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Research Paper

Design and Manufacture an Automatically Grinding Machine Applying To Grind the End-Surface of Bamboo Straws

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ABSTRACT: *This paper presents the results of the process of designing and manufacturing machines grinding the end surface, serving the mass production of bamboo straws. The grinding machine fully automatically performs the following functions: orienting the workpiece and continuously grinding the end surface of the workpiece. The parameters calculated during the design process include: speed chain, kinematic chain driving to each straw holding module. As a result of the manufacturing process, the machine achieves a processing capacity of 320 products per minute. Grinding machines after successfully manufactured have been widely applied in addition to actual production.*

KEYWORDS: *Bamboo straws; Grinding machine; Automatically; Kinematic.*

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I. INTRODUCTION

In the world, bamboo grows strongly in a humid tropical climate. The bamboo stem has many advantage properties, such as: hard, smooth and flexible. So, bamboo stem are very suitable for making straws. Bamboo straws, made entirely from bamboo, are very environmentally friendly and safe for users. Recyclable bamboo straws are a great idea to reduce plastic pollution because they are 100% biodegradable, washable and saving money [1,2,3]. It can be confirmed that, bamboo straws are ideal products gradually replacing for plastic straws, using to water, coffee, milk, tea... Figure 1 shows a photo of some bamboo straws used in daily life.

Figure 1: A photo of bamboo straws

The production process of bamboo straws usually goes through many steps [2,4]. Bamboos are first harvested and then dried or heat treated. After that they are selected and cut into suit the usage requirements. Then they are grinded body and tow-end to form straws. Finally, the straws were cleaned with a high-pressure pump. The bamboo straws can be also engraved on their body according to customers' requirements.

Of these steps, grinding the bamboo straw ends takes the longest time. Therefore, the cost of making straws will be large if done manually or using a grinder to grind each straw individually. During use for drinking, the ends of the straw will be in contact with the user's mouth. So the quality of the surface of the ends of the straw is of the straw is the most important factor. Manual grinding or grinding each straw individually results in poor and uneven results, resulting in unsatisfactory output quality. In the world, many firms have produced automatic production lines for bamboo straws with a capacity of about 400-500 work pieces per hour [5,6].

In this paper, we present results of research, design and manufacture of a grinding machine used to grind bamboo straws with outstanding productivity and quality. At the same time, the machine is fully automatic, reducing labor, time and processing costs.

II. THEORITICAL BASIS FOR DESIGN

In machining, for creating the necessary gloss for the product, the grinding process plays an important role. There are many different grinding methods, such as: outer round grinding, inner round grinding, flat grinding, centerless grinding, smart grinding, etc. For each grinding method, different movements are required to perform the grinding process. To perform the process of grinding the end of the bamboo straw, in this research, the combination of flat grinding and centerless grinding was chosen. In terms of flat grinding, the cutting motion is the circular motion of the grinding wheel, and the feed movement is the reciprocating motion of the table carrying the work piece. In terms of centerless grinding, the cutting motion is the circular motion of the grinding wheel; the feed movement is the axial reciprocating motion of the cylindrical work piece, while the work piece moves freely.Combining these two grinding processes, the author creates the main cutting motion on the machine, which is the circular motion of the disc-shaped grinding wheel; while the feed movement is both free rotation and translation in each bamboo straw holder module. From this idea, the principle of the grinding machine was developed, as shown in Figure 2.

