Bio-Fiber Integrated Production Equipment for Solvent-Free Agricultural Straw Recycling

Abstract

The invention relates to an integrated bio-fiber production equipment for solvent-free recycling of agricultural straw, which includes: a raw material conveying unit, a pretreatment unit (including cutting, cleaning, high-temperature steam, extrusion and other modules), a fiber pre-extraction unit (including ultrasound, enzyme catalysis, high-pressure water flow, high-temperature drying and other modules) and a fiber bundle quality control and spinning unit (including fiber bundle quality control module and spinning module) through specific physical structure and mechanical design, efficient solvent-free treatment of agricultural straw can be achieved, and the fiber extraction rate can reach more than 85%, which can produce high-quality, soft fibers, reduce the impact on the environment and optimize the fiber quality, which is suitable for large-scale production of bio-fibers for textiles.

【Designated representative figure】 Figure 1

Shows the production flow chart of solvent-free rice straw fiber regeneration technology, step by step explaining how to extract high-strength fibers suitable for textiles from rice straw.

【A brief explanation of the symbols of the representative diagram】

1. Raw material conveying unit

2. Preprocessing unit

3. Cleaning module

4. Cutting module

5. High temperature steam module

6. Extrusion module

7. Fiber pre-extraction unit

8. Ultrasonic module

9. Enzyme Catalysis Module

10. High pressure water flow module

11. High temperature drying module

12. Fiber bundle quality control and spinning unit

17. Raw material conveying module

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Specification

【Technical field】

[0001] This new model belongs to the fields of environmentally friendly material technology and textile engineering, especially solvent-free technology.
Integrated production equipment that extracts high-performance biomass fibers from agricultural waste (such as rice straw). This equipment solves the environmental problems of traditional solvent methods, achieves large-scale production of biomass fibers through efficient physical and biological combination processes, and promotes the sustainable application of renewable resources.

【Prior technology】

[0002] Traditional rice straw fiber extraction technology usually uses chemical solvents, such as acid or alkali, to decompose the lignin in the rice straw and release cellulose. However, this method produces a large amount of wastewater and residual chemicals, which imposes a huge burden on the environment and treatment costs. It has low production efficiency. A single technical method cannot efficiently process straw and extract high-quality fiber. The equipment integration is low. Most existing technologies are single equipment and cannot form integrated automated production equipment, affecting the economic benefits of large-scale applications.

【Content of the invention】

[0003] This paper proposes an integrated production equipment for bio-fiber recycling of agricultural straw without solvent.
The equipment combines cutting, cleaning, high-temperature steam, ultrasound, enzyme catalysis, high-pressure water flow, high-temperature drying and other modules to achieve efficient fiber extraction from rice straw and ensure the flexibility and strength of the fibers. The features and advantages of this new model are as follows:

1. Integrated structural design: The modular design of the equipment covers pretreatment, fiber separation and quality improvement, reducing energy loss between processes and improving production efficiency.

2. No chemical solvents: Physical and biological technology treatment throughout the process avoids chemical pollution and reduces environmental burden.

3. High extraction rate: The extraction rate is over 85%, and the fiber retains high strength and flexibility, making it suitable for textile use.

4. Flexible processing parameters: Adjust the high temperature steam pressure, ultrasonic frequency and enzyme catalysis conditions according to the type of straw to achieve the best effect.

Fiber Strength Data Comparison Table

Fiber Type	Average Tensile Strength (MPa)	Industry Standard (MPa)	Compliance Status
Extracted Straw Fiber (Solvent-Free)	350 - 450	300 - 500	Meets/Exceeds Standards
Extracted Straw Fiber (Traditional Solvent)	250 - 350	300 - 500	Below Standards
Cotton	300 - 500	300 - 500	Meets Standards
Polyester	500 - 700	500 - 700	Meets Standards
Nylon	600 - 800	600 - 800	Meets Standards

