Project GOLEM: New Construction and Modernization of an Existing Plant in Prague/Czech Republic

Ales Blaha and Norbert Eickhoff

Residual waste of municipal origin and similar industrial waste are usually treated in thermal waste treatment plants. The primary focus of thermal treatment is the environmentally friendly and efficient use of the energy contained in this type of waste.

In addition to increasing the energy efficiency of waste-to-energy (WTE) plants, the protection of resources and, consequently, the recovery of recyclable materials, is among the European Union's long-term goals. The Circular Economy Act is part of the effort to ensure that by 2030 the vast majority of EU countries will achieve recycling rates of 65 % for municipal waste and 75 % for packaging waste while at the same time observing a maximum landfill rate of 10 %. Reliable technological concepts need to be developed to meet these goals within the given time frame. The above-mentioned policy goals will make thermal waste treatment plants equipped with grate-based combustion systems even more attractive when it comes to actively protecting our resources because, in addition to achieving high levels of energy efficiency and reducing emission levels, improving the recovery rates of recyclables in order to substitute raw materials will gain in importance [1, 2].

The insights gained from operating the Malesice plant will, in combination with the technological further development of the Martin combustion system, ensure compliance with these goals in the long term.

1. Waste output of the Czech Republic

The Czech Republic's municipal waste output is 5,600,000 Mg/a. According to EUROSTAT (2016), 50 % is landfilled, 36 % is recycled and 16 % is used for energy recovery. The figure for energy recovery includes refuse derived fuels (RDF) from municipal waste (approximately 250,000 Mg) that are used in cement and lime factories. According to current legislation, as of 2024 it will no longer be permitted to landfill residual waste with an upper heating value of more than 6.5 GJ/Mg (dry substance) and a recycling rate of 50 % is to be achieved. If we subtract the quantity of residual waste that is currently combusted (760,000 Mg) from the residual waste quantity (2,800,000 Mg/a), this leaves approximately 2.000,000 Mg of residual waste. If we bear in mind that approximately 30 % will be landfilled, approximately another 1,400,000 Mg would have to be thermally treated, either directly in additional WTE plants or as RDF.

This is consistent with the EU's circular economy goals to achieve a minimum recycling rate of 65 % and a maximum landfill rate of 10 % by 2035. Consequently, approximately 25 % of the total municipal waste output is to be used for energy recovery. Some of the materials included in the recycling rate of 65 % can actually not be recycled (at least 400,000 Mg) but have a high heating value. These should be assigned to the category energy recovery, which would increase the required capacity by approximately 1.900,000 Mg/a.

2. Locations of existing WTE plants

There are currently four WTE plants in the Czech Republic with a combined capacity of 760,000 Mg (Liberec 100,000 Mg, Chotikov 100,000 Mg, Brno 230,000 Mg, Prague 330,000 Mg). There is opposition to the construction of new WTE plants in the Czech Republic from NGOs (green movement, Arnika, etc.). If waste combustion cannot be avoided, they would prefer extending the capacity of existing WTE plants to building new ones. An extension in capacity is only possible for the Brno and Prague-Malesice plants. The Liberec and Chotikov/Plzen plants lack the space required for an extension.

Brno plant

The Brno plant initially had three combustion lines. Two lines have already been modified and the construction of a third line with a capacity of 110,000 Mg is currently being prepared so that the plant will again have three lines. During modification of SAKO's Brno plant, most of the waste from Brno was landfilled as the plant was not in operation or the load was significantly reduced.

Malesice plant

The Malesice plant (Figure 1) is designated to primarily process waste from Prague. It is equipped with four combustion lines, one of which serves as a standby line (Figure 2). The plant is owned by Pražské Služby a.s., which has a 10-year contract with the City of Prague for the thermal treatment of approximately 260,000 Mg/a of residual waste, 90 % of which must be thermally treated. The approved capacity of the plant is 330,000 Mg/a. This means that it can treat part of the commercial or residual waste from the hinterland. Construction of the plant was started by the state in the late 1980s. After the Velvet Revolution in 1989, ownership passed to the City of Prague, and commissioning took place in 1998. When it became clear that the Prague plant was becoming outdated, and repair costs had reached the acceptable limit, it was decided to renew the plant.

