

Annex III

Manual for Bamboo Charcoal Production and Utilization

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May 2004

Preface

Bamboo charcoal is made of bamboo culms and waste material from bamboo processing. On one hand, bamboo charcoal not only provides a new way to utilize bamboo, but also benefits to environment protection by reducing the residues pollution. On the other hand, bamboo charcoal is a kind of environmentally functional material which has excellent absorption and friendly properties to environment. The production of bamboo charcoal will promote the sustainable development of economy and ecology in China. Bamboo charcoal industry is in small scale, less investment, specially attracting farmer's fund, and further to enhance their income and fasten the steps of local economy development. The aim of this manual is to disseminate technologies for bamboo charcoal production, to promote information exchange between China and INBAR member countries concerning its production and utilization, to increase the economic income of local farmers, and small- and medium scale investors in the bamboo area of China and other bamboo producing countries, and to promote the economic development in bamboo areas.

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1 Bamboo charcoal production

1.1 Bamboo charcoal production brief

Bamboo charcoal is made of bamboo by pyrolysis process. According to the types of raw material, bamboo charcoal can be classified as raw bamboo charcoal and bamboo briquette charcoal. Raw bamboo charcoal is made of bamboo body such as culms, branch, and root. ; bamboo briquette charcoal is made of bamboo residue such as bamboo dust and saw powder and etc. by compressing the residue into certain shape sticks and carbonizing the sticks. There are two kinds of equipment for carbonization, one is brick kiln, and the other is mechanical. Bamboo production process is divided into three stages: raw material preparation, carbonization, finishing process (Fig. 1).

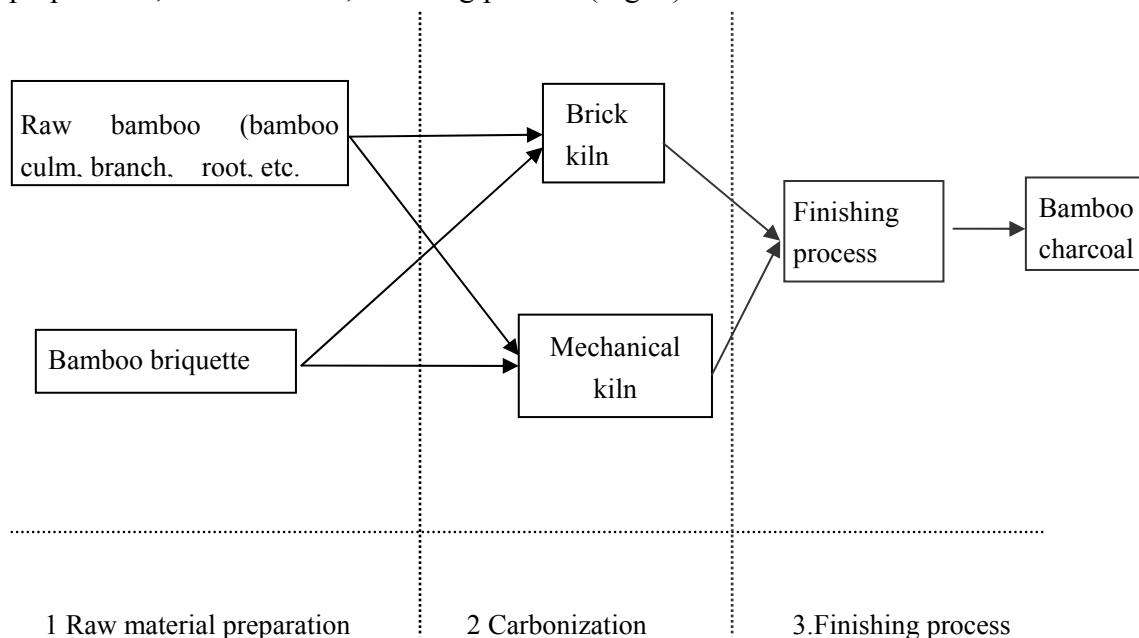


Fig.1 Three- period process of making bamboo charcoal

1.2 Raw material preparation

1.2.1 Raw material preparation for raw bamboo charcoal

Raw bamboo charcoal is made of bamboo culms, branch and root.

Raw bamboo charcoal products made of bamboo culm can be divided into bamboo tube charcoal, bamboo slice charcoal, particle charcoal according to their forms. Bamboo particle charcoal is made from bamboo tube charcoal and bamboo slice charcoal. See fig.2.

1.2.1.1 Bamboo tube charcoal\ bamboo slice charcoal



Bamboo culm



Bamboo tube charcoal



Bamboo slice



Bamboo slice charcoal



Bamboo particle charcoal

Fig. 2 Raw bamboo charcoal production illustration

Raw bamboo charcoal is made of bamboo culm and branch. The density, cavity structure and tissue composition of bamboo culms differentiate from bottom to tip. Meanwhile, the quality of bamboo is influenced by its age, soil and climate conditions. So it is reasonable to divide the culms into three parts (the upper, the middle and the lower) for processing. If possible, the culms may be divided with the consideration of age and soil conditions. There are abundant nutrient substances in bamboo material, so it is perishable. Therefore the storage time of bamboo material should be strictly controlled, especially in summer. The newly cut bamboo culms should be processed and dried rapidly and loaded into kiln as soon as possible to protect their quality.

For making raw charcoal, the bamboo at the age of four years or more should be selected. The culms should be chopped into segments according to the size of kiln before drying. The moisture content of raw bamboo should be 15%—20% by air drying before loading into kiln. Or the material is directly loaded into kiln for smoking drying before carbonization. Sawed bamboo culm can be made into bamboo tube charcoal, slice charcoal. Bamboo culm also can be split into slice before loading into kiln.

