ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P1

# Intelligent rubbish Bin Based on KJ-KANO Model Innovative Design Research

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**Abstract:** A design study of the problem of outdoor rubbish bins exposed in modern society is carried out to explore a solution to the problem with the mostprogramme. Firstly, the KJ method was applied to obtain 14 user requirements for indoor temporary rest furniture; secondly, the KANO model was established based on the 14 user requirements and analysed to obtain the user requirement hierarchy; finally, the four-phantom line diagram was used to classify the requirements. And according to the research results, the programme decision-making design is carried out for the bin problem, which is used in the optimization of the final design scheme, providing a new solution and research idea for solving the existing bin problem.

**Keywords:** kano model; user requirements; industrial design; product design; smart bins

## 1. Introduction

Intelligent rubbish bin, as a key part of smart home system and smart city construction, plays a pivotal role in promoting environmental protection and improving residents' quality of life. With the increasing popularity of the Internet and smart devices, contemporary consumers are more and more inclined to embrace the intelligent mode of life. In the wave of consumer upgrading, many consumers have regarded the convenience of life, environmental friendliness and high quality of life experience as important considerations. Although domestic waste, especially perishable waste, can be recycled through scientific means, it still faces the challenges of difficult separation and complex management. In addition to the shackles of the traditional waste treatment model, the sustainable development of the waste classification and resource recovery industry is particularly difficult. Currently, there is a lack of intelligent bins that can take into account multiple groups and meet diversified needs. Therefore, the design of a smart bin for users will undoubtedly become the key to solving many problems. This smart bin can not only significantly improve the user's experience of waste classification and disposal, but also more accurately meet the management and operational needs of community managers and users.

## 2. Analysis of the Current Situation of Existing Rubbish Bins

With the acceleration of industrialisation and the continuous growth of population, a large amount of rubbish is generated from production, consumption, service and other activities. In order to effectively deal with rubbish and improve the usage rate of users, technological innovations are needed to improve the efficiency of users in using and dealing with rubbish. Among them, Wang Chenghu [1] and others used the product innovation design method of INPD-ANP-TRIZ based on the concept of unconscious design to design smart bins; Huang Jinsong [2] and others clarified the design direction through scenario analysis combined with the AHP hierarchical analysis method, and ultimately designed a household smart bin product; and Li Jing [3] and others designed a smart bin product that is suitable for community use, based on the FOgg Behavioural Model in three aspects. Intelligent bin classification and recycling equipment for community use; Du Xuelin [4] and others used neural network MobileNetV2 model and migration learning method to further provide reference ideas for the research and development of intelligent classification and waste disposal devices.

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P1

### 2.1 Core Pain Point Analysis

Based on the existing survey, the core pain points of smart bins are:Therefore, according to market research and user feedback, there is not yet a smart bin product that can interact with overflow reminders. Although some smart home products cover the function of waste management, the functions are scattered, no interactive interface, and it is difficult to form an effective synergy, thus hindering the overall user experience.

In order to solve the above problems, the KJ method, KANO model and four-quadrant model can be used to conduct in-depth analysis of the current situation and demand mining, analyse the potential functional requirements of different user groups by collecting their detailed needs, and identify the key demand factors through the four-quadrant scatter diagram, so as to transform them into the appearance design and interactive system functional modules of the smart bin, and achieve efficient integration of the needs of multiple groups. The research process of smart bin design, see Fig. 1. With the development of digital technologies (such as IoT, AI and big data analysis), the future smart bins will not only be simple trash storage devices, but also intelligent systems that can autonomously learn user behaviours, optimize the trash recycling paths, and provide real-time data analysis and feedback, which will provide a strong support for the environmental protection industry and the construction of smart cities.

