Design Development to Improve Customer Satisfaction

To make a design that obtains high customer satisfaction, it is important to make the design attractive to all people and at the same time ensure high standards of safety and operability.

To provide the customer with a detailed design idea, we have employed a design process that minimizes reworking by using affective engineering and digital mockups.

Introduction

Although the market for railway systems in Japan has leveled off recently, demands for new cars are steady, such as replacement of existing cars and introduction of limited express trains.

Amid passengers' growing needs for attractive car designs these days, railway companies (our customers) are increasing their requirements for unique car designs. On the other hand, these designs also have to ensure high-quality manufacturing, safety, and operability. The challenging task is to design cars that meet both the required level of appearance and performance. We have won bids for our high evaluations in total assessment of bid proposals including not only prices but also designs, technologies, and quality—e.g., the new limited express train 500 Series (Fig. 1) of Tobu Railway Co., Ltd. (hereafter referred to as Tobu Railway), and the new commuter train

Fig. 1 Exterior of Tobu Railway's new limited express train 500 Series

Fig. 2 Exterior of Seibu Railway's new commuter train 40000 Series

40000 Series (Fig. 2) of Seibu Railway Co., Ltd. (hereafter referred to as Seibu Railway). They are large private railway companies in the Kanto region. We employed the new design process in these cars' designs and in their sales activities.

1 Background

In the conventional design process, detailed studies are made by using two-dimensional drawings, and three-dimensional checks are conducted only after making mockups and in the last stage of designing and the first actual car. In this process, the design often differs from the customer's expectation, which leads to reworking the design.

To respond efficiently to the customer's requests, we have implemented affective engineering and digital mockups as described below.

By employing effective engineering methods to scientifically verify our designer's multiple design proposals based on the customer's design concept, we made more specific perspective drawings. Consequently, we developed a new design process (Fig. 3) that provides a realistic car concept at an early stage of the design process, in which the customer can check 3D (three-dimensional) digital mockups of VR (virtual reality) images made from 3D data.

Fig. 3 Design workflow that incorporates the customer's requests

2 Affective engineering applied to car designs

Affective engineering is a technical field that makes objective data (visualization) out of physically unseen human information such as feelings, perception, mental images, emotions, and sense of values.

Generally, many people are involved in decision-making processes for assessing the design, and individuals' subjective ideas tend to affect the results. Consequently, discrepancies are often seen between the detail design and the concept design and oftentimes much time elapses before deciding on the final design.

Affective engineering, which objectively detects human feelings, provides persuasive evidence that the final design satisfy its initial concept. Kawasaki introduced affective engineering in designing motorcycles at first, and then in 2008 we started using it in projects for developing cars for the Japanese domestic market.

Seibu Railway's new commuter train 40000 Series (hereafter referred to as 40000 Series) shown in Fig. 2 aims at establishing a new standard commuter train, on which special areas called "Partner Zones" are set up to offer comfortable spaces for passengers who use wheelchairs or strollers.

At the technical proposal for the bid, we presented a new interior design that used our past research results in the field of affective engineering, which was highly evaluated.

The exterior design of the car head is an important factor for the customer's corporate brand, and it attracts passengers' interest every time they ride the train. The next paragraph starts to explain how we practically applied affective engineering to designing the head part of the 40000 Series.

First, our designers presented multiple design proposals based on the customer's concept that showed graceful shapes with some colors of existing cars. Next, many of the people involved, including our customer, shared their impressions regarding the exterior shapes and colors of each design by completing evaluation sheets. MDS (multidimensional scaling), a psychometric method, was used to compare the impressions obtained from these evaluation sheets such as "warm," "cold," and "splendid" with "gentle" and "advanced" that were conceptual key words of this project, and then the consistency of these exterior designs were checked on a 3D map (Fig. 4). Model D, for example, is visualized to show it is an exterior design that gives an impression of flowery and bright appearance. These processes were repeated multiple times to fine-tune the designs. As a result, a final satisfactory design that met the original concept was selected with confidence and speedily.