1.2.1.2 Bamboo root

After digging bamboo root from the soil and getting rid of soil, bamboo root can be dried by air and then loaded into kiln.

1.2.2 Raw material preparation for bamboo briquette charcoal—bamboo briquette making

The waste material from bamboo processing is used for making briquette charcoal, such as bamboo shavings, bamboo particle, bamboo ends, and bamboo sticks in different length. See Fig. 3 and Fig.4



Fig.3 Bamboo residues resulting from planing bamboo strips

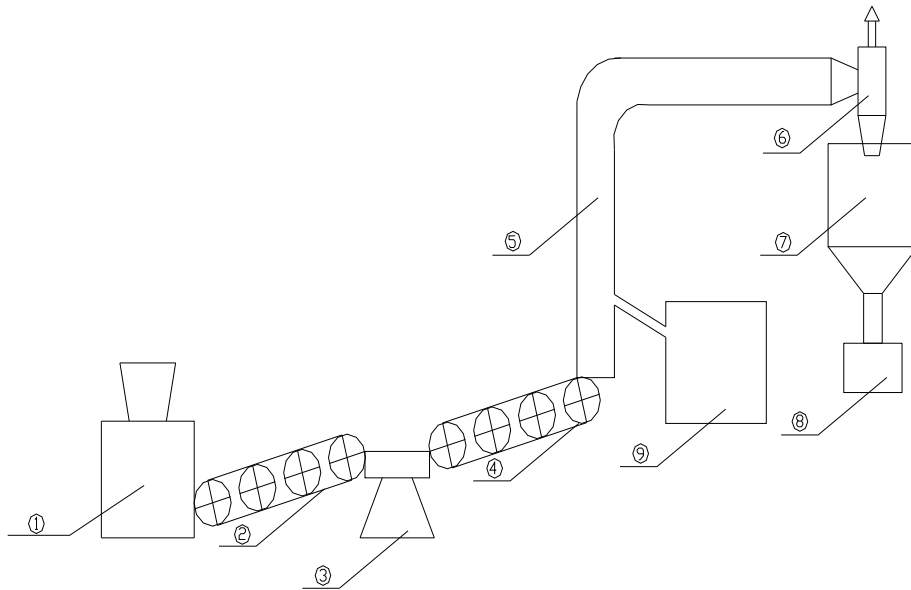


Fig.4 Shapes of bamboo residues

1.2.2.1 Process of making bamboo briquette

The making process of bamboo briquette is composed of the following operations: bamboo residue →disintegrating →screening →drying →conveying →extruding into stick

See the following fig. 5



1.disintegrator 2. 4.belt conveyor 3.screen 5.pipeline 6.cyclone separator
7. hopper 8. sawdust molding machine 9. heating furnace

Fig.5 Diagrammatic Sketch of particle briquette production line

(1) Disintegrating

Bamboo residue is feed into disintegrator for reaching smaller size which is suitable to the following process. Fig.6 is showing the worker feeding the bamboo residue into disintegrator.



Figure 6 Workers are feeding a disintegrator

(2) Sorting

After disintegrating, the bamboo smash will be sorted by screen. The fine particles with the size of 10 meshes are carried into the vertical pipeline by belt transporter. The coarse particles will be turned back to the disintegrator again. The process of disintegrating can be seen in Fig.4. Regular particles will be transported into a vertical pipeline where they are mixed with hot air coming from a heating furnace. They are to be dried and transferred into a hopper by an air current transportation system. The temperature of hot air is 85 °C. The belt deferent speed is 50 m/min and the diameter of roller of transporter is 0.7 meters.

(3) Drying

The regular bamboo particles will be dried in the vertical pipeline and transported to the hopper by an air current transportation system; and then pass through the cyclone separator to fall into the hopper. The moisture content of particles after drying should be within the

range of 4% to 6% before feeding into a screw-forming machine.

(4) Compressing into bamboo briquette

The regular particles in the hopper are fed into the screw-forming machine, which is heated by electricity to 160°C, and extruded into bamboo briquettes. See Fig. 7 and Fig.8.



Figure 7 Screw forming machine



Fig 8 Bamboo briquettes

1.2.2.2 Key equipment and main parameters

(1) Screen machine

Sorting bamboo residue according to the size of particles, the residue above the screen will be smashed again, and the residue below the screen will be delivered by air for drying.

(2) Smash Machine

Smash the bamboo residue into smaller size in order to compress the residue into certain shapes.

(3) Drying furnace

Dry the bamboo particle to required moisture content, about 8~10%. Drying machine: 100r/min.

(4) Air sorting and convey system

Sort bamboo particles into light, middle and heavy groups, and guarantee the energy value of briquettes.

(5) Screw-forming system

Compress bamboo particle into bamboo briquettes. Output of compressing machine: 2kg/min.

1.3 Carbonization process

Bamboo charcoal carbonization process sees fig. 9.

