Delight design of hair dryer sound

Koichi OHTOMI[1]

[1] The University of Tokyo, Japan

ABSTRACT

This paper describes the procedure for realizing a pleasant hair dryer sound by using a delight design platform technology that is based on sound quality metrics and the 1DCAE methodology [1]. 1DCAE consists of design concepts, methods, and tools for application to the early design stage. The 1DCAE output is input as the design requirements for a conventional computer-aided design/computer-aided engineering (CAD/CAE) system, which transforms the design requirements into an actual product image. The CAD/CAE results are then fed back to 1DCAE to verify the overall functions. The 1DCAE concept is expected to enable the realization of design innovation and, therefore, more innovative products. We applied the delight design platform technology concept to the design of the sound of a hair dryer. A product sound design platform based on 1DCAE can realize a 1D simulation environment in the early design stages of product development. The output from the 1D simulation (time domain) forms the input to the sound quality metrics calculation, such that we can express the delight factor as a function of the sound quality metrics. This design process thus enables the creation of a hair dryer with a pleasant sound.

Keywords: Sound design, Sound quality, Delight design, Product sound, 1DCAE, CAD/CAE, SD method, Evaluation grid method, Multiple classification analysis, 1D simulation, Contribution analysis.

1. INTRODUCTION

About ten years ago, we set out to classify designs to clarify the direction that design should take toward 2030. We correlated designs using the Kano model [2] and classified them as shown in Fig. 1.

I. Must design (corresponding to the "Must-be quality" in the Kano model)

The design must provide a design warranty. Many issues occur if Must design is ignored. Therefore, this forms the basis of the design, although it is very difficult to evaluate and handle.

II. Better design (corresponding to the "One-dimensional quality" in the Kano model)

This is easy to handle, since it can be clearly evaluated. It finally results in cost competition. This is the design for improving efficiency.

III. Delight design (corresponding to the "Attractive quality" in the Kano model)

Design in which the design concept is the most important factor. Many hit products have been produced by aiming to achieve this. The goal here is to anticipate the technological and customer needs, although these are likely to be regarded as being part of the creative design.

Three product types and design technologies correspond to the above three design classifications [3]: Better products that support mass production and mass consumption will be provided. Must products offering a design warranty will form the mainstream in the near future, and Design products that make us happy will also be needed in the future. To achieve the development of such products, the design technologies must change from traditional individual technologies to unified technologies, as shown in Fig. 2.

From the above-mentioned design technology background, we introduce Delight design that will become more and more important from the viewpoint of product sound quality, such as in the case of a hair dryer.

Figure 3 shows the definition of design based on Ashby [4]. The requirements pyramid he proposed consists of three tiers. The lower tier is "functionality," provided by an appropriate technical design that clearly fulfills a role. The second tier is "usability" that is related to how easy it is to use and operate. The third tier, at the top of the pyramid, is "satisfaction," which is the aspect that enhances our lives.

[1] koichi.ohtomi@delight.t.u-tokyo.ac.jp

The lower part of the pyramid corresponds to conventional design based on the Better and Must design technologies. On the other hand, the proposed design, called "Delight design," is a design technology in which all three tiers form part of a single process including not only Delight but also the Better and Must design technologies.

