A NEWLY PATENTED THREE-STAGE STEADY-BED GASIFIER CONCEPT FOR MUNICIPAL SOLID WASTE AND BIOMASS

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L. Elefsiniotis*, A. Karagiannidis, I.-S. Antonopoulos**, P. Samaras*****

* Prodagaz S.A., e-mail: prodagaz@otenet.gr

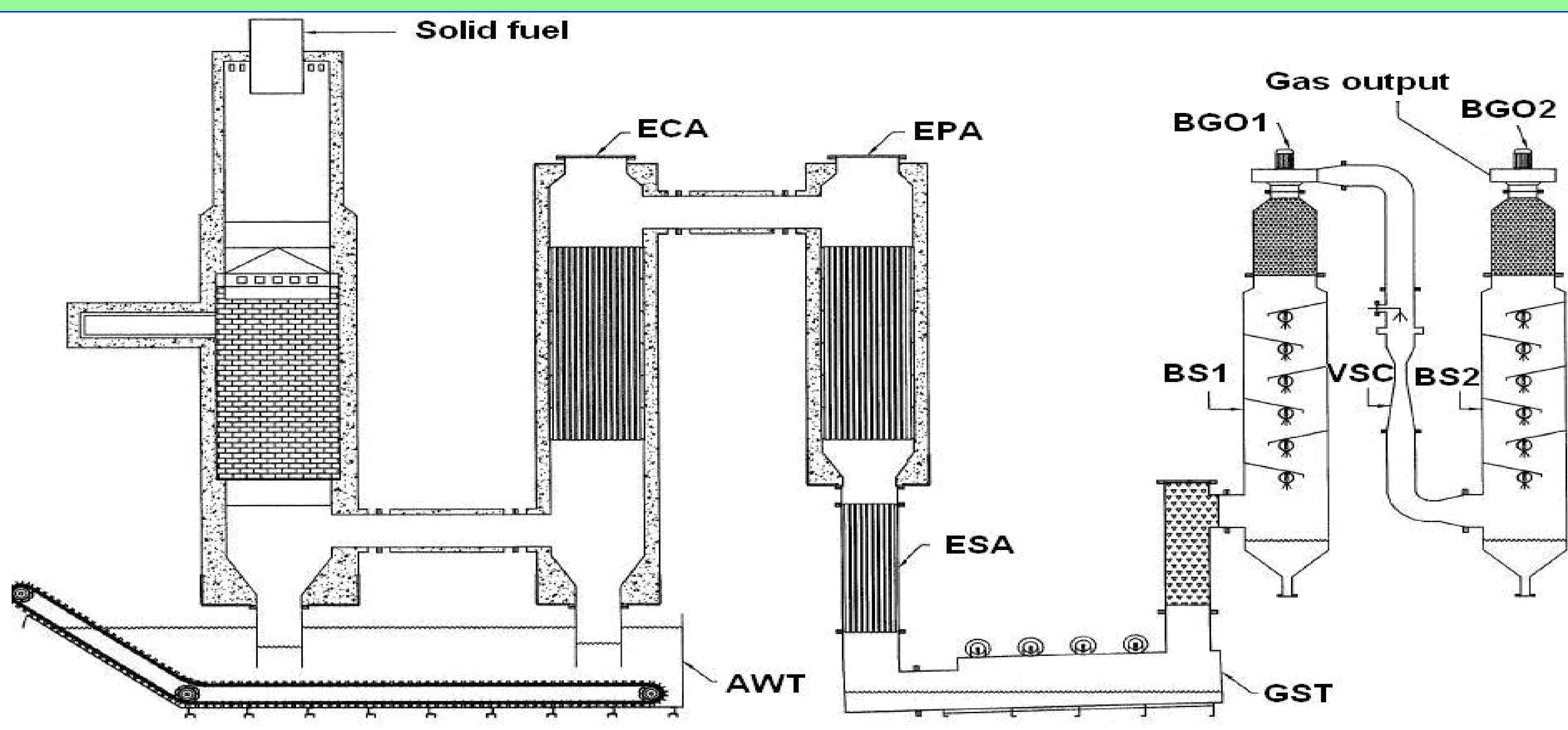
** Laboratory of Heat Transfer and Environmental Engineering, Department of Mechanical Engineering, Aristotle University of Thessaloniki

