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# Design and ANSYS analysis based on coconut dehusking machine

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## ABSTRACT

As the main cash crop in Southern China, coconut enjoys a high commercial value. However, coconut flesh suffers a high loss from the difficulty in dehusking process, and thus reducing the dehusking efficiency and value. This paper gives an ANSYS analysis of the newly designed coconut dehusking machine to testing its stability and reliability.

## KEYWORDS

Coconut; Dehusking machine; ANSYS analysis.

## INTRODUCTION

As a member of the family Arecaceae, the coconut tree is a typical woody oil-bearing plant. The coconut is known for its great versatility as seen in the many uses of its different parts. For instance, the coconut flesh is edible and the coconut oil can be used as a fuel. Hainan province is the main area of coconut cultivation in China; places like Guangdong, Guangxi and Taiwan also have very small cultivation areas. The coconut dehusking process is complicated and studies on the dehusking technology are still in the initial stage in all coconut cultivation countries around the world. Although main producing counties like Thailand have developed coconut dehusking machine, the application remains weak. Thus husking by hand remains to be the main way. However, with a higher risk of injury, hand-husking also has a low efficiency. As a researcher of the technology of coconut dehusking in China, we finally developed an automated-gripper coconut dehusking machine after continues research and experiments. This paper studies the stability and reliability of the machine through ANSYS analysis method.

## DESIGN OF THE COCONUT DEHUSKING MACHINE

### Working process

The coconut dehusking machine consists of four parts; they are clamping apparatus, mechanical hand, special cutter and the control system. Detailed working process is shown in Figure 1.

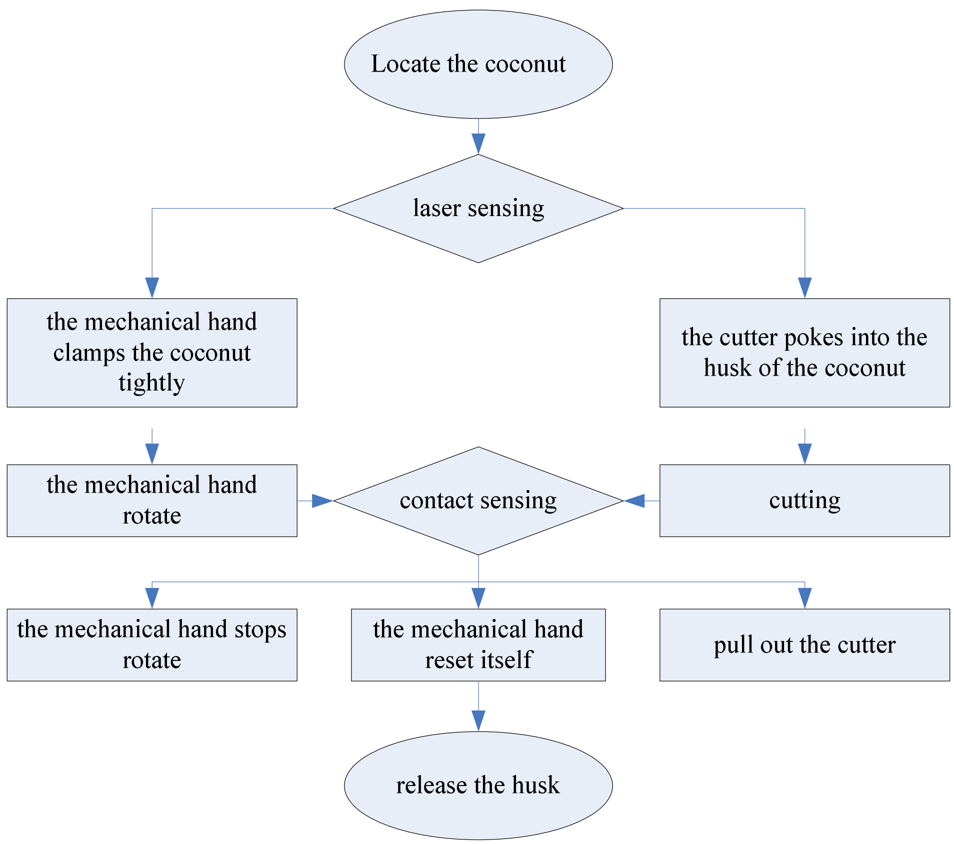
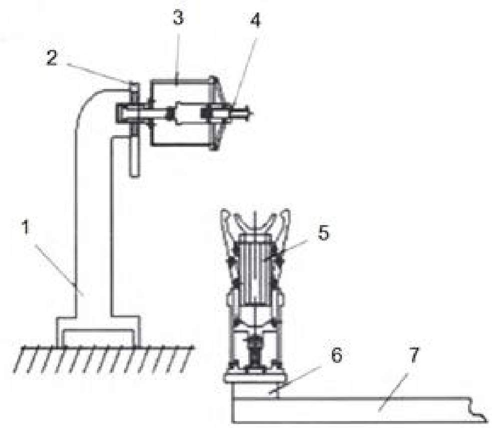



