Journal of Polish CIMAC
Gdansk University of Technology
The Faculty of Ocean Engineering and Ship Technology

# RENEWABLE FUELS - ADDITIONAL SOURCE OF HEAT ENERGY

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***Abstract***

*There is proposed a way of usage of dried sewage sediment with 90 % of dry mass as fuel to co-incineration with rape straw and next submitted to the process of gasification in order to increase the efficiency of the process. The purpose of putting into use that kind of fuel is to increase the possibility to obtain additional energy resources. The results of research on usage of fuel from sewage sediment and straw were presented.*

***Keywords:*** *biomass, dried sewage sediment, coburning/coincineration, gasifying, thermal process, heat*

## 1. Introduction

Signing by Poland Kyoto Protokol In 2002 introduces the duty of reduction of greenhouse gases and industrial dust emissions. Also EU supports these issues by introduction of Instruction 2001/77/WE on electric energy production generated in renewable energy sources. The regulation of Ministry of Economy, Work and Social Politics dated 30$^{th}$ May 2003 on particular duty of purchase of electric energy and heat from renewable energy sources and electric energy generated in the matching with heat generating what as a result gives the possibility of co-incineration of fuels.

All over the world the resources of biomass are estimated at the level of 280 EJ/year and are 6 times higher than the rate of their usage. And the increase of biomass production is connected with necessity of assignment of large areas of soil for energetic plants cultivation. World`s biomass resources at present constitute from 9÷13% of energy requirements.

Statistical data show clear rising tendency as for the amount of communal and industry sediments for management. It is estimated that in 2015 the stream of mass will reach 720 Mg of dry mass/year. The management of sewage sediments has been limited to their disposal, composting, remanagement in agriculture as fertilizer or further processing with usage of thermal methods. Sewage sediment in waste water treatment plant undergoes fermentation process so as to use it for biogas production and burning it in gas generators.

The basic purpose of employed renewable fuel is assignment of parameters of gasifying of mass in the form of rape straw and dried sewage sediment of 90% of dry mass in various mass proportions and burning the obtained synthesis gas. The obtained research results may undergo comparison analysis with other types of biomass to estimate usability of used fuel for energetic purposes.

## 2. Sewage sediment

Drying of sewage sediments constitutes the basic condition enabling their potential management as fuel. Burning of dehydrated sediments after pressing, with moisture in the range of 75÷84% is virtually technologically impossible process and economically inefficient. Sediment with that high moisture can be disposed in landfills or, if it fulfils requirements, it is used as fertilizer in forestry and agriculture. It depends on possibilities of its management in the region where there is waste water treatment plant, on content of hazardous elements e.g. heavy metals and sale conditions.

Drying of sediment is extremely energy-consuming technological treatment. But heat for drying can be obtained by burning of biogas from sewage fermentation.

Treating part of sewage sediment as biomass and giving it thermal transformation it would allow to obtain extra energy. From sewage sediment which undergoes the process of evaporation we obtain organic fertilizer in the form of granulate of value 90% of dry mass.

Dried sewage sediment may be used again for co-burning as a mixture with wastes of wood, rape and rye straw, pine bark, willow Salix viminalis, and Pensylvanian mallow Althea and coal in various volume and mass ratio.

Heat of burning of sewage sediment is 17 MJ/kg for containing 70% of volatile substances. But for dried sewage sediment the burning value is about 14 MJ/kg. Dried sewage sediment is free from heavy metals but contains large amounts of ashes constituting about 35%.

From the definition of instruction 2001/77/WE dated 27th September 2001 results that term: biomass means susceptible for biological decay fractions of products, wastes and other agricultural industries wastes (together with vegetable and animal products), forestry and relative with it industries branches as well as fraction of industry and municipal wastes susceptible for biological decay.

Co-incineration of dried sewage sediment with biomass will allow to improve energetic rating and biomass in that form would be more attractive fuel. That mixture of biomass may be gasified what will increase cost-effectiveness and efficiency of burning. Dried sewage sediments consist of components which can be used for further management e.g.in the process of co-incineration with other materials.

