POSSIBILITIES OF ENERGY RECOVERY FROM MUNICIPAL WASTE

MOŽNOSTI ENERGETICKÉHO VYUŽITÍ KOMUNÁLNÍHO ODPADU

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Abstract

The article summarizes possibilities of energy recovery from municipal waste. It describes the history of incineration and energy recovery from municipal waste in Czechoslovakia and then in the Czech Republic. The attention is paid to the three currently operated plants for energy recovery from municipal waste in the Czech Republic (ZEVO Malešice, SAKO Brno and TERMIZO Liberec). The following are the characteristics of the planned plants for energy recovery from municipal waste in the Czech Republic. All these plants operate essentially based on grate boilers with flue gas treatment at the highest technical level. The article also lists other technologies which can be used for energy recovery from municipal waste – these are gasification and pyrolysis units and plasma technology. The conclusion of this contribution is devoted to the current and future situation in the area of energy recovery from municipal waste in the Czech Republic with regard to the applicable legal standards.

Abstrakt

Příspěvek shrnuje možnosti energetického využití komunálního odpadu. Popsána je historie spalování a energetického využití komunálního odpadu v Československu a poté v České republice. Pozornost je věnována třem v současnosti provozovaným zařízením na energetické využití komunálního odpadu v České republice (ZEVO Malešice, SAKO Brno a TERMIZO Liberec). Dále jsou uvedeny charakteristiky připravovaných zařízení na energetické využití komunálního odpadu v ČR. Všechna uvedená zařízení pracují v zásadě na bázi roštových kotlů s čištěním spalin na nejvyšší možné technické úrovni. Příspěvek také uvádí další technologie, které je možno využít pro energetické využití komunálních odpadů – jedná se o zplyňovací a pyrolýzní jednotky a plazmové technologie. Závěr příspěvku je věnován současné a budoucí situaci v oblasti energetického využití komunálních odpadů v České republice s ohledem na platné právní normy.

Key words: municipal waste, energy use, boilers, gasification, pyrolysis, plasma technology

1 HISTORY OF INCINERATION AND ENERGY RECOVERY FROM MUNICIPAL WASTE IN OUR AREA

The **first municipal waste incinerator** with energy recovery was built in the Czech Republic in Brno in 1904-1905 (see Fig. 1). The incinerator had seven combustion chambers in conjunction with the Babcock-Wilcox steam boiler, behind it the Parson turbine was integrated with an output of 300 kW, connected to a three-phase AC generator with an output of 220 kW. Electrical energy generated by the generator was conducted to the electric distribution station to the distance of 300 meters [1].

The waste went through two rotary cylinders, which crushed it into larger pieces. Thus prepared waste was stored in a reservoir. From there, the waste was manually shovelled to a tray located in the space above the combustion chambers. The incineration process took 45 minutes.

Dosing the waste was carried out at intervals of 10 minutes per 60-80 kg. In full operation, the incinerator burned an average of 27.5 tonnes of waste per day; 1 kg of waste produced about 1.14 kg of steam with a pressure of 9 atm. In the 30ies, the incinerator was extended and served its purpose until 1941, when it was destroyed during the allied air raid over the city of Brno.

The **second municipal waste incinerator** was built in Prague in 1930-1933. The Prague incinerator station of solid waste, heating and power plant were put into operation in 1934. Refuse collection vehicles carted the waste into four containers for temporary storage. Subsequently, the waste was transported to a waste sorting plant and then to a building of combustion batteries with two boilers whose capacity was 200 tonnes per day. The combustion batteries allowed for the production of 6 to 25 tonnes of steam per hour. The steam was supplied to surrounding businesses as well as to its own power plant with two turbine generators of 5 MW each. During the World War II, a next boiler with an output of 45 tonnes per hour was built.

