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MODERN TECHNOLOGIES OF HEAT PRODUCTION AS AN OPPORTUNITY FOR COAL

1. Introduction

Apart from industrial power generation, system heat generation and individual heat generators are the major coal consumers in Poland. The heat generation sector comprises more than 8800 heat generators — ranging from big ones to small local boilers, with some of them producing not only heat but electrical power as well.

In total, depending on the heating season, heat production consumes from about 16.5 to 18.5 million tons of coal [1, 2].

There are approximately 7.5 thousand low power heat generators, with nominal power from 1.0 to 1.5 MW and in the nearest future their owners will not afford the necessary but expensive investments in air protection. The alternative solution for them would be to apply natural gas technologies.

Another major consumer sector is that of individual housing, who use mainly coarse coal types — with heating value of up to 30 MJ/kg, sulphur content below 0.5% and ash content below 8%. Total sale of these types of coal reaches about 6 million tonnes a year, however with a decreasing tendency [3].

A significant number of coal boilers, central heating boilers and boilers in individual houses are in bad technical conditions and have poor heat production efficiency (up to 50–60%), which increases the costs of heating. It should also be noted that very often these boilers use cheap fuels of bad quality, such as sulphated and low-calorific coals with high ash content, coal slurries and inter-layers. These are the real culprits generating the so-called ground-level emissions.

In the recent years a lot of boiler houses noxious to the environment have been modernised with the help of various means of funding (such us environment protection funds).

In particular the state owned entities were eager to use them. Modernization of boiler houses aimed at applying natural gas combustion and oil furnace technologies. However, a significant increase in prices of these fuels after 1995 resulted in difficult financial situa-

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tion numerous consumers found themselves in, as the operating costs, and thus also the heating costs, became very high.

Moreover, despite the fact that many houses were connected to a gas network, low emissions were not eliminated because having received their first bills for gas, in many instances they moved back to coal heating.

In addition, in many cases it is prohibitively expensive for gas distributors to connect individual users to the network.

Economic analyses recently done by many heat production plants in order to investigate and expand their markets showed that in some case new clients' connections will always generate losses resulting, among others, from the following reasons:

1) great distance between the clients and the heat generation plant;
2) the need to periodically operate a heat generator whose power significantly exceeds demand;
3) closures of industrial plants — so far the biggest heat consumers.

A perfect solution in such cases would be to have local heat generators built on the premises.

To combine economic and environmental requirements seems to be in such cases the most reasonable solution. In particular to combine modern combustion technologies with high-quality coal fuel.

2. Automatic, low-emission coal boilers with retort furnaces

These technologies appeared in the Polish market in the mid '90s, as a part of the PHARE program and their main advantages are as follows:

1) high efficiency — up to 85% — providing the lowest heat production costs ranging from about 4 USD to 5.5 USD/GJ (depending on coal price and size of the installation), while natural gas heating costs vary from 10 to 12 USD/GJ;
2) automated work and staff attention hardly necessary (coal intake in small units done once in 3–5 days, service time required for bigger units — up to 1 hour a day);
3) meeting the standards of toxic substances emission (technologies meeting the standards accepted in the EU countries and supported by the Polish environment protection programs).

Home producers offer units of 15–1800 KW power and 78–85% efficiency. Particularly recommended are the retort structures awarded heat efficiency and emission certificates (Power Certificate and Ecological Safety Mark) issued by relevant research entities [4].

Characteristics of the boilers offered by home producers

— thermal power — from 15 to 1800 KW,
— efficiency — from 78 to about 85%,
— furnace — "Stocker" retorts type,
— coal feeder — feeding screw,
— processor controller — Micro TERM (or another),
— power supply — 220 V,

— own power consumption — 0.4 to 1.0% of the thermal power value,
— max. working pressure — 0.2 MPa,
— water temperature — 95°C (not recommended to work with temperatures lower than 56°C),
— heating installations: open system,
— staff required for big units: 1 person once a day (30−120 minutes),
— staff required for small units: once in 3 to 6 days.

The boilers are designed for heating of individual houses, blocks of flats, farms and also municipal or industrial objects such as schools, hospitals, brickyards and bakeries. However they can also be used in heat generation plants as local generators and also as main boilers with power generation capacities of up to 7.0 MW. These boilers can also be used to produce hot water and technological steam.

They can be used for both dispersed and compact site development — in particular in the areas where the problem of ground-level emission exists and where it is difficult to remove it due to economic or technical problems.

