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# BRIEF REVIEW OF GASIFICATION BIOMASS TECHNOLOGIES, THEIR APPLICATION AND POTENTIAL RISK REGARDING THE SAFETY AND ENVIRONMENT

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# КРАТЪК ПРЕГЛЕД НА ТЕХНОЛОГИИТЕ ЗА ГАЗИФИКАЦИЯ НА БИОМАСА, ТЯХНОТО ПРИЛОЖЕНИЕ И ПОТЕНЦИАЛЕН РИСК ПО ОТНОШЕНИЕ НА СИГУРНОСТТА И ОКОЛНАТА СРЕДА

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**Abstract:** Biomass gasification as technology for energy production has recently significant development and perspectives for further increasingly application. A number of institutes in the EU work towards establishing a unified approach to the risk assessment of technology for gasification of biomass. The report takes a variant of how this approach can be applied to research of concrete installations. Covers all possible aspects and serves as an addition to the existing information. The report presents initial results up by research into installations for the gasification of biomass, which are intended to show their position on the safety and impact on the environment. They are a basis for future research focused on the formation of recommendations and proposals on specific aspects of the operation of these facilities.

**Keywords:** gasification, biomass, risk assessment, safety, environment

## INTRODUCTION

Process for gasification of biomass has some advantages in comparison with other technologies to generate energy from renewable energy sources, which are expressed in the environmental integrity and the ability to relatively easily construction of installations. In particular gasification of biomass has significant advantages in comparison with direct combustion, which are expressed primary of smaller quantities of gas subject to treatment, the easier control of the combustion process and lower emissions in the environment. All this confirms the relevance and importance of the process of gasification of biomass and therefore in this report is an overview of these technologies and shows some good examples in accordance with global best practices.

Receipt of biogas through the decomposition of organic substances is widespread in nature process. The use of biogas as an energy source began in the middle of last century, but the technology for gasification of biomass still being developed. Because each one installation has specific technological and individual characteristics, the main task of the report is to show some technological, operational, organizational, etc. risk factors concerning the safety and the environment [1].

## TYPES OF TECHNOLOGIES

Gasification of biomass, through modern technology can be used to produce electricity, heat and gas [2]. Have been developed various methods for gasification of biomass. According to the type the application of biomass and oxidant in the reactor, the method of heating, the reactors the gasifiers can be grouped into four main groups:

1) Gasifies with one-way downward movement of biomass and oxidant (fixed-bed downdraft) is shown in Fig.1. For them, the direction of feed at the top of the reactor biomass and oxidation, fed into the combustion zone is downward to the bottom of the reactor. A peculiarity in the construction of this type of gasifiers is the presence of a narrow zone (throat) inside them, which is located in the grid which is superimposed on the incoming biomass.

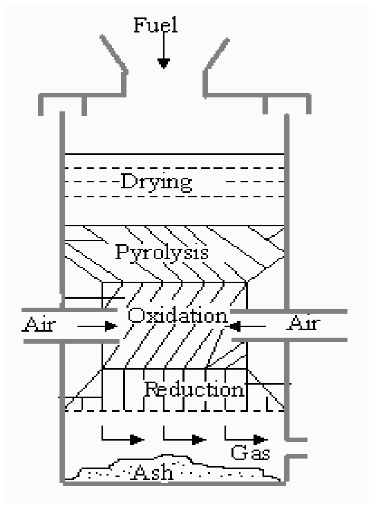


Fig.1. Fixed-bed downdraft gasifier.

Using similar structure gasifiers appears simple, reliable and tested method for gasification of biomass with a relatively dry humidity no higher than 20-30% and ash content less than 3-5%. The disadvantages of this technology may indicate the need for pre-drying of biomass, the limitations associated with the particle size of biomass (up to 30 cm) and high temperature resulting from the gasifier gas.

2) Gasifier with the opposite movement of the two streams - biomass is shown in Fig.2. The Gasifier is fed from the top and oxidizer moves in the opposite direction (fixed-bed updraft). They have the opposite movement of biomass and oxidant. Biomass is fed into the top of the gasifier and oxidizer enters through a great located in the lower part, where it became the area of combustion. Feeds oxidizer passes through the combustion zone and towards the top of the reactor. In the combustion zone is carried out complete combustion of biomass, in which release carbon dioxide and water.

