

GENERATION OF ELECTRICITY SURPLUS IN A SUGAR-ALCOHOL FACTORY BY MEANS OF GASIFICATION OF THE SUGAR CANE BAGASSE AND STRAW

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Abstract. *This work presents a thermodynamic analysis of biomass gasification systems integration in a sugar-alcohol factory. Four configurations combining the existing cogeneration plant with bagasse and straw gasification systems are considered. Case 1 studies the current situation of the plant, in which, modern and efficient equipment, including a high-pressure high-temperature steam boiler as well as an extraction-condensation steam turbine are deployed in such a way that all power driving is electrified. All the other cases associate gasification systems to the present plant, using the flue gas from a gas turbine and a heat-recovery steam generator to complete a combined cycle. In Case 2, the incorporation of the sugar-cane straw gasification to the current plant is considered. In Case 3, the whole bagasse gasification is taken into account, while all steam for the plant comes from the heat-recovery steam generator. Case 4 represents the incorporation of both straw and bagasse gasification. Similarly to Case 3, in Case 4 the conventional boiler is not used, being replaced by a recovery steam generator. The analysis is based on mass balance, as well as on the first and second thermodynamic laws for a suitable control volume around each equipment and the resulting system of equations is solved with the help of the IPSEpro® software. Several parameters are defined in order to compare products of distinct thermodynamic qualities, such as thermal energy and power generation. Results show that there is a power generation gain for all proposed cases involving gasification. Larger values for power generation and efficiencies are obtained in Case 3, in which there is bagasse gasification only. However, Case 4 presents the largest power generation values while exhibiting quite good levels of efficiency and performance.*

Keywords*: Gasification, bagasse, straw, sugar-alcohol factory, cogeneration.*

1. INTRODUCTION

Sugar cane is cultivated in almost all of Brazilian States. The Center-South area is the largest producer, with 78 % of the production, the remaining 22 % produced in the North-Northeast area. São Paulo State stands out as the main producer, responsible for about 60 % of the production (Oliveira, 2006).

It has been estimated that only 50 % of the solar energy synthesized in the sugar cane is currently utilized in the sugar-alcohol factories. One third is converted in sugar and/or alcohol and another third, corresponding to the bagasse, is utilized to assist the thermal processes and drive some equipment. The last third, constituted by sugar cane straw, used to be left to burn in the fields until very recently to ease the manual harvesting. However since 2002, São Paulo State government has passed through a law towards a gradual elimination of that procedure, therefore renewing the interest on recovering and deployment of straw as an additional fuel source. In July 2007 a Green Protocol was signed, which has determined that straw burning must be stopped after 2014 in areas with less than 12 % of declivity, in order to minimize air pollution effects. So, the amount of straw available for energy generation is bound to grow up and the processes of collection, transportation and utilization must be improved to make its use as an additional fuel economically feasible.

One way of better deployment of the straw and also of the bagasse would be the gasification process, that is a chemical process for biomass conversion into a low LHV (Lower Heat Value) fuel gas (Syngas), constituted mainly by hydrogen, carbon monoxide, carbon dioxide and methane. The integration of this system in a sugar-alcohol factory is possible by means of the BIG/GTCC (Biomass Integrated Gasification Gas Turbine/Combined Cycle) technology, coupling gas and steam turbines with a biomass gasifier.

Several works related to this subject are found in the literature and some of them will be briefly described in the following. Corrêa Neto (2001) has evaluated the technical and economical feasibility of electricity generation using bagasse, straw and points of the sugar cane as fuel, as a complementary option towards the expansion of the Brazilian electricity system. The technology deployed was the thermal-power combined cycle operating in cogeneration, incorporating the biomass gasification for the production of gas fuel (biogas), with and without addition of natural gas. An economical analysis has been performed and curve plots for the investment return in relationship to the electric energy prices and to the natural gas and biomass costs were exhibited.

Souza (2001) has analyzed the process of burning biogas from biomass and natural gas in plants BIGCC. Combined cycles of different types and capacities were modeled. For the case that only biogas from biomass is burned the results were appraised taking into account different control strategies for the use of gas of low LHV (biogas). In a short period, the mixture of gases from 30 to 50% in energy base can avoid considerable losses of efficiency and power production. The gains of efficiency and the growing of the number of plants will result in expressive economical benefits to the BIGCC technology to become competitive.

Pellegrini *et al.* (2005) have proposed a cogeneration system in which part of the bagasse is sent to a gasifier and part is burned in the heat recovery steam generator that uses exhaustion gases from the gas turbine. It has been observed that for amounts of bagasse lower than 45% of the total amount, it is necessary the injection of air in the heat recovery steam generator to assure total conversion. However, in these cases the steam production is enough to supply the demands of the plant, For amounts of bagasse higher than 45% of the total amount, the oxygen contained in the exhaustion gases of the gas turbine is enough for the complete combustion of bagasse, even so the steam produced is not enough to assist the demand of the plant.