【Simple explanation of the diagram】

[0004]
[Figure 1]: Layout of the integrated production equipment for solvent-free recycling of agricultural straw bio-fiber
[Figure 2]: Equipment diagram for raw material pretreatment and fiber separation
[Figure 3]: Ultrasonic and enzyme catalytic treatment flow chart
[Figure 4]: Efficiency improvement of physical enhancement and refining technology
[Figure 5]: Flow chart of solvent-free recycling of agricultural straw and bio-fiber spinning
[Figure 6]: Extraction efficiency comparison chart

【Embodiment】

[0005]

[0005] This novel method aims to achieve efficient and environmentally friendly fiber extraction and processing. The specific implementation steps and equipment structure are as follows:
First, the raw material transportation and pretreatment (raw material transportation unit 1, pretreatment unit 2) part, raw material conveying module 17 (raw material transportation unit 1), rice straw is sent into the equipment via a conveyor belt to ensure continuous and stable feeding. The equipment is equipped with a conveying speed adjustment device to adapt to the needs of raw material transportation of different magnitudes. Then, pretreatment (pretreatment unit 2) is carried out. The raw material passes through the cutting module 3, and the rotating blade is used to cut the rice straw into a size suitable for processing (5-10 cm). After passing through the cleaning module 4, it is washed by water to remove the dirt and impurities on the surface of the rice straw. Then, the high-temperature steam module 5 is used to set the steam parameters to 140°C-180°C and the pressure to 0.5-1.5 MPa, the processing time is 20-60 minutes, the initial structure is loosened, lignin and cellulose are separated, and the extrusion module 6, the multi-stage adjustable spiral rod structure, adjusts the extrusion pressure (1-10 MPa) according to the characteristics of the straw to further separate the cellulose, and then performs fiber pre-extraction and enhancement treatment (fiber pre-extraction unit 7) to make

the straw through the ultrasonic module 8, the ultrasonic vibration frequency is set to 20-40kHz, which promotes the further loosening of the straw structure. Through the ultrasonic energy transmission, the lignin residue on the fiber surface is removed, and the flexibility and strength are enhanced.

Then, it goes to the enzyme catalysis module 9, using cellulase and ligninase. The optimal conditions are pH 4.5-6.0, temperature 30°C-50°C, and processing time 30-120 minutes. The enzyme catalysis accelerates the fiber decomposition to ensure efficient and environmentally friendly processing effects. After obtaining more fibers, it enters the high-pressure water flow module 10. The high-pressure water flow treatment deeply cleans and strengthens the fibers. The pressure range is set to 5-15 MPa, improve the uniformity and toughness of the fiber, then move the straw to the high-temperature drying module 11, dry the treated fiber to a humidity of less than 10% to ensure the stability of subsequent processing, and then carry out fiber bundling and spinning (fiber bundling quality control and spinning unit 12). First, the bundling treatment is carried out to automatically bundle the fibers to ensure neat arrangement before spinning. The bundling device is equipped with a quality detection function to monitor the fiber diameter and strength in real time. Finally, the spinning process is carried out, and the treated straw fiber is made into yarn using advanced spinning technology.

【Explanation of symbols】

【0004】

1. Raw material conveying unit
2. Preprocessing unit
3. Cutting module
4. Cleaning module
5. High temperature steam module
6. Extrusion module
7. Fiber pre-extraction unit
8. Ultrasonic module
9. Enzyme Catalysis Module
10. High pressure water flow module
11. High temperature drying module
12. Fiber bundle quality control and spinning unit

13. Fibril
14. Fiber bundling
15. Spinning technology
16. Finishing touches
17. Raw material conveying module

Bio-Fiber Integrated Production Equipment for Solvent-Free Agricultural Straw Recycling

Claims

[Claim 1] An integrated production equipment for bio-fiber recycling of agricultural straw without solvent, comprising:
A raw material conveying unit, which includes a raw material conveying module, responsible for conveying the agricultural straw from the storage area to the pretreatment unit;
The pretreatment unit, which includes a cutting module, a cleaning module, a high-temperature steam module, and a mechanical extrusion module, is responsible for the preliminary removal of impurities and softening of the fiber structure;
The fiber pre-extraction unit includes an ultrasonic module, an enzyme catalysis module, a high-pressure water flow module, and a high-temperature drying module, which are used to further separate and purify the fibers;
Fiber bundle quality control and spinning unit, which includes fiber bundle quality control module and spinning module, to ensure fiber quality and manufacture finished products;
The various units of the equipment work together to improve the efficiency of rice straw fiber extraction and optimize the fiber quality, making it suitable for subsequent textile and biomaterial applications.

