Cooked egg sheller based on ADAMS optimization

Zhenxiong Huang¹, ² and Dapeng Ye¹, ², ³

¹ Fujian Agriculture and Forestry University, Fuzhou, 350000, China
² Fujian Engineering Research Center for Modern Agricultural Equipment
³ E-mail: fau_ydp@163.com

Abstract. In view of the problems of poor quality of existing hard egg shell shelly, such as shell breaking and shell stripping, the flexible modeling of eggs is carried out. Using this model, the ADAMS software is used to analyze the feasibility of the feeding mechanism and the peeling roll of the cooked egg shelly, and the structure parameters of the feeding mechanism and the peeling roll are obtained so that the working efficiency of the cooked egg can be reached to the best. It provides parameter basis of mechanization of cooked eggs.

1. Introduction

The peeling roll of the cooked egg sheller is used to strike the shell and the friction shelling of the egg. However, there are few studies on the egg stripping roll at domestic, which affects the quality of the broken shell and shelling of the cooked egg sheller and not conducive to the development of mechanization of the cooked egg processing. Experts and scholars have studied some food shelling machines, Zhang Xiuhua and other experiments verify the optimum parameters combination of the roll type shrimp shelly by testing the peeling rate, the kernel rate and the shell time, the response surface analysis and the optimization of the parameters [1]. Tong Qingtan and others designed peanut sheller, which made use of the gap between rubber roller and rubber concave plate to make flexible shelling [2]. Wang Ying and others adopts the combination of cutting method and rubbing method to realize peanut self-adaptive shelling [3]. Ji Wenhua designed a new type of walnut cores removing device, using the wrench mechanism to increase the extrusion pressure and increase the success rate of shell breaking [4]. Li Changyou and other designers have designed a lychee descaling machine which automatically adjusts the attitude, direction, nuclear removing, shell and separation of the litchi, and realizes the whole operation process of feeding, locating, nuclear removing and peeling at the same time [5]. Xu Xieqing and others developed a kind of lotus seed processing equipment with shell and peeling, so as to realize lotus seed's high efficiency and low loss continuous operation [6]. The feeding mechanism and the peeling roll have an important influence on the working efficiency of the cooked egg sheller. In this paper, in view of the development requirement of the mechanization of the cooked egg processing, this paper studies the working mechanism of the existing sheller in the market, and optimizes the structure parameters and operating parameters of the egg stripping roller and feeding mechanism by using the ADAMS (Automatic Dynamic Analysis of Mechanical Systems) software.

2. Structure and working principle

As shown in figure 1, the concrete structure of cooked egg sheller are mainly composed of a feeding mechanism, an egg stripping to roll group (an egg stripping roll(as shown in figure 2), a press egg roll), a spray mechanism, a driving device, a guide mechanism and a water storage tank. The core part is the
shelling roll group, which is composed of an egg roll and an egg stripping roller, each of which consists of two eggs stripping rollers and other one is covered with a convex cylinder for breaking eggs. When it is working, the egg is sent by the feeding mechanism into the working area of the egg stripping roll group, the driving device reverses the adjacent peeling roll back to strip the egg shell through rubbing. The egg roller is installed on the bow support by bolts, and the degree of adhesion between the egg and the egg stripper roll is increased by the spring adjustment, and the shell breaking rate is increased.

1. Water storage tank 2. Egg shelling rod drive device 3. Guide mechanism 4. Spray mechanism 5. Egg shelling roller 6. Press egg roll 7. Driving device

Figure 1. The structure of the cooked egg sheller.

Figure 2. Schematic diagram of egg stripping roll.

3. Feasibility experiment of feeding mechanism operation

3.1. Experimental design
In the feasibility analysis experiment of the feeding mechanism, the model is established by discussing whether the slope is 73.3 degrees and the distance between the bottom of the guide egg groove and the push rod is 34.5mm, and whether the egg is slipping from the push rod to the bottom is too large. ANSYS and ADAMS software are used to model the eggs flexibly and highlight the deformation of eggs. The results of modeling are shown in figure 3. The test scheme is shown in table 1. Since the egg sheller should be used for shelling eggs of various sizes, egg size is not considered as a factor that affects the test results. The experiment was divided into three groups: the first group was a slope of 17.3° and the pusher speed was 20 mm/s; the second group was a slope of 17.3° and the pusher speed is 80 mm/s. The third group was the slope of 10° and the pusher speed is 20 mm/s. The three groups became contrasts. Because the egg quality is normal distribution, a total of six eggs are imported, including two 40mm diameters, 50mm three and 60mm ones.