Seabra (2008) has investigated the technological options involving the utilization of sugar cane bagasse and straw, such as electric power generation by means of cogeneration with steam cycles (a commercial option now); cogeneration with gasification of the biomass integrated into combined cycles; and ethanol production through the hydrolysis and production of fuels starting from the gasification of the biomass. It has been estimated that the commercial choices would already yield an electric power surplus higher than 140 kWh/ton of cane, with costs around R$ 100/MWh, for the cases of cogeneration with high pressure and use of some straw together with the bagasse. For the future, cogeneration systems with combined cycles integrating the biomass gasification should allow energy surplus for about 200 kWh/ton of cane, although with higher costs (above R$140,00/MWh).

The goal of the present work is, therefore, to evaluate, from the thermodynamic point of view, the performance of some selected configurations that include the gasification of the sugar cane bagasse and straw, in a combined cycle, for a cogeneration thermal power system in a sugar-alcohol factory of northwest area of Sao Paulo State.

2. METODOLOGY

The solution of the problem involves the basic principles of Thermodynamics: mass conservation, First and Second Laws as well as their combination.

Considering a steady-state process and assuming overall negligible kinetic and potential energy, the mass conservation as well as First and Second Laws of Thermodynamics for a control volume are represented in a simplified form by Eqs. (1) to (3):

$$\sum \dot{m}_i - \sum \dot{m}_o = 0 \tag{1}$$

$$\dot{Q}_{c.v} - \dot{W}_{c.v.} + \sum \dot{m}_i h_i - \sum \dot{m}_o h_o = 0 \tag{2}$$

$$\dot{S}_{gen,c.v.} + \sum \left(\dot{Q}_{c.v,j} / T_j \right) + \sum \dot{m}_i s_i - \sum \dot{m}_o s_o = 0 \tag{3}$$

where:

$\dot{m}$: Mass flow rate crossing the control volumes (kg/s);

$\sum \dot{m}\, h$: Enthalpy flow rate crossing the control volumes (kW);

$\dot{Q}_{c.v.}$: Heat transfer rate to the control volumes (kW);

$\dot{W}_{c.v.}$: Power produced in the control volumes (kW);

$\dot{S}_{gen,c.v.}$: Irreversible entropy rate generated in the control volumes (kW/K);

$\sum \left(\dot{Q}_{c.v} / T \right)$: Entropy flow rate associated to $\dot{Q}_{c.v.}$ (kW/K);

$\sum \dot{m}\, s$: Entropy flow rate crossing the control volumes (kW/K).

Energy analysis alone is incapable of taking into account the energy quality and the sources of irreversibility for the processes. The combination of the First and Second Laws leads to the exergy inventory and to the evaluation of the irreversibility of the processes. For a steady-state process, the irreversibility generated is given by:

$$\dot{I}_{c.v.} = \sum \dot{Q}_j \left(1 - T_0 / T_j \right) - \dot{W}_{c.v.} + \sum \dot{m}_i ex_i - \sum \dot{m}_o ex_o \tag{4}$$

where:
ex_i: Specific exergy in the control volume inlet (kJ/kg);
ex_o: Specific exergy in the control volume outlet (kJ/kg);
T_j: Superficial temperature of the control volume (K);
T_0: Temperature of the reference state (K);
$\dot{I}_{c.v.}$: Irreversibility rate production in the control volume $\left(T_0\,\dot{S}_{gen,\,c.v.}\right)$ (kW).

In this work the reference temperature and pressure for the ground state are T_0 = 298.15 K and P_0 = 101.3 kPa, as usual.

According to Szargut *et al.* (1988), Kotas (1985) and others, total specific exergy is composed by physical and chemical exergies. Disregarding effects of kinetic and potential energy, the specific physical exergy of a flow is evaluated based on a restricted equilibrium state of the system with a standard environment (P_0, T_0), by means of:

$$ex_{ph} = \left(h - h_0\right) - T_0\left(s - s_0\right) \tag{5}$$

For an ideal solution of pure substances, the chemical exergy is given by (Bejan *et al.*, 1996):

$$\overline{ex}_{ch} = \sum_k x_i\,\overline{ex}_{ch;k} + \overline{R}\,T_0\sum_i\left(x_i \ln x_i\right) \tag{6}$$

where:
x_i : Molar fraction of the component in the mixture;
$\overline{ex}_{ch;k}$: Chemical standard molar exergy of the component in the mixture (kJ/kmol).

