# Tomato Sorting Machine Design


## ABSTRACT

This design is based on the existing fruit sorting mechanism, and the sorting mechanism has been improved by using a spiral roller to design a tomato sorting machine. Based on the size of tomatoes, this tomato sorter can classify tomatoes into three categories to meet the needs of different occasions for different sizes of tomatoes, improve the utilization rate of tomatoes, and also speed up the rate of tomato sorting. The threads on the outer layer of the drum push the tomatoes forward while the drum rotates, and the tomatoes fall through the corresponding drum gaps to complete this sorting stage, with the largest grade going all the way to the end of the drum for grading. And the whole machine is equipped with sponge as a cushioning material in the parts of tomatoes that are easy to be impacted to prevent tomatoes from being damaged and to facilitate storage and sale of tomatoes.The sorter is inexpensive, easy to maintain and suitable for small-scale farmers.



*Key words: Tomato sorting machine,Spiralroller,Tomato size*

## 1. INTRODUCTION

Entering the 21st century, China's rapid economic and technological development at the same time, also led to the rapid development of China's agriculture. Agricultural machinery as a production tool plays a driving role in the development of agriculture. To maintain the development of agriculture, it is necessary to have matching production tools. With the increase in the production of agricultural products, the workload of subsequent sorting and processing of agricultural products has become enormous. Traditional manual work is difficult to cope with the huge workload, so there must be agricultural machinery with high production efficiency to complete.

Tomato as an important part of agricultural products, to have to ensure that tomato production can meet the normal demand. From the domestic point of view, tomato as one of the indispensable vegetables in daily life, people's demand for tomatoes is constantly increasing. And with the improvement of people's living standards, the quality of the product requirements are also higher and higher. From abroad, the export volume of China's agricultural products also accounts for a considerable proportion in the international arena. Therefore, to improve the production efficiency of the tomato industry has just become a problem that needs to be solved at present. In the current form, in terms of fruit sorting, there have been a lot of related research at home and abroad, but not much research on tomato sorting. Due to the soft texture of tomatoes, thin skin characteristics, so tomatoes can not directly use ordinary fruit sorting machine for sorting. Moreover, most of the sorting machines based on machine vision and computers are complicated in structure and high in cost, which is not easy to be popularized. For this reason, I will design a simple and low-cost tomato sorting machine, which is easy to be used by small and medium-sized tomato growers and processing plants.

This sorting machine consists of inlet, sorting mechanism, outlet, motor and frame. The sorting mechanism consists of four conical drums placed horizontally and parallel to each other. The four conical drums form two V-shaped sorting paths, and the outer surface of the drums has prominent thread lines. The four drums can synchronize and rotate at a uniform speed, and the tomatoes are pushed by the rotating threads through the V-shaped gap to complete the sorting. This sorter can sort tomatoes into three levels of size to meet different grades. The design process of the sorting machine is based on solidworks, where the design and drawing of the parts are done first and finally the parts are assembled together to check for interference. Finally, the animation function comes with solidworks is used to generate animation to demonstrate the operation process of the sorting machine. The overall structure of the sorting machine is simple and small in size. And most of the parts are standard parts, which reduces the cost of the whole machine, shortens the production cycle, and facilitates the maintenance of the machine and the replacement of parts. The key parts are calibrated, and the sorting machine can operate normally and stably.

### 1.1 Background and Significance of Tomato Sorting Machine Research

China is the world's largest tomato planting area, the largest production of countries, but also

the largest consumer of tomatoes. China's annual output of about 55 million tons of tomatoes, accounting for 7% of the total amount of vegetables, close to 1/3 of the global tomato production. tomato is China's planting area ranked fourth vegetable varieties, tomato industry has become an important part of China's vegetable industry.