[Claim 2] An integrated production equipment as described in Claim 1, wherein the high-temperature steam module can operate in the range of 140°C to 180°C, the pressure range is 0.5 to 1.5 MPa, the processing time can be adjusted to 20 to 60 minutes, and is linked with the mechanical extrusion module to optimize the fiber structure and maximize the fiber extraction efficiency.

[Claim 3] The integrated production equipment as described in Claim 1, wherein the ultrasonic module has a frequency range of 20 kHz to 40 kHz, which is used to improve the flexibility and uniformity of the fiber and significantly improve the separation efficiency.

[Claim 4] An integrated production equipment as described in Claim 1, wherein the enzyme catalytic module is configured with cellulase and ligninase, and the optimal operating conditions are pH 4.5 to 6.0, temperature 30°C to 50°C, and processing time 30 to 120 minutes, for deep decomposition of lignin and improvement of fiber strength.

[Claim 5] An integrated production equipment as described in Claim 1, wherein the mechanical extrusion module is designed with a multi-stage adjustable spiral structure, the extrusion pressure range is 1 to 10 MPa, and is equipped with automatic pressure monitoring and adjustment functions to ensure stable fiber quality.

[Claim 6] In the integrated production equipment as described in Claim 1, a high-pressure water flow module is used to further improve the structure and physical properties of the fiber.

[Claim 7] The integrated production equipment as described in Claim 1 further includes an automatic control system that can monitor temperature, pressure, ultrasonic frequency, enzyme catalysis conditions and extrusion pressure in real time, and adjust the optimal parameters through an AI algorithm to ensure stable fiber quality.

[Claim 8] The integrated production equipment as described in Claim 1 to 7 further supports the spinning technology of blending the fiber with other natural fibers, and the blending ratio can be flexibly adjusted according to actual needs.

[Claim 9] The integrated production equipment as described in Claim 1 further includes a fiber quality monitoring module, which includes an optical detection system, a tensile testing device and an automatic data recording unit for real-time monitoring of the physical properties of the fiber, including length, diameter, strength and uniformity.

[Claim 10] The integrated production equipment as described in Claim 9 further includes a microstructure analysis module, which includes a high-resolution photography system and an image processing unit for monitoring the internal structure and surface morphology of the fiber to ensure stable processing quality.

[Claim 11] The integrated production equipment as described in Claim 1 further includes a fiber drying and curing module, which includes a multi-stage temperature-controlled hot air system and a compression dehydration device to improve the drying efficiency of the fiber and ensure that its final moisture content is controlled within a specific range.

[Claim 12] The integrated production equipment as described in Claim 1 further includes an adaptive spinning control module, which includes a variable speed spinning device and a tension control system to adapt to the blending and integrated processing of natural fibers of different types and specifications.

[Claim 13] The integrated production equipment as described in Claim 1 further includes a wastewater and residue recovery module, which includes a solid-liquid separation device, a filtration system and an automatic emission control unit to recover organic waste generated during the processing and improve resource utilization.

[Claim 14] The integrated production equipment as described in Claim 1 further includes an intelligent control and data management module, which includes a touch operation interface, a data storage unit and a remote monitoring system to provide real-time parameter adjustment, automatic fault diagnosis and production data tracking functions.

