

Research on the Design of Hand-held Electric Grinding Tool Based on Kansei Engineering

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Abstract:

Based on the research theory of perceptual engineering, systematically quantify the user's perceptual cognition of the shape of the household hand-held electric grinder, complete the shape design of the household hand-held electric grinder, and apply the analytic hierarchy process to determine the perceptual vocabulary of the household hand-held electric grinder. Apply the semantic difference method to establish a semantic difference scale; use the morphological analysis method to decompose the morphological design elements of the household hand-held electric grinding tool and complete the screening of the scheme. Through inductive analysis and evaluation, the design of household hand-held electric grinding tool is completed. The practical process is guided by perceptual engineering, which effectively combines the sensibility and rationality in the product form to meet the emotional and functional needs of users of household hand-held electric grinding tools in the operation process.

Keywords:

Kansei Engineering, Handheld Electric Grinder, Domestic, Semantic Differential Method

1. Introduction

With the improvement of people's living standards, DIY enthusiasts have the time and material resources to display their craftsman talents, and hand-held electric tools have become a standing tool for many DIY enthusiasts. Power tools were originally mostly used in factory workshops, but with the improvement of people's quality of life, the demand for spiritual culture and entertainment has increased year by year, and ordinary families have more energy and leisure time. People are interested in home decoration, furniture DIY, handicraft creation, etc. The enthusiasm has also gradually increased, which naturally promotes a new development trend in the field of hand-held power tool design. The development of hand-held electric tools towards humanization, convenience and multi-function is the result of this new trend.

The design mode of electric tools is no longer advocating the functional shape dominated by practicability. The strong mechanical feeling caused by factory processing has begun to be diluted in appearance. The new demand for electric tools in terms of categories and shapes has prompted designers to create Household hand-held electric tools are endowed with new design attributes of low power, light weight and portability. In terms of shape, they emphasize affinity and softness, and embody comfortable emotional elements in details. On this basis, small household tools and DC electric tools are introduced. Tool-based DIY style. Such trends have had an impact on the design tendencies of professional power tools. The design of professional electric tools exaggerates and emphasizes its sense of strength, strengthens the visual impact of the shape of the shell, and creates a new style that highlights the beauty of power and the impact of shape. In recent years, due to the commercial needs of both professional and domestic needs, the “semi-professional style”, a styling style that combines the above two characteristics, has begun to be widely accepted and loved by merchants and users. In general, the update and development of hand-held electric tools keep pace with the times in terms of function realization and shape innovation, and it is always inseparable from the household trend.

The household trend of electric tools makes it necessary to take the perceptual needs of users as an important consideration in the design process. Because different groups have different perceptual needs and aesthetic cognition levels for product design. Therefore, in recent years, the designer's design focus has shifted from the traditional design model to the emotional needs of consumers, using the knowledge of kansei engineering to explore the relationship between consumers' sensibility images and product modeling elements from multiple angles. This is conducive to designers to give full play to the spirit of innovation and exploration on the premise of respecting the inherent attributes of product design, focus on consumers, pay attention to consumers' higher-level emotional appeals, and make the design of hand-held electric grinding tools conform to the development needs of the times.

2. Overview of the Development of Electric Tools

2.1. Current Status and Overview of Electric Tools

Power tools are widely used in daily life, and they are ubiquitous application tools. They play an important role in machining, maintenance services, artistic creation and other fields. It is an important production equipment that plays an important role in social and economic development. In recent years, electric tools have broad prospects for development and have been included in the category of advanced equipment manufacturing.

Electric tools usually use small motors or electromagnets as the power source, and provide torque to the tool head at the front end of the shaft through the transmission structure. It is a light and portable electric mechanical tool that is mainly operated by hand. According to national standards, it is generally divided into three categories: hand-held electric tools, portable electric tools, and electric garden tools.

After the 1940s, the popularity of power tools has increased significantly, and it has become a global production and processing tool, and has become an indispensable practical tool in the daily life of families in developed countries.

Electric tools in China began to enter mass production in the 1970s, flourished in the 1990s, and the total industrial scale continued to expand. According to statistics, by 2013, the output value of my country's electric tool industry reached 58.512 billion yuan, a year-on-year increase of about 23.91%, and sales revenue was 47.878 billion yuan, a year-on-year increase of 15.28%.

As far as the current trend of the power tool industry is concerned, the future development prospects are expected to continue to grow at a high speed.

