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Research Paper

Design and manufacture grinding machine for grinding the outer surface of bamboo straws

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ABSTRACT: *This paper presents the results of the process of designing and manufacturing machines grinding the outer surface. The grinding machine performs the following functions: orienting the workpiece and continuously grinding the outer surface of the workpiece. The parameters calculated during the design process include: speed chain, kinematic chain, kinematic structrure of the machine. The machine achieves a processing capacity of 430 products per minute. Grinding machines after successfully manufactured have been widely applied in addition to actual production.*

KEYWORDS: *Bamboo straws; Grinding machine; Kinematic*

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I. INTRODUCTION

Bamboo is the earth's most sustainable plant. Bamboo can actually grow to full maturity between 3-5 years and grows in abundance, mainly in the warm and tropical climates of Asia. It represents strength and versatility and is used for a variety of things, not just for drinking straws. It's stronger than steel and is fully biodegradable, and the most important thing; it won't contribute to the heartbreaking damage that single-use plastic is causing to oceans, rivers and wildlife habitats all around the world [1].

Figure 1: Bamboo straws

Buying bamboo straws from real bamboo stalks that you can reuse over and over again is about as sustainable and planet-friendly as you can get. If we compare the damage that single-use plastics are causing to our coastlines with what happens when bamboo has reached the end of its' life, there really is no question on which material has the harshest effects on our environment. The good news is that once you have finished with your bamboo straw completely, you can simply toss them onto the compost heap where they will break down and compose naturally [3].

Bamboo straws can be used time and time again and look great in any drink. Because bamboo is a natural material, they of course won't last as long as a metal straw, but they cost a fraction of the price and can be used for many other things after they've finished their life as a straw; think plant stands and props for the kids school craft projects [4]. You can reuse bamboo straws hundreds of times over, so if we do the math, they can be far more economical than nasty plastic alternatives that are designed to be used once, and then instantly disposed of.

Bamboo is completely natural and our straws grow without the need for any harmful pesticides or chemicals. The bamboo is steam cleaned and pressure washed and unlike metal straws, do not conduct the heat from hot drinks which may burn your mouth [5]. Bamboo is also great for keeping the drink at the temperature in which it was poured at, meaning iced smoothies and milkshakes won't give you brain freeze.

In this article, we present the results of the process of researching, designing, manufacturing and testing a machine for grinding the outer surface of bamboo straws. The machine is partially automated, contributing to reducing costs and labor and being environmentally friendly.

II. THEORITICAL BASIS FOR DESIGN

In machining, there are many grinding methods. such as: flat grinding, outer rounded grinding, inner rounded grinding, centerless grinding, etc. Flat grinding is a method of finishing flat surfaces after milling or planing, whether or not heat-treated. Outer rounded grinding with a center has high universality. When grinding, you can mount the part on two center bits or on a chuck. It is recommended to use two center holes as unified quasi-crystals so that the residual amount is even and ensures concentricity between the axis levels. After heat treatment, the center hole needs to be repaired before grinding. In contrast to outer rounded grinding, inner rounded grinding has a larger axial contact between the grinding wheel and the part. As a result, the chip is thin and long, causing it to be compressed and pushed into the chip chamber void. The grinding wheel is limited by hole diameters and thereby rapidly changes size while grinding. In centerless grinding, the workpiece is held between two wheels, rotating in the same direction at different speeds, and a work-holding platform. One wheel, known as the grinding wheel (stationary wheel in the diagram), is on a fixed axis and rotates such that the force applied to the workpiece is directed downward, against the work-holding platform. This wheel usually performs the grinding action by having a higher tangential speed than the workpiece at the point of contact. The other wheel, known as the regulating wheel (moving wheel in the diagram), is movable. This wheel is positioned to apply lateral pressure to the workpiece, and usually has either a very rough or rubber-bonded abrasive to trap the workpiece.

In this article, we focus on the centerless grinding method and apply it in the process of grinding the outer surface of bamboo straws.