## 3. Straw

The implementation of burning technology of unconventional renewable fuel which is rape straw will in practical application contribute to limitation of environment contamination with wastes and hazardous products of burning containing harmful nitrogen and sulfur compounds. So there is a necessity of research to increase knowledge about running of thermodynamic processes of rape straw burning and the use of the knowledge at the same time for improvement of equipment for incineration and techniques of raw material preparation.

Obvious is the fact that to obtain high efficiency of burning rape straw there is a need of pressure agglomeration of rape chaff called briquetting. The treatment, although energy-consuming, increases energetic attractiveness of this form of fuel as a result of increased density, reduced moisture, made distribution easier as well as storage and burning in conventional furnaces. The second premise resulting from the observations and experiences so far is the necessity to use boilers of special construction enabling the usage of pyrolysis of fuel charge. Thanks to fuel pyrolysis the energetic and ecological efficiency will increase as a result of temperature rise in the burning of fuel sphere and products of pyrolytic decomposition of briquettes from rape straw. The improvement of running of renewable fuels burning in the natural state may be achieved through pressure agglomeration called briquetting. The primary form of fuel undergoes the treatment improving its properties. The processed rape straw in the form of briquette is homogenous, has

stabilized heat, density and moisture parameters. Burning briquettes runs without disturbances in the determined conditions with the high thermal efficiency of thermic processes and conversion of chemical energy of the fuel for heat.

Agriculture production brings harvest in the form of straw in the amount of 25 mln tons/year but large amount is used as bedding, feed, or component of organic fertilizer used in animal production. Since the beginning of 1990s, particularly in north-western part of Poland, in the areas of ex-national farm production units(communistic cooperative farms) the surplus of straw has been rising and thus the potential of straw as fuel used in power engineering consisting now 195PJ, out of which 150 PJ is from cereal straw, and the rest of agricultural wastes consist rape straw and hey. If from the earlier mentioned 25 mln tons of straw, 50% could be used for energetic purposes(12,5 mln tons) it is possible to save about 5 mln tons of coal/year when thermal value of straw is supposed at the level of 16 MJ/kg. One should also take into consideration the profits connected with less contamination of environment.

Straws characterizes with neutral balance of carbon dioxide emission, much smaller is emission of sulfur dioxide, and emission f nitro gen oxides is AT the comparable level. Thermal value of straw depends on such factors as moisture content, kind of cereal, kind of soil and way of fertilizing. Maximal content of moisture should range from 18% to 22%. Total use of surplus of straw production may cover 4% of requirements for primary /original energy. Chemical energy of 1kg of straw with 15% of moisture constitutes 14,3 MJ what corresponds to chemical energy contained in 0,81 kg of combustible wood or 0,41 $m^3$ of high methane earth gas.

Thermal efficiency of biomass gasifying may be counted from:

$$\eta_z = \frac{v_{g\,pal} \cdot Q_{wg_{pal}}}{Q_{wp}} \tag{1}$$

where:

$v_{g\,pal}$ - volume of combustible gas as the result of gasification 1 kg charge in $\frac{m^3 n}{kg}$,

$Q_{wg_{pal}}$ - fuel value of combustible gas is 4,6 ÷ 5,0 $\frac{MJ}{m^3 n}$,

$Q_{wp}$ - fuel value of fuel charge in $\frac{kJ}{kg}$.

Gas generated in gasifying chamber may be burnt in burning chamber and the emitting heat used for heating in air heat exchange or water or for water steam generation. Obtained gas after cleaning and cooling may be used as fuel for diesel engines.

Thermal conditions and the way of regulation of fuel pyrolysis decide about the amount of obtained decay products. Temperature regulation of processes in individual phases influences the speed of pyrolysis and composition of generated gas and process efficiency. Great influence for/on pyrolysis effects has the kind if biomass.