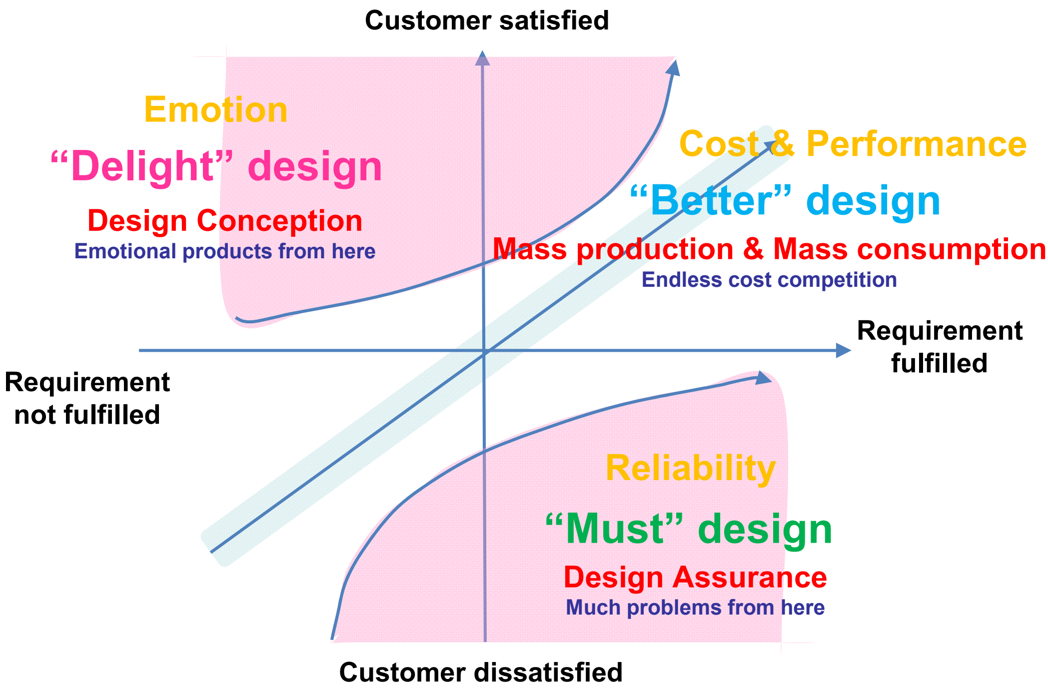


Figure 1 – Three kinds of design based on Kano model [2]

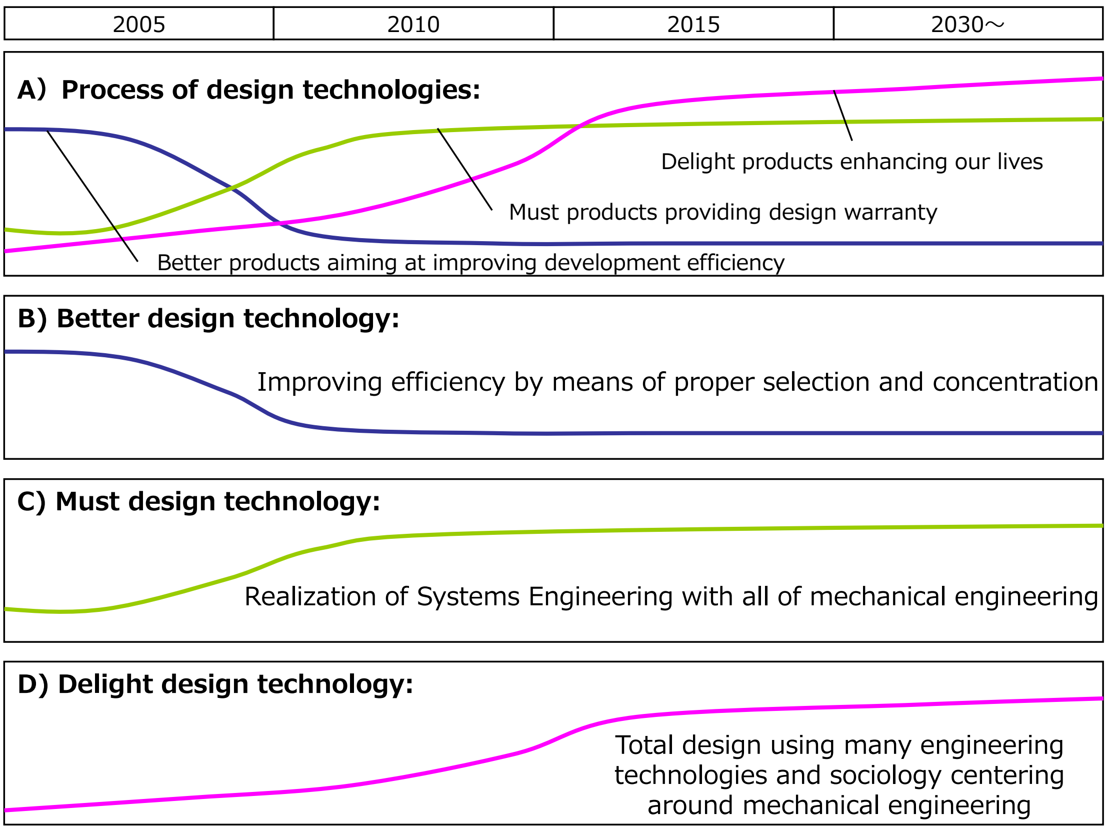


Figure 2 – Design technology roadmap formulated in 2007 [3]

