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# Biomass Energy Gasification Technology and Application

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***Abstract:*** Globally,the dual challenges of energy crisis and environmental pollution encourage people to seek sustainable energy solutions. Biomass energy, with its renewable and environmentally friendly characteristics, has gradually become an important choice to replace the traditional energy. Biomass gasification technology, as an advanced thermochemical process to convert biomass energy into combustible gas, not only improves the efficiency of energy utilization, but also shows great potential in the field of energy conversion and environmental protection due to its cleanliness and operability. In this paper, we deeply analyze the basic principles of biomass gasification technology, including the key steps such as pyrolysis, gasification and gas purification, and explore the application strategies of this technology in biomass energy conversion. In particular, the paper details the innovative practice of Shanghai Diyan Environmental Protection Technology Co., Ltd. in the field of biomass gasification, including its technological breakthrough in printing and dyeing sludge treatment, as well as the national utility model patent obtained. The successful cases of the company not only show the advantages of biomass gasification technology in practical industrial applications, but also provide valuable experience and inspiration for the same industry. Through these studies and practices, this paper aims to provide theoretical basis and technical support for the efficient and environmental protection utilization of biomass energy, in order to promote the further development and application of biomass energy gasification technology.

***Keywords:*** Biomass gasification; Energy conversion; Environmental protection technology; Sludge treatment; Shanghai Diyan Environmental Protection Technology Co., Ltd.

## 1. Foreword

This project takes environmental protection and environmentally friendly bioenergy as the research object, takes bioenergy as the entry point, adopts biochemical methods, constructs a bioactivity evaluation system based on available energy, constructs an environmentally friendly evaluation system based on bioactive substances, and based on this, constructs an ecological environment protection technology system based on renewable energy. On this basis, a sustainable development based ecological environment evaluation index system is constructed, and the feasibility of the theoretical model is verified through experimental verification, providing theoretical basis and technical support for the construction of ecological environment based environmental protection technology, and scientific basis for solving environmental pollution problems.[1]

## 2. Principles of biomass gasification technology

This project focuses on biomass as the research object, using thermal processing methods to extract energy from biomass and clean up the energy conversion process. The energy conversion process is divided into fragmentation, catalysis, oxidation (or classification), and the results are verified.

### 2.1 Dry stage

Initially, the biomass feedstock undergoes heating, which prompts the gradual evaporation of its embedded moisture. This drying phase draws thermal energy predominantly from external heat sources, encompassing air, oxygen, or steam.[2] Throughout this stage, the biomass's temperature ascends steadily, albeit not reaching the elevated temperatures necessary for pyrolysis. It is crucial to acknowledge that the drying efficiency has a direct impact on the overall energy consumption of the gasification process. Consequently, enhancing the drying conditions is a pivotal strategy to boost gasification efficiency.

### 2.2 Pyrolysis stage

Upon escalating temperatures, biomass commences undergoing pyrolysis, a process that unfolds in oxygen-deficient conditions. During this phase, the complex organic polymers within the biomass disintegrate, giving rise to smaller volatile gas molecules, liquid bio-oils, and solid char. For instance, at around 700°C, the biomass initiates pyrolysis, resulting in the decomposition of these polymers into volatile gases of lower molecular weight, liquid bio-oil, and solid carbon. Considering biomass with a calorific value of 2600 kcal/kg, approximately 1.5 cubic meters

of gaseous volatiles are generated per kilogram of raw material during pyrolysis, primarily consisting of methane, hydrogen, and carbon monoxide. These gases serve as key constituents of the combustible gas needed in gasification. Notably, the pyrolysis stage is the most intricate part of gasification, and its reaction dynamics and kinetics are significantly influenced by parameters such as the type of biomass, pyrolysis temperature, heating rate, and more.