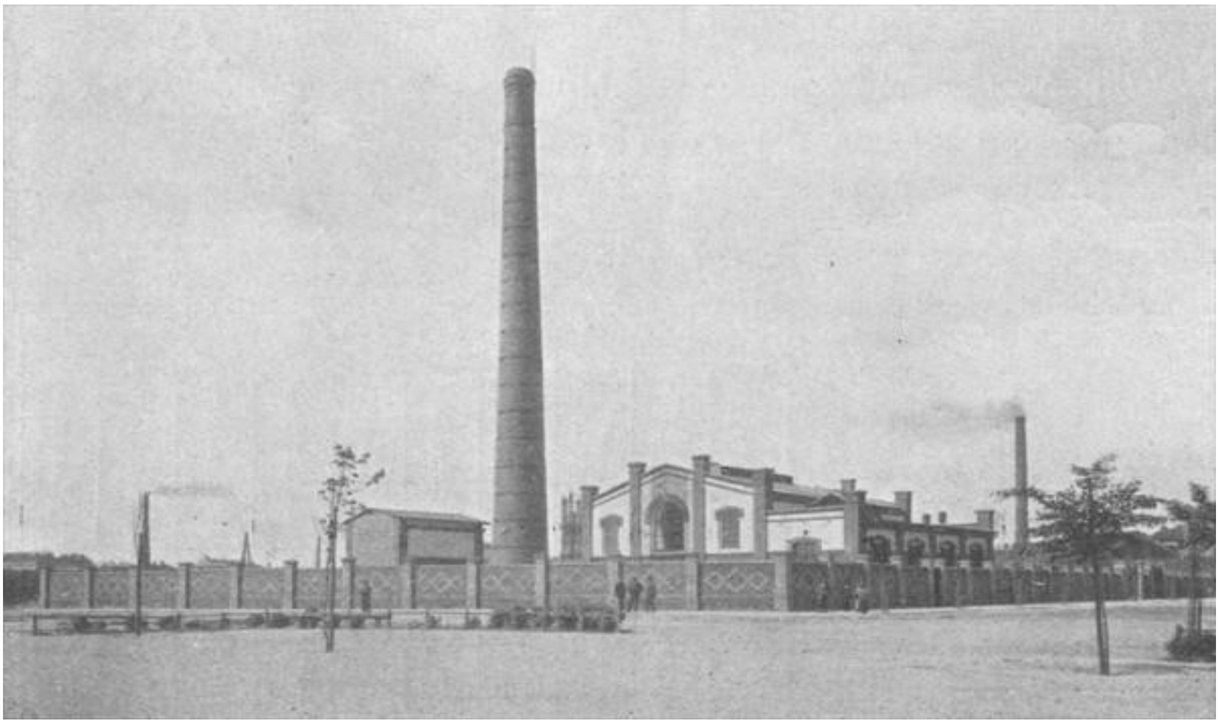

Fig. 1 Municipal waste incinerator in Brno (early 20th century) [12]

Later the incinerator was modernized and expanded. The total reconstruction of the incinerator ran from 1959 to 1982, but it was not too successful. At the beginning of the 70ies, there was only an old sorting plant, two original turbine generator units and two cranes at a slag dump in the incinerator plant. The capacity of the incinerator was 80 to 100 thousand tonnes annually. The boiler room had two boilers of 15 tonnes per hour, the first one combusted the waste and the other coal and black oil to ensure peak supplies of heat.

At the end of the 80ies of the 20th century, the incinerator was reconstructed again. Within the plant, four powder granulation high pressure boilers were installed with a chamber for waste incineration. The fifth boiler was intended for black oil. The total installed thermal capacity was 251.2 MW. At that time the incinerator burned MSW (municipal solid waste), brown coal and black oil. After the reconstruction the incinerator could dispose of up to 45 tonnes of waste per hour. The operation of the incinerator in Vysočany was closed in 1997.

2 THE POSTWAR HISTORY OF COMBUSTION AND ENERGY RECOVERY FROM MUNICIPAL WASTE IN CZECHOSLOVAKIA AND THEN IN THE CZECH REPUBLIC.

In the post-war history a large municipal waste incinerator was put into operation in **Brno** (now **SAKO Brno, a.s.**) as the first in the former Czechoslovakia. The incinerator was built in the years 1984-1989. Originally, the incinerator had three ČKD Dukla boilers with cylindrical grates. The total capacity of the incinerator was **240 thousand tonnes** of waste per year. Since 1998 the incinerator has also produced electricity using the equipment with an output of 400 kW_e.

In the years 2008-2011, the incinerator underwent large renovation and modernization (for around EUR 72 million), when two new lines for waste incineration were built. Each line includes a steam boiler with a rated output of 45 TPH of steam. The maximum incineration power of the grate of each boiler is 16 tonnes per hour, the minimum one is then 8 tonnes per hour. The total incinerator capacity is **248,000 tonnes** of waste per year for the heating value of waste of 8-9.6 MJ/kg. The municipal waste incinerator SAKO Brno, a.s. was officially re-opened on 7th September 2011 [1].

Waste energy recovery is a technologically sophisticated process whereby waste, which otherwise would end up in a landfill, is further used to produce electricity and heat as a heat transfer medium in a form of steam or

