# EVALUATION OF THE QUALITY OF COKE FOR BLAST FURNACE PROCESS IN CHOSEN METALLURGICAL PLANT

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**Abstract**

Economics of blast furnace process, which determines the total cost of production, is one of the most important elements of management in steelworks. In the article the coke consumption from different manufacturers in the blast furnace process in chosen metallurgical plant over five years was presented. Water, ash and volatile matter in the cokes used during this period was analysed. Quantitative and qualitative evaluation of the research cokes was also made. The obtained data was compared with guidelines contained in the BAT (Best Available Techniques), guideline for Iron and Steel Production.

**Keywords:** coke, pig iron, humidity, ash, volatile matter

## 1. INTRODUCTION

A coke, beside an ore and fluxes, is one of the components of the charge to the blast furnace. During the heating of the charge, these materials soften and melt, only the coke is in a solid state even at the highest temperatures of approx. 2000ºC. Solid state of the coke makes that it serves as scaffolding, which may be used by other material to run down during melting. This causes that one of the most important properties of the coke is pieces stability, especially at high temperatures. However, based on research literature [1] and following technological observation [2] attenuation of the coke grains was noticed.

The probable cause of this phenomenon may be melting ash, which at low temperatures causes the phenomenon of scaling, and after melting can cause increased mobility of this structure. Another important factor in the degradation of the coke is change of the coal structure in the coke and its progressing graphitization.

The aim of the article was to determine quality of the coke used during blast furnace process. The same time operation of the chosen blast furnace with the use of this coke was analysed. Main factors of the blast furnace were determined, then they were compared with the factors described in BAT including guidelines for the production of iron and steel in integrated steelworks.

## 2. COKE USED DURING PRODUCTION OF IRON PIG IN A BLAST FURNACE

### 2.1. Blast furnace as an research object

In the article operating status of one of the blast furnaces in Polish metallurgical plant was presented. Usable capacity of the blast furnace was 3200 m$^3$. Operation of the chosen blast furnace during 5 consecutive years, e.g. 2004-2008, was analysed. At the end of the fifth year (in November) the blast furnace was stopped to be partially restored. The amount of the blast furnace pig iron and technological slag was shown in **Table 1** and **Figures 1** and **2**.

**Table 1.** Production of iron pig in the blast furnace during 5 consecutive years

| | Year | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Production of pig iron, Mg | 2 190 800 | 1 811 700 | 1 835 300 | 1 871 161 | 1 468 450 |
| Production of technological slag, Mg, including: | 615 835,98 | 474 835,74 | 570 160,67 | 504 640,05 | 446 605,23 |
| granulated slag | 583 283,28 | 460 577,40 | 550 962,67 | 449 578,17 | 437 540,23 |
| lump slag | 32 552,70 | 14 258,34 | 19 198,00 | 17 353,45 | 9 065,00 |