### 2.3 Oxidation stage

On the basis of preliminary work, this project plans to use carbon dioxide and oxygen as raw materials, adopt liquid-phase co precipitation method, and conduct oxidation-reduction reaction on the oxidation product sunder the conditions of oxidation-reduction reaction. The impact of oxidation reaction on energy is studied, and the effective utilization of energy is achieved by adjusting the oxidation reaction of the oxidation products, thereby achieving effective utilization of vacuum circulation and energy.

Precise control of reaction conditions is the key to achieve high efficiency and high gas quality throughout gasification. The highest conversion efficiency is observed for biomass at gasification temperatures between 800℃ and 1000℃. For example, the gasification temperature, the ratio of the gasification agent, the reaction time and other factors all need to be optimized according to the specific biomass characteristics and the required gas use. In addition, advances in gasification technology include continuous improvements in gasifier design, gas purification systems, and automated control systems to improve the energy efficiency and operational stability of the entire system.

This project takes biochemical synthesis technology as the research object, studying biochemical synthesis methods from multiple perspectives such as biochemistry, biochemistry, and biochemistry, exploring the relationship between biochemical synthesis and biosynthesis, revealing the molecular mechanisms of biochemical synthesis, providing new ideas for biochemical synthesis, providing new ideas and approaches for the development of biosynthesis technology, and providing theoretical basis and technical support for solving the technical bottlenecks in current biochemical synthesis.

## 3. Biomass gasification process flow

Biomass gasification process is a comprehensive technology to convert biomass raw materials into available energy, and every link of the process has an important impact on the quality and application of the final product. Here are the four main steps of the biomass gasification process:

### 3.1 Raw material pretreatment stage

In the biomass gasification process, the pretreatment of raw materials is a crucial first step. Biomass raw materials usually include agricultural waste, forestry residues, urban organic waste, etc., which need to be broken and dried before entering the gasifier. The crushing process can increase the specific surface area of the raw material, thus improving the pyrolysis and gasification efficiency. For example, corn straw, as a common agricultural waste, can increase its specific surface area by about 30% after crushing treatment, thus significantly improving the efficiency of pyrolysis and gasification. Drying is to remove water from the raw material, because water consumes additional heat during the gasification process and reduces the quality of the gas, generally requiring the water content of the raw material to be reduced to less than 20%. The pretreatment can also include sorting and cleaning to remove impurities and non-gasifying components in the raw material to ensure the smooth progress of the gasification process.

### 3.2 Gasification stage

The pretreated biomass raw materials are sent to the gasifier, and the chemical reaction occurs with the gasification agent under high temperature and hypoxia or anaerobic conditions to produce combustible gas. Gification agents are usually air, oxygen or water vapor, which react with carbon and organic substances in biomass to produce combustible gases such as carbon monoxide, hydrogen and methane. The design of gasifier has a direct impact on the gasification efficiency and gas quality. Common types of gasifier include fixed bed gasifier, fluidized bed gasifier and circulating fluidized bed gasifier. Each type of gasifier has its own unique operating conditions and applicable scenarios.

### 3.3 Gas purification stage

The gas produced by gasification contains a variety of impurities, such as tar, dust, acid gas, etc., which will affect the utilization efficiency of gas and the safe operation of equipment. Therefore, gas purification is an indispensable link in the gasification process. The purification process usually involves steps such as condensation, filtration, adsorption and catalytic conversion to remove solid particles, tar and acid gases from the gas. With the development of technology, new gas purification technology, such as membrane separation technology and biological purification technology, are also being gradually developed and applied.

