GEMCO
ENERGY

Starter's Guide

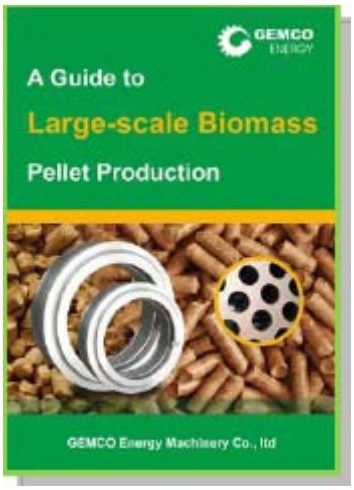
to Small-scale Wood&Biomass Pellet Production

PREFACE

As wood pellets has became an affordable and optimal choice as a substitute of fossil fuels. An increasing market demand and correspondent knowledge information requirement are seen in recent year, this guide is just your right resource providing everything you should know about pellets and how to make pellet.

! Please Note:

this guide is just for pellet making starters, it tells everything you need to know basically.
For investors and people who want to build a pellet factory in an industrial scale, you have to read the complete guide to large scale biomass pellets production for a deep understanding of total process and all equipments requirement in detail.



CONTENT

1. Introduction of Pellet

1.1 History and Background

Pellets have been produced for over a century, by using heat and pressure small cylindrical pellets can be produced from a variety of materials for different purposes. In the 1970's some companies who used pellet mills to produce animal feed, started to look into producing wood pellets as a fuel source. However because of the cheap fossil fuels that were available, the wood pellet market struggled to grow. In the 21st century wood pellets and fuel pellets in general are seeing rapid growth, even resulting in supply problems.

Due to high oil and gas prices, and concerns over climate change, fuel pellets are a clean, cheap heating fuel than can help to reduce global warming. Over the last decade there have been two major factors, which have been driving the growth of the pellet fuel market. The first is consistent rise in the cost of fossil fuels and price instability, and the second is the increased attention of the effects of using fossil fuels such as oil and gas on the environment. Other factors, which support the case for pellets is they are a fuel that can be produced locally, from local wood and biomass materials. Pellet production and distribution can produce an affordable fuel, creating local jobs while keeping the fuels carbon footprint to a minimum. The advantages of pellets over burning logs or briquettes are as follows.

1.2 Four Advantages

A. Price

Wood and biomass pellet fuel, as an alternative for fossil fuels, has fierce competitive and stable price than kerosene and natural gas in many countries. And supplied by green tax policy, wood pellet fuel is encouraged to use as a countermeasure against global warming, energy security and rise of oil price, and it has proved to have a good effect.

B. Wide Material

As to wood and biomass pellet fuel, the raw material source is various, such as wood waste (residual sawdust, wood shavings, wood peelings, etc.), yard debris (grass, leaves, tree sticks, forsythia, wisteria, bushes, etc.), farm waste (corn cobs, corn stalks, straw from plants, etc.) and other residues biomass waste. We can recycle energy from the above materials.

As a traditional heating fuel, fossil fuels are more expensive and easy to cause environmental pollution, trees (fire logs) grow slowly and the moisture is hard to control, both above mentioned are not good for stoves & boilers, besides the source is so limited.

C. Environment Friendly

Carbon-neutral is the green image and advantage of wood and biomass pellet fuel. Burn pellet fuel only liberates CO2 which is stored during the lifetime of plant, is harmless to the environment. But burning fossil fuels will liberate extra CO2 into atmosphere which stored million years ago, accelerates the global warming.

D. Convenience

Pellets are produced with uniform moisture content, shape, size, and density, which match the needs from the automated combustion systems of the stove and boilers, and also take less space in storage than other biomass fuels because they have a higher energy concentration.