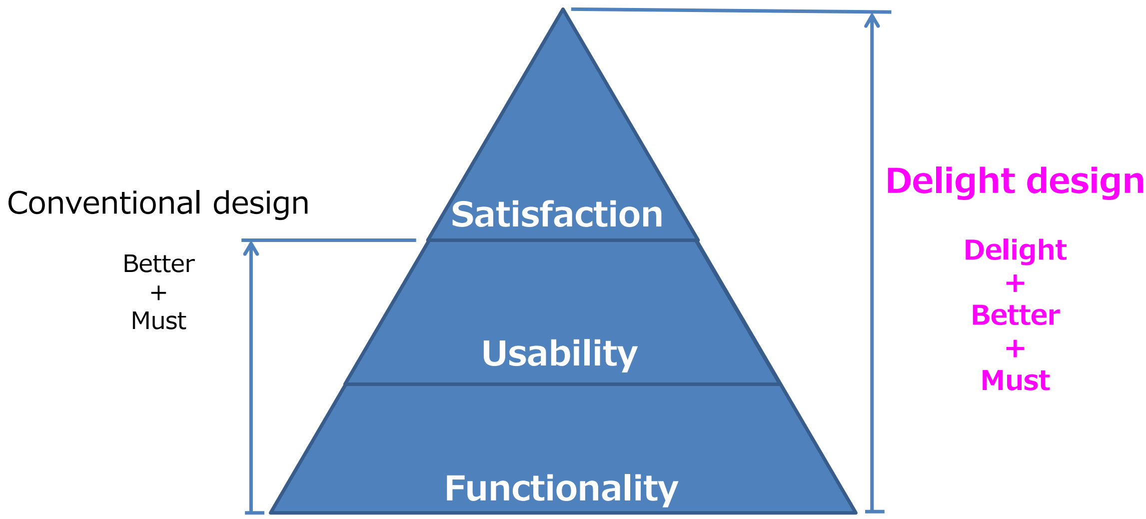


Figure 3 – Definition of design based on Ashby [4]

2. DELIGHT DESIGN PROCESS

The delight design process has two parts. The first is the "Definition of Delight" process and the other is the "Realization of Delight" process, as shown in Fig. 4. The pyramid of the delight design process consists of four stages. The first stage is "Products" that corresponds to the start point of Delight design and the final output of Delight design. The second stage is "Physical value" whereby products are expressed in a mathematically understandable form. The third stage is "Perception" in which physical values are translated into the sensations experienced by a human. The fourth stage is the "Human" who ultimately judges whether the products are attractive or not.

"Definition of Delight" is the process for understanding a customer's psychological feelings invoked by emotional/affective qualities of products and services. The goal of this process is to explain the customer's preference (objective variable) by using the Kansei metrics and/or physical values (explaining variables). The Kansei metrics are equivalent to the perceived values. The customer's preferences are defined as attractive metrics. In general, the attractive metrics (objective variable) are highly individual, while the Kansei metrics and/or physical values (explaining variables) exhibit fewer individual differences. The relationship between the objective variable and the explaining variable can be expressed with the "Delight map." The Delight map presents the most important information for delight design that acts as a bridge between "Definition of Delight" and "Realization of Delight." The attractive metrics of target products are plotted on the Delight map that also acts as the specification for the "Realization of Delight."

"Realization of Delight" is the process for realizing a Delight product according to the concept of 1DCAE. 1DCAE is a methodology, a method, and a tool for supporting the entire design process from the early stages of the design to the detail design stage, incorporating mechanical, electrical, and software design. 1D refers to the capturing of the essence of products including physical phenomena and expressing them with a simple model such that they are easy to understand. 1DCAE can realize evaluation by CAE in upstream to downstream design. In 1DCAE, the target for product development is established and a conceptual design and functional design are produced. By considering the function of a product, the preliminary decision of the design specification is carried out, and it is delivered to 3D-CAE. In 3D-CAE, a structural design and layout design are produced based on the specifications received from 1DCAE.

The Delight design platform, shown in Fig. 5, provides a design environment based on the Delight design process. The upper left of this figure shows an analysis of the product qualities that appeal to our senses in order to determine the potential needs of the users. Here, emotional design or Kansei design is applied to evaluate the needs of the users of a product. Through this analysis, we are able to determine the attractive metrics of a product. The Kansei metrics of products are also determined by measurement and calculation from the viewpoint of cognitive issues. Finally, we can derive a Delight map as shown in the top center of Fig. 5. The above description corresponds to the "Definition of Delight" process.

The lower part of Fig. 5 corresponds to the "Realization of Delight." Here, we introduce Kansei modeling based on the 1DCAE concept to realize Delight design. We define the technology for capturing the Kansei metrics into 1DCAE as “Kansei modeling” while the resulting model is the “Kansei model.” 1DCAE uses the so-called 1D tool based on the Modelica language. Designers perform Delight design by using a 1D tool incorporating the Kansei metrics. They can check the degree of attainment of their ideas by calculating the attractive metrics with the 1D tool. The results of delight design as obtained with this process are sent to the mechanical design and circuit design to perform the tangible design.