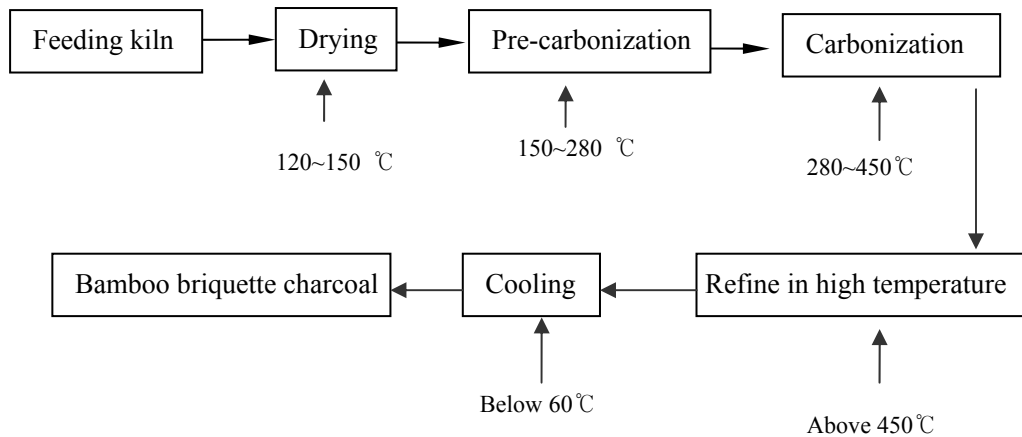


Fig. 9 Process flowing chart of bamboo carbonization

1.3.1 Carbonization process of brick kiln

1.3.1.1 Structure of brick kiln

Bamboo charcoal kilns are generally built in wide and open areas of solid soil with convenient traffic, sufficient electricity and water supply. Typical double brick kilns are shown in Fig.10. The vertical and lateral views of the double kilns are shown in Fig.10 (a) and (b). The dimension measures: 3.8 meters in length, 2.8 meters in width and 2.5 to 2.7 meters in height with wall 24 cm thick. The building process is as follows: First of all, 15 to 20 cm thick stones are levelly paved on the ground, followed by a layer of loess 20 cm thick. Then bricks are laid on the loess. After building the kiln with bricks a layer of loess 20 cm thick are laid on the top, which serves to keep out the moisture and preserves the heat. The flue of 100 × 100 cm is situated at the back.

Fig.10 (c) depicts an explicit illustration of a kiln gate, which is 1.5 meters high, with 50 cm wide at the bottom and 40 cm wide on the top. There are five intakes on the kiln gate. Intakes A and B serve not only to add firewood, but also to observe flame and burning situation. Intakes C, D and E, mainly used to control the increase rate of interior temperature by adjusting their opening. This type of kiln has a capacity of four to six tons of bamboo and consumes two tons of firewood in a cycle.

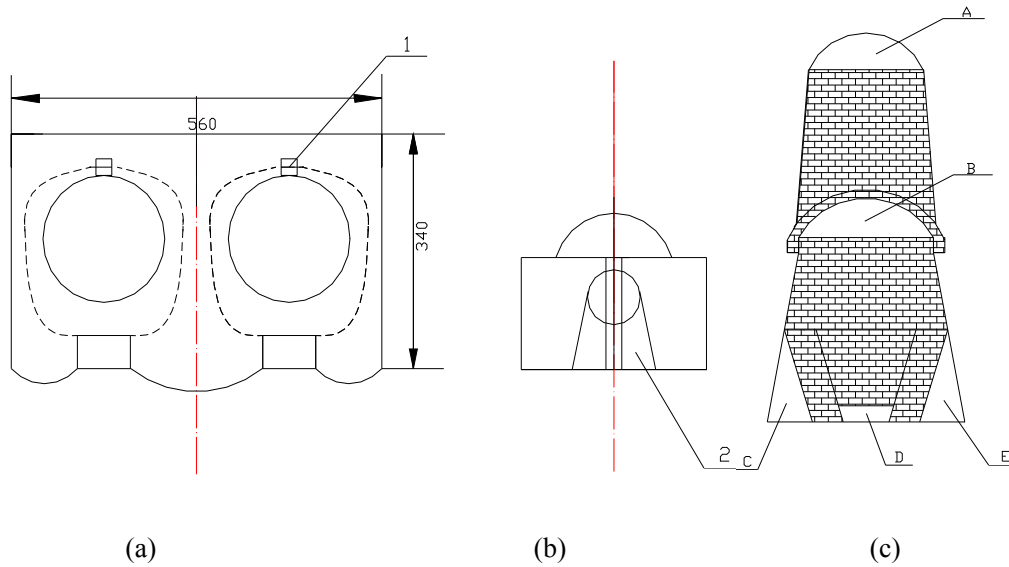


Fig. 10 Diagrammatic sketch of the structure of a typical double brick kilns

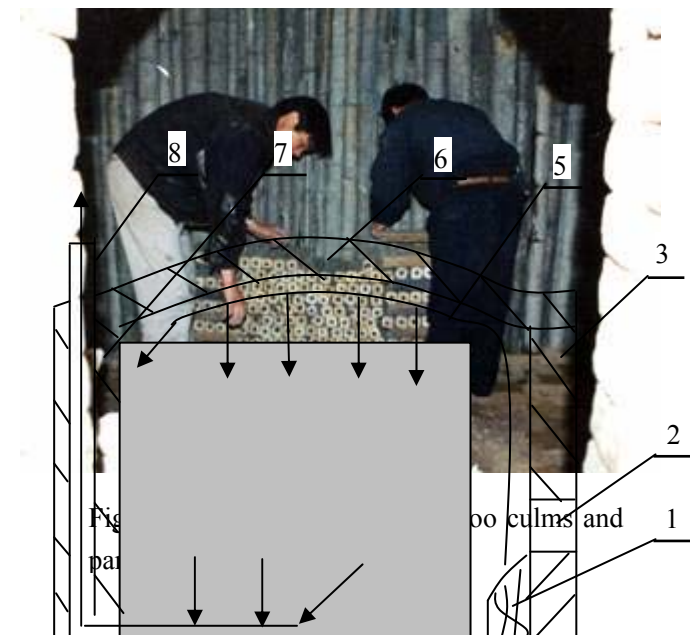
1.3.1.2 Carbonization process of brick kiln

1) Feeding kiln

All the raw material is to be fed into a kiln according to its size. A space of a half meter between the kiln gate and raw material should be left for burning firewood. Bamboo culms and bamboo briquettes in good quality will be set the most inner of kiln, and those in bad quality will be set near the gate of kiln. Bamboo culms are to be put with the smaller end downward. The Fig.11 depicts the process of loading with bamboo culms and particle sticks.

