

# EKOMPAKT, A NEW TECHNOLOGY FOR OBTAINING ENERGY FROM BIOMASS

Prof. DSc. PhD. Lech J. Sitnik, PhD. Anna Janicka, PhD. Wojciech Walkowiak, PhD. Radosław Wróbel, PhD. MSc. Monika Andrych.

The Division of Vehicle Engineering, Faculty of Mechanical Engineering, Wrocław University of Technology, Poland  
 lech.sitnik@pwr.edu.pl, anna.janicka@pwr.edu.pl, wojciech.walkowiak@pwr.edu.pl, radoslaw.wrobel@pwr.edu.pl,  
 monika.andrych@pwr.edu.pl

**Abstract:** *In the Division of Vehicle Engineering, Wrocław University of Technology, there is realized the grant which aim is to work out the innovative compact EKOMPACT module- the installation of electric energy generation from biomass renewable resources by new technology. Research results (primarily simulation) provide necessary data for any modification of the installation in a way that the implementation of a new solution will be possible in diverse locations which are characterized by different working conditions.*

**KEYWORDS:** BIOMASS, MODIFICATION, ENERGY

## 1. Introduction

Dynamic, global economy development implicates huge market demand for installations generating electric energy from renewable resources in a way that does not have any negative effects on the environment.

Both in Poland and in the world, numerous scientific researches are carried out, which effect is visible in the knowledge concerning gasification processes of solid fuels of natural origins and solids of synthetic origins.

Knowable are: standard gasification technologies (among them chemism of the process, the impact of particular parameters on its progress), combustion technologies of gas received from substrates transformation, catalysts of medium and high caloric combustion of gasified gas product, technologies of heat recovering from technological processes (e.g. ORC systems), methods of combustion gases purifying, technologies of purifying and stabilizing solid products of gasification process, methods: measurement supporting chemical processes, remote control and archiving of installation working parameters.

In the currently knowable technologies, total energy extraction from the acquired fuel is not fulfilled, which is reasoned by technical-economical considerations. Scientific- technological progress is not sufficient in this case.

As an effect of project fulfilling, the new product will be implemented, which fully inscribes into existing technological gap. In the world, there is missing the technology that allows the conditioning of acquired gas and fumes in a way which safety enables their heat energy use.

Carrying out of the present project, enables to work out a new, compact module for obtaining electric energy from biomass. The novelty of this module will result from the making use of innovative technological solutions which are not currently applied in the branch.

## 2. Assumptions regarding biomass transformation process.

Standard gasification of solid fuels of natural origins and solids of synthetic origins is the issue known and well described in scientific literature. Workings over congregation systems connected with biomass gasification are pursued in the whole world, mainly in the USA and UE countries.

Experimental installation of biomass gasification for obtaining electric energy are launched by such companies as:

- Institut für Wärmetechnik w Graz (Austria) – demonstrative installation, gasification in solid bed, gas engine Jenbacher company 38 kWe power (electric energy) [1],

- Blackwater Valley Energy (UK) - demonstrative installation, downdraft gasification of 200kWe power [2],
- Xylowatt (Switzerland) – downdraft gasification, heat interchanger, filter, mud of 55kWe power[3],
- HKV Hogild (Dannemark) – two-sided gasification, heat interchanger, filter of 120kWe power, [4],
- KHD Koln (Germany) - two zonal gasification, mud of 38kWe power, [5],
- Hermogenics Albuquerque (USA) - downdraft gasification of 300kWelectric energy power. [6],
- A.H.T. PyrogasVertriebs GmbH (Germany) - multi zonal gasification modules 50-500 kWe, [7].

EKOMPACT is technology of new pro energy process of biomass energy extraction together with the elimination of wastes.

Project fulfilling enables to work out a new installation module for the process fulfilling.

The novelty of process results from making use of innovative technological solutions which are the issue of the project. The innovation results from carrying out of the process in a way that, there will be fulfilled its subsequent functions:

- Biomass conditioning
- Double phase gasification (the first- pyrolysis where the heat is provided to biomass by radiation, the second- gasification of fluid and solid products by overheated steam)
- Conditioning of gas as fuel (the quality of gas is researched on-line, gas purification and mixing it with other gases in order to obtain the particular mixture parameters),
- Conditioning of fumes (the quality of fumes is researched on-line, for utilization the catalytic systems will be used, among them the DENOSOX system of catalytic denitrifying, desulfurization of fumes)
- Utilization of process solid holdovers to the environmentally harmless form.
- Management of heat energy stream,
- Piloting (individual piloting of each system; integrated piloting of installation system based on mathematical models; working monitoring piloting of particular piloting systems, which when necessary takes its role with the use of artificial intelligence and fuzzy logic when it is ended; piloting in actual time through the use of signal processes).

What is more, electric energy will be obtained in both generator powered by engine and by the multisided use of holdovers heat. Currently working installation for renewable resources gasification does not have such advanced solutions which enable the high electric energy yield with low harmless in the environment.

## 3. General project conception description

The aim of the project is development of an innovative, on the world scale, compact module for obtaining electric energy mainly from biomass.

The effect of project fulfilling will be the activation of demonstrative installation and testing of compact module EKOMPACT in

which all system elements will be integrated in one standard container.

The results of demonstrative installation researches will provide necessary data for any process installation modification in order to make the implementation of a new solution in various locations, characterized by different working conditions, possible.

Expected economic effects result from introducing the new product into the market and they are supposed to enable the multiple turn of outlays borne for B+R workings in five years from the project beginning.

After finishing the project, the demonstrative installation will be used for pursuing further B+R working which aim will be, among others, obtaining synthetic fuels from biomass.