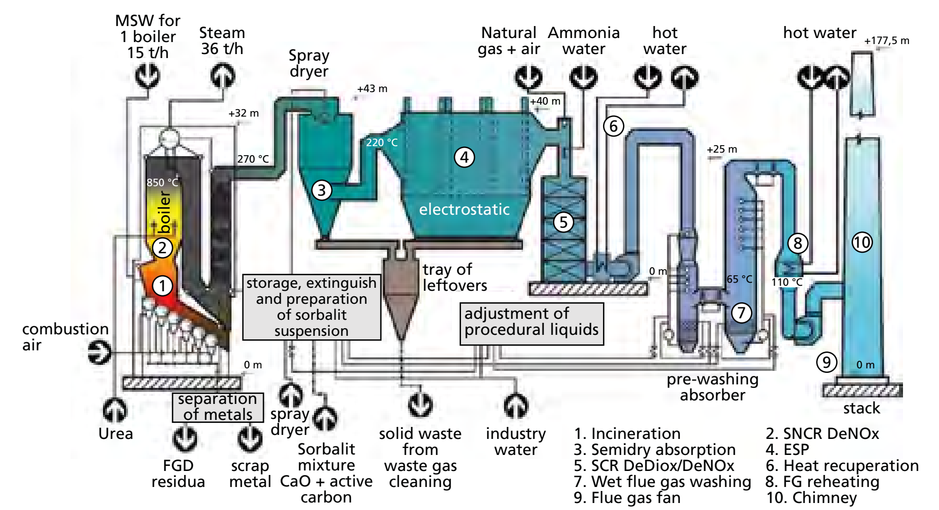


Figure 1: Existing Malesice plant

Figure 2:

Overview of Malesice WTE plant

Source: Google

3. Renewal and tender process

3.1. Preparatory activities

In autumn 2013, the board was informed that the plant had to be renewed. Subsequently, the board instructed ZEVO's plant management to gradually start preparatory work and to carry out a status inspection. Comparisons were made with renewals of roller grate plants carried out in the former Eastern Bloc and in the West (Budapest, Bratislava, Brno). ZEVO visited these plants and looked for still existing or new roller grate suppliers while examining alternative grate systems (with regards to the space below the boiler, angle of inclination, adjustment of bottom ash removal system, for example). The first concept for renewal of the plant was drawn up by ZEVO's operating staff. For this purpose, operating tests were carried out (maximum steam and flue gas flows). More detailed status inspections of the existing technology were conducted and the potential for extending and using the capacity reserves of the existing components were investigated (permitted steam parameters for the steam turbine) and several major repairs were carried out. For example, the air preheater in the third pass was converted to a plate design and the second scrubber in the flue gas cleaning system of line 2 was fitted with additional rubber lining. However, ZEVO realized that the required results could not be achieved by just carrying out some necessary repair measures. ZEVO had two status studies carried out by independent engineering firms, one for the thermal part and one for the flue gas cleaning system. In autumn 2016, the board instructed ZEVO's plant management to commission a technical-economic study that should also cover aspects such as location, infrastructure, expected changes in legislation, expected development of waste quantities as well as ZEVO's market potential while at the same time taking Pražské Služby's strategic interests into account. The study was to include several implementation options and one implementation suggestion. It was conducted by the engineering firm EUCS Ingenieurbüro GmbH and presented to Pražské Služby's board in February 2017. Of the three options assessed, the one which provided for the most comprehensive renewal measures was suggested for implementation. The board of management approved this option because, due to the future development of the location and the expected waste market potential, it was considered to be the ideal solution in terms of cost efficiency and strategy. In January 2017, five engineering firms were invited to submit tenders for the drawing up of the required tender documents, for evaluation of the supplier's tenders, participation in supply contract negotiations and for the technical supervision of the work carried out to renew ZEVO. EUCS Ingenieurbüro GmbH was awarded the contract.

3.2. Tender conditions and awarding of the contract

The technical-economic study defined several essential conditions for implementation and the drawing up of the tender documents. One basic requirement was fulfilment of the disposal contract concluded with the City of Prague. During renewal work, the landfill rate for waste from Prague was not to exceed the 10 % limit and the minimum heat supply for the city's heating network had to be ensured, in particular in the winter months.