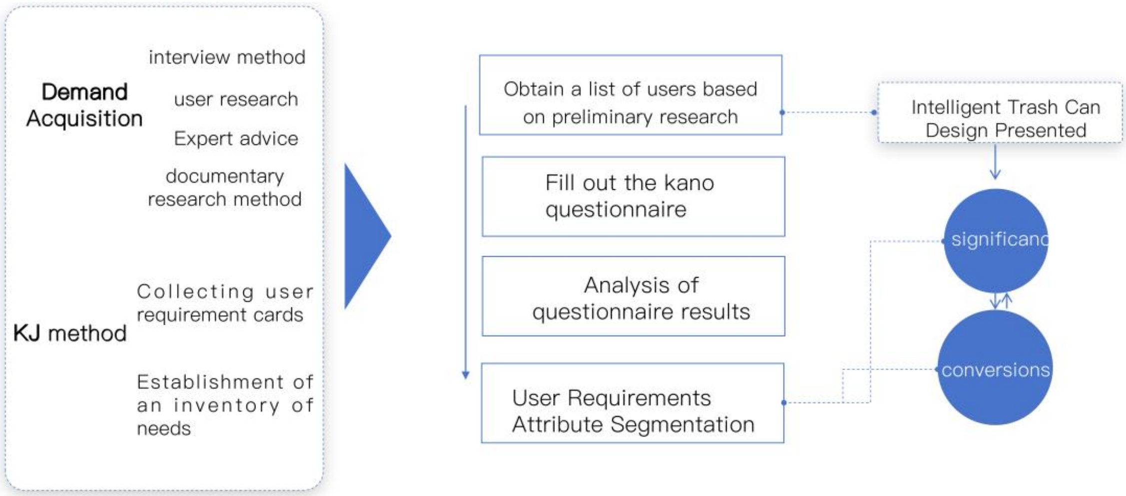


Fig. 1 Research flow of intelligent rubbish bin design

## 3. Research Methods of User Requirements

### 3.1 User Requirements Acquisition Based on KJ Method

3.1.1 KJ method process development

Kawakita Jiro Method (KJ Method), proposed by Japanese scholar Jiro Kawakita, also known as Affinity Diagram, is a research method used for information organisation, problem analysis and creativity diffusion. The method is widely used in design research, user requirements analysis, quality management and other fields, which can help scholars clarify their thoughts, refine core information and form systematic solutions when facing complex problems. Tang Xi [5] and others use the KJ method to complete the design study of beekeeping devices; Liu Fuqin [6] and others complete the innovative design of forest fire trucks based on the KJ method; Zhou Feng [7] and others use the KJ method to analyse the human-computer interaction interface of mechanical products and grasp the production usability solutions. This method can effectively analyse the key information of the data, form structured product design ideas, and improve the user experience and market competitiveness of smart bins.

Identify 30 interviewees: the interviewees of this research are 20 community users and 10 are community cleaning workers.

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P1

Collecting interviewee requirements: Inform the theme of this seminar is the functional design of smart bin products, aiming at guiding the interviewees to think out of the box and discuss the functional requirements of smart bins in depth. Provide a part of the function association expansion key vocabulary, key vocabulary, see Figure 2, can help the interviewees to think about the functional requirements from different perspectives. And the collected vocabulary is organised and optimised to make the functional description more precise and comprehensive.

Aggregation requirements: collate user information, refine key words, integrate synonyms, and exclude semantically similar words.

Organise and classify requirements: Integrate requirements that relate to the same category into three-level indicators, and attach them under the same second-level indicators, and finally group them under the first-level indicators.

Form a list of smart bin user requirements.

The flow of KJ method to obtain user requirements of smart bin is shown in Figure 3.

