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The Design of Double Screw Threads Soymilk Stone Mill

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Abstract

In order to solve the problem of traditional stone mill, such as bulky structure, low efficiency, easy to be blocked, this paper design and implement a new conical double-screw threads stone mill refiner, rotating stone mill body is conical with two right-hand threads. As the diameter increases, its depth decreases. This structure can improve mechanical efficiency. The experiments showed that the machine's low-speed layer-by-layer uniform crushing grinding soybeans, the soymilk less susceptible to high temperature damage, is conducive to a variety of nutrients reserved.

Keywords: Soymilk; Stone mill; Conical mill; Refiner

Introduction

Amid the improvement of living conditions in China, the Chinese have more requirements for foods nutrition and variety. The grinded soymilk and flour porridge mixed by grains, such as rice, corn and bean, are nutritious and delicious. Having more than 2,000-year history and being still in use today, the stone mill is the traditional grinding device. But presently the stone mill refiner available has large size and high cost, high operation temperature, offering bad taste. Moreover, the grinding wheel has high rotate speed and short service life. Security accidents occur from time to time caused by different quality standards of grinding wheels, poor adhesive strength, and poisonous components in the binder [1].

The conical stone mill refiner, a kind of ecological stone mill device, is developed through researching the processing technique of the traditional stone mill and performing modern improvements. It delivers power by motors and may retain nutrition of agricultural products and effectiveness of Traditional Chinese Medicine.

It takes the granite in the Taihang Mountains area as the raw material of the stone mill. There are excellent granite resources in the Taihang Mountains area in China, such as Fengzhen, Hunyuan, and Fuping. Its products export to overseas countries and enjoy worldwide high reputation. The granite has excellent physical performance, namely, high hardness, abrasion resistance, low water absorption rate, compressive strength 100 ~ 127 MPa, and Shore hardness 78 ~ 80. Historically in the Taihang Mountains area, the granite is the traditional material to make the stone mill, which is still in use nowadays [2]. It has formed a complete system to manufacture the stone mill. There is no regional disease record of local residents caused by foods made by the granite stone mill. Therefore, this kind of granite is unlikely to do harm to human body. Based on its essential performance, considering that it is applicable regionally, it may develop resources in the Taihang Mountains area, which will be advantageous to promote the local economy.

Principles and Features of the Soymilk Stone Mill

As the main part of the processing, the stone mill designs include stone materials selection and determination of grinding marks.

The selection of stone materials

It is traditional to make the stone mill in various parts of China in history. To take regional materials may avoid long term conveyance. Generally, it selects fine materials to manufacture stone mills, such as the sandstone, the bluestone, and the granite. As the crystallization formed by gradual magma condensate from deep underground, the granite is known as the King of the Rock. It is hard and durable in use, acid-resistant, alkali-resistant, and anti-weathering. The granite appearance is shown in Figure 1.

There are excellent granite resources in the Taihang Mountains area in China, such as Fengzhen, Hunyuan, and Fuping. Based on its prominent performance, considering that it is applicable regionally, the granite in the Taihang Mountains area is used as the raw material of the stone mill [3]. So that local residents will be richer than before through making stone mills, which can also develop resources in the Taihang Mountains area. The granite is illustrated in Figure 2.

The design of grinding marks

The earliest grinding marks were shown in millstones in the Spring and Autumn and Warring States Periods of China. The history

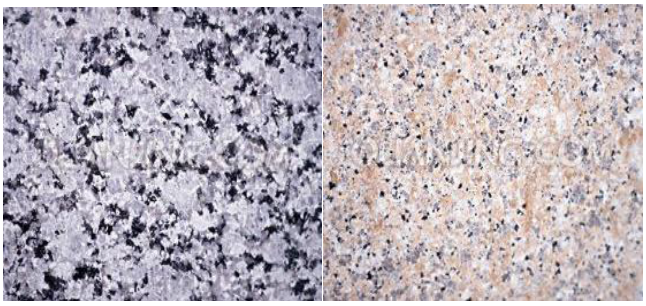

Figure 1: Different types of granite.