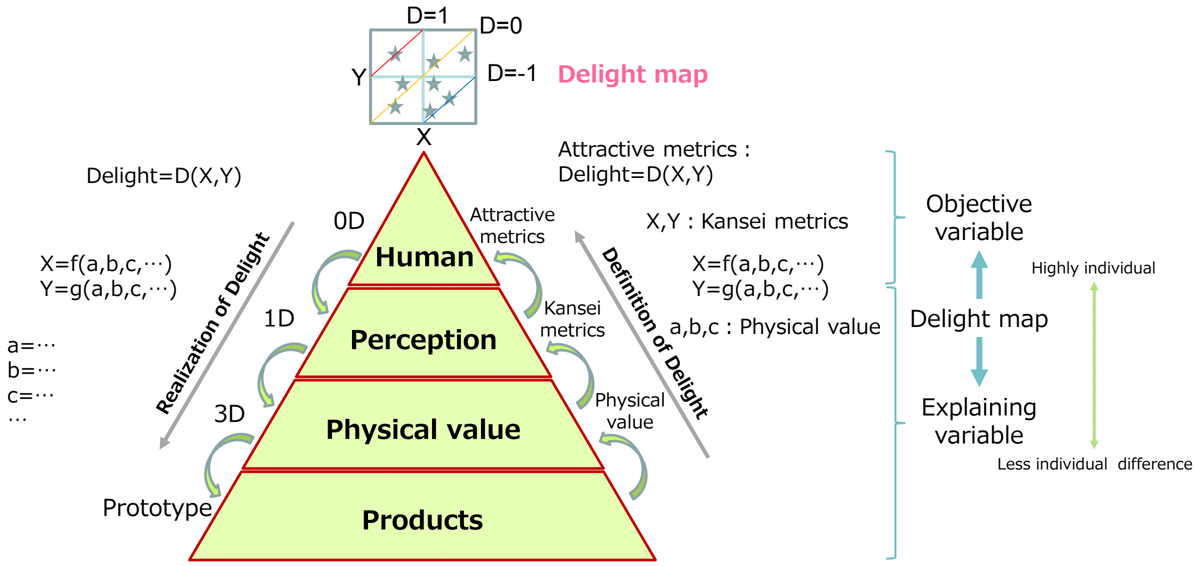


Figure 4 – Delight design process

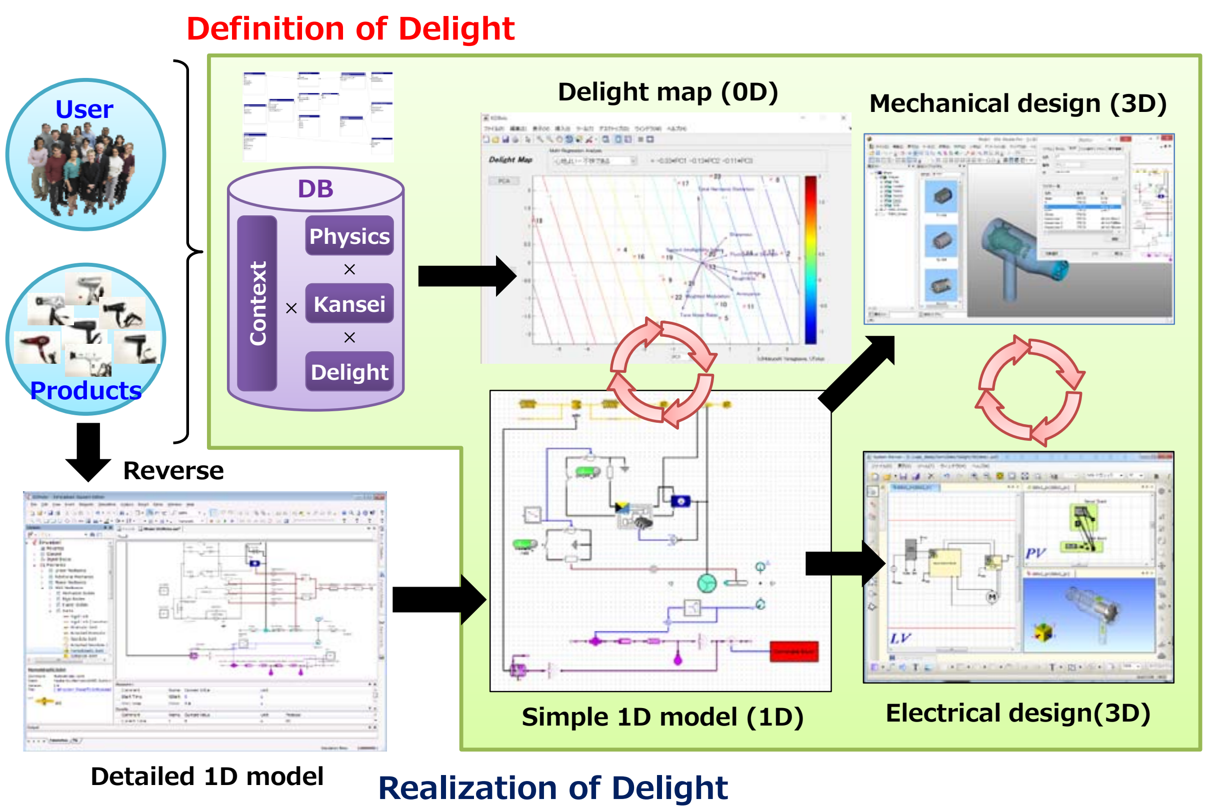


Figure 5 – Delight design platform

3. DEFINITION OF DELIGHT

The "Definition of Delight" involves deriving the Delight map as shown in Fig. 6. First, we applied the evaluation grid method to extract the keywords related to hair driers, using six subjects and 18 kinds of hair dryer. By using the keywords derived from the evaluation grid method, we applied the SD method to 37 subjects. Figure 7 shows the 14 keywords extracted through the evaluation grid method, the SD sheet for 14 pairs of adjectives, and the test conditions.

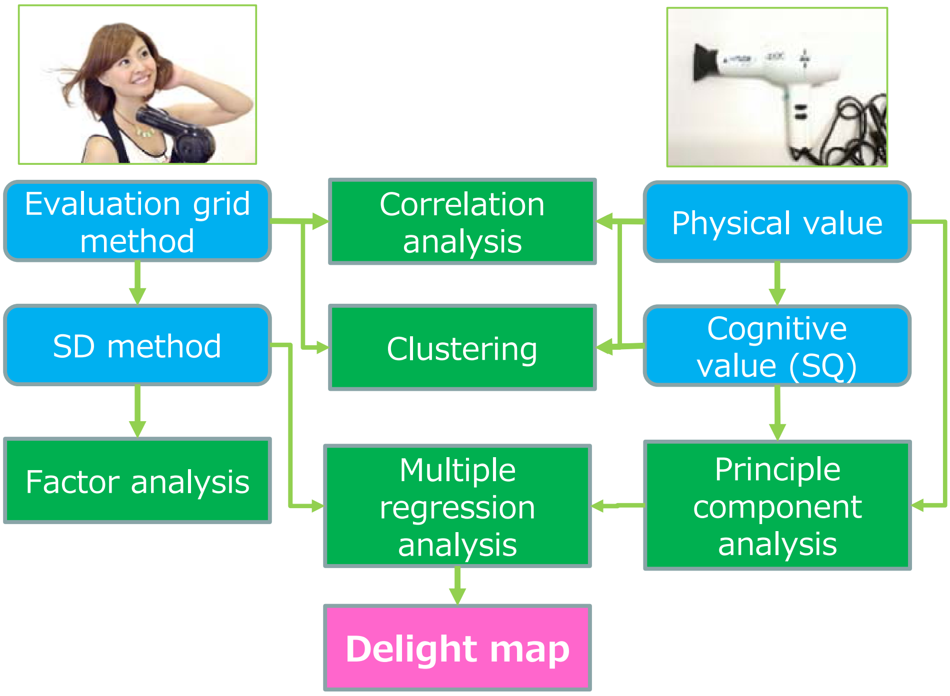
