

Study on Corn Straw Crushing Characteristics Test

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Abstract: this paper mainly presents the research on the corn straw crushing characteristics test through the property parameters such as the electricity consumption per ton materials, hammer pitch thickness and output per kWh etc. when the different moisture rates, sieve pore diameters and hammer quantity are different. The results show: as for the machine with the same sieve mesh diameter, with the increment of the moisture rate, the load input power keeps unchanged basically, while the electricity consumption per ton materials is increased and the productivity is reduced; as for the corn straw with the same moisture rate, with the increment of the sieve pore diameter, the electricity consumption per ton materials and load input power are reduced; the output per kWh and crushing efficiency are increased with the reduction of the hammer thickness. When the hammer thickness is 4mm, it can not only maintain a high crushing efficiency but also guarantees the durability to a certain extent.

Key words: moisture rate, electricity consumption per ton materials, load input power, sieve pore diameter, output per kWh

0. INTRODUCTION

Confronted by the increasing deterioration of the mineral energy and environmental problems, the scale-up utilization of the bio-mass resources becomes vital. As for the corn straw with its output ranking number one, its comprehensive utilization is very significant for the sustained social, economic and environmental development. For the time being, the scale-up utilization technologies for corn straws mainly includes the carbonization technology, gasification technology, feedstuff technology, density forming technology, liquefaction technology and so on. The above-mentioned technologies all require crushing the straws at first, thus the research on the crushing characteristics of the corn straws is inevitable.

The equipment used to crush the corn straws has a history of more than 30 years^[1], with complete types. But it also shows the shortcomings of instable operation, poor adaptability of materials, large energy consumption and so on^[2], which can't effectively satisfy the requirements of the scale-up crushing of corn straws. Therefore, by introducing the representative 9FQ-650 pulverizer in the current market, this paper has provided testing evidences to improve the pulverizer performance through a great lot of research on corn straw crushing and analysis on the crushing characteristics of corn straws, thus to further offer scientific reference on the pre-treatment technology for the utilization of crop straw resources.

1. TESTING MATERIALS AND METHOD

1.1 Testing Materials and Equipment

The original corn straws, which are naturally dried, are adopted, and the typical 9FQ-650 pulverizer is used as the testing equipment which is reconstructed partly for the crushing test.

1.2 Testing Method

Based on the test of studying the effects of moisture rates on the crushing characteristics, and by controlling the moisture rate of corn straws, we have carried out the test of researching the impacts of different sieve pore diameters on the electricity consumption per ton materials; by controlling the sieve pore diameter, we have conducted the test of studying the influence of different moisture rate of corn straws on the pulverizer output and electricity consumption per ton materials; by adopting different hammer patch thicknesses, the test of researching the influence of the hammer patch thickness on the one-kwh yield, crushing efficiency and durability has been done.

2. TESTING RESULTS AND ANALYSIS

2.1 Effects of Moisture Rates on Crushing Characteristics

When crushing, the moisture rate of materials bears a significant influence on the pulverizer performance indexes, including the mechanical

consumption, processing cost, operation life, product output and quality and so on. Table 1 has indicated the testing data of the effects of moisture rate of corn straws on the key performance index of the pulverizer ---output.

Table 1 The connection between the moisture increment rate and output slip

Moisture increment/(%)	1	2	3	4	5
Output slip/(%)	4-6	5-9	8-11	11-13	14-16

From Table 1, we can see that when crushing the corn straws, the higher the moisture increment is, the lower the output slip is. The reasons are as follows: first, during the delivery of corn straws, the increment of moisture rate will increase the friction coefficient between the materials and delivery equipment and thus reduce the flowability of corn straws, which not only increases the delivery equipment power, but also adds the friction among equipment lines, and it is liable to form an arch on the discharging port^[3], unbeneficial for the delivery and collection of corn straws. Second, when crushing the corn straws, the increment of moisture rate will increase the hammering times of hammers; meanwhile, the heat will be generated due to the friction among corn straws and the hammering, leading to the water evaporation inside the straw. The evaporated water forms humid and hot air in the crushing room and then the vapor forms paste with the refined powder on the sieve plate, which may clog the sieve pore, reduce the pulverizer discharge and thus increase the idle work^[4].

When crushing the corn straws, the lowest moisture rate is not the best one. The test indicates that when the moisture rate is lower than 10%, the hardness of corn straws will be increased drastically^[5], leading to the electricity consumption increment, production cost rise and reduction of the equipment service life.

2.2 Analysis on the Electricity Consumption Per Ton Materials under Different Working Conditions

Figure 1 has indicated the testing data of effects of different moisture rates and sieve pore diameter on the electricity consumption per ton materials.

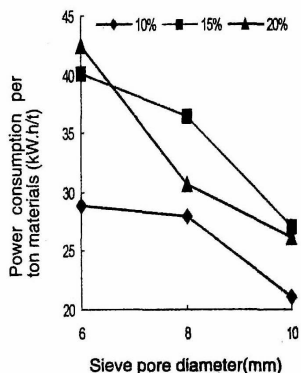


Figure 1 Effect of different moisture rates and sieve pore diameters on the electricity consumption per ton material

Through the analysis on the testing data, the following conclusion is achieved: as for the sieve ports with the same diameter, the electricity consumption per ton materials for the corn straws with high moisture rates is obviously higher than that of straws with a lower moisture rate. So with the increment of moisture rate, the electricity consumption per ton materials rises up. As for the corn straws with the same moisture rate, with the increment of the sieve pore diameter, the electricity consumption per ton materials drops down.