The specific chemical exergies of the bagasse and straw are evaluated with the help of the expression presented by Szargut *et al.* (1988) that takes into account the correlation between the chemical exergy and LHV of each fuel, considering its elementary composition, the ash content and the humidity, as follows:

$$ex_{ch} = \beta\,(LHV_{comb} + L_{water}\,Z_{water}) + ex_{water}Z_{water} \tag{7}$$

being:

$$\beta = \left\{1.0412 + 0.2160\left(Z_{H_2}/Z_C\right) - 0.2499\left(Z_{O_2}/Z_C\right)\left[1 + 0.7884\left(Z_{H_2}/Z_C\right)\right] - 0.0450\left(Z_{N_2}/Z_C\right)\right\} \Big/ \left[1 - 0.3035\left(Z_{O_2}/Z_C\right)\right] \tag{8}$$

where:
β : Function of the mass fraction of the chemical components of the biomass (%);
Z_i: Fraction in mass of the chemical components (%);
Z_{water}: Fraction in mass of the water in the biomass (%);
L_{water}: Water vaporization enthalpy (2,442 kJ/kg);
ex_{water}: Chemical exergy of water liquid (50 kJ/kg).

In order to evaluate each plant performance, some useful parameters are defined in the following, which will be used to compare products of different thermodynamic qualities, such as thermal energy and electric power production (Sánchez Prieto, 2003).

The Factor of Energy Use (*FEU*) is the relationship between the thermal and electromechanical energies utilized for steam generation:

$$FEU = \left(\dot{W}_{total} + \dot{Q}_{use}\right) \Big/ \left(\dot{m}_{fuel} LHV_{fuel}\right) \tag{9}$$

The Index of Energy Saving (*IES*) refers to the economy of energy of fuel obtained by cogeneration systems in comparison with conventional plants that produce electric power and thermal energy separately:

$$IES = \left(\dot{m}_{fuel} LHV_{fuel}\right) \Big/ \left(\dot{W}_{total} / \eta_{therm\_ref} + \dot{Q}_{use} / \eta_{boiler\_ref}\right) \tag{10}$$

For the calculation of *IES*, efficiencies from steam-power generation reference plants (η_{therm_ref} and η_{boiler_ref}) are assumed as 40% and 77%, respectively. The amount of energy saved due to cogeneration (*ESC*) is given by:

$$ESC = 1 - IES \tag{11}$$

The Index of Power Generation (*IPG*) is a parameter defined to calculate the efficiency of the power generation separately, discounting of the available fuel energy the energy used for heating:

$$IPG = \dot{W}_{total} \Big/ \left(\dot{m}_{fuel} LHV_{fuel} - \dot{Q}_{use} / \eta_{boiler} \right) \tag{12}$$

Another important parameter is the Power-Heat Rate (*PHR*) that is the relationship between the total power produced and the thermal energy used in the process:

$$PHR = \dot{W}_{total} \Big/ \dot{Q}_{use} \tag{13}$$

In practical terms, there is a parameter usually deployed in the sugar-alcohol factories, expressing the electric power production by ton of sugar cane milled (*PCR*), expressed as:

$$PCR = \dot{W}_{ele} \Big/ \dot{m}_{cane} \tag{14}$$

The global plant efficiency (η_{global}) is the relationship between the net energy (thermal or electromechanical) and the energy supplied to the system from the fuel:

$$\eta_{global} = \left(\dot{W}_{ele} + \dot{Q}_{use} - \dot{W}_{comp} - \dot{W}_{pump} - \dot{Q}_{cond} \right) \Big/ \left(\dot{m}_{fuel} LHV_{fuel} \right) \tag{15}$$

Each equipment is surrounded by a control volume in which suitable (1) to (3) equations are applied, leading to a large system of equations. In order to obtain the thermodynamic properties and accomplish the numerical simulation of the plant, the software IPSEpro® (SimTech, 1991-2003) is employed.

Due to stringent paper size rules, details of the mathematical models used in the simulation are not presented, but some general information can be found in the SimTech website (www.simtechnology.com).

Four studies of cases are selected, starting with the current plant and integrating gasification systems, which will be described in the sequence. The operating data obtained from the sugar-alcohol factory are presented in Tab. 1.

Table 1. Data of the harvest 2007/2008 in the sugar-alcohol factory.

Parameters	**Values**
Harvest period (days)	223
Total cane milled (t)	1,350,000
Effective hours of milling (h)	4,730
Daily milling (t/h)	285.0
Bagasse humidity (%)	50.09
Bagasse consumption in the boiler (t/h)	78.3
Bagasse-Steam rate (kg/kg)	0.47
Steam consumption in the boiler (t/h)	165.0
Steam consumption in the processes (t/h)	130.0
Alcohol production (m^3/h)	12.5
Straw production (t/h)	24.0

2.1. Case 1

Case 1 considers the current thermal power plant of the sugar-alcohol factory, which uses modern and efficient equipments, including a boiler that produces 165 t/h of steam at 6,860 kPa and 530 °C and an extraction-condensation steam turbine. Additionally, all the driving (mills, extractor fans, fans, feeding water pump) is electrified (Fiomari, 2004). A plant scheme for Case 1 is presented in Fig. 1.