Based on the information above, the primary features of pellets present as follows:

- ✧ Density of at least 40lbs/cubic foot
- ✧ Flows like a liquid, ideal for automatic systems
- ✧ Can be used in Stoves and Boilers

- ✧ Can be used in small and large scale applications
- ✧ Easy to handle, store and transport
- ✧ Improved combustion characteristics over raw material

1.3 Industry Standards

The fuel pellet market now has several industry standards in the US and Europe, that pellet producers need to comply with. This does depend on the size of production, and where and if the pellets are sold on the open market. Before purchasing equipment it is recommend researching any industry standards that may apply.
Below lines show terms of interpretation in pellet manufacturing industrial from *Pellet Fuels Institute Standard Specification for Residential/Commercial Densified Fuel October 25, 2010.*

- ✓ *bulk density* – the fuel mass per cubic foot of the fuel sample
- ✓ *diameter* – the average diameter of the fuel pellets in the fuel sample.
- ✓ *Pellet Durability Index (PDI)* – a standardized parameter for specifying the ability of the fuel pellets to resist degradation caused by shipping and handling.
- ✓ *fines* – the percentage of fuel material in the fuel sample passing through a 1/8 inch screen.
- ✓ *inorganic ash* – the percent inorganic material in the fuel sample.
- ✓ *length* – the weight percent of pellets exceeding 1.5 inches in length in the fuel sample.
- ✓ *Moisture* – the moisture content of the as-received fuel sample.
- ✓ *heating value* – The higher heating value of the fuel sample.

PFI Fuel Grade Requirements

Residential/Commercial Densified Fuel Standards See Notes 1&2			
Fuel Property	PFI Premium	Pfi Standard	PFI Utility
Normative Information-Mandatory			
Bulk Density, lb./cubic foot	40.0-46.0	38.0-46.0	38.0-46.0
Diameter,inches	0.230-0.285	0.230-0.285	0.230-0.285
Diameter,mm	5.84-7.25	5.84-7.25	5.84-7.25
Pellet Durability Index	≥96.5	≥95.0	≥95.0
Fines,%(at the mill gate)	≤0.50	≤1.0	≤1.0
Inorganic Ash,%	≤1.0	≤2.0	≤6.0
Length,%greater than 1.50 inches	≤1.0	≤1.0	≤1.0
Moisture,%	≤8.0	≤10.0	≤10.0
Chloride,ppm	≤300	≤300	≤300
Informative Only-Not Mandatory			
Ash Fusion	NA	NA	NA
Heating Value	NA	NA	NA

Table 1 Notes:

a. the following applies to all limits in this table: For purposes of determining the fuel grade, all properties must fall at or within the specified limits listed for a particular grade. Observed or calculated values obtained from analysis shall be rounded to the nearest unit in the last right- hand place of the figures used in expressing the limit in accordance with ASTM E 29 Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications.

b. It is the intent of these fuel grade requirements that failure to meet any fuel property requirement of a given grade does not automatically place a fuel in the next lower grade unless it meets all requirements of the lower grade.

1.3.1 Quality Pellets

When we describe a 'quality pellet', this is a term that describes a pellet made from any biomass material, not just wood. The reason I'm stating this is because in the premium wood pellet market a 'quality pellet' refers to a pellet with very low ash, for example 0.3%. This book describes all types of biomass

pellet production; some of the pellets produced will have higher ash content. We define a quality pellet through mechanical durability and moisture content.

1.3.2 Mechanical Durability

Mechanical durability simply refers to how dense the pellet is, and how well it is formed.

Pellets that are denser are of course stronger, the advantage is the pellets withstand transportation better, and work more efficiently in the pellet burner.

When a quality pellet has exited the pellet mill, it should have a smooth surface, with little or no cracks. If the pellet is cracking and expanding it is because there is too much moisture within the pellet, or poor compression within the pellet mill. Once a quality pellet has cooled, it should be like a coloring crayon. The surface of the pellet should be smooth, and have a surface shine.

Wood pellets tend to shine more than others; the most important thing is the pellets smooth compact state. Try tapping the pellet against a hard surface, to see if the pellet stays intact, or if they crumble or easily crush and separate. The length of the pellet is not really that important. However if pellets are too long (above 1 inch) they can cause damage to the auger in the pellet burner.

1.3.3 Moisture Content

The less moisture within a pellet, the more energy the pellet burner can use. However a certain percentage of moisture is required in the pelleting process, so the target is to keep moisture as low as possible while still creating quality pellets. Targets should be for moisture content in the finished pellets below 10%. Pellets with more than 10% will burn, but at the cost of efficiency.