No construction work was to be carried out, which means that the existing buildings may not be extended. Since the technical condition of the plant was progressively deteriorating, the renewal measures had to start in 2018. Therefore it was clear that only one line would be renewed each year while the remaining three would continue to be available for operation. This would be a major challenge, not only for the suppliers, but even more so for the operating staff and technical supervisors. Tenders were invited simultaneously and separately for the thermal part (GOLEM-TZO) and for the flue gas cleaning system (GOLEM-CS). The scope of supply for the thermal part was in effect a new vertical boiler and the associated combustion system. In the flue gas cleaning system, several components were to be replaced: the spray dryer, fabric filter (to be replaced with an electric filter), quench system, scrubber 1 (GFRP instead of steel and rubber), nozzle bars (GFRP instead of steel and new nozzles), droplet separators downstream of scrubbers 1 and 2 (to be made of GFRP), induced draught fan and most of the flue gas ducts. Most of the media piping and the respective shut-off devices will be left in place.

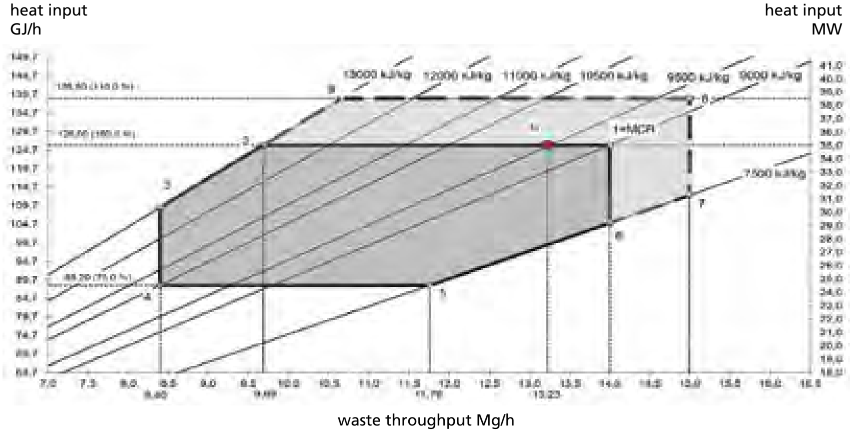
Due to the tight schedule, only those companies were invited to tender that were familiar with the plant because they had already cooperated with the investor (either by submitting offers or by providing maintenance services) before the decision for a plant renewal was taken. These companies had submitted budget offers to the investor in connection with the technical-economic study. Since the investor set 1 March 2018 as the date for the beginning of dismantling work, the signing of the contract could not take place after the beginning of September 2017. This left only seven months for the drawing up of the tender documents, submission of tenders as well as evaluation and selection of suppliers.

A complex evaluation matrix was developed for selection of the best tenders. The main evaluation criteria and the main evaluation items were included in the tender documents (investment costs, operating costs based on consumptions, maintenance costs, service life guarantees, technical parameters, guarantees for the performance and emission values, bank guarantees). A questionnaire in which the bidders had to specify information concerning the evaluation items was part of the tender documents. A total of more than 100 parameters had to be evaluated for each tender. Subsequently, several rounds of detailed technical-commercial negotiations were conducted with the best bidders for each category. On 05/10/2017, letters of intent were signed with Martin GmbH for GOLEM-TZO and with Zauner Anlagentechnik GmbH for GOLEM-CS. On 10/10/2017, a letter of intent was signed with EUCS for the technical supervision. The contracts were signed on 09/11/2017.

4. Technical challenges

4.1. Technical data, stoker capacity diagram

The grate (Figure 3) was designed to fit into the very limited space available, using a two-run grate with a total width of 4.4 m.



▭ normal load range   ⌈ ⌉ range for control fluctuations (set point specification not permitted)

number of runs: 2
grate width: 4410 mm
grate area: 35.2 m²
number of steps: 13

load point	1=MCR	N	2	3	4	5	6
temp. primary air, °C	140	140	100	100	120	160	160
temp. secondary air, °C	40	40	40	40	40	40	40

Figure 3: Stoker capacity diagram of the Malesice plant

4.2. Boiler parameters

The flue gases (flue gas volume approximately 63.000 Nm³/h) leaving the grate combustion equipment are cooled in a five-pass superheated steam generator.