2) Drying

Ignite the firewood lying behind the kiln gate and then close the top two intakes on the gate when the firewood is burned, leaving two intakes at the bottom of the gate to keep the hot flow circulating in the kiln. It is necessary to add firewood whenever the firewood below is burned out and clear up the ash to avoid blocking the fire. Bamboo materials in brick kiln are heated in Fig. 12. The igniting and sealing after igniting was illustrated in Fig. 13.



1. firewood
2. entrance of firewood
3. front wall
4. bamboo sticks
5. smoking track
6. roof made of brick
7. back wall
8. chimney

Fig. 12 sketch map of a brick kiln heating bamboo charcoal

It is a process raising the temperature

inside the kiln by dismounting the feeding intake on the gate everyday and feeding firewood to keep burning. The temperature inside the kiln must escalate gradually in the process. The bamboo in the kiln will crack if the temperature escalates quickly. The temperature of drying period is 120~220 °C. The temperature in the kiln should be controlled under the self-igniting point of bamboo in seven to eight days after igniting. Firewood feeding should be decreased or stopped if the temperature is enough. The temperature in kiln can be regulated by blocking the intakes and flue rim with bricks. Fig.14 is a curve of heating, which delineates the change of the temperature in the process of heating.



Fig. 13 The igniting and sealing after igniting

temperature before refining

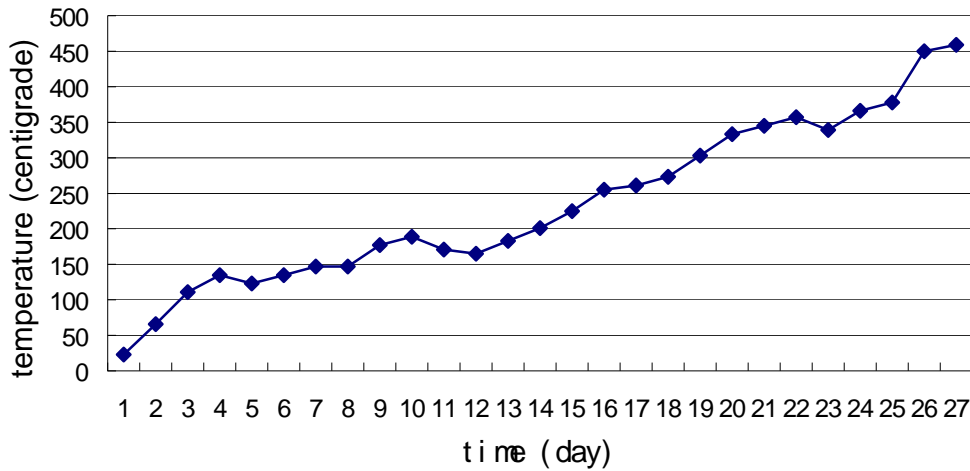


Fig. 14 Heat escalating day after day in the heating stage

3) Pre-carbonization

Close attention should be paid to the change of temperature in kiln, keeping it under the autoignition of bamboo pieces and briquettes at 150~280°C. As a rule, the temperature in kiln is to be adjusted with bricks blocking floss and air inlet. In this stage a large quantity of heat is needed to maintain the raising of temperature for thermolysis.

4) Carbonization

The temperature in the stage of carbonization is 280~450°C, which exceeds the autoignition point of bamboo, the thermolysis process is rapid, releasing a large amount of heat, this is a stage of exothermic reaction.

5) High temperature refining

High temperature refining is completed at the temperature above 450°C. This is a stage of high temperature thermolysis. The volatile matter is discharged in this process by the raised temperature, consequently, the fixed carbon content in charcoal is increased.

After the end of carbonization open the intakes on the gate and feed more firewood quickly to raise the temperature inside the kiln. In this process, the intakes of kiln gate shouldn't be opened wholly in a short time, and they are to be opened gradually within twenty-four hours or so to make the bamboo charcoal contracted absolutely. At the end of refining stage, all the intakes should be opened again for one or two hours to raise the temperature of the charcoal in the kiln to 1000°C or more. Fig. 15 depicted the curves of temperature during the refining stage. The beginning and ending of refining process will be controlled according to the temperature on the curve. The kiln gate situation is shown in Fig.16.

refining temperature

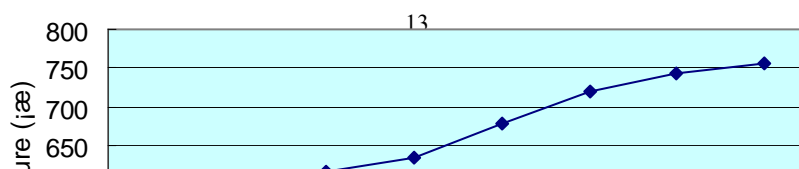


Figure 15 The curve of temperature – time during refining stage



Fig.16 the kiln gate situation during refine stage



Fig.17 the gate after sealing



Fig.18 the bamboo charcoal cooling in kiln

6) Cooling

After the finishing of refining, seal the kiln (fig. 17) and start the natural cooling of charcoal in the kiln. When the temperature in the kiln is below 60°C, unload the charcoal. The kiln gate should be partly opened at first to make sure that the bamboo charcoal in the kiln no longer ignites. Then the kiln gate can be opened thoroughly. The temperature in the kiln should not be too high during unloading; otherwise bamboo charcoal will be broken easily. Fig.17 and Fig. 18 show sealed gate and cooling bamboo charcoal.

