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Application of Multichannel Lances in Steelmaking Processes. Bottom Units

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The history of adoption of multichannel lances for oxygen blowing of steel-smelting bath is stated. The equation for definition of lance position in relation to bath providing high oxygen uptake factor on refining is obtained.

Keywords: BOTTOM UNITS, OXYGEN LANCING, LANCE POSITION

Introduction

When Linde-Fraenkl invented oxygen generation from air in 1928, Allegheny Ludlum St. Corp applied this method in open-hearth bath lancing through steel tubes in 1946, and in 1947 Wheeling St. Corp and USS used single-channel roof lances for this purpose. But only in 1958, Weirton St. Corp and USS applied six-channel lances which reduced metal loss and wear of open-hearth furnace lining. Further, these lances were used all over the world.

The history repeated after invention (1952) and development of oxygen-converter process of top blast. Single-channel lances have been used for oxygen-converter process of top blast for the first time with restricted blowing intensity due slopping of metal and slag. In 1954, August Thyssen Hütte tested lances with a number of nozzles (n_n) 3-6 which axis made an angle of 7-15° with a vertical (α). But only in 1964, experimental smelting operations were carried out in Beckerwerte taking into account the experience of Yawata Iron & Steel Corp. Single-channel lances were used at Tobata Works as far back as 1959, but in 1964 the participants of annual conference I&SI Japan were informed about successful mastering of oxygen-converter process through multichannel lances. Obviously, patent by Air Prod & Chem. Corp (USA), which later merged with Linde, was declared on a multichannel lance in 1960 and published in 1962. Johnes & Loughlin St. Corp tested multichannel lances in Graham Res. Lab. in the same years and carried out industrial tests in Cleveland in 1963.

The first domestic oxygen converter at Dnepropetrovsk Iron & Steel Works named after G. I. Petrovskiy mastered multichannel lancing in 1964.

The first oxygen nozzles for blast furnace and basic-oxygen converter had cylindrical nozzles. In 1948, Republic St. Corp. (USA) tested open-hearth bath blowing through single-channel lances with de Laval nozzles, and patent of Great Britain was received in 1949. In domestic practice, de Laval nozzles in lances were tested at “Zaporozhstal” (1957), MakMz (1959), KMK (1962), ChelMz (1975). M. Ya. Medzhibozhsky, who was devoted to open-hearth bath air blowing, tested them on 300-ton (1967) and 900-ton (1971) blast furnaces. Obviously, de Laval nozzle for single-channel lances of basic-oxygen converter has been used by Consett I&S Corp. (Great Britain, 1961) for the first time. Cases of using cylindrical nozzles with 30-32 mm in diameter for basic-oxygen converters are known in the world practice. As follows from stated above, bath lancing in blast furnace and basic-oxygen converter is reasonable to carry out with the use of de Laval nozzles. This is problematic in open-hearth lances due to small diameter of nozzles, but seems to be possible if de Laval nozzle configuration is simplified.

Results and Discussion

In bottom units (blast furnace and electric arc furnace), preliminary slag formation takes place during furnace charge, therefore there is no initial stage with higher position of lance (h_1). Lancing starts at nominal position of lance h_2 which can be constant along the length of the lance.

Nozzle diameter several times smaller than converter lance complicates lance installation at desirable height h_2, that is why in many cases the height was $h_2 = 0$. However, reduction of lance tip durability needs $h_2 > 0$, this height calculation method is of theoretical and practical interest.

Thickness of foamed slag h_s is commensurable with h_2. If slag foaming is undesirable due to lower heat exchange from flame to metal, slag foaming should be in electric arc furnace as it enhances wall lining resistance.