**Figure 1 : The schematic diagram of the cutting workflow of the coconut dehusking machine**

### Principle of operation

First, locate the coconut onto the mechanical hand. With the laser sensing device on it to sense the coconut, the mechanical hand will clamp the coconut tightly and rotate itself. The cutter starts to cut while the mechanical hand is rotating. In the cutting process, the cutter could automatically adjust the cutting depth and thus avoid the spilling out of the coconut milk resulted from the damage of the coconut flesh. The mechanical hand is equipped with a pressure pickup on its subject site. The cutter will continue to poke in until it touches the pickup, and then the control system react and executive the order to pull out the cutter. The mechanical hand reset itself and the dehusking process is completed. Figure 2 is the coconut dehusking machine.




(1- fixture strains,2-sliding caliper,3-cutter gripper,4-cutter,5-mechanical hand,6-mechanical hand rotating seat,7-fixed mount)

**Figure 2 : The schematic diagram of the coconut dehusking machine**

## DESIGN OF THE COCONUT DEHUSKING MACHINE

### Special cutter

The design of the cutter must meet the requirement of dehusking so as to cause as less damage to the coconut flesh as possible. So one end of the cutter is a knife, the other end is processed into the screw thread so as to make it more convenient for the installation. In order to confine the damage to the coconut flesh to the minimum, a spacer or an arc nut must be installed to limit the cutting depth. Thus, the nose of the knife also needs to be processed into the screw thread. See Figure 3.

### Materials used for cutter manufacturing

The nose and the support bar of the cutter are processed as a whole with steel Q345 as the materials. Nitriding and quenching are used in the process of the steel.

### Principle and functional analysis of various components

The design of the trigonal pyramidal nose of the special cutter is out of the convenient of poking. The arc nut and the support bar coordinate with each other at the place of the screw thread to limit the depth of poking and adjust automatically in accordance with the thickness of the coconut shell. The arc nut rotates up and down, and the distance between the arc nut and the nose of the knife is controlled within 1.5-2.0mm. The arc nut remains in the inner shell of the coconut and thus prevents the cutter from poking deeper inside the coconut. The spring of the cutter will compress or stretch itself in accordance with the force while the nose of the knife is moving. That is how it helps to protect the coconut flesh from being damaged.

During the work, A supporting bar without the screw thread keeps making telescopic movement. For this reason, changes in the length of the spring (e.g. become shorter or longer) will happen when facing uneven force. The back and forth movement of the supporting bar without the screw thread will lead the nose of the knife to move along the trajectory. The cutter moves gradually under the force of the clamping. The three-D schematic diagram of the special cutter is shown as Figure 3.

**Figure 3: Three-D schematic diagram of the special cutter**

**Parameter determination**

The letter h stands for the distance from the nose of trigonal pyramidal knife to the ground, namely h=1.2mm; the perimeter of equilateral triangle is 6mm; h nut stands for the height of the arc nut, namely h nut=4mm;the letter d stands for the diameter of the nut, namely d=15mm; the letter l stands for the length of the support bar without screw thread, namely l=15mm; the letter l stands for the support bar with screw thread, namely l=16mm;the letter D stands for the ground diameter of the outer shell, namely D=8mm; the letter D stands for the ground diameter of the inner shell, namely D=6mm.

**Stress analysis of the special cutter**

The cutter is made from steel Q345 with the following characteristic. Yield strength $\sigma_5 = 345Mpa$ ; Poisson's ratio $\mu = 0.26$ , Young's modulus $E = 210Gpa$ .

