Innovation Design of Persimmon Processing Equipment Driven by Future Scenarios

DUAN Xiao-fei 2, SU Xiu-juan 3, GUAN Lei 4 and ZHANG Wei-she 1,5
1 School of Engineering Machinery, Chang’an University, Xi’an 710064, Shan Xi, China.
2 sharfling@foxmail.com, 3 739618547@qq.com, 4 956461303@qq.com, 5 zwshe@chd.edu.cn

Abstract. This article aims to discuss the methods of innovative by future scenarios design, to help the designers be more effective of the design of persimmon processing machinery. By analyzing the persimmon traditional processing process, conceiving persimmon processing future scenarios and using the UXD and Morphological matrix, it can get the comprehensive function schemes. It Select the most optimal schemes which match the future scenarios best by illustrating the schematic design of the rotary-light Dried-persimmon Processing Machinery. It is feasible and effective to carry out the scenario design research and construct the reasonable future scenario, and combine the function analysis method to carry on the product plan innovation and the development.

1. Introduction
With the progress of industrial society, product replacement cycle is shorter and shorter, and effective product innovation design method can accelerate the development of new products. In the development of the product, to build the future scenario, the product concept can be gradually specific, conducive to finding unexpected discoveries (UXD) for innovative design [1] [2]. Based on the future scenarios, use functional analysis and morphological matrix for functional scheme integration, conducive to do a more comprehensive and more targeted design.

Persimmon processing in our country has a long history, mainly made to be dried persimmon. The existing persimmon processing equipment, have the problems of labor intensity, time-consuming and low-quality [3]. In this paper, the persimmon processing equipment scheme is innovatively designed by the combination of future scenarios, UXD and morphological matrices to improve the quality and production efficiency of persimmon and provide an effective method for the development and innovation of persimmon processing equipment.

2. The construction of persimmon processing in future scenarios
2.1 Build future scenarios of persimmon processing
(1) Persimmon traditional processing needs to achieve the main functions are: cleaning, peeled, up-shelf, drying or baking, kneading, frosting, down-shelf and storage, etc. [4]. The processing and equipment we designed need to ensure the persimmon's taste and texture, as far as possible in accordance with the traditional process to achieve the function, do not merge in this deletion.
(2) Persimmon up-shelf and down-shelf are reciprocal behavior, which could combine into an action.
(3) The environmental space of "drying" scenario and the "frosting&storage" scenario are
similar, which can be combined and share a set of environmental space equipment; "up-shelf" and "down-shelf" are the mutual action, which can share a set of structures. Among them, in the "persimmon peeling" scenario, the current semi-automatic peeled machine to meet the basic requirements, so follow the original technology and equipment. In the process of artificial kneading, the times of press is lesser, and the operation is sophisticated; on the contrary, the cost of the robot is expensive and the frequency of use is low, the effect is less than the manual. Figure 1 to Figure 3 shows the series of scenes, depicting the future of persimmon formation.

3. Design and optimization of persimmon processing equipment

In fact, the function of the product is often complex and diverse, the scheme design is the process of defining the product features and functional solving of the product[5]. In the process of design, the morphological matrix is constructed by the functional definition, functional decomposition and functional element solving of the product, and the possibilities of the design scheme are obtained. On this basis, the scheme design will be brought back to the future scenario that has been built, select the optimal solution which meet the design requirements.

3.1. Functional analysis

Functional decomposition is an important step in the design of innovation[6], according to Figure 1 to Figure 3 the three scenarios in the future scene of the use of equipment, persimmon forming process, to get the functional decomposition results shown in Figure 4. The "persimmon up-shelf" and "persimmon down-shelf" share a set of equipment, the functions both are fixed persimmon. The three processes of "Drying", "frosting" and "storage" are mainly affected by the environment, which is related to the temperature, humidity, wind speed and other factors, collectively referred to as drying function. The "kneading" process need human intervention, defined as kneading processing function. The final shape of persimmon are shaped with the space and shape constraints, defined as shaping function.

3.2. Scheme integration

According to the results of the functional analysis in Figure 4, the feasible realization of the corresponding functional scene is extracted by analyzing the unexpected discovery (UXD) and future scenarios of persimmon processing, resulting in possible sub-functional solution. According to the morphological matrix synthesis method to get a large number of possible design[7], as shown in Table 1, theoretically available persimmon processing and forming equipment, the number of integrated scheme N = 192.
Figure 4. Persimmon processing equipment functional decomposition.

Table 1. The solving of morphological matrix.

| Sub-function | Possibility scheme |
|--------------|--------------------|
| 1             | 2                  | 3               | 4               |
| A placed of Persimmon | pulling plate | Mold fixed | Free placement | Space mobiling |
| B Drying processing | Natural light | photothermal hot air | photothermal cold air | Naturally dry |
| C kneading processing | Hand kneading | Four-bar mechanism | Manipulator kneading |
| D shaping processing | Horizontal squeeze | Vertical squeeze | Mold shaping | Natural forming |

3.3. Determine the feasible scheme
Morphological matrix can provide a large number of solutions, and it is difficult to select, so according to the functional compatibility and the need gratification the two principles to screen, to get the following four feasible solutions.