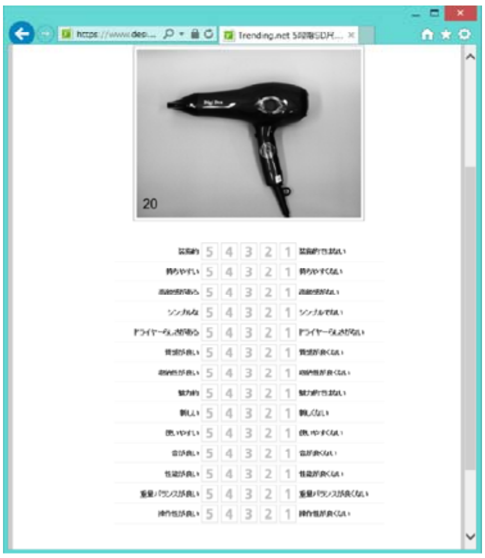


Figure 6 – Procedure for deriving Delight map

Decorative
Easy to hold
Looks expensive
Simple
Looks like dryer
Good texture
Easy to store
Attractive
New
Easy to use
High performance
Good weight balance
Easy to operate
Pleasant sound



14 pairs of adjectives for SD method

Figure 7 – Keywords and SD method

We applied a factor analysis by using the set of mean values for the 37 subjects, 14 pairs of adjectives, and 18 kinds of hair dryer. Figure 8 shows the results of the factor analysis for a hair dryer. This shows that the visual aspects, usability, and sound are the predominant characteristics of a hair dryer.