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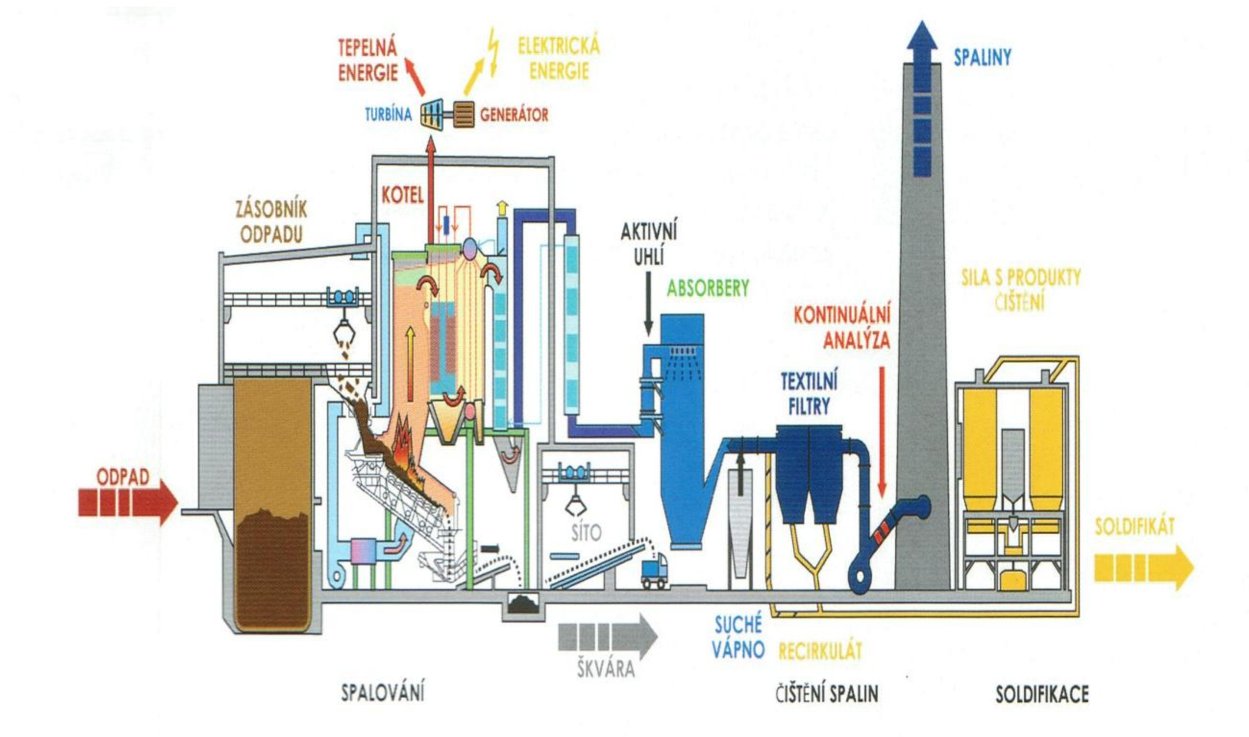
hot water. The renovated plant of the Brno incinerator (see Fig. 2) can satisfy up to 30 % of steam consumption in the city of Brno.

Each boiler is equipped with an internal incineration reverse grate by Martin GmbH, developed specifically for the incineration from municipal solid waste; the boiler itself is of water-tube kind with natural circulation, three-pass design with two drums. The modern operation of the Brno incinerator meets stricter emission limits than required by current legislation on air quality protection.

The **treatment of flue gas**, resulting from the incineration of waste, has the following steps:
The flue gas generated during the incineration of waste is fed to the top of an absorber at the outlet from the boiler at a temperature of 195 °C. The flue gas treatment is based on a semi-wet type system, and along with technical and operational measures also addresses issues of heavy metals, dioxins and other persistent organic pollutants. The CNIM-LAB semi-wet type system consists in injecting fine-atomized aqueous lime slurry into the flue gas stream at a temperature of 195° C. The result is a series of chemical reactions taking place during gradual evaporation of water between the parallel flow of hot gaseous acidic components of flue gas and alkaline sorbent which is a lime slurry aerosol. The result is a very fine powder which is separated from the flue gas on fabric filters. Into the flue-gas duct of each line before absorbers, the **activated carbon is forced down** under pressure, to the surface of which the **heavy metals and dioxins** are mainly bound which were not removed by the previous reactions.

If necessary to capture the increased concentrations of acidic components of the flue gas, in addition to the semi-wet type system, the dry type flue gas treatment system can be run, during which a dry hydrate of lime is fed into the flue-gas duct before the fabric filter to increase the efficiency of the neutralization reaction. The flue gas, including fly ash, reaction products of neutralization and residua of unreacted reagents are led through the flue-gas duct on the fabric filter. Prior to entry into the chimney with a height of 125 m, the cleaned flue gas is subjected to a continuous analysis.



LEGEND: TEPELNÁ ENERGIE-THERMAL ENERGY, ELEKTRICKÁ ENERGIE-ELECTRICAL ENERGY, SPALINY-FLUE GAS, TURBÍNA-TURBINE, GENERÁTOR-GENERATOR, ZÁSOBNÍK ODPADU-WASTE HOPPER, KOTEL-BOILER, AKTIVNÍ UHLÍ-ACTIVATE CARBON, ABSORBÉRY-ABSORBERS, KONTINUÁLNÍ ANALÝZA-CONTINUOUS ANALYSIS, SILA S PRODUKTY ČIŠTĚNÍ-STORAGE BINS FOR TREATMENT PRODUCTS, TEXTILNÍ FILTRY-FABRIC FILTERS, ODPAD-WASTE, SÍTO-SCREEN, SOLIDIFIKÁT-SOLIDIFICATE, SPALOVÁNÍ-INCINERATION, ŠKVÁRA-CINDER, SUCHÉ VÁPNO-POOR LIME, RECIRKULÁT-RECIRCULATE, ČIŠTĚNÍ SPALIN-FLUE GAS TREATMENT, SOLIDIFIKACE-SOLIDIFICATION

Fig. 2 Scheme of municipal waste incinerator of SAKO Brno, a.s. [1]

The construction of a new incinerator for disposal from municipal solid waste in **Prague** was considered already in the late 70ies. The construction itself was commenced in September 1988. The **Plant for energy recovery from municipal waste (ZEVO) Malešice** was put into operation in the fall of the year 1998. There were four steam boilers by ČKD DUKLA in the incinerator, with a capacity of 15 tonnes of waste per hour each. The total capacity of the incinerator is 310 thousand tonnes of waste per year. This capacity is used from two thirds only. In 2010, a new co-generation unit was put into operation, allowing increased production of energy from waste. The incinerator delivers about 1,000 TJ of thermal energy annually to Pražská teplárenská, a.s., and produces about 90,000 MWh of electricity per year. The output of the installed turbines is 17.6 MW_e.