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of stone mill forms change can be divided into three periods, with corresponding forms of grinding marks. During the initial forming stage from Warring States to the Western Han Period, the stone mills had irregular shapes and the corresponding grinding marks showed miscellaneous forms. Pit was the most popular grinding mark, having the shapes of rectangle, circle, triangle and shuttle. There were scattered pits distributed at the upper and lower parts of the millstone. The second phase for stone mill developments was from the Eastern Han Period to Three Kingdoms Period. Thanks to manufacture technique developments at that time, the round stone mill was the domain form in this stage. Grinding gears had diversified developments during this period, having the radial divisional sector types, including four-section, six- section and eight- section [4]. The third developing phase, Sui and Tang Period, was the mature state of the stone mill, when the most popular grinding mark was eight-section sector type, also ten-section sector type, which was still in use nowadays.

The stone mill can be used to process soymilk, flour, sesame oil, and tea, also used as a kind of handiwork. Different functions of the stone mill require different grinding marks. Figure 3 shows stone mills for flour and soymilk. Comparing the stone mill for flour with that for soymilk, it shows that their grinding marks are similar and characteristic respectively. They all have divisions in the millstones and are scattered anti-clockwise relative to the center and its edge. What makes these marks different is that the grinding mark of the flour millstone is connecting from its center to its edge, while that of the soymilk stone mill is not connecting at 2 cm from the its edge. The grinding lip, the disconnecting part on the millstone, refers that the grinding mark cannot carve to the edge of the millstone and it shall reserve a circle of smooth blank. It depends on different processing objects. The flour stone mill aims to process wheat to powders, whose particle diameter is greater than 100 nm. But the soymilk stone mill aims to successfully get the protein out of the grinded soya beans. As a kind of colloid, its particle diameter is smaller, ranging from 1-100 nm. The grinding lip of the soymilk stone mill is meant to smash larger particles into pieces by a dull knife so that the colloid in the refined granule will be extracted.

Figure 2: Taihang Mountain granite.

A B

Figure 3: Stone mills for (A) Flour and (B) Soymilk.

The Structure Design of Double Screw Threads Stone Mill

As Figure 3 illustrated, the traditional stone mill is composed of the upper and the lower flat cylindrical millstones that are made of carved boulders. The top of the upper millstone is a concave that is low in the center and high around. The lower millstone is a little bit thicker that the upper one. There are grinding marks on the surface where the upper and lower millstones cooperate. On the soya bean stone mill there is only one feed inlet.

The upper millstone makes low-speed rotation movement, which can be driven by manpower and animal power. Grinding marks of the upper and lower millstones occlude and interweave each other. Their grooves become shallower and shallower from the center to the edge, which will be advantageous for the grinded fines to flow to the outside. Generally, directions of grinding marks are anticlockwise, in accordance with the habit of using the strength [2-4].

In this paper it purposes a new modernized electric conical stone mill, in order to ensure effective processing area in limited spaces and to make the process smooth. The structure is illustrated in Figure 4. The stone mill is composed of two millstones, (1) the inner one and (2) the outer one. The inner one is a cone that its small end is at the top, with double right-turn thread grinding marks. The outer stone mill is a hollow column. Two millstones cooperatively compose the finished surface (inside discharge hopper). The conical stone mill, the gap between two stone mills becomes smaller and smaller from top to bottom. The soaked soya beans are a little bit large so that the great gap on the finished surface will be convenient for soya beans to be put and grinded here. The grinded soya beans fall into gaps under the functions of flow, friction and squeezing for further accurate grinding. By taking the conical millstone it is possible to increase its valid finished surface area within limited space and to lower the weight of the stone mill. By adjusting the position of two stone mills it may adjust the gap of the finish surface, so that the juice grain fineness can pass through 100 mesh screen. Nutrition can be fully released after several grinding processing. It may avoid the bean pulp (bean dregs and skins) to be mixed into the soymilk, which will affect the taste.

The outer stone mill rotates with side type motor. Structures are shown in Figure 5A.

The whole set of structure is placed in a sealed enclosure, shown in Figure 5B.

Pour beans and water from the funnel. Soymilk flow out from the bottom left.

In order to ensure that the soybean into the wedge gap, should meet the following conditions:

$$L < \frac{(D - d/2)}{2} \quad (1)$$

Where,

L = soaked soybean width, about 7 mm

D = the inner stone mill top diameter, mm

D = the inner stone mill bottom diameter, mm

Then the wedge angle between the stone mills:

$$a = \arctan\frac{D-d}{2H} \quad (2)$$

H = the inner stone mill height, mm; When H is too large, easy to plug; when H is too small, the efficiency is low.

