Fruit Processing Equipment based on Model Processing

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Abstract. The technology and equipment of this study can improve the technical level of the equipment for peeling and cleaning of Camellia oleifera fruit. Based on the biological characteristics of Camellia oleifera fruit, the size distribution model of Camellia oleifera fruit was established, and the equipment structure and key parameters were determined based on the working principle and design method of the shelling and cleaning mechanism. Based on the analysis of the movement track of the shell stripping and cleaning executive parts, the test scheme is established, and it is optimized that when the crankshaft speed is 240-260r/min and the track speed is 0.4-0.6m/s, the treatment capacity can reach the level of 2000kg/h, and the purification rate is more than 99%. When the vibration frequency of the vibrating motor is set to 50Hz and the horizontal inclination of the separation belt is 50°~55°, the cleaning effect of the equipment is the best.

Keywords: Fruit, Peeling, Cleaning, Optimize

1. Introduction
Camellia oleifera fruit is used as raw material of high quality edible oil in China. It is an evergreen shrub or small tree [1]. Camellia oleifera in the world is mainly distributed in the Yangtze River Basin and south of China [2, 3]. By the end of 2019, the planting area of Camellia oleifera in China will be expanded to 68 million mu, and the output value of Camellia oleifera industry will exceed 100 billion yuan [4].

At present, in addition to the mechanical operation in the early stage of land preparation, the other production links of Camellia oleifera industry are mainly labor-intensive, labor-consuming and time-consuming, which not only leads to low production efficiency, increased production costs, but also makes it difficult to guarantee the operation quality [5-8]. The shelling of Camellia oleifera fruit is a heavy process of raw material treatment in the early stage of Camellia oleifera processing plant. If it is not shelled in time, it will affect the subsequent drying, storage and processing of Camellia oleifera seeds, and ultimately affect the quality and oil yield of Camellia oleifera [9-12]. The fruit of Camellia oleifera is mainly peeled manually after being picked and dried in the air. The research on mechanized husking methods and institutions of Camellia oleifera fruit is imminent [13-15].

Therefore, the project team plans to analyze and test the method and mechanism of peeling and cleaning of Camellia oleifera fruit. In accordance with the biological characteristics of Camellia
oleifera fruit, the size distribution model of Camellia oleifera fruit is established, and the equipment structure and key parameters are determined based on the working principle and design method of peeling and cleaning mechanism.

2. Feature of Machining Object
The size and shape of Camellia oleifera fruit are different due to the nature, variety, tending and other factors. The size of small fruits may be smaller than the seeds of large fruits. The shell of Camellia oleifera is thick and hard, and the shell of Camellia oleifera seed is thin and brittle. The above-mentioned reasons lead to high damage rate and low clarity during mechanical processing of Camellia oleifera, which makes the processing cost high. Besides, the damaged Camellia oleifera fruit and Camellia oleifera seed are prone to mildew, rot and oil rancidity due to the cloudy and cold weather from October to December in southern China, which seriously affects the product quality. Camellia oleifera fruits were collected in Hunan Province. A total of 1443 Camellia oleifera fruits were investigated.

The fruit diameter of Camellia oleifera varied greatly, ranging from 19 mm to 49 mm, with an average of 29.8 mm and a standard deviation of 5.66 mm. The transverse diameter of the fruit is mainly distributed between 22~38mm, reaching 90.37% of the total. Among them, most of the camellia fruits with a fruit diameter of less than 24mm contain only one seed. The number N of Camellia oleifera fruit was related to the diameter D of Camellia oleifera fruit:

\[ N = 14.43 \times (0.49 + \frac{84.4}{8.52 \sqrt{\pi / 2}} e^{-\frac{(d-28.08)^2}{8.52^2}}) \]  

(1)

3. Mechanism Design

3.1. Design of Roller Screen
The feeding inlet of the drum screen is high and the end is low, which is composed of multiple levels. Each level is distributed with different sizes of rectangular holes, and the sizes of the rectangular holes of each stage are different. From the entrance to the final export of the material, the size of the rear-grade rectangular hole is larger than that of the previous grade, and the camellia fruit that is smaller than the size of the first-grade rectangular hole falls from this grade. The material of this grade enters the subsequent processing link, and so on. The trommel screen carries out multiple classification treatments on the camellia fruit with a fruit diameter below 26mm, which effectively prevents the single seeds from breaking during the processing, thereby improving the processing quality of the
mechanism and reducing the processing pressure in the later processing links. At the same time, the trommel screen has a large grading difference of more than 26mm, which can effectively ensure the compactness of the mechanism and the processing capacity of the mechanism.