Model generation approach: ⑴ ANSYS is used to generate the model, namely it means to directly create the entity model during the working process of ANSYS software. Models created in this way is relatively simple and has a regular shape; ⑵Regarding complex models like surface model or other models with a complicated structure, first is to use import interface of entity model to input the complex model. ANSYS has many interfaces, such as CATIA、CAE、PRO·E, etc. Then use the interfaces of the complex models developed by other models creating software to directly input them into ANSYS. Considering that this experiment is out of the convenient of the study, so we generate simplified entity model in ANSYS software directly. See Figure 4.

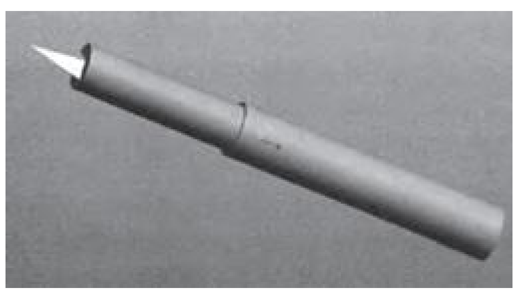


**Figure 4 : Simplified entity model**

**Mesh generation of the cutter**

There are two mesh generation methods based on ANSYS system, they are mapping mesh generation and free mesh generation. With a higher precision analysis, mapping mesh generation applies to objects with regular shape. Compared with mapping mesh generation, free mesh generation could apply to various objects even those with irregular shape, but its analysis precision is not that high. Besides, the generation area needs to satisfy different conditions. This study adopts free mesh generation as the method in which the three-D solid element with 8-node hexahedron is used. The stereogram is composed of 8096 elements and 12602 nodes. See Figure 5.

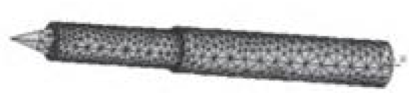


**Figure 5 : Free mesh generation model**

## Constrain condition and load application of the cutter

To guarantee the scientific rationality of the project, accurate data loading and effective simulation analysis should be ensured while doing the analysis with the ANSYS software. In the process of cutting, the 8 fixed point beneath the cutter should be checked. The degree of freedom of the outer part of the cutter is 0, and the force of the nose of the knife is 1.0*104N.

## Use ANSYS software to analyze the stress force of the cutter

When performing the stress force analysis, the first step is to fix the bottom of the cutter directly with clamping apparatus. In the process of dehusking, the high speed revolution force comes from the rotating mechanical hand. At the same time, the cutter keeps moving downwards. The applied force of cutting is 1.0*104N. It was found by the stress detection that the nose of the knife suffers the strongest force at this moment. Besides, under the influence of the force, the nose of the knife bends, but not very obviously. As the cutter keeps moving downwards, the closer it gets to the bottom, the weaker the force become. In order to make the intensity of nose of the knife to comply with the standard, the study chooses steel Q345 as the material of the cutter in this experiment.

## Data and result of the experiment

Dehusking experiment was carried out after stress force analysis. 50 coconuts were chosen for this experiment and were divided into two groups. The two groups are control group and study group. 25 coconuts in control group were dehusked by hand, while the other 25 coconuts in study group were dehusked by the machine. Thus damage rates and efficiency of the two groups were compared with each other. As for the experiment criteria, coconut flesh damage rate exceeds 10% was regarded as non-conformity. Besides, factors like the number of successfully dehusked coconuts ware also taken into consideration. The detailed results are shown in TABLE 1.

**TABLE 1 : Results comparison of the two groups**

| Groups | Number | Dehusking Time | Average Time | Number of Losses |
|---|---|---|---|---|
| Control Group | 25 | 1795s | 59.4s | 10 |
| Study Group | 25 | 342s | 11.4s | 3 |

According to the experimental results, the efficiency of the dehusking machine is significantly higher than that of the hand-dehusking while the damage rate of the machine is lower than that of hand-dehusking. Most importantly, machine dehusking could avoid the injury of workers. Hence， the dehusking machine is of rational design and has strong stability.

## CONCLUSION

The difficulty of coconut dehusking not only decreases its economic benefits but also troubles the growers. The newly developed coconut dehusking machine, which was analyzed by the ANASYS software and passed cutter stress force test and dehusking experimental test, proves the rationality of its design. Besides, it also has a strong stability. All this shows that the development of the machine is very instructive to the study of coconut dehusking machine.

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