Research progress of biomass energy conversion technology and application in China

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ABSTRACT

With the rapid development of the people's economy, the consumption of various energy sources is increasing. The increasing consumption of non-renewable energy sources can lead to increased sources of air pollution. In addition, energy sources from fossils if used continuously can run out. To overcome this problem, renewable energy sources are created to replace fossil fuels. As a renewable energy source that can replace fossil fuels, biomass is currently receiving a lot of attention from countries around the world and is increasingly being used. Biomass can be produced from animal waste or manure that is put in a reactor tube. In this paper, we focus on the technology of converting biomass to energy and describe the application of biomass to energy to implement efficient application of biomass to energy.

KEYWORDS
Biomass;
Sustainable development;
Environmental pollution;
Energy conversion;

1. Introduction

Energy is the important foundation and guarantee of national economic development at this stage, and the supply capacity of energy directly affects the long-term and stable development of the whole national economy, and also relates to the survival of a country [1]. At present, China's use of major energy sources is rising, mainly on coal, oil and gas, and other fossil energy consumption is particularly obvious, fossil energy as a non-renewable resource, if not effectively controlled in the use of the process, will cause a lot of waste of resources and air pollution caused by the burning of resources [2-4]. At this stage, the amount of fossil energy available in China is decreasing, so we must continue to seek new renewable energy to replace fossil energy, mainly biomass energy, wind energy, solar energy, and tidal energy to develop and use, effectively reducing the consumption of fossil energy, and play a good guarantee for environmental protection [5].

2. Biomass and Biomass Energy

Biomass is mainly converted into various organisms through a series of photosynthesis, including various plants and animals, animal manure, microorganisms, and agricultural and forestry waste. The sulfur and nitrogen content of biomass is relatively low, and the combustion process does not produce large amounts of sulfide and nitrogen compounds [6-8]. Biomass energy is mainly based on biological energy carriers, and its energy supply mainly comes from the sun and photosynthesis formed between plants. According to statistical analysis, plants on earth can synthesize 1400~1900 Gt of biomass energy through photosynthesis every year, which contains more than 10 times the total global energy consumption, and the total amount of biomass consumed in the world accounts for about 15% and more than 60% in some relatively backward areas [9].

Biomass energy has many advantages in the process of use:

- Biomass energy is widely distributed, more abundant than non-renewable fossil resources, and is a renewable resource.
- The energy carriers extracted and transformed from biomass energy are cleaner than fossil resources in the process of use. The effective development of biomass energy can promote the long-term and stable development of the social economy and can also achieve good environmental benefits.

- The extraction of methanol and liquid hydrogen from biomass resources by inner-city vehicles is beneficial to the protection of the environment. The development and use of biomass energy are receiving more and more attention, and the overall distribution of the resources is very wide, which can be effectively transformed into a common liquid and solid fuels by biomass energy, which is of great significance to the improvement of people's quality of life.

3. Method and application of biomass energy chemical conversion technology

Direct combustion technology

Direct combustion technology can be carried out in several ways, such as stove combustion, boiler combustion, and waste incineration, and the process is relatively simple [10]. The direct combustion of biomass releases a certain amount of carbon dioxide, which is equivalent to the fixed carbon dioxide produced by photosynthesis during the growth process, effectively achieving zero carbon dioxide emissions and alleviating the greenhouse effect of the natural environment [11]. From Table 1, compared with coal, biomass fuel mainly has the following differences:

- Less carbon content and less fixed carbon
- More oxygen content and more water content
- High volatile content
- Low density
- Low sulfur content

Table 1. Comparison of the composition of biomass fuel and coal

Type of combustion	C/%	O/%	H/%	Ash/%	Volatile/%	Density/(t/m^3)
Biomass fuel	38~50	30~44	5~6	4~14	65~70	0.47~0.64(wood)
Coal	22~90	3~20	3~5	5~25	7~38	0.8~1.0

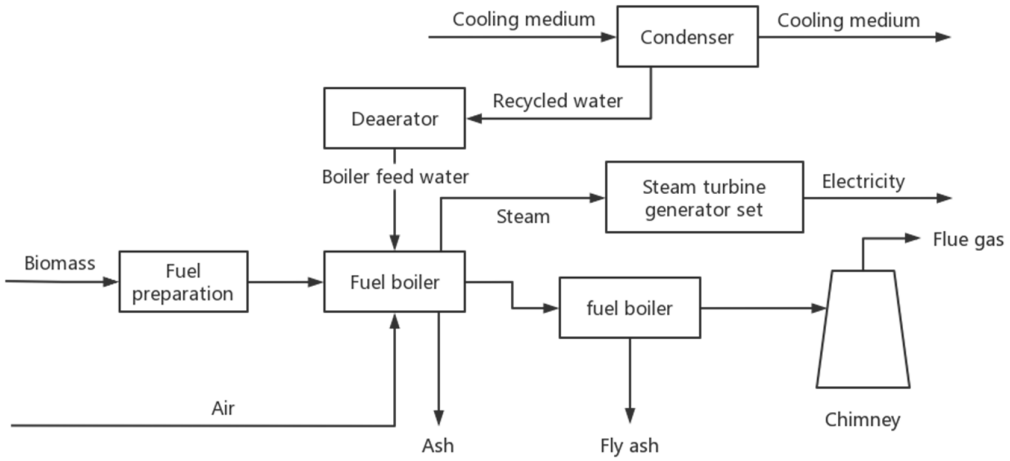

Fig. 1. Flow chart of biomass direct combustion power plant

Figure 1 is the working flow chart of the biomass direct-fired power plant. The combustion products of biomass are widely used and can be recycled at home [12]. Biomass combustion can be mixed with mineral fuels, which effectively reduces the cost of combustion operation and improves the efficiency of combustion, and can effectively reduce the emission of harmful gases [13].