1.3.1.3 Collection of bamboo vinegar

Measures are taken to prevent the air pollution by smoke emitted in the process of charcoal making and to collect by-products. The specific procedures are as follows: Make two holes in a jar, one is square (10 × 10 cm) and the other is round. Next, build a passageway with bricks connecting the square hole and the flue rim to let smoke go through. Take four or five bamboo culms with eight meters in length, remove the internal joint layers. Then put one end of them into the jar, and fix the other end on the beam. Seal the jar completely with plastic

films and earth. See Fig.19.

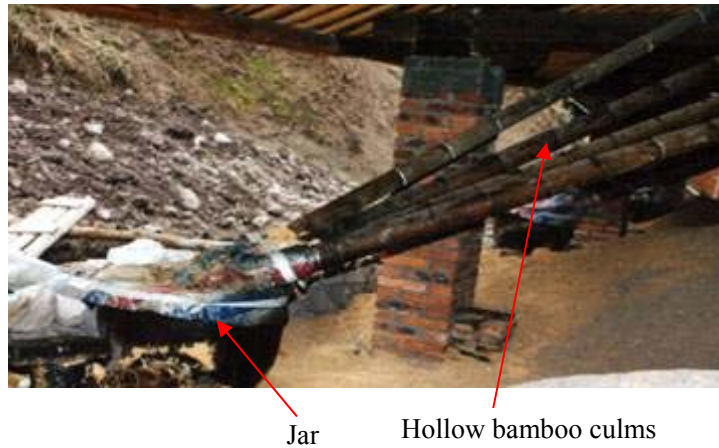
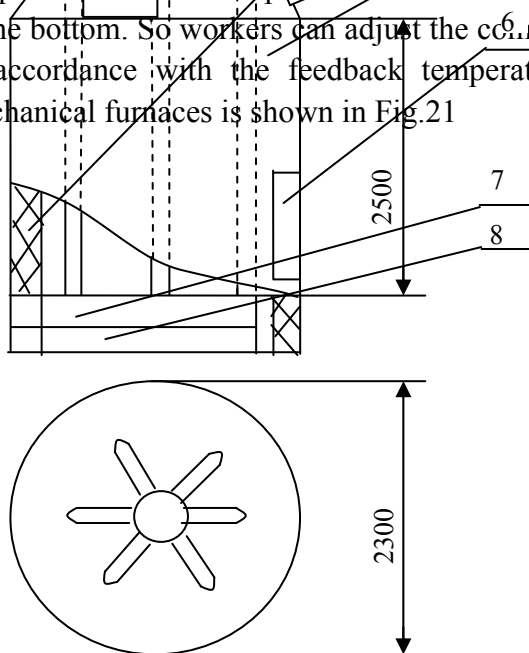


Fig. 19 the instrument for condensing smoke and colleting crude bamboo vinegar.

1.3.2 Carbonization process of mechanical kiln

1.3.2.1 Structure of mechanical furnace

A mechanical furnace is depicted in Fig. 20. It is 2.5 meter high and 2.3 meter in diameter. The body is made of thick iron sheet lined with firebricks and coated with heat preservation material. There are two intakes on the body. One is fixed in the upper part and the other is lower that serve for raw material loading. Near the bottom of body is a fuel feeding intake and a hole for ash exit. There are 4 thermocouples in the furnace for measuring the temperature at different points. Two of them are situated at the upper part and the other two at the bottom. So workers can adjust the combustion situation and master the product quality in accordance with the feedback temperature from the thermocouples. The outline of mechanical furnaces is shown in Fig.21



1 smoke channel 2 top intake 3 firebrick 4 thermocouple 5 body 6 bottom intake 7 fuel feeding 8 ash exit

Fig.20 Structure of a mechanical furnace



Fig.21 Outline of mechanical furnaces

1.3.2.2 Carbonization process

The production process for the mechanical furnace is similar to that for brick kilns. The furnace is mainly used in the bamboo stick charcoal production at present. The main procedures are introduced as follows:

1) Loading

At the beginning, particle sticks are loaded in through the lower intake until half of the furnace space is loaded. Then other sticks can be loaded in through the upper intake. When the furnace is full, the upper intake ought to be completely covered and sealed.

2) Drying

The firewood placed at the bottom of the furnace is ignited. Then it is necessary to keep feeding firewood or coal during heating stage. At the initial stage, heating not only increases the temperature in the furnace but also eliminates the moisture content in the raw material. The temperature should be enhanced tenderly to avoid material cracking that will happen if the temperature rises quickly. It is recommended that the temperature in the furnace should be raised to 120°C--150°C in 24 hours. The material begins to pre-carbonize between 150--280°C and vinegar starts flowing. When it reaches 450°C, the smoke comes from chimney change into light blue color, and this indicates that material carbonizing is completed. During carbonizing stage, a lot of bamboo vinegar and tar are pyrolyzed and flowed out. So the speed of temperature rising should coordinated with the speed of liquid flowing to get more byproducts. Fig.22 depicts the process of temperature rising in the furnace during the heating, carbonizing and refining stages.