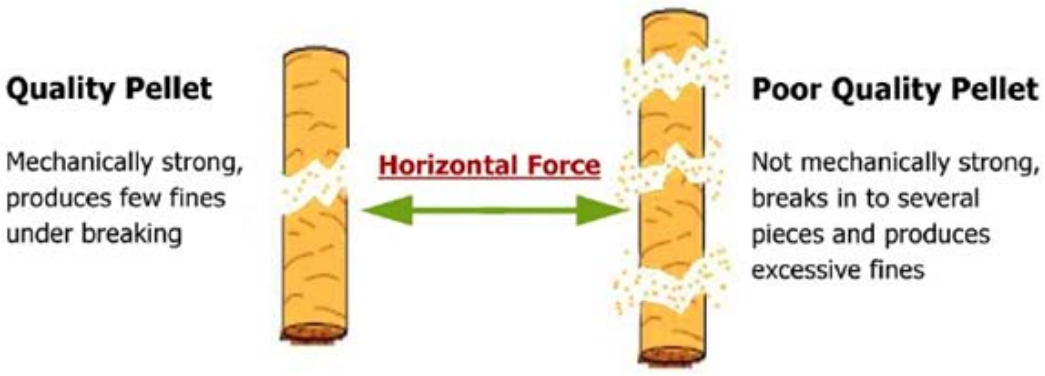
1.3.4 Quality Pellet Test

As stated quality pellets should have moisture content below 10% and be mechanically strong with a good density. The simplest way to test pellet quality is to place a pellet in a glass of water, if the pellet sinks to the bottom

the pellet has a high density, and was formed under sufficient pressure. However if the pellet floats it will be a poorer quality pellet with a lower density, lower mechanical durability and more likely to crumble and produce fines.

The second test is to take a vessel, which can hold at least 1 liter of water and weight it. Fill the container to the top with pellets and weigh again, now fill the container with water and weigh. Deduct the weight of the container from both measurements, and then divide the weight of the pellets by the weight water. For quality pellets the results should be between

0.6 and 07.kg/litre, the figure may also be referred to as the pellets specific gravity. Specific gravity is a crucial indicator that the pellets were produced under the correct pressure. Poor quality pellets, for example with a specific gravity under 0.6 will break/crumble easily, and produces excessive fines.