ZEVO Malešice has four identical lines, two of which were in operation previously and two of them were shut down, but in winter three of them worked if there was a high enough demand for heat. It is now moved to 3 + 1 after the adaptation with the co-generation [2].

About 2 years ago, the flue gas treatment system in ZEVO Malešice was reconstructed. Now the plant disposes of a **top multi-stage flue gas treatment system**. The flue gas is first fed to a spray dryer for pre-treatment of dust particles, acidic components and heavy metals. The effect of the first stage is also the fact that water is evaporated from a washing suspension so that the waste leaves the system in the solid phase only. The flue gas continues passing to an **electrostatic precipitator** where particles are removed (the **second** treatment stage). Behind the electrostatic precipitator, a new **combined catalyst (SCR -** selective catalytic reactor**)** is integrated, where the degradation of nitrogen oxides and oxidative decomposition of dioxins and furans take place ($DeNO_x$ and DeDiox catalytic reactor). The flue gas is thus deprived of nitrogen oxides, dioxins and furans, and is pre-treated in terms of acidic components, and particles are removed. Further it proceeds into **the two-stage wet flue gas treatment system**. There is a so-called **pre-scrubber** placed here, which dissociates chlorides, iodides, bromides and fluorides, and **in the next stage** the absorption SO_2 and SO_3 takes place as well. Thus, it is a **five-stage flue gas treatment system**. As regards the achieved emission levels, it is clear that all emission values are **below ten per cent** of the allowed limits, only CO reaches 30 % and NO_x 70 % of the level of emission limits [2].

A last modern municipal waste incinerator in the Czech Republic was put into operation in **Liberec (TERMIZO a.s.)**. The construction was commenced in 1997; the trial operation started in 1999 and was completed in 2000 by final building acceptance. The incinerator has a capacity of 96,000 tonnes of waste per year, has one incineration line with a moving grate of the Von Roll system with a capacity of 12 tonnes per hour. The made preheated water steam is supplied to a local heating system.

3 PROPOSED NEW SYSTEMS FOR ENERGY USE FROM MUNICIPAL WASTE IN THE CZECH REPUBLIC

Currently the construction of other municipal waste incinerators is considered, which would partly address the issue of waste management at regional levels. In all the cases the usage of conventional grate boilers is considered.

The projects in the Moravia-Silesian Region (**KIC Odpady**) and the Pilsen Region (**ZEVO Chotíkov**) are developed the most.

The project preparation of the KIC Odpady, a.s. incinerator (**Regional Integrated Centre of Waste Management**) is at an advanced stage. The project has passed the assessment of the impacts of construction on the environment; land-use and building proceedings. The incinerator should be put into operation in 2015. Currently, its realization is suspended due to the action against the validity of the building permit filed by a civic association. The incinerator design parameters are **192,000 tonnes of used municipal waste**; the turbine output is 15 MW_e. There are two variants of the overall energy balance. The first variant assumes 90 GWh of electricity per year and 576 TJ of heat per year when taking out heat in hot water. The second, more likely option assumes the supplies of 20 GWh of electricity per year and 1,152 TJ of heat per year when taking out heat in steam of 1.1 MPa.

The planned **Plant for energy recovery from municipal waste** (ZEVO) **in Chotíkov near Pilsen** should also operate in a cogeneration mode. Up to **100,000 tonnes of municipal waste** per year should be used for energy recovery. Its commissioning is planned for 2015. Currently, the project passed the environmental impact assessment, planning procedure and building permit. Details are illustrated below.

The Highlands Region prepares the project **Integrated waste management system in the Highlands Region** whose part is a municipal waste incinerator as well.

Other upcoming projects:

- The company United Energy, a.s. is preparing the construction of plants for energy recovery from waste at the premises of the **Komořany heating plant** with an annual capacity of 100 to 150 thousand tonnes of waste. The commencement of operation is also planned for 2015.
- Further construction of the municipal solid waste (MSW) incinerator being considered is located at the premises of the **Opatovice power plant**. Its capacity should be about 100,000 tonnes of incinerated waste and the heat should be used in the agglomeration of Pardubice and Hradec Králové.

4 PLANT FOR ENERGY RECOVERY FROM COMMUNAL WASTE IN CHOTÍKOV (ZEVO CHOTÍKOV)

The project ***Plant for energy recovery from municipal waste (ZEVO Chotíkov)*** is designed as a **grate incinerator** with a capacity of 95,000 tonnes of processed mixed municipal waste (MMW) per year.