With increased production comes the problem of increased processing. The continuous development of tomato storage technology, tomato picking after the sorting work is also increasingly important. Must be completed in a short period of time on the screening of tomatoes, spend too much time, may cause the occurrence of tomato dehydration, quality deterioration and so on, so this work has a strong timeliness. Therefore, the mechanization and automation of tomato sorting is very much needed. The production of tomato and its sorting technology is particularly important. With the accelerated pace of life and the increase in demand for tomatoes, tomato sorting becomes more and more important. And at present there is a lack of machinery specialized in tomato sorting. Therefore, tomato sorting machine has a large potential market in China.

Sorting plays a crucial role as the beginning of the whole processing program. The traditional manual sorting efficiency is too low, and it is difficult to meet the mass production. Sorting results are easily affected by individual subjective judgment and emotions, resulting in the same requirements under the sorting of tomatoes large and small, preferences for bad, resulting in inconsistent sorting results, affecting the quality of sorting. Moreover, long-time manual sorting requires high physical strength and patience of workers, who are prone to fatigue and boredom, thus resulting in the phenomenon of wrong selection and omission of selection, which easily affects the quality of sorting. Therefore, in the face of large quantities of tomato processing, the use of suitable sorting equipment to increase production efficiency is very necessary.

## 1.2 Tomato sorting machine domestic and international research status

### 1.2.1 Overall form of development

In terms of the current situation, there is a large amount of research on fruit sorting machine at home and abroad, but relatively few machines specifically for tomato sorting. Tomatoes are softer than apples and pears, thinner skin, more sensitive to collision and friction, tomato damage will affect the next step of storage and transportation, so it can not be directly applied to tomato fruit sorting machine. From the current situation at home and abroad, most of the sorting machine using machine vision systems[12345], this system requires a complete set of image acquisition, processing equipment, which improves the accuracy of the screening, but also greatly increased the cost of the entire device. The high cost causes this kind of equipment is only suitable for large-scale factories and farms at home and abroad, and is not suitable for small-scale processing plants.

### 1.2.2 Domestic situation in China

Domestically, Sun Kai, Yan Xuehui[6] and others used cage roller structure. The drum has holes of different sizes to allow the fruit to make a parabolic motion in it, and the fruit will come out of the caged drum through the holes of the appropriate size. However, this causes the tomatoes to make impact with the cylinder wall, which causes damage to the tomatoes. In the design process of tomato sorter should pay attention to the mechanical collision between tomato and sorter, but in the sorting process, the collision can not be avoided, so we can only try to minimize this collision. Cheng Deming[7] and Wang Xinting[8] used PLC and microcontroller for the collection and processing of sorting information, respectively, and these devices can greatly improve the sorting accuracy of the sorting machine, but the structure is complicated and the cost is high. Moreover, when the machine fails, the technical requirements for maintenance are high. It is not convenient for common users such as farmers to carry out maintenance. Therefore, I will design a tomato sorting machine with simple structure, low maintenance cost and low maintenance technology requirement. Leping Cao[9] designed a conveying and turning mechanism of vertical rotary drum fruit sorter. Deguang Wu and Zongshou Cai studied a double-roller fruit grading device[10], which has a simple structure and high sorting efficiency, and is suitable to be used as a low-cost, easy-to-maintain sorting machine design. The shortcomings are: there is a certain inclination angle between the double rollers and the horizontal plane, and the fruits roll downward on the double rollers by their own weight, but not all fruits are standard spherical, and some ellipsoidal fruits may stay on the double rollers and block the fruits behind them. If these ellipsoidal fruits also pass smoothly, we must increase the angle of inclination of the double rollers and the horizontal plane, but the consequences of doing so will lead to the original those who can pass through the fruit more quickly through, thus reducing the accuracy of screening.