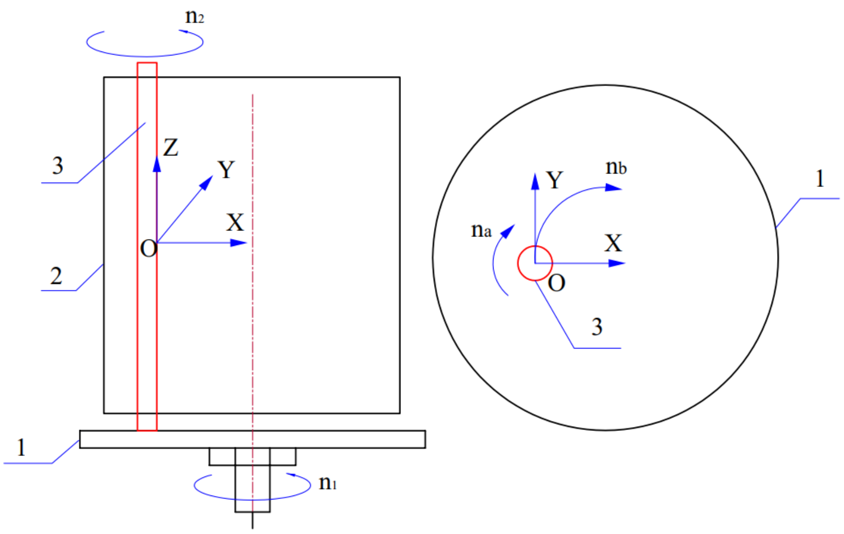


Figure 2: Complicated movement of ends of bamboo straws during grinding

Figure 2 depicts the necessary and actual movements that will occur during machining. The disc grinding wheel (1) performs a circular motion around its axis to produce the main cutting motion. The straw holder module (2) is a cylindrical tube that is rigidly mounted on a grinding wheel. Straw holder module is responsible for keeping the work piece in an almost vertical state. The work pieces (3) are freely dropped vertically into the tube holder module (2), the tightness ranges from 70-80% of the space inside the straw holder module. During the machining process, the disc grinding wheel (1) performs a circular motion (n_1) around its center and simultaneously drives the bamboo straws to follow. The motions of bamboo straws can be classified into components including: circular motion around its axis (n_2), translational motion in the Ox direction, and translational motion in the Oy direction perpendicular to Ox. Besides, receiving the drive from the disc-shaped grinding wheel (1) through the frictional force between the end face and the grinding surface, the work pieces perform complex movements including linear motion in the two directions Ox, Oy and rotation about its axis (n_a) and rotation about the axis of the grinding wheel (n_b). These complex movements, including na and nb, the author will continue to research in the next publications.

The combination of these three movements will form the surface to be machined, which is the end surface of the bamboo straw. Because the bamboo straws are placed in a module that holds the straws not tightly, a certain angle of inclination is always created between the center-line of the straw and the disc-shaped grinding wheel surface. This leads to the process of grinding the end of the straws to be performed while adding the chamfering of the end of the straws. Then this helps to save production costs as much as possible.

III. DESIGN THE KINEMATIC DIAGRAM OF GRINGING MACHINE

In order for the grinding process to take place fully automatically and to easily control the n1 and n2 movements, one of the following two options can be used. The first option, perform independent drive, where each movement will be driven by a separate motor. This option increases costs and reduces efficiency due to the use of many electric motors. The second option, which is used in this study, an electric motor is used to drive all axes, as depicted in the Figure 3, Figure 4 and Figure 5. The advantage of this option is that only one motor (M) must be used to drive all movements through the transmissions and the mechanical structure. Figure 3 shows the diagram of the kinematic structure of end-straw grinding machine. In which, i_v is the speed chain and $i_s$is the feed chain of the machine.

During the machining process, the main electric motor M rotates with speed n_{motor}, which will transmit the motion to the main shaft (I) of the bamboo straw end grinding machine, as shown in Figure 3 and Figure 4, through the speed chain i_v. Then the main shaft (I) will rotate at the speed:

$$n_I = n_{motor} \times i_v$$

$$\text{or } i_v = \frac{n_I}{n_{motor}}$$

The main shaft (I) directly drives the disc-shaped grinding wheel and at the same time drives an additional 7 axes, from (II) to (VIII), placed parallel to the satellite arrangement with the axis (I) through belt drives, as shown in Figure 4 and Figure 5.

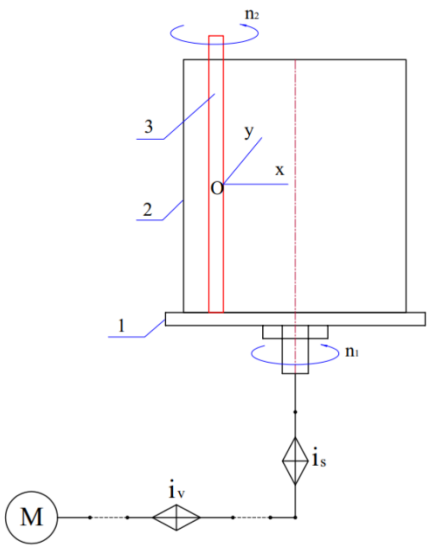


Figure 3: Kinematic diagram of bamboo straw ends grinding machine:*(1) Disc-shaped grinding wheel; (2) Straw holder module; (3) Work pieces*