In higher-power boiler houses several units of different powers can be installed in parallel and work in one hydraulic system and thus the heating system becomes very flexible to match various demands in various heating seasons.

The work characteristics of the boilers are almost flat which provides optimum efficiency within the range of 30–100% of the thermal load.

The boilers of this type have self-cleaning retort furnace, which burns exactly such portion of coal as is necessary to generate the temperature a user demanded by setting it on an electronic controller.

The boiler is entirely operated by a microprocessor controller (coal feeding, aeration) which allows to maintain the demanded room temperature, also in systems depending on the outside temperature, and room temperature can be set differently for different periods of day.

They do not require permanent staff involvement.

Boilers designed for individual houses (15−50 KW) can function for 3–6 days without service, depending on weather conditions. Coal consumption in such cases ranges from about 1–1.5 kg per hour for a boiler working at its nominal load.

The boilers with bigger power can be equipped with a container loaded once or a few times during the heating season, from which the coal is fed into the boiler in a continuous way.

The ash is discharged in a continuous way as well, however its volume is very small as the coals used are of high quality.

Most of the units produced are designed to burn certain precisely defined types of coal that need to have appropriate physical and chemical parameters to provide:

— failure-free boiler's operation (appropriate coal size, no solid impurities, low sinterability, high temperature of ash sintering and softening);
— meeting emission standards (high calorific value, low sulphur content: 0.3–0.6%, low ash content: 4–10%);
— the lowest heat generation costs.

Katowicki Holding Węglowy S.A. has undertaken to produce such fuels whose technical parameters are presented below:

— Trade name of the coal fuel: EKORET®.
— Coal type: 31 or 32.1.
— Grain size [mm]: (5) 8–25.
— Heating value [MJ/kg]: >26.
— Ash content [%]: 4–10.
— Sulphur content [%]: <0,6.
— Coke type (Gray-King method): A to D.
— Sinterability [RI]: max. 10.
— Ash sintering temperature t_s [°C]: >1000.
— Ash softening temperature t_A [°C]: >1250.
— Moisture content [%]: to 12.

In order to produce EKORET, Katowicki Holding Węglowy started a new dedicated technological line and increased availability of this fuel through a network of authorised KHW S.A. dealers, who run about 500 store yards throughout the country. At present, KHW S.A. is conducting a research to combine EKORET and biomass in one combustion process, which in some cases can reduce heat production costs even more.

3. Ecological and economic aspects of using modern coal boilers

The combustion process taking place in retort boilers is technologically advanced, worked out in details and precisely controlled which, together with the requirement to use high quality coal results in significant reduction in the level of emissions of toxic substances from these boilers in comparison to traditional coal boilers (Tab. 1).

TABLE 1

Emission ratios of retort boilers — reduction of emissions in comparison to traditional coal boilers

Type of emission	% Reduction
SO_2	up to 35%
No_x	up to 22%
CO_2	up to 25%
CO	up to 97%
Dust	up to 92%
TOC	up to 90%
16 WWA acc. to EPA	up to 93–98%
Benzopyrone	up to 97%

At present 42 home producers offering such units hold certificates issued by authorised research and scientific entities (such as IChPW in Zabrze). The certificates specify actual emission ratios as observed during the operation. The differences in the emission ratios between traditional and retort boilers are shown above.

High thermal efficiency of these facilities ranging from 78 to 85% has a direct impact on the heat production cost. In case of the boilers designed for individual houses (up to 25 kW), the heat production costs are as much as 40% lower than in the case of traditional coal boilers and almost two times lower than in the case of natural gas heat production — applying the tariff applicable for flats and individual houses (Fig. 1).