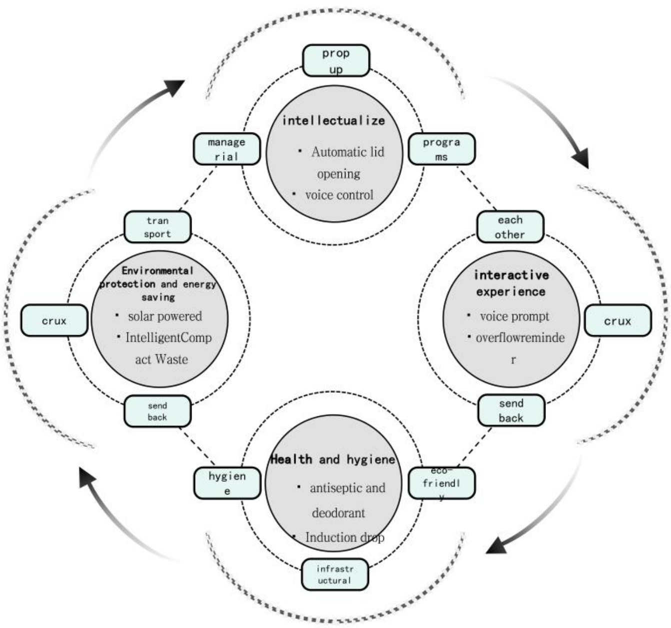


Fig. 2 Associations to expand key vocabulary

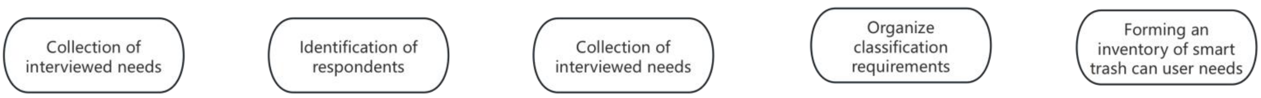


Fig. 3 Flow of KJ method to obtain user requirements for smart bins

3.1.2 User requirement card design

Focusing on the theme of ‘Smart Bin’, we expand our thinking widely and associate in depth, and meticulously excavate the core elements that are closely related to its functional requirements. Through careful sorting, integrate and summarise similar or common functional points, and at the same time accurately eliminate redundant or irrelevant information, to form a concise, standardised and clear smart bin function card to ensure the comprehensiveness and reasonableness of the functional design. Finally, a clear demand card is formed. See Table 1 for the smart bin user requirement card.

Table 1 Smart Bin User Requirement Card

| serial number | user requirement item |
| --- | --- |
| 1 | woody material |
| 2 | Sealed anti-odour |

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P1

| | |
|---|---|
| 3 | medium-sized |
| 4 | Conforms to man-machine dimensions |
| 5 | smart touchscreen |
| 6 | baling |
| 7 | LED screen to show status |
| 8 | colour matching |
| 9 | Large capacity design |
| 10 | monitoring system |
| 11 | voice control |
| 12 | waterproof and dustproof |
| 13 | Induction lid opening |
| 14 | Simple styling |

3.1.3 User demand indicators

Based on the user demand analysis and combined with the actual application scenarios of the smart bin design, three main demand categories are identified, which are named as: functional demand, modelling demand and technical demand. These three categories of demand are used as secondary indicators of intelligent bin product demand, and further combined with the actual use environment, a complete product demand system is constructed. The system contains 14 tertiary indicators, which comprehensively reflect the user requirements of smart bins, see Table 2.

Table 2 Indicators of user demand for intelligent rubbish bins

| offerings | control indicator | serial number | demand indicators |
|---|---|---|---|
| Intelligent rubbish bin | Functional requirement A | A1 | waterproof and dustproof |
| | | A2 | Large capacity design |
| | | A3 | Sealed anti-odour |
| | | A4 | Induction lid opening |
| | | A5 | baling |
| | | A6 | Conforms to man-machine dimensions |
| | Modelling requirements B | B1 | Reliable material |
| | | B2 | Simple styling |
| | | B3 | medium-sized |
| | | B4 | colour matching |
| | Technical requirement C | C1 | voice control |
| | | C2 | smart touchscreen |
| | | C3 | LED screen to show status |
| | | C4 | monitoring system |

## 3.2 Kano Model Construction

The Kano model, proposed by Japanese scholar Noriaki Kano in 1984, is a tool for analysing the relationship between user needs and satisfaction. The model emphasises that different types of needs do not have the same impact on user satisfaction, and that the fulfilment of some of these needs does not significantly increase satisfaction, while others may bring more than expected surprises [8]. The Kano questionnaire can identify and classify user needs, which in turn can optimise product design and enhance user experience. Among them, Han Dawei [9] and others used the KANO model to propose a 'simple and practical' headboard design scheme from the perspective of aging research; Mao Hong [10] and others analysed the new path of modern desk products based on the KANO model, and put forward the design concept of a liftable desk.