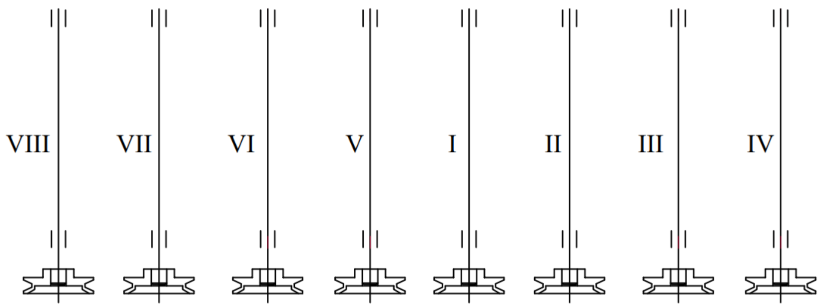


Figure 4: Drive shaft and pulley system

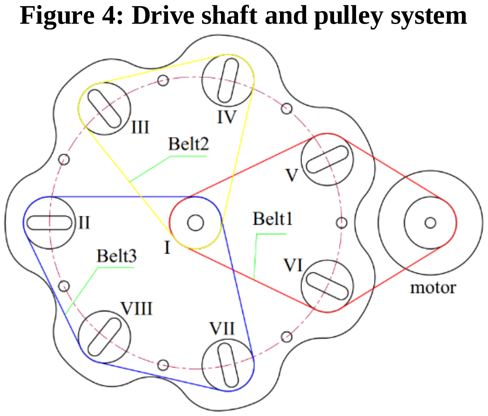


Figure 5: The motor drives the shafts by the belts

Rotation speed of satellite axes:

$$n_{II} = n_{III} = n_{IV} = n_V = n_{VI} = n_{VII} = n_{VIII} = n_I$$

The movement from the supplied motor to the main shaft (I) of the machine can be done in different ways, such as using gear drives, using belt drives, etc. The spindle can also receive many different speeds. In this study, the bamboo straw end grinding machine was designed with the specific goal of processing several sizes of straws with a small difference in diameter and length, so the main shaft produces the main cutting movement in just one step speed. Because the rotation speed of the motor is large enough, the belt transmission was chosen. The advantage of the belt drive is that it is suitable for large axial distances and works quietly at high speeds. The selected electric motor is a 1-phase motor with a capacity of 0.75kW, the speed of 1450 rpm.

The transmission ratios in the speed chain are selected as follows:

$$i_{belt1} = \frac{n_I}{n_{motor}} = \frac{n_V}{n_{motor}} = \frac{n_{VI}}{n_{motor}} = \frac{1450}{1450} = 1$$

$$i_{belt2} = \frac{n_{III}}{n_I} = \frac{n_{IV}}{n_I} = \frac{1450}{1450} = 1$$

$$i_{belt3} = \frac{n_{II}}{n_I} = \frac{n_{VII}}{n_I} = \frac{n_{VIII}}{n_I} = \frac{1450}{1450} = 1$$

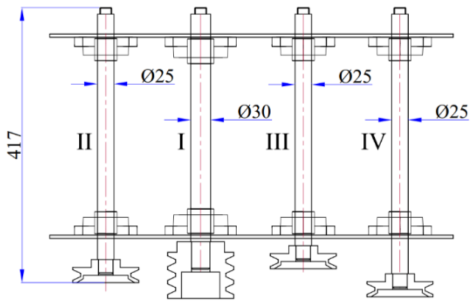
Then, the kinematic equation of the speed chain is expressed as follows:

$$1450 \times i_{belt1} = n_I \text{or} 1450 \times \left(\frac{1}{1}\right) = n_I$$

The main shaft (I) directly drives a disc grinding wheel moving at the same speed n_1 to perform the main cutting motion and the other 7 shafts also drive 7 disc grinding wheels moving at the same speed n_1 as the main shaft (I).

IV. STRUCTURAL DESIGN AND MANUFACTURE OF AUTOMATIC GRINDING MACHINE

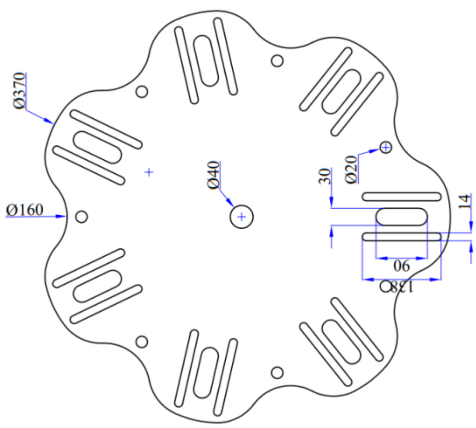
After the kinematic design is completed, the grinding machine is structurally designed and manufactured, as shown in Figure 6 and Figure 7.



(a) Mechanical structure of machine

(b) A photo of mechanical structure

Figure 6: Mechanical structure of shaft and pulley system of grinding machine



(b) A photo of face plates

(a) Structure of face plate

Figure 7: Face plate of grinding machine

V. CONCLUSION

The bamboo straw end-face grinding machine has been researched, designed and manufactured successfully. The machine ensures to perform the grinding process of bamboo straws with a design capacity of 320 work pieces per minute. Products after grinding meet technical requirements for quality and aesthetics. The study calculated the complete design of the kinematic structure diagram of the bamboo straw end-face grinding machine. The results of successful manufacturing of the bamboo straw end-face grinding and experimental processing with the calculated parameters achieved the right productivity as designed.

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