

Research Article

Method of Humanity Design for Food Slicer

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Abstract: The main purpose of the research is to investigate an effective method of humanity design for food slicer, thereby raising the external appearance quality and pleasant of food slicer, strengthening additional value and whole shape effect of product, satisfying the demand of market competition and creating higher economic efficiency. The article elaborates on the humanity design of each part of the slicer, including selecting electric motor and V belt, the design of V belt pulley and color design, to introduce the structure adjustment and manufacturing requirement of the slicer, based on which the conclusion has been reached.

Keywords: Color design, food slicer, humanity design, slice thickness

INTRODUCTION

The slicing technology has already been developed mature abroad in 1970s, in the mid-eighties most of the slicers can process mono-crystal with large diameter up to 125 mm (5 inches), like the horizontal inside diameter slicing machine manufactured by Mayer Bbu Geyer company in Switzerland which can slice materials with the maximum diameter up to $\phi 304.8$ mm (12 inches). In the following one or two years in the mid-eighties, the slicing technology has experienced its peak of development, many of the automatic multi-function slicers have been commercialized (Xie, 1996).

As to the structure of the slicer, it can be divided into horizontal type and vertical type (Zhou, 2003), which depends on its principal shaft supported by the air bearing or rolling bearing. There're inside diameter slicer, outside diameter slicer, single-blade slicer and multi-blade slicer and the former one is more popular. In the mid-1980s, wire saw, a cutting machine which has a unique design and is totally different from the traditional slicing technology, has come to the semiconductor market quietly, which uses a steel wire to coil the four guide wheels to form hundreds of saw bands. When they operate in a high speed, the silicon carbide will be taken to the machine to produce the effect of cutting. Its advantages are to cause less kerf, small deviation, even cut surface, big quantity and less costs. Its application in the market has created a new chapter for the cutting technology in the 21st century (Huang *et al.*, 1996).

The function of the slicer has been very complete, composite and the way of slicing is diverse. The comb shape cutting machine in 1980s is not new anymore, which has been replaced by the cutting and rotating one, surface grinding one and the one with an air cushion which can prevent the blade from bending and

distorting, which can repair and maintain the blade automatically (Jiang, 2013). The chip material can roll and grind by itself while cutting, which can reduce the bending of the mono-crystal. In recent years, Tokyo Precision Corporation in Japan has developed and produced a processing system, which combines the steps of loading mono-crystal into machine, slicing, transmitting slices, dismantling graphite bearing pad, chamfering, scrubbing, inspection, sorting and storage etc, to realize the full-automation for processing by connecting many equipments and devices of many kinds according to the technological working flow (Liang, 2003).

The main purpose of the research is to investigate an effective method of humanity design for food slicer, thereby raising the external appearance quality and pleasant of food slicer, strengthening additional value and whole shape effect of product, satisfying the demand of market competition and creating higher economic efficiency.

MATERIALS AND METHODS

Selection of the electric motor: It's a good choice to use Y series motor which has an international interchangeability, can prevent the dust, iron scurf and some other foreign substance intruding into the interior and is B class insulation. It requires the temperature of working environment can't exceed +40°C, the relative humidity can't exceed 95%, the altitude can't be above 1000 m, the rated voltage shall be 380v and the frequency shall be 50 Hz, which only applies to the mechanical machine without special requirement (Jiang and Du, 2012).

The model number of the electric motor is Y90S-6 according to the Mechanical Design Manual. It can be placed on the left or the bottom of the shelf. See the

Table 1: Selection of the electric motor

Model No.	Power rating/kw	Full load speed (r/min)	Rated torque		Efficiency
			Locked rotor torque	Peak torque	
Y90S-6	0.75	910	1.5	2.2	0.70

following parameter: The motor is the Y series three-phase asynchronous motor, as shown in Table 1.

Selection of V belt: The narrow V belt uses synthetic fiber rope or steel wire as its bearing bed. Compared with the ordinary V belt, when they have the same thickness, its width is 30% less. The narrow V belt's transmission power is stronger than the ordinary one's, which allows high speed and bending frequency, has a shorter transmission center distance and is suitable for the transmission of high power and compactness-required structure. The outstanding character of household slicer is light and handy, so the narrow V belt is chosen in its design.