Adopting the Kano model and strictly following the classification system of Kano evaluation results, this study accurately classifies the user needs of smart bin services into five major categories: basic needs (M), glamour needs (A), expectation needs (O), undifferentiated needs (I), and reverse needs (R). It is worth noting that questionable results (Q) often stem from the

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P1
respondent's understanding bias or operational errors, so they are usually excluded as invalid data in the data analysis session. Based on the above careful categorisation [11], this study further prioritised the user requirements. For details of the evaluation results against the Kano model, see Table 3.

Table 3 Comparison of Kano model evaluation results

| Functions/Services | | the reverse problem | | | | |
|---|---|---|---|---|---|---|
| | | very happy | that's the way it should be | cannot be said be | accept sth. reluctantly | unsatisfactory |
| forward-looking issue | very happy | Q | R | R | R | R |
| | that's the way it should be | M | I | I | I | R |
| | cannot be said be | M | I | I | I | R |
| | accept sth. reluctantly | M | I | I | I | R |
| | unsatisfactory | O | A | A | A | Q |

In the statistical questionnaire, attitudes were collected for the secondary indicators of the smart bin function list in both positive and negative dimensions, and these data were collated and filled in Table 3. As a result, an analytical quantitative table of the 28 findings was obtained, which in turn led to the specific values of R, A, M, I, O, and Q. The data were then analysed to see if they could be used as a basis for the analysis. For the neediness scores of each need type, the calculation is detailed in Equation (1), where the category with the highest score is judged to be the main need attributed to the function.

3.2.1 Based on kano questionnaire design

In order to accurately measure the subtle differences in users' satisfaction with the demand elements, this study adopts the KANO questionnaire design concept proposed by Sauerwein, and carefully constructs positive and negative probing questions for each demand element. Specifically, the feedback of users when the demand element is satisfied and when the demand element is not satisfied were explored in depth to comprehensively assess the users' perception of demand.

In the questionnaire, five levels of satisfaction were set for each question, namely, ‘very satisfied’, ‘should be’, ‘don't care’, ‘barely accept’, ‘accept’, ‘don't care’, ‘don't care’, ‘don't care’, ‘don't care’, ‘don't care’ and ‘don't care’, ‘Barely Acceptable‘ and “Dissatisfied”, aiming to comprehensively measure users’ subjective feelings and attitudes towards specific demand elements [12]. The questionnaire is presented in Table 4.

Table 4 KANO questionnaire presentation

| questionnaire question | Questionnaire content | | | | |
|---|---|---|---|---|---|
| forward-looking issue | How would you feel if it was converted into a ‘smart bin setup’? | | | | |
| | very happy | that's the way it should be | cannot be said be | accept sth. reluctantly | unsatisfactory |
| the reverse problem | How do you feel when the ‘smart bin setup’ is not modified? | | | | |
| | very happy | that's the way it should be | cannot be said be | accept sth. reluctantly | unsatisfactory |

3.2.2 Basic Information Analysis

The questionnaire was distributed in the form of electronic questionnaires, and a total of 101 questionnaires were recovered. In order to ensure the reliability of the data, the questionnaires were screened for validity according to the established criteria: participants were required to make choices for both positive and negative descriptions of each demand, and there was no logical contradiction between the choices. After this process, 96 valid questionnaires were screened.

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P1

Based on the basic statistical information collected from the questionnaires,that there is a balanced distribution of gender and age, and most of the users have had experience in using smart wastebaskets. And the overall data organisation was carried out to get the summary table of KANO category users of smart bins, see Table 5.Overall, the data set shows good rationality and representativeness.