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Figures

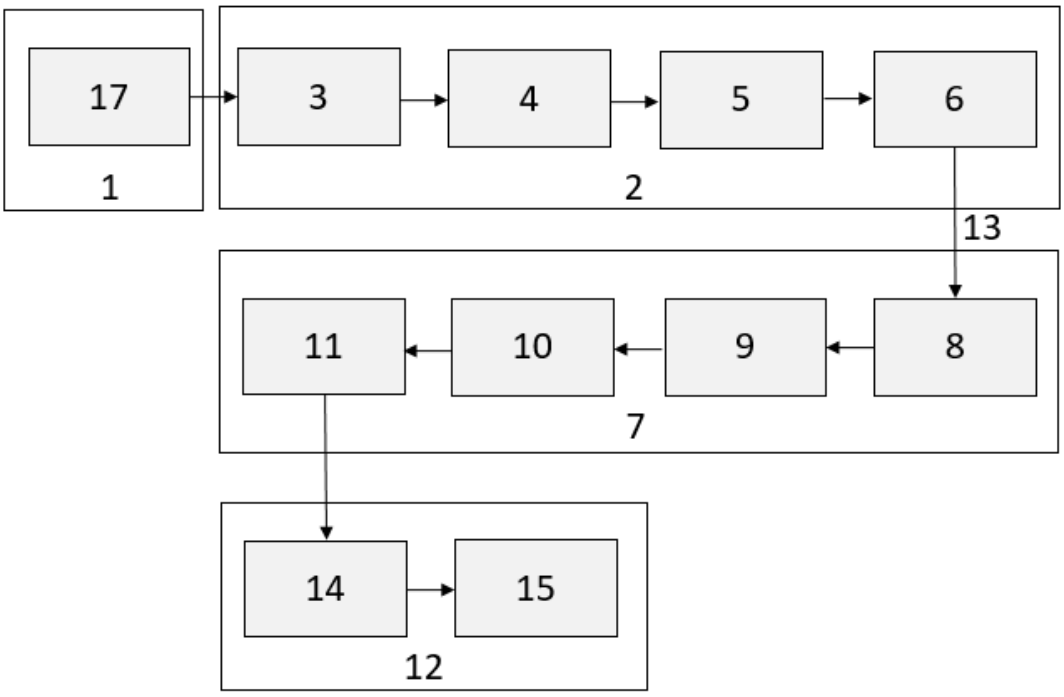

Figure 1.

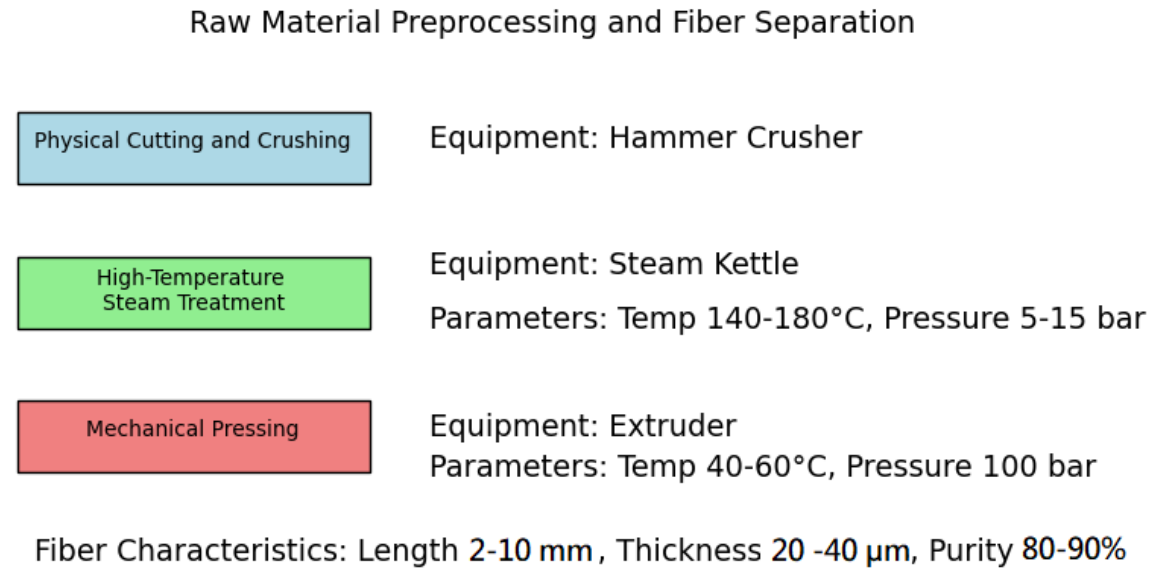

Figure 2.