Figure 3. Steel results.
### Table 1. Feasibility analysis tests scheme for feeding mechanism.

| Group | Slope of feeding mechanism(°) | The speed of the push rod(mm/s) | The diameter of the short axis of the egg(mm) |
|-------|-------------------------------|---------------------------------|---------------------------------------------|
| 1     | 17.3                          | 20                              | 40                                          |
| 1     | 17.3                          | 20                              | 40                                          |
| 1     | 17.3                          | 20                              | 50                                          |
| 1     | 17.3                          | 20                              | 50                                          |
| 1     | 17.3                          | 20                              | 50                                          |
| 2     | 17.3                          | 80                              | 40                                          |
| 2     | 17.3                          | 80                              | 40                                          |
| 2     | 17.3                          | 80                              | 50                                          |
| 2     | 17.3                          | 80                              | 50                                          |
| 2     | 17.3                          | 80                              | 50                                          |
| 3     | 10                            | 20                              | 40                                          |
| 3     | 10                            | 20                              | 40                                          |
| 3     | 10                            | 20                              | 50                                          |
| 3     | 10                            | 20                              | 50                                          |
| 3     | 10                            | 20                              | 60                                          |
| 3     | 10                            | 20                              | 60                                          |

3.2. Analysis of test results

Six eggs for each group are labeled as JD 1, 2, 3, 4, 5, 6. Since egg size is not a factor, no distinction is made here. After the simulation, the displacement of the eggs in the vertical direction is generated. The first group of test results, as shown in Figure 4(a), showed that during the simulation, the egg 4 fell smoothly in the egg push rod and the guide egg trough, and the other two eggs were unable to stay in the guide egg slot together and stayed in the second push and guide egg grooves. The eggs 4 and the egg 6 was displaced in the second stage. The results of the second groups, as shown in Figure 4(b), showed that during the simulation, four eggs fell smoothly in the egg push rod and the guide egg trough, and the other two eggs continued to rise steadily in the second push and guide egg grooves. The curve of egg 3 rises rapidly after 5.2 seconds, which is the displacement curve after falling from the egg container. The egg 4 and the egg 6 only took vertical direction after 2.6 seconds. The results of the third groups, as shown in Figure 4(c), showed that the egg 4 fell steadily in the egg push rod and the guide egg slot in the simulation process. The egg 1 and the egg 2 was steadily rising under the action of the push rod, the egg 5 fell at the first push rod, and the egg 4 and the egg 6 reached the inner push rod of the second push rod in the container. But the egg 4 dropped from the egg stick, and the egg 3 did not enter the egg trough through second egg pushing rods. Finally, the egg 3, 4 and 5 are rolled down from the feeding mechanism.

Three groups of experiments can be compared with each other: the speed of the push rod and the angle of feeding mechanism increase the possibility of egg sliding, which is not conducive to the transportation of eggs. The first group of experimental data is the actual parameters used by the machine. Through the simulation experiment, it can be found that three kinds of small medium and large size eggs can rise steadily under the action of the egg push rod, which proves the feasibility of the design parameters of the machine and meets the design requirements.
4. Adams simulation analysis of the egg stripping roller

The egg stripping roller is divided into broken shell section which is rubber and shell stripping section. Two eggs stripping rolls are combined to work together, the length design of the broken shells section and the shelling section, the cylindrical size of the convex hull section, the depth of the grooves and the speed of the shelling section has an effect on the effect of the egg shells stripping. The eggs with a mass of about 50 grams were tested, the diameter of the shafts was 50 mm, and the test scheme was shown in table 2.

