Research on Cleansing and Drying System of Rice Husk before Pyrolysis

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Abstract. Rice husk gasification technology has been concerned by many scholars at home and abroad. Because the rice husk contains too much impurities and dust, too much air is mixed into the combustion, which affects the purity of pyrolysis gas, causing difficulties in gas purification, blockage and corrosion of pipelines and other problems. In order to improve the quality of rice husk pyrolysis gas, the authors designed a cleansing and drying system of rice husk before pyrolysis. This paper analyzed the design principle of the system, designed the structure of screw conveyor and the dryer, determined the structure parameters of the system. The study indicates that the system can cleanse and dry the rice husk into the system, and can be used as a pretreatment device for rice husk pyrolysis.

Keywords: Rice husk; Pyrolysis; Cleansing system; Drying system.

1. Introduction
Petrochemical energy is not renewable, and energy shortage has become a major problem facing mankind. Biomass is recognized as one of the most potential renewable energy sources in the world [1]. Rice husks are the most typical biomass. China is the world's largest rice grower and consumer. Rice husk resources are very rich, producing about 360 million tons every year [2]. If we can make good use of rice husk resources, we can not only save resources, purify the environment, but also bring considerable economic benefits. At present, rice husk gasification technology has been concerned by scholars at home and abroad. Rice husk gasification uses gasifier to burn rice husk under anoxic state, converting most combustible materials into combustible gases such as carbon monoxide, hydrogen and methane. After cooling and purification, combustible gases can be used for power generation or heating combustion or as raw material gas for chemical synthesis [3]. This is consistent with our energy and environmental policies. At present, the high tar content and low carbon conversion rate of combustible gas produced by rice husk gasifier on the market make gas purification difficult, plug and corrode pipelines, and affect the normal work of internal combustion engine or gas turbine. The root cause of the above problems is that the rice husk contains too much impurities and dust, and the combustion mixed with too much air, which affects the purity of the gas produced. Therefore, it is necessary to cleanse the rice husk entering the gasifier. In addition, the researches of Zhu Xifeng and Zhou Yayun show that a large part of the heat absorbed in the pyrolysis reaction is to remove the water from the biomass, and the water in the biomass will delay the start of the pyrolysis reaction [4,5]. Therefore, it is necessary to carry on the drying pretreatment to the rice husk entering gasifier. To this end, this paper designed a rice husk cleansing and drying system.
2. System Composition
The rice husk cleansing and drying system is composed of two parts, as shown in Figure 1. One part is the rice husk cleansing system, mainly including blower 3, dust collecting box 4 and screw conveyor 6, which is used to remove the dust in the rice husk and the air mixed in the rice husk. The other part is the rice husk drying system, mainly including dryer 9, blower 8 and screw conveyor 10, which is used to remove water in the rice husk.

The working principle of this system is: when the bottom valve controller 2 is open, the rice husk in the bin falls through the bottom valve. Under the action of blower 3, dust blown into the dust collection box 4, and the husks fall into the feed hopper of the screw conveyor 6 and through the screw conveyor 6 into the dryer 9. A material level sensor and an alarm are installed in dust collector 4. When the box is full of dust, the alarm is turned on and it reminds the staff to remove the dust or replace the box. Spiral conveyor 6 is a variable pitch and variable diameter conveyor. When the rice husk passes through this conveyor, it is gradually squeezed, and the mixed air and residual dust in the rice husk are discharged through the radial hole in the conveyor shell, so as to achieve further cleansing of the rice husk. The rice husk in dryer 9, after drying, enters gasifier 11 through screw conveyor 10, and produces the finished product that meets the requirements. Dryer 9 adopts the principle of hot air drying. The rice husk drops from top to bottom, and the high-temperature flue gas generated by gasifier enters into dryer 9 to dry the rice husk. After drying, the exhaust gas is discharged by blower 8. The whole system realizes the recycling of rice husk drying - cleansing - high temperature flue gas - drying.

![Figure 1. Schematic diagram of rice husk cleansing and drying system](image)

1-bin, 2-bottom valve controller, 3 and 8-blower, 4-dust collecting box, 5-motor, 6 and 10-screw conveyor, 7-dust cover, 9-dryer, 11-gasifier

3. Screw Conveyor Design
3.1. The Basic Structure
As shown in Figure 2, the screw conveyor includes spindle 63, blade 66, casing 65, feed port A 61 and discharge port A 69 A, etc. The feed port and discharge port A are installed on both ends of the casing, and the spiral blades are welded on the spindle. The spiral conveyor is divided into three sections: L1,
L2 and L3. The casing at both ends is cylindrical, the middle is conical. The spiral blade is also divided into three sections too, and both ends is cylindrical, the middle is conical. On the case of L2 section, 6 radial holes are evenly set along the circumference with the aperture of 1mm within each pitch range. Disc 64 and 67 are welded on both ends of the casing in L2 segment. Dust cover 7 is installed on the disc 64 and 67 to prevent the dust discharged through the radial hole of the casing from diffusing outwards and polluting the environment.