Table 6 Summary of KANO Category Users of Smart Waste Bins

| Generalisation project | serial number | Demand indicators | Type of requirement | | | | |
|---|---|---|---|---|---|---|---|
| | | | A | O | M | I | R |
| Functional requirement A | A1 | waterproof and dustproof | 52 | 1 | 1 | 30 | 6 |
| | A2 | Large capacity design | 12 | 0 | 5 | 56 | 18 |
| | A3 | Sealed anti-odour | 43 | 4 | 12 | 31 | 4 |
| | A4 | Induction lid opening | 10 | 37 | 12 | 26 | 8 |
| | A5 | baling | 12 | 1 | 6 | 56 | 20 |
| | A6 | Conforms to man-machine dimensions | 16 | 24 | 26 | 14 | 6 |
| Modelling requirements B | B1 | Reliable material | 23 | 21 | 28 | 23 | 0 |
| | B2 | Simple styling | 14 | 0 | 0 | 39 | 31 |
| | B3 | medium-sized | 19 | 2 | 3 | 61 | 9 |
| | B4 | colour matching | 17 | 12 | 36 | 26 | 2 |
| Technical requirement C | C1 | voice control | 1 | 42 | 40 | 3 | 9 |
| | C2 | smart touchscreen | 13 | 36 | 16 | 26 | 4 |
| | C3 | LED screen to show status | 16 | 20 | 15 | 19 | 11 |
| | C4 | monitoring system | 27 | 23 | 13 | 24 | 5 |

# 4. Research Results and Analysis of User Requirements

## 4.1 Reliability and Validity Analysis

Table 7 shows in detail the results of the reliability and validity tests of the questionnaire data. According to the values of the Cronbach Alpha coefficient in the table, it can be ensured that the overall reliability of the Kano questionnaire and its positive and negative questions is high; at the same time, all the KMO values exceeded the critical value of 0.8, coupled with the results of the Bartlett's test of sphericity showing 0, which is a strong proof that the questionnaire not only possesses excellent structural validity, but also its data are extremely reliable. This result fully meets the strict requirements of research analysis and lays a solid data cornerstone for the in-depth development of subsequent research work.

Table 7 Questionnaire reliability and validity tests

| sports event | Cronbach αratio | KMOworth | Bartlettsports event |
|---|---|---|---|
| Kano questionnaire | 0.863 | 0.918 | 0 |
| forward-looking issue | 0.912 | 0.887 | 0 |
| the reverse problem | 0.857 | 0.874 | 0 |

## 4.2 Better-Worse Analysis

Better-Worse is an effective means of measuring the extent to which a product or service feature affects user satisfaction. In this case, the Better coefficient, also known as the satisfaction index, reflects the extent to which user satisfaction can be increased after the provision of a feature or service, and its value ranges from 0 to 1. The closer the value is to 1 [13], the more significant the enhancement effect of the feature or service on user satisfaction is, and the higher the corresponding priority is. The Worse coefficient, or dissatisfaction index, on the other hand, reveals the extent to which user satisfaction will decrease if a feature or service is not provided, and its value lies between -1 and 0. The closer this value tends to -1, the greater the impact of the absence of the feature or service on user dissatisfaction [14], and its priority will likewise be higher.

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P1

Table 8 Better-Worse coefficients for smart bins

| Generalisation project | serial number | Demand indicators | Satisfaction factor | |
|---|---|---|---|---|
| | | | SSI | DSI |
| Functional requirement A | A1 | waterproof and dustproof | 63.10% | -27.38% |
| | A2 | Large capacity design | 31.76% | -2.53% |
| | A3 | Sealed anti-odour | 56.37% | -29.21% |
| | A4 | Induction lid opening | 82.61% | -71.04% |
| | A5 | baling | 69.07% | -24.91% |
| | A6 | Conforms to man-machine dimensions | 50.00% | -62.50% |
| Modelling requirements B | B1 | Reliable material | 31.87% | -52.75% |
| | B2 | Simple styling | 31.76% | -23.53% |
| | B3 | medium-sized | 24.71% | -5.88% |
| | B4 | colour matching | 46.32% | -51.58% |
| Technical requirement C | C1 | voice control | 51.43% | -50.00% |
| | C2 | smart touchscreen | 53.85% | -57.14% |
| | C3 | LED screen to show status | 68.21% | -41.23% |
| | C4 | monitoring system | 57.47% | -41.38% |

Better coefficient is also called satisfaction coefficient (SI), Worse coefficient is also called dissatisfaction coefficient (DSI), Better coefficient and Worse coefficient are calculated as follows: Better-Worse coefficient of intelligent rubbish bin, see Table 8.

$$\begin{cases} S_{SI}= (S_A+S_O)/ (S_A+S_O+S_M+S_I) \\ D_{DSI}= (S_O+S_M)/ (S_A+S_O+S_M+S_I) \end{cases} \quad (1)$$

### 4.3 Type Analysis Based on Four-Quadrant Model

A four-quadrant scatterplot of the functional demand satisfaction of smart bins was constructed using the mean value of SSI and DSSI as the dividing line, in which the satisfaction and dissatisfaction coefficients were used as the vertical and horizontal coordinates, respectively. The four-quadrant scatter plot of the satisfaction of each functional requirement of smart bin products is shown in Fig. 4.