These gases have a temperature around 1000 º C. Passing through the next area of reduction they decompose to hydrogen and carbon monoxide and cooled to 750 º C. In its upward movement to the top of the reactor, these gases help in the process of dry biomass pyrolysis, are then used for drying of the incoming biomass in the reactor, which makes the outgoing gas gasifier temperature is 500 º C.

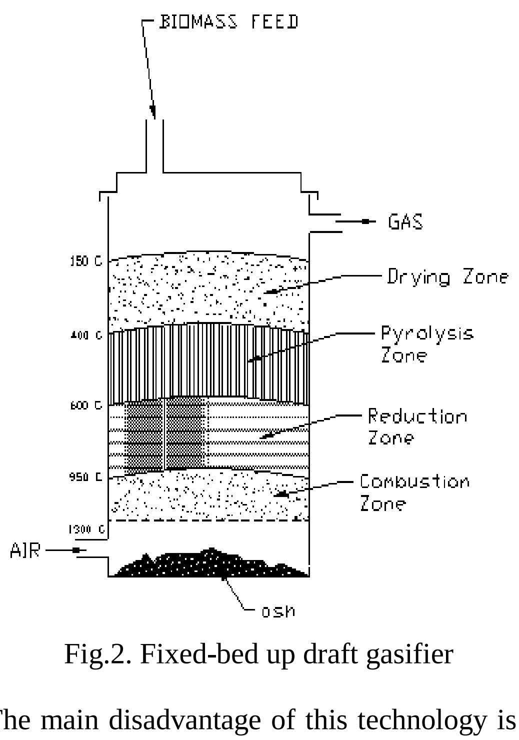


Fig.2. Fixed-bed up draft gasifier

The main disadvantage of this technology is that the resulting gas has a high content of tar. This requires for its use as a fuel for heating or for submission to engines, turbines and other applications, it can be subjected to preliminary purification or use in close proximity to the gasifier.

The advantages of this gasifier appear simple in construction and high thermal efficiency - a significant part of the heat of the produced gas is consumed for heat exchange with incoming biomass thus dry heat and the process of pyrolysis of biomass takes place before it gets into gas system area. This enables the use of biomass with high humidity to about 50% that does not negatively affect the sustainable operation of the gasifier. There is also no strict requirements regarding the composition of the biomass in terms of size of individual particles.

3) Fluidized bed gasifiers (bubbling fluidized bed) is shown in Fig.3. They allow achieving high efficiency thanks to the almost complete combustion of fuel with lower emissions of combustion residues. Typical of the gasifier fluidized high speed flow of heat and mass transfer processes, and better mixing of the solid phase, which provides high speed response and a layer with nearly constant temperature. The use of fluidized bed gasifiers, using biomass, with a relatively small size of individual particles. This requirement often requires preliminary digestion of biomass. The creation of a fluidized bed is through the air or other gas through a layer of inert material.

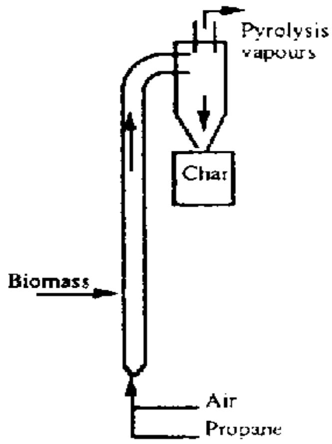


Fig.3. Bubbling fluidized bed gasifier

Often used in gasifiers is inert sand its quantity exceeds the quantity of fuel which provides stable and highly efficient combustion process. To reduce the tar content in the fluidized bed can be added catalyst. Temperature in the gasifier is 800-850 º C. The degree of utilization of carbon reaches 100% in the absence of excessive removal of particulate matter that can result from a top supply of biomass.

4) Gasifiers with circulating fluidized bed (circulating fluidized bed) is shown in Fig.4. They are recommended for installations with relatively large capacities. Typical of these is the higher rate of purge of inert particle layer in comparison with the fluidized gasifier, therefore they are removed from the layers together with the products of combustion. To capture them using cyclones and they returned to the fluidized bed.

Resulting from these gasifiers gas is suitable to be used mainly in boilers and thermal power plants. Gasifier operating at very high temperature, 1200 - 1500 º C, which is determined depending on the type of oxidant air or oxygen.