The waste will be stored in an exhausted indoor bunker and disposed through incineration in the fireplace equipped with a **movable grate**. The premises where MMW is stored or handled (unloading hall and bunker), will be equipped with an air exhaust, which will provide a slight negative pressure in these premises. The exhaust air will be fed to the boiler, where it will be used as the secondary air for the incineration process. **The hydraulically operated grate is typically divided into five sections** where the second and third sections of grate bars are cooled with water of a circulation circuit at a temperature of 80 - 110 °C using an exchanger which is cooled by the primary air [3].

The energy occurred in the fireplace will be used in an associated steam boiler with an output of **38.7 tonnes of steam per hour** for steam production (4.1 MPa and 400 °C). The steam will be used in a condensing turbine generator (TG) with a controlled consumption for power generation (**7.3 MW_e**). The steam from the controlled consumption will be used for the **production of hot water** to be supplied to the CZT heating network of Plzeňská teplárenská (140/70 °C).

It is assumed for cleaning the ***flue gas*** to use a **combined method**, consisting of the following basic steps (**spray drying reactor, fabric filter, three-stage flue gas scrubber and SCR method - $DeNO_x$ and DeDiox catalytic reactor**).

The flue gas from the boiler is led tangentially into the *spray drying reactor*, where concentrated slurry of waste water containing heavy metals and salts of the captured acidic components and other pollutants in the scrubber together with calcium hydroxide or sorbent (e.g. activated coke or sorbalit) is sprayed using a counter current. All the water is evaporated here (thus waste in the solid phase only leaves the plant). These dry components are then collected on the *fabric filter* in which a layer of the **mixture of calcium hydroxide, reaction product and fly ash** is formed on the filter fabric. In this layer, the first capture of acid components of flue gas (sulphur, chlorine, fluorine, etc.) and heavy metals occurs. Behind the fabric filter, a ***three-stage flue gas scrubber*** is installed, where the **residue of acidic components and heavy metals** (chlorine, fluorine and heavy metals *in the first stage*, sulphur *in the second stage*, aerosols *in the third stage*) is captured [3].

To reduce the consumption of water in the flue gas, a flue gase/flue gas exchanger No. 1 is included before and behind the scrubber, which cools the flue gas at the inlet into the scrubber and heats the flue gas at the outlet of the scrubber. Behind the scrubber, the ***$DeNO_x$ and DeDiox reactor*** is included, which decomposes nitrogen oxides, dioxins and furans (PCDD/F). Behind the reactor, there is an exchanger (No. 2 - see below) and a steel chimney with a height of 80 m.

Before the SCR reactor itself, an indirect steam heater of flue gas is integrated that heats the flue gas for the temperature needed for the SCR reactor activity (approx. 240 °C). The flue gas is heated by steam drawn from a boiler drum (4.1 MPa, 400 °C). To reduce the steam consumption, the flue gas/flue gas exchanger No. 2 is integrated in the duct system before the heater and behind the SCR reactor, which heats the flue gas at the inlet to the steam heater and cools the flue gas at the outlet of the SCR reactor (before the inlet to the flue gas exhauster and before a chimney).

The **SCR reactor** is equipped with a **catalyst**, whose active ingredients are **oxides of vanadium** (vanadiumpentoxid - V_2O_5) and **tungsten** (wolframtrioxid - WO_3) on a **titandioxid carrier** (TiO_2) **in ceramics**. These will allow oxidation of dioxins and furans (PCDD/F) at the temperature of around 150 to 220 °C (otherwise PCDD/Fs decompose without the presence of a catalyst at temperatures above 850 °C – the SNCR method). Dioxins and furans oxidatively decompose into trace amounts of hydrogen chloride (it can be washed in a wet flue gas treatment), water vapour and carbon dioxide [3, 4].

To reduce NO_x, the catalytic reactor must have an appropriate temperature (240 °C – see above) and spraying the NH_3 solution before the catalyst must be ensured. In this way, the nitrogen oxides decompose into nitrogen and water.

In fact, the ***emission concentrations of dust particles*** from incinerators into the air range at **one-tenth of the permitted limits**, and incinerators emit in the air **less TOC and PCDD/F than enter them with the waste or the combustion air**. Also other emissions of incinerators are lower than those occurred in producing an equal amount of energy in conventional combustion sources [4].

5 GASIFICATION OF WASTE

The essence of gasification is the conversion of carbonaceous materials at higher temperatures (above 800 °C) into combustible gaseous substances under the supply of under-stoichiometric amount of air or other oxidising agent. The gasification is a strongly endothermic process. The **advantage** is that due to the high

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temperatures there are no problems with the formation of **toxic dioxins**, furans and polycyclic aromatic hydrocarbons. The reducing environment prevents the formation of nitrogen oxides [5].

The gasification is partial combustion of organic compounds forming gases which can be used as a raw material (using reform processes) or as a fuel. The gasification processes are suitable for the treatment of municipal waste, some hazardous waste and dried sewage sludge.

Very interesting structures are e.g. gasification units working in the plant for energy recovery from municipal waste of the company **Kazusa Clean Systems** Co., Ltd. The plant was built in Kisarazu City, in the Japanese Prefecture of Chiba, by the firm Nippon Steel Engineering Co., Ltd. (see Fig. 3) [6].

