POSSIBILITIES OF ENERGETIC AND ECONOMIC UTILIZATION OF WASTE MINE GAS

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Abstract

Moravian Silesian region, Czech Republic is typical of coal mining and mining gas occurrence. The gas is during the coal mining drawn and further it is exploited as degasation gas. As the mine is closed, the gas is not drawn and it moves freely to the surface which might present a danger of exploitation in the concentration of 5 – 15% CH₄ in the air. Methane is the second significant substance in emission causing the greenhouse effect. One of the possibilities of energetic utilization is the gas exploitation for metallurgy. As gaseous alternative fuel for blast furnace, it would present an economic alternative for coke savings.

Keywords: waste mine gas, alternative fuels, emission

1. INTRODUCTION

The inhibition of mining brings about many of risks in Ostrava-Karviná mining distrik (OKR). The main risk consists in the outlet of waste mine gas (WMG) from the closed mines. The main component of this waste mine gas is methane (30-47%), the second significant substance in emission causing the greenhouse effect. Suitable closing shafts it is possible to get through the use of technical equipment a relatively significant source of energy. As is well known, that the OKR larger quantities of degassing boreholes were established to protect the atmosphere and settlements.

Development of residual gas capacity at the Paskov Plant (Paskov Mine) after its closure in 1999 shown Fig. 1. Here during 11 years the residual gas capacity (VMG) grows.[1]

It offers therefore a logical question, whether the gas drained by these boreholes can also be economically exploited. One of the possibilities of energetic and economic utilization is the gas exploitation for metallurgy as substitute fuels.
2. POSSIBILITIES OF UTILIZING WASTE MINE GAS IN BLAST FURNACE

Reduction gas originates directly in a blast furnace during blast-furnace process, mainly in front of the tuyeres. Not only conventional metallurgical coke is used as carbon and hydrocarbon carriers with the blast furnace but also alternative fuels such as various kinds of oils, tars, modified plastic material or coal dust [2]. Fossil fuel is the main source of greenhouse gas emissions for steel plant, especially for ironmaking [3].

Methane contained in the waste mine gas reacts with oxygen of the blast-furnace wind according to the reaction

\[
\text{CH}_4 + \frac{1}{2} \text{O}_2 = 2 \text{H}_2 + \text{CO} \quad \Delta H_{298}^0 = -41994 \text{kJ} \tag{1}
\]

however, CO\textsubscript{2} and H\textsubscript{2}O are temporarily formed, as well.

In the case of using coke, combustion of 1 kg of C in a current of unenriched wind will give 5.21 m\textsuperscript{3} of gas, and in the case of using methane, it is 9.1 m\textsuperscript{3}.

Adding of carbon gas causes the following technological effects: saving of specific coke consumption, increasing of richness of the mixture by lower need for basic slag formers and increasing of specific occurrence of gas in the lower part of the furnace, reducing of specific occurrence of slag, combustion temperature before tuyeres, changing of counter-current intensity and gas flowing structure in the lower part of the furnace, changing of lower zone permeability and fuel combustion intensity. [4]

Methods of the evaluation of application of waste mine gas during iron pig production results from general elementary relations of determination of costs on blast-furnace process and from simulation results and practical tests when gaseous alternative fuel is added. The eco-innovation in connection with metallurgical products means technical, organizational and marketing changes. [5]
The conventional route for making steel consists of sintering or pelletization plants, coke ovens, blast furnaces, and basic oxygen furnaces [6], [7].

Recent research studies show that the steelworks management should: seek opportunities, focus on the revealed opportunities, improve marketing and develop their technological capabilities. [8]

From the economic point of view saving of coke specific consumption is dominant. Coefficient decreases with the growth of the specific consumption of fuel (it is influenced by changes of the structure of gas flow in the lower part of the blast furnace). Methane content has significant influence as well. Nevertheless with the lower content ballast nitrogen content is increased at the same time and this finally results in reducing coke savings.

Increase of charge abundance is a secondary impact of the saving of coke specific consumption. It follows from reduced need of basic substances in sinter and it also maintains lower sulphur input from coke dust (gaseous fuel does not contain remarkable sulphur).

When influences of coke savings and reduction of basic substances in the charge are combined specific occurrence of sinter is decreased. This fact reduces a negative influence on contra-flow in the lower part of the blast furnace. All mentioned changes arising from WMG injection can be determined on the basis of material and heat balances. Dominant influence of cumulative substitution coefficient was considered for economic calculations.

Structure of gas flow in the lower furnace part depends on centre shape, combustion centre size, softening zone shape and sinter creation. Generally it can be expected that deterioration of permeability in the initial phases that are sufficiently off congestion (critical porosity) leads to flow equalization along the furnace cross-section. It can lead to the improvement of the substitution coefficient.

3. REALIZATION OF ADDING WASTE MINE GAS AND CHANGES OF ECONOMIC PARAMETERS

Realization of adding WMG causes also changes of economic parameters: necessary investment and operation costs becoming evident in the amount of depreciation, expenses on maintenance and in an increase of operation costs. Results of calculations are mentioned graphically in the following Fig. 2.

![Fig. 2 Economic savings for injecting gas into a blast furnace [9]](image-url)
It is obvious from the running of the curves that a significant decrease of costs occurs in all investment variants when minimum amount of injected gas of about 2000 Nm\(^3\).hour\(^{-1}\) is exceeded. While adding the natural gas is actually the least favourable option because of the high price (but still advantageous), elimination of nitrogen from the common WMG seems to be the most advantageous option [9]. From the above mentioned follows that injection of alternative fuel does not solve only reduction of costs but it also solves the problem of disequilibrium or lack in need of blast-furnace coke.

It was carried out analysis of sensitivity to the changes of decisive parameters for WMG option and injected amount of 10000 Nm\(^3\). hour\(^{-1}\). The results are mentioned in the following table 1.

### Tab. 1 Analysis of sensitivity to the changes of decisive parameters

<table>
<thead>
<tr>
<th>Changing the parameter</th>
<th>Economies decrease [CZK . t(^{-1}) pig iron]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coke price decrease 500 CZK . t(^{-1})</td>
<td>17,24</td>
</tr>
<tr>
<td>Decrease in the coefficient of substitution</td>
<td>8,31</td>
</tr>
<tr>
<td>WMG prices increase 200 CZK.Nm(^{-3})</td>
<td>16,23</td>
</tr>
<tr>
<td>Investment costs exceeding 5 million CZK</td>
<td>0,94</td>
</tr>
</tbody>
</table>

To make a final decision about an investment on the gas adding it will be decisive the prognosis of development of coke price and price of injected gases, eventual exceeding of investment costs is less important.

### 4. CONCLUSION

This article presents economic evaluation of utilizing the WMG from OKR in the blast-furnace production of iron. However, it is also important that the injection of the substitute gas fuel not only brings a cost reduction, but it also resolves the problems of CO\(_2\) emission. Prognosis of the traditional alternative fuels is much easier where the prosperous experiences with operation under various conditions are on the other hand the advance technological estimation of the replacement coefficient is always very problematic in case of not traditional fuels. Increasing of efficiency of metallurgical technologies together with decreasing of emissions are the most important tasks in abroad and in the Czech Republic for the time being.

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### LITERATURE


GAJDZIK B., BURCHART-KOROL D. Eco-innovation in manufacturing plants illustrated with an example of Steel products development, Metalurgija, 2011, vol. 50 (1). pp.63-66, ISSN 0543-5846.


