POSSIBLE IMPROVEMENT OF IRONMAKING TECHNOLOGY ECONOMICS BY BLAST FURNACE FEEDSTOCK OPTIMIZATION

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Abstract

The paper deals with possibilities of improvement of iron making technology in economic point of view. The optimization of blast furnace feedstock is one of approaches how to reach it. The paper focuses on blast furnace feedstock properties. It devotes to blast furnace reducibility which is an important characteristic which determines the whole process of feedstock reduction. There are presented results of reducibility tests. These results are correlated with important parameters of blast furnace operation. Finally, the paper concludes an economical evaluation of materials typical with variable reducibility and calculates costs for their processing in a blast furnace aggregate.

Keywords: blast furnace feedstock, reducibility, optimization

1. INTRODUCTION

The blast furnace technology is the most energetically determined in the whole metallurgical cycle and requires about 12 - 18 GJ /t H.M. The half of this energy relates to processes of iron oxides reduction. The Energy Police of Czech Republic includes a strategy for decrease in energy in the field of metal production. To reach this aim, it is necessary to implement measures in all the phases of metallurgical cycle, especially those ones which do not require high investments. The optimization of blast furnace feedstock properties is an essential way how to reach it. [1]

Nowadays, there are intensively discussed requirements for decrease in carbon consumption as well as relating CO_2 emissions in blast furnace affected by balance transformation of reaction FeO-Fe at a decrease in temperature of heat ineffective zone. The relation between iron and wüstite, magnetite, hematite and gaseous mixture of carbon monoxide and carbon dioxide on temperature is presented in Baur - Glaessner diagram in **Fig. 1**. [2]

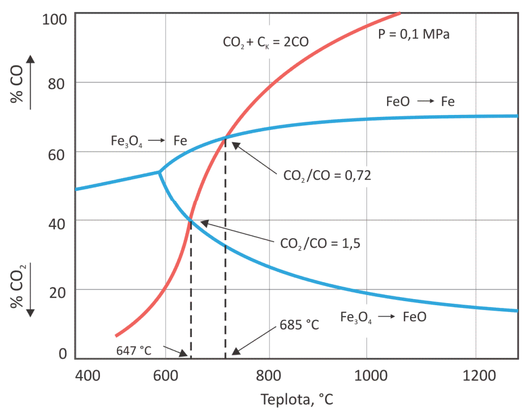

Fig. 1 Baur - Glaessner diagram of Fe - O - C at 0,1 MPa

There are several possibilities to reach the mentioned balance in the system:

- Coke of high reactivity
- Direct reduction by solid carbon
- Decrease in balance temperature between reductive gas and wüstite for some metallurgical materials

2. REDUCIBILITY AS AN IMPORTANT CHARACTERISTIC OF BLAST FURNACE FEEDSTOCK

Reducibility is an important blast furnace feedstock characteristic. Generally it presents a mass loss in the sample caused by oxygen reduction in iron ores and its transformation into output gases. The reducibility is possible to use for determination of optimal blast furnace feedstock composition. The method for blast furnace process optimization might include convenient combination of experimental reducibility tests of metallurgical materials, fuels and reductants together with approaches of chemical engineering for predictive models of metallurgical processes. The comprehensive and specific experimentally-acquired information enable to design sophisticated kinetics models of reductive and heat processes. It enables overall optimization of energy consumption as same as consumption of reductant (coke) for the production process. Moreover, it results in optimization of input iron ore feedstock in the view of required blast furnace productivity. The methodology arises from the fact that properties of input materials, fuels and reductants, as same as, technological conditions relate each other, therefore they should by optimize as a complex. The solution relates to exploitation of exceptional possibilities of experimental laboratory for identification of comprehensive properties of raw materials such as ores reducibility, coke reactivity) and new knowledge about dynamics of their relation which is reflected into possibilities of process prediction in the aggregate and enable a variant assessment of progressive technology. [3-5]

Reducibility is one of input data entering the simulation model. The methodology for technology optimization works on the presumption the lower temperature of reaction (1) and initiation temperature of Loss Reaction result in higher η (grade of CO utilization) resulting in lower carbon consumption for indirect reduction.

$$FeO + 1/\eta . CO = Fe + CO_2 + (1/\eta - 1) \qquad (1)$$

For balance conditions, the lowest specific carbon consumption is at temperature 685 °C. In this point $CO_2/CO = \log K_p = 949/T - 1.134 = 0.72$. Amount of CO necessary for wüstite reduction is minimal 2.4 mol, grade of CO utilization for it is $\eta = 0.42$. In comparison, at 900 °C it is $\eta = 32\%$. [5-9]

2.1 Reducibility of tested material in correlation with blast furnace parameters

In Laboratory for Testing of High Temperature Properties of Raw Materials, at Centre ENET, several samples of metallurgical materials were tested. The reducibility test was carried out according to ISO 4695. The conditions of worked out test are presented in **Table 1**.