### 3.4 Gas utilization stage

The quality of purified gas has been significantly improved and can be used for a variety of purposes. The calorific value of purified gas can reach about 5 to 10 megajoules / m 3, enough to drive a gas turbine or internal combustion engine for efficient power generation. The most common is used as fuel for power generation, heating and cogeneration. In heating applications, each cubic meter of gas provides the equivalent

of 8 to 10 kilowatt-hours of heat to meet the heating needs of homes or commercial buildings. In addition, gas can also be used as a chemical raw material for the production of ammonia, methanol and other chemicals. In the process of ammonia synthesis, every cubic meter of gas can be converted into about 0.3 to 0.4 kilograms of ammonia. In methanol production, about 0.2 to 0.25 kilograms of methanol can be produced per cubic meter of gas. In some cases, gas can be further purified to produce bio-natural gas or hydrogen to meet more stringent energy needs. During the production of bio-natural gas, purified gas can be upgraded to about 0.8 to 0.9 cubic meters of biomethane, with a calorific value comparable to that of conventional natural gas.

Throughout the biomass gasification process, system integration and optimization is the key to improve energy efficiency and reduce costs. For example, the heat generated by the gasifier can be used to dry the raw material for the internal recycling of the energy. At the same time, the application of the automatic control system can improve the stability of the gasification process and the convenience of operation.

The development of biomass gasification technology also faces some challenges, such as the supply of raw materials and pretreatment costs, the further improvement of gasification efficiency, the improvement of gas purification technology and the diversification of gas utilization. Future research needs to focus on new development processes, system integration and optimization, as well as economic analysis to drive biomass gasification technology toward wider commercial applications.

## 4. Key technologies and innovation points

### 4.1 High-efficiency gasifier design

Shanghai Diyan Environmental Protection Technology Co., Ltd.'s innovation in gasifier design not only improves the heat exchange efficiency, but also significantly reduces the energy consumption, which is of great significance for the efficient utilization of biomass energy. The company's gasifier design enables efficient heat transfer under lower energy consumption conditions by using advanced heat exchange technology, which is particularly critical in biomass gasification technology. According to the research data, through this design, the thermal efficiency of the gasifier can be improved to more than 70%, which is a fairly high efficiency level, meaning that only a small part of the energy is wasted in the conversion process.

Further data show that the company's designed gasifier has successfully reduced fuel consumption by about 20% while improving thermal efficiency. This improvement not only reduces operating costs, but also reduces the environmental impact, in line with the current pursuit of clean energy and sustainable development. In addition, the structural design of the furnace body also fully considers the uniform heating of the raw materials and the optimization of the reaction dynamics, which is crucial to ensure the high yield and high quality of the gas. For example, by optimizing the design, the concentration of combustible gases such as methane and hydrogen in gas can be increased to more than 80%, which greatly improves the calorific value and application range of gas.

Specifically, the gasifier design of Shanghai Diyan Environmental Protection Technology Co., Ltd. adopts a multi-stage heat exchange system, which ensures the efficient conversion of biomass raw materials in the gasification process by accurately controlling the reaction temperature and gas flow. This design also allows for the efficient recovery and reuse of the by-products generated during the gasification process, further improving the energy efficiency of the entire system. For example, the heat energy generated during the gasification process can be recycled for drying the raw material, while the waste heat discharged from the gasifier can be used to preheat the feed or generate steam, thus achieving internal recycling of energy.

### 4.2 Gas purification technology

During biomass gasification, gas purification is the crucial step in ensuring its availability. The gas purification technology developed by Shanghai Diyan Environmental Protection Technology Co., Ltd. can effectively remove tar, dust and other impurities in gas, and significantly improve the cleanliness and calorific value of gas. Specifically, the tar content in the purified gas can be reduced to less than 50 mg / $Nm^3$, and the dust content can be reduced to less than 10 mg / $Nm^3$, thus meeting the more stringent energy utilization standards. The innovation of this technology lies in its multistage purification process and an efficient separation mechanism, which can adapt to the purification needs under different gasification conditions.

### 4.3 Automatic control system

The stability of the gasification process is crucial to ensure the quality of the gas and the safety of the system. Shanghai Diyan Environmental Protection Technology Co., Ltd. has realized the automatic control of the gasification process, and ensured the continuity and stability of the gasification process through precise parameter monitoring and real-time adjustment. The application of automatic control system not only improves the convenience and security of operation, but also reduces the risk of human operation error.

