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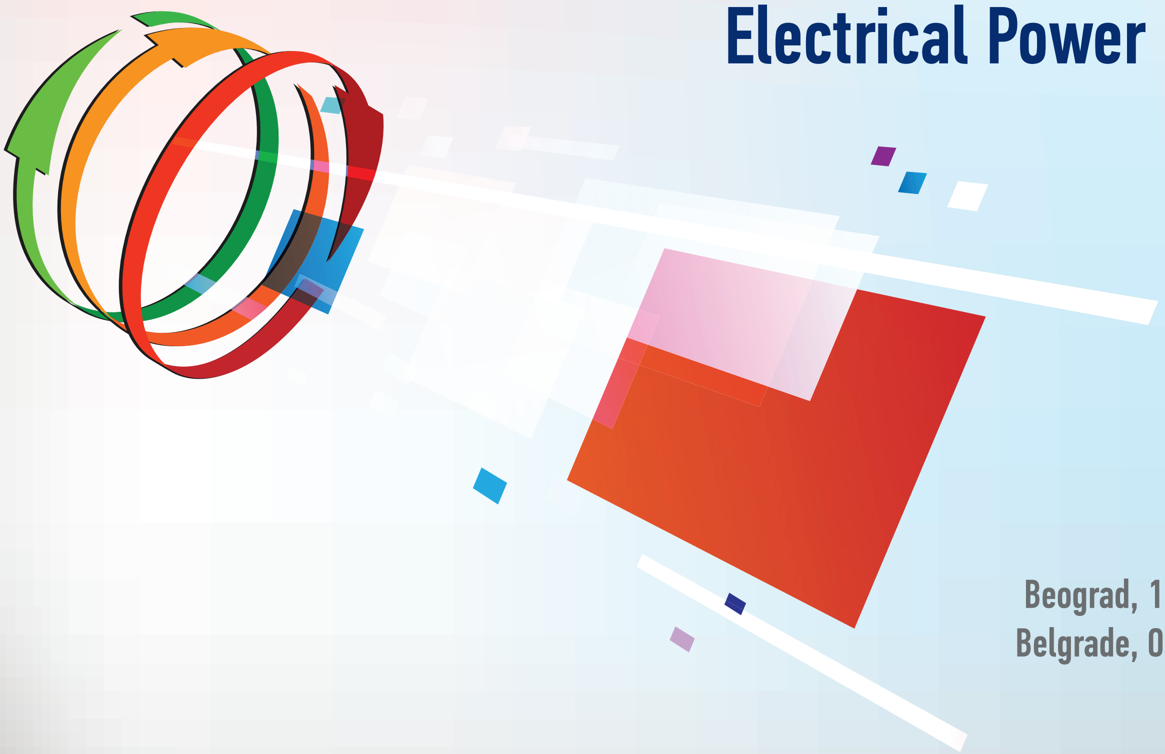

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Ubrzani napredak nauke, tehnologije i industrije dovodi do poboljšanja kvaliteta ljudskog života, ali i do stvaranja novih rizičnih situacija. Čovečanstvo je suočeno sa rizicima kakvih u ranijoj ljudskoj istoriji nije bilo. Globalno zagrevanje je tipičan primer. Jedan od glavnih problema vezanih za nove rizične situacije jeste – pitanje odgovornosti. Vlade država u svetu ne smeju teret odgovornosti prepustiti isključivo naučnicima i ekspertima, ali takođe ne smeju same odlučivati i preuzimati (ne)odgovornost. Trebalo bi da se konsultuju sa ekspertima i da dobro procene kada i kakve mere treba preduzimati. Potrebna je jaka politička inicijativa da bi se počeli rešavati ozbiljni ekološki problemi kao što je globalno zagrevanje, ali i lokalno zagađenje životne sredine. Politički dogovori na svetskom nivou koji su do sada postignuti u okviru Kjoto protokola, nedovoljni su za zaustavljanje ovog fenomena. Čiste tehnologije - tehnologije koje su dizajnirane da obezbeđuju superiorne performanse za nižu cenu dok istovremeno kreiraju manji gubitak energije od konvencionalnih ponuda - imaju velike šanse da budu motorna snaga koja će obezbediti ekonomski rast.