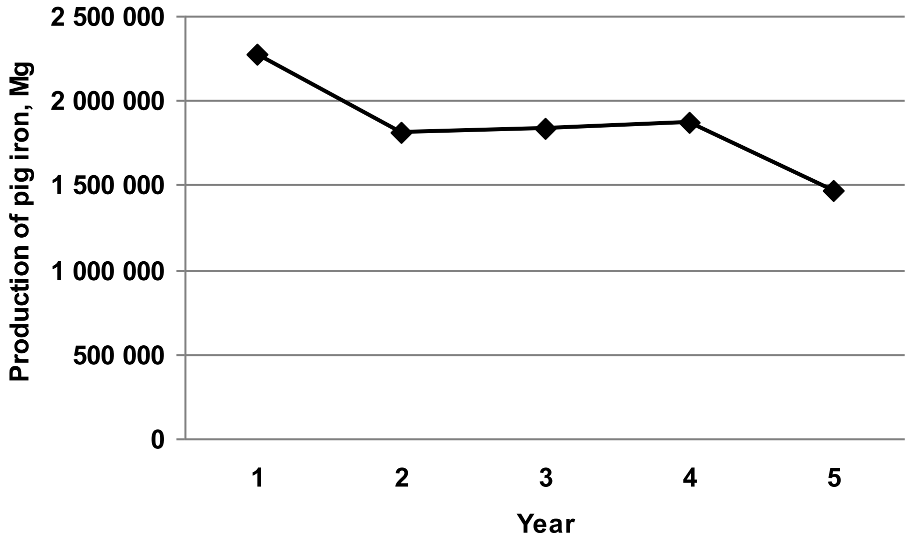


**Fig. 1.** Production of iron pig in the blast furnace during 5 consecutive years in Polish metallurgical plant

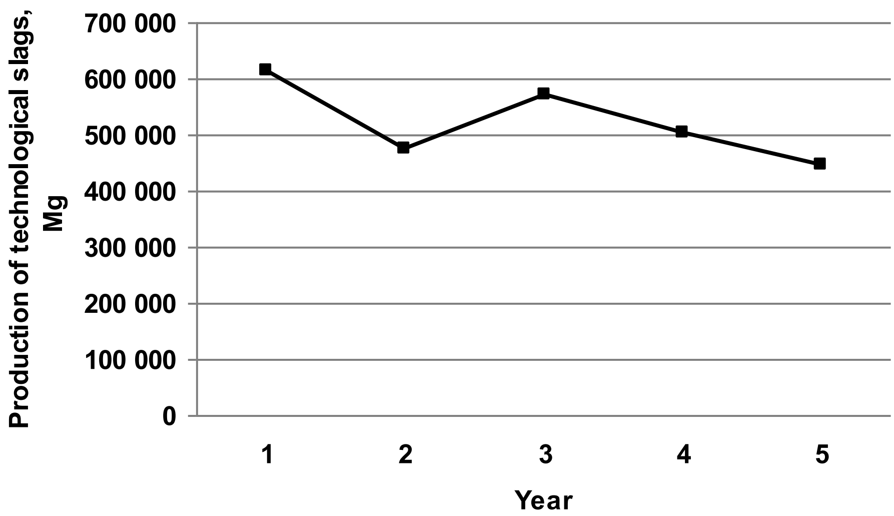


**Fig. 2.** Production of technological slag in the blast furnace during 5 consecutive years in Polish metallurgical plant

Factors of slag production (kg) (**Fig. 3**) and use of coke (kg) (**Fig. 4**) per 1 Mg produced iron pig in the research period were calculated.

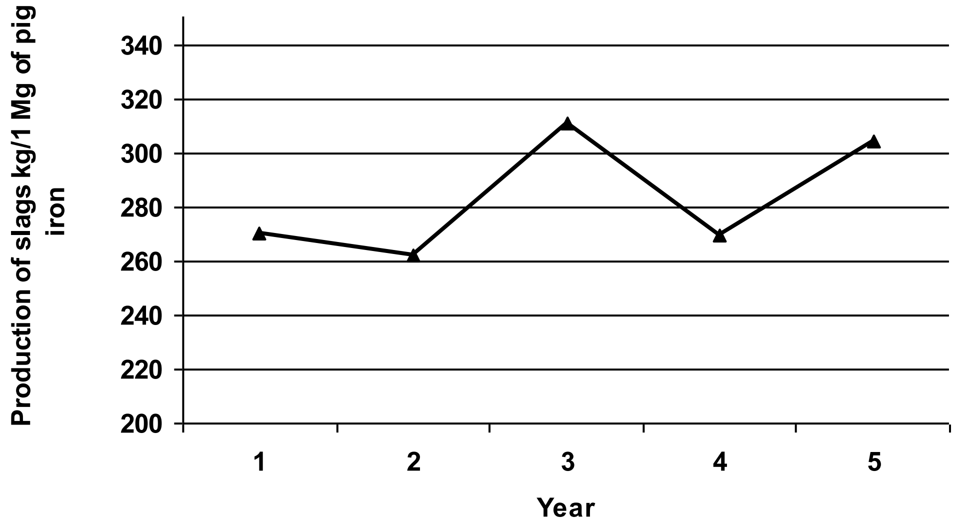


**Fig. 3.** Production of technological slag per 1 Mg of pig iron in the blast furnace during 5 consecutive years in Polish metallurgical plant