Table 1 Conditions of reducibility test according to ISO 4695

Standard	REDUCTION MIXTURE [%]				Flow [l·min]	t [°C]
	CO	CO_2	H_2	N_2		
ISO 4695	40	0	0	60	50	950

There were tested five samples of prepared sinter. The results were correlated with significant blast furnace parameters such as grade of CO utilization η_{CO} (see **Fig. 2**) and ω (see **Fig. 3**) calculated as a deviation from ideal state and presenting a possible coke reserve, at the same time. [10,11]

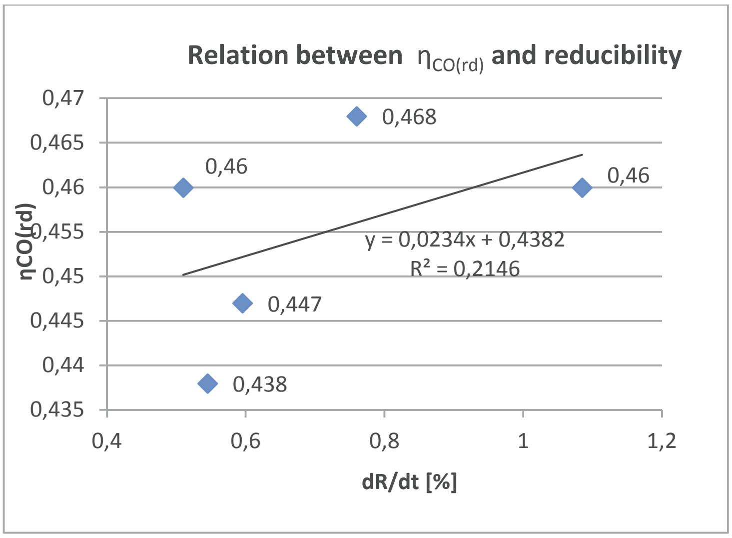

Fig. 2 Correlation between grade of CO utilization and reducibility

In **Fig. 2**, there is an obvious low correlation in that sense that sinter reducibility increases gas exploitation for reduction process. The mentioned trend is confirmed by analogical correlation between coke reactivity indexes and coke consumption. The more reactive coke decreases in consumption of coke as fuel. The designed kinetics curves of oxide reduction at the sinter reducibility testing were used for model interpretation. The curves were used as input data for models at Centre ENET - Energy Units for Utilization of non-traditional Energy Sources. The curves were used for calculation of deviation from ideal reduction process, generally presented as ω. This counted parameter is important information defining possibilities for blast furnace optimization.

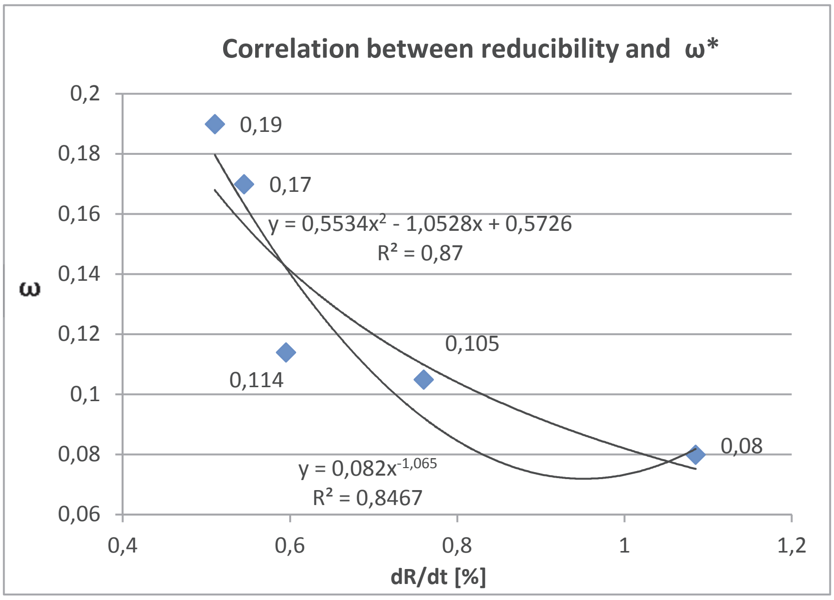

Fig. 3 Correlation between reducibility and ω

This parameter determined by model data interpretation of reductive test presents the lowest values of deviation which are possible the tested sinter to reach. It is a practically reachable approximation to that theoretical reserve for the specified operation of blast furnace processing the tested sinter. It is possible to interpret this potential coke reserve as cost savings. In case ω = 0.002 the specific coke consumption would be 0.475 [kg coke/t HM]. Within the total production of 1 000 000 t and price for metallurgical coke

3 500 CZK per ton it is more 1.5 mil. CZK per year. This amount presents just possible savings without additional costs for coke reserve implementation. The changes in raw materials purchase are not considered. [12]

CONCLUSIONS

The calculated coke reserve expressed as ω might be used as a recommendation for optimalization of blast furnace production to change wind humidity, amount of oxygen or to affect on iron ore feedstock reducibility, coke reactivity. It is a deviation determined from reducibiliy tests presentin a real coke reserve of used iron ores such as pellets or sinter. In economical point of view, fully exploitation of technological reducibility utilization of iron ore might present savings about 1.6 mil. CZK per year.

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