If $h_s > h_2$, oxygen jet forms gas space of size D_1 (primary interaction zone) which can be counted [1]. At number of nozzles n_n and their axis tilt angle to vertical α, the angle between axes of bystander nozzles φ can be found from expression tg (φ/2) = sin α· tg (180/n_n). It is possible to show that in the range α = 10-60 °, used in open-hearth furnace and electric arc furnace, in narrow interval n_n = 6-7 φ→ α and superposition of primary interaction zones occurs almost the same for both nearby standing and opposite nozzles. This obviously explains the universal use of multichannel lances for bath lancing of bottom units with six channels selected by empirical method.

If the distance between centers of primary interaction zones l_1 should be less than zone radius ($l_1 \le D_1/2$), this is provided at $\alpha \ge 30^0$ which is featured for blowing in bottom units. There is a space of size $D_n = D_1 n_c^{1/2}$ at merger of primary zones D_1. And to prevent this space going beyond interface slag-metal, the following equation is necessary

$$h_2^* \le D_n / \cos\alpha \qquad \text{(Eq. 1)}$$

According to published data, we computed the necessary height h_2^* and ratio of actual h_2 to this value $\bar{h}_2 \equiv h_2 / h_2^{*-}$ which is presented in **Table 1** as a range of values (numerator) and average value and number of average values (denominator) depending on n_n and α for domestic (A) and foreign (B) open-hearth furnace and electric arc furnace and their generalization (C).

Analysis of presented data shows that in some cases value $\bar{h}_2$ is close to 1 but is less which provides emersion of primary reaction zone on metal surface and its refining. Domestic (A) and foreign (B) blast furnaces operated approximately at equal $\bar{h}_2$ which is increased for six-channel lance, but, obviously, does not depend on α. In electric arc furnace, value $\bar{h}_2$ is more than in open-hearth furnace. Probably, α > 30 ° is inexpedient as breaks the identity of primary reaction zone interaction for the next and opposite nozzles. Values h_2 above which we observed considerable reduction of blown oxygen uptake factor are defined in the investigations [2-4]. Calculations by equation (1) showed that in these cases $\bar{h}_2$ was 0.39-1.27 (compare 0.63) that correlates with data of **Table 1** for OHF-A at n_n = 6. Thus, it is reasonable to choose position of multichannel lance by equation (1) in bottom units with bath lancing.

Table 1. Values $\bar{h}_2$ for blast furnace and electric arc furnace

Unit	n		α, degree			
	1	6	0	20	30	45
OHF-A	$\frac{0.26-0.52}{0.41/7}$	$\frac{0.23-0.93}{0.63/11}$	$\frac{-}{-}$	$\frac{-}{-}$	$\frac{0.25-1.02}{0.75/7}$	$\frac{0.68-0.73}{0.42/10}$
OHF-B	$\frac{0.22-0.63}{0.39/5}$	$\frac{0.55-0.82}{0.67/4}$	$\frac{0.40-0.65}{0.52/4}$	$\frac{0.82}{0.82/1}$	$\frac{0.63-0.75}{0.69/2}$	$\frac{-}{-}$
OHF-C	$\frac{0.22-0.63}{0.40/12}$	$\frac{0.23-0.93}{0.64/15}$	$\frac{0.40-0.65}{0.52/4}$	$\frac{0.82}{0.82/1}$	$\frac{0.25-1.02}{0.74/9}$	$\frac{0.08-0.73}{0.42/10}$
EAF-A	$\frac{0.51-1.10}{0.80/2}$	$\frac{0.33-0.89}{0.67/8}$	$\frac{0.51-1.10}{0.80/2}$	$\frac{0.33-0.79}{0.61/3}$	$\frac{-}{-}$	$\frac{-}{-}$

Conclusions

Expression for lance height definition at bath lancing in bottom units, providing bath refining with high oxygen recovery rate is obtained.

References

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Использование многоканальных фурм в сталеплавильных процессах. Подовые агрегаты

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Изложена история освоения многоканальных фурм для продувки кислородом сталеплавильной ванны. Получено выражение для определения положения фурмы относительно ванны, обеспечивающего высокий коэффициент усвоения кислорода на рафинировку.