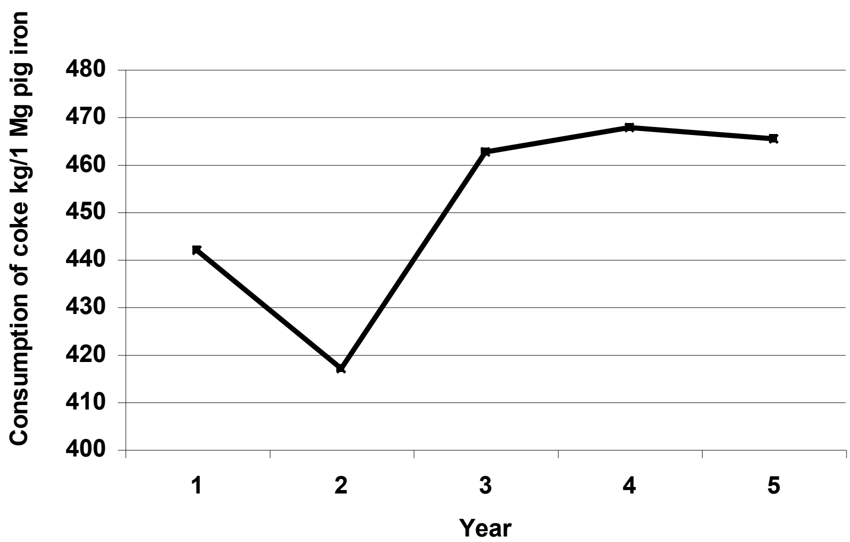


**Fig. 4.** Consumption of blast furnace coke per 1 Mg of pig iron in the blast furnace during 5 consecutive years in Polish metallurgical plant

### 2.2. Quality assessment of the coke for the blast furnace process in chosen metallurgical plant

Coking plant Zdzieszowice was the main supplier of the blast furnace coke in the research period. Moreover, Coking plan Częstochowa, Szczecin Dębie and Zabrze also delivered this material (**Table 2**). So the cokes used in the blast furnace had different types.

**Table 2.** Blast furnace coke supplier in the research period

| Mass of coke, % | | | | | |
|---|---|---|---|---|---|
| Supplier | Year | | | | |
| | 1 | 2 | 3 | 4 | 5 |
| Coking plant Zdzieszowice | 99.93 | 99.86 | 84.67 | 97.21 | 97.87 |
| Coking plant Szczecin Dębie | - | 0.14 | 1.96 | 1.29 | 2.13 |
| Coking plant Częstochowa | 0.07 | - | 1.81 | - | - |
| Coking plant Zabrze | - | - | 11.56 | 1.49 | - |
| Total | 100 | 100 | 100 | 100 | 100 |

In the research period continuous supplies of the coke were made from the Coking plant Zdzieszowice. The coke from the Coking plant Zdzieszowice was the basic material, however, in the third year there was an disturbance of supply - fall to 85%, aligned to the level of 97-98% in the fourth and fifth year. The share of Coking Plant Czestochowa in the supply of the coke was noticeable in the first and third year of the research period. In the fourth and fifth year there was no supply due to the general overhaul of the coke oven battery in this Coking Plant. In years 2 - 5 years the supplies from Coking plant Szczecin Dębie in the amount of 0.14 - 2% of the total supply were made. In years 3 - 4 years supplies were supplemented from Coking plant Zabrze (respectively 11.5% and 1.5%).

The quality of the cokes analysed in the research period from listed suppliers was shown in **Table 3**, **4** and **5**.

**Table 3.** Humidity content (%) in blast furnace cokes from different suppliers in the research period

| Humidity content, % | | | | | |
|---|---|---|---|---|---|
| Supplier | Year | | | | |
| | 1 | 2 | 3 | 4 | 5 |
| Coking plant Zdzieszowice | 4.29 | 4.60 | 4.44 | 4.53 | 4.91 |
| Coking plant Szczecin Dębie | - | 6.5 | 6.10 | 6.75 | 5.65 |
| Coking plant Częstochowa | 6.20 | - | 5.59 | - | - |
| Coking plant Zabrze | - | - | 4.72 | 4.30 | - |

The coke from Coking plant Zdzieszowice had humidity which ranged from 4.29 to 4.91%. Higher humidity content was observed in case of the cokes from Coking plant Szczecin Dębie - at 6.25%, and for Coking plant Czestochowa at 5.89%. The coke delivered from Coking plant Zabrze had set humidity level at 4.5%.

