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DETERMINATION OF HYDROGEN PRODUCTION POTENTIAL FROM GREENHOUSE WASTES BY GASIFICATION ANTALYA EXAMPLE

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ABSTRACT
Antalya is the largest greenhouse production in Turkey. So it has a significant biomass potential due to high levels of greenhouse wastes. In this study, was carried out to investigate the potential of hydrogen production from greenhouse residues for Antalya blending gasification. In addition, the importance of hydrogen production in reducing carbon footprint will be examined. As a result of the modeling study, gasification performances were examined in terms of hydrogen production of 5 different wastes. The highest yield is in cucumber wastes and the lowest yield is in tomato.
Keywords: Gasification, Greenhouse residues, Energy

1. INTRODUCTION
Greenhouse production in Turkey began in 1940s in glasshouses built in Antalya province, which is still the centre of such production due to the very advantageous climatic conditions for greenhouse cultivation. As shown in Table 1; 82.77% of the glasshouses and 51.93% of the plastic houses of the country were located in Antalya[1,2].

Hydrogen production plays a very important role in the development of hydrogen economy. One of the promising hydrogen production approaches is conversion from biomass, which is clean and renewable. Alternative thermochemical and biological processes can be practically applied to produce hydrogen [3].

The design and operation of a gasifier requires understanding of the influence of fuel and operating parameters on the performance of the gasification process. There are numerous contemporary studies related to the syngas production for power generation in the literature. A review of the basic technology of coal gasification, with particular application to the production of synthesis gas for power generation is presented in the study [4].

Steam gasification has become an area of growing interest because it produces a gaseous fuel with a relatively higher hydrogen content. Furthermore, steam gasification has other advantages; it is capable of maximizing the gas product with higher heating rates involved, advantageous residence time characteristics, and the efficient tar and char reduction brought about by steam reforming [5].

Table 1. Distribution of greenhouse area of Turkey and Antalya (ha)

Greenhouse Cultivation	Turkey		Antalya		The Part Of Antalya In Turkey (%)
	Area	%	Area	%	
Glasshouse (a)	8097.571	12,47	6702.480	27,00	82.77
Plastic house(b)	29865.101	46,01	15509.140	62,47	51,93
Greenhouse (a + b)	37962.672	58,48	22211.62	89,47	58.50
High plastic tunnels	11277.137	17,37	1351.400	5,44	11,98
Low plastic tunnels	15672.003	24,14	1262.300	5,08	8,05

In this study, it was evaluated that gasification performance and importance of hydrogen production of Tomato, Pepper, Eggplant, Zucchini, Cucumber residues (Table 2). The numerical model developed for the gasification system assumes that all carbon in the mixture is gasified and defines the optimum working condition as the amount of hydrogen as the double of the amount of carbon monoxide at the gasification system exit.

Table 2. Properties of greenhouse residues [6]

Residues	C (%)	H (%)	O (%)	N (%)	Moisture (%)
Tomato	38,17	4,08	36,24	2,30	10
Pepper	39,27	4,17	35,01	3,28	10
Eggplant	42,09	4,56	37,95	2,18	10
Zucchini	33,88	3,70	27,84	4,70	10
Cucumber	33,81	3,87	31,12	3,00	10

2. MODELING AND VALIDATION

Achieving the best synthesis gas composition for power generation and production of biomass chemicals is a challenging problem. Accurate understanding of the gasification phenomena is needed for a reliable performance prediction through modeling and can greatly avoid expensive upsets. From this point of view, in this study, a biomass gasification model is developed based on five simultaneous reactions in Table 3. Equals show the reactions used in the model. The equilibrium constants of these reactions are given in Table 3 [7-9].

