Plasma Gasification in Costa Rica: First Steps

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The gasification of municipal solid waste is one of the thermo-chemical processes that reduce the high volume of waste; other available processes are the combustion and pyrolisis. The gasification provide some useful purpose for waste: the production of synthetic gas, it could be used as chemical feedstock or for energy generation. Recently in Costa Rica, the interest on these kinds of treatments and technologies has grown due to the social issues generated by landfills and the concern of give a better use of the solid waste. The Costa Rica Institute of Technology in order to attend this national problem, and in the objective of research in applied plasma technologies, started to develop a series of projects that will culminate in the creation of experimental prototype of an plasma gasification reactor. Some results of the research like computer simulations including computational fluids dynamics, thermal and chemical aspects of the gasification reactor are included. Some facts of this technology are included too.

Keywords: Plasma Gasification, Computer Fluid Dynamics.

I. OBJECTIVE

The objective of this projects is the research and development of plasma gasification technology, which it is a viable and recent technology [2]. According to that, we are researching the plasma gasification in order to improve and implement it in Costa Rica. The guideline to fulfill this objective is shown in Fig. #1. Currently, we started phase 2.

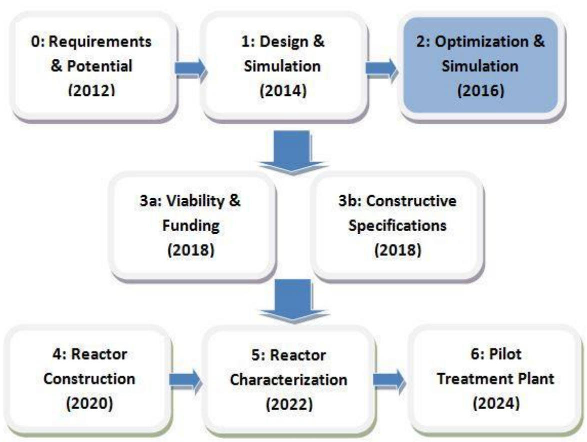

Fig. 1 Plasma gasification technology research and development guideline of the Costa Rica Institute of Technology.

II. FACTS OF THE COSTA RICA MSW SYSTEM

The phase 0 was carried out to determine the potential and the requirements for the implementation of the gasification technology in Costa Rica [3]. The table 1 shows some basic data of the Costa Rica's municipal solid waste (MSW) composition considered. This study reveals certain facts that encourage the application of this technology, among which can be mentioned:

- The majority of the waste corresponds to organic type.
- Lacks of landfills (only disposal method available).
- The increasing volume of MSW
- The recent approval of MSW's thermal treatment law.

TABLE I
MSW Material Composition (USA, CR & Brazil)

Material Composition (%)	USA	Brazil	Costa Rica	Curritibia, Brazil	San José, Costa Rica
Glass	8.5	1.6	1.5	2.1	2.3
Paper	47.0	24.5	21.0	20.0	20.6
Plastic	5.5	2.9	11.0	16.0	18.1
Metals	8.5	2.3	2.0	4.2	2.1
Organics	20.0	52.5	58.0	45.0	49.8
Others	10.5	16.2	6.5	12.7	7.1

Adapted from reference [4].

The Costa Rica Institute of Technology (TEC) have a team of physicist and engineers interested in the development and the improving of this technology. Also it have capabilities in the experimental characterization and study of plasma behavior through their Plasma Laboratory for Fusion Energy and Industrial Applications.

III. MODEL

The phase 1 comprehends the design and computational simulation of the MSW treatment plant core: the plasma reactor and the plasma torches. Fig. #2 shows the reactor's geometry considered for the 3D modeling. It could be seen the four plasma inlets (bottom) and the syngas outlet (top).

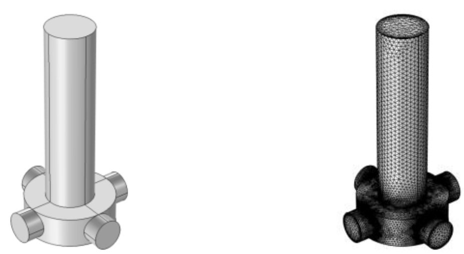

Fig. 2. Simplified geometry of the reactor and mesh discretization for the thermal, CFD, and chemical computational analysis.

The computational modeling in the internal domain of the reactor has considered the following features:

- Compressible Turbulent 3D Flow.