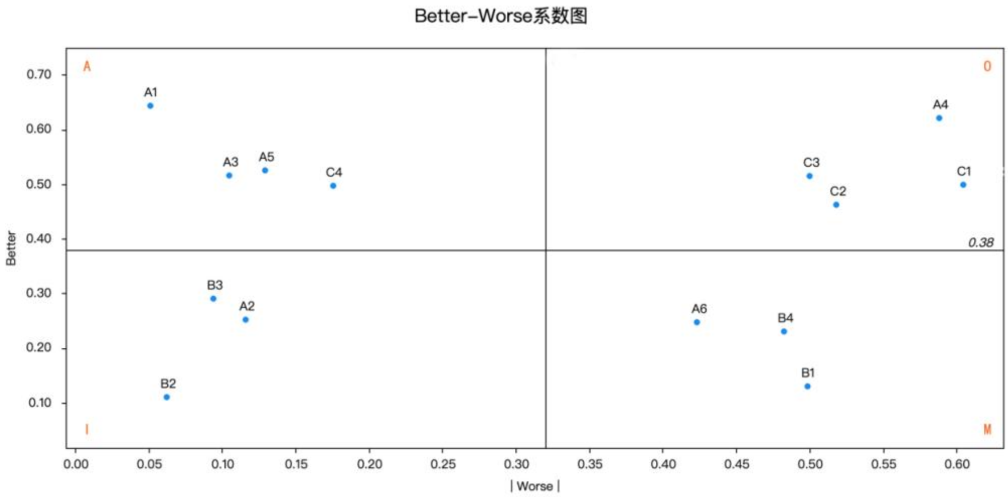


Fig. 4 Quadratic scatterplot of smart bins

The user's functional needs are distributed in the form of a hierarchy, based on the data derived above, it is concluded that the user's functional needs for smart bins are mainly reflected in the 3 basic attributes, 4 desired attributes, 4 glamour attributes with the 3 and undifferentiated needs.

The 3 basic needs (M): 40 < B < 50; -65 < W < -55, in the fourth quadrant of the four-quadrant model, ‘conformity to man-machine dimensions’ ‘wood material The three items of ‘human-machine size’, ‘wood material’ and ‘colour matching’ refer to the basic functions that users

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P1
think the smart bin should have. Therefore, these three functions need to be fully integrated into the design to ensure that the user's demands are accurately met.

Expected demand (O) 4 items: $50 < B < 60$; $-65 < W < -50$ The first quadrant focuses on the expected demand of the users, and if the smart bin incorporate these functions, it will significantly increase the user's satisfaction, and vice versa, it may weaken the user's satisfaction experience. During the design process of the smart bin, all efforts should be made to realise these functions in order to meet users' expectations.

Attractive demand (A) 4, in the second quadrant of the four-quadrant model, means that if there are such functions as ‘waterproof and dustproof’, ‘sealing and anti-odour’, ‘quantitative packing’, it will greatly The second quadrant means that if there are such features as ‘waterproof and dustproof’, ‘sealing and odour-proof’ and ‘quantitative packing’, it will greatly enhance the satisfaction of the users, and even if the demand is not realised, the satisfaction of the users will not fluctuate. Therefore, there is no need to over-exert resources in the design process to optimise these three requirements.

The undifferentiated requirement (I) 3, which is located in the third quadrant of the four-quadrant model diagram, is characterised by the fact that it does not have a significant effect on user satisfaction regardless of its presence or absence. Therefore, in the user design of the smart bin, these three requirements can be designed as additional features aiming to provide a richer and more diverse user experience.