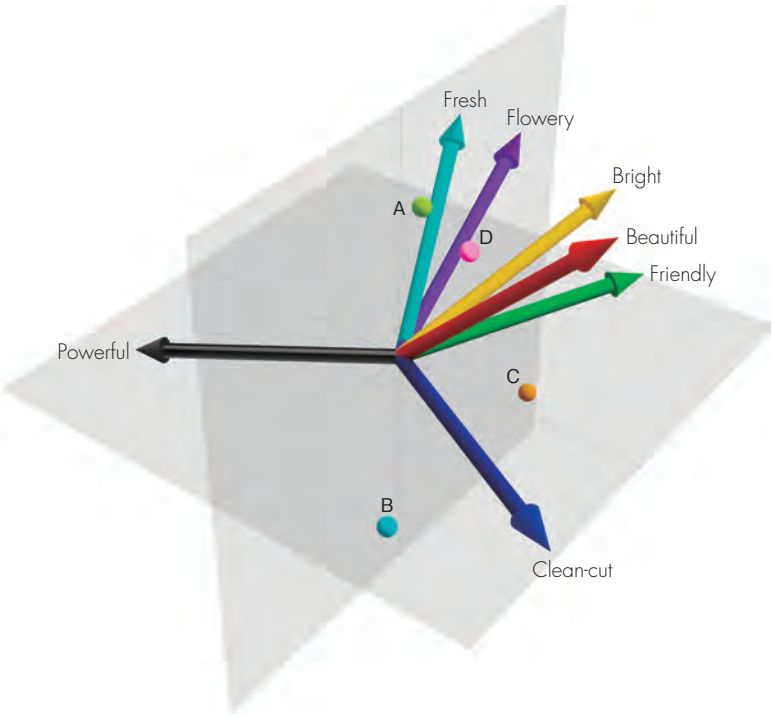


Fig. 4 3D map created by MDS (multidimensional scaling)

3 Digital mockups used in design processes

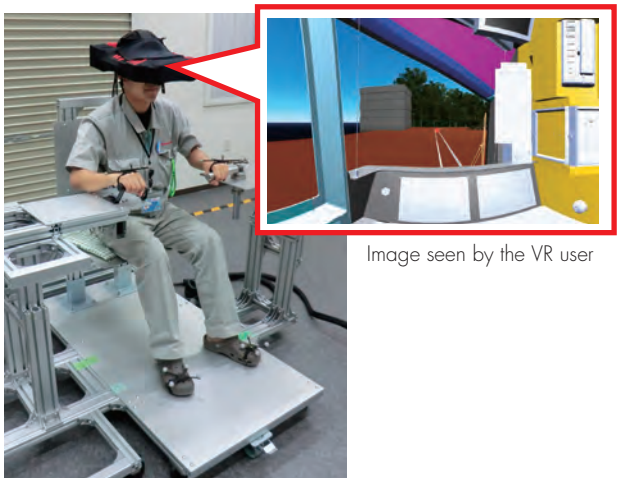
To realize the new design process shown in Fig. 3, we invented a method that evaluates human factors from both subjective and objective perspectives by introducing digital mockups that use VR and human engineering (3D human simulator). The VR technology creates a virtual space on a computer and provides users' senses with appropriate information to allow them to experience things in the space as if they were there although they do not physically exist in reality.

Meanwhile, human engineering puts up 3D human models of various shapes in a virtual space on a computer. They can be moved freely to check operability of a machine numerically. Combining these technologies enables human factors to be evaluated from both subjective and objective perspectives.

By using digital mockups, designers can check their designs and customers can check the design specifically by experiencing it before the product is constructed. At this stage of designing, digital mockups allow flexible design changes making it easy to reflect the customer's requests on the car design. Figure 5 shows scenes of using digital mockups.

Tobu Railway's new limited express train 500 Series (hereafter referred to as 500 Series) shown in Fig. 1 has a concept of providing quick-deliverability and comfort in various operating conditions. This is realized by forming the 500 Series consisting of two three-car unit trains connected together (for a total of six cars), which can operate as one train of six cars or be separated along the route and operate as two trains of three cars each.

The exterior design gave a car head that had never been used for past limited express trains and this raised an issue about securing an adequate viewing area for the



(a) Virtual reality

(b) 3D human simulator

Fig. 5 Design review with digital mockups

driver. Conventionally, verification has been conducted by making a mockup after reviewing two-dimensional drawings. For the 500 Series, VR was used in checking the visibility through 3D digital mockups and the head shape was optimized, and then by simulating the 500 Series with an existing car, a final design was validated (Fig. 6).

