

DESIGN AND MODELING OF A NEW TYPE OF THE NX-BASED 6-ROLLER SUGARCANE JUICER

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Abstract. Aiming at the shortcomings of 2 and 3-roller sugarcane juice extracting machines that are being widely used in the domestic market, this paper optimizes the structural design of the juicers by using the NX-based 3D-technology, depending on its speed reduction gear box design and parallel 6-roller operating method. The application of worm drive system changes the direction in which sugarcane is squeezed at the third stage, making sugarcane dry and shrunken after repeated squeezing from different directions, which is a guarantee for sugarcane entering into gaps between rollers. Meanwhile, the juice extraction rate is improved.

Keywords: NX; sugarcane juicer; new-type 6-roller; squeezing from different directions.

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Problem statement. China is a country with a wide distribution of sugarcane planting. Sugarcane can be stored in cellars to maintain a long-term supply. Rich in multiplex vitamins like calcium, phosphorus and iron, sugarcane juice is a kind of purely natural and green drink quite popular among consumers [1]. With the improvement of economic conditions and increasing demand for purely green drinks, the market demand for high-efficiency sugarcane juicers begins to increase [2].

The squeezing technology as the core economic technology in the squeezing workshop must ensure not only the production capacity of the workshop but also safe operation of workshop equipment and balance of production [3]. The problems existing in the use of 2- and 3-roller sugarcane juicers that are being widely used in the domestic market are addressed, as well as the bottlenecks encountered during the R&D of new-type sugarcane juicers.

THE ARTICLE AIM is to introduce a kind of the structurally reasonable sugarcane juice extracting machine that enables sugarcane materials to be fed smoothly and at the same time ensures a high juice extraction rate by using the NX-based 3D design technology.

Basic material

1. Overall Structural Design of the New-Type 6-Roller Sugarcane Juicer

1.1 Determination of the overall design scheme

Scheme 1. By referencing plenty of the existing data on sugarcane juicers collected from sugar mills and the market, our initial conception is to change the 3-roller design as shown in Fig. 1 into a “parallel” 4-roller one, so that sugarcane may fall down vertically from the top of the first-stage rollers. The advantage of such design lies in a reduction of the juice reabsorption in the absence of the bottom comb; however, the bagasse is still not dry enough when discharged from the machine because sugarcane has just undergone squeezing twice as before.

Scheme 2. All the existing sugarcane juicers work by squeezing sugarcane along only one direction, so what we think of first is to use a bevel gear to achieve changes in direction. As indicated in related materials, crossed helical gear and worm gear can both transmit the rotary motion of two crossed shafts. Of them, the crossed helical gear is easy to be worn and has a small bearing capacity as a result of its point contact design.

Meanwhile the worm gear is featured by its large drive ratio and smooth motion, but easy to become hot and has a low efficiency [4]. A crossed helical gear mechanism is as shown in Fig 2.

Through analysis and comparison, giving consideration to the requirements of this design, worm gear is chosen (in general, there is a slight impact in the working environment). The preliminarily proposed design is as shown in Fig 3.

In order to overcome the shortcomings of the existing technologies and provide a type of the structurally reasonable device that can be used widely, manufactured

and installed easily, Schemes 1 and 2 are combined into a scheme according to the design purpose, as shown in Fig 4.

The advantages of this new-type 6-roller sugarcane juicer and its squeezing method are listed below.

1. The speed reduction gear design and the parallel 6-roller operating method are adopted. Sugarcane may fall in from the top of the first-stage roller; reabsorption of juice is reduced in the absence of the bottom comb.
2. The first-stage sugarcane feeding roller pair has oblique threads on both rollers which rotate against each other, and a juice draining channel is reserved at the out-