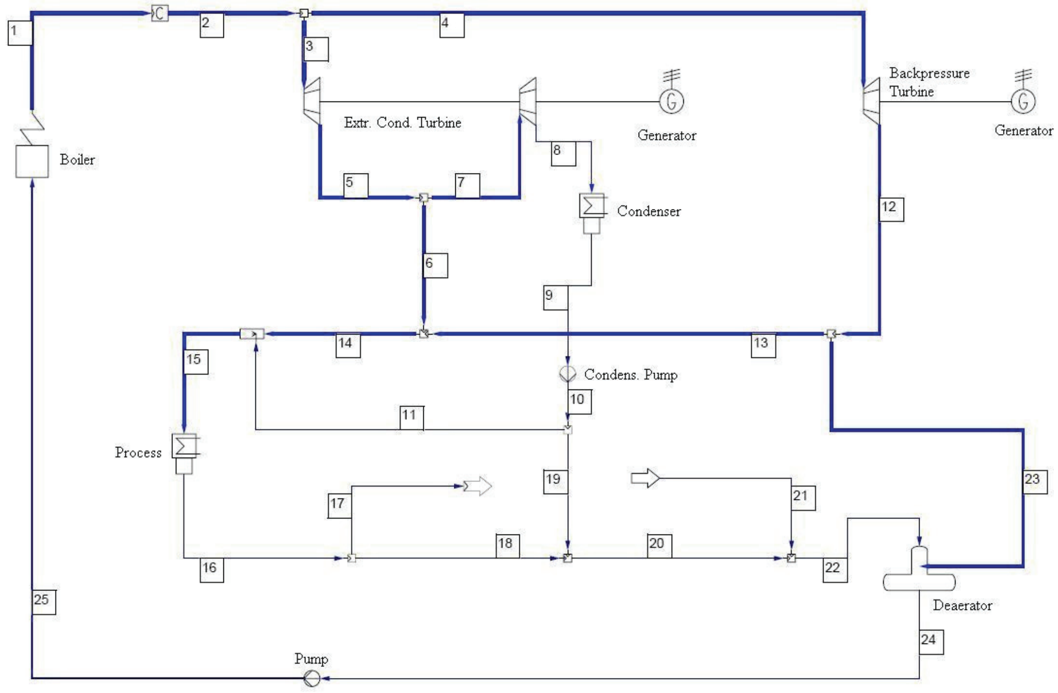

Figure 1. Current plant of the sugar-alcohol factory (Case 1).

2.2. Case 2

Case 2 incorporates to the current plant a system for straw gasification. The biogas generated is compressed and utilized in a gas turbine, whose exhaustion gases are used in a recovery boiler, generating steam for the condensation turbine, as depicted in Fig. 2.