VR was also used for the basic design of Seibu Railway's 40000 Series. For example, 3D data were created based on the perspective drawing of Partner Zone in Fig. 7(a), and a VR user moved a real stroller to check the comfortability inside the car as shown in Fig. 7(b).

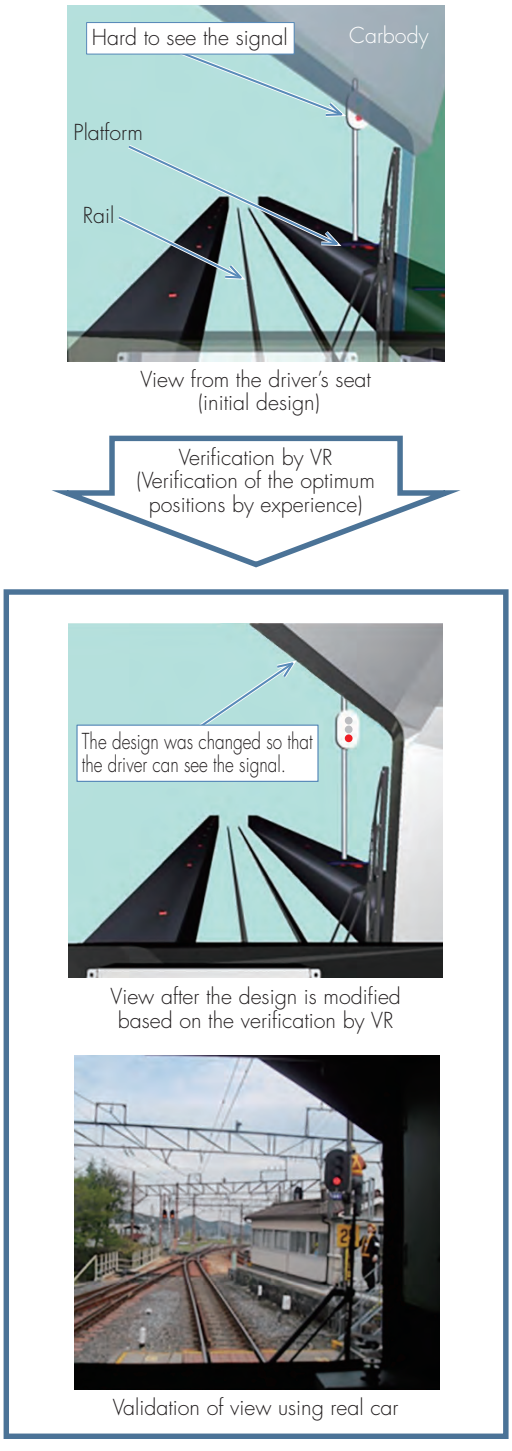
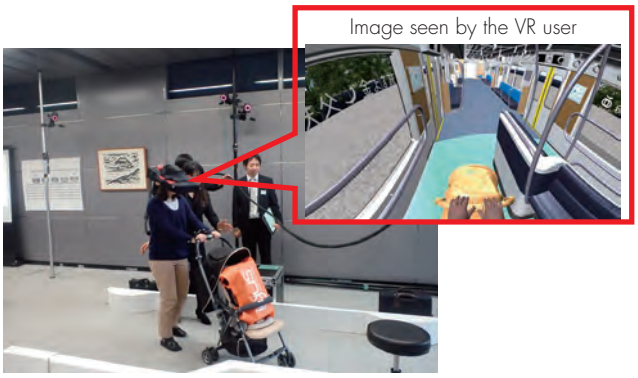


Fig. 6 Design verification by VR (Tobu 500 Series)

(a) Image of Partner Zone



(b) Scene of verification by VR

Fig. 7 Design verification by VR for Partner Zone (Seibu 40000 Series)

Conclusion

Applying affective engineering and digital mockups to car designs in the early stages of the design process helped us win bids for the new limited express train 500 Series from Tobu Railway and the new commuter train 40000 Series from Seibu Railway.

The bid conditions required by these customers included not only prices but also design and technology evaluations. We made front-loading proposals focused on creating designs that satisfy customers.

We expect an increase in designs requiring originality going forward. We will use this newly developed design process to design cars that will assure that our customers are highly satisfied.

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