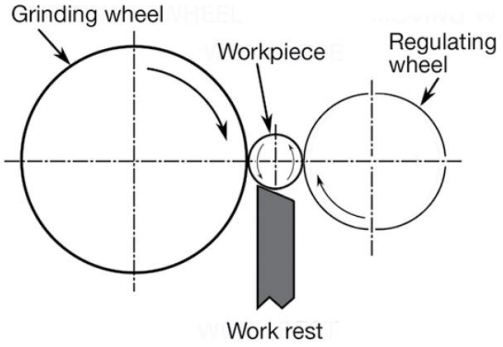

Figure 2: Operating principle of centerless grinding

In centerless grinding, the workpiece is held between two wheels, rotating in the same direction at different speeds, and a work-holding platform. One wheel, known as the grinding wheel (stationary wheel in the diagram), is on a fixed axis and rotates such that the force applied to the workpiece is directed downward, against the work-holding platform. This wheel usually performs the grinding action by having a higher tangential speed than the workpiece at the point of contact. The other wheel, known as the regulating wheel (moving wheel in the diagram), is movable. This wheel is positioned to apply lateral pressure to the workpiece, and usually has either a very rough or rubber-bonded abrasive to trap the workpiece [2].

Figure 3 depicts the movements required during machining. The grinding wheel rotates around its axis to perform the main cutting motion. The regulating wheel rotates around its axis to perform a feeding motion. The special point here is that the regulating wheel is positioned at an angle A compared to the axial direction of the grinding wheel. This causes the regulating wheel to simultaneously drive two movements of the workpiece. Includes circular motion around the center and translational motion. During the machining process, the part performs two movements simultaneously, including rotation around the axis and translation along the axis.

Movements during machining include:

- Circular motion around the axis of the grinding wheel n_1
- Circular motion around the axis of the regulating wheel n_2
- Circular motion around the axis of the workpiece n_3
- Axial translational movement of the workpiece n_4

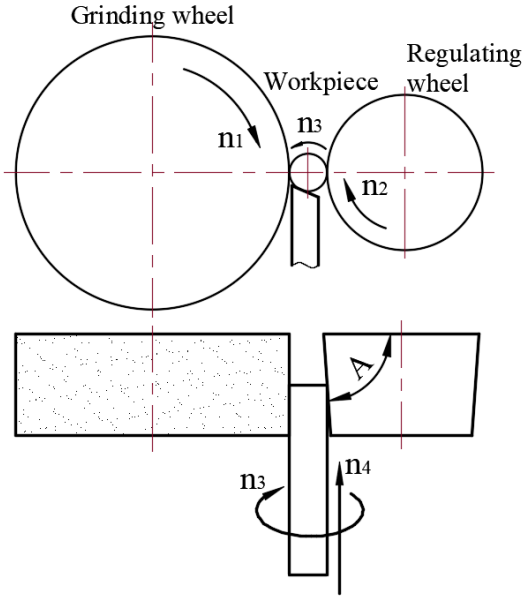

Figure 3: Complicated movement of bamboo straws during grinding

The combination of these movements will form the surface to be machined, which is the outer surface of the bamboo straws. These movements also directly affect the surface quality of the workpiece. In the following section we will learn more about this influence.

III. DESIGN THE KINEMATIC DIAGRAM OF THE MACHINE

The kinematic design process includes the following steps:

1. Speed kinematic chain:

$$n_{motor1}(round/min).i_{12}.i_V.i_{34} = n_{grinding\ wheel}(round/min)$$

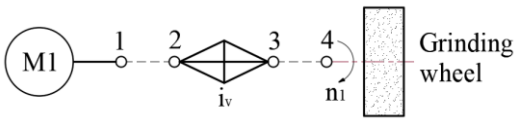

Figure 4: Speed kinematic chain of grinding machine

2. Tool feed kinematic chain:

$$n_{motor2}(round/min).i_{56}.i_s.i_{78} = n_{regulating\ wheel}(round/min)$$

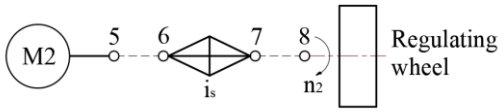

Figure 5: Tool feed kinematic chain of grinding machine

The process of kinematically connecting the two kinematic groups was not successful because the above 2 kinematic groups have no kinematic relationship with each other. These two kinematic groups are completely independent in terms of kinematics. The kinematic connection process here is simply mechanical connection

Material cutting technology on machine tools has the function of shaping the surfaces of machined parts according to technical requirements. The mechanism for forming the machined surface is quite complex, not only depending on the machining technology and machining tools but also on the motion processes, motion coordination and control of the machining technology process. And with the intention of focusing on the definition of forming a machined surface on a machine tool, the surface is formed by a moving line (dynamic forming line - generating line) resting on a fixed line (creating line). static image - standard line) according to a certain dynamic law. Thus, shaping the machined surface on machine tools is essentially shaping the generating line and the reference line (often collectively called the surface shaping line).

