STUDY ON THE USE OF BALL MILLS IN THE MANUFACTURE OF CHOCOLATE

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ABSTRACT

In a world where the consumption of chocolate increases, quality plays an important role. In the manufacture of chocolate, grinding as well as the construction and operation of ball mills play an important role.

INTRODUCTION

The history of chocolate dates back to the 6th century AD when the Mayan people of the Yucatan cultivated the cocoa tree. This tree was one of the riches that the conquerors exploited and brought to the New World.

Christopher Columbus was the first explorer to come into contact with cocoa beans in the New World. Although in the New World, chocolate was one of the riches, in Europe no one enjoyed it, because they did not know what it is used for.

In 1519 the conquistador Hernando Cortez discovered that Montezuma, the ruler of the Aztecs, used to drink a drink made from cocoa beans, called "chocolatl".

At the beginning of the 17th century, the consumption of chocolate expanded. With each passing day, it became more and more tasty, and the recipes improved, becoming a commodity with exceptional sales. Thus, chocolate becomes a delight for both adults and children. The 19th century represents two important transformations in the history of chocolate.

[https://www.historia.ro/sectiune/general/articol/arta-ciocolatei-o-scurta-istorie]

In 1847 an English company created a technological process for solidifying chocolate, and two years later, the Swede, Daniel Peter, thought of adding milk as a new ingredient.

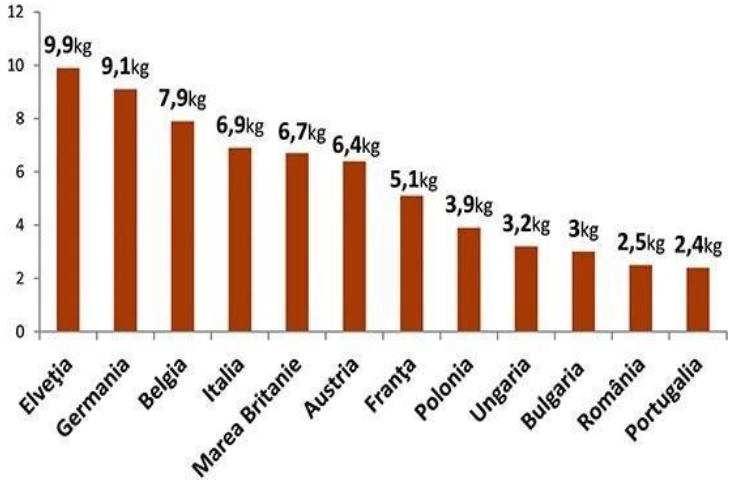

Figure 1. Chocolate consumption / per capita in Europe

MATERIAL AND METHOD

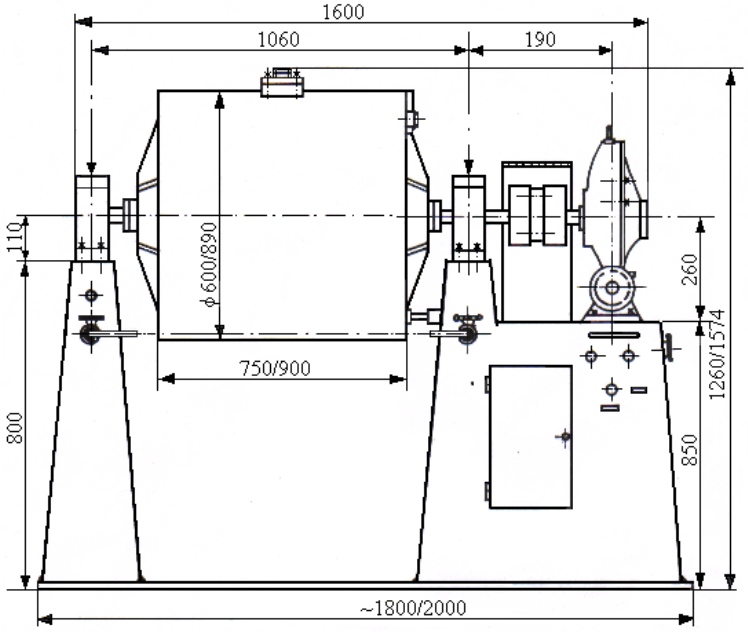

Figure 2. Ball mill used to make ceramic powders

Ball mills are found in: agriculture, biology, geology, metallurgy, chemical industry, building materials, electronics, medicine, pharmaceuticals, environment, recycling, glass, ceramics.
Figure 2 show ball mill used to make ceramic powders. The ball mill has a drum liner and ceramic grinding balls. The technical characteristics are the following: drum capacity 50kg; drum volume 10-1 m^3; engine power: 1.5 kW; engine speed: 1500 rpm; drum speed: 60 rpm; overall dimensions: 1800x1260x1050 [Şugar, 2007; Alexandrescu et al., 2019].