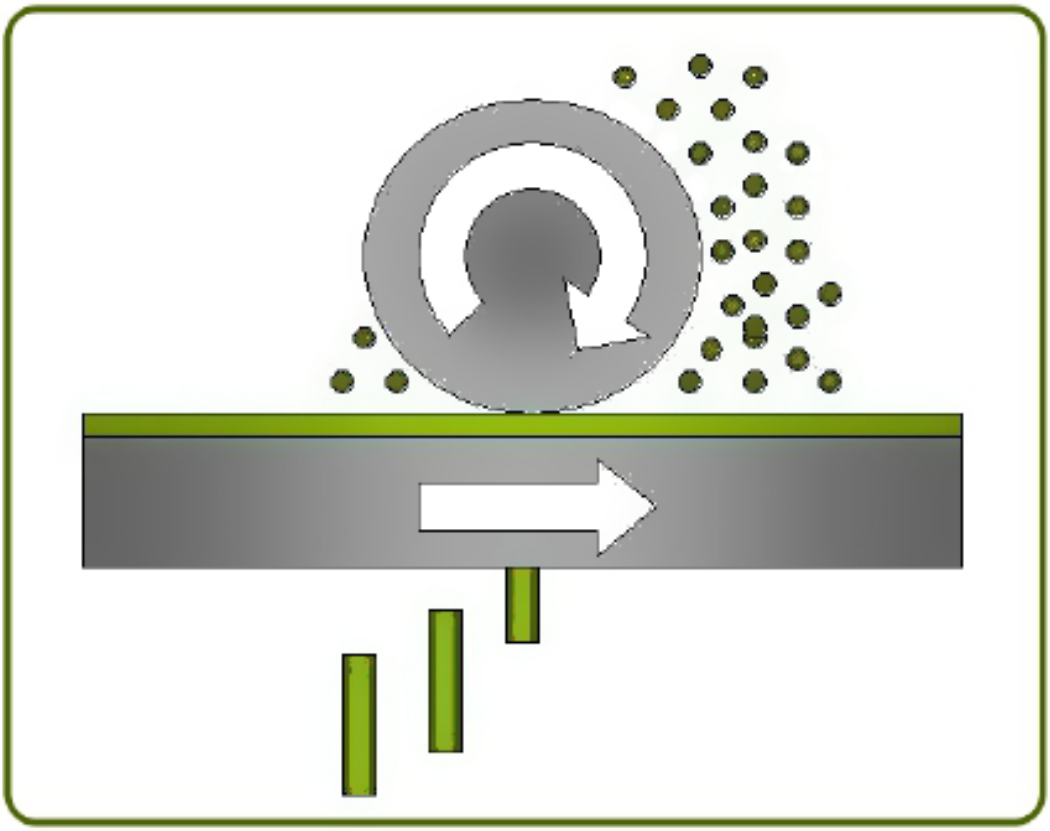


2. Introduction of Pellet Machine

There are two types of pellet mills, one is a flat die pellet mill and the other is a round die pellet mill. The flat die pellet mill came first and the round die was invented later. Generally flat die pellet mills are used for small to medium scale pellet production and round die pellet mills are used for medium to large-scale pellet production.

2.1 Flat Die Pellet Mill

The Flat die pellet mill works on the principle of material falling from above on to the rollers, which are rotating over the pellet mill die.



The material is then compressed between the roller and die surface through the die holes. Once the pellets emerge from the die a knife cuts the pellets off at a set length. Worm and wheel drive is used for some flat die pellet mills; others are driven via bevel gears.

In some flat die pellet mills the die is stationary and the rollers are driven. In

other flat die pellet mills the die is driven and the rollers rotate as material passes between the roller and the die.

Advantages of Flat Die Pellet Mills:

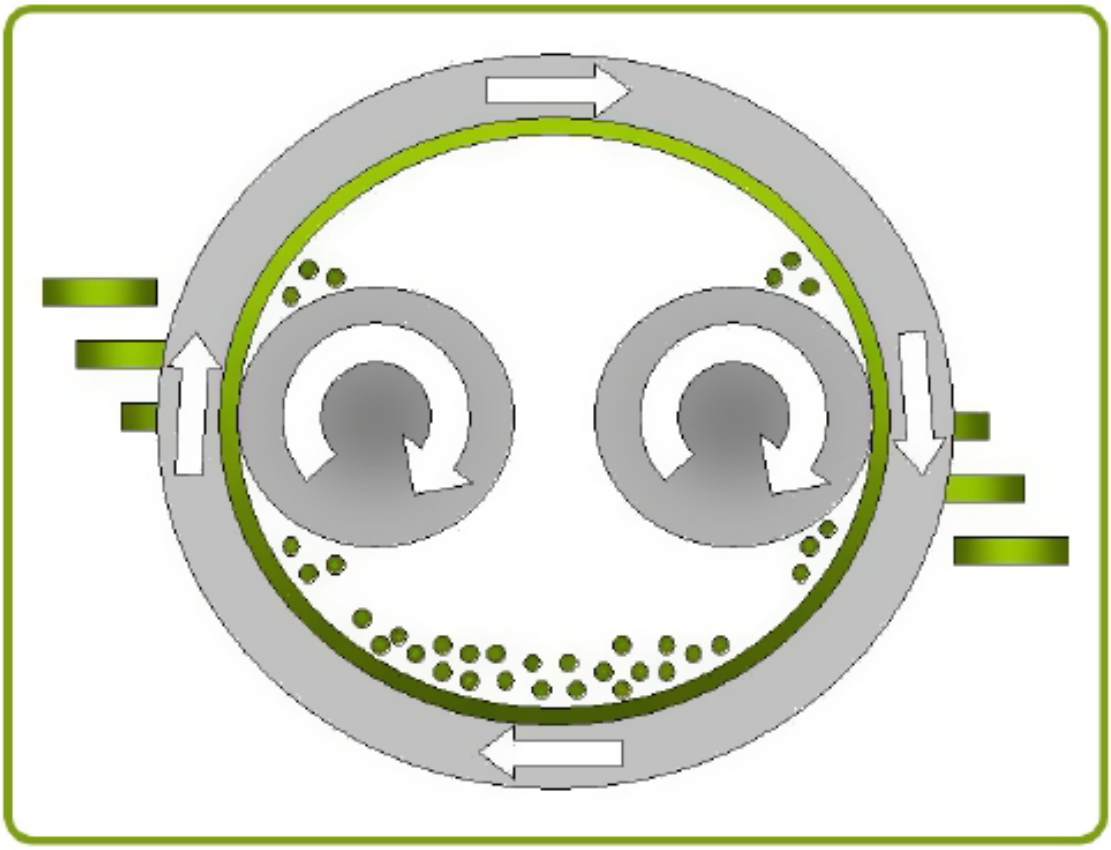
Flat die pellet mills are generally easier to clean than round die pellet mills. Quick access to the pellet mill chamber means faster die and roller changes, which means more time in production. The compact design of the flat die pellet mill means small, lightweight models are available, making them more suitable for small-scale production. Another key advantage of the flat die pellet mill is visibility. If a material is producing poor quality pellets or no pellets at all, viewing the material during the pellet process can give the best information on the reason why and how to correct it. With many flat die pellet mills it is possible to see into the pellet mill chamber during the pellet process; others have quick access doors to see into the chamber. Finally flat die pellet mills are regarded as been more robust for pelleting problematic feedstock. Therefore flat die pellet mills have a wider material tolerance than round die pellet mills.