We get the kinematic structure diagram or kinematic diagram of the full machine.

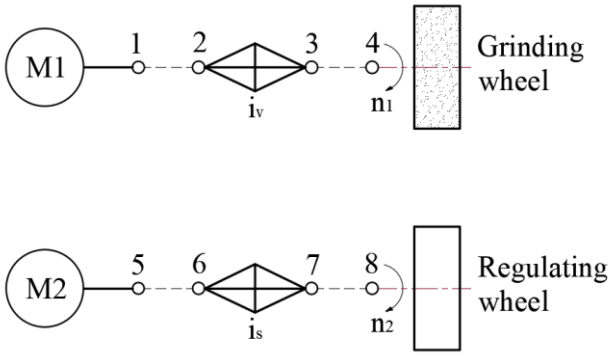

Figure 6: Kinematic diagram of grinding machine

During machining, movements take place independently. The main cutting motion performed by the grinding wheel will create the main cutting velocity. The tooling motion performed by the regulating wheel will create a feeding motion. Feeding motion includes rotation around axis n_3 and translational motion along axis n_4. The n_3 motion makes the grinding process cover the entire outer circumference of the bamboo straws. The n_4 reciprocating motion makes the grinding process cover the entire length of the bamboo straws.

IV. DESIGN STRUCTURAL DESIGN AND MANUFACTURE OF GRINDING MACHINE

After the process of designing the dynamic structure of the machine, the process of designing the drawings and manufacturing the complete grinding machine is shown in Figure 7, 8 and 9.

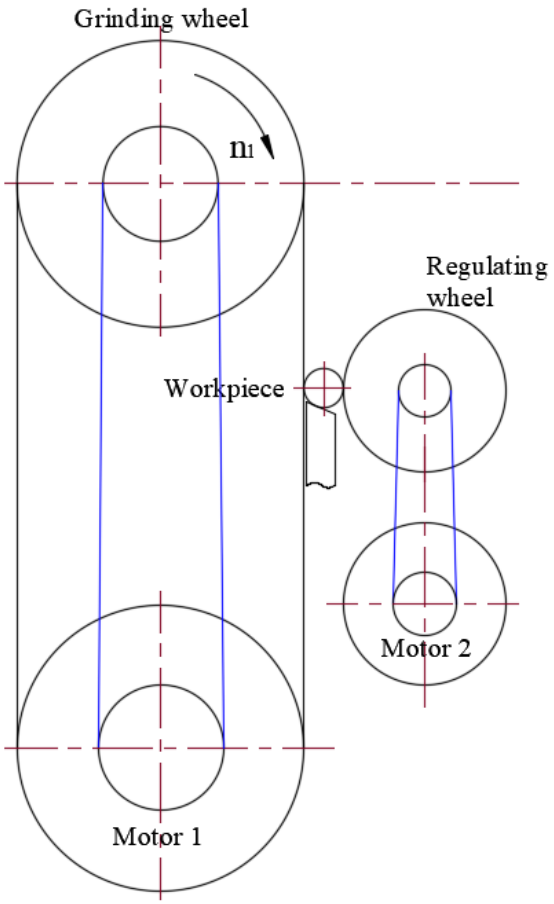

Figure 7: The motor drives the shafts by the belts

Figure 8: A photo of grinding machine

Figure 9: A photo of grinding machine

V. CONCLUSION

The bamboo straw outer surface grinding machine has been successfully researched, designed and manufactured. The design process includes establishing machine kinematic structure diagrams, making design drawings, and manufacturing drawings. The manufacturing process includes manufacturing the machine frame and assembling the complete machine. Then test run and adjust the machine. Bamboo straw surface grinding machine helps save processing time, costs and labor, increasing labor productivity many times. Estimated productivity is 430 products per minute. The results received after completing the manufacturing process are consistent with what has been designed.

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