech 2017

3. User experience cycle

Conventionally, 3D VR technology was applied to the entire value chain. At present, we have promoted efforts to increase the user experience (UX) value by widening the scope of application. Many framework diagrams about UX have been released, and we place the UX cycle given in **Figure 5** as the basis for our efforts. This shows the relationship with the MHI Group from the perspective of customers and the value chain is incorporated in the cycle. For example, the product review using VR described in the previous section (1) corresponds to "(4) Check the design or check the manufacturing status."

As a result of the price reduction of VR technology and the improvement of contents use and production environment, the scope of application of VR technology has become wider and VR technology has been positioned as "a tool whose existence is taken for granted" in the same way as PCs or smartphones. Until now, only the possession and use of VR facilities were an advantage, whereas at present, it is important where and how they are used. We have conducted specific studies according to the ISO13407 Human-centered design process. The flow of the human-centered design process is presented in **Figure 6**.

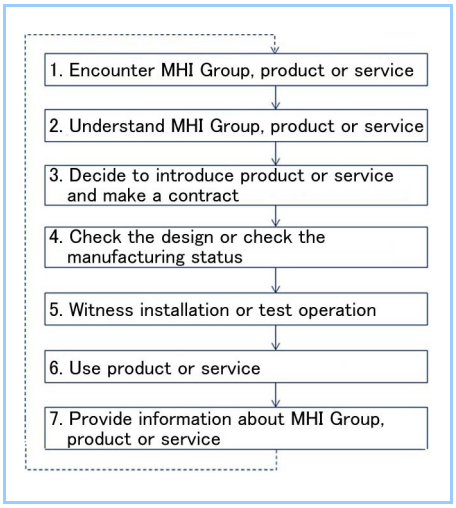

Figure 5 UX cycle

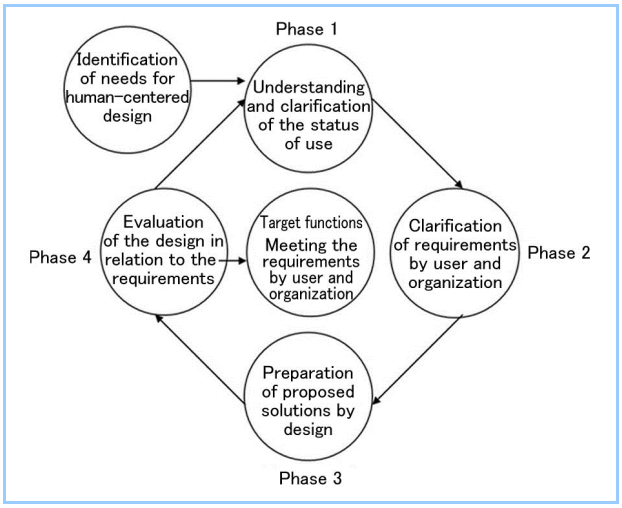

Figure 6 ISO13407 Human-centered design process

4. Example of efforts to improve the user experience

An example of efforts to improve the experience in the factory tour at the MHPS Takasago Works to "check the design or check the manufacturing status" using the human-centered design process is described.

The Takasago Works (**Figure 7**) is one of the main factories of MHPS and mainly manufactures gas turbines for power generation, and every year, many customers visit for factory tours. This effort is intended to make customers more deeply understood the manufacturing carried out at the Takasago Works and provide further customer satisfaction.

Figure 7 MHPS Takasago Works

In the effort described below, VR technology is used for the extraction of issues with prototypes, for the case study of proposals, etc. The use of VR technology as contents is also under study.

(1) Phase 1: Understanding and clarification of status of use

To understand the current state of the factory tour at the Takasago Works, we accompanied the customers, experienced the factory tour and made sure that the following flow was followed:

- Before the factory tour, an explanation about the Takasago Works and the gas turbine technology was given in the meeting room.
- We visited and observed several manufacturing processes and the major facilities such as the demonstration power generation facility, the laboratory, the remote monitoring center and the manufacturing education center.
- At each facility, the person in charge of the facility gave us an explanation.
- After the factory tour, a question-and-answer session was held in the meeting room.

(2) Phase 2: Clarification of requirements by user and organization

In the workshop (**Figure 8**), the user actions and mindset were analyzed. After that, the analyzed data was organized in the customer journey map (**Figure 9**) to clarify the issues. Examples of the issues are described below.