## 4. Research on usage of fuel from sewage sediment and straw

Research of co-burning of rape straw with dried sewage sediment of 90% of dry mass were conducted for various percentage proportions of fuels fraction. Measures were conducted in air heater VIGAS-25N,where there was used double row heat exchanger of dimension 57x5 mm of 6 items in each row. The following percentage proportions of dried sewage sediment were taken: 20% and 40%. For research portions of fuel of 5 kg mass were taken co-incinerating percentage partitions for individual biomasses. For the suggested fuel proportions from biomass were assigned: burning heat, fuel value, contents of ashes, density, moisture, contents of volatile fractions. Measures of analysis of exhaust fumes were done. Measures results are presented in tables 1 to 3 and graphically on charts.

*Table 1. Results of exhaust fumes analysis during burning of biomass and sewage sediment*

| Parameter | Unit | Fuel | | | |
|---|---|---|---|---|---|
| | | Rape straw | Sewage sediment | Straw 80% and sediment 20% | Straw 60% and sediment 40% |
| $O_2$ | % | 8,7 | 15,9 | 16,8 | 15,1 |
| CO | ppm | 1654 | 1776 | 3725 | 3509 |
| NO | ppm | 30 | 169 | 115 | 232 |
| $NO_2$ | ppm | 0,0 | 0,0 | 0,0 | 0,0 |
| NOx | ppm | 27 | 169 | 113 | 230 |
| $SO_2$ | ppm | 0,0 | 0,0 | 0,0 | 0,0 |
| Chimney losses | % | 15,3 | 19,1 | 25,9 | 25,5 |
| λ | | 16,7 | 4,11 | 4,95 | 3,55 |
| $CO_2$ | % | 1,4 | 3,3 | 2,8 | 3,9 |
| $H_2S$ | ppm | 0,0 | 0,0 | 0,0 | 0,0 |
| $H_2$ | ppm | 2450 | 669 | 3633 | 3638 |
| Draught | mbar | 0,0 | 0,0 | 0,01 | 0,0 |
| E | % | 77,6 | 80,9 | 74,1 | 74,5 |
| Air temp. for burning | $^oC$ | 16,9 | 24,5 | 17,9 | 18,9 |
| Temperature of combustion gas | $^oC$ | 231,1 | 169,6 | 189,0 | 241,6 |

Boiler-room with boilers straw-fired with power of 1MW burns about 800 Mg of straw during one heating season as it is known rating of straw to coal is that for 1,5 kg of burnt straw we burn 1,0 kg of coal. Thus burning of 800Mg of straw replaces 533 Mg of coal. During burning of 1Mg of coal we generate about 2,05 Mg $CO_2$. Replacement of coal with straw reduces emissions of $CO_2$ of 1.100 Mg per year.

*Table 2. The amount of heat and energy obtained from gasifying of biomass for rape straw and dried sewage sediment of o content 9% of dry mass (listing for fuel of total mass 5kg )*

| Kind of biomass | Heat kJ | Stream of heat kJ/h | Energy kWh |
|---|---|---|---|
| Rape straw 100% | 6943,710 | 1,5107 | 16,278 |
| Dried sewage sediment of value of 90% dry mass | 5257,090 | 0,4867 | 13,410 |
| Rape straw 80% fraction and dried sewage sediment 20% fraction | 2275,255 | 0,2632 | 13,541 |
| Rape straw 60% fraction and dried sewage sediment 40% fraction | 1910,555 | 0,2033 | 12,546 |