Nauka, naravno, pre svih uočava probleme opstanka planete i života na njoj. Ona takođe pokušava da ih reši i uspeva onoliko koliko je to realno moguće, imajući u vidu političke, socijalne, ekonomske i tehnološke faktore. Može se konstatovati da su praktično svi prioriteti posvećeni očuvanju života na Zemlji. Nauka i razvoj tehnike i tehnologije mogu tome doprineti u više segmenata:

- *obnovljivi izvori energije;*
- *energetska efikasnost;*
- *smanjenje količine otpada;*
- *smanjenje štetnosti otpada;*
- *reciklaža;*
- *prečišćavanje zemlje, vode i vazduha;*
- *neutralizacija preostalog otpada.*

Bitan faktor za donošenje političkih odluka je i javno mnjenje. Zato je jako važno podizanje opšte svesti i što šira edukacija stanovništva o nephodnosti prelaska na obnovljive, ekološki prihvatljive izvore energije, što je jedan od dugoročnih ciljeva ove Konferencije.

Ovaj međunarodni skup po deveti put organizuje Društvo za obnovljive izvore električne energije (DOIEE) Saveza mašinskih i elektrotehničkih inženjera i tehničara Srbije (SMEITS), uz suorganizaciju Instituta za arhitekturu i urbanizam Srbije (IAUS).

U Beogradu, oktobra 2021.

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Typically, in such systems do use microprocessors with limited computing resources. This circumstance departs from their use peculiarities. In fact, calculating equation (5) is difficult and requires a more advanced microprocessor. However, the obtained ratios are not easy to calculate, due to a large number of simple calculations.

When building and switching an analog processing path on the same type of components (chips), it is necessary to work out the structure options depending on the noise-signal situation. In this case, we can calculate equations (1), (3) and (5) on limited values and store them into memory for operational adjustment. This option of preliminary calculation is most acceptable.

In conclusion, it should also be noted that equations (1) and (3) show that when a cascade connection, the frequency response steepness increase rate is higher for the Butterworth filter.

Thus, in case of cascade connection, it is advisable to use second-order analog filters, which provide a good increase in the amplitude-frequency response decline steepness and the cutoff frequency predicted value.

GASIFIKACIJA OSTATAKA BIOMASE
ZA PROIZVODNJU ELEKTRIČNE ENERGIJE

GASIFICATION OF BIOMASS WASTES AND RESIDUES FOR ELECTRICITY PRODUCTION

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Tehnologija gasifikacije predstavlja jednu od obećavajućih opcija za pretvaranje energije biomase u električnu energiju. Proces gasifikacije konvertuje ugljovodonične materijale u ugljen-monoksid, vodonik, ugljen-dioksid i gasovite ugljovodonike (proizvodni gas). Proizvedeni gas se može koristiti u motorima sa unutrašnjim sagorevanjem, i time za proizodnju elelektrične i toplotne energije. U ovom radu analizirana je podobnost koršćenja kukuruznog oklaska, stabljike kukuruza i drvne sečke za za proizvodnju električne i toplotne energije. Postrojenje se sastoji od istosmernog gasifikatra i gasnog motora. Rezultati modeliranja pokazuju da se za 1000 kg suve biomase može proizvesti: 1566 kWe i 1016 kWth (za drvnu sečku HHV=19.70 MJ/kg); 11142 kWe i 977.8 kWth (za kukuruzni oklasak HHV=19.25 MJ/kg); 1399 kWe ai 960.4 kWth (za stabljike kukuruza HHV=17.31 MJ/kg). Rezultati pokazuju veliki potencijal trenutno neiskorištenog poljoprivrednog otpada, posebno kukuruznog klaska.

Ključne reči:*biomasa, gasifikacija, električna i toplotna energija*

Gasification technology presents one of the promising options for converting biomass energy into electricity. Gasification process converts carbonaceous materials into carbon-monoxide, hydrogen, carbon-dioxide, and gaseous hydrocarbons (producer gas). Producer gas can be supplied as fuel to the internal combustion engines and power generators. In order to maximize the efficiency of biomass conversion, producer gas should be utilized not only for power generation but also for thermal production from the producer gas sensible heat. In this paper, one of common types of agricultural residues, in Serbia, corn cob and corn stalks, were compared with wood chips and analysed in order to evaluate their possible utilisation for electric and thermal energy production. Plant consists of downdraft gasification unit coupled with gas engine. Modelling results show that for 1000kg of dry biomass can be produced: 1566 kWe and 1016 kWth (for wood chips material with HHV=19.70 MJ/kg); 11142 kWe and977.8 kWth (for corn cob HHV=19.25 MJ/kg); 1399 kWe and 960.4 kWth (for corn stalks with HHV=17.31 MJ/kg).

