ENERGY ENGINEERING AND CONTROL SYSTEMS

Volume 4, Number 1, 2018

Alternative Energy Source for Heating System of Woodworking Enterprise

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Received: March 12, 2018. Revised: May 03, 2018. Accepted: May 14, 2018.

Abstract

At woodworking enterprises, there is a large amount of wood waste the energy potential of which can be used as an alternative source of energy for the generation of heat energy at boiler houses. Gasification is one of the cheapest and environmentally friendly methods for processing organic wood waste and obtaining an additional source of energy. The process of gasification occurs when wood waste is heated to high temperatures in the presence of oxygen, which results in the generation of combustible gas. Producer gas should be used to save traditional energy sources in the generation of heat energy. This article discusses the design of the gasifier which is intended for utilization of wood waste from a wood-processing enterprise and the simultaneous generation of producer gas. Generted producer gas is used in a boiler-house of a wood-processing enterprise as an alternative source of energy for the preparation of the heating system coolant. The lower heat of generated producer gas combustion is established.

Keywords: waste wood; gasifier; producer gas; heat of combustion.

1. Introduction

As is known, a source of heat is a combination of equipment and instruments which transforms traditional or alternative types of energy into heat energy with the parameters required by consumers. Natural gas, fuel oil, and coal are the types of traditional fuels. They are used in combined heat and power (CHP) systems, which simultaneously produce electric energy and heat, and in boiler-houses. For industrial enterprises with a thermal load up to 500 MW, it is expedient to use boiler-houses. Depending on the nature of the heat load, boiler plants can be classified into heating, production-heating, industrial ones. Depending on the coolant used in heating, ventilation, hot water systems and, if necessary, technological needs, there are water heating boiler houses, vapor boiler houses and combined boiler houses. The equipment in which the coolant is prepared with the required parameters is referred to as boiler unit. Alternative energy types include secondary energy resources which are formed as a byproduct in industrial enterprises. These include: physical heat, excess pressure of waste and products, as well as combustible waste, the potential of which is not used in technological cycles. The secondary energy resources of woodworking enterprises that are expedient to use for the generation of thermal energy include waste wood [1] [2].

At present, the three main areas of wood waste recycling into heat energy have been the most developed: direct combustion, pyrolysis and gasification [3]. In the case of direct combustion, wood waste is burned in a variety of machines, the main drawback of which is the formation of ash, which increases the wear of pipes of the gas path of boiler units and pollutes the environment. When recycling waste wood by pyrolysis, wood charcoal and gas-vapor mixture, which after the condensation system is divided into liquid (bio-oil) and non-carbonated gases, is obtained. In addition, non-condensated gases of the pyrolysis process are used exclusively as additional fuel for drying and

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This paper should be cited as: O. Savchenko, V. Zhelykh, Y. Yurkevych, K. Kozak, S. Bahmet. Alternative energy source for heating system of woodworking enterprise. Energy Eng. Control Syst., 2018, Vol. 4, No. 1, pp. 27 – 30. https://doi.org/10.23939/jeecs2018.01.027

pyrolysis of wood. Gasification of wood waste is considered one of the cheapest and environmentally friendly ways to produce combustible gas. When wood waste is heated to high temperatures in the presence of air, combustible gas formed. It consists of carbon monoxide 20-23% vol., hydrogen - 3-7% vol., methane - 4-8% vol., carbon dioxide - 10-16% vol. and nitrogen - 54-60% vol. Producer gas has advantages over direct combustion of wood: it can be transmitted over long distances through pipelines and in cisterns; it is convenient to use for the needs of heating and hot water supply systems, as well as in technological and power plants; the process of gas combustion is easy to automate; combustion products are less toxic than products of direct wood combustion. In addition, the wood waste is recycled in the process of gasification, which allows improving the ecological and sanitary state of the territory of the woodworking enterprises.

Thus, the development of alternative energy source on the basis of integrated energy-technological processing of wood waste that would allow obtaining combustible gas for the needs of heating systems of woodworking enterprises and recycling wood waste is currently relevant.

2. Aim of the research

The aim of the work is to develop an alternative source of energy for the needs of heating systems of woodworking enterprises, which allows for the production of combustible gas and the recycling of wood waste, and the determination of the composition of the producer gas and its heat of combustion.