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Gasification utilization technology

Biomass gasification is a process of pyrolysis, oxidation, reduction, and reforming of biomass polymers under certain thermodynamic conditions by the action of air (or oxygen) and water vapor, which eventually transforms into combustible gases such as carbon monoxide, hydrogen, and low-molecular monsters [14]. After combustion, a mixture of carbon dioxide and other gases is produced, which is described as having low carbon content, high moisture content, high volatile content, low density, and low sulfur content, but the overall efficiency of the biomass is significantly increased after conversion into combustible gas, which can be used for power generation [15].

Biomass gasification power generation technology is the most researched and applied technology and the most well-equipped. There are three ways to generate electricity by biomass gasification:

- Burning as fuel for steam boilers to produce steam to drive steam turbines to generate electricity. This method is not very strict on gas requirements, directly in the boiler burning gasification gas [16]. It is ready for use after passing through a cyclone separator to remove impurities and ash. The burner is able to maintain a stable combustion state when there are changes in gas composition and calorific value and emits fewer pollutants.
- Combustion in a gas turbine drives a generator to generate electricity. This method requires the pressure of the gas, which is generally 10~30kg/cm2. This technology has pollution problems such as dust and impurities.
- Combustion in the internal combustion engine to drive the generator to generate electricity. This method is widely used and highly efficient. However, this method has extremely strict gas requirements, and the gasification gas must be purified and cooled [17]. Large-scale biomass gasification power generation systems use gas turbine generators, which are the most advanced biomass power generation technology in the world.

Anaerobic fermentation

In biomass energy conversion technology, anaerobic fermentation, also known as biogas fermentation or anaerobic digestion, uses organic matter, mainly human and livestock manure, vegetation straw, weeds, etc [18-20]. Under a certain amount of water, temperature, and anaerobic environment, based on the action of various microorganisms to produce decomposition and metabolism, and eventually form methane and carbon dioxide gas, which can provide the necessary energy for people's daily life.

Thermochemical method

Biomass is heated in an environment with little oxygen or completely isolated from oxygen, and the large molecular bonds of biomass are broken and gradually transformed into small molecules, which is also called pyrolysis [21-22]. Under the long time burning conditions of biomass, a certain amount of mixed hydrocarbon gas will be released, and according to the residence time and specific temperature of biomass raw materials in the pyrolysis process, it can be divided into the following different types:

- Slow thermal junction type. It is mainly used for charcoal burning.
- Conventional pyrolysis puts the biomass raw material directly into the conventional thermal testing equipment to decompose, after the decomposition is completed, 20%-30% of the biomass energy and 10%-15% of the bio-oil can be obtained [23].
- Fast pyrolysis method. The biomass raw material is placed in the fast pyrolysis device to carry out the reaction, and the bio-oil in the pyrolysis product can usually reach 40%~50% of the total weight of the raw material, the fast pyrolysis process needs to be based on a large amount of heat supply to effectively improve the efficiency and stability of the whole thermal junction work [24].

Direct liquefaction technology

Liquefaction technology is the best way to convert biomass energy into liquid fuels for people's production and use. Liquefaction technology is divided into two forms: direct liquefaction and indirect liquefaction [25-26]. The direct liquefaction technology requires the use of various solvents and catalysts, which are directly transported to the corresponding high-pressure vessels, where the biomass is directly liquefied at a specific temperature and pressure by using hydrogen and other inert gases as auxiliaries [27].

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Liquefaction is carried out in several forms, such as pyrolysis, catalytic liquefaction, and hydrogenation. The direct liquefaction of biomass has the following advantages:

- The raw materials do not need to be dehydrated or crushed, and the operation steps are relatively simple.
- The equipment composition is relatively simple, the quality of the product is better, and the thermal stability is higher, but there are still certain problems, such as the directional catalytic and directional conversion rate of biomass is higher, and the equipment can also be scaled up and optimized. The amplification and optimization of the system improve the quality of the whole liquefied product [28]. Pyrolysis liquefaction of biomass refers to the rapid heating of biomass under oxygen deprivation conditions and maintaining the temperature between 500C and 600C to transform it into the corresponding liquefied product.

Indirect liquefaction technology

Indirect liquefaction technology mainly involves the gasification of biomass into gas, followed by subsequent catalytic synthesis to form the corresponding liquefied product [29]. Biomass gasification is an indirect liquefaction process and is an important method of thermochemical conversion and use of biomass. Synthetic fuels are relatively accurate and free of impurities such as sulfur and nitrogen and do not produce black smoke emissions after combustion. The tail gas of the synthesized fuel can be used directly for power generation or residential heating, the residue from gasification is an important production material for agricultural land, which can effectively improve the added value of the elements in the soil, and the organic compounds separated from the gas can be used for the production of plastic products [30].

4. Conclusion

Biomass energy is a renewable and clean resource that does not cause significant environmental pollution even when used in large quantities. Compared with common fossil energy sources, biomass energy is more economical and environmentally friendly in terms of development and use and can be developed and improved at a deeper level in the subsequent development process, which is worthy of wide application and promotion.

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Author Contribution

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Conflict of Interest

The authors declare no conflict of interest.

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