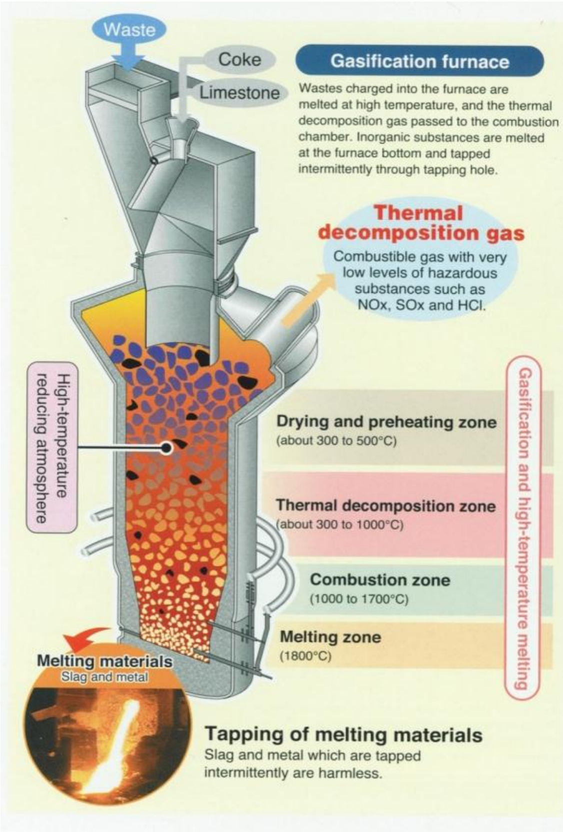

Fig. 3 Kazusa Clean System – a gasification and melting furnace [6]

In the gasification furnace, the temperature of up to 1,800 °C is reached in the melting zone (here municipal waste is melted in the last phase), while the leaving slag is granulated in a water trough and then crushed. From the slag, metals are obtained by magnetic separation, and the rest is used in civil engineering.

The gas comes into the combustion chamber, where it is burned. Flue gases are fed to the waste heat boiler which produces superheated steam driving the turbine and the generator, producing electricity. Units are available with a capacity of 100 or 125 tonnes of municipal waste per day. The company Kazusa Clean Systems Co., Ltd. has 2 units in place for processing 100 tonnes of municipal waste per day and 2 units for processing 125 tonnes of municipal waste per day. The output of the generators is then 3,000 kW_e and 5,000 kW_e [6].

Flue gases are cleaned in a multistage process as is the case of the ZEVO Malešice plant and, also, as projected for the *Plant for energy recovery from municipal waste Chotíkov (ZEVO Chotíkov)*, including the SCR - the $DeNO_x$ and DeDiox catalytic reactor.

6 PYROLYSIS

Pyrolysis is the thermal decomposition of organic materials in the absence of oxygen-containing media (air, carbon dioxide, water vapour) which leads to the formation of gaseous, liquid and solid fractions. This process is an alternative to combustion.

The essence of this method is that organic compounds are less stable at higher temperatures. High molecular substances are decomposed to low molecular ones, which leads to their breakdown into volatile products and coke. Pyrolysis is carried out at the temperatures ranged from 150 °C to 1,000 °C. According to the temperatures, we distinguish:

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- Low-temperature pyrolysis (reaction temperature up to 500 °C),
- Medium-temperature pyrolysis (reaction temperature from 500 °C to 800 °C),
- High-temperature pyrolysis (reaction temperature above 800 °C).

Advantages of pyrolysis processes [7]:

- Easier and less capital-intensive plants,
- Produced fuels are easily merchantable, than heat and steam,
- There is only a small fraction of gaseous products of incineration compared to the same amount of fuel.

Disadvantages of pyrolysis processes:

- More expensive operation,
- A problem to remove the pyrolysis residue (pyrolysis coke), liquid hydrocarbons, containing a high content of heavy metals.

Pyrolysis can be used in addition to the thermal treatment of municipal waste and sewage sludge also to:

- Decontamination of soils,
- Treatment of plastic waste and used tires,
- Treatment for the substance utilization of cable waste, metal and plastic materials.

For a long time, the pyrolysis and gasification of coal are considered to be very promising also in the field of energy recovery from waste. Although research in this area is quite wide and technological development is well advanced, neither of these technologies is still established in the waste area so that the future operator could get it complete, as we say "turnkey". This is currently a big problem, because there is nothing in this field in the Czech Republic the entrepreneurs could equipped with the intended operations for treatment of waste (municipal waste, tires) that they would like to operate as a plant for waste energy recovery [4].

One of the plants that is, however, offered in our country for tire processing (other types of waste can be used as well), is the M3RP pyrolytic line from the supplier AmbientEnergy LLC (USA), the SCOGEN manufacturer (India) [8]. Another plant is the one from the SIMUL trust, a.s. company, with a trade name PTR, which is able to use both waste rubber materials, tires and municipal waste, and a variety of other waste (sewage sludge, waste oil, plastics, biomass) [9].