Key words: *biomass; gasification; electric and thermal energy*

1 Introduction

Biomass residues represents an important source of alternative energy and provides an opportunity to decrease environmental problems such as pollution and depletion of natural resources [1]. It is widely available and regenerates in a relatively short time. The utilisation of biomass as an energy resource allows us to increase the share of renewable energy sources. The potential of biomass as a renewable energy resource in Serbia is high. It is estimated that every year in Serbia around 3,118.89 kilo tonnes of agricultural waste, and around 4.08 million of m^3 of wood residues, available for energy use is produced [2]. The most frequently applied thermochemical technologies for converting biomass into energy, fuels or chemicals are combustion, pyrolysis, gasification, and high-pressure liquefaction [3]. Due to the low energy density and high moisture and contamination content, waste biomass usually requires additional treatment, such as thermochemical conversion, to improve its energy properties to meet the requirements for direct combustion [3]. In pyrolysis and gasification technologies,

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lower-quality fuel is acceptable [2, 3] and gasification is one means of releasing the stored energy within biomass through transformation into other useful products (fuels, chemicals, electricity and heat).

A gasification process is a partial thermal oxidation, which results in mainly gaseous products (carbon dioxide, hydrogen, carbon monoxide, water vapour, methane and other gaseous hydrocarbons), and small quantities of charcoal, ash, and condensable compounds-tars [4]. The quality of produced gas from gasification, called producer gas, vary as a function of gasifying medium (air, oxygen, steam, carbon dioxide or a mixture of these) and the operating conditions. Installation of small, low-cost and efficient gasifier-engine systems can be an attractive alternative to direct combustion, considering achievable electric efficiency and costs related to storage and transport of biomass fuels [4]. The producer gas, after cleaning and conditioning, can be used as a fuel in gas engines and turbines owing to its acceptable thermochemical combustion properties (flame speed and knock tendency) [5]. Gasification is also considered as a cleaner and more efficient technology than combustion, since it gives lower NO_X and SO_X emissions, and possibilities for CO_2 capture [4].

Regarding the high potential of biomass residues in Serbia and the positive characteristics of gasification process, present study, shows potentials for utilisation of biomass residues (such as corn cob and wood chips) for electric and thermal energy production. For this purpose mathematical modelling of the small-scale biomass gasification system for combined heat and power production were done. For model development and process simulation the Aspen Plus software was used.

2 Model formulation

The pathway for electricity and heat generation consists of biomass downdraft gasifier and internal gas engine. The main components of "the downdraft – internal combustion engine system" include: the gasifier, producer gas heat exchanger, producer gas cleaning section, internal gas engine and heat recovery unit, Fig.1.. The cycle involves air gasification of biomass residues in a fixed bed downdraft gasifier and the producer gas obtained is then led to a gas cleaning section in order to remove impurities such as dust and uncracked tar. After cleaning, the gas is fed into the heat exchanger and thereafter gas is fed into the engine to generate electricity. The exhaust gases from the internal gas engine are led to a heat recovery where drops it temperature. Process heat or district heating or hot water heat exchange can be installed to further extract energy from the exhaust gases.

Plant capacity at which this technology is used ranges from 1kWel – 10MWel [5, 6]. The efficiency is seen to be averagely 30% for 100 kWel size, 35-45% for more than 1 MWel [7]. Also, internal combustion engines are high flexibility, long lifecycle, reliability, low cost, etc. However it should keep in mind that internal gas engines requires emission control systems because its operation produces high quality of NOx and CO pollutants [6]. In developing countries, internal combustion engine technology is used for generating electricity for small industries, residential buildings and etc.

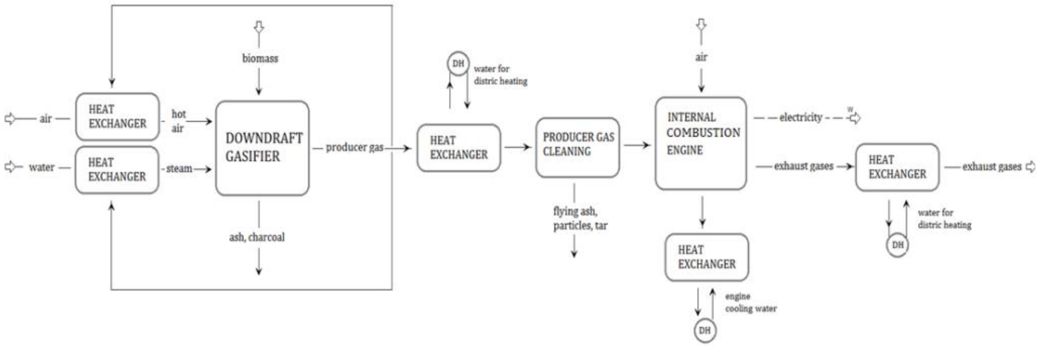

Figure 1 The gasification internal combustion engine simulation flowsheet

2.1 Downdraft gasification model description

The pure thermodynamic equilibrium model, described elsewhere (e.g. Zainal et al. [8] and Melgar et al. [9]), has been modified to increase the results' accuracy. The gasification model consists of a series of sub-processes, each containing one process (biomass drying, pyrolysis, gasification, air preheating, and steam generation), see Fig. 2.