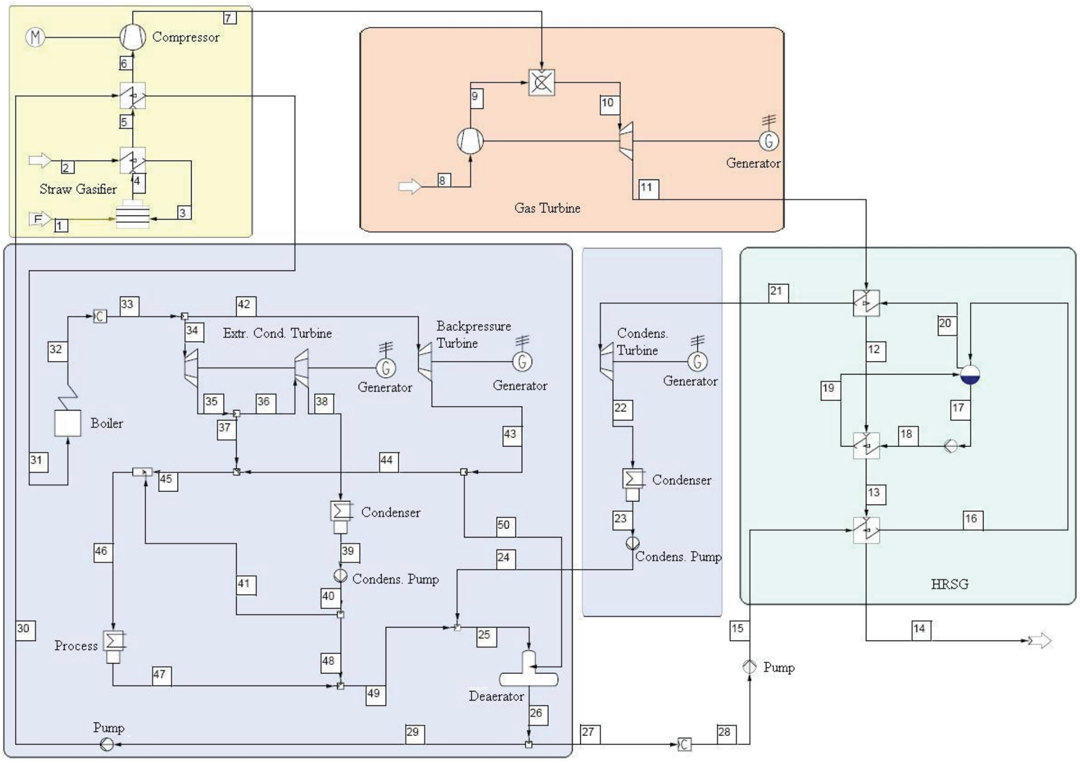

Figure 2. Current plant with integration of a system for straw gasification (Case 2).

2.3. Case 3

Case 3 incorporates to the current plant a system for gasification of all the bagasse produced in the sugar-alcohol factory. The biogas produced is consumed in a gas turbine and the energy of the exhaust gases is used for steam generation in the recovery boiler, which also provides all the steam for processes, as showed in Fig. 3.

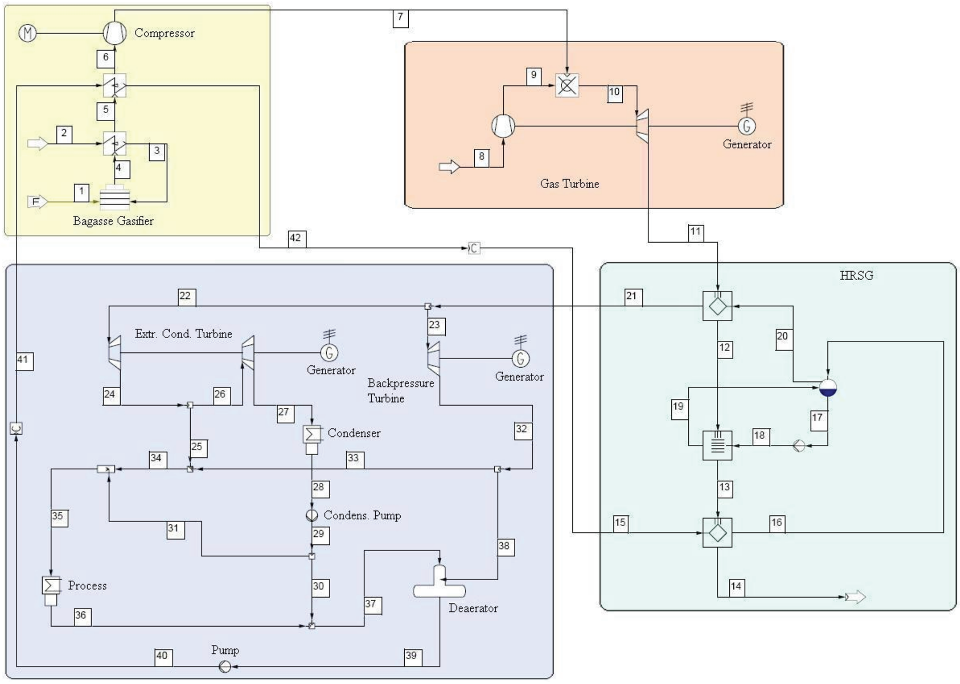

Figure 3. Current plant with integration of a system for bagasse gasification (Case 3).

2.4. Case 4

Case 4 considers the possibility of the integration of systems for bagasse and straw gasification. The biogas generated is compressed and deployed in a gas turbine, so that the exhaustion gases are used in the recovery boiler to generate steam for a condensation turbine, according to Fig. 4.