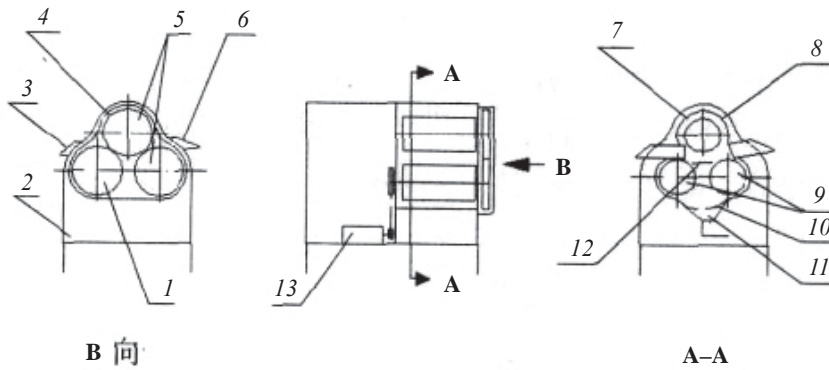


Fig. 1. Structure of a 3-roller sugarcane juicer in the market: 1 — drive wheel; 2 — machine frame; 3 — bagasse outlet; 4 — gear shield; 5 — driven wheel gear; 6 — sugarcane inlet; 7 — upper squeezing roller; 8 — squeezing shield; 9 — lower squeezing roller; 10 — filter screen; 11 — juice outlet; 12 — sheet support; 13 — motor

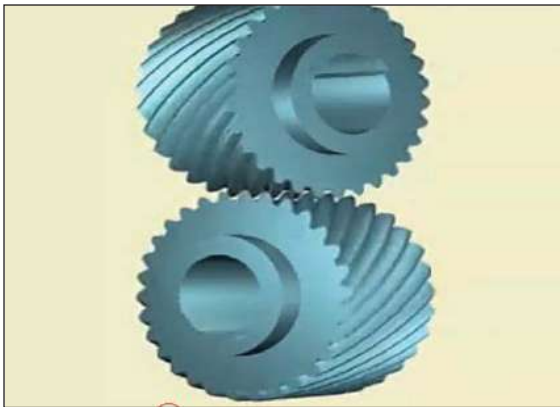


Fig. 2. Crossed helical gear mechanism

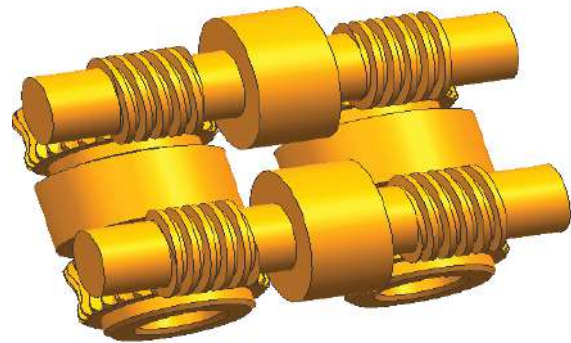


Fig. 3. Sugarcane undergoes squeezing from different directions in a worm gear mechanism

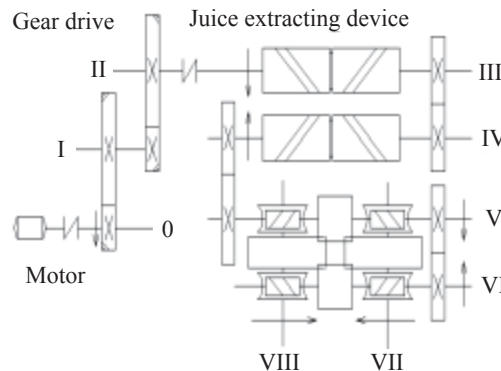


Fig. 4. Final scheme

er ring of the roller, which is a guarantee for sugarcane arriving at the middle of two fist-stage narrow rollers smoothly from the sugarcane inlet for a high-efficiency squeezing, but an effective guarantee or sugarcane falling into the gap between the second-stage roller shafts smoothly [5].

3. Worm drive is adopted in the third-stage squeezing device to change the direction in which sugarcane is squeezed for the third time, thus effectively guaranteeing sugarcane to become dry and shrunken when being discharged from the machine.

1.2 Overall structural design of the sugarcane juicer

The sugarcane juicer mainly consists of a feed inlet allowing materials to be charged internally, a drive unit, squeezing rollers, and a casing. The sugarcane feeding roller pair has oblique threads on both rollers, which rotate against each other. A juice draining channel is reserved at the outer ring of the roller, which is a guarantee for sugarcane arriving smoothly from the inlet for a high-efficiency squeezing at the middle of the two first-stage squeezing rollers and entering the gap between the second-stage squeezing roller shafts.

