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Alternative Coke Saving Technologies are the Prospect of Blast-Furnace Practice Development

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The expansion of coal injection under shortage conditions of necessary coal grades and dynamic change in prices needs the development of a wide range of coke replacement production technologies for implementation of the most effective option at each stage on the basis of combination with coke gas, stone coal, coal gasification products, etc. Blast-furnace smelting with hot reducing gas injection - low-grade coal gasification products – needs to work out for fundamental solution of coke saving problem.

Keywords: PULVERIZED COAL, RANGE OF COAL GRADES, COKE REPLACEMENT, COKE GAS, STONE COAL, COAL GASIFICATION PRODUCTS, ALTERNATIVE PRODUCTION TECHNOLOGIES

Introduction

Growing natural gas prices stimulate the development of production technologies with the use of pulverized coal fuel (PCF) mastered and widely applied in the advanced countries. The necessity of this production technology development at Ukrainian plants has no doubts. However considering this method like a "single prospect" of blast-furnace practice [1] contradicts the prevailing conditions and technological principles of industrial engineering.

First of all, the above is true for increased requirements to coke quality and charge coal composition as well as coal grades for PCF preparation. These requirements are impossible to meet because of short supply of necessary coal grades not only in Ukraine but also in the majority of countries at inaccessibility of the world market for Ukrainian plants. Other factor (organizational-technological) does not allow effective implementation of coal injection technology in case of small coal consumption restricted by real conditions on coke quality and range of injected coals.

In view of stated above, the problems of this method implementation at metallurgical plants of Ukraine and Russia and especially considering not quite successful results of pulverized coal fuel adoption at Alchevsk Integrated Iron & Steel Works have been discussed recently. The authors of report [2] showed raw material and technological restrictions in mining-metallurgical and fuel complexes of Ukraine based on the corresponding analysis. Coal injection is problematic at levels above 120 kg/t of pig-iron.

Specialists from East Scientific and Research Coal-Chemical Institute of Russia [3] mention that it is not simple to implement coal injection in general and at high coal consumption in particular. It was noted on the fifth international congress on theory and blast-furnace operation practice (Shanghai, 2009) that power engineering, environmental contamination and short supply of natural resources turned back the development of iron and steel industry in the majority of countries [4]. On this basis, specialists from different countries mentioned a number of risks caused by depletion of coked coal reserves and started developing combined coke-replacing blast-furnace operation practice.

Results and Discussion

It is shown earlier that implementation of expected results of coal injection needs, first of all, solution of technical problems related to radical improvement of coke and iron-ore raw material

properties [1, 5]. Solution of process control problems at low coke consumption are also referred to mentioned-above problems.

The specified restrictions, not observed in the initial stage of using coal injection in Europe and Asia, are now not only characteristic for Ukraine and Russia but soon will have a conjunctural effect on the development of the whole world metallurgy.

In view of the aforesaid, it is necessary to combine coal injection development with working out alternative coke-replacing production technologies. In this conjunction, we notice that a "single prospect" coal injection declared in [1] under conditions of growing deficiency of coked coals and coals for pulverized coal fuel preparation, and also high-quality iron-ore raw materials can become a deadlock prospect for certain plants.

This strategic step in the development of blast-furnace practice in Ukraine and Russia needs thorough understanding as the arguments against alternative technologies stated in [1] are at least unconvincing:

1. Coke gas injection is rejected in [1] because of its short supply, while the question is about not additional resources of coke gas but rational balance at the plant, under which coke gas resources required for blast-furnace smelting can be found by coke replacement with coal gasification products [6].

2. Partial replacement of coke by anthracitic coal is accepted [1]. In addition, the specificity for replacement of only 10-20 % coke and also long-term positive experience of using this method in blast furnaces with capacity from 1143 to 5000 m^3 at JSC "ArselorMittal Kryvyy Rih" [7], JSC "Makeevskiy Iron & Steel Works" [8], OJSC "Alchevsk Iron & Steel Works" [9], etc. are ignored.

3. Efficiency of hot reducing gas (coal gasification products) injection is called in question based on unreasonable acceptance of loss value 30-50 % in [1] and an emotional announce of efficiency of hot reducing gas (coal gasification products) injection decreased in 10 times as compared to coal injection. Having asserted that at coal injection there were no such losses, the authors [1] ignored the known considerable losses hidden in incomplete carbon gasification and fluidization of pulverized coal fuel ash in lances as well as restrictions of acceptable concentration of ash and sulfur in the coal.