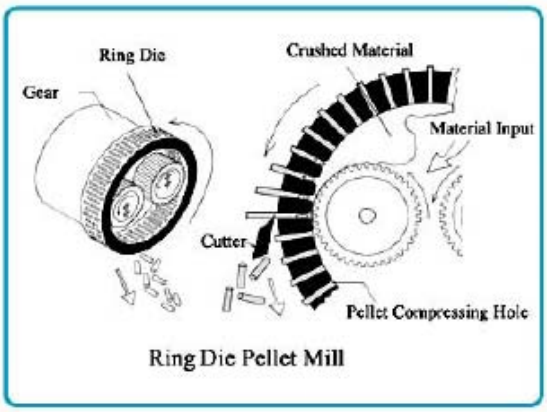
Disadvantages of Flat Die Pellet Mills: Due to the principles of the flat die pellet mill, this can result in uneven roller and die wearing. As the rollers rotate across the die surface the inner and outer edges of the roller are covering different distances. The outside edge covers a greater distance than the inner edge, which means the rollers slip, this slipping action can cause increased wear. However this is not always the case, and some flat die pellet mills have tapered rollers to correct the problem.

2.2 Round Die (Ring Die) Pellet Mills

The round die pellet mill comprises of a vertical ring die with rollers on the inside, applying pressure against the ring die.

Material is fed from a surge bin through a variable speed conditioner above the pellet mill; the conditioned material is then fed into the door of the pellet mill. A screw auger then feeds material into the center of the pellet mill chamber. Inside the chamber the rollers are stationary and the die is driven, similar to a washing machine. Once in the chamber the material is taken up by the rotating die and then compressed by the rollers.





Advantages of Round Die Pellet Mills: Firstly round die pellet mills do not suffer uneven roller and die wear as the inner and outer edge of the roller covers the same distance. For this reason round die pellet mills are preferred for large scale production as the costs of roller and die consumables are perceived to be lower. Round die pellet mills are also preferred for large-scale production as they are considered more energy efficient. Roller slip in flat die pellet mills causes extra friction during the pelleting process, which uses more energy during production. However this extra friction is not totally a bad thing, as more friction results in more heat, which can produce better pellets. All round die pellet mills come complete with a conditioner and variable speed feeding.

Disadvantages of Round Die Pellet Mills: The first obvious disadvantage of the round die pellet mill is its size and weight. This may not be a problem for large-scale production, however for small- scale production this can be a major problem. Also changing rollers and dies in a round die pellet mill is a far more labor intensive process. The dies particularly are very large and heavy and in most cases lifting equipment is required to remove or replace the die. Also roller adjustment is more difficult, as the majority of round die

pellet mills require manual roller adjustment, which can only be accessed by opening the pellet mill chamber. However this is not always the case, as some now come with optional remote roller adjustment at extra cost. Cost is another key disadvantage of the round die pellet mills, as the machines themselves and the dies and rollers are generally more expensive than flat die pellet mills. Finally visibility of the pellet process, as the die and roller are encased behind a solid door, viewing the process to gain information on possible issues and correction is not possible.