According to expectations, the future design and development trends of electric tools are roughly as follows: First, clean energy will gradually replace non-renewable energy as the main source of power supply for electric tools in the future. The gradual application of lithium battery technology will bring new improvements to the battery life and battery safety of handheld mobile power tools, and the battery cost will continue to decrease, thus abandoning the original single-phase and three-phase power supply methods.

Second, multi-functional compound power tools will become dominant. Power tools are gradually moving towards home use, and the demand for one machine with multiple functions will become more obvious. It is difficult for professional power tools with a single function to meet the diverse needs of home use.

In addition, the emergence of intelligent electric tools has fueled the generalization of electric tools. The revolutionary development of motor technology and the breakthrough of electronic control technology will lead to a qualitative leap in motor technology. At the same time, as the application of artificial intelligence in the daily field gradually heats up, the intelligence level of electric tools may be greatly improved.

2.2. Requirements for Handheld Electric Grinding Tools

This design is mainly aimed at home non-professionals and handmade creation enthusiasts. The mobile power supply is required to be portable, the power does not need to be too high and within the safe voltage range, with a battery, and the body shell is all plastic. As far as the classification reference standard of hand-held electric grinding tools is concerned, the product should belong to Class III hand-held electric tools.

The development of hand-held electric grinding tools to the family field is the main line of development; hand-held electric grinding tools have a development tendency of humanization, multi-function, and convenience; Electric grinding tools are endowed with low-power, light-weight, and portable design attributes. In terms of styling, they emphasize softness and affinity, and the details reflect a comfortable human-machine relationship.

At present, household hand-held electric grinding tools on the market have the requirements of miniaturization, high power, and high speed, which can meet the replacement of various accessories, and are suitable for various types of operations such as engraving, grinding, cutting, polishing, drilling, and rust removal. Since hand-held electric grinding tools need to be used with a variety of different tool heads to achieve different types of operations such as drilling, milling, grinding, sawing, and polishing, the storage and arrangement of the tool heads when carrying them is inevitably time-consuming and labor-intensive. Hand-held electric grinding tools need to replace the cutter head during use. During the operation, it is often necessary to

suspend the work and replace the cutter head repeatedly, resulting in a decrease in work efficiency. The development of hand-held electric grinding tools in the household field has put forward new requirements for the humanization and versatility of electric tools. Non-professionals who lack operating experience should also be able to use electric grinding tools conveniently and safely. Therefore, there is a demand for operating aids .

3. Research Methods

3.1. Kansei Engineering

Kansei engineering emerged in Japan, aiming to connect customers' emotional responses with the product design process through a series of processes such as acquisition of perceptual imagery, model building, and design optimization. Domestic research on Kansei Engineering has been increasing year by year since 2004, and has received great attention. Kansei Engineering's research on product shape, color, material, texture, etc. has played a pivotal role in the fields of automobiles, textiles, daily necessities, handicrafts, engineering and social services. In product categories with similar functions and technologies, shape optimization becomes the focus of design, and Kansei engineering technology can provide a theoretical basis for it. The perceptual image research and modeling optimization of products can be completed through the steps of product market research, acquisition of perceptual image, decomposition of modeling elements, establishment of mapping relationship and product design practice. [2][5]

3.2. Semantic Difference Method

The semantic difference method (SD method) is a method that uses scales to evaluate users' subjective feelings, and is a commonly used method in Kansei Engineering. It can convert users' perceptual cognition of products into accurate data, thus providing a basis for establishing a mapping relationship between perceptual cognition and design elements. [5] The steps to implement the semantic difference method are to select a certain number of perceptual words, select typical product pictures, determine the evaluation scale of perceptual words, compile the semantic difference scale, and then recruit subjects to conduct semantic difference experiments.

4. Research Process

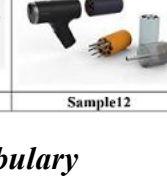
4.1. Design Positioning

In the early stage of product design, the design positioning must be clearly defined. The determination of the design positioning makes the design goals of the product more clear, and also provides a basis for later design evaluation. This research is mainly aimed at designing a hand-held electric grinding tool for the home use environment, which requires safety, beauty and easy operation.

4.2. Create Product Sample Space

Widely collected pictures of hand-held electric tools from the Internet, mainly obtained information from e-commerce platforms and designer communication platforms, and screened out 12 product pictures with large differences and covering many design elements to establish a product sample library (Table 1).

Table 1. Product sample library.

