Study on the form design of silage equipment based on Kansei Engineering

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Abstract. In order to improve the product image and market competitiveness of silage equipment, the silage equipment form design model was established based on Kansei Engineering. Firstly, the market research analysis method was used to analyze the form design and target user characteristics of silage equipment, and the form design requirements were determined. Then, the correspondence between design requirements and form characteristics was established after the perceptual measurement experiment. Finally, the common elements and individual elements of the form characteristics were integrated into the product design. As a result, the feasibility of the silage equipment form design model is preliminarily verified.

1. Introduction

With the rapid development of China’s agricultural machinery industry and the vigorous implementation of the “grain to feed” policy, the functions and performance of silage equipment have been continuously improved. However, the problem of product homogeneity is prominent without much attention of a good form design. This results in that products that cannot satisfy the perceptual needs of users, lack of quality and market competitiveness. Kansei Engineering is a technical means to transform consumers’ perceptual cognition of products into design elements, and can provide an effective method for product form design. Mazda Motor Corporation's Yokohama Research Institute took the lead in setting up the “Kansei Engineering Research Laboratory”. The design of the Mazda Miata sports car has adopted the Kansei Engineering technology and achieved good results [1]. Scholars at the Linking University in Sweden established a Kansei Engineering research group in 1999 to apply Kansei Engineering to forklift design [2]. Google's scholars used eye tracking technology to study user behavior and publish a series of study results [3]. Researchers at the Eindhoven University of Technology in the Netherlands used eye trackers to simulate car driving to determine the driver's blind zone [4]. In China, the scholar at Shandong University applied semantic difference method and eye tracking method to the study of human-machine system design of loader [5]. Bi Yifei and other scholars used the theory of Kansei Engineering as the support to study the form design of accompany robot for the elderly [6].

Judging from the studies of domestic and foreign references, the main application fields of perceptual engineering are automobiles, engineering machinery, robots, etc. There are only a handful of applications in silage equipment.

2. Methods

This paper mainly uses market research analysis method, questionnaire survey method, semantic difference method (SD method) and eye tracking method. Usually the research process of Kansei
Engineering is divided into four stages: determining the design objectives, determining the perceptual vocabulary and product samples, perceptual measurement experiment and quantitative analysis and design implementation. First, the product design objectives are determined by analyzing product design elements and target user groups. Second, collect perceptual vocabulary and product samples and screen them. Third, carry on the perceptual measurement experiment to analyze the correspondence between perceptual vocabulary and product design elements quantitatively. Fourth, design the product according to the correspondence.

Based on the Kansei Engineering, the form design model of silage equipment (Figure 1) was constructed. Firstly, analyze the form design elements and target user characteristics of silage equipment by the market research analysis method to determine the form design requirements. Then, establish the correspondence between the design requirements and the form characteristics by the semantic difference method. Finally, the common elements and individual elements of the form characteristics are integrated to form the design plan.

![Silage equipment form design model](image)

**Figure 1.** Silage equipment form design model.

### 3. Preliminary analysis

In the preliminary research stage, designers need to conduct thorough investigation of the development status of silage equipment and target user groups to obtain design requirements.

#### 3.1. Analysis of silage equipment

Domestic silage equipment can be divided into three types: self-propelled, suspended and towed silage equipment. The self-propelled silage equipment (Figure 2) has high production efficiency, good maneuverability and large turning radius [7], but the power cannot be fully utilized and does not meet the consumption level of Chinese farmers. Although the production efficiency and work quality of the suspended silage equipment (Figure 3) are not as self-propelled, it has smaller turning radius and
lower price. Moreover, after use, its supporting power will not be idle. And it is more suitable for small and medium-sized farmers, so it has a higher market share. Although the towed silage equipment also has the above advantages, there is almost no advantage over the suspended silage equipment, due to its lower degree of mechanization, lower efficiency, and poorer quality of shredding.

![Figure 2: Self-propelled silage equipment.](image1)

![Figure 3: Suspended silage equipment.](image2)

Compared with other products, the performance design of silage equipment seems to be paid more attention than the form design. However, a good form design can not only bring users a new experience of use but also have a profound impact on corporate image. Industry leaders in silage equipment such as Klaas in Germany, John Deere in the US and New Holland in the US have long recognized the importance of form design. Although the appearance, craftsmanship and structure of their products are changing constantly, the core design elements have been used consistently to form a unique product image.

The study object of this paper is the modular suspended multifunctional silage equipment used in conjunction with tractors. It consists of a header, a power unit, a baling device, a coating device, a telescopic device and a lifting device. It can cut, smash, bale and coat corn straws, and it can also be self-loading.

