WASTE CONVERTING INTO PRODUCTS

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The usage of the fossil must reduce because of a negative effect on the environment. Waste, such as municipal solid waste (MSW), which includes a lot of carbon hydrogen, is resource for chemical and energy productions. This applied study presents the methodology, which is reused the different MSW from unsorted to sorted, created by the mathematical model and the Aspen Plus® simulator for syngas synthesised into different products: methanol, ethanol, synthetic gasoline etc. The mathematical model based on the most real and something simulated parameters. MSW was gassed by using the gasification and the purified circulated flue gas from chimney can enter as raw materials into reforming for syngas production. After the reforming was synthesised the syngas, which is raw material for many products, such as methanol, ethanol and/or synthetic gasoline. During the processes are generated a lot of hydrogen, which can be cleaned and produced as co-product. An existing methanol process can be replaced natural gas with waste different for the methanol or ethanol or synthetic gasoline productions, which could reduce the garbage and CO_2 emission of $0.106 \cdot 10^6$ t/a and of $0.084 \cdot 10^6$ t/a.

Keywords:
waste,
syngas,
methanol,
ethanol,
synthetic gasoline

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1 Introduction

Non-renewable petroleum resources could be replaced with gasification of sustainable resources, such as waste, intermediate raw materials, bio-waste, for methanol, ethanol, gasoline or other product` productions, using different catalytic converters of Fischer-Tropsch (FT) synthesis, fixed-bed reactors, plasma etc.

Santos and Alencar (2020) upgraded the research of the syngas production from biomass gasification, which is converted into fuels through the Fischer-Tropsch synthesis. This study included many analyses of the catalysts, industrial process requirements, and chemical reaction kinetics and mechanisms of Fischer-Tropsch synthesis. Lignocellulosic material of biomass would be considered a low-cost raw material to the liquid biofuel production. Campanario and Ortiz (2017) presented the upgrade of the Fischer-Tropsch biofuels` production from syngas obtained by supercritical water reforming of the bio-oil aqueous phase. The highlights of this research contained the upgraded production of syngas by using water-gas-shift, dry reforming and Fischer-Tropsch (FT) reactors, and achieved the optimal conditions in the upgraded FT reactor. Gharibi et al. (2024) developed the study of the metaheuristic particle swarm optimization for enhancing energetic and exergetic performances of hydrogen energy production from plastic waste gasification. The improvements contained multi-objective particle swarm optimization for plastic gasification, using grey relational analysis, and achieving lower heating for the polypropylene gasification. Gharibi et al. (2024a) prepared a few novel research to predict polyethylene waste performance in gasification using multilayer perceptron (MLP) machine learning algorithms and interpreting them using multi-criteria decision-making methods, including MLP artificial neural networks and regression models for polyethylene gasification. Mojaver et al. (2018) researched the novel thermodynamic assessment of an integrated solid oxide fuel cell with a steam biomass gasification, including power production. The model of the system was performed using mass and energy conservation laws and equilibrium constants. Mojaver et al. (2019) developed the multi-objective optimization using response surface methodology and exergy analysis during integrated biomass gasification, including the electrical power and the exergy efficiency. Hasanzadeh and Azdast (2024) presented the novel machine learning utilisation on air gasification of polyethylene terephthalate waste, including the machine learning algorithms. Doniavi et al. (2024) defined the efficiency of polyethylene gasification. This study was based on the energy, exergy, and environmental impact in relation to the material conditions, including the generation the optimal parameters. Hasanzadeh and Abdalrahman (2023) presented the improvements of the processing parameters for polyvinyl chloride waste gasification, including the validated thermodynamic model and different regression models. Khalilarya et al. (2021) presented stud, which combined a heat and power system which consisted of a gasifier, a micro gas turbine, an organic Rankine cycle, a heat exchanger and domestic heat recovery, including the generated power system. Mojaver et al.(2019a) presented the study of a fluidised bed gasifier system with steam as the gasifying agent. The results indicated that the amounts of hydrogen and carbon dioxide were increased, and the amount of carbon monoxide was reduced. Hasanzadeh et al. (2021) developed the gasification model of polyethylene waste, by using the Gibbs free energy minimisation and Lagrange method of undetermined multipliers. Hydrogen production was increased significantly by 48% during steam raising. Mojaver et al. (2022) compared the performances between biomass and plastic waste gasification. The improvement of this study was the analytical hierarchy process/technique for order performance by similarity to the ideal solution coupled method that was employed in gasification of conventional biomass and plastic waste. Mojaver et al. (2021) researched the steam gasification system of polyethylene, polypropylene, polycarbonate and polyethylene terephthalate waste, including the effect of plastic waste ratio, temperature and pressure. The findings revealed that the gasification of polypropylene waste led to the highest hydrogen production at all the processing conditions.