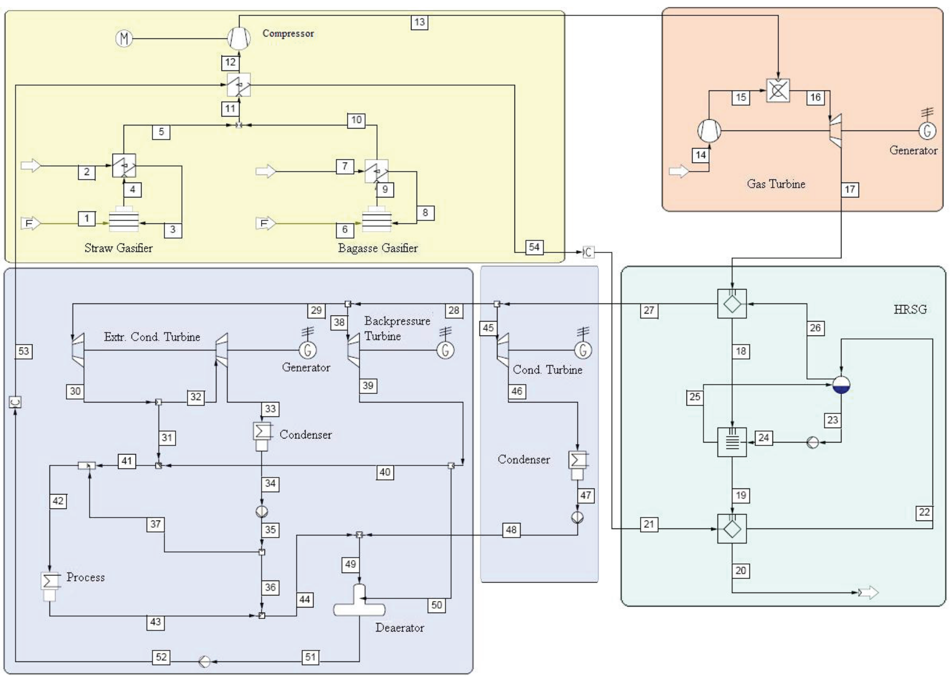

Figure 4. Current plant with integration of a system for bagasse and straw gasification (Case 4).

3. RESULTS

In the present simulation, compressor and pump isentropic efficiencies were assumed to be 80 and 75% respectively. The efficiencies for electrical and mechanical conversion were estimated as 98%. The exergy of the straw and bagasse were calculated by means of Eq. (7), resulting 15,121 kJ/kg and 10,170 kJ/kg, respectively. Lower Heat Value (LHV) of the straw and bagasse were considered, respectively, as 13,151 kJ/kg and 7,736 kJ/kg, according to Hassuani *et al.* (2005). A model validation test has been performed for Case 1 and a good agreement was found with actual plant data including those in Tab. 1. For the other cases, further data should be necessary to fully guarantee the validity of the results.

Table 2 presents the power generated/consumed by equipment for each case studied. In the case of compressors and pumps, the power values exhibit a negative sign, since they need energy for driving. Table 3 shows the thermal power demanded by evaporation and condensation processes. Tab. 4 shows the irreversibilities generated only by the gas turbine components and in Tab. 5 the irreversibilities generated by all turbines and compressors are presented, for each case studied. Table 6 shows the plant performance parameter values for each case studied.

Table 2. Power generated/consumed by equipment for each case studied (kW).

Equipment	Case 1	Case 2	Case 3	Case 4
Compressors	0	- 802	- 33,718	- 44,000
Pumps	- 531	- 614	- 463	- 580
Gas Turbines	0	9,796	68,256	93,700
Extraction-Condensation Turbine	25,500	25,100	21,158	28,360
Backpressure Turbine	6,850	6,930	6,160	7,971
Condensation Turbine	0	6,000	0	1,870
Total	**31,819**	**46,410**	**61,393**	**87,321**

Table 3. Thermal power demand in evaporation and condensation processes for each case studied (kW).

Process	Case 1	Case 2	Case 3	Case 4
Evaporation	79,791	79,791	80,251	80,251
Condensation	22,707	37,415	11,828	29,004

Table 4. Irreversibilities generated in the gas turbine for each case studied (kW).

Component	Case 2	Case 3	Case 4
Compressor	1,006	4,644	5,662
Combustion Chamber	10,546	33,004	37,885
Turbine	1,346	7,344	9,166
Total	**12,898**	**44,992**	**52,713**

Table 5. Irreversibilities generated by turbines and compressors for each case studied (kW).

Equipment	Case 1	Case 2	Case 3	Case 4
Gas Turbine	-	12,898	44,992	52,714
Extraction-Condensation Turbine	7,255	5,716	5,518	6,066
Backpressure Turbine	1,814	1,734	1,505	1,384
Condensation Turbine	-	1,479	-	446
Compressors	-	104	4,186	2,718
Total	**9,069**	**21,931**	**56,201**	**63,328**

Table 6. Plant performance indexes for each case studied.

Index	Case 1	Case 2	Case 3	Case 4
FEU	0.654	0.567	0.845	0.765
IES	0.939	1.013	0.651	0.682
ESC	0.061	- 0.013	0.349	0.318
IPG	0.426	0.371	0.709	0.761
PHR	0.379	0.599	0.765	1.053
PCR (kWh/t cane)	112	163	215	306
η_{global} (%)	51.9	39.9	77.4	63.5

The current plant (Case 1) presents reasonably good *FEU* and global efficiency values since it uses modern and efficient equipment for electrical driving the mills as well as an extraction-condensation turbine.