		
Sample01	Sample02	Sample03
		
Sample04	Sample05	Sample06
		
Sample07	Sample08	Sample09
		
Sample10	Sample11	Sample12

4.3. Analysis and Screening of Emotional Vocabulary

In Kansei engineering research, obtaining representative vocabulary is an important basis for further research. Emotional vocabulary is the description of the user's subjective feelings about the product. [1][6][7] Collect as many perceptual words about hand-held electric grinding tools as possible through various means to express the user's overall feelings on hand-held electric grinding tools. After preliminary screening, 50 perceptual adjectives related to hand-held electric grinding tools were obtained. According to the product demand of hand-held electric grinding tools, the perceptual words were distinguished according to innovation and reliability, and the semantic distinction map of handheld electric grinding tools was obtained (Figure 1).



Figure 1. Semantic Differentiation Map.

Further screened and paired by the semantic distinction map, the most common pairs of perceptual adjectives that meet the characteristics of household hand-held electric grinding tools are obtained: fashionable - traditional, concise - cumbersome, smooth - rigid, labor-saving - strenuous, powerful - feeble, amateurish - professional. On this basis, a semantic distinction scale (as shown in Figure 2) was established.

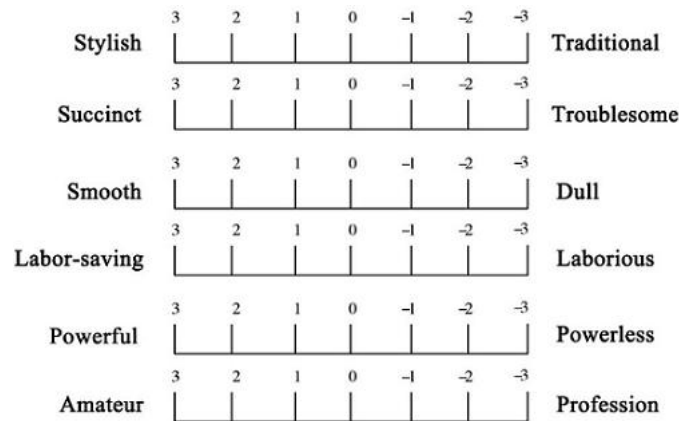


Figure 2. Semantic Discrimination Scale.

4.4. Relation Between Perceptual Vocabulary and Morphological Elements

The perceptual evaluation scale of perceptual vocabulary is listed by semantic difference method, and six perceptual adjective pairs are used as the evaluation scale. The scale is marked with values 3, 2, 1, 0, -1, -2, -3. Select 10 respondents to evaluate the sample based on the above adjectives, and the scale values correspond to “very agree with the left statement”, “agree with the left statement”, “relatively agree with the left statement”, “unclear trend”, “relatively agree The right statement”, “agree with the right statement”, “very agree with the right statement”, to indicate the degree of agreement or disagreement of the survey respondents with the adjective pairs of the sample. The interviewees scored their preferences for perceptual images (see Table 2 and Figure 3).

Table 2. Sample and Sensibility Vocabulary Relationship 1.

Samples	Kansei Evaluation Value (-3~3)					
	Traditional / Stylish	Troublesome / Succinct	Dull / Smooth	Laborious / Labor-saving	Powerless / Powerful	Amateur / Professional
Sample01	-0.6	0.8	1.6	2.3	2.5	-2.2
Sample02	0.5	0.4	-2	-2.2	1.9	-0.5
Sample03	1.9	1.6	1.7	-1	2.3	1.1
Sample04	2.5	2.2	2.3	1.3	-1.5	2.8
Sample05	2.4	1.9	2.1	1.6	-0.7	1.8
Sample06	1	1.4	2.1	-1.2	2.6	-1.7
Sample07	2.2	0.9	1.4	1.9	0.3	2.3
Sample08	-1.1	-1.3	-1.2	-1.7	2.1	-2.7
Sample09	0.8	1.5	2.5	2.6	1.3	1.6
Sample10	2.7	-2.4	-0.8	1.9	-1	2.4
Sample11	2.8	1.2	2.3	-2.1	-0.3	2.7
Sample12	2.1	2.2	-1.3	0.5	-0.7	1.7

According to the morphological analysis method, the hand-held electric grinding tools are divided into seven basic elements: contour shape, drill bit, button, handle, color, material texture, and gripping method. A comprehensive analysis of the

morphological elements of the 12 samples and their corresponding perceptual evaluation values shows that the perceptual demands of users for household electric grinding tools are as follows: simple curved surface shape; simple and easy-to-use drill bit replacement structure and switch mode . Comfortable grip method; Smooth operation steps; Flexible and portable use process.