3. Preparation before Starting Making Pellets

3.1 Introduction of the Standard Procedure of Pelletizing Process

1 Size Reduction: Chippers/Shredders, Hammer Mills

2 Material Transportation: Fans, Cyclone Separators and Screw Augers

3 Drying: Rotary/Drum Dryers, Pipe Dryers

4 Mixing: Batch Mixers

5 Conditioning: Water and Steam Addition, Binders

6 Pellet Production: Round and Flat Die Pellet Mills

7 Sieving: Removing Fines

8 Cooling: Counter Flow Coolers

9 Pellet Transportation: Bucket Elevators

10 Bagging and Storage: Bags, Sacks and Silos

3.2 Material Input

Regulated material input into the pellet mill is very important for many materials. During the pellet production process moisture is released as steam. If the rate of material feed is greater than the productivity rate of the pellet mill this can cause problems. If the steam generated from the pellet process cannot escape the pellet chamber, the material above the roller will absorb the steam. This can cause bridging of the input material, which will stop material feed or affect pellet quality. If the material above the roller absorbs the steam this will increase that materials moisture content and the characteristics of the material in the pellet mill and pellet quality will change.

Therefore material feed rate should be regulated in tern with pellet mill productivity. At the beginning of production the pellet mill should be fed at a lower rate and increased as the pellet mill temperature increases. Therefore the feed rate should mirror the performance of the pellet mill and slowly increase up to maximum productivity. As the productivity of the pellet mill is variable based on the characteristics of the raw material, the feed rate will also have to adjust. The target feed rate should be to have the pellet mill rollers covered but no more.

3.3 Moisture

The moisture content of the raw material plays an integral role in how the material performs in the pellet mill. Too little or too much moisture and quality pellets cannot form, it's also important to keep the level of moisture within the finished pellet as low as possible, so the pellets burn efficiently. Moisture is required to produce pressure, and therefore heat the two essentials of pellet production. For more information about raw material moisture and pellets quality, check this article: http://www.biofuelmachines.com/What-Affect-Pellets-Strength-With-Pelletizing-Equipment.html

3.4 Reduce the Size of Raw Material

In this section, the raw material needs to be crushed, you can choose a hammer mill, chipper or wood waste shredder in accordance with your raw material. Based our comparison tests to different pellet mill and common wood & biomass materials, the pellet produced from crushed raw material has better and consistent quality than that produced from rough raw material. If your raw material is sawdust, or similar wood & biomass materials, you can skip this section.

Whether the raw material is wood, grass, straw or any other type of biomass, it must be reduced to a sufficient uniform size for the pellet mill. The general rule of thumb is the milled material going into the pellet mill must be smaller than the die holes in the pellet mill. For example to produce 6mm pellets the milled material must be smaller than 6mm. There are various types of equipment to conduct size reduction; each has different abilities and strengths. In some cases one piece of equipment is required, in other cases two are

needed.

3.5 Dry the Size-reduced Material

The moisture content of the pellet will straightly affect the pellet quality on the burning efficiency and the clean burning (zero smoke). According to our years` of studying and consultation experiences, the general requirement for moisture content of wood & biomass materials is from 10% to 15%. And by choosing and controlling on the right moisture content, you can cut down your cost on energy consumption.
In this section, a rotary drum dryer is a good option. To produce quality pellets the moisture percentage of the raw material will be between 10-20%. Most materials produce the highest quality pellets with a moisture percentage around 15%, however the percentage to produce quality pellets is specific to each raw material. If the raw material has a moisture percentage above 15-20% it must be dried or mixed with a dryer material, this will be described in STEP

3.6 Mixing

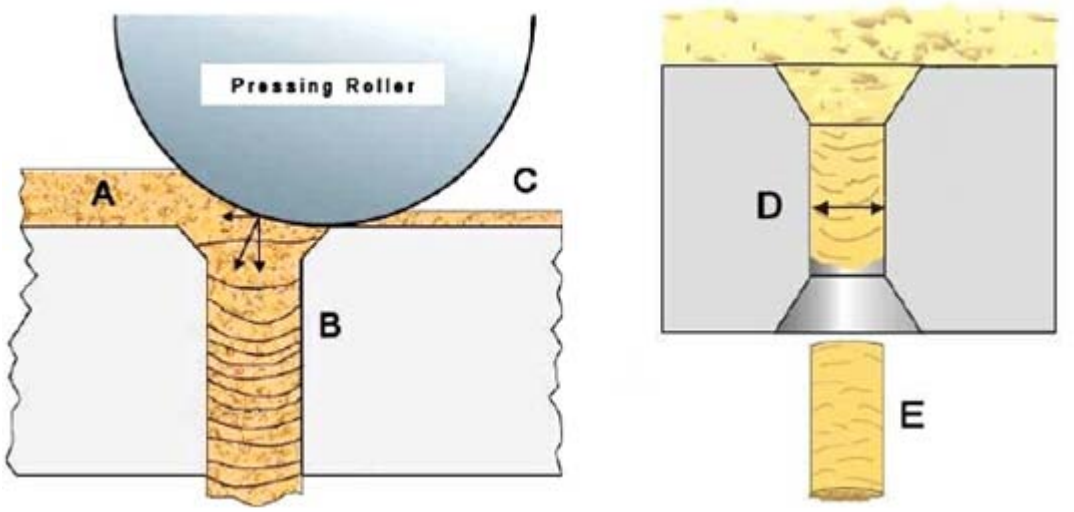
Mix the dried material with the binder, lubricants or other needed material Due to the different characteristics of various raw materials, the pellet quality is unequal. To improve the pellet quality or maximize the production capacity, you can add binder (a kind of glue, e.g., vegetable oil or rapeseed cake) to help the lignin-lacked material to compress into pellets much easier. Whether producing a single material pellet or a mixed material pellet, material consistence is crucial to a consistent, reliable and efficient pellet plant. Batch mixers are used after the material has been milled and dried (if required). Through mixing the material, a more consistent material blend is fed into the pellet mill. Mixing may occur before or after conditioning. The graphs below illustrate the possible effects of poor material consistency.