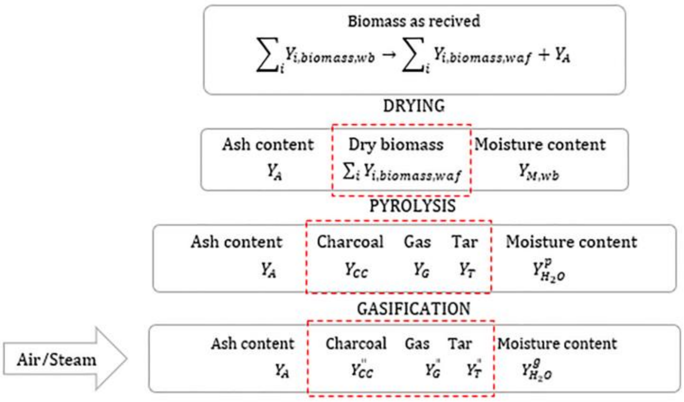

Figure 2 Overall mass balance for the biomass gasification process

The following implementations or assumptions were made:

1. Adding a drying unit, that predicts the removal of moisture from raw biomass. The percentage of removed moisture can alternatively be set by the user.
2. Adding a pyrolysis unit that, using empirical correlations, predicts the formation of pyrolysis products (charcoal and volatiles, including tar).
3. The tar and charcoal were considered as products of the gasification process. The maximum tar content was limited to 6 g/Nm^3 (the concentration of tar, for downdraft gasifiers, ranges from 0.01 g/ Nm3 to 6 g/Nm^3).
4. Particles leaving the gasifier are set by the user as mg/Nm^3 in the producer gas. These particles are considered to consist only of carbon.
5. Biomass-bound nitrogen, is during the gasification process converted into diatomic nitrogen (N_2).
6. Gas products consists of CO_2, CO, H_2, CH_4, N_2, and H_2O.
7. Setting the amount of produced CH_4 = 2 vol% as an initial guess, needed for the iterative solution process.
8. No heat losses are considered from the gasifier, i.e. adiabatic condition.
9. The air for the gasification process is considered as dry air, containing only 21 vol% O2 and 79 vol% N_2 (the traces of water vapor, CO2, Ar, and various other components are not considered).
10. Biomass is assumed to enter the gasification process at 25 °C and 1 atm.

Regarding this, an empirical predictive model is developed to describe the general trends of product distribution as a function of temperature, which is based on balance of elements, energy balance and empirical relationships. The mass balance, energy balance, and mass and molar balances for each element (C, H, O, and N) are set and used to calculate the gasification products. Detailed mass, energy, mass and molar balances for each element considered in gasification process are presented in Trninić et al.[4]. An initial gasification temperature is assumed in the iterative solution procedure.

The “Engineering Equation Solver (EES)” has been found to be very suitable for modelling this kind of system, because it contains all of the necessary thermodynamic functions and it is possible for the model builder to make a user interface, which can make the model user friendly [4].

3 Results and discussion

Model operating parameters (biomass characteristics - proximate analyses and the elemental compositions of biomass), drying temperature, percentage of removed moisture, pyrolysis temperature, air inlet temperature, steam inlet temperature, gasification temperature and percentage of charcoal, tar and particles leaving the gasifier can be directly introduced by the user. The ultimate and proximate analysis of the biomass given in Table 1 were used in the model.

Table Ultimate and proximate analysis of feedstock (db)

	Corn cob [4]	Corn leaves [11]	Wood chips [10]
C	45.80	43.92	48.56
H	5.88	6.01	5.78
O	46.45	40.44	44.25
N	1.20	0.42	0.30
S	0.10	0.07	-
Ash	1.60	5.13	1.10
VM	80.30	75.63	-
fC	18.10	15.23	-
HHV (MJ/kg)	19.25	17.31	19.70

Predicted results from the present modified equilibrium model are presented in Table 2.

