Report on the Short Term Scientific Mission (STSM) carried out

in the frame of the COST Action CM 1404

Scientific Report

Investigation on environmental effects of biogas combustion for a possible use in industrial burners

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STSM Reference Number: CM1404 - 41726

Host Institution: Chemical Process and Energy Resources Institute (CPERI) of CERTH

Home Institution: Öztiryakiler Madeni Eşya San. Ve Tic. A.Ş – R&D and Technology Center, İstanbul/Turkey

Host Supervisor: Dr. George SKEVIS, gskevis@cperi.certh.gr

1. Purpose of the STSM

The aim of this Short Term Scientific Mission (STSM) was to establish contact with the CERTH/CPERI, as well as to obtain new references on past and present research needed to further develop the theoretical and conceptual tools used in "**Investigation on environmental effects of biogas combustion for a possible use in industrial burners**". Furthermore, as I am doing research in biogas for commercial use (experimental and modeling approach) at home Company (ÖZTİRYAKİLER), visiting CERTH/CPERI provided me with the opportunity to network with CERTH/CPERI research team, under supervisor of Dr. George SKEVIS, as well as expose, compare, and evaluate my work in relation to current relevant work being undertaken on the same research field.

Generally, the purpose of the STSM is to investigate on combustion and emission characteristics of biogas for a possible use as clean fuel in industrial burners. In this study, biogas combustion will be examined for a possible use in industrial burners. As a result of experimental observations, the optimum combustion and emission characteristics will be achieved to have clean combustion regarding biogas usage in our industrial applications. Another aim is presenting research activities of (ÖZTİRYAKİLER and CERTH/CPERI) in order to establish possible collaboration research work inside the SMARTCATs Cost Action.

2. Description of the work carried out during the STSM

a) Theoretical contextualisation of the international and European research

Updating the theoretical framework of the research task, collecting newest results from CERTH/CPERI research team which are published in sci journals

b) Research contextualisation in the host (CERTH/CPERI) research team

The CERTH/CPERI research team, George SKEVIS, developed an experimental setup and a model for a biogas semi-industrial burner. Dr. George gave me an opportunity to extend my research about environmental effects of biogas combustion modelling, by exchanging experience, knowledge and by sharing methodologies and results. In particular, I was able to learn about the analysis and explanations they found in their researches in order to improve my interpretation of the results. The discussion and comparison was undertaken considering theoretical and experimental aspects relating to environmental effects of biogas combustion for a possible use in industrial burners.

3. Description of the main results obtained:

STSM mission focused on the environmental effects of biogas combustion to understand the biogas combustion mechanisms. The use of biomass and waste products from the agriculture, has attracted partners in the world of energy generation. These wastes can be converted to solid, liquid, or gas fuels that are capable of creating energy as a renewable sources of energy. Certain agricultural waste products are rich in moisture and can be efficiently converted to produce biogas consisting of mostly methane, a highly flammable gas.

Most digesters are anaerobic in nature, meaning that they perform their work in an airless environment. Digesters are inhabited by four or more different types of bacteria in a sealed environment. As waste matter enters the digester, the first bacteria starts breaking down the material into simpler components. The second bacteria takes the materials that were created by the first and breaks them down even further as they take their sustenance. The process continues through the entire group of symbiotic bacteria until the material that comes out the end of the digester is a dry plug of solid matter that can be burned in a furnace or to power a generator and biogas which is then used to run the engines of electrical generators that are capable of supplying power, cooking and heating water, as well as providing heat to maintain the digester at an optimum temperature for the bacteria inside.

The environmental impact of such a system is that it removes waste material that would be a potential source of pollution and converts it into usable energy. Biomass and biogas technology has helped to improve the quality of our environment by eliminating usable wastes that would otherwise accumulate and become a major source of pollution and possible contamination.

There aren't systematic and comprehensive studies to investigate environmental effect of biogas combustion systems for a possible use in industrial burner. In this study, various biogas compositions and burner hole diameters were examined and the most suitable design for a biogas burner were obtained. As a result of numerical simulations and experimental observations, the best optimum configuration was chosen for applying in industrial burners.

There are several studies on environmental effects of biogas. Some of them are related to its detailed combustion and calculations while others focused more on the designs to improve the devices such as burners that utilize as a fuel in an efficient way.

The urgency of reducing Greenhouse gas (GHG) emission is increasing and countries around the world have begun investing a substantial amount of resources into renewable energy sources. Biomass co-firing can have a very influential role in achieving this new energy target as it can reduce the potential environmental impacts associated with the combustion of fossil fuels. Greenhouse gases such as CO_2, NO_x, and SO_x emissions can be reduced by replacing a portion of coal with biomass during co-firing. [1].