3. Analysis of recent research and publication

Gasification is carried out in vertical shafts which are referred to as gasifiers. Gasifiers differ by many indicators [4]. Thus, the gasifiers depending on their intended use are stationary and transportation ones, depending on the pressure - high or atmospheric pressure ones, depending on the produced gases – gasifiers for receiving air gas, water gas and mixed gas, depending on the characteristics of the biomass layer - a dense layer, a weighed layer and "Boiling" layer ones, depending on the degree of mechanization - mechanized, semi-mechanized and non-mechanized ones. Depending on the direction of the gas flow in the active zone, the gasifiers are can be direct process, reverse process and horizontal process ones [5].

In the gasifiers of the direct process, the air enters the active zone through the air pipe at the bottom of the producer gas and the grate, and the gas is taken from above. The main processes of gasification occur in the gasification chamber. The wood wastes are loaded through hopper, which has a loading cylinder and a loading hatch at the top. Gasifiers of the direct process have a simple design, but the producer gas has a large amount of harmful impurities, in particular resins and acids. Only non-resin varieties of fuel are used as raw materials for gasifiers of the direct process, for example, charcoal.

In the gasifiers of the return process, air enters from the top of the active zone, for example through the tuyere. Therefore, the combustion zone is located above the recovery zone. Above the combustion zone there is a dry distillation zone and drying zone. Gas formation in separate zones is similar to that described for gasifiers of the direct process, but dry distillation and drying products, without having an exit from above, pass through the active zone. In this case, organic acids and resins decompose under the influence of high temperature giving flammable gases, or burn. Gasifiers of the return process do not require water additive since the steam enters the active zone directly from the hopper. Gasifiers of the return process can burn resinous fuels.

The gasifiers of the horizontal process have a nozzle that blows the flow into the thickness of the active zone, and the gas sampling is carried out through the grate on the opposite side. These gasifiers are characterized by a rather compact active zone, which operates at an elevated thermal regime. Only non-resin varieties of fuel such as charcoal can be used as fuel. Such gasifiers are simple, easy to use and ensure fast start up.

In addition to the design of the gasifier, the gasification process is influenced by many factors: fractional composition and humidity of wood; amount and speed of air supplied to the gasifier; height of the active layer. [6],[7]

In order to produce combustible gas from organic wastes through their gasification, gas-generating units are developed, which, in addition to the gasifier, include units for cleaning and cooling the resulting gas, devices for fuel combustion, waste supply to the gasifier, etc. At present, small-scale (domestic) gas-generating units for private and farm enterprises and industrial gas-generating units are being developed. They differ by the amount of waste wood that can be disposed of and, accordingly, the amount of producer gas that is generated during the gasification process.

4. Main material

The woodworking enterprise in Zaporizhzhia produces wood furniture made from oak, willow, birch. In the process of production, the wood undergoes the following stages of processing: sawing, planing, chopping, drilling, milling and grinding. They are accompanied by the formation of wood waste such as shavings, sawdust, dust. Waste accumulation is carried out in special bunkers which are located on the territory of the enterprise. To dispose of waste at a woodworking enterprise, a design of a gas-generator unit was developed which scheme is depicted in Fig.1.

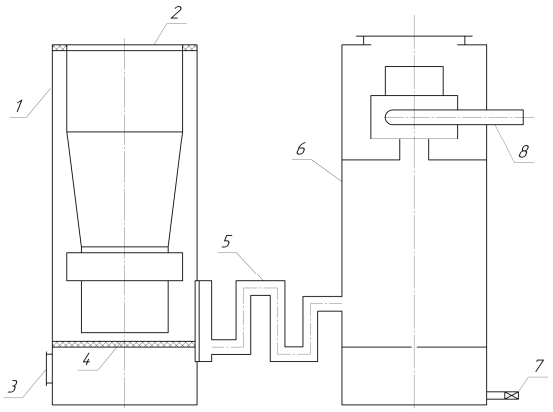

Fig.1. Scheme of a gas-generator unit for the recycling of wood wastes:
1 – gasifier, 2 – loading hatch, 3 – door of ashpit, 4 – grate, 5 – gas pipeline, 6 – cooler, 7 – pipe with the tap, 8 – gas pipeline.