*** Department of Food Technology, TEI of Thessaloniki, 57400 Thessaloniki, Greece

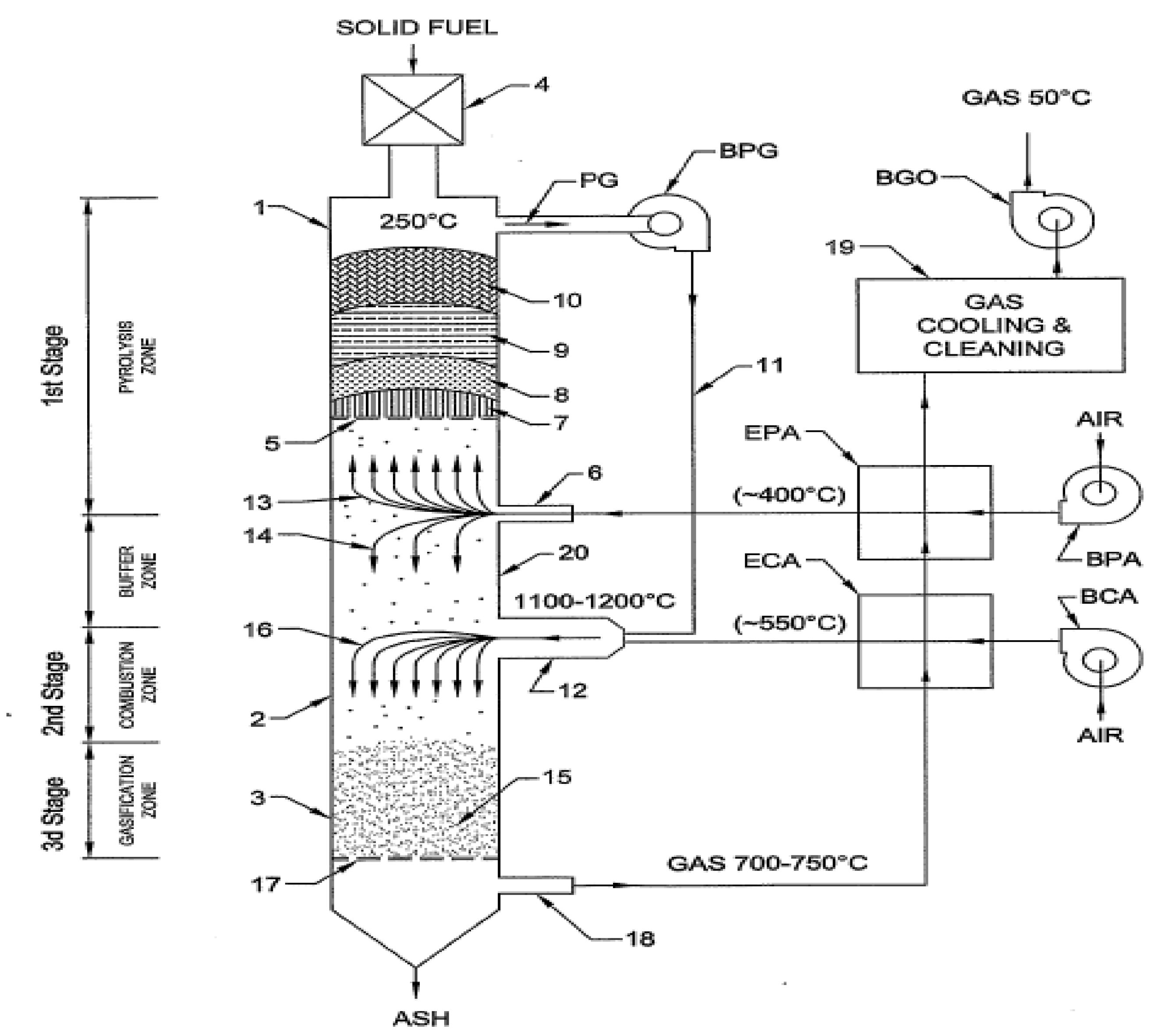
Box 483, 54124 Thessaloniki, Greece, Tel.: +302310996011, Fax: +302310996012

1. INTRODUCTION

Presented in this study is a new, recently patented, three-stage gasification scheme, designed for biomass and municipal solid wastes, as well as waste-derived products and residues. The produced gas is free of dioxins and tars. The innovation of this technology is based on the proper rotation settings of four blowers creating a new model of gaseous flow management between the three stages. A crucial advantage is that no moving seal mechanisms between the stages of the gasifier are exposed at high temperatures (>750^{o}C) and is validated as suitable for small-to-medium scale capacities, achieving an overall electrical efficiency of 30% and minimum environmental impacts.