Working coefficient KA = 1.0 (Mechanical Design Manual, form 12-1-67). Transmission power P = 0.75 KW, design power of the synchronous belt Pd = KaxPd = 0.75×1.5 KW = 0.75 kW. Efficiency of the transmission belt = 0.9, efficiency of the shaft transmission = 0.75×0.9 = 0.7 kW.

Transmission ratio: Rotational Speed of principal shaft = Rotational Speed of big pulley = 425 r/min.

Rotational Speed of motor = Rotational Speed of small pulley = 910 r/min:

$$\text{Transmission ratio } i = \frac{n_1}{n_2} = \frac{425}{910} = 2.14$$

Selection of the small pulley's diameter: Rotational Speed of small pulley n1 = 910 r/min. The dimension of the pulley's diameter is calculated by the speed reducing ratio, which is designed according to the working rotational speed and motor's rotational speed. Working Rotational Speed/Motor's Rotational Speed = Driven Pulley's Diameter/Driving Pulley's Diameter×0.98 (sliding coefficient):

- Initial small pulley's datum diameter dd1 ≥ (dd) min, (dd) min = 90 mm
dd1 = 140 mm shall be chosen according to Mechanical Design Manual, form 14.1-8
- Checking belt speed:

$$V_1 = \frac{\pi d_{d1} n_1}{60 \times 1000} = \frac{3.14 \times 140 \times 910}{60 \times 1000} = 6.67 \text{ m/s}$$

Small Pulley's Rotational Speed 5 < V1 < 25 m/s

- Calculation of the Big Pulley's datum diameter:
dd2 = idd1 = 2.14×140 = 299.6 mm
- Calculating the center distance a and choose the narrow V belt's datum length Ld:

- According to the overall dimension's restrictive condition or the required center distance of the transmission belt, based on formula (8-20), the initial center distance is a 0:
 $0.7 (dd_1 + dd_2) \leq a_0 \leq 2 (dd_1 + dd_2)$
 $307.72 \leq a_0 \leq 879.2$

Finalizing the center distance a0 = 400 mm

- **Calculation of the relevant belt's length Ld0:**

$$Ld_0 \approx 2a_0 + \pi/2 (dd_1 + dd_2)$$

$$\approx 800 + 690.2 + 15.9$$

$$\approx 1506.1 \text{ mm}$$

The belt's datum length Ld is chosen from form 8-2 1600 mm.

- **Calculation of the center distance a and its fluctuation range:** Transmission's actual center distance is approximate to:

$$a = a_0 + (Ld - Ld_0) / 2 = 400 + (1600 - 1506.1) / 2 = 447 \text{ mm}$$

Considering the manufacture error of the pulley, belt's length error, elasticity of the belt and the need of supplementing the tension because of the loose belt, the fluctuation range of the center distance is normally given as the following:

$$a_{min} = a - 0.015Ld = 447 - 0.015 \times 1600 = 423$$

$$a_{max} = a + 0.03Ld = 447 + 0.03 \times 1600 = 495$$

- **Checking the wrap angle α1 on the small pulley:** The wrap angle α1 on the small pulley is smaller than the wrap angle α2 on the big pulley and the total friction force of the small pulley is relatively less than the big pulley's, so sliding can only happen to the small pulley. In order to improve the transmission working ability, the following formula should be used:

$$\alpha_1 \approx 180^\circ - (dd_2 - dd_1) 57.3^\circ / a \geq 90^\circ$$

$$\approx 180^\circ - (299.6 - 140) 57.3^\circ / 447 = 159.5^\circ$$

- **Finalizing the number of the belts:** In order to make each V belt bears strength evenly, the number of the belts should not be too many, normally less than 10, or else, the belt with larger cross-sectional area shall be chosen to reduce the number. Here the number of the belts is z = 2.