Figure 8 Workshop

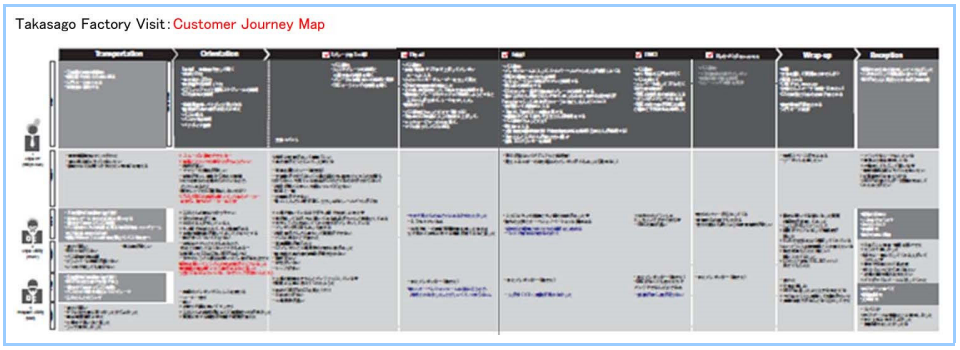

Figure 9 Customer journey map

- For deeper understanding of the major characteristics of the Takasago Works
  At each facility, the person in charge gives a detailed explanation so that visitors can deepen their understanding of individual facilities, and we want you to deeply understand that we have all the necessary facilities, such as laboratory, design, manufacturing and demonstration facilities, required for manufacturing.
- For easy-to-understand presentation of all manufacturing processes for gas turbines
  We want to present, in an easy-to-understand manner, how all the processes are configured and what part of all the processes we see. But only several manufacturing processes can be seen on the tour, and it is also difficult to conduct a tour along the manufacturing process for the sake of convenience of passage, etc.
- Difficulty in asking questions during factory tour
  To make it easy to hear voices in an environment with factory noise, a wireless guide system (Panaguide) is used. But it provides one-way transmission of voices, and it is difficult for visitors to ask questions at the site and visitors have to wait to ask questions

until the question-and-answer session in the meeting room.

(3) Phase 3: Preparation of proposed solutions by design

For the issues extracted in Phase 2, the following solutions were proposed:

- For deeper understanding of the major characteristics of the Takasago Works
  The Takasago Works has all the necessary facilities, such as laboratory, design, manufacturing and demonstration facilities, required for manufacturing. The fact that reliable products are produced by all the facilities working closely with each other was clarified as a "story," and it was summarized into a book and made known to the concerned parties (**Figure 10**). At each point in the factory tour, with the story kept in mind, the person in charge explains about the actual facilities, work and efforts in detail. Thus, an explanation following along with the story is made at each point so that visitors can more smoothly understand.

Figure 10 Story Book of MHPS Takasago Works

- For easy-to-understand presentation of all manufacturing processes for gas turbines
  A time-lapse video in which all the gas turbine manufacturing processes are organized in a short time is shown in the meeting room before the tour and the facilities that the visitors will see on the tour and in what part of the processes they are located are explained in advance. By using the video, visitors can easily imagine what they are about to see and their expectations for the factory tour are increased.
- Difficulty in asking questions during factory tour
  A two-way intercom was introduced to allow questions and answers at the site. The person in charge of the tour answers questions during the explanation, and quicker responses can be provided compared to the question-and-answer session in the meeting room after the tour, allowing easier-to-understand response while pointing at facilities with a finger.

(4) Phase 4: Evaluation of design in relation to requirements

As a result of introducing and implementing the solutions made in Phase 3 to the actual factory tour, the customers made comments such as, "Compared to past tours, the message was conveyed more clearly and I could feel the sense of togetherness of the factory" and "I could really understand that the way the Takasago Works operates with the quaternity of design, factory, demonstration power generation facility and laboratory leads to the high reliability of gas turbines." As such we could verify that customer understanding was promoted and customer satisfaction was increased.

5. Conclusion

In this report, the state of recent 3D VR technology, the status of application to the value chain of the MHI Group and efforts to increase the user experience value beyond the value chain were described.

The factory tour at the MHPS Takasago Works presented as an example continues to be developed. We wait for customers at the factory where they can experience and feel MHPS's pride through our state-of-the-art technologies and manufacturing based on these technologies and the demonstration power generation facility for proving the reliability of our products. We will continue this approach to the user experience cycle while incorporating state-of-the-art technologies including VR so that customers can understand the value of their partnership with the MHI Group.