The torque of the egg at a speed of 120 r/min is shown in figure 5 (a). The graph shows that the peak value of the JD3 curve is approximately 0.2563–0.64 (N*m), and the rest show a lower value. The eggs are stressed between 7.32 N–18.57 N. The torque of the egg at a speed of 200 r/min is shown in figure 5(b). The graph shows that the peak value is approximately 0.75–1.7 (N*m), and the rest show a lower value. The eggs are stressed between 21.43 N–48.57 N. The torque of the egg at a speed of 208 r/min is shown in figure 5(c). The graph shows that the peak value is approximately 1.54–4.5 (N*m), and the rest show a lower value. The eggs are stressed between 44 N–128.57 N.
Table 2. Feasibility test scheme of egg peeling roller.

| Egg roll number | Length of the egg roll (mm) | Length of shredded section (mm) | Length of shelling section (mm) | Radius of the convex hull of a broken shell R (mm) | Grooves depth of shelling section (mm) | Rotation speed of the egg roll (r/min) |
|----------------|----------------------------|---------------------------------|-------------------------------|-----------------------------------------------|-------------------------------------|-------------------------------------|
| 1              | 1000                       | 600                             | 400                           | 7                                             | 5                                   | 120                                 |
| 2              | 1000                       | 500                             | 500                           | 7                                             | 5                                   | 120                                 |
| 3              | 1000                       | 600                             | 400                           | 10                                            | 5                                   | 120                                 |
| 4              | 1000                       | 600                             | 400                           | 7                                             | 5                                   | 120                                 |
| 1              | 1000                       | 600                             | 400                           | 7                                             | 5                                   | 200                                 |
| 2              | 1000                       | 500                             | 500                           | 7                                             | 5                                   | 200                                 |
| 3              | 1000                       | 600                             | 400                           | 10                                            | 5                                   | 200                                 |
| 4              | 1000                       | 600                             | 400                           | 7                                             | 5                                   | 200                                 |
| 1              | 1000                       | 600                             | 400                           | 7                                             | 5                                   | 280                                 |
| 2              | 1000                       | 500                             | 500                           | 7                                             | 5                                   | 280                                 |
| 3              | 1000                       | 600                             | 400                           | 10                                            | 5                                   | 280                                 |
| 4              | 1000                       | 600                             | 400                           | 7                                             | 0                                   | 280                                 |

(a) The moment curve of the egg at the speed of 120 r/min
(b) The moment curve of the egg at the speed of 200 r/min
(c) The moment curve of the egg at the speed of 280 r/min

(Note: the labels of egg stripper 1, 2, 3 and 4 are expressed in JD1, JD2, JD3 and JD4 respectively.)

Figure 5. The moment curves of eggs corresponding to different rotational speeds.
Compared to the three groups, the No. 3 egg roll can produce certain torque to the egg, but the moment produced by the 1, 2 and 4 egg stripping rolls is relatively small, and the three different rotational speeds produce similar results. The size of the No. 3 egg roll can produce sufficient percussion force and 3 is chosen as the peeling roll of the cooked egg sheller. The length of the peeling roll is 10.00 mm, the length of the shell segment is 600 mm, the length of the shell segment is 400 mm, the radius of the cylindrical shell is 10 mm, and the groove depth of the shell section is 5 mm. Three different speeds were set up, and the hitting forces of three intervals were obtained: 7.32 N~18.57 N, 21.43 N~48.57 N and 44 N~128.57 N. The percussion force range obtained from the third groups meets the maximum load capacity of eggshell 48.8N, and the egg roll can be selected to rotate around 208 r/min.

5. Conclusions
The feasibility of the feeding mechanism of a cooked egg sheller at 17.3 degrees and a push rod speed of 20mm/s is verified. The possibility of increasing the slipping of eggs will be obtained by accelerating the speed of the push rod and increasing the angle of the feeding mechanism.

Through the optimization of simulation test, the eggshell roll is 1000 mm long, the shell length is 600 mm, and the shell length is 400 mm. The diameter of the shaft of the broken shell section is 50 mm, the column of the bulge is R=10 mm, the depth of the shell section is 5 mm, and the rotation speed is 208 r/min.

It provides a parameter basis of mechanization of egg shelling.

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