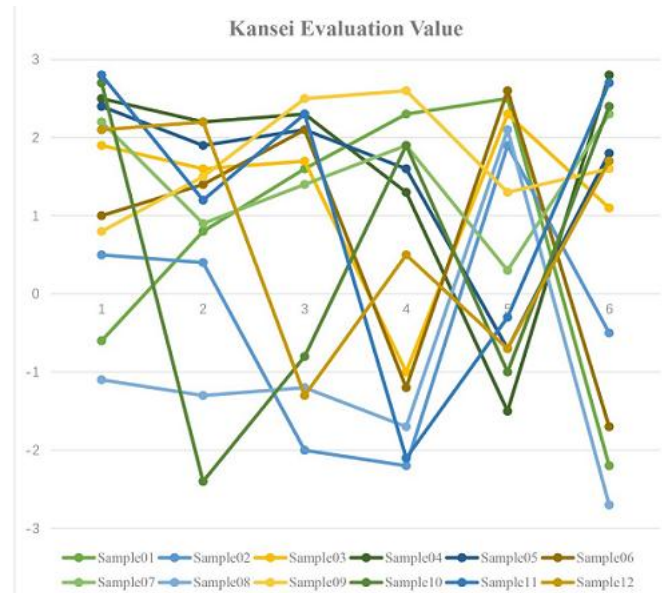


Figure 3. Sample and Sensibility Vocabulary Relationship 2.

5. Design Practice

According to the above analysis results, the design of household hand-held electric grinding tools should focus on how to improve the convenience of use and the fluency of operation in terms of meeting the perceptual needs of users. At present, the common hand-held electric grinding tools on the market need to manually replace the cutter head from time to time to meet the requirements of different operations. The selection and replacement process of the cutter head is time-consuming and interrupts the continuity of the worker's creation, resulting in the use of the product. The fluency and convenience of the game are inevitably affected. A corresponding solution is put forward to integrate and innovate the structure of the cutter head module and the electric grinding tool body. After design, the whole body is divided into five parts: 1. The cutter head clamping component 2. The motor transmission component 3. The cutter head Integrated conversion components 4. Battery components 5. Operation auxiliary components.

Because the target users are home non-professionals and handmade creation enthusiasts, this design is mainly used for non-professional purposes such as repairs, DIY home decoration and handmade product creation. It has a strong trend of family and life. Therefore, as a household product, it is to satisfy users' perceptual needs in terms of fashion, the design should have an appearance in line with the home environment, reflect the simplicity and delicacy of home appliances, and integrate with the visual experience of home life. Taking this as a standard, when designing the shape of the hand-held electric tool, it is possible to divide and nest on the basis of a simple straight shape, reducing the common bumps and ridges on the shell of professional electric tools, so that the appearance looks as simple as possible. The simple light prompts the power level, while enhancing the fashion sense, it also

simplifies the difficulty of use with its intuitiveness. Because it is mainly used for home use, low voltage, no wiring, the possibility of accidents is lower than that of professional electric tools, so it is possible to use plain colors that are more suitable for home atmosphere instead of overly conspicuous warning colors. [4] (as shown in Figure 4, Figure 5 and Figure 6)

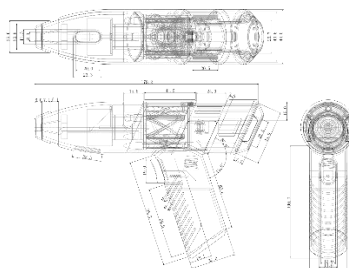


Figure 4. Exploded-View.

Figure 5. Product Dimensions.

Figure 6. Product renderings.

6. Epilogue

Kansei engineering is a technology that is oriented to the perceptual needs of consumers and develops new products based on ergonomics and computer science. It meets the needs of consumers and the trend of design development. In the design of the household hand-held electric grinding tool, the perceptual data analysis, perceptual test and perceptual evaluation were completed by using perceptual engineering. Among them, the morphological analysis method is used to decompose the morphological design elements of household handheld electric grinding tools, and the semantic distinction scale is used to interview and investigate product samples to clarify the morphological characteristics corresponding to each perceptual vocabulary, and finally complete the design proposal. Under the guidance of the Kansei Engineering method, the design process of household hand-held electric grinding tools becomes more systematic and orderly.

Introducing the method of Kansei Engineering into the product design process can effectively analyze the relationship between the form of the product, that is, the functional elements and the perceptual needs of users, and study the emotional changes that different design features have on users, so that based on a clear design positioning Find a better combination of form elements to meet the perceptual needs of users.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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