The productivity $P$ is calculated by the following formula:

$$P = \frac{3600z\lambda m}{1000 \times 1000}$$  \hspace{1cm} (2)

$Z$ is the total number of holes on the roller screen; $P$ is the productivity; $\lambda$ is the coefficient of the material falling from the hole in the same second, which varies with the classification machine and the nature of the material, and the roller type can take 1.0%~2.5%; $m$ is the average mass of the material. According to the productivity $P$, the total number of sieve holes $Z$ can be calculated.

3.2. Design of Rotary Speed of Roller Screen

The rotating speed $n$ of the trommel directly affects the screening effect, and is also closely related to the radius of the trommel. The force of the camellia fruit in the roller is shown in Figure 2:

![Figure 2. Stress of Camellia oleifera fruit.](image)

For the Camellia oleifera fruit in the drum as the particle $Q$, when it is in the rising angle $\beta$, it is under the action of gravity $G$ and centrifugal force $F_c$, then the friction force $F_f$ produced by the Camellia oleifera fruit on the drum screen; when the gravity component of the Camellia oleifera fruit along the tangent direction of the drum $G \sin \beta \leq F_f$, the Camellia oleifera fruit and the drum screen move upward together; when $G \sin \beta > F_f$, it begins to slide downward, which is also the highest point of the Camellia oleifera fruit on the inner surface of the drum. Therefore, when $G \sin \beta = F_f$, Camellia oleifera fruit is at the highest point of effective screening.

$$\begin{align*}
F_f &= f_0 (G \cos \beta + F_c) \\
F_c &= \frac{mv^2}{R} = \frac{Gv^2}{gR} \\
v &= \frac{2\pi Rn}{60} \\
f_0 &= \tan \varphi
\end{align*}$$  \hspace{1cm} (3)

$f_0$ is the friction coefficient between fruit and squirrel-cage sieve; $m$ is the mass of Camellia oleifera fruit; $g$ is the acceleration of gravity; $R$ is the inner radius of roller screen; $v$ is the linear velocity of $Q$ movement of Camellia oleifera fruit; $n$ is the rotation speed of roller screen; $\varphi$ is the friction angle.
Simplify with $G\sin\beta = F_f$:

$$n = \sqrt{\frac{900\sin(\beta - \varphi)}{R \sin \varphi}}$$

(4)

3.3. Design of Shelling and Cleaning Mechanism

When the camellia oleifera fruit is just picked, the high water content and the hard shell make it difficult to shell. Because the diameter of Camellia oleifera is different greatly, the designed kneading shelling machine should be divided into five levels on the basis of the diameter distribution. The fruit is screened by barrel sieve. The different size of Camellia oleifera fruit enters the different size of kneading cavity respectively, and the flexible kneading plate and flexible surface transport belt are used to move relatively on the Camellia oleifera fruit for kneading and shelling.

In the whole dehulling and sorting process, the crankshaft speed, rubber track speed, vibration frequency and the horizontal inclination of the sorting belt have an important influence on the processing effect, so these factors are mainly considered in the design and manufacturing process.

4. Result and Analysis

The roller screen of the camellia fruit processing equipment is designed to be 2.0m divided into 5 levels. Other main parameters are selected as follows:

| Number | Parameter name | Reference value |
|--------|----------------|-----------------|
| 1      | Productivity   | 1.5t/h          |
| 2      | Friction coefficient between fruit and squirrel-cage sieve | 0.4~0.6 |
| 3      | rising angle   | $\varphi^+ (5^\circ$~$10^\circ)$ |
| 4      | Density of material | 0.9~1.1g/cm$^3$ |
| 5      | Filling coefficient | 0.05~0.10 |
| 6      | Transmission efficiency | 0.6~0.7 |

The calculation results show that the radius of the roller screen $r = 268.58$mm, which is convenient for design to take 300 mm; the rotational speed $n (22.4r/min$~$31.6r/min)$, considering that the roller screen has a certain inclination $n (20r/min$~$27r/min)$; the power $P_{work} = 0.586$kw, so the power 0.75kw is selected to facilitate motor selection.

5. Conclusion

When the crankshaft speed is 240-260 r/min and the crawler speed is 0.4-0.6m/s, the treatment capacity can reach 2000 kg/h and the removal rate is over 99%. But with the increase of speed, the noise and wear of the machine increase, which is not conducive to the stable and lasting operation of the equipment. When the vibration frequency of the vibration motor is set at 50 Hz and the cleaning belt operation angle is 50° to 55°, the cleaning effect of the equipment is the best.

Therefore, comprehensive consideration of various factors, the most suitable process conditions are as follows: after picking, the cracked Camellia oleifera fruit is piled, retted and sun dried, the moisture content is less than 55%, the frequency of vibration motor is 50 Hz, and the cleaning belt operation angle is 50° to 55°. Under these conditions, the treatment capacity is more than or equal to 15000kg/h, the removal rate is more than or equal to 97%, the cleaning rate is more than or equal to 97%, the broken seed rate is less than 5%, and the loss rate is less than or equal to 1%.

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