### 4.4 harmless treatment of sludge

Sludge harmless treatment is an important topic in the current field of environmental protection. Shanghai Diyan Environmental Protection Technology Co., Ltd. has made a breakthrough in this field. The company's sludge gasification technology, through a series of innovative processes, to

achieve efficient sludge transformation and resource utilization. Specifically, this technology can reduce the volume of municipal sludge with 80% water content to less than 30% of the original volume after treatment. This significant reduction effect greatly reduces the cost of subsequent treatment and disposal of sludge.

In the transformation process, the organic matter in the sludge is converted into combustible gases, in which the methane content can be increased to more than 35%. This increase in the conversion rate not only improves the calorific value of the gas, but also increases its utilization value as an energy source. According to the experimental data, each ton of sludge, after gasification treatment, can produce about 50 cubic meters of combustible gas, of which the calorific value of methane is about 35.8 megajoules / cubic meter, which means that each ton of sludge can provide about 1.79 megajoules of heat energy. In addition, the company's sludge gasification technology has also performed well in the harmless treatment. By accurately controlling the temperature and pressure in the gasification process, the formation of harmful substances, such as dioxins and heavy metals, which are often difficult to control in the traditional sludge treatment process. At the same time, the technology can also kill the pathogens and parasitic eggs in the sludge to ensuring the safety of the treated sludge.

The sludge gasification technology of Shanghai Diyan Environmental Protection Technology Co., Ltd. not only improves the overall performance of biomass gasification technology, but also provides new solutions for the field of environmental protection and energy. The innovation of this technology lies in its deep understanding of sludge characteristics and precise control of process parameters, which makes the gasification process more efficient, clean, and adaptable to different types of sludge feedstock.

As the technology continues to mature and the market gradually expands, the sludge gasification technology is expected to play a more important role in the environmental protection and energy market in the future. The successful experience of Shanghai Diyan Environmental Protection Technology Co., Ltd. not only provides a valuable reference for enterprises in the same industry, but also provides a new idea and direction for the efficient utilization and sustainable development of biomass energy. With the growing global demand for clean energy and environmental protection, sludge gasification technology is expected to be more widely used and develop faster.[4]

## 5. Application example of Shanghai Diyan Environmental Protection Technology Co., LTD.

Under the leadership and promotion of Mr. Wang Hong, Shanghai Diyan Environmental Protection Technology Co., Ltd. has become an important force in the field of biomass gasification technology. Company focus on biomass gasification technology research and development and practical application, the development of sludge pyrolysis device and sludge gasifier have won the national utility model patent, the application of these technologies significantly improved the efficiency of sludge treatment, and realize the recycling of resources, for environmental protection and energy conservation made a positive contribution, for example, through the sludge pyrolysis device, each ton of sludge can be converted into about 50 cubic meters of combustible gas, significantly improve the recycling utilization rate of resources.

Sludge pyrolysis device is an innovative technology of the company, which can effectively convert the organic matter in the sludge into combustible gas, and realize the reduction and harmless treatment of the sludge. The design of the device takes into account the characteristics of the sludge, and optimizes the pyrolysis efficiency and gas quality by accurately controlling the temperature and pressure of the pyrolysis process. The pyrolysis device can operate efficiently within the temperature range of 500°C to 700°C, and the conversion rate of organic matter in the sludge reaches more than 85%. The application of this technology not only solves the environmental problems of sludge treatment, but also provides a new way for the energy recovery in sludge.

The company's sludge gasifier technology, also obtained the national utility model patent, it adopts the unique structural design and gasification technology, in the relatively efficient gasification process to achieve low energy consumption. The design of the gasifier allows the rapid decomposition of water and organic matter in the sludge at high temperature to produce high-quality combustible gas, while minimizing the emission of pollutants.[5]

The technology application of Shanghai Diyan Environmental Protection Technology Co., Ltd. has not only made remarkable achievements in the field of environmental protection, but also opened up a new growth point in the field of energy. The company's technology helps solve the environmental problems of sludge treatment, while providing clean energy products for the society, and achieving win-win social and economic benefits. It is estimated that through the application of these technologies, the company is able to provide about 2 million kilowatt-hours of renewable energy to the grid every year.

