

The Design of a New Type Fruit Dicing Machine

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Abstract: The demand for fruit is very large, especially fresh-cut fruit is more and more popular, custom-cut fruit machine has emerged. However, the current market of automatic cutting machine exists in general low efficiency, poor applicability of the problem. The author has carried on the market research according to the people's consumption habit, and has completed a new-type fruit cutting machine design. In this paper, a small automatic dicing machine is designed for household use, which adopts the design idea of household appliances, in the work efficiency, product appearance, the use of experience and manufacturing costs to give the most appropriate solution, the use of rotary cutter plus combination of cutter design of raw materials to cut into ding. The structure of the cutting machine is designed by 3D modeling software, and the rationality of the design is verified by movement simulation and finite element analysis. After the design is completed, some physical models are made to verify the working principle of the core structure, and the improvement scheme is put forward. The experiment shows that the fruit cutting machine can complete the specified task, cutting efficiency is higher, fruit waste less, fill the gap in the market, but also provide a reference for other designers.

Keywords: New Type; Minibench; Fruit; Cuber; Verify

1. Introduction

At present, the demand of fruit consumers has changed greatly, and new requirements have been put forward for the packaging style, taste and freshness of products. Compared with ordinary unprocessed fruits, fruit cubes are easier to be canned and packaged in boxes, and the appearance of the product will be more

exquisite, and it will be more convenient to eat, and it is more suitable for sale as leisure food [1]. At present, the preparation of diced fruit is still manually processed by using simple tools, with limited production efficiency and uneven quality. The dicing machine used by medium and large enterprises is limited by its size, price and use environment, and it is difficult to be the first choice for small and medium-sized enterprises to improve productivity [2].

In the design, we use solidworks 3D modeling software to carry out dimensional and appearance design of each component, use finite element analysis tools and strength calculation formulas to check the strength of important structural components, and finally analyze the physical model of functional executive components to verify the rationality of its design [3]. The design focuses on considering the user experience of consumers, the overall use of detachable split design, more convenient cleaning, the whole machine is more concise and hygienic. The main working principle of the dicing part adopts the design of crosscutting knife and combined knife net, which is more simple and compact in structure, and can effectively control the overall volume of the machine. Appearance parts use plastic as the main material, its production efficiency is higher, and the appearance is more beautiful, more attractive to consumers. Other parts in direct or indirect contact with food ingredients are made of food-grade metal materials to ensure the health of the product [4].

2. Overall Design Scheme

The dicing machine designed in this paper is mainly for the daily use of small and medium-sized restaurants, fruit shops and families, and the raw materials are common fruits and vegetables that can be made into cubes, such as apple, cucumber, eggplant, radish and so on. Therefore, the volume of the equipment should be as light as possible, and

the weight should be controlled within a certain range [5]. Daily use should meet the needs of convenience and speed. And dicing machine belongs to food processing machinery, such products after the use of cleaning is particularly important, the design should be considered.

Material selection as a whole in accordance with the design ideas of household appliances, the whole machine and raw materials directly or indirectly in contact with the part of food grade materials, to ensure the food safety of the product. The non-important structural parts are made of ABS plastic, which is more beautiful and easy to clean than metal [6]. Other components such as cutting tools, the shaft is made of 316 stainless steel, which has similar mechanical properties compared with 304 stainless steel, a commonly used food machinery metal material, but has stronger corrosion resistance, and can also be used as food grade materials [7].

The final use of split type design, the whole machine is divided into two parts of the host and the cup body, the connection of the more use of rotary button structure, to achieve the purpose of easy disassembly and cleaning, while ensuring the integrity of each part. The minimum bolt connection also makes the appearance more overall beautiful and more attractive to consumers [8].

3. Transmission Scheme Design

According to the use environment, the motor is selected as the machine power source, and the selection of the motor is calculated. The center of the rotary cutter is taken as the force point, its moment-arm $L=0.075\text{m}$, the cutting force during cutting is 80N , and the rotational speed of the rotary cutter is $v=120\text{r/min}$.

The minimum output torque of motor:

$$T = F \cdot L = 80 \times 0.075 = 6\text{N/m} \quad (1)$$

The minimum output power of the motor:

$$P_w = \frac{T \cdot n}{9550} = \frac{6 \times 120}{9550} = 0.075\text{Kw} \quad (2)$$

The effective power of the motor:

$$P_d = \frac{P_w}{\eta^3} = \frac{0.075}{0.99^3} = 0.077\text{Kw} = 77\text{w} \quad (3)$$

The transmission part uses the split type design as a whole, and the shaft is connected with the sleeve tenon in the mortise and tenon structure as shown in Figure 1. Mortise and tenon structure is a traditional Chinese solid

wood furniture and large wood structure, when connecting two members, a convex joint is used: the convex part is called the tenon (or mortise), the concave part is called the tenon (or mortise, mortise). It can meet the needs of convenient disassembly and cleaning after daily use, and the maintenance is also more convenient.