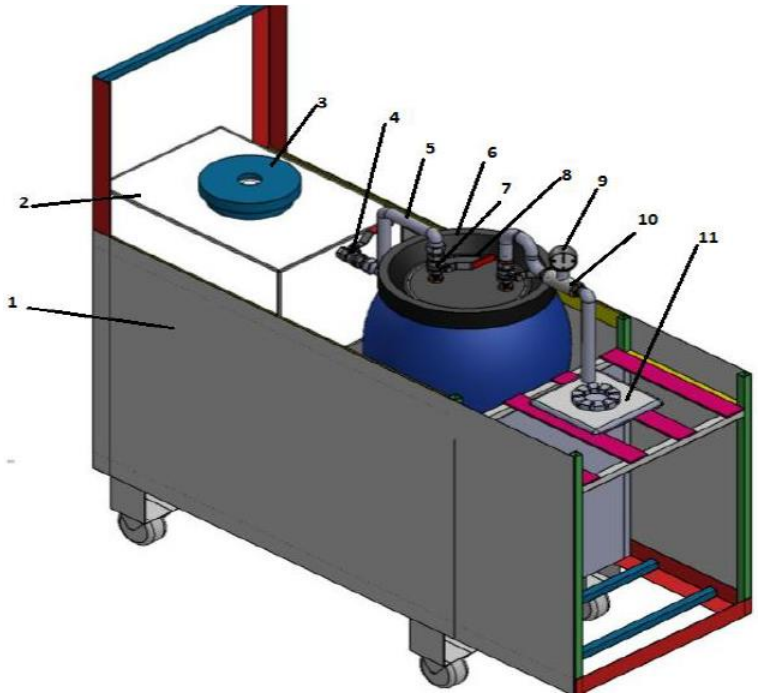
The stability of turbulent non-premixed biogas flame was studied experimentally by varying the fuel composition (i.e., changing the carbon dioxide content in the fuel, which is mainly composed of CH_4 and CO_2) and altering the fuel nozzle geometry. The results revealed that the biogas flame stability limits are highly sensitive to fuel composition in that a small increase in carbon dioxide content can lead to a significant shrinkage in the flame stability operating conditions. The experimental data with varying both the fuel composition and fuel nozzle geometry was used to develop semi-empirical non-dimensional correlations capable of describing both the lower and upper flame stability limits of both biogas and methane fuel [2].

Flame stability of premixed biogas flame for Reference Test Burner (RTB) was investigated. In this study, six kinds of test gases were used to simulate biogas in which CO_2 volume fraction varied from 30% to 45%. The intercept increases with a decrease of the CO_2 concentration in biogas and with an increase of port diameter or gas temperature [3].

Although, the brief review above reveals that while there are many studies for biogas burners in the literature, the studies about the effect of many parameters all together in a single study on environmental effects appear to be inadequate. Therefore, current study provides a detailed results and discussion on biogas environmental effects for possible usage in energy production. In this study, environmental effects of biogas is investigated combustion and emission characteristics during biogas combustion in industrial burners. As a result of experimental observations, an optimum environmental effects will be chosen for local level energy production.

RESULTS AND DISCUSSION

Within our visit, after the discussions with Dr. George Skevis and his group members, a starting design for a prototype which can be used to produce biogas on site for an experimental applications is developed. Details of the sketch is shown in Figure 1 and the details of the components of the system are shown in Figure 2. Figure 3 shows the model developed to simulate our new innovative design using biogas.



1-) Body
2-) Waste tank
3-) Waste tank cover
4-) Valve
5-) Flex pipe
6-) Buoy tank cover,
7-) Nipple
8-) Buoy tank,
9-) Manometer
10-) Filter
11-) Owen

Figure 1. Sketch of the system.