## 5. Intelligent Rubbish Bin Innovative Design

(1) Design for basic needs: The natural wood-coloured material is used as the main construction material, aiming to blend harmoniously with the environment and add a touch of natural beauty. At the level of modelling design, the overall bin cleverly presents a regular hexagonal structure, which not only enhances the structural stability of the bin, but also doubly improves the convenience and aesthetic appreciation of the user's rubbish disposal.

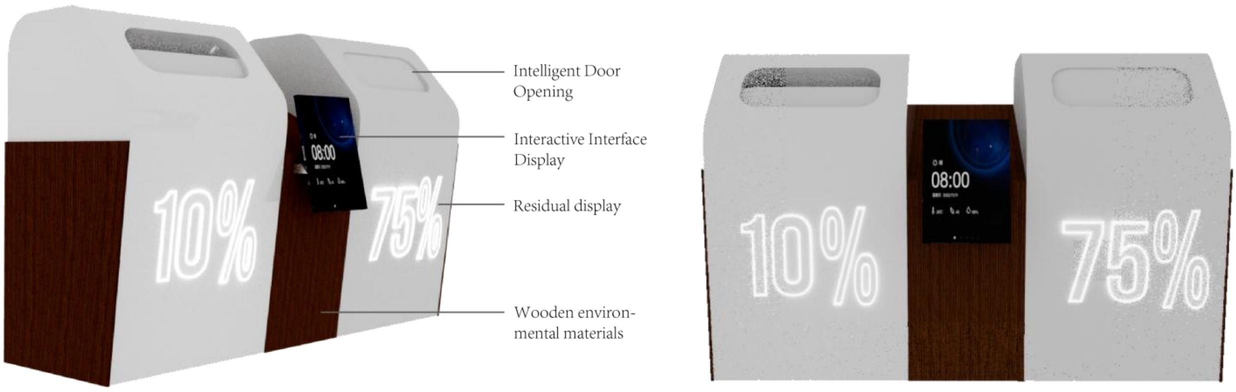


Fig. 5 Intelligent Wastebasket Design Solution

(2) Design for Expected Demand: Realising the expected demand of a product is one of the important strategies to enhance user satisfaction. In order to further optimise the user experience, it is proposed to integrate a percentage display of the remaining capacity on the front of the bin. This design not only provides the user with intuitive information about the current status of the bin, but also encourages the user to manage the rubbish more rationally, so as to avoid overfilling or underfilling of the bin. In order to further enhance the intelligence level of the product, an intuitive and easy-to-use touch screen interface is designed, which not only provides a wealth of functional options, but also can be intelligently adjusted according to the user's operating habits, thus improving the user's operating efficiency and satisfaction .

(3) Design for glamorous needs: Among the design elements of the bin, ‘waterproof and dustproof’, ‘sealed and anti-odour’, ‘quantitative packing’ and ‘monitoring system’ are taken into

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.3.1.P1
consideration. The four core requirements are ‘waterproof and dustproof’, ‘sealed and odour-proof’, ‘quantitative packing’ and ‘monitoring system’. Among them, ‘waterproof and dustproof’ and ‘sealed and anti-odour’ belong to the physical level of design, aiming to achieve the improvement of environmental adaptability and hygienic performance through physical means. In order to achieve this goal, the design cleverly incorporates an intelligent on/off switch structure to provide effective isolation when necessary, ensuring that the bin can not only resist the intrusion of external moisture and dust, but also effectively sealed to prevent the leakage of internal odours and maintain a good operating environment. The ‘Quantitative Packaging’ and ‘Monitoring System’ focus on innovative design at the technical level.

# 6. Conclusion

This study closely follows the actual needs of community users, uses the Kano model to deeply analyse the mapping of users' needs in terms of smart bin services, and meticulously categorises the 14 needs extracted. By combining the demand hierarchy with the Better-Worse coefficient, the priority order of each bin modification content is clarified. On this basis, an intelligent bin design strategy based on the interaction behaviour model is proposed as the cornerstone. This strategy closely matches the current high demand for interactivity and intelligence in society, and aims to help users use the product more smoothly. It not only provides a solid theoretical basis for the design of community service products, but also provides a design strategy with reference value, which is of far-reaching practical significance to meet the actual needs of users in an all-round way.

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