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CONVERSION OF INDUSTRIAL LIQUID CONSTRUCTION WASTE WITH PLASMA ON HYDROGEN

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1. INTRODUCTION

The main objective is to design a plasma eco-innovative technology to optimize syngas by controlling the plasma conversion of liquid waste according to the results obtained from modeling and simulation of thermochemical plasma processing.
The management of plasma hydrogen reactor is controlling the temperature of the reactor so that it can evolve as a profile imposed by technology, designed based on the information on the type, chemical composition, viscosity, quantity and density of dangerous industrial liquids.

2. MATERIALS AND METHODS

The general principles of waste management are:
- waste prevention targets to reduce emissions, reduction of hazardous substances in material streams and increase resource efficiency,
preparation for reuse involves checking, cleaning, or recovery by which products or components of products that have become waste are prepared for reuse, energy recovery from waste and other recovery activities.

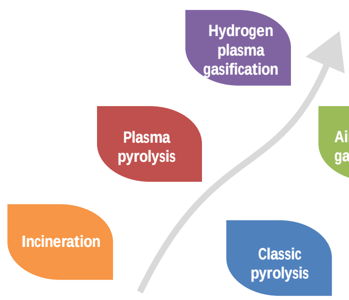


Fig.1 The increase in the efficiency of the technological process

a) Incineration
- an auxiliary fuel is used to start the process, the combustion temperature is reduced
- gases with a low calorific value, a different chemical composition and a low degree of purity are produced
- the process has a negative impact on the environment
- the amount of inert waste is high
- the area occupied by the installation is large

b) Clasic pyrolysis
- the process temperature is high
- gases with a low calorific value, a different chemical composition and a low degree of purity are produced
- the process has a negative impact on the environment
- the amount of inert waste is high

c) Plasma pyroysis
- the temperature in the reactor is high above 2,000 ℃
- a small amount of syngas used in cogeneration equipment is produced
- the amount of inert waste is more than 15%

d) Air plasma gasification
- the temperature in the reactor is high over 4,000 ℃
- high-purity, high-calorie syngas is produced and used for cogeneration equipment for energy production
- the gases emitted into the atmosphere have a minimal impact on the environment
- the amount of waste is reduced approx. 5 - 10%
- the installations are large, require expensive consumables, the carbon footprint of the equipment is reduced

e) Hydrogen plasma gasification
- the temperature in the reactor is very high above 10,000 ℃
- high-purity, high-calorie syngas is produced and used for cogeneration equipment for energy production
- by controlling the chemical reactions in the reactor, raw materials can be obtained, the gases emitted into the atmosphere have a minimal impact on the environment
- the amount of waste is reduced approx. 5%
- the installations are compact, small in size, fully automated, the carbon footprint of the equipment is reduced

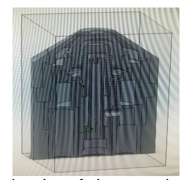
The working methodology used in the experimental research involves the following steps:
- Mathematical modeling for the prediction of the technological parameters of the plasma - chemical gasification unit.
- Finite element analysis of the time evolution of temperature and heat flux in the plasma - chemical gasification unit controlled with PID type thermoregulator and one - step predictive.
- Experimental identification of the driven process model, the identification is performed online in the normal working conditions of the installation, as the input data become available by measurement.
- Simulation of the control structure of the plasma - chemical gasification unit using the Simulink package.
- Implementation on the plasma - chemical gasification unit of the simulated control structures and following the evolution in time of the monitored parameters.

The following figure shows the system for conversion with hydrogen plasma for hazardous recyclable liquid waste, the authors have redesigned plasma torches on hydrogen and system for controlling the variable power sources.

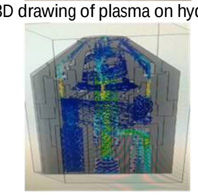
Fig. 2. The system for conversion with plasma with hydrogen of industrial hazardous recyclable liquid waste

Designing a system for automatic control of a reactor temperatures involves the following steps:
• mathematical characterization of the behavior of the controlled plasma hydrogen reactor and acting on operating mode, setting goals adjustment determined by the type of reactor process management, external signals and nature awareness of the mathematical model of the reactor;
• choice of method design involves optimizing parameter values agree, establish criteria for the selection and award regulators and determining optimal control algorithms, identification experimental model driven process, identification is performed online in safe working condition without raw material inside the reactor, as input data becomes available through measurement;
• simulating the control structure of the plasma hydrogen reactor using the Matlab & Simulink package;
• test design and analysis of algorithms, possibility of achieving implementation, the optimal choice of equipment that ensures a precise implementation of the algorithm of management;
• finite element analysis of the evolution in time of the temperature and heat flow of the raw material subjected to heat conducted in the reactor with thermoregulator controlled PID algorithm.

Plasma torches on hydrogen have been redesigned so that fluid flow is swirling to uniformly blend spray liquids and compressed air resulting a homogeneous flame with high temperature and very high dispersion, figure 3 is a part of the modeling and simulation performed in Ansys software (Fig. 4, 5) that have been validated experimentally on the existing plant in the research laboratory.



a) 3D drawing of plasma on hydrogen



b) Fluid flow simulation

Fig. 3. Plasma torches on hydrogen, nozzle diameter 2,5 mm

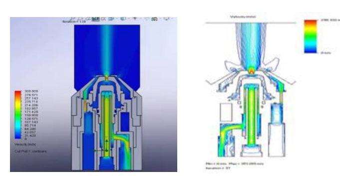


Fig. 4. Modeling of fluid flow and thermal analysis of plasma on hydrogen nozzle diameter D=1,5 mm

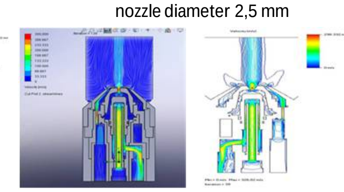


Fig. 5. Modeling of fluid flow and thermal analysis of plasma on hydrogen nozzle diameter D=2,5 mm

3. CONCLUSIONS

The main objective is the design of an eco-innovative plasma-based technology for the recovery of waste as a renewable energy source, improvement of the technical and economic performance of the plasma installation for the waste processing by upgrading some components of the plant (plasmas, adaptive thermal conduction processes from the plasma reactor enclosure, plasma gas purification system) and optimization of the syngas production technology by controlling the plasma conversion of waste depending on the results obtained from the modeling and simulation of thermo-chemical processes of plasma waste processing with the help of specialized software. Modeling and simulation of thermochemical plasma process performed using specialized software Solidworks, Matlab & Simulink, Ansys allows the optimum control of the temperatures and chemical reactions of the plasma reactor on hydrogen, allowing the conversion of hazardous industrial liquid waste into electrical and thermal energy and useful raw materials that can be reused in the production process.

Acknowledgments

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