#### 1.2.3 Status of other countries

S. Mangaraj and R K Pajnoo, India, have designed a high-capacity fruit grader for commercial use[11], which classifies fruits into five grades according to size. Multi-grade sorting improves the utilization of fruits. However, five grades are not necessary for sorting common tomatoes, and they increase the size and cost of the sorter. The benefit of more sorting grades is much lower than the extra manufacturing cost it requires, so the tomato sorter is designed with three sorting grades. This not only increases the utilization of tomatoes but also reduces the cost of the sorter and reduces the size of the sorter. Iran Ahmadi V F and Ziyaee P et al. developed and tested a low-cost belt and roller machine for sorting spherical fruits, which is a simple and ingenious structure[12], but the fruit travels in a single route, and the fruit in front of it that is not sorted in time causes the fruit behind it to be unable to move forward, which creates a congestion and reduces the efficiency of sorting. Therefore, I design the tomato sorting machine as a dual-channel sorting machine. When the sorting machine works, tomatoes can be sorted from two paths at the same time, improving the sorting efficiency of the sorting machine.

### 1.3 Problems with current sorting machines

Most of the machine vision-based sorting machines on the market today have a complex

structure, large machine size, large footprint, and high production and manufacturing costs. Despite the high sorting accuracy of this type of sorting machine, the high cost still does not allow it to be popularized in small-scale farmers and processing plants, this design will highlight the solution to the above problems.

### 1.4 Main design elements

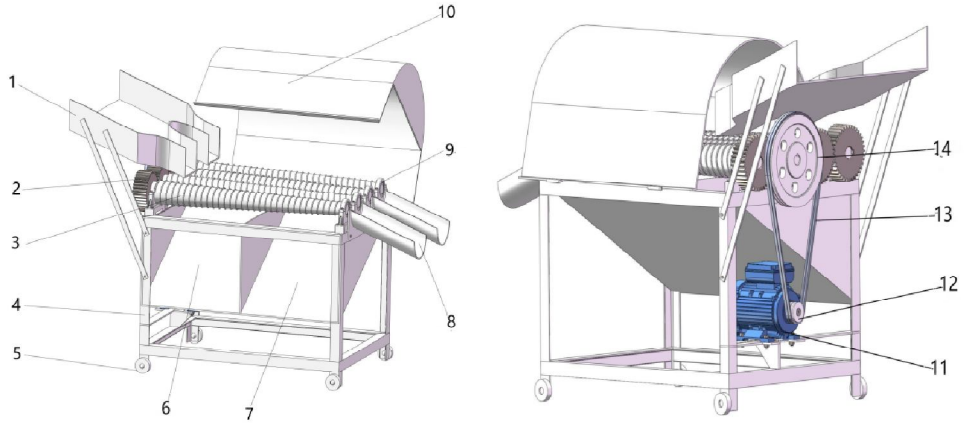
To design an inexpensive, simple structure, compact and flexible tomato sorter that is easy to operate and simple to maintain to meet the use of small-scale farmers and processing plants.

## 2. STRUCTURAL DESIGN AND WORKING PRINCIPLE OF TOMATO SORTING MACHINE

### 2.1 Determination of the type of sorter

This design is mainly for medium and small scale tomato growers or processing plants. A tomato sorting machine with simple structure, lighter quality and low cost is designed. Sorting machines by weight are complex and have a large floor space. Sorting by appearance and internal quality is too costly and not suitable for small farmers. Therefore, the sorting machine classified by size is chosen as the type of sorting machine in this design. Among them, the spiral-roller sorting machine has the simplest structure and higher sorting efficiency, but there are some defects in the existing spiral-roller structure. Therefore, I will design a spiral-roller tomato sorter and solve some of its defects. Because the spiral-roller of this sorter adopts hollow design, and the spiral line is added on the outer surface. So in this design the steel sword is called as spiral drum.