Due to high speed will cause temperature rise, affecting the quality and taste of soy milk, so, the bottom diameter must meet the following conditions:

$$D \le \frac{60 \times 1000 \times V_{max}}{n \times p}$$

V_{max} = Maximum line speed, m/s

N = rotation rate, r/min

Through the experiment contrasts, it suggests that when it is processing the soymilk, the linear speed of the grinding slice 9.16 m/s is proper. This millstone diameter is 150 mm and the setting speed is 80-350 r/min in operation. The allowed maximum rotating speed is 960 r/min.

A lot of experiments show that the following parameters are the best, shown in Table 1.

Results and Discussion

The double threads can make the stone body symmetrical structure, smooth operation, speed up feed, and is not easy to be blocked. The right screw is used to conform to the artificial force, and the artificial intervention is convenient when necessary. Pitch of screws is 30 mm. The thread depth gradually becomes shallow and completely disappeared at the distance 20 mm from the bottom. The design parameters of conical stone mill, outer diameter are 150 mm, height is 130 mm, taper is 3 degrees, and working surface area is about 43977 mm^2. But the traditional 150 mm diameter stone working surface area is about 13266 mm^2, only 1/3 of the conical stone mill.

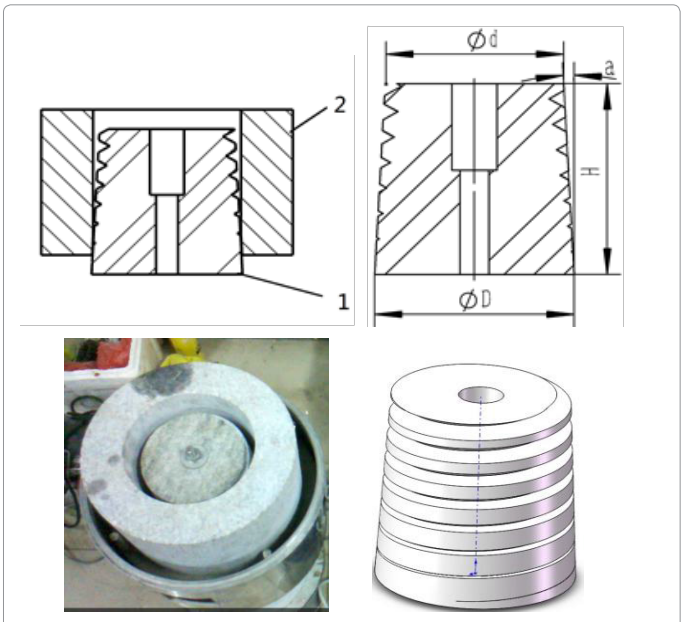

Figure 4: Conical stone mill.

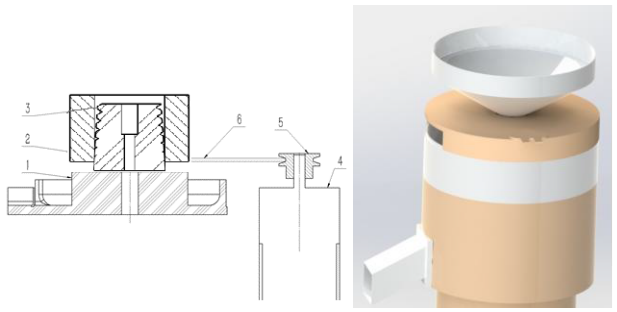

Figure 5: Conical stone mill structure (1) Stone mill on the chassis (2) The outer and (3) Inner. (4) The motor (5) driven the outer stone mill rotate through a belt pulley and a (6) Belt.

D	d	H	α	V_{max}	Pitch
150 mm	130 mm	190 mm	3°	400 r/min	30 mm

Table 1: Parameters of the conical stone mill.

Summary

By modernization technology and devices, considering features of mechanical juice and the traditional stone mill, it improves the design of the traditional stone mill. It proposed a kind of conical stone mill refiner, which increases grinding area. It grinds for several times for accurate grinding, in order to avoid gross powder. Therefore, the nutrition can be easily mixed with water. It will be homogenized and emulsified in a better way, which makes it easier to digest. The gaps of the finishing surface can be adjusted to meet requirements of different processing grains. This machine has stable reliable structure, being easy to install and maintain. It does not need to separate juice and residue, all of which promote its efficiency.

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