Next, we focused on sound design. Attractive metrics for sound are obtained from the SD mean value for the 37 subjects, while the Kansei metrics for sound are calculated by using SQ software. Table 1 lists the Kansei metrics and attractive metrics for 18 kinds of hair dryer. The principal component analysis is applied to the value of the four SQ metrics for the sound from 18 hair driers. The primary and secondary principal components are defined as new Kansei metrics. Then, the mapping between the attractive metrics and the new Kansei metrics is performed by applying multiple regression analysis. As a result, the Delight map is derived as shown in Fig. 9. This figure shows that, as the attractive metrics increase, the 37 subjects evaluate the sound quality as being more pleasant.

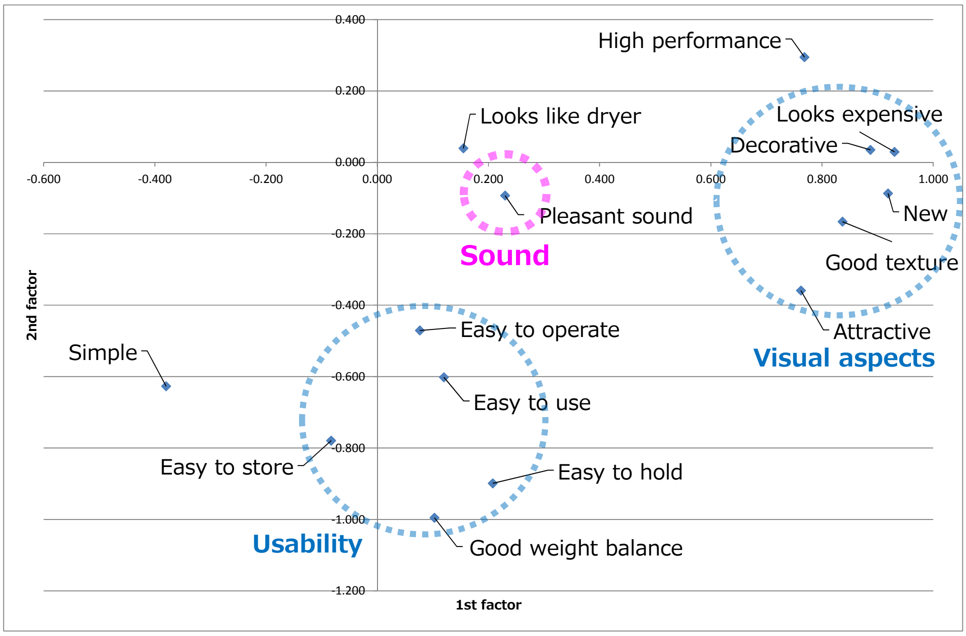


Figure 8 – Results of factor analysis for hair dryer

Table 1 – Basic data for Delight map

	Kansei metrics for sound				Attractive metrics for sound
	[soneGF]	[acum]	[asper]	*10^-3[vacil]	
Hair dryer number	Loudness	Sharoness	Roghness	F.S.	Pleasant sound
1	41.3	4.01	0.043	3.04	3.3
2	47.6	4.30	0.055	4.47	2.9
3	32.5	3.47	0.042	3.36	3.8
4	30.6	3.99	0.031	2.87	3.4
5	47.3	4.48	0.041	4.54	3.1
6	48.6	4.14	0.054	6.14	2.6
7	41.5	4.18	0.042	4.35	3.4
8	45.6	4.12	0.051	3.80	3.4
9	40.1	4.25	0.042	3.34	2.8
10	43.2	4.47	0.048	3.54	3.4
11	38.4	3.59	0.053	2.76	3.2
12	30.0	4.01	0.031	3.01	3.2
13	32.8	4.04	0.039	3.59	4.0
14	17.1	3.11	0.033	2.68	3.8
15	38.4	4.28	0.043	3.15	3.4
16	36.3	3.89	0.046	2.98	3.2
17	38.7	3.66	0.035	2.67	3.6
18	38.0	4.27	0.041	3.92	3.2