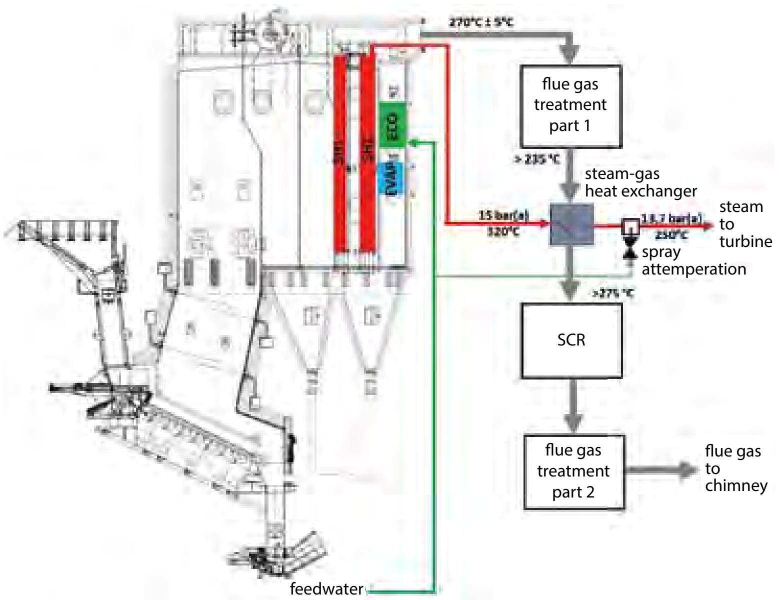


Figure 4: Boiler data of the Malesice plant

Leeds (UK)
Energy-from-Waste plant 160.000t/a
Image courtesy of Thomas Graham - Arup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A 5-pass vertical boiler with the steam parameters 15 bar(a) / 320 °C was designed.

The produced steam amount per line will be approximately 39 to/h.

An external steam-gas heat exchanger for reheating the flue gases was integrated into the steam circuit upstream of the SCR unit.

The boiler ash is removed from the system via the existing dischargers.

The supporting steel structure of the boiler was designed such that the existing foundations can remain in place.

4.3. Dismantling of the existing combustion systems and boilers

Dismantling of the existing line 4 is shown in Figures 5 and 6. The goal is not to interrupt operation of lines 1 to 3 during dismantling and renewal of line 4. When line 4 has been returned to operation, the next line will be dismantled. The transport routes for the waste, bottom ash and reagents always have to be ensured.

Figure 5:

Boiler house

Figure 6:

Crane situation

4.4. Grate system

Thanks to the modular design of the Martin reverse-acting grate, its widths can be perfectly adjusted to the process parameters for the ZEVO Malešice project, i.e. the throughput capacity and thermal output. A two-run grate is used for this purpose.

The Martin reverse-acting grate is inclined at an angle of 26° to the horizontal, from the feeding system to the clinker weir at rear the end of the grate, and comprises stationary and moving steps in alternating order.

The grate's thirteen steps are adjusted to suit the quality of the fuel to be combusted. For the purpose of agitation, the moving steps perform about 15 to 30 strokes per hour with a length of approximately 400 mm in the direction of the grate front end. The number of strokes, in other words the grate speed, primarily depends on the composition of the fuel and only to a lesser extent on the waste throughput. The residence time of the fuel on the grate is approximately 60 to 70 minutes.

By means of the reverse-acting motion (agitation strokes) of the moving grate steps against the natural downward movement of the fuel bed, an intensive mixing and agitation motion arises in the fuel bed [4]. Constant recirculation of glowing particles from the main combustion zone to the freshly fed waste ensures stable ignition at the grate front end. The characteristic mixing and agitation motion of the Martin reverse-acting grate also helps to achieve uniform coverage of the grate.