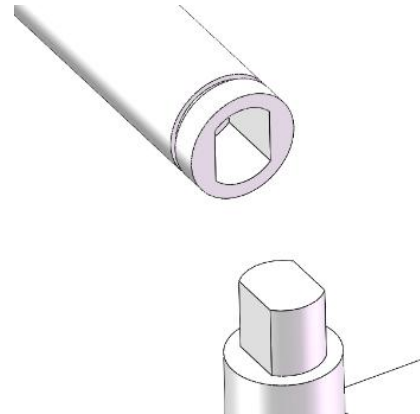


Figure 1. Tenon Construction

The dicing assembly is mainly composed of a rotary cutter and a combined cutter net and a tool rest disc, as shown in Figure 2.

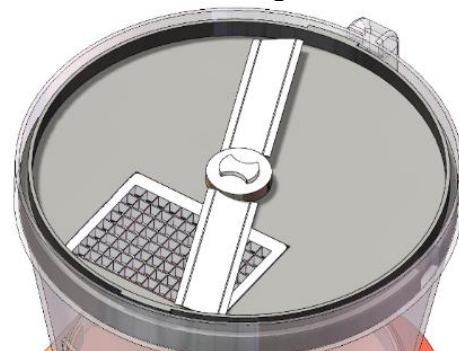


Figure 2. Diced Assembly

As shown in Figure 3, the knife mesh has a variety of specifications of $8\text{mm} \times 8\text{mm}$, $10\text{mm} \times 10\text{mm}$, $12\text{mm} \times 12\text{mm}$, $14\text{mm} \times 14\text{mm}$, which can meet different product needs. The blade is 0.5mm thick, and the upper edge is opened to ensure clean cutting and blanking. Combination knife net independent design, can be directly removed from the tool holder tray replacement or cleaning, convenient and fast.



Figure 3. Different Specifications of the Combination of Knife Nets

There are two kinds of cutting tools: linear reciprocating and rotating. Analysis of the linear reciprocating cutting knife on the market, its work will produce a certain extrusion of the material, thus causing damage to the material, so that it loses a certain amount of water, the quality of the slice is general, corresponding, because of its non-linear movement, the rotary cutting knife not only has the effect of "cutting" during processing, but also has a certain displacement in the direction of the blade relative to the material, resulting in the effect of "cutting". The slicing is more crisp, and the damage to the material is small, the water loss is small, so the slicing effect is better; On the transmission structure, the linear reciprocating cutter adopts eccentric wheel and crank slider mechanism, which will have certain impact and vibration when working, and the transmission components are easy to wear, and the machine life will be affected by it. The rotary cutting tool is simple in structure, only composed of shaft and tool, smooth transmission, small wear, long service life; In terms of production efficiency, the linear reciprocating cutter is limited by its structure, and the speed increase space is limited, and the rotary cutter is relatively easier to improve the work efficiency.

The common dicing machine on the market now, including three-dimensional dicing machine, plane division class dicing machine, the storage part is separated from the theme of the equipment, which often requires more space than the machine when used, in order to solve this problem, this paper adopts an integrated design to make the storage part and the main body of the machine as a whole. The structural design is shown in Figure 4.

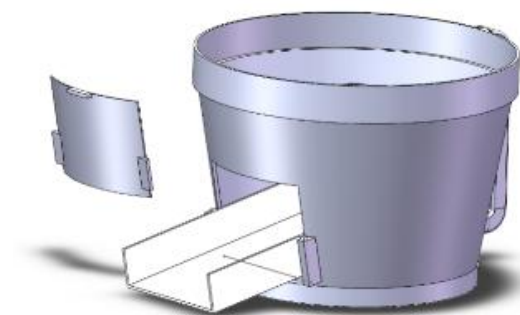


Figure 4. Storage Cup Body

The side of the cup body is provided with a handle for convenient hand-holding, and the

front is opened to make a feeding port. In order to facilitate discharging, the processed fruits and vegetables can slide out along the chute and fall into the prepared storage container. If required, the chute can be removed and the side cover installed, at which time the cup body can be used as a container to store materials.

The material of the cup body is ABS plastic, which is lightweight and non-toxic, pollution-free, and more beautiful. The wall thickness is set at 3mm to ensure that it has a certain strength and is not easy to damage. When the cup body is used as a storage container, its 10L volume can store a large number of processing materials.