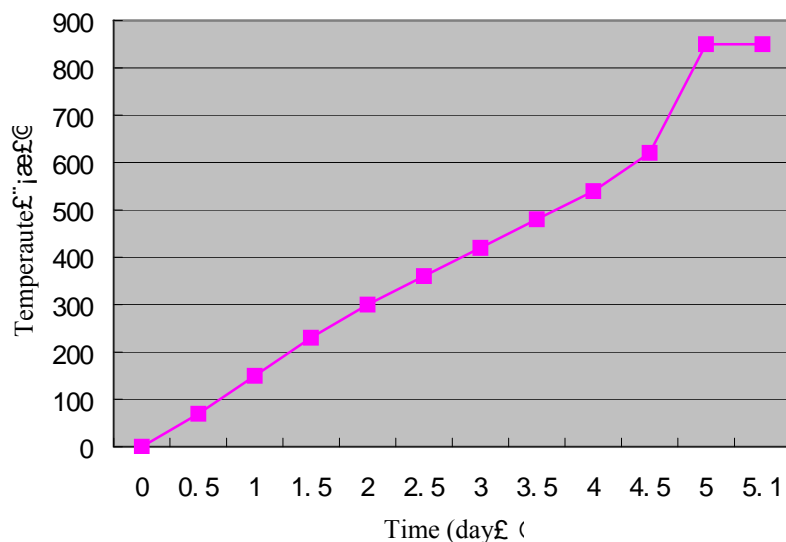


Fig.22 The temperature rises with time during heating, carbonizing and refining in mechanical furnace.

3) Pre-carbonization

When the temperature in kiln is about 150~280°C, chemical content of bamboo is pyrolyzed a little, while bamboo is in need of large amount of heat for further carbonization.

4) Carbonization

The carbonization process starts when the temperature in the furnace is about 280~450°C, which exceeds the temperature of bamboo autoignition. The carbonization process is basically completed when blue smoke exits from floss hole. A large amount of bamboo tar and vinegar are extracted from raw material. During this stage the temperature should not be raised rapidly. The tar extraction should be kept in balance with the bamboo carbonization. The curve of temperature evolution in kiln is shown in Fig. 22.

5) High temperature refining

The process of high temperature refining requires the comparatively rapid raise of temperature in kiln. In general, the temperature should be raised to 850°C and be kept for several hours for further thermolysis and carbonization. (The 5th day on the curve in Fig. 22)

6) Cooling and unloading

Seal the feeding intake at the end of refining to isolate the air contact, and start the natural cooling of charcoal. When the temperature in the furnace is below 60°C, the bamboo charcoal can be unloaded.

1.3.3 Comparison between brick kiln and mechanical furnace

Contrasting analysis of processing bamboo briquette charcoal technology between mechanical furnace and brick kiln is shown in table 1.

Table 1 Comparison between brick kiln and mechanical furnace

| Item | Output T | Production period days /circle | Fuel needed T/T(charcoal) | Cost ¥ | Temperature control |
|---------------------------------------|----------|--------------------------------|----------------------------|--------|---------------------|
| Brick kiln (6m ³) | 1.5 | 25 | 0.25 | 2,000 | difficult |
| Mechanical furnace (3m ³) | 0.8 | 7 | 0.2 | 28,000 | relatively precise |

As shown in the above table, that mechanical furnace has advantages compared with brick kiln:

- 1) Shorter production cycle, which is usually 6-7 days.
- 2) Easier control. Temperature inspecting rod can be mounted at multi-place in the mechanical furnace, operator can easily control.
- 3) The shortage of mechanical furnace is that lump-sum invest is very high, and experts for maintaining and repairing.

1.4 Finishing process of bamboo charcoal

Finishing process of bamboo charcoal includes sorting, finishing processing, checking and packing shown by Fig. 23.

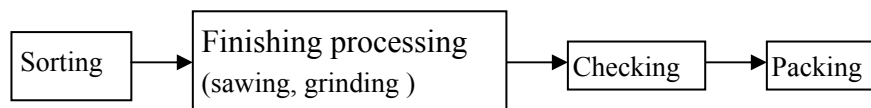


Fig. 23 finishing processing flowing chart

Sorting: Sort bamboo charcoal according to its after unloading from the kiln or furnace. Bamboo charcoal of better shape is to be sawn into dimensions according the requirement of clients. Charcoal of uncompleted shape, or bamboo particle is to be used as fuel or adsorption charcoal. Bamboo charcoal for fuel should not be required strictly in the completion of shape, crashed bamboo charcoal can be grinded into bamboo particle charcoal or powder charcoal.

Checking: Check the appearance of bamboo charcoal and its chemical and physical properties according to the requirements of clients or quality control parameters of bamboo charcoal.

Packing: Pack bamboo products into paper box and plastic bags, bamboo kind, properties and usage will be marked on the outer package materials.

2 Properties of bamboo charcoal

2.1 Basic properties of bamboo charcoal

In order to study the effects of carbonization temperature on the properties of bamboo charcoal, and to improve the production technology, the yield rate, ash, volatile content, fixed carbon, density, specific resistance and specific area are at different carbonization temperature are analyzed. The results are shown in table 2.