In Case 2, which includes the straw gasification, the global efficiency of the plant and the *FEU* present the smallest values among all of the cases, since in this configuration there is a great amount of additional fuel for the plant (15 t/h of straw), although generating a low LHV gas.

Case 3, which considers the bagasse gasification, presents the highest values for *FEU* and global efficiency, although the power generation is not the largest.

In Case 4, which includes both bagasse and straw gasification, shows lower *FEU* and global efficiency values than Case 3 due to the higher amount of additional fuel utilized (straw).

It should be noticed that the smaller *IES* corresponds to the best use of energy in the plant. Case 2 presents a higher value of this parameter that means a worse result for this case if compared with one taken as reference. On the other hand, due to the higher power generated with the same fuel flow rate of Case 1, Case 3 presents a considerably low value of this parameter.

The highest value for *IPG* is reached in Case 4, which includes gasification of the bagasse and straw. *IPG* considers only the power production in relationship to that one could be used for this end, in other words, this parameter disregarding the energy portion destined to the production of useful heat.

The *PHR* shows an increasing trend, reaching a maximum in the Case 4. As this parameter represents only the relationship among the brake power generated and the useful heat, and as the thermal power is approximately the same for all the plants, the cases that present the largest values for this parameter are the ones that have higher potential for energy export. Although Case 4 exhibits the highest generated power values among all of the cases, the efficiency of the cycle is smaller than in the Case 3 in reason of the straw gasification.

Finally, in Tab. 7 some data are included, corresponding to mass flow, temperature and pressure values at the places indicated in the plants in the Figs. 1 to 4, data from which all unknown thermodynamic properties have been obtained.

4. CONCLUSIONS

The biomass gasification, besides providing a larger production of electric power, is a system that presents better efficiencies and, consequently, better use of energy.

Although straw gasification has made possible a high increment in electric power generation, the plant in Case 2 presents low values for the performance parameters.

The advantages of the gasification become evident in Case 3, in which there is an increase of 61.4 MW in the useful generated power, in other words, 215 kWh for ton of cane milled. This case still presents the best global efficiency values among the cases studied and the best values for the performance parameters. In addition, the energy savings due to cogeneration is substantial, since the larger production of energy is obtained with the same amount of fuel.

Case 4 shows a useful power generation of 87.3 MW, reaching the top value of 306 kWh for ton of cane milled. Although this case is responsible for the highest power generation, its global efficiency is lower than Case 3, because there is the influence of the low efficiency of the straw gasification in this plant. In spite of that, the economy of energy due to the cogeneration is still substantial in relationship to the current plant of the sugar-alcohol factory, due to the large amount of bagasse gasified.

The analysis reveals that the power generation is higher than the current plant for all cases. However, larger generation and efficiency values are obtained for cases including bagasse gasification. Considering only the gasification of this kind of fuel (Case 3), the best efficiency and performance parameters values are achieved, following by Case 4, from which the highest power generation is obtained.

Finally, the analysis could provide some help to deciding on the best configuration for a future cogeneration plant, either prioritizing the best deployment of the energy (Case 3), or the generation of electric power surplus (Case 4), in the endless search for a solution for a possible energy shortage crisis.

Table 7. Mass flow (t/h), pressure (bar), temperature (ºC) in the points indicated in the plants of the Figs. 1 to 4.