RESULTS AND DISCUSSIONS

Results and discussions. The crushing operation is characterized by the degree of crushing and is given by the ratio between the average diameter D of the material before the operation and the average diameter d of the product obtained:

$$\lambda = \frac{D}{d}$$

The ball mill is used for the very fine dispersion of solid particles in order to obtain products with a high consistency and temperature sensitive (eg chocolate). Crushing the cacao beans is done by hitting the material with small diameter balls (2.3 mm) made of hard steel (alloyed with chrome and nickel). The mill is 80% loaded with balls, which constantly receive the energy of movement from the shaft of the discs and bars and transmit it to the product to be crushed [Bâlc G., et al., 2016; Ţucu, 2007]. The mill is made of a cylindrical body suspended from the head. Inside the body is mounted the hollow shaft with discs, having the inner space used to supply a coolant.
The discs have impact bars mounted on the periphery, which project the balls onto the periphery of the cylindrical body, on which the bars are also mounted. The tapered movement of the bars ensures a helical upward movement of the product, which is fed into the machine through the connection at the bottom.
The material crushed to the desired fineness is discharged through the space provided with a sieve that does not allow the evacuation of the balls. Because heat is produced during hitting and rubbing of the balls and grinding material, it is necessary to cool the cylindrical body to maintain the consistency of the product at the initial value, thus ensuring the operation of the machine with optimum efficiency.

[http://materiale.pvgazeta.info/utilizator-174/principiul-moara-cu-bile.html]

In order for the movement of the balls to produce maximum effect, it is necessary to adopt a speed slightly lower than the critical one. Thus, the balls move together with the mantle, on a circular path to a certain point, from where they then begin to detach and fall on a circular path to a certain point, from where they then begin to detach and fall on a parabolic trajectory. The higher the ball drop speed and the hitting action, the higher the ball lifting point relative to the jacket. It follows that the kinetic energy will be maximum. The higher the drop height of the balls leads to a more efficient grinding. At a high mill speed, above the critical speed, the balls adhere to the inner surface of the mill due to the high centrifugal force and rotate together with the jacket. In this case, the crushing process does not take place. At a low speed, below the critical speed, the balls roll down and are not raised on the jacket, the balls rotating around their own axis, which is parallel to the mill axis, the resulting processing capacity being very low due to friction between the balls. and the mantle. The following figures show the movements of the balls at different speeds [Diaconu, 2003].

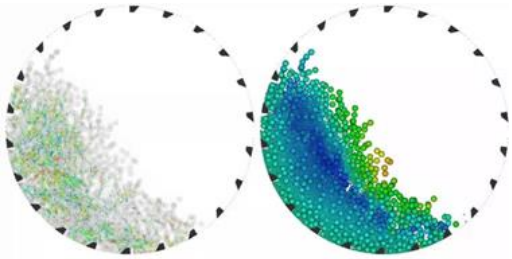

Figure 3. The movement of the balls

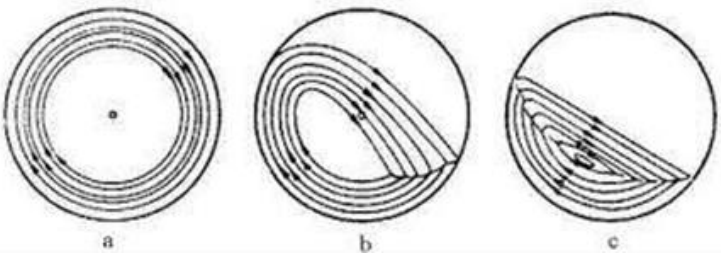

Figure 4. Scheme of the movement of the balls in the mill at different speeds: a-speed too high; b-optimal speed; c-speed too low

The operating cycle of a ball mill involves three phases: start-up period, idle period and operating period during pregnancy (Figure 5).

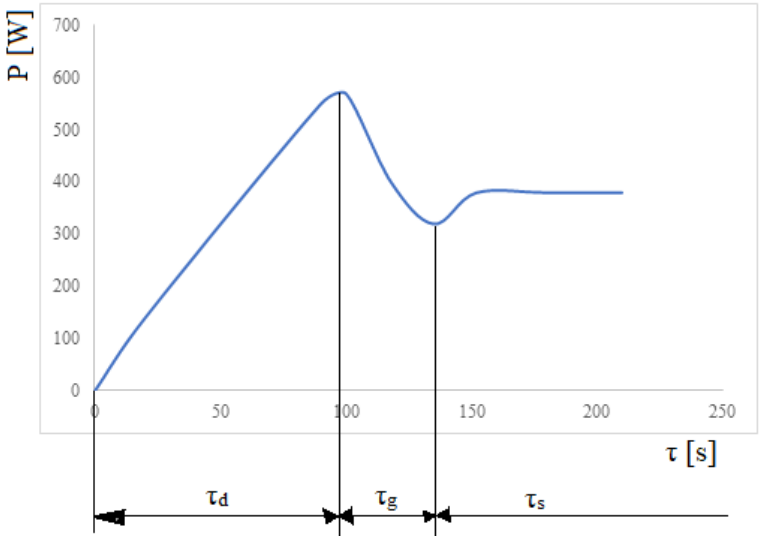

Figure 5. The operating cycle of a ball mill

The training is done with a single-phase asynchronous motor. When choosing the engine, the starting power is taken into account. Thus the power of the chosen motor must be greater than $\frac{5}{3}$ the starting power.

CONCLUSIONS

The advantages of this mill are: ensuring a high degree of crushing, safety in operation as well as a simple construction. Shredding can be combined in this case with drying and / or sorting operations.
The disadvantages of the classic mills are that the volume of the working chamber is used only in a proportion of 35-45%, the energy consumption is high and in operation they produce a loud noise.
This does not preclude the search for solutions that involve specialists from all over the world.

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