*Table 3.Technical analysis for rape straw and dried sewage sediment of content 90% of dry mass depending on percentage content of fractions for individual fuels*

| Kind of biomass | Moisture content % | Ashes content % | Hydrogen content % | Volatile Parts content % | Burning heat kJ/kg | Combustible value kJ/kg |
|---|---|---|---|---|---|---|
| Rape straw | 15,050 | 1,970 | 4,660 | 69,710 | 15880 | 14495 |
| Dried sewage sediment – 90% of dry mass | 10,90 | 32,80 | 3,127 | 53,290 | 13350 | 12401 |
| Rape straw 80% fraction and dried sewage sediment 20% fraction | 7,128 | 10,649 | 4,567 | 73,632 | 14422 | 13251 |
| Rape straw 60% fraction and dried sewage sediment 40% fraction | 6,506 | 16,540 | 4,275 | 68,854 | 13656 | 12564 |

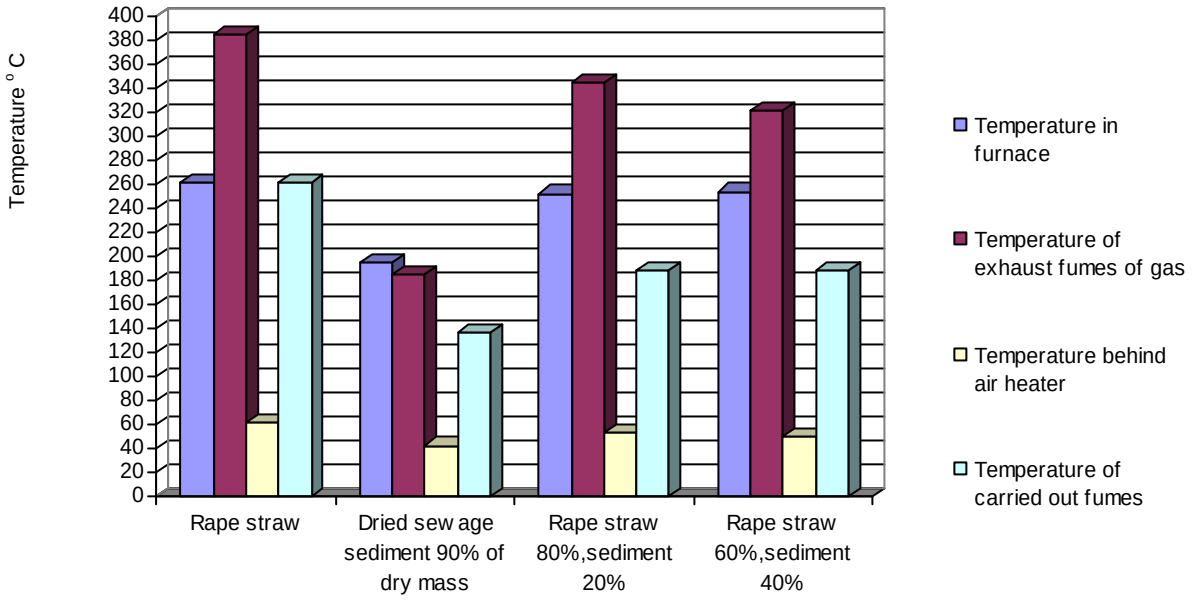


*Chart 1. Temperature depending on percentage contents of biomass*

## 5. Summary

The surplus of biomass and sewage sediment will force the search of new solutions so as to its proper management and usage. The instruction approved by EU saying about the fraction/partition of renewable energy in the general energy production, for Poland will extort/force activities connected with more efficient usage of energetic potential of straw as well as sewage sediment.

The presented research shows possibility to use ripe straw and dried sewage sediment for co-burning in the rate 20% to 40 %. With bigger rates proportions co-burning is not profitable because of low fuel quality.

The presented research show possibilities of rape straw usage and sewage sediment for co-incineration in the rating 20% to 40%. With bigger rating of co-burning is not profitable due to low combustible value.

Co-burning of both fuels is profitable assuming that moisture of rape straw is below 15% and dried sewage sediment is 10%. However one has to remember that the process of sediment drying till obtaining such parameters is energy–consuming one. Rape straw after pressure agglomeration is an ecological fuel of full value possible to use in heat engineering with the usage of dried sewage sediment with content 90% of dry mass.

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