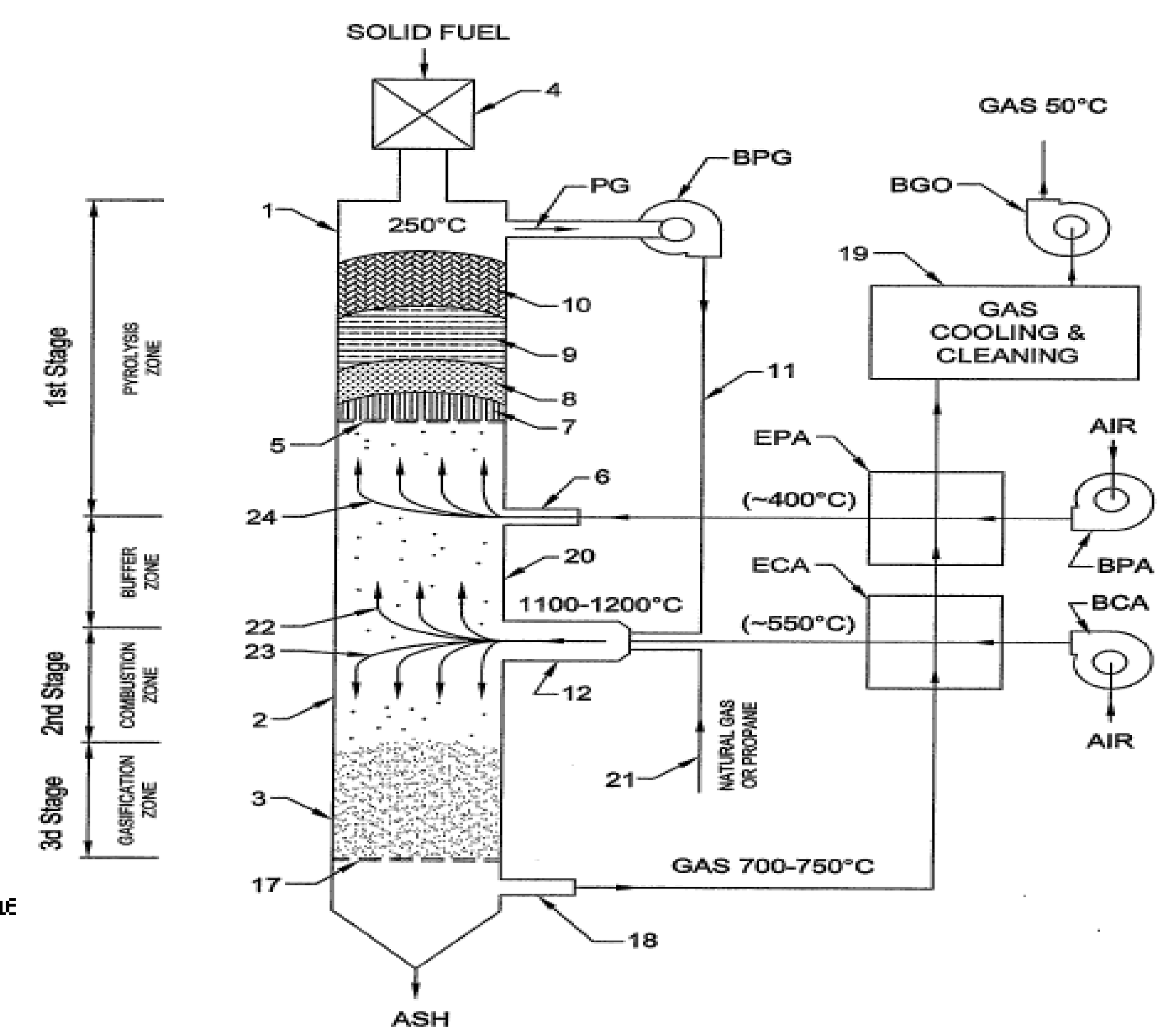


2. NORMAL OPERATION



1. Pyrolysis zone
2. Combustion zone
3. Gasification zone
4. Material feeding system
5. Grate
6. BPA pump
7. Burning hearth
8. Reduction layer
9. Distillation layer
10. Drying layer
11. Pyrolysis gas duct
12. Torch
13. Up-draught stream
14. Down-draught stream
15. Gasification bed
16. Flue gas
17. Discharge system
18. Gasification zone
19. Gas cooling and cleaning
20. Buffer zone
21. Additional supply of natural gas or propane
22. Up-draught stream flue gas stream
23. Down-draught stream flue gas stream
24. Up-draught stream

3. REVERSED OPERATION



1. *Pyrolysis zone:* In normal operation, through the Blower of Preheated Air (BPA) and the Exchanger of Preheated Air (EPA), preheated air at a temperature of almost 400^{o}C is supplied in order to dry the incoming fuel. In reversed operation, proper rotation settings of the blowers are applied to change the buffer zone.
2. *Combustion zone* (same in the reversed operation): The Pyrolysis Gases derived from the first stage is a mixture of CO, CO_2, CH_4, C_nH_m, H_2, H_2O and N_2. At the torch, through the Blower of Combustion Air (BCA) and the Heat Exchanger of Combustion Air (ECA), preheated air around 550^{o}C is supplied. The torch blends the Pyrolysis Gases with the preheated air and creates a flame. The combustion of Pyrolysis Gases generates steam, which becomes a component of the gasification reactions and releases heat, which is energy source for the reactions of the gasification bed.
3. *Gasification zone* (same in the reversed operation): The pieces of charcoal derived from the second stage, form the gasification fixed bed. Gasification bed operates within a temperature range from 1100-1200^{o}C (upper side) to 700-750^{o}C (lower side), due to the endothermic gasification reactions.

4. RESIDUE PROCESS INSTALLATIONS

i) Bottom ash holding: Produced gas is expanded in the bottom of the main gasifier part and afterwards in the preheater.

ii) Heat reallocation: Preheaters of the flue and Pyrolysis Gases are heat exchangers, which reallocate heat in the system.