- Non-isothermal flow including conduction & convection.
- Chemical species transport.
- Homogeneous chemical reactions.

A feasible model of the reactor can be achieved , and it serves as a virtual experiment to estimate temperature, heat fluxes, chemical composition, velocity fields, plasma power, performance, rates, and related quantities.

IV. Results

Fig. #3 presents the velocity field showing high velocity zones, where the highest turbulence and the highest reaction rates occurs. According to this, some geometrical variations are considered, in order to evaluate the best configuration to improve the reactor performance.

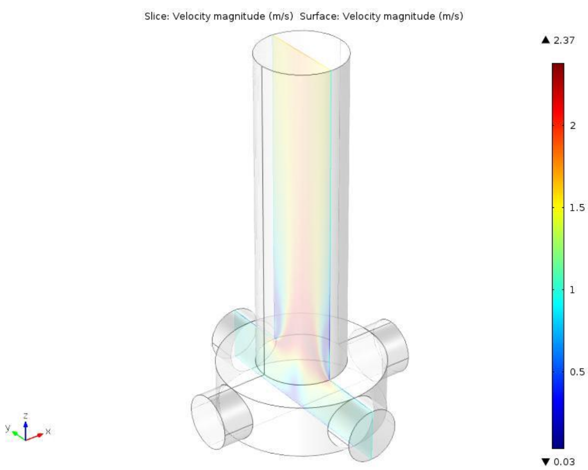

Fig. 3. Velocity field inside the gasification reactor.

Fig. #4 presents the temperature distribution in the walls, to take into account for the material specification of it. At this stage, some modifications have to be introduced in order to reduce the wall's temperature at the base of the reactor.

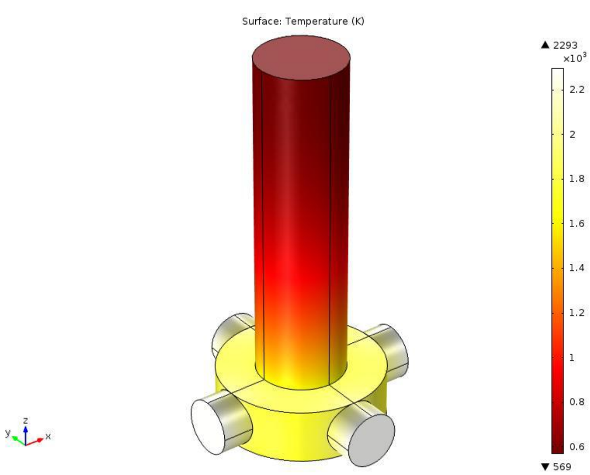

Fig. 4. Temperature distribution at reactor's wall.

Fig. #5 presents the chemical species concentration time's variation in two different scenarios, gasifying with air (fig. 5a) and gasifying with steam (fig. 5b). It serves to quantify the reaction rates, the chemical conversion efficiency and general performance of the gasification reactor, which are one's of the main parameters to optimize.

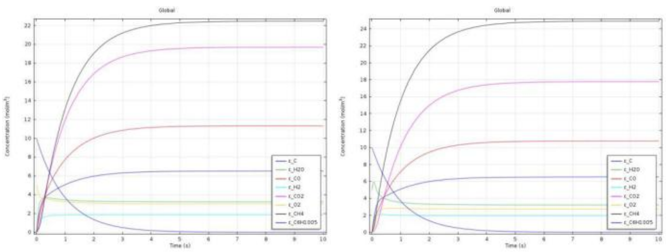

Fig. 5. Chemical species concentration variation in time, gasifying with air (5a) (left) and with steam (5b) (right).

V. Summary and Conclusions

The computational fluid dynamics are a valuable and useful tool to simulate the thermal, chemical and mechanical aspects of the gasification reactor. Although the specific model illustrated before, was not experimental validated yet, the computational model used in it was validated against other similar references [5-7].

The gasification technology is a viable solution in order to reduce the landfills demand in Costa Rica, consequently the plasma gasification technology is being researched in Costa Rica today by TEC. A plasma gasification pilot plant will be implemented soon, after the completion of the optimization and construction phases.

Future work will include variations in the geometrical and the functional design parameters, also the improvements in the chemicals models in order to optimize the design reactor, and the start of the experimental phase of the project.

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