CONCEPTUAL SOLUTION OF TECHNOLOGY LINE FOR FUEL PRODUCTION FROM BIODEGRADABLE COMMUNAL WASTE

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ABSTRACT

Our objective was to design a conceptual solution of technology line for fuel production based on biodegradable communal waste. The article contains analysis of default state of art and restrictive conditions of the design, block diagram of the technology line and basic conceptual design of calculation of the energy balance of the system.

Key words: biodegradable waste, aerobic fermentation, waste technology, fuel

INTRODUCTION

Biologically degradable communal waste is one of the main components of communal waste. Following the outputs of Czech Statistical Office there were 3,232 thousand tons of communal waste produced in Czech Republic in 2012 from which 1,505 thousand tons is biodegradable communal waste (1,645 thousand tons in 2011). This volume is then ca 47 % of all the communal waste produced annually in Czech Republic. Communal waste is nowadays from 56,5 % disposed with landfilling, ca 20 % is disposed using thermic processes and only ca 2,6 % is composted. The statistics don´t publish the rate of other methods of disposal (disposal in biogas plants, other ways).

Communal waste (CW) management
Tonnes

	2007	2008	2009	2010	2011	2012
CW landfilled	2 120 528	2 057 429	2 113 893	2 161 801	2 167 041	1 827 868
CW incinerated with energy recovery	388 681	367 470	369 953	494 949	607 222	651 563
CW incinerated without energy recovery	1 646	1 723	2 120	2 152	2 618	2 834
CW recycled	276 075	279 849	352 787	451 765	495 695	665 279
CW composted	30 444	50 187	55 712	75 724	73 762	85 099

Tab. 1 CW management rate 2012 - source: Czech Statistical Office Annual Report 2012

Biodegradable waste so makes significant part of communal waste and the usage, especially for power generation is nowadays still insufficient and represents a large potential of research, design and subsequent application in waste management praxis.

MATERIAL AND METHODS

VIA ALTA company in cooperation with Faculty of Agronomy of Mendel University, Brno are starting a development project focused on development and design of complex technology line for production of fuel usable for power generation based on raw biologically degradable communal waste. Raw material is meant a mixture of biodegradable waste obtained through separated waste collection and/or post-collection waste sorting with no other physical (humidity, fraction, homogenisation etc.) and chemical or biological (fermentation, digestion etc.) processing. The objective of the project is to provide a facility which can be operated in market praxis and which has raw biologically degradable waste on input (including food waste which is more regulated by Czech legislation from the process and hygienic point of view) and on output a material suitable for direct combustion in power generation facilities either in the form of loose mixture or with subsequent shape or handling treatment (pelletizing, briquetting).

The facility (device) should meet some basic requirements for the operation and the output quality, which in the end drives the development to a complex optimisation task with following criteria:

Physical parameters:

- minimization of the relative humidity of the output mixture
- maximization of the homogeneity of the output mixture
- minimization of the particle size of the mixture
- maximal hygienic safety of the input and output mixtures

Chemical parameters:

- maximization of combustible compounds and carbon factor of the output mixture
- minimization of the concentration of heavy metals (to minimize the hazardous properties when used as a fuel in house heating)
- minimization of the compounds causing the sintering of ashes, respectively lowering the melting point of the ash
- minimization of the concentration of compounds causing chlorine, SO_x, NO_x and other emissions production

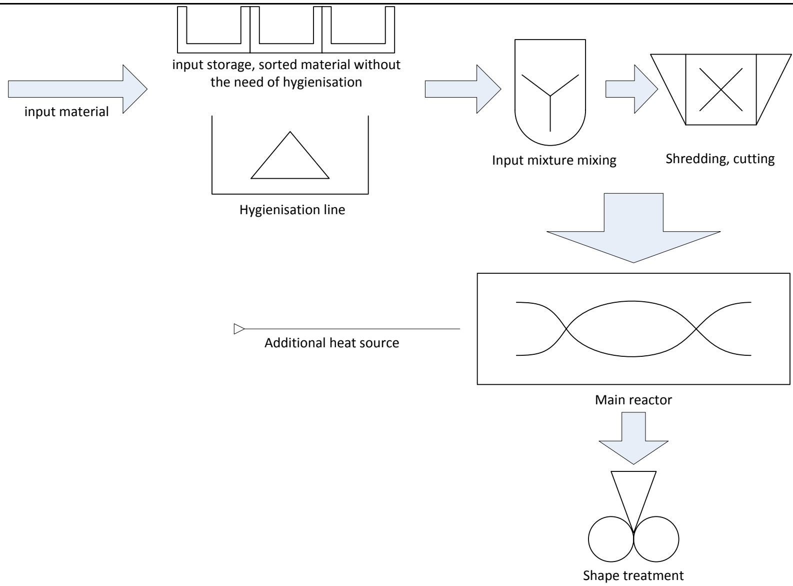
Technical-economic parameters:

- positive energy balance of the device/facility
- positive economic balance of the device/facility
- mobile or semi mobile device/facility

Within the first thesis of the development project there was a block scheme of the planned device designed, respecting particularly fulfilling of physical and technical-economic requirements. Another research project in parallel is developed for fulfilling the chemical parameters – this project is held on the Blansko composting facility.

The block scheme of the planned device is based on the basic requirements and is using following technical operations and processes to fulfil the defined parameters and requests above:

- preparation of the material – hygienisation – process to fulfil the legislation requirements for food waste processing and disposal
- preparation of the material – mixing, shredding in order to obtain homogenous input mixture
- logistics and manipulation in device – conveyors among the parts of the technology, ensuring fluent operation and fulfilling the legislation requirements for safe operation
- main reactor – cylindrical reactor ensuring mixing (aerification), artificial aerification, outlet of humid warm air to air-air heat exchangers to dry air for forcing the dehumidification process
- source of additional heat – according to the energy balance there shall be a need of additional heat (boiler, thermal panels, heat pumps, output of waste heat from CHP etc.)
- final shape treatment (pelletizing, briquetting)



Pic. 1 Block scheme of the device/facility

ENERGY BALANCE OF THE TECHNOLOGY

The main parameter of feasibility of whole development project and following successful operation is the detailed review of energy balance of whole system and then strict observance of positive energy balance in all phases of development. In the technology there is crucial to abide the default assumption that the price of additional heat added to the system for final dehumidification and supporting processes must be lower than the price of input material waste disposal fees (paid by the customer).

The basic shape of the energy balance is following:

$$E_{mat} + E_{sup} + E_{add} + E_{ferm} = E_{mat.d.} + E_{H2O} + E_{los}, \text{ where} \qquad [1]$$

E_{mat} [GJ] ... internal energy of humid material (input; GCV)

E_{sup} [GJ] ... supporting energy – manipulation, instrumentation and control etc.

E_{add} [GJ] ... additional energy – heating, dehumidification

E_{ferm} [GJ] ... energy of thermophillicfermentation (mean surplus of energy brought by fermentation process to original material “internal” energy)

$E_{mat.d.}$ [GJ] ... internal energy of dry material (output; GCV)

E_{H20} ... energy needed for evaporation of water from material

E_{los} ... energy losses of heat exchangers, surroundings, convection and conduction of heat

Focusing on the economic profitability of the technology the key parameter is the ratio between the additional energy, the energy of thermophillic fermentation and the energy needed for evaporation of the water from the material. The necessary condition is that the additional energy must be minimal, so

$E_{sup} + E_{ferm} = E_{H2O}$ and E_{sup} shall be minimal. [2]

This is the basic presumption for the whole facility device and its success and it is the main challenge on the next stage of development of the technology.

During the theoretical design calculations there is a possibility to calculate (with sufficient accuracy)the need of energy for evaporation of the water from the material if the input relative humidity and required output relative humidity is known [2]. Based on these calculations, with knowledge of the amount of energy released during thermophillic fermentation reduced by the loss energy in conduction, convection and exchange of heat there is a possibility to calculate the amount of additional energy. This calculation is subject of next phase of the project development.

CONCLUSIONS

During the first block design of the technology the technic feasibility was confirmed, the boundary and restrictive conditions were identified and new challenges to solve during the project development were placed. There were the theoretical starting points for subsequent energy balance evaluation and capacity planning found out respecting mainly its future economically rational operation.

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