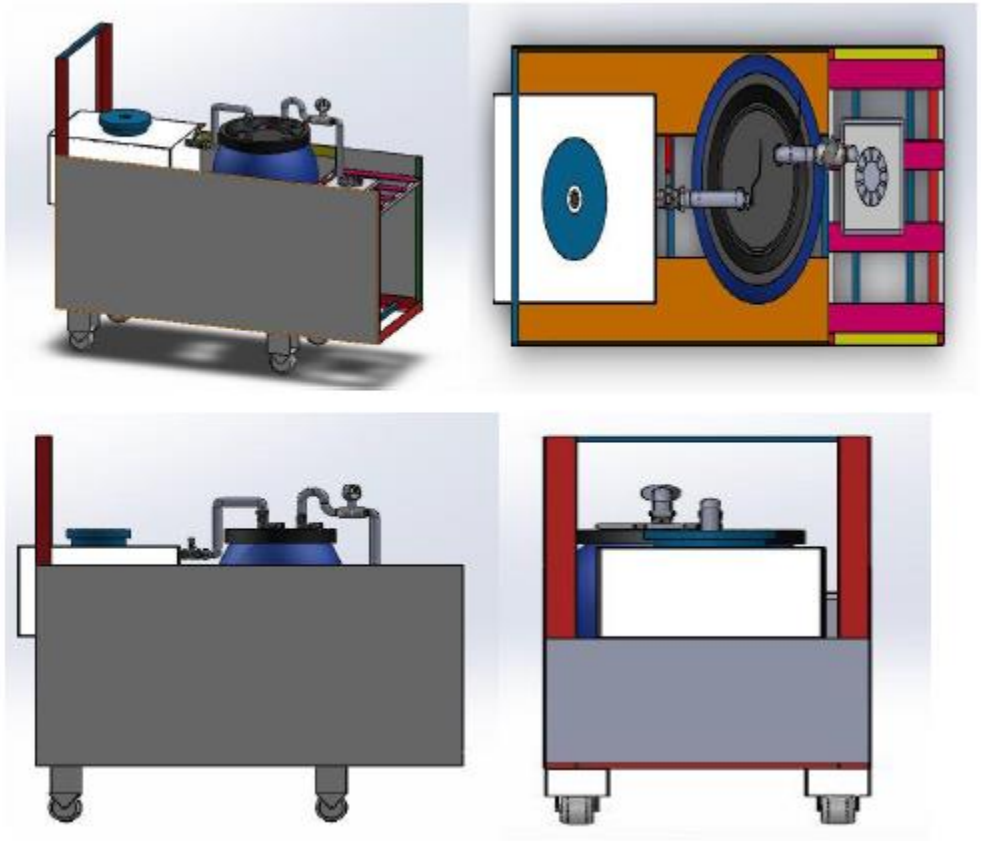


Figure 2. Details of the components of the system

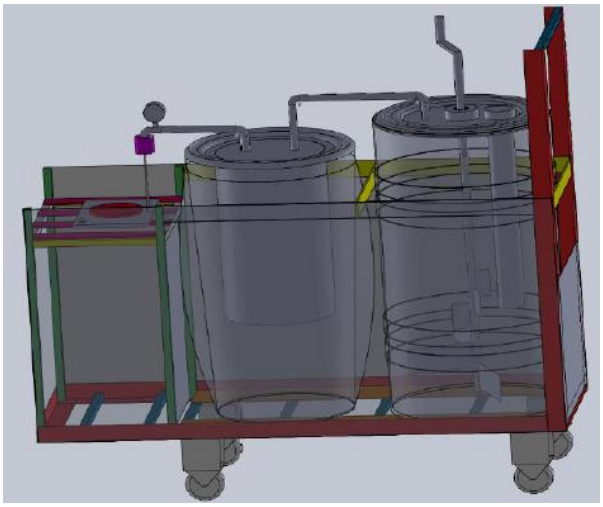


Figure 3. Model for simulation

4. How the STSM has contributed to the Action's aim

"SMARTCATs COST Action aims to set-up a Europe-wide network of leading academic and research institutions and key industries to promote the use of smart energy carriers on a large scale in order to increase fuel flexibility and carbon efficiency of energy production and to support distributed energy generation strategies", (www.smartcats.eu). Regard to mention, this STSM gave opportunity for network establishing between ÖZTİRYAKİLER and CERTH/CPERI. The plan for further collaboration work was made (experimental and modelling work exchange in field biomass and waste to energy).

5. Future collaboration with host institution (if applicable)

This mission has passed in good spirits and understanding. In the future, I will stay in contact with Dr George SKEVIS and his research team to follow up on the experimental and modeling results in field of biogas usage in industrial equipment. Further collaboration would be beneficial hopefully for both sides. In addition, proposal preparation for H2020 calls related to local level energy production will be provided.

6. Foreseen publications/articles resulting or to result from the STSM (if applicable)
Publications resulting from STSM activities must acknowledge COST Action CM1404

If further analysis of modeling and experimental observations give valuable results, hopefully results of this analysis would be published.

7. Confirmation by the host institution of the successful execution of the STSM

The confirmation letter of the successful execution of the STSM from the host institution is attached.

8. Publications resulting from STSM activities must acknowledge COST Action CM1404

YES, when I make a publication regarding this STSM activities, I will acknowledge COST Action CM1404.

I would like to express my special gratitude and appreciation to the Chair of COST Action CM1404 (SMARTCATs), Dr. Mara de Joannon, for her support during my STSM. Furthermore, I would like to record my appreciation to the MC of Cost Action CM1404 (SMARTCATs) for granting the funding to allow me to carry out this STSM. I would like to thank Dr. George SKEVIS and other members of the CERTH/CPERI research team for friendly hospitality and given support.

References

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