Scheme 1: Semi-automatic Simple Persimmon Molding Equipment (A1 + B2 + C1 + D4). The dry time and the ambient temperature of this scheme are controllable. The use of artificial kneading and natural forming, effectively reduce the cost of equipment, but the labor workload. The pulling plate placing device can improve the equipment space utilization, and according to the site, the placing device can expand in both vertical and horizontal.

Scheme 2: Natural Light Rotary Persimmon Forming Equipment (A4 + B1 + C1 + D3). This scheme simulates the natural environment, to ensure persimmon taste, and the dry time and ambient temperature are controllable. Processing process transparent, there is a certain ornamental. But need manually kneading, the workload is greater. Due to the simulation of traditional processing methods, the production cycle is longer.

Scheme 3: Automatic Persimmon Forming Equipment (A2 + B2 + C2 + D1). This scheme has a high degree of automation, shorter processing and forming cycle. But the equipment structure is more complex, and the higher production costs. It is applicable to a single small amount of persimmon fast processing and shaping processing.

Scheme 4: Persimmon processing and rapid forming equipment (A3 + B3 + C3 + D3). This scheme has a high degree of automation, and the kneading process is unity, fine, and the results of the consistency of good. The machine and mold control forming, shaping faster, modeling more accurate.

3.4 Scheme Optimization
The above four schemes are matched with the proposed future scenario model, and the application of the cost analysis method and the fuzzy evaluation method are used to optimize the scheme[8][9], and
select the optimal scheme. Scheme 2 Compared with other programs, its advantages are: ① mobile truss components transform from horizontal to multi-layer rotation, making full use of space, at the same time, facilitating the flow of air in the equipment; ② the equipment appearance transform from the opaque box to the transparent shell, using ambient light to drying, which is more energy efficient.

4. Functional design of the scheme
Design the structure of the optimal functional design scheme, that is, natural light rotary persimmon forming equipment, and considering the human-machine-environment constraints to optimize the scheme[10], the final model is expressed by the Computer three-dimensional model. The result is shown in Figure 5.

4.1. Persimmon placement structure design
Persimmon "kneading area" and "mold forming area" have the door with $3 \times 1.2 \text{m}$, as shown in Figure 6. The staff can fix the persimmon on the persimmon dish from the both sides, after the completion of the persimmon formation, also from this area off the shelf.

4.2. Drying processing structure design
Equipment drying processing mainly through air flow and natural light to exchange the heat produced by persimmon, improve the efficiency of persimmon processing. In the drying process, the truss module is in a rotating state, powered by the motor, and assisted by chain and orbital to rotate, as shown in Figure 7. The fan provides the air source of the internal space, and the airflow discharges moisture from the outlet along the path shown in Figure 8 (a), and can be in full contact with the persimmon surface. In the truss, the persimmon is placed staggered between the upper and lower layers, increased the airflow and persimmon contact opportunities, and the air flow has a good guiding effect because of the truss trapezoidal mouth design, as shown in Figure 8 (b) below.

![Figure 5](image1)
**Figure 5.** Construction Scheme of Light Rotary Persimmon Forming Equipment.

![Figure 6](image2)
**Figure 6.** Double door structure scheme.

![Figure 7](image3)
**Figure 7.** Rotation structure scheme.

![Figure 8](image4)
(a) (b)
**Figure 8.** Closed space airflow path

![Figure 9](image5)
**Figure 9.** Structure of frame and persimmon disc

4.3. Kneading processing structure design
In the process of persimmon formation, the persimmon truss is fixed on the rotating structure. When
the persimmon truss unit is rotated to the kneading area, the persimmon is pressed. In the persimmon truss unit, the persimmon disc adopts the pull type, as shown in Fig. 9, to facilitate the operation and speed up the kneading speed. Here can use the external equipment to pinch or manual press pinch in two ways, which is high flexibility.

4.4 Persimmon shaping structure design

The persimmon shape is implemented in the mold forming area, in the same time the other side of the device can knead the persimmon. It use mold to forming, as shown in Figure 10, put the corresponding mold of persimmon plate just on the persimmon for a period of time, and use the force of gravity to shape the persimmon. For the kneaded persimmon, do the forming operation. The the force of gravity of the mold forming, the standing time and the pressing times are all from experiments. "Five-pointed star" persimmon shaping results shown in Figure 11.

5. Conclusion

In this paper, based on the construction of future persimmon forming scenario model, the functional matrix of the persimmon shape forming equipment is solved and the morphological matrix is used to synthesize multiple functional schemes. The optimal four functional schemes are matched with the future situation model. Finally, a functional scheme of persimmon shape forming equipment with high matching degree is obtained: the light rotary persimmon shape forming equipment, and expressed and illustrated by the three-dimensional entity. It verified that construct the reasonable future scenario and combine the functional analysis method to innovate and develop the product scheme is feasible and effective.

Figure 10. Persimmon shape forming mold.

Figure 11. "Five-pointed star" persimmon shape.

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