In this study, the waste raw material can be synthesised into syngas, such as raw material for further sustainable different products production. This applied technique based on the complete circular economy, the input unit was upgraded with combustion, gasification and reforming. The conventional natural gas can be replaced with the municipal solid waste (MSW) and flue gas and thereby can reduce the dependence on natural gas.

2 The Applied technique

The municipal solid waste (MSW) and the flue gas can be used as the sustainable raw materials. The usage of waste by using combustion, gasification can be reduced the waste on landfill. The applied technique was presented on the reusage of different MSW from unsorted to sorted and purified flue gas from chimney, based on the mathematical model including real and simulated data, by using Aspen Plus® simulator. Syngas can be produced from waste by using combustion, gasification and reforming. Syngas was converted into different sustainable products: methanol, ethanol, synthetic gasoline etc. The mathematical model contains the most real and something simulated parameters, giving by Aspen Plus® simulator. The existing reforming system can be enlarged with combustion and gasification for MSW processing (Fig. 1). The purified fuel gas of combustion, including steam and carbon dioxide, such as additional raw materials, is entered into the gasification-reforming system. A comparison between natural gas and waste for syngas production was analysed. The wastes allow higher syngas productions.

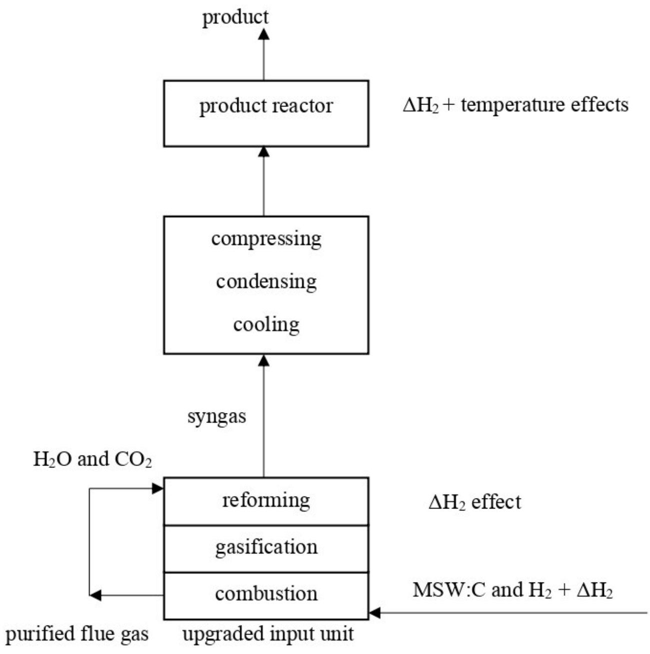


Figure 1: The upgraded system of the combustion, gasification and reforming.

From sustainable syngas can be synthesised the basic methanol product (process P1) during first level (Fig. 2), which can be produced for sales and further formaldehyde production (process P2) during the second level. Different products, such as ammonia (process P3), urea (process P4) and glycolic acid (process P5), can be synthesized from surplus components (hydrogen, nitrogen, carbon dioxide and carbon monoxide) after methanol cleaning during the second level. Products from the second level (ammonia, urea, formaldehyde) can be synthesized for urea formaldehyde resin (process P6) and hexamine (process P7) productions during the third level. The third level contains products with the highest added value. Methanol production is dependent on the amount of carbon monoxide (CO). The processes of the second and fourth levels are dependent on the amounts of components, such as hydrogen, carbon dioxide, carbon monoxide (H_2, CO_2, CO).

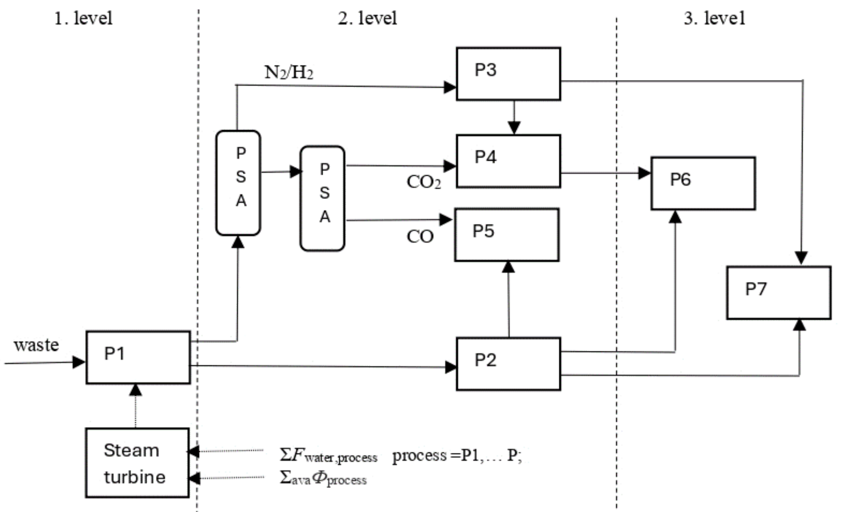


Figure 2: The different products productions from methanol process.