#### 4. Research tasks expected for fulfilling in the project

The key research tasks includes the verification of:

- Installation working on the basis of biomass wastes, which will produce electric energy for sale ( positive energy balance) and selling solid product ( installation will work without wastes),
- Construction of the reactor for biomass from wastes gasification, which produces medium caloric gas and fluid that after conditioning will be suitable for feeding engine of unit generating electric current ,
- Internal combustion engine modification in a way allowing it to work efficiently and stably while powering it by conditioned gas regardless the type of biomass that empowers the gasifying reactor,
- Unit of biomass dosing and unit of purifying exhaust gases in a way allowing them to be efficient during working of installation empowered by different types of biomass,
- Unit of separating and packaging of wastes from products, to make them obtain solid form which will be possible for transferring it to the natural environment,
- Piloting-measurement system to make possible the semiautomatic, optimal installation working with remote control of its exploitation.

#### 5. Description of researching methods and techniques applied in the project.

Within the frames of fulfilling the project, the following researching methods have been applied:

- Chemical analyses ( among them chromatographic ones): chromatographic (GC-FID, GC-MS), spectrometric, usefulness of biogas as engine fuel, waste after gasification process. The analyses will be performed with the use of devices from Pracowni Badań Emisji PWR equipment
  - Quality and quantity parameters evaluation: biogas, fumes, process wastes
  - Toxicological analyses concerning cytotoxicity of fumes emitted from EKOMPACT device (according to PN-EN ISO10993-5). For the researches the line of cell from human lungs lining ((ATCC CCL185).
- Evaluation of fumes toxicity by the use of equivalent toxicity quotient methods,
  - Toxicity evaluation of fumes emitted form installation (actual toxicity)
  - Evaluation of systems for fumes purification efficiency.
- Researches over engine roller performance tester: Engine studies on unique, complexly equipped roller performance tester location dedicated to studies of engines empowered by gas fuel with the system of analyzers based on reference methodology.
  - Methodology of matching engine to EKOMPACT device.
  - Authorial methodology of internal catalyst of combustion process implementation according to method pa-

mented by project authors relying on catalytically active substance introduction into the inside of engine combustion chamber ( on a special, optimized mover) what enables

- Shortening of ignition delay of biogas and air mixture in engine, r
- Carcinogenic emission reduction.
- Thermal characteristics of devices studies: Researches with the use of thermo vision cameras and apparatus for heat inspection which are among the equipment belonging to The Division of Vehicle Engineering, Wroclaw University of Technology.
  - Evaluation of process pursuing parameters and thermal characteristics of devices in the container.
- Numerical simulations: MES- computer calculating programs which use the MES method in static, dynamic, modal analysis issue.
  - Durability calculations of device and units elements and their numerical optimization
  - Numerical CFD simulations, calculations of: turbulent flow, stationary and non stationery, multi phase: flows with cavitations
  - Heat flow modeling
  - Combustion processes calculations,
- Proliferation of pollution indicating- flow with constant phase.
  - Calculations of gas ang heat flow inside device and its units with numerical optimization of these processes.
  - Numerical simulations CHEM-CAD: numerical modeling of chemical reactions which take place during gasification phase and engine combustion.
    - Process optimization according to chemical reaction process in gasification and combustion process of mixture of known quality and quantity composition, in order to develop device working mode.
  - Numerical simulations MBS (Multibody Symulations): numerical kinematic-dynamic modeling.
    - Optimal packaging of devices and units in container.
- Vibrant acoustic analyses:
  - Acoustic object researches: assignment of pressure level and acoustic power, location of sound sources with the use of probe and acoustic holography.
  - Object vibration research: spectral analysis, modal analysis. In the researches there is planned making use of application for non stationary acoustic holography, impulse hummer of strength detectors, accelerometers 3-axial PCB-ICP, multichannel dynamic signal analyzer, low frequency microphones, sound level meter with G filter.
  - Optimizing of device according to minimizing noise and vibrations emission.

#### 6. Conclusions

Module EKOMPACT will be a total novelty in the world market. This module, currently, does not have any equivalent which would enable the high yield of electric energy together with providing, at the same time, huge possibility of installation modification for each of users, in order to its optimal adaptability for requirements of localization and charge. There will be implemented the series of totally innovative conceptions and solutions, which will cause the creation of new market for new product.

In development workings it is also predicted the use of gathered experiences for creating future installation generating synthetic, hydrocarbon fluid fuels from biomass gasification ( according to new synthesis processes).

Predicted economic effects, connected with introduction of a new product in the market, enable the multiple turn of outlays borne for B+R workings in five years from the project beginning.

The implementation of new technology confirms the inception of new, stable work places for high qualified people in the European Union.

## **7. Literature:**

- [1][http://www.energetische-biomasse-nutzung.de/fileadmin/user\\_upload/Optmierung\\_Achental/Dokumente/SNG-Stand\\_der\\_Technik.pdf](http://www.energetische-biomasse-nutzung.de/fileadmin/user_upload/Optmierung_Achental/Dokumente/SNG-Stand_der_Technik.pdf)
- [2][http://www.ieatask33.org/app/webroot/files/file/country\\_reports/IEA\\_Task33\\_UK\\_CReport\\_June\\_2006.pdf](http://www.ieatask33.org/app/webroot/files/file/country_reports/IEA_Task33_UK_CReport_June_2006.pdf)
- [3]<http://www.xylowatt.com/>
- [4]<http://hogild.dk/>
- [5]<http://www.aht-pyrogas.de/de/component/content/category/86-ah-t-auf-deutsch/>
- [6]<http://www.thermogenics.com/>
- [7]<http://www.thermogenics.com/>