- **Calculation of belt's initial pulling force F0:** Considering the influence of the centrifugal force and wrap angle, the minimum initial pulling force of each V belt shall be:

$$(F_0)_{\min} = 500 \times (2.5 - K\alpha) \times P_{ca}/K\alpha \times z \times v + qv^2 = 500 \times (2.5 - 0.925) \times 0.825/0.925 \times 2 \times 6.67 + 0.1 \times 6.667 = 53N$$

The actual initial pulling force of the belt shall be larger than 53N.

- **Calculation of the force F_p in belt transmission:** In order to design the bearing of the pulley, the force F_p imposed on the shaft in belt transmission needs to be calculated:

$$F_p = 2zF_0 \sin \alpha / 2 = 213N$$

Design of V pulley: The wheel hub of the pulley is normally connected by key. The main requirements towards pulley are light in weight, good workmanship, even distributed mass and the groove face that is in contact with the ordinary V-belt should be bright and clean to reduce the wear of the belt. As to forging and welding the pulley, the internal stress needs to be small.

According to the size of the diameter, the frequently-used pulley's structures include type S: solid pulley (used for the small-sized one), type P: plate pulley (used for the small and medium-sized one), type H: orifice plate pulley (used for the pulley with bigger size) and type E: pulley with oval wheel arms (used for the large-sized pulley). Because the angle between the two sides of the ordinary V-belt is 40° , in order to adapt the distortion of the cross-sectional area and the decrease of wedge angle when the V belt bends on the pulley, so the groove angle f of the ordinary V belt is stipulate as 32° , 34° , 36° , 38° (as per the type and diameter of the belt).

The four commonly-used structures are solid type, plate type, orifice plate type and wheel arms type. When the datum diameter is $d \leq 2.5d$ (d is shaft's diameter, the unit is mm), the solid type can be used. When it's $2.5d \leq d \leq 300$ mm, the plate type is normally adopted. When it's $D_1 - d_1 \geq 100$ mm, the orifice plate type is normally used. The wheel arms type is normally adopted when it's $d > 300$ mm. The design of the pulley's structure mainly depends on the pulley's datum diameter, as per belt's type and number to calculate the width of the wheel flange, as per belt's type to calculate the dimension of the wheel's groove. So small pulley $D = 108$ mm will take the solid type and big pulley $D = 272$ mm will take the plate type. Small pulley's width $L_1 = (1.5 \sim 2) \times d = 2 \times 16 = 32$ mm. Big pulley's width $L_2 = (1.5 \sim 2) \times d = 2 \times 45 = 90$ mm.

Color design: The color design is an important constituent part of the humanity design of food slicer, as color has more ocular, more strong and more attractive magic power than the body. The color could firstly influence the person's sense organs than the body, moreover, that could raise operator recognizing and watching degree to some operation controls, show instrument and appearance by making use of vision recognizing effect and psychology of color, sequentially, the function of these device could be well

developed and the mental request of operator could be satisfied and the work efficiency could be enhanced, in the meantime, the occurrence of production could be also reduced. The humanity design of the color of food slicer should follow the following few important points.

Satisfy the request of man-machine coordination:

The color design of food slicer should well embody the relation of man-machine coordination, so as to make operator's mood pleasant, have a sense of security, don't easily produce fatigue and then attain to the purpose of operating accurately and enhancing production efficiency. For example, generally, the base and body of food slicer properly adopt heavy and solid deep color, not only bearing dirty but also making person have the dependable sense of stability to machine. The workbench, sliding plate and other parts are the components that person usually use, which properly adopt bright color, so as to get rid of depressed feeling, satisfying the request of operating accurately and man-machine coordination.

Satisfy the request of environment and function:

The color should well express the function characteristic of product and mutually coordinate with the use environment. If the greasy dirt of use environment is serious, usually the dark color is proper for bearing greasy dirt. The color of the panel of food slicer generally properly use the neutral base color of low bright degree and low pure degree, contrasting with component color, so as to enhance the vision recognizing degree. The panel should have no strong reflection and dazzle light. The color of display part should be obvious and refreshing, but not dazzle eye. The color of caution part should be fresh and gorgeous to come into notice and the color of concealment part should be quiet, as shown in Fig. 1.