3 Case study

The research study was included the simulation of the methanol, ethanol or synthetic gasoline productions from waste gasification, by using the existing process units and real parameters (Fig. 3). The productions of all processes were profitable.

3.1 Methanol

The sustainable syngas was compressed by using the two-stage compressors. Methanol was synthesized by using the catalytic hydrogenation of carbon monoxide and/or carbon dioxide within reactor, during the following reactions:

$$CO + 2H_2 \rightleftharpoons CH_3OH \quad \text{(Re1)}$$

$$CO_2 + 3H_2 \rightleftharpoons CH_3OH + H_2O \quad \text{(Re2)}$$

From the crude methanol was separated the non-reacted syngas and the water.

3.2 Ethanol production

The syngas, from waste generating, was compressed during the two-stage compressors. Ethanol was synthesized by using the catalytic hydrogenation of carbon monoxide within reactor, during the main reaction:

$$2CO + 4H_2 \rightleftharpoons C_2H_5OH + H_2O \quad \text{(Re3)}$$

From the crude ethanol was separated the non-reacted syngas and the water.

3.3 Synthetic gasoline production

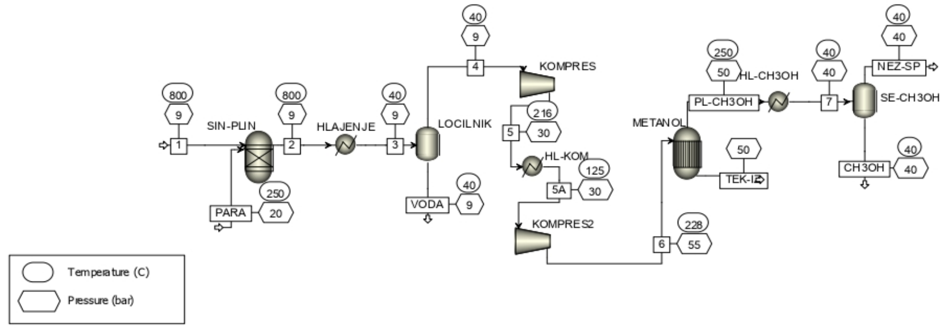
The syngas converts to the synthetic gasoline (C8H18) into the reactor by using two basic exothermic reactions:

$$8\,CO + 17\,H_2 \rightleftharpoons C_8H_{18} + 8\,H_2O \quad \text{(Re4)}$$

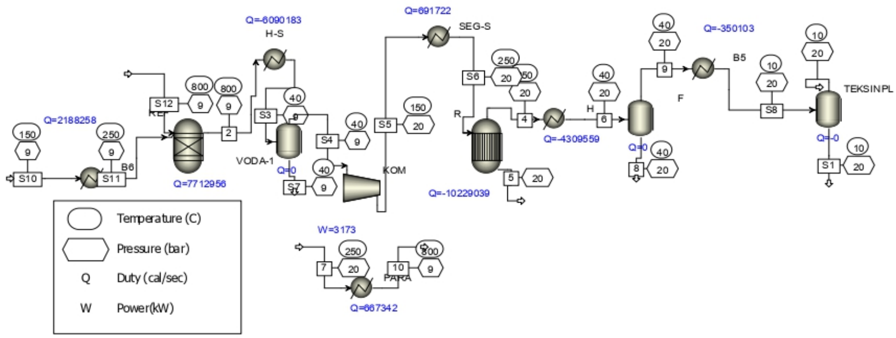
$$8\,CO_2 + 25\,H_2 \rightleftharpoons C_8H_{18} + 16\,H_2O \quad \text{(Re5)}$$

From the crude synthetic gasoline was separated the water and the non-reacted syngas.

Methanol:



Synthetic gasoline



Ethanol

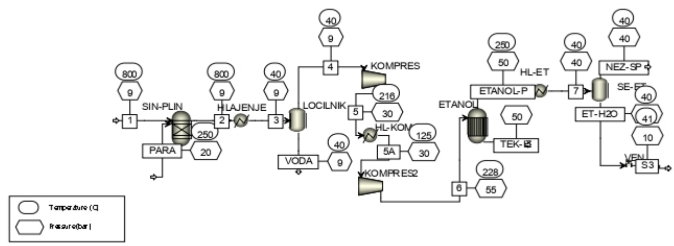


Figure 3: The different products productions from syngas.

4 Conclusions

Natural gas can be replaced with MSW and flue gas for syngas production. From syngas can be synthesized different useful sustainable products, such as methanol, ethanol and synthetic gasoline, by using the applied technique. This technique base on the upgraded input system with combustion, gasification and reforming for syngas production from wastes, and mathematical model, which is depending on the real and simulated parameters. Simulated parameters were obtained by using the Aspen Plus simulator. This technique allows the higher products` production. The MSW and flue gas as raw material can be synthesized sustainable products` production after the complete circular system. A comparison between natural gas and waste as raw material for different products` production were analysed. The wastes allow higher products` productions.

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