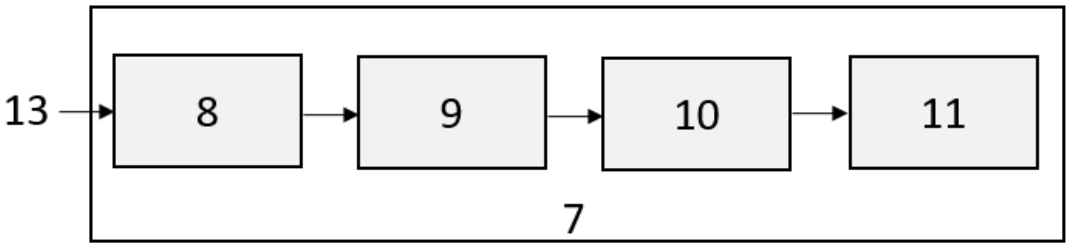

Figure 3.

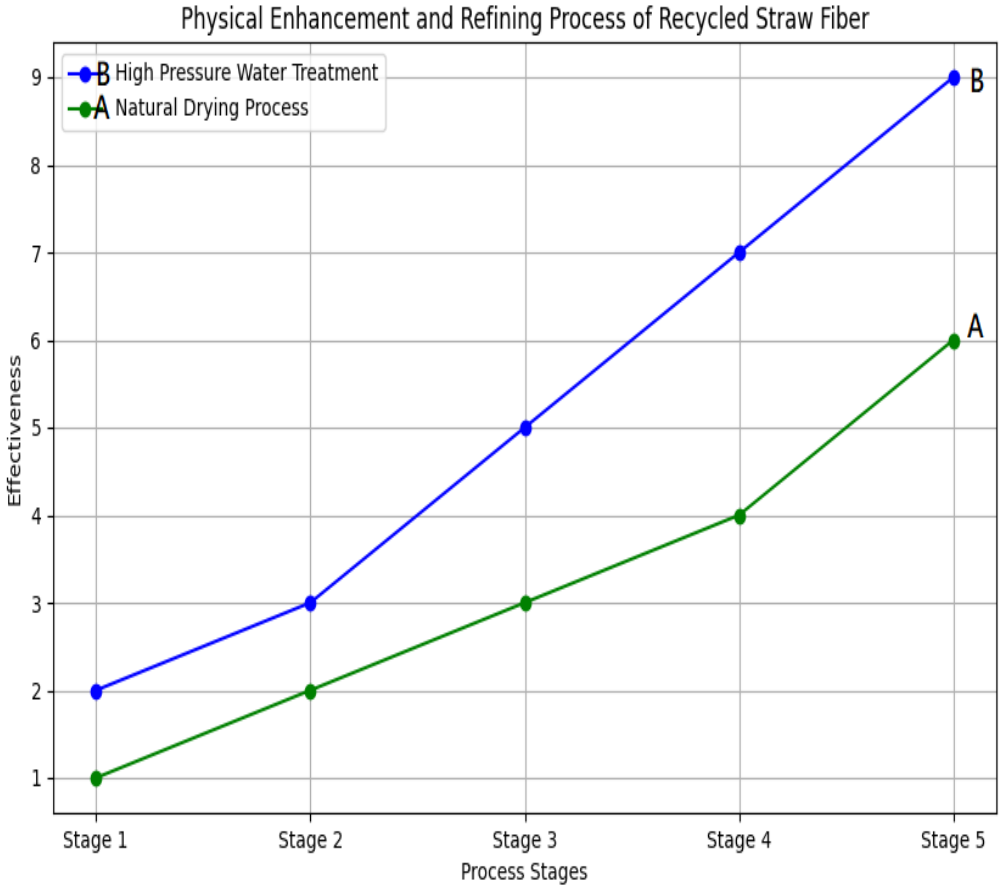

Figure 4.