1.2.1 Material charging unit

The sugarcane feed inlet is designed with an internal charging structure, made of 5 mm stainless steel pipes and located right on top of the machine frame. The sugarcane feeder has contact with the upper cover of the juicer and keeps tangent with the squeezing roller shafts of the first group sugarcane feeding rollers, thus guaranteeing that the peeled sugarcane may fall between the squeezing roller shafts vertically from the upper end of the first-stage squeezing roller.

1.2.2 Squeezing unit

The squeezing unit is mainly composed of three groups of new-type squeezing rollers. Sugarcane is squeezed between three groups of squeezing rollers. The bagasse that has been squeezed dry falls into a built-in bagasse bin across the gap between squeezing rollers, and eventually, the sugarcane juice is collected into a container after being filtered with a filter screen.

1.2.3 Casing unit

The casing unit is composed of the left casing, rear casing, seat, bagasse outlet and sugarcane juice discharging valve. Of them, the casing holder plays a key role in supporting the sugarcane juicer. The casing support is designed to be relatively stable and firm, so that it would not become inclined during operation, which may pose a threat to people' lives. For this purpose, the seat of the juicer is made of steel plates with the thickness of 3 cm.

1.2.4 Overall design of the sugarcane juicer

To optimize its structural design, the material feeding movement and the squeezing operation of the sugarcane juicer are driven by an energy-saving motor, which is installed on the left of the juicer on the same base plate as the machine frame; in this way, the motor occupies less space.

This sugarcane juicer features an integrated design from material feeding to juice extraction and then to the separation of juice from bagasse. Allowing the workload of several people to be completed within a short period of time, this machine will shorten their working hours. In addition, this machine is characterized with a high efficiency and good safety, solidity and endurance, simple structure and easy maintenance.

2. Design of a direction-changeable sugarcane squeezing unit

2.1 Direction-changeable squeezing unit

As a new type of 6-roller sugarcane juice extracting equipment, it includes a motor, couplings, a cylinder gear speed reducer, sugarcane feeding rollers, spur gears, worm shafts, worm wheel shafts, worm gears, bolts, double end studs, nuts, a machine frame and a seat. The diagram of the drive system in motion is as shown in Fig 5.

2.2 Structural characteristics of the sugarcane juicer

From the structural standpoint, 6 squeezing rollers of the-new type sugarcane juicer compose 3 groups, with each group containing 2 squeezing rollers.

The first group (the first-stage squeezing rollers) is located on the top, and the gap between the rollers (25.7 mm) is wide and suitable for the first-stage squeezing. Of them, the front squeezing roller 3 rotates

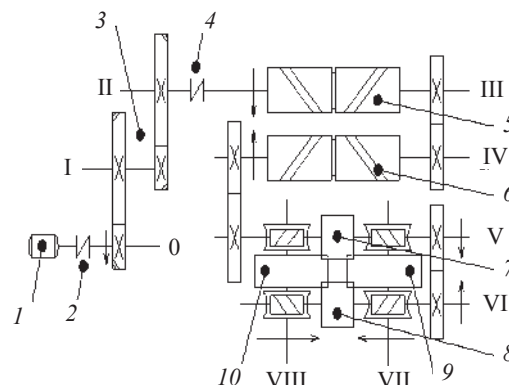


Fig. 5. Diagram of the drive system in motion: 1 — motor; 2, 4 — coupling; 3 — two-stage cylinder gear speed reducer; 5, 6 — sugarcane feeding roller; 7, 8 — second-stage squeezing roller; 9, 10 — third-stage squeezing roller

clockwise while the rear squeezing roller rotates against it. The combination of the first-stage squeezing with the double helical gear rotating in the same direction produces a pushing and guiding force. The purpose of this stage is to guide sugarcane to enter the machine on a proper way, thus achieving the first-stage squeezing.

The second group (the second-stage squeezing rollers) is located in the middle, and the gap between rollers (19 mm) is narrowed slightly to form the second-stage squeezing. Of them, the front squeezing roller 3 rotates clockwise, while the rear squeezing roller rotates in the opposite direction. The combination of the second-stage squeezing with the bevel wheel rotating in the same direction generates a pushing and guiding force.