iii) Gas cooling and separation: A gas cleaning system makes produced gas suitable for an internal combustion engine.

5. SWOT ANALYSIS

	Strengths	Weaknesses
Internal	Low volume of produced solid residues Low weight of produced solid and liquid residues Dioxin and tar free solid residues Easy neutralisation Dioxin and tar free producer gas Low emissions and long life for internal combustion engine parts Biological treatment of liquid residues Electrical efficiency ~ 30%	Moderate investment cost
	Opportunities	**Threats**
External	A developing market Moving into new market segments that offer imroved profits	Competitors have superior access to channels of distribution. Change of the existing charging policies. Development of a new other competitive waste-to-energy technology.

6. COMPETITIVE WtE TECHNOLOGIES

Categories	Three-stage gasifier	Plasma gasification	Mass burn incineration
Residues after process			
Solid waste	(+) 1:100 of initial volume (+) 1:10 of initial weight (++) dioxin & tar free (+) easy, neutralisation	(+) low volume (+) low weight (++) thermal neutralisation of solids	(+) low volume (+) low weight (--) high toxicity
Liquid waste	(+) low weight (+) biological treatment	(+) low weight (+) biological treatment	(-) high weight (--) high toxicity
Air emissions	(++) emissions from internal combustion engine operating with dioxin & tar free gas	(+) emissions from boiler which burns gas mixed with tars	(--) high toxicity (-) cleaning difficulties
Costs			
Investment cost	(~) moderate	(-) high	(~) moderate
Waste prevention cost	(+) low	(~) moderate	(-) high
Maintenance cost	(+) low	(-) high	(+) low
Operation cost	(+) low	(-) high	(+) low
Mechanical attributes			
Electrical efficiency	~ 30%	<20%	<20%
Economic balance	(+)	(-)	(-)

7. CONCLUSIONS

This WtE concept is specialized for a city up to 50,000 habitants and/or for industries with biomass residues and wastes.

This model can handle a wide range of possible variations in humidity and/or composition of the inserted fuel.

The high electrical efficiency (~30%) increases the independence from fossil fuels and saves significant GHG emissions.