3.2. Analysis of target user characteristics

50 questionnaires (Figure 4) were distributed to 18-45-year-old target users of silage equipment (farmers, professional operators of cooperatives and producers), and 45 questionnaires were recovered. Incomplete questionnaires were removed. After removing the incomplete questionnaire, there were 42 questionnaires remaining, accounting for 84% of the total questionnaire, which belonged to the effective questionnaire. Data statistics show that, simple, fashionable, cordial and realistic accounted for the majority in the personal image. Users are more inclined to share in the way silage equipment is used. In the desired product style, concise, upmarket and trendy accounted for the main part (Figure 5).

| 1. Your age: |
|---------------|
| □A. 18-25 |
| □B. 26-35 |
| □C. 36-45 |
| □D. >45 |

| 2. Do you have the experience of driving a silage equipment? |
|---------------------------------------------------------------|
| □A. Yes |
| □B. No |

| 3. What do you think of your personal image? |
|---------------------------------------------|
| □A. Simple |
| □B. Complicated |
| □C. Conservative |
| □D. Fashionable |
| □E. Cordial |
| □F. Cool |
| □G. Fantastic |
| □H. Realistic |

| 4. Which way do you expect to use silage equipment? |
|--------------------------------------------------|
| □A. Exclusive |
| □B. Shared |
| □C. Rented |

| 5. Which product style do you desire? |
|--------------------------------------|
| □A. Concise |
| □B. Trendy |
| □C. Upmarket |
| □D. Warm |

Figure 4. Questionnaire.
3.3. Analysis of form design requirements
According to the development status of silage equipment and the characteristics of target users, the form design requirements of silage equipment are fashionable, upmarket, concise and stable.

4. Establishment of correspondence and extraction of characteristic lines
Semantic difference method experiments are carried out on the form design elements according to the design requirements, and the correspondence between design requirements and form characteristics is established.

4.1. Screening of perceptual vocabulary
Through online stores, user reviews, brochures, manuals, related papers, books, magazines, newspapers and other means, a large number of perceptual vocabulary that can express the form and style of silage equipment were collected. The collected vocabulary contained many synonyms and partial words, which would affect the study results. Therefore, it is necessary to screen the perceptual vocabulary twice [8]. In the first screening, the words with similar meanings were integrated. The five most representative adjectives were obtained: personalized, trendy, concise, tough and cool. The five adjectives were screened for the second time to identify three adjectives that are most suitable for the form design requirements and pair them with antonyms. The survey was conducted by 40 teachers, students and designers for design majors. Finally, the perceptual adjective pairs screened are “trendy-classical”, “concise-complicated”, “tough-soft”.

4.2. Screening of form samples
Through browsing the agricultural equipment websites, 45 silage equipments of domestic and foreign mainstream brands were collected. By integrating products with similar form design elements, the six representative product form samples were obtained (Figure 6).

Figure 5. Questionnaire data statistics.
(a) (b) (c)

Figure 6. Form samples.
4.3. **Perceptual measurement experiment and establishment of correspondence**

Using the semantic difference method, all six samples were made into a 7-level semantic difference scale for investigation (Table 1), and the subjects scored the form samples.

| Trendy  | 3 | 2 | 1 | 0 | -1 | -2 | -3 |
|---------|---|---|---|---|----|----|----|
| Classic |   |   |   |   |    |    |    |

| Concise | 3 | 2 | 1 | 0 | -1 | -2 | -3 |
|---------|---|---|---|---|----|----|----|
| Complicated |

| Tough  | 3 | 2 | 1 | 0 | -1 | -2 | -3 |
|---------|---|---|---|---|----|----|----|
| Soft |

This investigation distributed 100 questionnaires to designers and graduate students for design majors. They have good economic conditions and have certain requirements for quality of life. 91 questionnaires were recovered containing 83 valid questionnaires. The average score of 83 questionnaire data was calculated by Excel, and the correspondence between the perceptual vocabulary and the form samples was obtained (Table 2).

The eye movement test was carried out on the product form samples to analyze the design elements affecting the form characteristics. The experimental subjects were selected as 40 students in the industrial design major. They were told to observe the parts that best can reflect the shape of the sample. By analyzing the eye movement hotspot map, it is found that the main area of the eye movement hot spot is at the outline and transition of the form (Table 2). Form characteristics of the form samples were extracted (Table 3).

| Eye movement hotspot map | Vocabulary | Eye movement hotspot map | Vocabulary | Eye movement hotspot map | Vocabulary |
|--------------------------|------------|--------------------------|------------|--------------------------|------------|
| Trendy | Complicated | Tough |
| Classic | Concise | Tough |
| Trendy | Concise | Soft |
| Classic | Complicated |

| Eye movement hotspot map | Vocabulary | Eye movement hotspot map | Vocabulary | Eye movement hotspot map | Vocabulary |
|--------------------------|------------|--------------------------|------------|--------------------------|------------|
| Trendy | Complicated | Tough |
| Classic | Concise | Tough |
| Trendy | Concise | Soft |
| Classic | Complicated |

| Extraction |
|------------|
| Form samples |
| Form characteristics |

5. **Integration of characteristics to the plan**

The common elements of the form samples characteristics corresponding to each perceptual adjective were extracted. They were integrated with the core design elements of the enterprise (Figure 7) to generate final form characteristics meeting design requirements. The design plan is formed by modeling and rendering with software (Figure 8).
6. Summary
Based on the Kansei Engineering, the silage equipment form design model was established. The form design requirements were generated after analyzing the form design and target user characteristics of silage equipment. Then the correspondence between design requirements and form characteristics was established after the perceptual measurement experiment. Finally, the common elements and individual elements of the form characteristics were integrated into the product design. The feasibility of the silage equipment form design model is preliminarily verified.

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