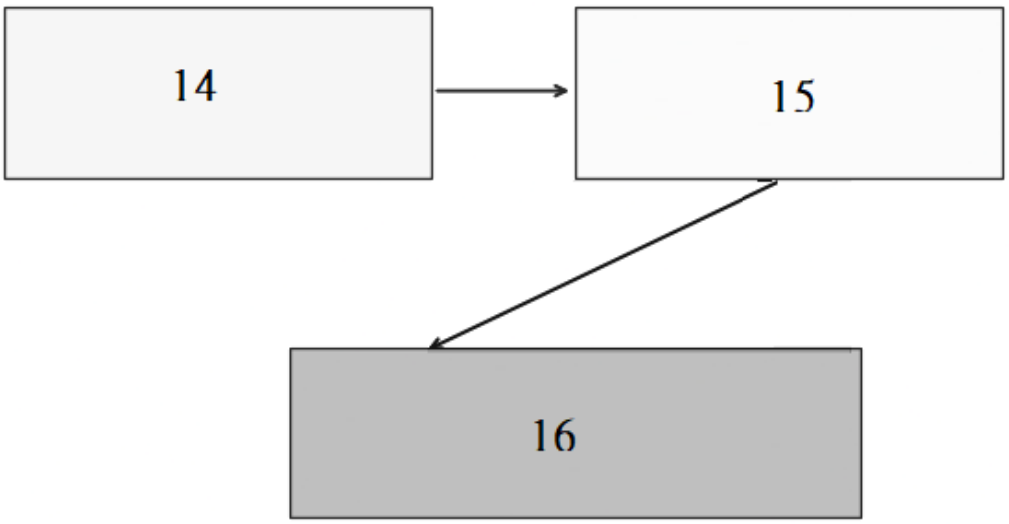

Figure 5.

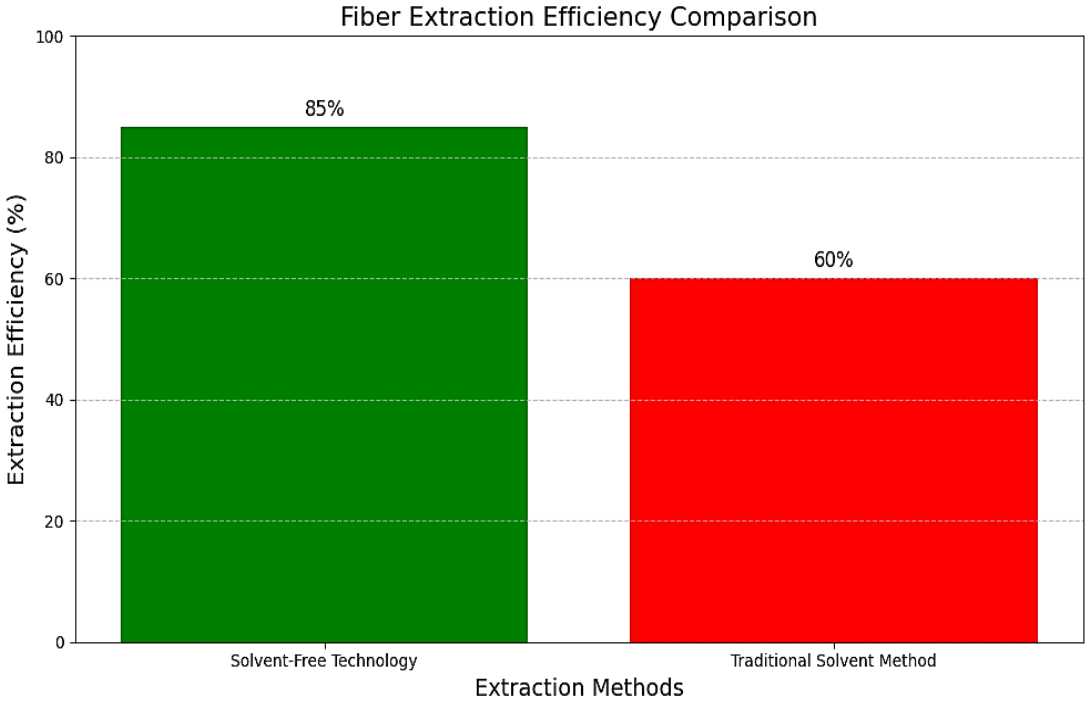
Fiber Extraction Efficiency Comparison
Extraction Efficiency (%)
100
80
60
40
20
0
85%
60%
Solvent-Free Technology
Traditional Solvent Method
Extraction Methods

Figure 6.