Under the leadership of Mr. Wang Hong, the company continues to carry out technology research and development and process optimization, and constantly explore new gasification technologies to adapt to different types of biomass raw materials, and improve the gasification efficiency and gas quality. At the same time, the company also innovates in gas purification and automation control to improve the stability and economy of the entire gasification system.

The sludge gasification technology of Shanghai Diyan Environmental Protection Technology Co., Ltd. has become a successful case in the

field of resource recycling, which has an important demonstration and reference significance for other enterprises and research institutions. With the continuous maturity of the technology and the gradual expansion of the market, biomass gasification technology is expected to play a more important role in the future, providing innovative solutions to global energy and environmental problems.

## 6. Conclusion

Biomass gasification technology, with its significant advantages in environmental protection and energy replacement, is gradually becoming one of the key technologies to solve the global energy crisis and environmental pollution problems. By converting biomass feedstocks into combustible gases, this technology not only improves the efficiency of energy utilization, but also reduces the dependence on fossil fuels, thus playing an important role in promoting the transformation of energy structure and promoting sustainable development.

Under the leadership of Mr. Wang Hong, Shanghai Diyan Environmental Protection Technology Co., Ltd. has significantly promoted the development and application of biomass gasification technology through continuous technological innovation and patent protection. The sludge pyrolysis device and sludge gasifier developed by the company, as recognized by the national utility model patent, have demonstrated its technical strength and innovation ability in the efficient utilization of biomass energy. The application of these technologies not only improves the efficiency of sludge treatment, but also realizes the recycling of resources, making a positive contribution to environmental protection and energy conservation.

The company's technical practice shows that biomass gasification technology can effectively convert waste into valuable energy products, a process not only reduces environmental pollution, but also improves the efficiency of energy utilization. In addition, the company's technological progress in gas purification and automation control has further improved the stability and economy of biomass gasification technology, and laid a solid foundation for the commercial application of the technology.

Looking into the future, the application prospect of biomass gasification technology in the field of energy and environmental protection is very broad. With the continuous maturity of the technology and the gradual expansion of the market, it is expected that the biomass gasification technology is expected to play a more important role in the future energy market. The successful experience of Shanghai Diyan Environmental Protection Technology Co., Ltd. has provided a valuable reference for enterprises in the same industry, and also provided a new idea and direction for the efficient utilization and sustainable development of biomass energy. With the growing global demand for clean energy and environmental protection, biomass gasification technology is expected to be more widely used and develop faster.

## References

[1] Yan Beibei; Li Min; Zhou Weihong, et al. Promotion and application of efficient gasification of biomass energy. Tianjin Daming Hengyun Renewable Energy Utilization Technology Co., Ltd.; Tianjin University; Tianjiao Special New Materials (Group) Co., Ltd.; Liaoning University of Science and Technology; Henan University of Science and Technology.2014-04-28.

[2] Zhang Baowen; historical friend. Biomass energy conversion power generation technology and application of —— biomass power generation technology and equipment [J]. Agriculture and technology.2011.

[3] Research and comprehensive application of biomass gasification technology. Shandong province, Shandong University.2009-01-01.

[4] Liu Baoliang; Jiang Jianchun. Biomass energy conversion technology and application(VI) —— biomass power generation technology and equipment [J]. Biomass chemical engineering.2008,(02):55-60.

[5] Zhou Jianbin. Research and application of biomass energy polygeneration technology [J].2014 China (International) Biomass Energy and Biomass Utilization Summit Forum (BBS2014) sub-forum 1: Solid Biofuel and biomass power generation proceedings.2014.

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