### 2.2 Main structure of tomato sorter




1-Feed opening 2-Gear 3-Spiral roller 4-Rack body 5-Ferry 6-Primary tomato outlet
7-Secondary tomato outlet 8-Three-stage tomato outlet 9-Bearing seat
10-Protective cover 11-Electric motor 12-Pulley 13-V-belt 14-Large pulley

**Fig. 2.1 Three-dimensional assembly diagram of tomato sorting machine**

Sorting machine mainly consists of inlet, outlet, spiral drum, motor and frame. The sorting structure consists of two conical spiral drums placed horizontally, with the adjacent surfaces of the two drums forming a “V” shape, each spiral drum in a pair rotates in the opposite direction from its adjacent drum, and the drums rotate in the opposite direction, the machine consists of two pairs of spiral drums. The materials used in the whole machine are cheap and easy to obtain. The machine is powered by an electric motor, the overall structure is simple, the energy used is clean and environmentally friendly, and the manufacturing cost is low.

### 2.3 Tomato Sorting Machine Working Principle

This tomato sorting machine will be divided into three grades of tomatoes according to the size of the first level for the diameter of ≤ 70mm; the second level for the diameter of > 70mm and ≤ 90mm; the third level for the diameter of > 90mm; in the normal operation of the sorting machine, each pair of spiral drum for reverse rotation, when the tomatoes from the feed port to the spiral drum, the spiral drum surface protruding from the helix will push the tomatoes to move forward. As the two surfaces of the drum into a “V” shape, tomatoes continue to move forward at the same time, the gap below is getting bigger and bigger, when the gap is larger than the diameter of the tomato, the tomato will fall below the tilted elastic slant, the first level of sorting is complete. The sorting process of the second level is the same as that of the first level. Tomatoes with a diameter greater than 90mm will go all the way to the end of the roller into the semi-circular groove, to facilitate the next step in the fine packaging. At this point, the third level of tomato sorting is completed.

## 3. DESIGN OF TOMATO SORTING MACHINE COMPONENTS

### 3.1 DesignSummary

The whole process of this design 3D parts drawings and assembly drawings were done in solidworks. The approximate shape of the part is drawn first, then changes are made and final dimensions are determined according to the function of the sorter. To save drawing time and increase design time. The bolts, nuts and gears are generated from the model library that comes with solidworks and the 3D model of the motor is obtained from the model library of its manufacturer. After completing the 3D drawing of the parts, all the parts are then assembled together and checked for any interference between the parts. If there is interference, further modifications are made to some parts. After the modification is completed, the solidworks assembly drawing is utilized to generate the 2D drawing to complete the relevant drawings.

### 3.2 Design of Spiral Roller

The sorting mechanism consists of two pairs of spiral drums. For the selection of drum diameter, too small a drum diameter, tomatoes are easy to fall, too large a drum diameter will cause material waste, and increase the size of the sorting machine, so the drum diameter is selected as 90mm. for the selection of drum length, too short a length will result in tomatoes in the drum stroke is too short, can not be thoroughly tomato sorting, too long a length will increase the quality of the sorting machine and the size of the drum length is designed as 800mm. the first stage of sorting stroke and the second stage of sorting stroke is 400mm. The length of the drum is designed as 800mm, the sorting stroke of the first stage and the sorting stroke of the second stage are each 400mm. in order to reduce the quality and cost, the drum adopts the hollow structure, the thickness of the cylinder wall is 10mm. because the two ends of the drum are subject to additional fixing force, as well as the squeezing force generated by the gears meshing with each other, the thickness of the end face of the drum is designed to be 100mm. the thickness of the thread on the drum is 3mm, the height is 4mm, the pitch of the

thread is 3mm, and the height is 4mm, and the thread thickness is 3mm, and the height is 4mm. The threads on the drum are 3mm thick, 4mm high, and have a pitch of 25mm. to prevent the top of the threads from scratching the tomatoes, the top of the threads are rounded with a radius of 1.5mm.