3.7 Conditioning Process to the Mixed Material

By adding dry steam into the mixed material can heat and soften lignin, which helps the mixed material to be compressed into final pellets much easier, and maintains consistent quality of the mixed material which ensures the consistent quality of pellets. Its final purpose is to increase the production capacity.

3.8 Pellet Mill Characteristics

Each material has different qualities and characteristics. Therefore each material will behave differently in the pellet mill based on its moisture, density and binding qualities. Below is what a material should behave like, and what to aim for.



3.9 Cooling

When the pellets leave the pellet mill, they are very hot, soft and releasing moisture. Before the pellets can be used or stored they must first be left to cool and dry. The simplest form of pellet cooling is to spread the pellets out, and let them cool at room temperature.

3.10 Sieving

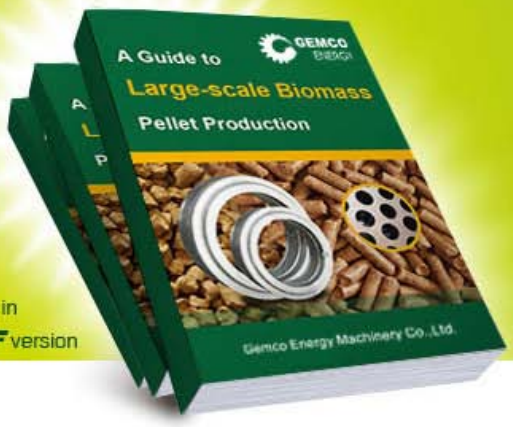
As the pellet mill compresses the raw material into pellets some material is not compressed into pellets, this dust is referred to as fines. Fines are particles of material that failed to bind to the pellet during pellet formation; this could be due to lack of pressure in the pellet mill or a lack of binding. If the pellets produced are not mechanically strong, as the pellets move and rub against other pellets and surfaces particles break away from the pellet, again these are described as fines. So the performance of the pellet mill and the quality of the finished pellets affect the percentage of fines.

3.11 Pack and Store

Because the wood pellet will not enter into the fuel process immediately, in order to keep the wood pellet as dry as possible, to avoid the influence from water or dampness, the packing process is necessary. To reduce your cost on labor source, a pellet packing machine is recommended, you can choose a semi-auto or a completely auto one in accordance your needs.
Once the pellets have been cooled and are of sufficient quality, the pellets are ready to be packaged, stored and sold. How the pellets are packaged and stored again depends on the target market. Pellets must be protected from moisture and breakage. If moisture comes into contact with the pellets, the pellets will absorb the moisture and expand, making them useless.

3.12 Equipment and Pellet Mill Maintenance

The equipment used in pellet production is exposed to high pressures and temperatures, extreme forces are placed on the equipment and proper maintenance can increase equipment life and reduce energy demand.



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It is the objective of this complete guide to large scale pellet production illuminate the necessities of large-scale pellet production for the prospective investor, or to serve as a condensed reference for existing operators. In the appendix is a list of pellet plant machinery manufacturers. From the policy environment, to the raw material, to the machinery used in pelletization, to the final product, GEMCO Pellet Mill seeks to assist those who share in our common interest: the international advancement of biomass energy.

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