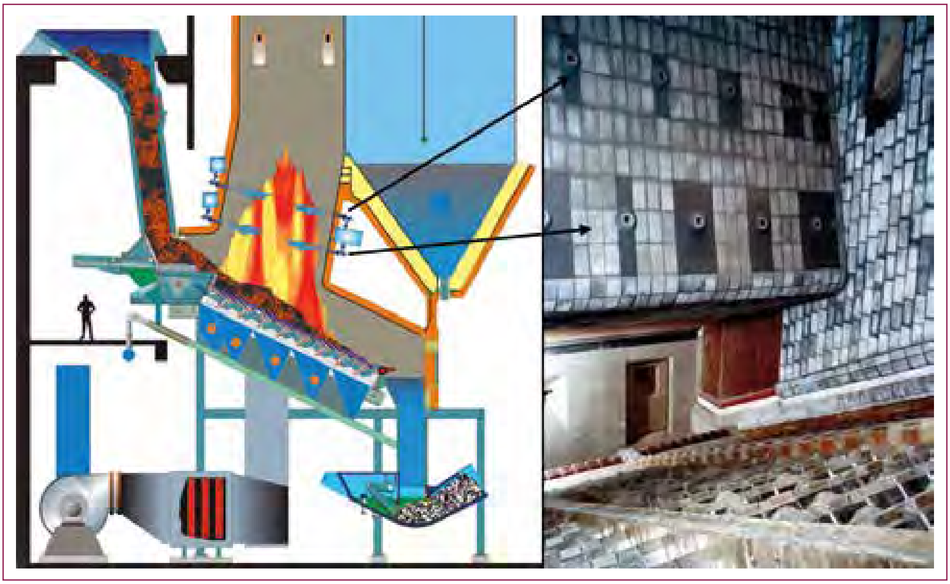

Figure 7: Reverse-acting grate

4.5. Boiler system

One of the main advantages of the 5-pass boiler concept is the size of the system, which makes it possible to install it in the existing boiler house of the ZEVO Malešice plant without having to modify its original cubature. The boiler is planned taking the specific requirements applying to waste-fired boilers into consideration. The amply dimensioned furnace and radiation passes bring about low flue gas velocities, ensuring a high flue gas retention time [3].

The convective heating surfaces are fully drainable and arranged in alignment.

The configuration of the waste-fired boiler is as follows:

- Combustion chamber and 1st open vertical (upward) pass,
- Tube pitch membrane walls (transverse): 80 mm,
- 2nd open vertical (downward) pass,
- Tube pitch membrane walls (transverse): 80 mm,
- 3rd open vertical (upward) pass,
- Tube pitch membrane walls (transverse): 80 mm,
- 4th vertical (downward) pass with integrated suspended convection superheater (SH) surfaces,
- Tube pitch membrane walls (transverse): 120 mm,
- Tube pitch superheater 1 (transverse/longitudinal): 240 mm/120 mm,
- Tube pitch superheater 2 (transverse/longitudinal): 160 mm/120 mm,
- 5th vertical (upward) pass with integrated horizontal convection evaporator (EVAP) and economizer (ECO) surfaces,
- Tube pitch membrane walls (transverse): 120 mm,
- Tube pitch evaporator (transverse/longitudinal): 90 mm/120 mm,
- Tube pitch economizer (transverse/longitudinal): 90 mm/90 mm.

An extensive and reliable tube system ensures optimum heat transfer while avoiding the formation of bridges due to fouling. Sufficient space is provided between the individual heating surface banks and there is an adequate number of inspection doors.

5. Layout planning

As Figures 8 and 9 show, very precise and careful planning is required to ensure that the bunker, waste cranes and staircases, etc. can be fitted into the limited space available in the existing building.

Martin is carrying out planning work using Laserscan and combined 3D modelling to perfectly suit the actual situation on site.

The time schedule shown below is very ambitious and can only be successfully met if the client and supplier work in close cooperation. All milestones have been completed on schedule or are on track (Table 1).