2.3 Load Input Power under Different Working Conditions

Table 2 has indicated the testing data on the load input power of the pulverizer under different moisture rates and sieve pore diameters.

Table 2 Effects of different moisture rates and sieve pore diameter on load input power of pulverizer

Moisture rate (%)	Sieve pore Diameter(mm)		
	6	8	10
10	9.6	8.4	8.4
15	9	9.6	8.4
20	9.6	9.6	8.4

From Table 2, we can see that for the sieve pore with the same diameter, the moisture rate of materials bears minor effects on the load input power, and there is basically no change; as for the straws with the same moisture rate, with the increment of sieve pore diameter, the load input power drops down. Additionally, the test indicates: however the moisture rate and sieve pore diameter change, the load input power is always larger than that of the standard power of the motor. The power at zero load is high and rises up at geometric series with the revolution. If the revolution is doubled, the power will be increased by twice. This rule tells us that as long as the hammering and crushing effects of the crushed materials can be fully fulfilled when designing the pulverizer power to avoid the energy waste, the lower the revolution is, the better it is. So a lot of energy can be saved, and the vibration and noise of small-sized machines can be reduced thus to cut down the stress on the principal axis and prolong the bearing service life and so on.

2.4 Analysis on the Relationship between the Hammer Patch Thickness and Crushing Characteristics

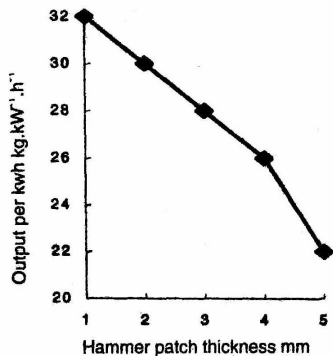


Figure 2 Graph of relationship between the output per kWh and hammer patch thickness

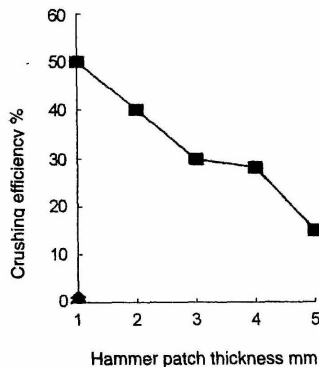


Figure 3 Graph of relationship between the crushing efficiency and hammer patch thickness

When crushing the corn straws, the pulverizer crushes the materials mainly through the violent friction between the materials and hammer pitch edges and corners, sieve plates and toothed plate with the high-speed impacts [6]. For different hammer patch thicknesses, the impacting force and contact area are varied. From Fig.2 and Fig.3, we can see that the output per kWh and the crushing efficiency are increased with the reduction of hammer patch thickness. Taking the 3-mm-thick and 5-mm-thick hammer patches for comparison, the output per kWh of the pulverizer is increased by 30%, and the crushing efficiency is improved by 10%. The testing results show that the thin hammer patch is beneficial for the improvement of the output per kWh and crushing efficiency. However, with the reduction of hammer patch thickness, its durability becomes poor, which is unsuitable for the long-term working under heavy load. Therefore, to design a suitable hammer

patch thickness is vital. Depending on the tests and practical operation, when the hammer patch thickness is 4mm, it can not only maintain a high crushing efficiency but also guarantee the durability to a certain extent.

2.5 Effect of Hammer Patch Number on the Output Per kWh

In this paper, a hammer patch thickness of 5mm and a patch number of 4, 8, 12 and 16 respectively are adopted for the crushing tests of corn straws. The testing results are indicated in Fig.5.

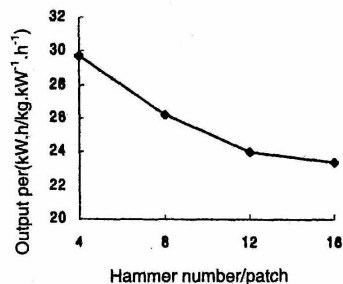


Figure 4 Relationship between hammer patch number and output per kWh

The Fig.4 indicates that the number of hammer patches bears a heavy impact on the output per kWh, which is reduced with the increment of hammer patch number. For an instance, the output per kWh for the pulverizer with 4 hammer patches exceeds that of the machine with 16 patches by 27%. Because with the increment of the hammer patch number, the idle power consumption is increased, while the efficient power is relatively reduced; with the increment of the hammer patch number, the material granularity is reduced and the specific surface is increased. Thus the excessive sifting becomes the major problem, leading to a drop of the output per kWh.

3. CONCLUSION

(1) However the moisture rate and sieve pore diameter change, the load input power is always larger than that of the standard power of the motor. The power at zero load is high and rises up at geometric series with the revolution.

(2) When crushing the corn straws, the higher the moisture increment is, the lower the output slip is. But the lowest moisture rate is not the best one, when the rate is lower than 10%, the pulverizer energy consumption is increased.

(3) As for the corn straws with the same moisture rate, with the increment of the sieve pore diameter, the electricity consumption per ton materials will drop down.

(4) The output per kWh and the crushing efficiency are increased with the reduction of the hammer patch thickness. When the hammer patch thickness is 4mm,

it can not only maintain a high crushing efficiency but also guarantee the durability to a certain extent.

(5) The number of hammer patches bears a heavy impact on the output per kWh, which is reduced with the increment of hammer patch number.

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