Table 2 Properties of bamboo charcoal made in different temperature

| Item of Properties | Temperature of Carbonization (°C) | | | | | | | |
|----------------------|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|
| | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 |
| Yield rate (%) | 40.70 | 35.6 | 29.68 | 28.96 | 27.52 | 27.43 | 26.39 | 26.69 |
| Ash (%) | 2.93 | 3.48 | 3.54 | 3.92 | 4.07 | 4.58 | 4.69 | 4.57 |
| Volatile content (%) | 30.98 | 25.24 | 14.41 | 7.20 | 3.24 | 2.71 | 2.7 | 2.11 |
| Fixed carbon (%) | 66.69 | 71.28 | 82.05 | 88.88 | 92.69 | 92.71 | 92.61 | 93.32 |

| | | | | | | | | |
|---------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Density (g/cm ³) | 0.564 | 0.593 | 0.599 | 0.638 | 0.690 | 0.687 | 0.712 | 0.723 |
| Specific resistance (10 ⁻² Ω ·m) | 18.6 | 9.5 | 7.4 | 3 | 5.4 | 2.15 | 1.45 | 8.29 |
| Specific area (m ² /g) | 23 | 133 | 316 | 360 | 385 | 259 | 133 | 35 |

- Yield rate means the percentage of final bamboo charcoal made from raw bamboo.

As we can see from the table, the conclusions are drawn as follows:

(1) The yield rate is inverse to the temperature of carbonization, that is, the higher carbonization temperature, the lower yield rate.

(2) Ash and fixed carbon and density of bamboo charcoal are positively correlated to the temperature of carbonization.

(3) The relationship between specific resistance and temperature is just like a quadratic curve equation. With the temperature increasing from 300°C to 900°C, the value of specific resistance decreases from high point to bottom, then go up to higher value just as the level of 400°C, though slightly increasing in 700°C.

(4) The relationship between specific area and temperature is similar to quadratic equation. When temperature goes up from 300 °C to 700°C, the value of specific area increases from 23 to 385, then gradually goes down to 35 in 1000°C.

2.1.2 Parameters of bamboo charcoal properties

Bamboo charcoal industry was developed in recent years. Therefore, there is no standard of bamboo charcoal. For studying main properties of bamboo charcoal it is suggested to refer to the following table 3.

Table 3 Chemical parameters of bamboo charcoal

| Item | Bamboo slice, particle, powder, tube charcoal | | Bamboo briquette | |
|---------------------|-----------------------------------------------|-------|------------------|-------|
| | Moisture content (%) | ≤ 7 | ≤ 7 | ≤ 7 |
| Ash (%) | ≤ 2.5 | ≤ 3.0 | ≤ 3.0 | ≤ 4.0 |
| Volatile Matter (%) | ≤ 8 | ≤ 8 | ≤ 8 | ≤ 8 |
| Fixed carbon (%) | ≥ 88 | ≥ 85 | ≥ 86 | ≥ 82 |

2.2 Basic properties of bamboo vinegar

Crude bamboo vinegar is a kind of brown-black liquid containing more than 300 organic compounds except a quantity of water (include reaction water). Some of the compounds are

as follows (Huang 1996):

- (1) Saturated acid: acetic acid, formic acid, propanoic acid, and butanoic acid
- (2) Unsaturated acid: propenoic acid
- (3) Hydroxyl-acetic acid: 2-hydroxyl-acetic acid
- (4) Heterocyclic acid: β -furan-carboxylic acid
- (5) Alcohol: methanol
- (6) Un-alcohol: allyl alcohol
- (7) Ketone: acetone, methyl ethyl-ketone, methyl propyl-ketone, and cyclopentanone
- (8) Aldehyde: formaldehyde, ethyl-aldehyde, and furoal
- (9) Ester: methyl formate, methyl acetate
- (10) ArOH: phenol, methyl-phenol, and O-benzene-diol
- (11) Lactone: butyrolactone
- (12) Aromatic substance: benzene, toluene and naphthalene.
- (13) Heterocyclic compounds: furan, and α -methyl furan
- (14) Amine: methylamine

The crude bamboo vinegar can be divided into two layers by setting for two months. The upper layer is clarified bamboo vinegar, which is a light yellow or light brown liquid with special smell, and the lower layer is sediment-bamboo tar.

3 Utilization of bamboo charcoal and bamboo vinegar

3.1 Usage of bamboo charcoal

As a kind of carbon material, bamboo charcoal has the following functions shown in the fig. 21.

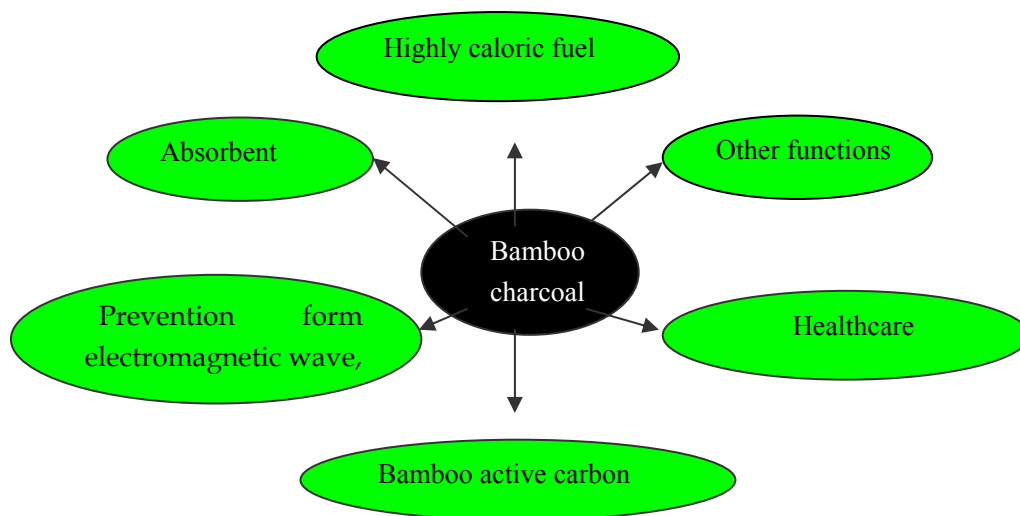


Fig.24 Bamboo charcoal functions

The tissue of bamboo charcoal contains much mineral matter with great porosity. The area of pores exceeds the surface area charcoal, reaching $300\text{m}^2/\text{g}$. Consequently, bamboo charcoal possesses high adsorption ability. The microbes epibiotic on the surface of charcoal molecules decompose the adsorbed matter thoroughly. The charcoal processed at high temperature (1000°C) releases far-infrared, produces anions and absorbs magnetic waves. Due to its special properties and exceptional functions, bamboo charcoal is used widely:

(1) Fuel

Bamboo charcoal mainly is used as fuel for cooking and drying tea in china. Most of bamboo charcoal for fuel is bamboo briquette charcoal, the rest of which is raw bamboo charcoal.