7 PLASMA TECHNOLOGY

Plasma systems require temperatures around 5,000 to 15,000 °C. These high temperatures accompany the conversion of electrical energy into heat forming plasma. Plasma is a mixture of electrons, ions and neutral particles (atoms and molecules). The ionized, conductive gas of high temperature occurs by the interaction between the gas and the electric or magnetic field. Rapid chemical reactions are promoted by high temperatures. Plasma is a source of reactivity. Hot plasma can be created by a passage of direct or alternating electric current through the gas between electrodes through the use of the radio magnetic field without using electrodes or microwaves.

When injecting hazardous substances such as PCBs, furans, pesticides, etc. into plasma, these substances decompose into atomic components. The process is used to modify organic compounds, PCBs and HCB (hexachlorobenzene). The effectiveness of this technology is higher than 99.99 %. The process of plasma methods is expensive and operationally challenging.

There are different kinds of plasma technology [7]:

- Plasma arc in argon,
- Inductively coupled plasma radio waves (ICRF),
- Alternating current (AC) plasma,
- Plasma arc in carbon dioxide,
- Microwave Plasma,
- Plasma arc in nitrogen,
- Plasma arc in water.

A substantial disadvantage of the plasma technology is that no reference unit for the use of mixed municipal waste exists for the technology as a whole, and the equipment is not operationally tested. Plasma technologies generally use MMW rarely only.

The equipment by the Safina Prague company, which uses a plasma unit for processing electronic waste (probably 10 kilo-tonnes per year), is usually reported in the literature. Furthermore, systems in Japan and two in Germany are reported.

Recently we speak of the plasma arc in water. The mentioned system (a so-called water plasmatron) creates the plasma, i.e., the fourth state of matter, when electricity passes through a water vortex. The water plasmatron is ten times faster than the gas technology and the plasma speeds up to 8 km per second. Another big advantage of the Czech plasmatron, designated as WSP, from the Institute of Plasma Physics of the Academy of Sciences CR is the fact that thanks to twice the temperature of plasma, a much higher level of ultraviolet radiation is maintained in the reactor, which is a very effective way to decompose complex hydrocarbon molecules during the destruction of undesirable waste [10].

8 CONCLUSIONS

Currently, we get only about **3.6 million GJ of energy** at the average calorific value of mixed municipal waste (MMW) of about 10 MJ/kg and the **actual annual burning about 360 thousand tonnes of MMW**. According to well-known balances and overviews of the current waste management and following the strategy of development of waste management, it is stated that in 2020 it will be necessary to operate the plants for energy waste recovery with a total annual processing capacity of **2.0 million tonnes of MMW**. With an average calorific value of mixed municipal waste, we obtain at least 20 million GJ of energy (potential energy) per year through the energy recovery of that amount of waste [11].

The capacity of three municipal waste incinerators in our country is about 600 thousand tonnes of waste per year. The use of selected and modified municipal waste in cement plants through the gasification and in biogas stations is about **350 thousand tonnes** per year.

Thus, from 2 million tonnes, 600 thousand tonnes can be processed in existing incinerators, **in the three planned incinerators another 400 thousand tonnes**, and in other energy waste recovery plants, 350 thousand tonnes of municipal waste. To the year 2020, about **650 thousand tonnes** of mixed municipal waste still remains, which we will not be able to put on landfills.

It should be noted that the waste energy recovery saves e.g. an equivalent of the brown coal volume, which would otherwise have to be extracted and consumed in power plants and heating plants. It should also be pointed out that no matter how well cleaned flue gases from power plant processes are, their quality is incomparable with that of treated flue gases from waste energy recovery processes. The above facts should be taken into account in drafting the energy policy in the Czech Republic for the next period.

The current waste policy in the Czech Republic does not allow to contribute to the construction of incinerators, while the relevant European Directive (Directive 2008/98/EC of the European Parliament and of the Council on waste) **prefers energy recovery of waste to the landfilling** already for quite a long time [11]. The implementation of the European Directive will most likely change the approach to the issues of waste incineration and energy recovery of heat content in the Czech Republic (see the proposed new Waste Act) [4].

For illustration, it should be noted that Article 9a(1) of the existing Act No. 185/2001 Coll., on waste, as amended, states:

„As part of waste management, the following waste hierarchy must be respected:

- prevention,
- preparing for re-use,
- recycling,
- other recovery, e.g. energy recovery."

In addition, Article 9a(2) of Act No. 185/2001 Coll., on waste, as amended, states: „**It is possible to depart from the waste hierarchy if this is justified** based on the assessment of life-cycle of overall **impacts, involving the generation and management of such waste**". So much says the current valid legal regulation in the area of energy recovery in the Czech Republic.

Often, citizens and representatives of civic associations talk about the need to prefer new technologies for energy recovery from municipal waste (gasification, pyrolysis, or plasma technology) and not consider the use of such grate incinerators, although at the output equipped with plants for treatment flue gases at the highest possible technical level (see, e.g. the above flue gas treatment in ZEVO Malešice). Certainly, it is appropriate to introduce new innovative technologies. However, it should be pointed out that e.g. the plant for gasification of municipal waste shall be equipped with the same equipment for flue gas treatment (see above the plant of the firm Kazusa Clean Systems Co., Ltd.), as is in grate incinerators equipped with the plant for capturing pollutants at the highest level. Then, of course, it is debatable whether it is necessary at any cost to seek to build often more expensive and technologically complex plant, when securing the air protection is assured in both cases practically by an identical capturing plant.