**Table 4.** Ash content (%) in blast furnace cokes from different suppliers in the research period

| Ash content, % | | | | | |
|---|---|---|---|---|---|
| Supplier | Year | | | | |
| | 1 | 2 | 3 | 4 | 5 |
| Coking plant Zdzieszowice | 9.45 | 9.62 | 9.74 | 9.24 | 10.1 |
| Coking plant Szczecin Dębie | - | 10.5 | 10.70 | 11.80 | 12.30 |
| Coking plant Częstochowa | 9.6 | - | 9.3 | - | - |
| Coking plant Zabrze | - | - | 9.42 | 9.38 | - |

The coke delivered from Coking plant Czestochowa had ash content at 9.45%. Similar ash content was observed in case of the coke from Coking plant Zabrze – at 9.4%. Larger amounts of ash content was observed for the coke from Coking plant Zdzieszowice - at 9.63%. The highest ash content was noticed in case of the coke from Coking plant Szczecin Dębie – at 11.33%. In case this coking plant deterioration of the quality level of delivered coke was observed.

**Table 5.** Volatile matter content (%) in blast furnace cokes from different suppliers in the research period

| Volatile matter content, % | | | | | |
|---|---|---|---|---|---|
| Supplier | Year | | | | |
| | 1 | 2 | 3 | 4 | 5 |
| Coking plant Zdzieszowice | 0.67 | 0.59 | 0.63 | 0.58 | 0.45 |
| Coking plant Szczecin Dębie | - | 1.14 | 1.17 | 1.14 | 2.45 |
| Coking plant Częstochowa | 0.68 | - | 0.64 | - | - |
| Coking plant Zabrze | - | - | 0.69 | 0.64 | - |

In case of volatile matter content in the coke, similar relations as in the case of ash content were observed. The coke delivered from Coking Plant Czestochowa had stabilized volatile matter content at 0.66%. Similar volatile matter content was observed for cokes from Coking plan Zabrze – at 0.67%, and for cokes from Coking plant Zdzieszowice – 0.62%, with the trend of reduction of the volatiles matter to the level of 0.45% in the last analysed year. The highest content of volatiles matter was observed in cokes from Coking plan Szczecin Dębie – at 1.48%. In this coking plant deterioration of the quality level of delivered coke was observed, and in the last year even a drastic fall in the case of ash and volatile matter content.

### 2.3. Quality assessment of the coke for blast furnace process in chosen metallurgical plant according to BAT

In the reference documents for blast furnace technology [3-5] the share of solid fuels for blast furnace technology at 520 - 580 kg/Mg of product was mentioned. According to conducted observations the coke in the amount of 420-470 kg/Mg of product and other assortments at 5% does not exceed the indicated levels of fuel consumption in the blast furnace process. At the same time it was noted that in case of blast furnace slag creation, the standards included in these regulations 200 – 290 kg/1 Mg of iron pig have been slightly exceeded, i.e. in the third year it reached 310 kg/ 1 Mg of pig iron.

## CONCLUSION

On the basis of conducted analysis of pig iron production in the chosen Polish metallurgical plant during 5 consecutive years it was found that the furnace worked steadily, without major interruptions. In the research period there were some difficulties connected to fuel deliver, i.e. the blast furnace coke. The metallurgical plant was not able to buy this material only from one supplier. The coke was delivered also from other three suppliers. The cokes from all coking plants had similar properties, i.e. content of: humidity, ash and volatile matter. Qualitatively the worst coke was supplied by Coke plant Szczecin Dębie. The reason for the deteriorating quality of the coke were shortcomings in the relevant product range of carbon, which was used to form carbon mixtures. The blast furnace worked steadily when using delivered cokes. According to BAT the average efficiency of the blast furnace with a capacity of 3200 $m^3$ is 2.2 million Mg of pig iron. The capacity of the research blast furnace was like this. 2008 was the fifth year of the conducted analysis. The same time it was the first year of the world crisis. This caused the plant management decided to partially repair the blast furnace.

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