3.1 Complete Machine Design

Different from traditional industrial equipment, home appliances should have a sense of design while having certain functions, and their design mainly refers to the "people-oriented" principle of amenity. In recent years, the term "ergonomics" has been introduced into the design of many furniture and household appliances. It is to consider the user's experience in the design, so that they feel relatively comfortable when using the product. This is a very important point in the design of modern home appliances.

The machine is 600mm high and 350mm wide. Placed on the table with a common height of 600mm to 700mm, the highest point can reach 1200mm-1300mm, which is in line with the arm comfort range of people with a height of about 165cm when standing. Central shaft diameter analysis. Select the Z6BLD200-220GU motor for reference, the output shaft diameter $D_1=15\text{mm}$, and the central shaft is connected with a sleeve tenon structure, and the central shaft is selected with the same shaft diameter $D_2=15\text{mm}$. The feed port adopts a semi-circle with a radius of 60mm to ensure that the material can pass through the whole, and the mesh cutter size is set to $100\text{mm} \times 130\text{mm}$, while ensuring that the rotary cutter can completely cut the material, and its size $D=300\text{mm}$. At this point, the size of the tool holder is determined. In order to ensure that the cup body has a certain storage function and ensure the overall appearance of the machine coordination, the height

H=200mm. The height of the main machine is mainly determined by the motor, and its height H=200mm.

The designed parts are built in solidworks 3D models and assembled, as shown in Figure 5.

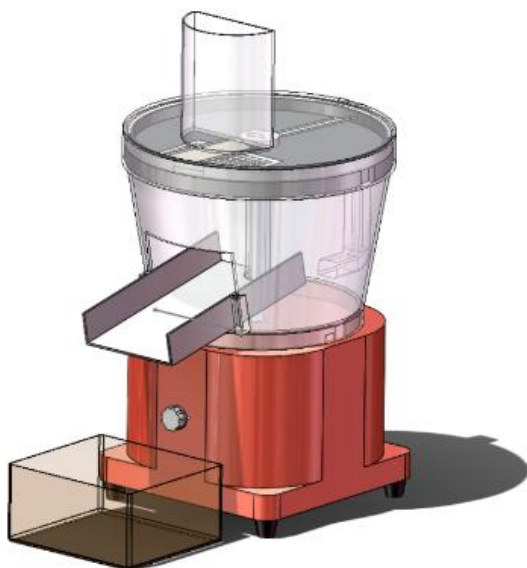


Figure 5. Assembly Diagram

3.2 Working Experiment and Analysis of Dicing Machine

Physical analysis is to obtain relevant data and check design defects through experiments with scaled or proportional physical models, which can provide important data support in subsequent design and improvement. The small bench dicing machine designed in this paper has a relatively simple structure. In order to verify the reliability of the design, a physical model for experiment is made.

The experiment mainly verifies the working principle of dicing components. The raw materials that can be processed in the design are common seedless fruits and vegetables such as dragon fruit, radish, eggplant, etc. In the experiment, apples are used as raw materials due to conditions. Two whole apples were selected as raw materials, with a total weight of 387 g before processing. Before dicing the apple, the core was removed manually with a fruit knife, and the apple was sliced. In order to observe the influence of the apple skin on the working process, the apple was not peeled during the experiment. By removing the irregular wool fragments which did not meet the quality requirements, 242g

apple cubes with complete shape were prepared, and the yield was calculated to be 62.5%. According to the conditions found in the above experiments, the design is improved. It is mainly applicable to seedless fruits such as strawberry, dragon fruit, banana, melon and fruit vegetables such as radish, eggplant, cucumber and so on. For the problem that it is difficult to clean the clogging material of the grid knife when cleaning after use, a matching grid knife cleaning tool is designed to improve the use experience.

4. Conclusions

The small desktop dicing machine designed in this paper can meet the needs of common fruits and vegetables dicing processing such as radish, eggplant, dragon fruit, strawberry, banana, cucumber, etc. The replaceable combination knife net can make the machine cut different sizes of dicing, which can basically meet the needs of beverage shops, small and medium-sized restaurants, cantages and daily household. The overall use of split design, the cup body can be separated from the host, in addition to the host can be completely immersed in water, can meet the daily use of disassembly and cleaning needs. The main shell adopts ABS as the main material, which ensures the process and mechanical properties while being beautiful. The front of the host is equipped with a hierarchical speed control knob to meet the needs of different scenarios, and the back is equipped with a switch, which can be started or closed with a key. The whole structure is simple, the operation is convenient, the function is complete.

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