Table 2 Process parameters

Unit	*Value*		
Gasifier			
Gasification media	air		
Gasifier operating pressure	1 bar		
Air entering conditions	25°C, 1 bar		
Biomass input conditions	25°C, 1 bar		
Biomass feed rate	1000 kg/h		
air/feedstock ratio	0.3 kg/kg		
Gasification Zone	850°C		
Producer gas characteristics			
	Corn cob as a feedstock	Corn stalks as a feedstock	Wood chips as a feedstock
Gas flow, kg/h	2228	2823	2392
Gas composition, vol %, db			
CO	29.29	22.59	30.34
CO_2	8.28	9.99	7.168
CH_4	2	2	2
H_2	21.61	17.69	20.46
N_2	38.81	47.72	40.03
LHV, kJ/Nm^3	6474	5478	6.755
Cold gas efficiency, %	85.3	83.42	85.68
CHP with internal combustion engine			
Electrical output, kW	1142	1399	1566
Engine el. Efficiency, %	36.18	35.96	36.74
Heat, kW	977.8	960.4	1016

Modelling results show that for 1000kg of dry biomass can be produced: 1566 kWe and 1016 kWth (for wood chips material with HHV=19.70 MJ/kg); 1142 kWe and 977.8 kWth (for corn cob HHV=19.25 MJ/kg); 1399 kWe and 960.4 kWth (for corn stalks with HHV=17.31 MJ/kg).

Results show that all three kind of biomass residues, has potentials to produce considerable amount of electricity and heat. However, use of wood chips would give higher

4 Conclusion

From the preliminary analysis, the results show that the proposed CHP systems are feasible with self-sustaining heat generation and recovery to satisfy the process goals. The systems also demonstrates the potential of obtaining relatively high electrical efficiency. However,

Unfortunately CHP systems still characterises technical uncertainties namely operational difficulties, poor reliability and low overall efficiency which requires considerable technical advances prior to commercial viability. Therefore, there is a research need to overcome the existing technical obstacles, and to demonstrate energy-efficient biomass-fuelled CHP systems.

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MOGUĆNOST REMEDIJACIJE ISTORIJSKE DEPONIJE OTPADNE ŠLJAKE U FIRMI MG SERBIAN BALJEVAC

POSSIBILITY OF REMEDIATION THE HISTORICAL TAILING DUMP OF THE MG-SERBIAN BALJEVAC PLANT

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U cilju smanjenja uticaja na životnu sredinu deponije jalovine koja se nalazi u firmi Mg Serbian Baljevac, istraživana je mogućnost sanacije 700 000-800 000t istorijskog otpada. Otpad je nastao u periodu između 1979. i 2001. godine kao rezultat primarne proizvodnje magnezijuma u fabrici Mg Serbian Baljevac. Kako bi se eliminisao negativni uticaj koji ova deponija ima na životnu sredinu i smanjilo zagađenje vazduha i tla, izvršena je karakterizacija uzoraka sa različitih lokacija na deponiji. Različite biljne kulture su zasejane na stvarnim uzorcima, u laboratorijskim uslovima, i praćena je efikasnost sanacije.

Ključne reči: *remedijacija; deponija jalovine*

In order to reduce the environmental impact of the tailings dump located in the company Mg Serbian Baljevac, the possibility of remediation of 700,000-800,000 tons of historical waste was investigated. The waste was generated between 1979 and 2001 as a result of primary production of magnesium in the Mg Serbian Baljevac factory. In order to eliminate the negative impact that this landfill has on the environment and reduce air and soil pollution, the characterization of samples from different locations on the landfill was performed. Different plant cultures were sown on actual samples, in laboratory conditions, and the efficiency of remediation was monitored.

Key words: *monitoring remediation; tailings dump*

1 Introduction

Mining activities result in various environmental problems such as the air, soil and water pollution [1]. Tailing dump created by the deposit of waste, due to a high content of harmful components represent a wide range of problems to the environment. They do not have biological potential, so their remediation should be done in order to minimize their environmental impact [2,3]. The abandoned mines and tailing dumps have different physical, chemical and environmental conditions [4,5].

Tailing dumps usually are differing in their physical composition, content of the basic plant nutrients, especially nitrogen (N), phosphorus (P) and potassium (K). Some tailings may have high levels of heavy metals or other toxic materials. Taking plants with potentially toxic chemicals or heavy metals and incorporating them into the food chain are real problems [6,7].

Selection of plant species for remediation of the tailing dumps is based on several criteria: (1) chemical and physical properties of tailings, (2) geographic location and climatic characteristics, (3) elevation, (4) season of seeding, (5) compatibility with other vegetation, (6) topographic exposure, and (7) land use objectives. If the selected plant species are not compatible with one or more of the above criteria, then the remediation is likely to fail.

Biological measures include the application of agricultural and forest land remediation, which contribute to the stability and maintenance of the remediated areas, but are much more significant from the aspect of space revitalization and establishment the natural biocenoses. Horticultural species play a significant role in biological measures. The aim of the study was to plant easily accessible

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