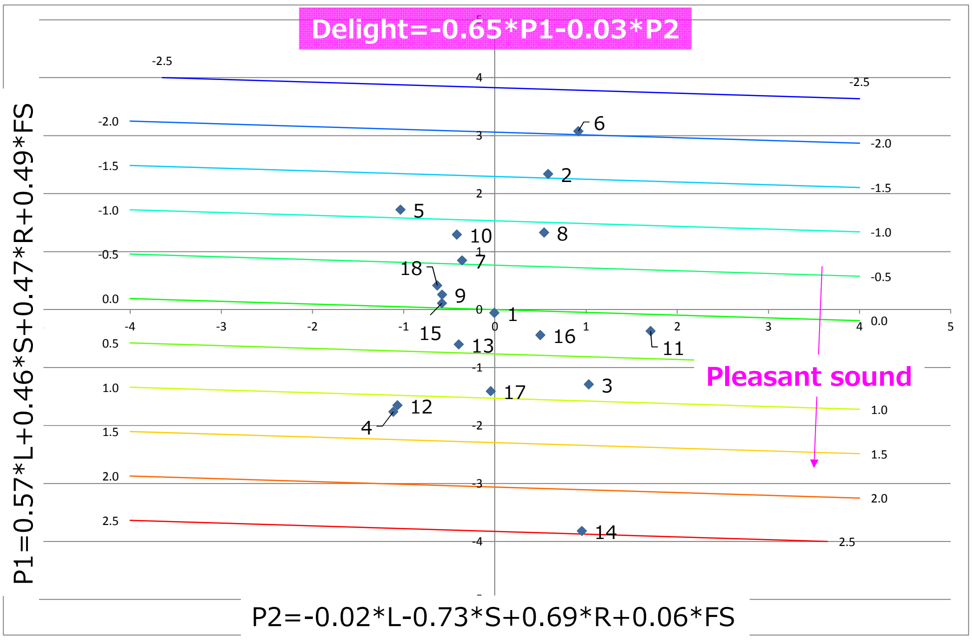


Figure 9 – Delight map for hair dryer sound

4. REALIZATION OF DELIGHT

The "Realization of Delight" process is performed by introducing Kansei modeling based on the 1DCAE concept. The technology used to capture the Kansei metrics is defined as the Kansei modeling and the resulting model is the Kansei model. 1DCAE is done by using the so-called 1D tool based on the Modelica language. Figure 10 shows the 1DCAE model for evaluating the dryer sound. The upper half shows the machine model for the hair dryer hardware and software. The lower left shows a physical model of the sound, for which the units are Pa. The lower right shows the cognitive model and human model. The cognitive model is capable of performing the SQ calculation. Therefore, by using the cognitive model we can obtain the Kansei metrics virtually. The human model corresponds to the attractive metrics. The Kansei metrics are plotted on the Delight map to check the degree of Delight for the new Delight design. The 1DCAE model for the hair dryer sound can be applied to the sound contribution analysis shown in Fig. 11. The results show that the airborne sound from the outlet makes the greatest contribution, that the airborne sound from the inlet has high-frequency components, and that the structure-borne sound has low-frequency peak modes.