Technologies for utilization of biomass by gasification continue to develop and impose. People working in this field seek solutions associated with many difficulties, such as dirt, wear, failures for various reasons, the impact of operator actions on specific processes and others.

## RISK IN THE GASIFICATION OF BIOMASS

The main factors for the safety of personnel during gasification of biomass and electricity, which affect the risk to health, safety personnel and the environment come from the working processes and working equipment in the plant for gasification of biomass [3].

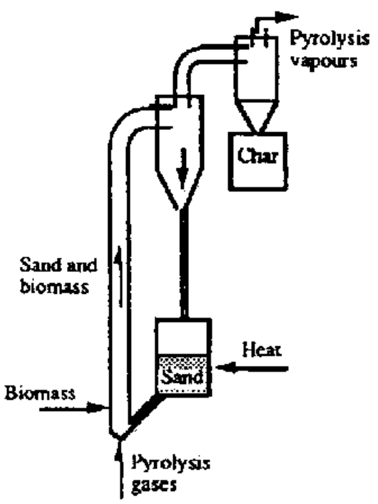


Fig. 4. Circulating fluidized bed gasifier

Factors determining the risk in work processes are:

- random-operation - inclusion, exclusion;
- non-allowable gas pressure;
- operating error;
- unregulated power increase;
- temperature has exceeded acceptable levels;
- emissions and residues, and a high level of noise in rooms accessible to people;
- state of malfunction;
- fault system automation;
- improper operation, technical and others.

Factors of risk in consequence of work equipment are:

- failure in automation in blocking mechanism of control - measuring instrument in mechanical load;
- hot surfaces, mechanical damage, leakage of steam;
- damage to the gas circuit and the reactor;
- fire, damage to the burner and more.

Factors determining a risk to the environment in biomass gasification and electricity production are:

- leakage of fluid (may contain: fats, alkali, glycerin and sludges), washed leak agents,
- emissions in the ambient air as fine particulate matter, SOx, NOx, CO and total organic carbon (TOC);
- incomplete combustion, and all damages and accidents in the individual process units of biogas plants, leading to environmental pollution [4].

Factors determining the risk for each technology are strictly defined. In one type of technology a chance to get damage and pollution is very high (wear parts or system performance under pressure), while for others these same factors can hardly affect the risk assessment. This should take into account any system of biomass gasifier and to determine the risk it is damaged and affects the environment and human health.

## METHODS FOR RISK ASSESSMENT

In the process of risk management is made qualitative and quantitative risk assessment. For qualitative assessment, risk is seen as an event or group of related events causing losses (damage) of the object. For quantification, risk is viewed as a likely event, or frequency of occurrence of the event with sufficient statistics.

The risk assessment using various methods which are divided into two main groups - statistical methods and expert methods.

Statistical methods are accurate and are used for forecasting and risk management in complex and responsible entities. Disadvantages are that they are complex and need a large amount of statistical information. They require the use of mathematical methods.

Expert methods are easy to use, accurate enough and do not require statistical information. Disadvantages of them are that they can be used for complex objects and responsible and can not be used to predict hazards. In installations for the gasification of biomass and energy production using expert methods that are qualitative methods.

One of them is the method of rick analysis and performance. Through it, after a risk assessment should identify hazards, and is to assess the significance of risk. This was tested by the three components of risk - probability, exposure and severity of injury.

Adopted a numerical expression for defining the risk (P) as a benchmark consisting of the product of - probability (B), exposure (E) and consequences (P).

(1) $$P=B*E*P$$

The likelihood of injury is assessed by: frequency, duration and specifics of exposure, the likelihood of an event, the technical options for limiting or avoiding damage; human possibilities to avoid or reduce injury (qualification, experience, practical experience and skills, etc..) values of the parameters of the environment [5].

In considering the likelihood must comply with regulations and limit values (LV). When assessing hazards associated with LV always take into consideration the fact that they are normal, healthy workers (mostly male) in the active age of 30-40 years LV. These are not bad for about 80% of employees.

## CONCLUSION

The risk assessment of the technologies for gasification of biomass is priority of the European Union efforts to create an unified approach. The report shown the opportunity for application of this approach to studies of specific installations.

The review of different installations for the gasification, their advantages and disadvantages, and also the analysis of the main factors influencing the safety and environmental impact are good basis for future research, and definition of recommendations and proposals on specific aspects of the operation of the installations for gasification of biomass.

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