(2) Adsorption products of bamboo charcoal

A. Purifying agent for water

Bamboo material has extraordinary micro-structure, it produces high absorptive capacity after carbonization, and becomes more effective after activation. Bamboo charcoal can be used for purifying water, eliminating organic impurity substances and smells. Drinking water sterilized with chlorine is to be treated with bamboo charcoal to remove the residue chlorine and chlorides. Bamboo charcoal is to be used as follows:

- a) To purify water from rivers and lakes, and sewage -- bamboo briquette charcoal
- b) To purify drinking water, to absorb harmful components, and to release minerals -- bamboo tube charcoal, bamboo slice charcoal

- c) For cooking: absorb harmful components and pesticide residues, release minerals -- bamboo tube charcoal, bamboo slice charcoal

B. Purifying agent for air in dwelling environment

The air in dwelling environment is mainly polluted by sulfur dioxide, carbonic oxide and sulfureted hydrogen discharged from chimneys, and smells occurred in living environment. The bamboo charcoal arranged in dwellings can absorb these smells and harmful gases, and regulate the humidity, keep the temperature going up within limits, and prevent the mould microbe multiplication.

- a) Charcoal for purifying indoor air: to allocate bamboo charcoal and charcoal handicrafts in dwellings, kitchens, refrigerators, wardrobes, shoe boxes, washing rooms, vehicles, pet-rooms to eliminate smells and purify air -- bamboo particle charcoal
- b) Charcoal for absorbing harmful chemical matter: bamboo charcoal can be used to absorb acetaldehyde, acetone, formaldehyde and other chemical components, released in newly built houses and newly decorated rooms -- bamboo tube charcoal, bamboo slice charcoal, bamboo particle charcoal.
- c) Charcoal for regulating humidity: charcoal can be used to regulate indoor humidity during rainy season -- bamboo tube charcoal, bamboo slice charcoal and bamboo particle charcoal.

C. Bamboo active carbon

Bamboo charcoal can be processed into bamboo active carbon after activation. Bamboo active carbon is widely used in many fields of industry as absorbent, additive and so on...

D. Electromagnetic shielding capacity

Allocate bamboo charcoal beside television sets and micro-wave ovens to shield the radiation of electromagnetic waves -- bamboo particle charcoal

F. Healthcare

Possessing extraordinary microstructure, bamboo charcoal absorbs odor and humidity from air indoor, emits natural smell, and radiates far infrared as well. Far infrared stimulates blood circulation and prevent human body from harmful electromagnetic wave. Therefore bamboo charcoal has healthcare properties. It can be used as follows:

- a) Bath absorbent -- bamboo particle charcoal
Absorb harmful substances, release minerals and radiate far infrared.

- b) Sleeping products -- bamboo particle charcoal

Bamboo charcoal can absorb odor and moisture in living room, and radiate far infrared which is comfortable to human body, stimulates blood circulation, improve self-circle of body. The minus ion from bamboo charcoal can release nerve of human, keep the emotion and relieve tired feeling. Proper products are bamboo charcoal pillow and mattress.

(5) Other use of bamboo charcoal

Bamboo charcoal has many specific functions which are to be exploited by development research. For example, bamboo charcoal is an additive for making-up agent to improve the skin by cleaning and whitening. Bamboo charcoal can keep fruits fresh when put together with fruits. Bamboo charcoal also can be made into artcrafts for decorating inner room and adjusting the humidity of air in room (Fig.27, Fig. 28).



Fig.25 a mattress filled with bamboo charcoal inside



Fig. 26 pillows filled with bamboo particle charcoal inside



Fig.27 Bamboo charcoal crafts

Bamboo charcoal has the function to meliorate the soil and promote the root system of plants. Therefore the perspective of its exploitation is quite broad. Bamboo charcoal used as soil modifier -- bamboo particle charcoal.



Fig. 28 bamboo root charcoal crafts

Bamboo charcoal has following effects in agriculture and forestry:

1. Improve water permeability of soil and preserve water.
2. Adsorb residues of pesticide and fertilizer.
3. Supply microelement
4. Adjust degree of acid-base in soil.

Bamboo charcoal performs good effect in cultivating bean, fruit, flower and grass by means of these capacities. It is a good case to use bamboo charcoal as soil modifier in golf-links.

3.2 Usage of bamboo vinegar

The content of organic matters in purified bamboo vinegar is 10 ~ 20%. In accordance with the business requirements the vinegar can be refined further to produce acetic acid, propionic acid, butyric acid, carbinol and organic solvents. The deposited bamboo tar is a kind of viscid oily liquid, containing a great amount of phenol substances and can be processed into mixed phenol products.

Main use of bamboo vinegar: diminish inflammation, sterilization, deodorization and dermatophytosis treatment. .



Fig.29 Crude bamboo vinegar solution



Fig.30 Refined bamboo vinegar solution