Thus, to reduce technical advance in the blast-furnace practice to using only coal injection in the modern dynamical world of market economy under short supply of all resources means making many plants naked to unexpected turns of market condition. Expansion of coal injection technology at improvement of metallurgical properties of raw materials and coke should be accompanied by working out complementary and alternative production technologies. More and more specialists follow this ideology including its former opponents [5].

Mobile combination of pulverized coal fuel and coke gas (or other reducing gas) is one of coal injection alternatives. This method enables to inject 100-150 kg/t of pulverized coal fuel on particular blast furnaces at lack of required coal grades. In this case, it is necessary to inject 100-150 m^3/t of coke gas or equivalent amount of other reducing gas, for example, multipurpose pulverized coal fuel [6] with coke consumption corresponding to injection of 200 kg/t pulverized coal fuel for maintenance of optimum temperature in lances. If required metallurgical properties of coke are impossible to reach (for any reasons) it is expedient to reduce pulverized coal fuel consumption up to zero and increase coke gas rate to 200-250 m^3/t that will allow coke saving.

Now the Japanese specialists are developing a method of iron smelting with coke gas injection in blast furnace. And this coke gas is subjected to conversion and has high hydrogen content [10].

Charging practice of prepared lumpy hard coal can be used in various combinations with pulverized coal fuel. The most indicative results of this production technology are achieved at JSC "ArselorMittal Kryvyy Rih" during the periods when there was no hard coal short supply [8]. So, in October 2006 the coke consumption in the furnace with capacity 5000 m^3 was 426.8 kg/t at hard coal consumption 56 kg/t and natural gas rate 87.1 m^3/t, and in BF-6 with capacity 2000 m^3 in August, 2006 the coke rate was 436.1 kg/t at hard coal consumption 74 kg/t and natural gas rate 69.9 m^3/t [11].

Comparison of operational experience of BF-5 with capacity 1719 m^3 at OJSC "Alchevsk Iron & Steel Works" by two production technologies with charging lumpy hard coal through the furnace mouth and coal injection since 2006 till November 2010 showed the following:

- at hard coal charging the minimum coke consumption was 444 kg/t at hard coal consumption 44 kg/t (on the average for 2006) and natural gas rate 89 m^3/t [9];
- at coal injection the minimum coke consumption was reached in March 2009 - 477 kg/t at pulverized coal fuel consumption - 64 kg/t of pig-iron and natural gas rate 51.8 m^3/t.

A variety of reasons of unsuccessful mastering of coal injection technology do not allow well-founded conclusions, however lessons learned need further study. Considering the problems of coke replacement by blowing

components it is necessary to keep in view that technological measures of "compensation" [1, 5] to raise coal injection efficiency promote the substantial improvement of blast-furnace smelting parameters. The specified measures are the elements of blast-furnace practice advancement system to ensure the minimum coke rate at high efficiency of units.

The problem related to reduction of coke rate with the use of low-grade coal for replacement can be solved on the basis of working out new production technology of blast-furnace smelting with injection of hot reducing gas - pulverized coal fuel produced in special gasificators [6]. Theoretical interest to the problem is not diminished, however expected difficulties of practical implementation restrict the initiative of potential users. Nevertheless, [5] there is a hope for understanding the real situation with coal resources and necessity to solve this problem urgently [6].

Conclusions

A wide range of coke replacement technologies by various energy resources need to be developed under market conditions at dynamical change of fuel prices and transportation possibilities. Expansion of coal injection technology at improvement of raw materials and coke properties should be accompanied by working out complementary and alternative methods. The production technology of mobile combination of pulverized coal fuel, coke gas and stone coal is one of coal injection alternatives.

Coke consumption with the use of low-grade coals for replacement can be reduced on the basis of working out new production technologies of blast-furnace smelting with injection of hot reducing gases - coal gasification products produced in special gasificators under modern conditions of short supply of necessary coal grades [6].

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Альтернативные коксосберегающие технологии – перспектива развития доменного производства

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Расширение вдувания пылеугольного топлива в условиях дефицита углей необходимого сортамента и динамичного изменения цен требует развития широкого арсенала технологий замещения кокса для реализации на каждом этапе наиболее эффективного варианта на основе сочетания с коксовым газом, кусковым антрацитом, продуктами газификации углей и др. Для фундаментального решения проблемы коксосбережения необходима разработка технологии доменной плавки с вдуванием горячих восстановительных газов – продуктов газификации низкосортных углей.