The gas-generator unit consists of two vertical columns made of steel 5 mm thick and has overall dimensions of 1250x500 mm. The vertical columns are connected by a gas pipeline. One column is the gasifier of the horizontal process, the second column is the cooler of producer gas. The gas-generator unit works as follows. Through the loading hatch 2 in the gas-generator 1, waste wood is fed. After loading, the sunroof 2 is closing. Waste wood in the gasifier are burned through the ashpit and grate 4. The air for the gasification process is flowing through the door of ashpit 3. In the process of gasification, the producer gas is formatted in the gasifier. After that gas through gas pipeline 5 enters the cooler 6. The cooler works like a sediment chamber where the producer gas is cooled and drained. The condensate formed during the dehumidification of the producer gas is collected at the bottom of the dehumidifier and, if necessary, removed through the pipe with the tap 7. The cooled and drained gas through the gas pipeline 8 enters the boiler burner as an alternative energy source for the woodworking enterprise. Ash, which is formed during the gasification process through the grate 3, gets into ashpit and is removed through the door of ashpit 3.

The composition of the producer gas was determined using the chromatograph 6890 N of company Agilent. Results of the analysis of the gas composition are presented in Table 1.

Table 1. Component composition of producer gas from waste wood.

Component	H_2	N_2	CO	CO_2	CH_4	C_2H_6	C_3H_8	i-C_4H_{10}	n-C_4H_{10}
Component share, % vol	21.60	46.24	16.62	13.93	0.93	0.31	0.21	0.04	0.12

The main indicator of combustible gas is its lower calorific value, which is determined by the formula:

$$Q = 0.01 \cdot \sum_{i=1}^{n} Q \cdot y_i, \quad (1)$$

where Q is lower heat of combustion of the i-th component of combustible gas, MJ/m^3 [8]; y_i is volume fraction of the i-th component of combustible gas, %.

For the available values of lower combustion heat of producer gas individual components and their volumetric particles in the combustible mixture (Table 1), the lower heat of combustion of the producer gas, which is formed during gasification of wood waste at a woodworking enterprise, was determined. The lower heat of combustion is 5.358 MJ/m^3. For comparison, Table 2 shows the values of heat of combustion of different types of fuel.

Table 2. Lower heat of combustion of certain types of fuel.

Fuel	The old brown coal	The young brown coal	Oak wood	The green wood	Biogas	Hay	Charcoal	Natural gas	Gas from sewage
The lower heat of combustion, MJ/m^3	18.6	8.4	19.90	6.3	24.1	14.7	30.2	36.63	20.93

As can be seen from Table 2, the heat of combustion of producer gas made from wood waste is lower than the heat of combustion of various types of fuel, but it can be used for the needs of the woodworking enterprise as an alternative source of energy for the preparation of a coolant in boiler-houses.

5. Conclusion

The proposed design of a gas-generating unit allows for the utilization of wood waste of woodworking enterprises and makes an alternative source of energy for the heating system. Although the lower heat of combustion of producer gas is low compared to other known types of fuel, it is advisable to use it to save traditional fuels. In the future, it is advisable to propose the design of a gasifier, which, due to the introduction of additional equipment, would increase the quantity of the producer gas and its heat of combustion.

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Альтернативне джерело енергії для системи опалення деревообробного підприємства

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Анотація

На деревообробних підприємствах наявна велика кількість відходів деревини, енергетичний потенціал яких можна використовувати як альтернативне джерело енергії для вироблення теплової енергії на котельнях. Одним з найдешевших та екологічно безпечних способів переробки органічних відходів деревини вважається газифікація. В процесі газифікації утворюється горючий газ, який доцільно використовувати для заощадження традиційних джерел енергії при виробленні теплової енергії. У даній статті розглянуто конструкцію газогенераторної установки, яка призначена для утилізації відходів деревини та одночасного вироблення генераторного газу. Утворений генераторний газ використовується в опалювальній котельні деревообробного підприємства в якості альтернативного джерела енергії для приготування теплоносія системи опалення. Встановлено нижчу теплоту спалювання виробленого генераторного газу.

Ключові слова: відходи деревини; газогенератор; генераторний газ; теплота спалювання.