The third group (the third-stage squeezing rollers) is located in the lower part, and the rollers are arranged closely, as the distance between is just 11 mm. Of them, the left squeezing roller 5 rotates clockwise, while the right squeezing roller 6 rotates counterclockwise. The combination of the three-stage clamping and

squeezing pattern and the gear rotating in the same direction produces a pushing action to discharge bagasse into the built-in bagasse bin. Squeezing at this stage enables sugarcane to be clamped and squeezed from different directions, thus the juice extraction rate is increased significantly.

3. 3D-Assembly Design and Engineering Drawings of the NX-based Sugarcane Juicer

3.1 3D-Assembly Design of the Sugarcane Juicer

The new 6-roller sugarcane juicer includes the following key parts and components: machine body, the first squeezing assembly, the second squeezing assembly, and a unit driving the assemblies. The NX-based 3D-models for its major parts and components are as shown in Fig. 6–10.

3.2. Engineering drawing of the new type 6-roller juicer

The engineering drawing of the new type 6-roller juicer is as shown in Fig. 11.

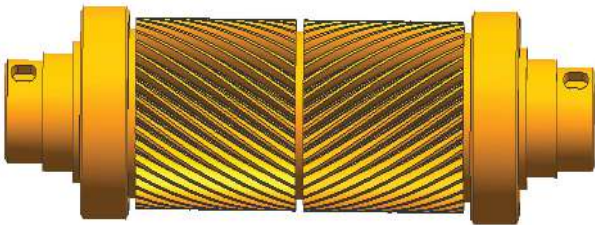


Fig. 6. First-stage sugarcane feeding roller

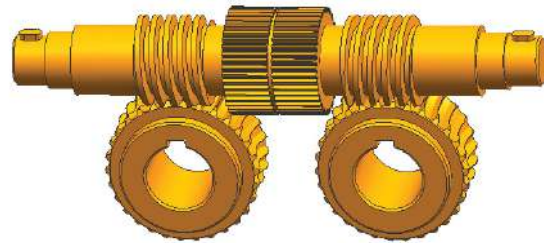