Value the choice of tone:

The choice of main tone of food slicer is a problem of very importance, the different tone will form different art effect. In matching color of food slicer, having main tone can seem to be to unify. The color is more little, the main body characteristic is more strong, the decorate characteristic is more good and the external form relation of food slicer is more unify. Contrary, the color matches more much, causing the color more disorderly, so that it is difficult to adjust generally, the main body characteristic is unclear and the harmonious effect is broken.

The choice of tone still needs to notice whether unique beauty. It needs to hold tight people's mental request for the color of food slicer, transform the tone of food slicer to make it produce an unusual attraction, in the meantime, increase the category of tone to satisfy people's fondness for different colors.

Moreover, the base, the body and other big pieces of food slicer are suitable to use a low pure degree color



Fig. 1: The color design of food slicer satisfying the request of environment and function



Fig. 2: The color design of food slicer matching the new age request of appreciation beauty

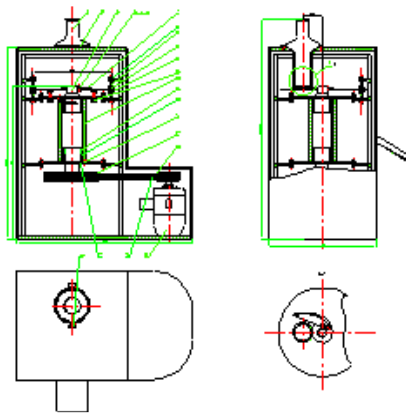


Fig. 3: The structure of the food slicer

as the main body color and use clear, elegant and clean color to unify overall situation to make the main tone definite. Using little area of high purity color to embellish to make the whole seem to be abundant, change and organic. The whole color generally uses monochrome or two sets of colors, not more than three sets of colors (Fu, 2002).

Match the new age request of appreciation beauty: With the progress of the age, the improvement of people's living standard and the increase of cultural art accomplishment, the appreciating beauty standards also change. In a certain period or a certain region or world scope, some colors are popular of people and are extensively popular, becoming the "popular color". The "popular color" has a strong age characteristic, as a result, in a period, it become the color which is used extensively. The color design of food slicer also should sufficiently consider using the "popular color" to accord with the age request, as shown in Fig. 2.

Notice novelty: The color design of food slicer should notice novelty and creativity to make it have vitality and more competitiveness. The color of food slicer not only can satisfy the request for appreciating beauty, under the particular condition, but also has strong influence, which can cause the transfer of people's emotion and interest to attract people's attention. For example, on an international industrial product exhibition, a red food slicer produced by some country appeared in the mechanical exhibition hall. Though the red is not the color that the food slicer consistently uses, the factory surprisingly adopted red color to decorate food slicer, causing the purchaser to crowd in its vicinity and then understood its function characteristics, which produced a surprising sensation effect and made its order enormously exceeded other nation. It is thus clear that the novelty of color design is very important.

RESULTS AND DISCUSSION

Structure adjustment: According to the requirement of material size, slice thickness and production efficiency, it could make the following adjustment to the food slicer (Liang, 2003).

Cutting speed: Through adjusting and replacing the belt pulley, changing its diameter ratio, it could realize the adjustment of cutting speed.

Slice thickness: Making use of the elevating system, it could change the slice thickness and make the slices processed by slicer have even thickness, neat cut surface, as shown in Fig. 3.

Manufacturing requirement: In order to reduce manufacturing costs and expand the applicable scope, as much as possible, the gear, the pulley and others that are used in the food slicer choose the standard parts in the market. It should also equip with some spare parts of different specifications for replacing to produce material of different slice thickness daily.

Installing the guide rail of the blade should make it forward tilt a certain angle (such as 20°), so that the blade steadily touches material until cutting off, reducing vibration (Liang, 2003).

CONCLUSION

- The food slicer is easy to install, repair and replace spare parts. The design is in accordance with principles of ergonomics and it is convenient to operate and safe and reliable to use.
- The overall structure of the food slicer is concise and reasonable.
- The manufacturing technical requirement and manufacturing cost of the food slicer is low and the standard parts are plenty, so general small and medium-sized machinery factories are all homemade.
- Making use of the elevating system, it could adjust the slice thickness according to the need.

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