![Schematic diagram of screw conveyor](image)

61-feed port A, 62 and 68-shaft black, 63-spindle, 64 and 67-disc, 65-casing, 66-blade, 69-discharge port A

**Figure 2.** Schematic diagram of screw conveyor

### 3.2. Design Principles

In addition to transporting the rice husks, the screw conveyor also removes the air mixed into the husks. In order to achieve this goal, the design of variable pitch and variable screw diameter is adopted. The cylindrical blades at both ends and the variable pitch and variable screw diameter blades at the middle part are adopted. From the feed port A to the discharge port A, the pitch decreases gradually. In L1 and L3, the casing is 1.5 times the pitch, and in L2, the casing length is 4 times the pitch. The screw diameter and pitch of spiral blades in L2 section are calculated according to the void ratio of rice husk, so as to ensure that rice husk can be compacting from natural accumulation state to compacting state after passing through this section.

### 3.3. Parameter Calculation

The outside diameter of the spiral of the screw conveyor is determined by the following formula[6].

\[
D \geq K \left( \frac{Q}{a \cdot r \cdot c} \right)^{\frac{5}{2}}
\]  

(1)

The inner diameter of the spiral is

\[
d = (0.2 - 0.35)D
\]  

(2)

The pitch of the spiral is

\[
S = (0.5 - 2.2)D
\]  

(3)

The speed of the spiral is

\[
n \leq \frac{A}{\sqrt{D}}
\]  

(4)

Where, \( Q \) is productivity, here is taken as 1500kg/h. \( K \) is Material synthesis coefficient, here is taken as 0.05. \( a \) is filling coefficient, here is taken as 0.25-0.65. \( r \) is bulk density of material, here is taken as 120kg/m³. \( c \) is angle coefficient, here is taken as 1. \( A \) is comprehensive characteristic coefficient of
material, here is taken as 50.
For L1 and L3, formula (1) is used for calculation respectively.
In L1, take \(a=0.3\), plug in (1), and get \(D_1=560\text{mm}, \ d_1=112\text{mm}, \ S_1=300\text{mm}, \) and \(n_1=66.7\text{rpm}.
In L3, take \(a=0.5\), plug in (1), and get \(D_3=156\text{mm}, \ d_3=31.2\text{mm}, \ S_3=80\text{mm}, \) and \(n_3=126.7\text{rpm}.
Considering the processing technology of spiral shaft and blade, take \(D_1=560\text{mm}, \ S_1=300\text{mm}, \ D_3=200\text{mm}, \ S_3=100\text{mm}, \ d_1=d_2=d_3=100\text{mm}, \) \(n=65\text{rpm}.
In L2, take the pitch of the spiral by decreasing from S1 to S3, and they are 260mm, 220mm, 180mm and 140mm. Therefore, the length of each section of the conveyor is \(L_1=450\text{mm}, \ L_3=150\text{mm}, \ L_2=800\text{mm}.

4. Rice Husk Drying System
The rice husk drying system includes dryer 9 and screw conveyor 10 (see figure 1). In the dryer, as shown in figure 2, rice husk enters by feed port B 91, flows out by discharge port B 98, the high-temperature exhaust gas discharged from the gasifier 11 enters the dryer by inlet 93 and flows out by outlet 94. Dryer 9 consists of preheating layer, drying layer and aggregation layer [7]. The preheating layer is provided with a dispensing device 95, which is used to evenly distribute the rice husks entering the feed port B 91 on the dry layer. The disturbance device 96 is provided in the dry layer to slow down the falling speed of the rice husk. A temperature sensor 92 is set near the feed port B 91, which is used to monitor the feeding temperature of rice husks and return it to the computer. When the temperature is higher than the threshold value, the spiral conveyor 6 is controlled by the computer to increase the speed of rotation and improve the updating speed of rice husk. When the temperature is lower than the threshold value, the spiral conveyor 6 is controlled by the computer to reduce the rotating speed, reduce the updating speed of the rice husk, and make the rice husk fully warm up. In the same way, a temperature sensor 97 is provided near the discharge port B 98, which is used for monitoring the outlet temperature of rice husk and return the computer, when the temperature is higher than the threshold, the computer control screw conveyor 10 increase speed, speed up the discharge of rice husk, when the temperature is lower than the threshold, the computer control screw conveyor 10 reduce speed, reduce the discharge rate of rice husk, let the rice husk accumulated in the discharge section continue to dry. The whole system is controlled by computer to ensure the drying effect of rice husk.

![Figure 3. Schematic diagram of the dryer](image)

5. Summary
This paper presents a designed rice husk cleansing and drying system, which uses the hot discharge gas of rice husk retort as a heat source, furthermore the structural characteristics of the dryer is analyzed and provides the calculation of the parameters of the variable pitch and variable screw
diameter of the screw conveyor. A simulation test is done. The inlet temperature of hot gas is 150°C and the outlet temperature is 50°C. When the inlet temperature of rice husk is 20°C, the outlet temperature is 35°C. The screw conveyor works normally. Through the simulation test, the system can run normally and meet the design requirements.

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