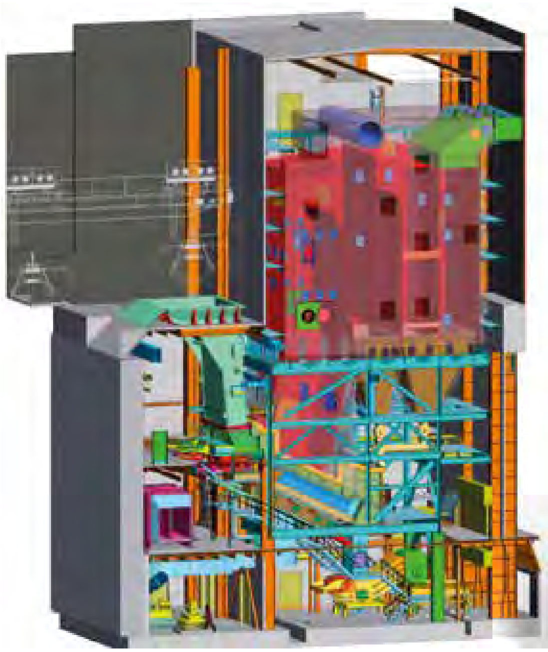

Figure 8:

3D layout, line 4 of the Malesice plant

Schedule	(1st boiler / K4)
Project start	09/11/2017
Documentation for implementation of project stage 1	04/12/2017
Submission of detail engineering (documentation for implementation of project stage 2)	25/01/2018
Beginning of preparatory work for dismantling	25/02/2018
Beginning of dismantling	01/03/2018
Beginning of steel structure erection	23/04/2018
Delivery of grate and hydraulic system	15/05/2018
Delivery of fans and air preheater + part of air ducts	18/05/2018
Delivery of feed chute (to be installed as separate items)	25/05/2018
Beginning of erection work for heavy boiler equipment	26/06/2018
Beginning of boiler precision assembly	17/07/2018
Beginning of installation work for electrical, measure-ment and control equipment	15/08/2018
Boiler pressure test	2/09/2018
Beginning of boiler insulation work	14/09/2018
Mechanical completion	17/11/2018
Beginning of cold start-up	15/11/2018
Beginning of warm start-up	11/01/2019
First waste firing	28/01/2019
First continuous steam supply	15/03/2019
PAC, line 1 (K4)	15/05/2019

Table 1:

Milestones for K4 of the Malesice plant

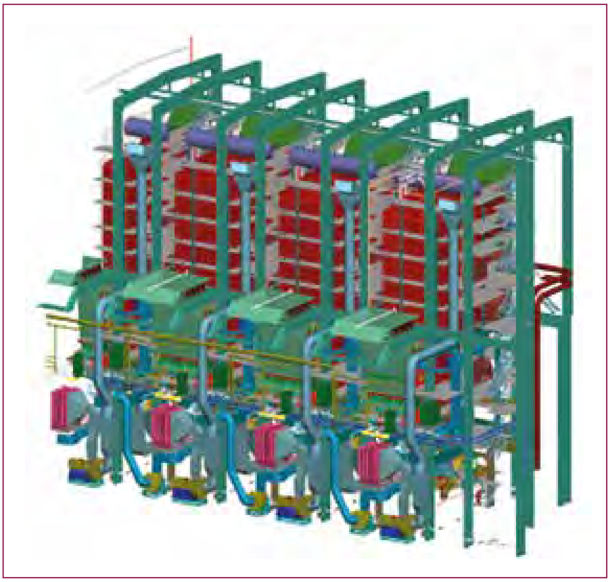

Figure 9:

3D layout for 4-line concept of the Malesice plant

6. Summary

Having carefully analyzed various scenarios, ZEVO decided to replace the existing roller grates with reverse-acting grates.

The boiler concept was optimized to achieve high levels of availability and a high energy output.

At the same time, reliable waste disposal is ensured because the existing lines continue to operate.

A large part of the equipment and services required for the project will be provided by Czech suppliers.

This is a challenging project, which can be successfully handled thanks to the excellent partnership and cooperation between ZEVO and Martin.

7. References

[1] European Parliament, Council, Directive 2008/98/EC: Waste Framework Directive

[2] European Industrial Emissions Directive, IED, 2010

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Contact Person

Dipl.-Ing. Norbert Eickhoff
Martin GmbH für Umwelt- und Energietechnik
Senior Vice President
Projects and Acquisition
Leopoldstraße 248
80638 München
GERMANY
Phone: 089 - 3 56 17 - 1 83
Email: norbert.eickhoff@martingmbh.de

Other Institutions

Prazske Sluzby A.s., Praha, Czech Republic

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