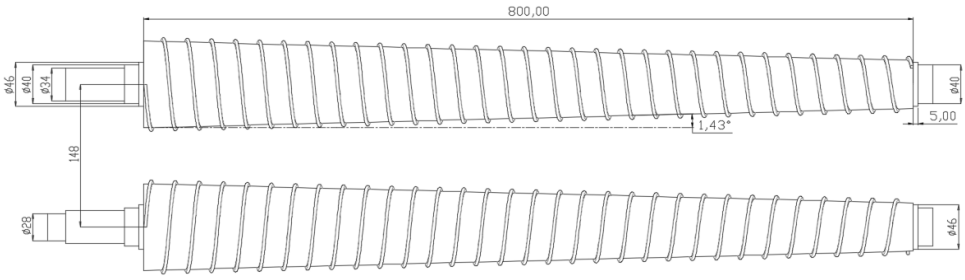



**Fig. 3.1 Spiral roller**

### 3.3 Torsional Strength Calibration of Roller Face Shafts

When the shaft can work normally and stably, the shaft section with the thinnest diameter should be satisfied:

$$\tau_T = \frac{T}{W_T} \approx \frac{9550000 \times \frac{P}{n}}{0.2 \times d^3} \leq [\tau_T] \tag{3.1}$$

Formulas:$\tau_T$--torsional shear stress, MPa;

T--Torque on the shaft, N*mm;

$W_T$--Torsional cross-section coefficient of the shaft, $mm^3$;

n--Shaft speed, r/min;

P--Transmitted power of the shaft, kW;

d--Calculate the diameter of the shaft at the cross section, mm;

$[\tau_T]$--Permissible torsional shear stress, MPa.

Upon review of the relevant information, it was found that:$[\tau_T]$=25MPa.

$$P = P_0 \times \eta_0 = 0.55 \times 0.7 = 0.385kW \tag{3.2}$$

$$n = n_0 / i = 1400/5 = 280r/min \tag{3.3}$$

$$d = 28mm \tag{3.4}$$

Then:

$$\tau_T \approx \frac{9550000 \times \frac{0.385}{280}}{0.2 \times 28^3} = 3MPa < 25MPa \tag{3.5}$$

Therefore, the torsional strength of the shaft meets the requirements and can work normally and stably.

## 4. CONCLUSION

The purpose of this design is to design a small, low-cost machinery for grading tomatoes on the basis of size, thus improving the utilization of tomatoes and the efficiency of the tomato processing process. Most of the parts used in the sorting machine are standardized, which greatly shortens the production cycle of the sorting machine, reduces the manufacturing

cost,and also improves the interchangeability of the parts of the sorting machine. Sorting machine in the event of damage to certain parts, easy to replace them, but also reduces the cost and time of maintenance. The sorting mechanism of the sorting machine is mainly composed of spiral drums, relying on the change of the gap between the drums, so that the tomatoes fall into the sponge slant below at the corresponding gap, to complete the sorting of tomatoes. The roller adopts a hollow design, and the frame also uses the common triangular steel as the main body, which reduces the quality of the sorting machine and saves the materials used. This design has a simple structure, small footprint and low price. There are many designs of large-scale fruit sorting machines based on machine vision at home and abroad, which are complicated in structure, cover a large area, and are costly and not applicable to small-scale farmers. This design is a good solution to these problems. This sorting machine is easy to operate, simple structure, easy to maintain, ordinary people can carry out parts replacement and maintenance. This design is not only applicable to tomatoes, but also to other spherical fruits and vegetables of similar size to tomatoes, thus realizing the multi-purpose use of one machine.

## 5. LIMITATIONSANDFUTUREWORK

This design also has shortcomings. The upper half of the bearing seat at the end of the drum is higher than the centerline of the drum rotation, when the third level of tomatoes traveling to the end of the drum to enter the discharge port, the upper half of the bearing seat on the tomatoes have an obstructive effect. In this regard, the bearing seat must be used to meet the strength requirements under the premise of the bearing seat to minimize the thickness of the upper half of the bearing seat to reduce the impact of the bearing seat on the tomatoes into the outlet. Because the sorter only sorts tomatoes by size and cannot distinguish tomatoes by color, it is not suitable for use in applications that require a high level of tomato appearance.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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