Table 3. Chemical reactions involved in the gasification system

No	Reactions	Equals	No	Reactions	Equals
1	Oxidation I	$C + O_2 = CO_2 \quad (-394.5\, kj / mol)$	5	Methanation Reaction	$C + 2H_2 = CH_4 \quad (-74.9\, kj/mol)$
2	Oxidation II	$C + \frac{1}{2} O_2 = CO \quad (-111.5\, kj / mol)$	6	Steam Reforming Reaction	$CH_4 + H_2O = CO + 3H_2 \quad (+206.2\, kj/mol)$
3	Steam Gasification	$C + H_2O = CO + H_2 \quad (+131.4\, kj/mol)$	7	Water Gas Shift Reaction	$CO + H_2O = CO_2 + H_2 \quad (-41.2\, kj/mol)$
4	Boudouard Reaction	$C + CO_2 = 2CO \quad (+172.6\, kj/mol)$			

An interpolation routine is implemented in the cascade WGS reactor model to compute the equilibrium constantw, $K_{p,s}$ of the WGS reaction at the intermediate temperatures. The gas compositions from the gasifier model are used as the input conditions to compute the output concentrations of the first shift reactor based on WGS reaction equilibrium, which are then used as the input conditions to compute the output of the second shift reactor again based on WGS reaction equilibrium.

According to the flowchart, the model requires SYNGAS composition to be known at the beginning of calculation and after entering the operation parameters such as the steam/fuel ratios, air/fuel ratios and reactor temperatures, the model performs calculations for H_2/CO ratio. If the calculations converged to a solution, the program save the results to a file and stops. Otherwise perform the following operations; updating the values of S H_2/CO ratio and giving an initial value to the bypass ratio, the WGS reaction is solved to get a SYNGAS composition. As a final step, the desired H_2/CO ratio is checked. If this ratio satisfies the criteria, the program computes the HHV of the resulting SYNGAS composition, hot and cold gas efficiencies of the system.

The model was validated with experimental data for co-gasification of pelletized wood residues [11]. Hydrogen content produced by the model is less than 2.77%.
The temperature of the gasifier has to be maintained within the range 700–850◦ C. At the lower temperature the efficiency of gasification is lower, and the tar content of the gas is excessive [12]. The gasifier temperature is 877 C (1150 K) for developed model.

3. RESULT AND DISCUSSION

Hydrogen has an important place among the new energy sources. As a result, hydrogen production is gaining momentum every day. In this study, hydrogen production from greenhouse wastes was discussed. The use of greenhouse wastes in the production of hydrogen helps in the production of hydrogen as well as harmless destruction of wastes.

Table 4 shows the gasification performances of the wastes of the most growing greenhouse products in Antalya. The highest proportion of hydrogen was found in cucumber wastes with 59,78 percent. Secondly, 56.20 percent hydrogen production was found in zucchini wastes. When examined in terms of yield, the highest yield was 86.77 percent in cucumber wastes. Eggplant is the second rank with 84,04 percent. The lowest yield is 83.04 percent of tomato.

If it is finally evaluated in terms of carbon footprint, direct carbon dioxide emissions are the same for all greenhouse wastes. The average rate of 12.80% is an acceptable level of hydrogen production. In summary, hydrogen production from greenhouse wastes by gasification is an important technology for reducing carbon footprint.

Table 4. The composition of SYNGAS from gasifier[*]

SYNGAS Composition	Tomato	Pepper	Eggplant	Zucchini	Cucumber
H_2 (%)	52,19	49,08	54,61	56,20	59,78
CO (%)	31,45	31,55	29,43	26,94	26,99
CH_4 (%)	0,39	2,82	0,00	0,00	0,00
CO_2 (%)	12,80	12,80	12,80	12,79	12,80
H_2O (%)	0,03	0,03	0,03	0,03	0,04
N_2 (%)	3,13	3,72	4,22	6,02	4,88
H_2 / CO	1,66	1,56	1,86	2,09	2,22
HHV (MJ/kg)	17,22	17,67	20,42	17,72	19,73
Efficiency (%)	84,03	83,45	84,04	83,14	86,77

[*] A/F = 0.05, S/F = 0.05, P = 1 atm and T = 1150 K

4. CONCLUSION

Renewable energy sources are vital for a clean and sustainable world. One of these sources is the use of hydrogen. There are many studies on hydrogen production. Hydrogen production by the gasification method is also an important part of these studies. From this point, in this study, a numerical model was developed for the production of hydrogen by the gasification method from the greenhouse wastes in Antalya province. As a result of the modeling study, gasification performances were examined in terms of hydrogen production of 5 different wastes. The highest yield is in cucumber wastes and the lowest yield is in tomato wastes.

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