Point	Case 1			Case 2			Case 3			Case 4		
	$\dot{m}$	P	T	$\dot{m}$	P	T	$\dot{m}$	P	T	$\dot{m}$	P	T
1	165.0	68.6	530.0	15.0	-	30.0	78.3	-	30.0	15.0	-	30.0
2	165.0	68.6	530.0	20.3	1.0	30.0	105.7	1.0	30.0	20.3	1.0	30.0
3	125.0	68.6	530.0	20.3	1.0	700.0	105.7	1.0	700.0	20.3	1.0	700.0
4	40.0	68.6	530.0	35.3	1.0	750.0	184.0	1.0	750.0	35.3	1.0	750.0
5	125.0	2.45	184.0	35.3	1.0	445.6	184.0	1.0	445.6	35.3	1.0	445.6
6	88.0	2.45	184.0	35.3	1.0	120.0	184.0	1.0	150.0	78.3	-	30.0
7	37.0	2.45	184.0	35.3	10.0	172.7	184.0	14.0	635.1	105.7	1.0	30.0
8	37.0	0.07	39.0	152.9	1.0	30.0	620.6	1.0	30.0	105.7	1.0	700.0
9	37.0	0.07	38.0	152.9	8.8	329.2	620.6	13.7	412.4	184.0	1.0	750.0
10	37.0	2.45	38.0	188.1	8.8	916.0	804.6	13.7	1.193.5	184.0	1.0	445.6
11	5.0	2.45	38.0	188.1	1.3	536.5	804.6	1.3	661.4	219.3	1.0	445.6
12	40.0	2.45	184.0	188.1	1.2	475.2	804.6	1.2	550.3	219.3	1.0	180.0
13	37.1	2.45	184.0	188.1	1.1	270.0	804.6	1.1	297.6	219.3	16.0	724.4
14	125.0	2.45	184.0	188.1	1.0	193.2	804.6	1.0	260.3	739.5	1.0	30.0
15	130.0	2.45	135.0	24.9	57.8	111.8	147.2	81.4	232.7	739.5	15.0	430.5
16	130.0	2.45	124.7	24.9	45.3	250.8	147.2	68.9	277.8	958.7	15.0	1227.3
17	13.0	2.45	124.8	30.0	45.3	257.8	200.0	68.9	284.8	958.7	1.3	668.3
18	117.0	2.45	124.8	30.0	46.0	257.8	200.0	69.6	284.8	958.7	1.3	551.9
19	32.1	2.45	38.0	30.0	45.3	257.8	200.0	68.9	284.8	958.7	1.3	286.5
20	149.1	2.45	106.3	24.9	45.3	257.8	147.2	68.9	284.7	958.7	1.3	235.7
21	13.0	2.45	35.0	24.9	45.0	450.0	147.2	68.6	530.0	184.0	81.4	218.8
22	162.1	1.47	100.6	24.9	0.1	45.8	109.0	68.6	530.0	184.0	68.9	277.8
23	2.9	2.45	184.0	24.9	0.1	45.8	38.2	68.6	530.0	220.0	68.9	284.8
24	165.0	1.47	110.8	24.9	2.5	45.8	109.0	2.45	175.8	220.0	69.6	284.8
25	165.0	83.6	112.1	181.0	1.5	98.8	90.0	2.45	175.8	220.0	68.9	284.8
26	-	-	-	184.9	1.5	110.8	19.0	2.45	175.8	184.0	68.9	284.7
27	-	-	-	24.9	1.5	110.8	19.0	0.07	39.0	184.0	68.6	530.0
28	-	-	-	24.9	1.5	110.8	19.0	0.07	34.0	177.4	68.6	530.0
29	-	-	-	160.0	1.5	110.8	19.0	2.45	34.0	130.0	68.6	530.0
30	-	-	-	160.0	83.8	112.3	13.7	2.45	34.0	130.0	2.45	175.8
31	-	-	-	160.0	83.6	134.1	5.3	2.45	34.0	90.0	2.45	175.8
32	-	-	-	160.0	68.6	530.0	38.2	3.43	201.6	40.0	2.45	175.8
33	-	-	-	160.0	68.6	530.0	34.7	3.43	201.6	40.0	0.07	39.0
34	-	-	-	120.0	68.6	530.0	124.7	2.45	182.3	40.0	0.07	34.0
35	-	-	-	120.0	2.5	175.8	130.0	2.45	130.0	40.0	2.45	34.0
36	-	-	-	30.5	2.5	175.8	130.0	2.45	121.7	34.4	2.45	34.0
37	-	-	-	89.5	2.5	175.8	143.7	2.45	113.5	5.6	2.45	34.0
38	-	-	-	30.5	0.1	39.0	3.5	3.43	201.6	47.4	68.6	530.0
39	-	-	-	30.5	0.1	34.0	147.2	2.45	126.8	47.4	3.43	201.6
40	-	-	-	30.5	2.5	34.0	147.2	81.6	128.1	39.4	3.43	201.6
41	-	-	-	4.4	2.5	34.0	147.2	81.6	128.1	129.4	2.45	183.0
42	-	-	-	40.0	68.6	530.0	147.2	81.4	232.7	135.0	2.45	130.0
43	-	-	-	40.0	2.5	184.0	-	-	-	135.0	2.45	121.7
44	-	-	-	36.2	2.5	184.0	-	-	-	169.4	2.45	104.1
45	-	-	-	125.6	2.5	178.2	-	-	-	6.6	68.6	530.0
46	-	-	-	130.0	2.5	135.0	-	-	-	6.6	0.1	45.8
47	-	-	-	130.0	2.5	121.7	-	-	-	6.6	0.1	43.8
48	-	-	-	26.2	2.5	34.0	-	-	-	6.6	2.45	43.8
49	-	-	-	156.2	2.5	107.2	-	-	-	176.0	2.45	101.8
50	-	-	-	3.8	2.5	184.0	-	-	-	8.0	3.43	201.6
51	-	-	-	-	-	-	-	-	-	184.0	2.45	126.8
52	-	-	-	-	-	-	-	-	-	184.0	81.6	128.1
53	-	-	-	-	-	-	-	-	-	184.0	81.6	128.1
54	-	-	-	-	-	-	-	-	-	184.0	81.4	218.8

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