REFERENCES

[1] Materials from SAKO, a.s. Brno. 2011. (in Czech)

[2] An incinerator needs an attractive look. *Waste Forum*, No. 5, 2011, pp. 8 – 10. (in Czech)

[3] VURM, Karel et al. Environmental Impact Assessment Documentation as of Appendix 4 to Act No 100/2001 Coll., as amended, for the project "*Municipal-Waste-to-Energy Plant Chotíkov (ZEVO Chotíkov)"*. Prague: Chemoprag, Ltd., August 2011. 159 p. (in Czech)

[4] LAPČÍK, Vladimír. Expert Report for Environmental Impact Assessment Documentation as of Appendix 5 to Act No 100/2001 Coll., as amended, for the project "*Municipal-Waste-to-Energy Plant Chotíkov (ZEVO Chotíkov)"*. Prepared for the Regional Office of the Plzeň Region. Ostrava, December 2011. 98 p., photo-documentation (2), appendices (2). (in Czech)

[5] OBROUČKA, Karel. *Thermic waste disposal and energy recovery*. 1st edition. Ostrava: VŠB – Technical University Ostrava, 2001. 140 p. ISBN 80-248-0009-8. (in Czech)

[6] Materials from Kazusa Clean Systems Co., Ltd. Nippon Steel Engineering Co., Ltd., Environmental Solution Division, Japan. 11 p., 2012.

[7] Integrated prevention and reduction of pollution: Reference document on best available technologies of waste incineration. Prague: CENIA, Czech Information Environmental Agency [online], 2005 [accessed on 2012-04-24]. Available at http://www.cenia.cz/web/www/webpub2. (in Czech)

[8] SKOŘEPA, Jaroslav. Environmental Impact Assessment Documentation as of Appendix 5 to Act No 100/2001 Coll., as amended, for the project "*Velká Dobrá – pilot and demonstration line for waste disposal using vacuum pyrolysis"*. 2010. 43 p. (in Czech)

[9] Materials from SIMUL trust a.s. 2012. (in Czech)

[10] BAUMAN, Milan. Plasmatron or burning plasma under shower. *Visions (people, technology, innovation)*. Siemens, Autumn 2012, pp. 24-25. (in Czech)

[11] Multiple authors. Waste-to-Energy: Waste as an inexhaustible source of energy. *Waste Forum*. Prague: CEMC, MPO, 09/2010. 20 p. (in Czech)

[12] The first waste incineration plant was in Brno. *Waste is energy* [on line]. Praha, 1.6.2007 [cit. 2012-04-19]. (in Czech)

RESUMÉ

Příspěvek shrnuje možnosti energetického využití komunálního odpadu. Je popsána historie spalování a energetického využití komunálního odpadu v Československu a poté v České republice. Pozornost je věnována třem v současnosti provozovaným zařízením na energetické využití komunálního odpadu v České republice (ZEVO Malešice, SAKO Brno a TERMIZO Liberec). Dále jsou uvedeny charakteristiky připravovaných záměrů pro energetické využití komunálního odpadu v ČR (Krajské integrované centrum nakládání s odpady v Moravskoslezském kraji a ZEVO Chotíkov v Plzeňském kraji), které již prošly procesem posuzování vlivů na životní prostředí. Uvedená zařízení pracují v zásadě na bázi roštových kotlů s několikastupňovým čištěním spalin na nejvyšší možné technické úrovni, kde je mj. zařazen stupeň, který zachycuje dioxiny a furany (PCDD/F).

Příspěvek také uvádí přehled dalších technologií, které je možno využít pro energetické využití komunálních odpadů – jedná se o zplyňovací a pyrolýzní jednotky a plazmové technologie. Jako příklad z oblasti zplyňování komunálního odpadu je uvedeno japonské zařízení, kde ve zplyňovací peci je v tavicí zóně (zde se v poslední fázi taví komunální odpad) dosahováno teploty až 1 800 °C, přičemž odcházející struska je granulována ve vodním žlabu a poté drcena. Ze strusky jsou magnetickou separací získávány kovy a zbytek je využíván ve stavebnictví. Spaliny jsou čištěny několikastupňově, jako je tomu u spalovacích pecí s rošty.

Závěr příspěvku je věnován současné a budoucí situaci v oblasti energetického využití komunálních odpadů v České republice s ohledem na platné právní normy. Je mj. poukázáno na významnou skutečnost v oblasti současné odpadové politiky v České republice, která neumožňuje přispívat na výstavbu spaloven, zatímco příslušná Směrnice Evropského parlamentu a Rady (ES) 98/2008 o odpadech dává již poměrně dlouhou

dobu přednost energetickému využití odpadů před skládkováním. Je zde rovněž uvedena bilance kapacit, které bude nutno vybudovat za účelem energetického využití odpadu, aby Česká republika splnila požadavky EU pro nakládání s odpady do roku 2020 (snížení objemu skládkovaných komunálních odpadů).