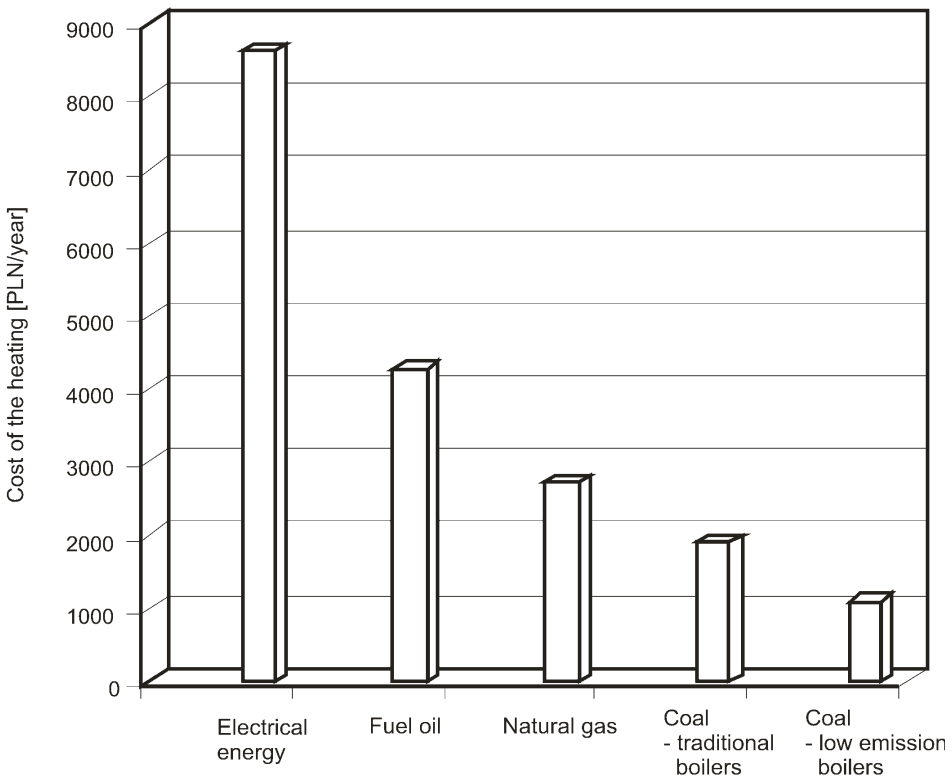

Fig. 1. Example — cost of heating of the room with the surface 100 m^2 at the use of different types of energy and technologies of combustion

The boilers' unit costs ranges from 50 to 70 USD (excl VAT) per 1 KW, depending on the manufacturer. The entire installation cost may range from 110 to 150 USD per 1 KW of the installed power.

It should be noted that the cost of construction of a boiler house in which retort boilers are installed can be about 25–35% higher than for an oil boiler house of similar parameters. However, with the significantly lower operating costs (in particular fuel-related), in most cases the higher investment costs are returned within up to 2 years.

The economic, ecological and technical advantages of these facilities, together with the relevant infrastructure established by Katowicki Holding Węglowy S.A. such as:

— informational and advertising actions performed on a large scale,
— cooperation with the manufacturers of the installations,
— cooperation with local authorities,
— cooperation with developers,
— help in designing, assembly, servicing and funding of installations,
— coal fuel — EKORET — available on the market,

resulted in a significant increase in the demand for these technologies, the demand showing a geometrical increase tendency.

KHW S.A. conducted an analysis to find out how many retort boilers were sold by various manufacturers (Figs 2 and 3) and also to assess the demand for EKORET. The results show that since 2004 about 25 000 facilities of this kind were installed throughout the country and their total thermal power exceeded 800 MW. The manufacturers predict a large increase in demand before 2005 which would increase the demand for coal to 240 000 tons a year.

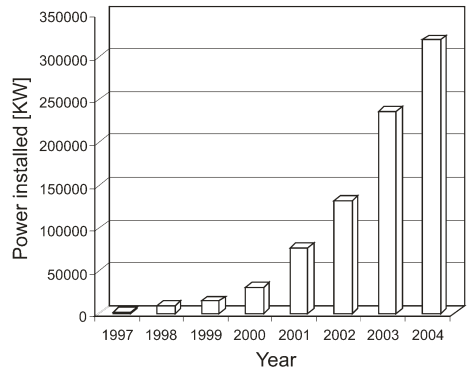

Fig. 2. Retort boilers — total power installed in Poland

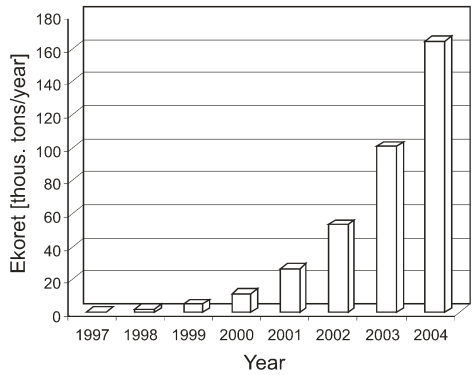

Fig. 3. New coal fuel market (EKORET) for retort boilers

In summary: the high prices recently reached by fuel oil and natural gas make coal more competitive as a power generating fuel, in particular if new generation coal boilers are used. They work very well both in individual houses and in small or medium boiler houses, especially in such locations where network heating is cost-ineffective or where ground-level emissions should be avoided.

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