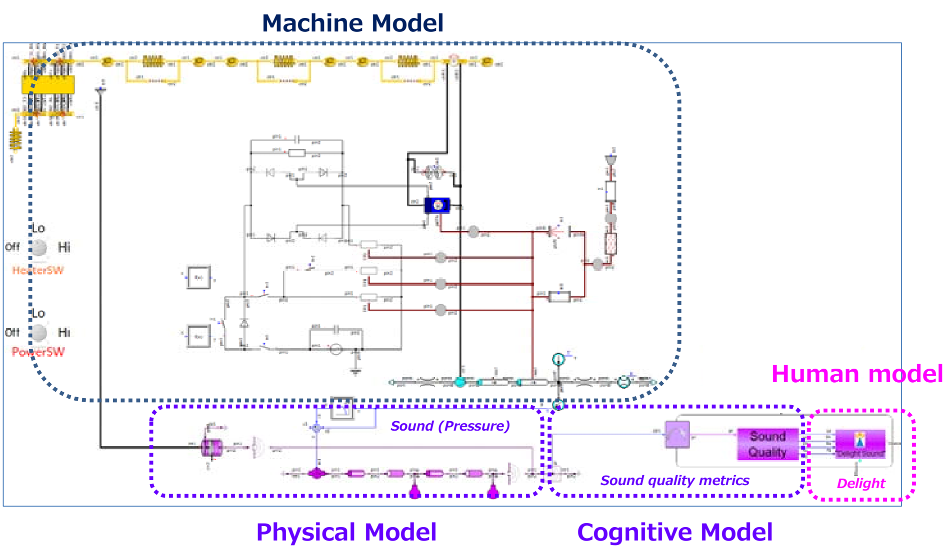


Figure 10 – 1DCAE model for dryer sound evaluation

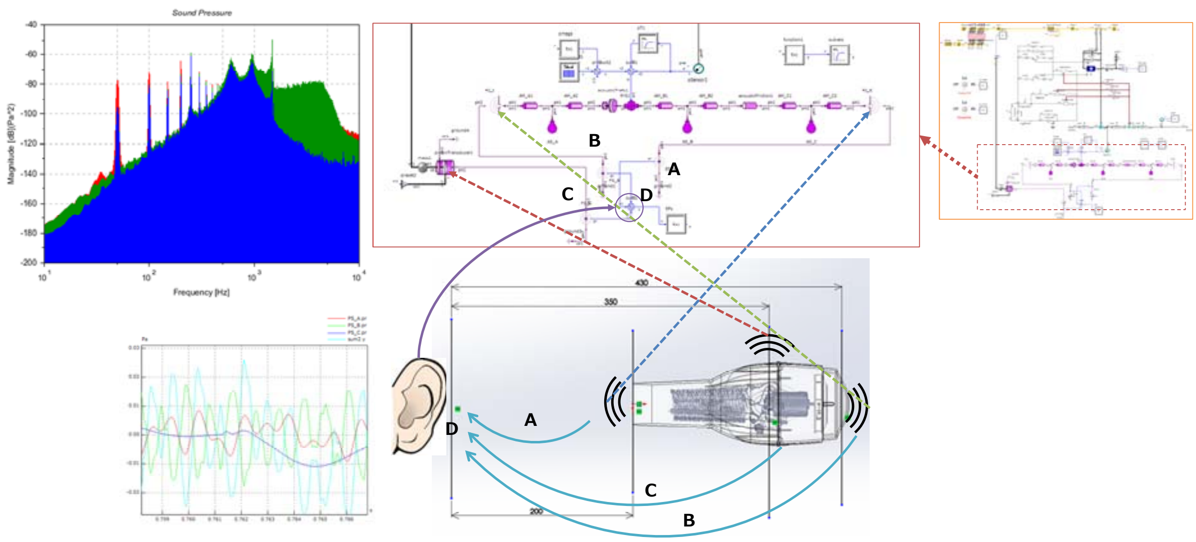


Figure 11 – Sound contribution analysis using 1DCAE model

5. APPLICATION OF DELIGHT DESIGN PROCESS

We applied the delight design process described above to a new-concept hair dryer, shown in Fig. 12. The new concept hair dryer aims to be attractive, offer a high level of usability, and a pleasant sound, based on the results shown in Fig. 8. New technology derived from other applications is applied to realize a pleasant sound. The preliminary design for realizing the idea is performed by using the simple 1D model and the attractive factor is checked on the Delight map. The prototype of the new concept hair dryer is completed through a detailed design with a 3D model. The prototype hair dryer is stylish, as shown in Fig. 12. On the other hand, although the sound is better than that of a conventional dryer, a pleasant sound has not yet been achieved. We are trying to improve the sound of the new dryer from different aspects.

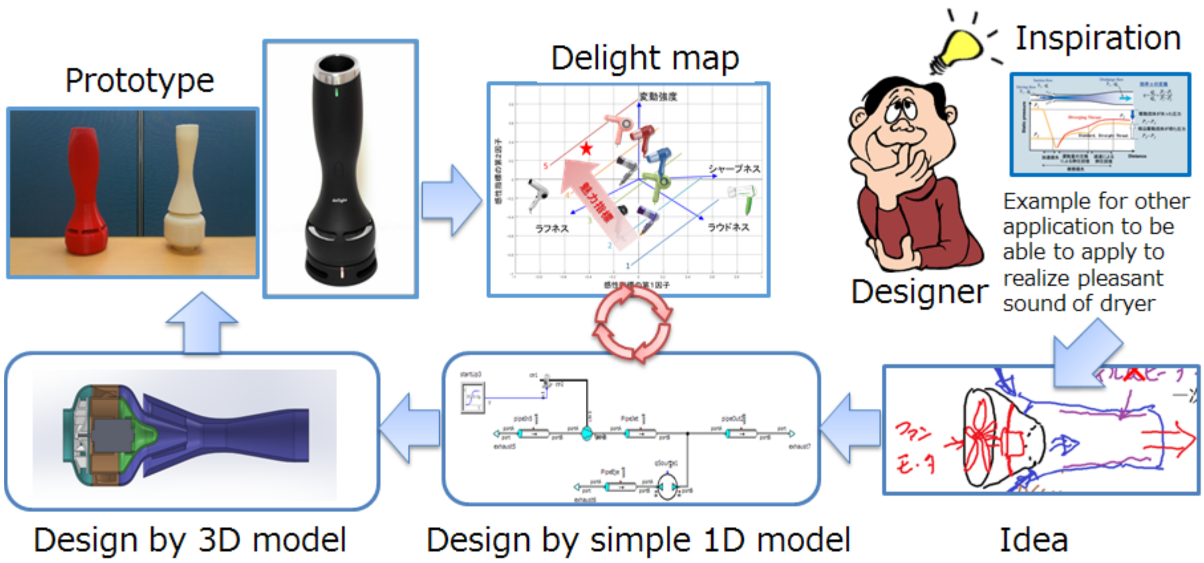


Figure 12 – Delight design process for new-concept hair dryer

6. CONCLUSIONS

We introduced the Delight design process and the Delight design platform technology to realize a hair dryer with a pleasant sound. The Delight design process is divided into “Definition of Delight” and “Realization of Delight” with the Delight map forming a bridge between them. The Delight design process has been explained, as well as its application to the design of a new-concept hair dryer. The Delight design process described here is general and thus can be applied to different types of products.

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