Fig. 7. Second-stage squeezing roller

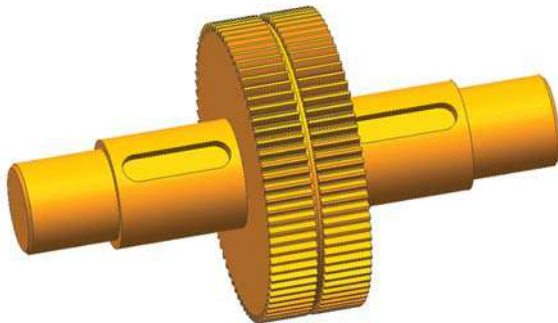


Fig. 8. First-stage sugarcane feeding roller

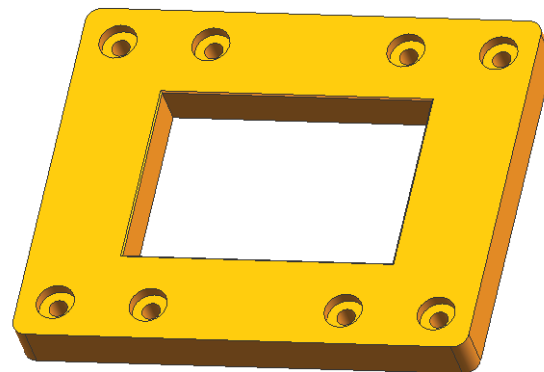


Fig. 9. Second-stage squeezing roller

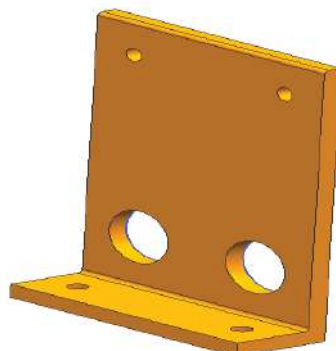


Fig. 10. Second-stage squeezing roller

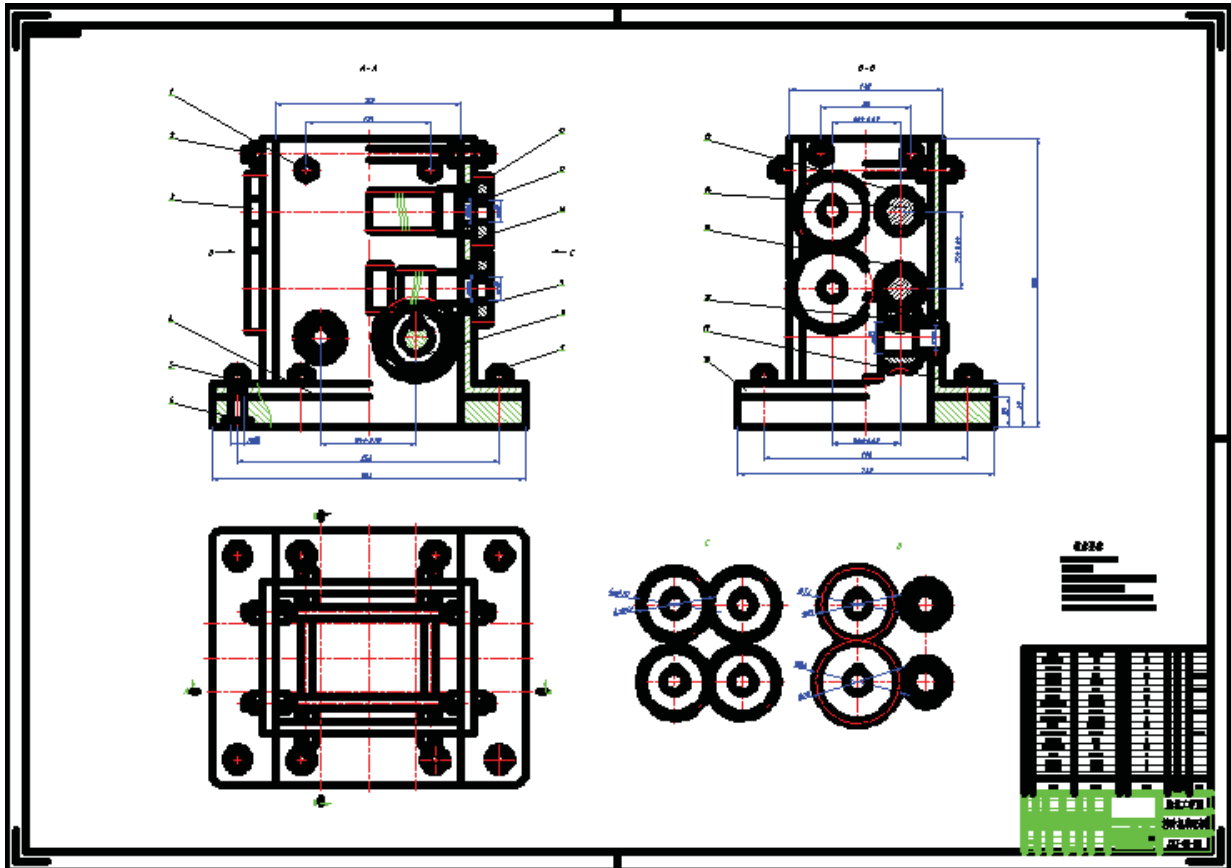


Fig. 11. Engineering drawing of the new type 6-roller juicer

CONCLUSION. Speed reduction gear box design and parallel operating method are adopted in the new type 6-roller sugarcane juicer designed in this paper; the surface of the sugarcane feeding roller is designed with a double helical gear and reserved with juice draining channels so that the squeezing roller plays a guiding role, guaranteeing sugarcane materials to fall into the gap between rollers smoothly and be crushed fur-

ther; the adoption of worm gear drive allows sugarcane to become dry and shrunken after being squeezed repeatedly from different directions through changing the direction of the third-stage squeezing of sugarcane. The adoption of a totally enclosed structure and a built-in bagasse bin make the equipment convenient to use and easy for operation, while improving the juice extraction rate.

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